International Conference

on "Environmental impact of military conflicts" dedicated to the "Year of Constitution and Sovereignty"

ABSTRACTS

10-12 September 2025

Baku - Azerbaijan

INTERNATIONAL CONFERENCE

on “ENVIRONMENTAL IMPACT OF MILITARY CONFLICTS”

dedicated to the

“Year of Constitution and Sovereignty”

September 10-12, 2025

ABSTRACTS

Baku- Azerbaijan

ORGANISERS

Institute of Radiation Problems of MSE Azerbaijan
Azerbaijan University of Architecture and Construction
EGE University of Turkiye
Western Caspian University
Tbilisi State University, Georgia
Academy of Ministry of Emergency Situations AR
Karshi State University of Uzbekistan

ORGANIZING COMMITTEE

Chairman:	**Aliguliyev R.M.-** academician, vice-president of ANAS
Co-chairman:	**Mustafayev I.I.** – Professor, Director-General of IRP
Secretary:	**Mehdiyeva R.N.** – Ass.Prof. Executive director of IRP

Members:
G.Mammadova- Rector of AUAC
V.Kerimov – Deputy Minister of MENR AR
N.Mammadli - advisor of MSE AR
H.Baghirov – President of WCU
S.Yusan – Ege University, Turkiye
G.Tatishvili – Tbilisi State University
S.Mammadaliyeva - Corr. Memb. of ANAS
V.Dolin - Ukraine NAS
A.Sadikhov – Rector of SSU
S.Hajiyeva – Professor of BSU
B.Salayev – Academy of MES AR
A.Hasanov – Ministry of Defence of AR
R.Khatibi - UK
I.Bekbulatov –Karshi State University, Uzbekistan

CONTENT

SECTION 1. RADIOECOLOGICAL RISKS IN MILITARY CONFLICTS 14

THE COEXISTENCE OF MILITARY AND ENVIRONMENTAL ACTIVITIES - A MANIFESTATION OF THE CONTRADICTORY NATURE OF HUMAN
Nizami Mammadov, Sevda Mammadaliyeva 14

A NEGATIVE IMPACT OF LANDMINES AND EXPLOSIVE REMNANTS OF WAR TO THE ENVIRONMENT OF THE REPUBLIC OF AZERBAIJAN
Elnur Gasimov 17

THE IMPACT OF ILLEGAL MINING ACTIVITIES ON THE ENVIRONMENT DURING THE OCCUPATION IN EASTERN ZANGEZUR REGION
Famil Humbatov, Aysel Suleymanova-Rahmanli 19

IS HUMANITY MATURE ENOUGH FOR A PARADIGM SHIFT TO EMBRACE ENVIRONMENTALLY FRIENDLY WARS? Rahman Khatibi 21

DEVELOPMENT OF PERMEABLE BARRIER SYSTEMS USING NATURAL MATERIALS FOR NUCLEAR SAFETY: MITIGATION OF Sr-90 AND Cs-137 MIGRATION Sabriye Yusan, Sule Aytas, Berkay Camgoz, Sema Erenturk, Ikbal Gozde Kaptanoglu, Canan Uraz, Senol Sert, Ilker Sert, Gunseli Yaprak, Ozge Elmastas Gultekin, Mumtaz Colak, Osman Candan 24

POTENTIAL FOR SORPTION-BASED EXTRACTION OF HEAVY METAL IONS FROM WATERS CONTAMINATED AS A RESULT OF MILITARY ACTIONS USING CARBONACEOUS MATERIALS OBTAINED FROM SECONDARY WASTE G.Tatishvili, N.Giorgadze, N.Ananiashvili, L.Kvinikadze, M.Gachechiladze 26

ASSESSMENT OF THE ENVIRONMENTAL EFFECTS OF MILITARY ACTIVITIES DURING THE WAR IN UKRAINE ON SOIL-PLANT SYSTEMS
V.V.Berezhna, V.I.Sakada, N.K.Kutsokon, N.M.Rashydov 28

MODERN RADIOECOLOGICAL SITUATION IN THE LIBERATED TERRITORIES OF KARABAKH AND EAST ZANGEZUR
Ch.S.Aliyev, A.R.Aliyeva, F.F.Mahmudova, R.J.Baghirli, Kh.M.Karimli 29

RADIOACTIVE-INVENTORY-DRIVEN NUCLEAR THREATS AT UKRAINIAN NPPs Viktor Dolin, Yevgeni Yakovlev, Viktor Smyrnov, Oleksandr Kopylenko31

THE IMPACT OF HIGH-FREQUENCY ELECTRO-MAGNETIC RADIATION ON BIOLOGICAL SYSTEMS Saltanat Aghayeva 33

A NEW TECHNOLOGICAL APPROACH FOR REMOTE RADIATION MONITORING IN THE LIBERATED TERRITORIES OF AZERBAIJAN
N.N.Heydarov, I.M.Nuruyev, M.H.Kazimov, A.Z.Sadigov, N.S.Babakhanov, E.N.Sabziyev, A.B.Pashayev, N.Y.Suleymanova 34

POTENTIAL RADIOECOLOGICAL THREAT TO REMOTE TERRITORIES DURING MILITARY ACTIONS IN NUCLEAR POWER PLANT ZONES
M.E.Gogebashvili, N.I.Ivanishvili, S.D.Uchaneishvili, S.L.Kalmakhelidze 38

THE ROLE OF RADIATION SAFETY IN THE RESTORATION OF ECOLOGY IN LIBERATED TERRITORIES Sevinj Melikova 39

RADIOACTIVE POLLUTION AND MILITARY OPERATIONS: MODERN CHALLENGES AND SOLUTIONS S.M.Farajova, A.H.Jafarova.........................41

RADIOACTIVE CONTAMINATION OF THE ENVIRONMENT AS A RESULT OF MILITARY CONFLICTS AND INTERNATIONAL LAW Aysel Hasanova .43

ENVIRONMENTAL RISKS CAUSED BY ILLEGAL EXPLOITATION OF THE VEJNELI FIELD Famil Humbatov, Aysel Suleymanova, Geys Ibrahimov, Gultakin Aslanova, Husniya Nejati Solut, Valeh Balayev, Nisakhanim Karimova, Intizar Karimbeyli, Sabir Osmanov 49

IMPACT OF MILITARY OPERATIONS ON THE RADIOECOLOGICAL SITUATION: CASE STUDY OF THE NAGORNO-KARABAKH CONFLICT Elshan Hashimov, Ramil Akhundov 52

ASSESSMENT OF THE RADIOECOLOGICAL CONDITIONS FOLLOWING MILITARY OPERATIONS Sakit Rasulov, Latifa Kazimova 58

DEVICE FOR CONTINUOUS MONITORING OF RADIATION CONDITIONS N.M.Muradov, I.R.Hasanov, B.A.Sharifova 60

IMPACT OF MILITARY ACTIONS DURING THE WAR BETWEEN UKRAINE AND THE RUSSIAN FEDERATION ON THE RADIOECOLOGICAL SITUATION OF THE DONETSK REGION O.Raksh-Slyusareva, O.Slyusarev, P.Kovalenko, Ya.Tur..62

ASSESSMENT OF THE HISTORICAL TRENDS OF HEAVY METALS FROM FLOODPLAIN SEDIMENT RECORDS IN THE TRANS-BOUNDARY RIVER BASIN, MARITZA–TUNDJA–ARDA G.Yaprak, I.Sert, S.Aytas, S.Yusan, C.Kıncal, S.Hakan Sazak, O.Candan, D.Yasar..64

MEASUREMENT OF RADIOACTIVITY ON THE EARTH'S SURFACE Hokuma Dunyamaliyeva..66

POSSIBILITIES OF USING ELECTROMAGNETIC WEAPONS IN INFORMATION WARFARE IN MILITARY CONFLICTS Elvira Huseynova ...68

TRANSFORMATION OF TOXIC COMPONENTS IN THE ENVIRONMENT CAUSED BY FUEL LEAKS Nigar Guliyeva, Gulara Imanova, Samira Aliyeva, Islam Mustafayev 71

TECHNOLOGY AND CHEMICAL AGENTS USED IN MODERN MILITARY OPERATIONS Shahla Hajizade 73

STUDY OF FISH ORGANISMS EXPOSED TO DIFFERENT DOSES OF IRRADIATION Leyla Kazimli, Rovshan Khalilov, Nisakhanim Karimova, Intizar Karimbeyli, Gulay Humbatli...75

THE IMPACT OF PLASTIC MASSES ON THE ECOLOGICAL BALANCE M.A.Manafov, S.M.Khalilova, G.J.Ismayilova, S.A.Salahova 76

THE ENVIRONMENTAL IMPACT OF PESTICIDES AND MEASURES TAKEN TO REDUCE THEM Nigar Hashimova 78

THE ROLE OF THE ZEOLITE MINERAL IN ENVIRONMENTAL IMPACT Nizami Naghiyev, Vagif Mammadov 80

ENVIRONMENTAL TERRORISM THROUGH LANDMINES DURING THE ARMENIAN OCCUPATION OF AZERBAIJANI TERRITORIES Col. (Ret.) Mehman Gadimaliyev 82

ASSESSMENT OF TERRITORIES DEGRADED AS A RESULT OF MILITARY IMPACT IN THE TERRITORIES OF OGUZ, AGSU, KHYZY AND HAJIGABUL, USING GIS Valida Mammadaliyeva, Rovshan Ramazanov, Vusala Nasirova, Nargiz Abilova 86

SECTION 2. IMPACT OF MILITARY OPERATIONS ON FLORA AND FAUNA, THEIR ROLE IN FOREST FIRES AND CO_2 EXCHANGE 89

A BRIEF SUMMARY OF RESEARCH CONDUCTED IN KARABAKH AND NEW STRATEGIES Sayyara Ibadullayeva....89

ASSESSMENT OF AIR POLLUTION BY HEAVY METALS IN THE AREA OF CITY OF GROZNY, CHECHEN REPUBLIC, USING BIOMONITORING WITH MOSSES Marina Frontasyeva, Zarina Okazova 91

THE IMPACT OF MILITARY OPERATIONS ON FOREST FIRES, WATER POLLUTION, AND LAND RESOURCES: A CASE STUDY OF THE NAGORNO-KARABAKH CONFLICT Ramil Akhundov, Islam Islamov 92

THE IMPACT OF FOREST FIRES ARISING DURING MILITARY OPERATIONS ON THE STATE OF THE ENVIRONMENT Narmina Abdullayeva 96

ENVIRONMENTAL DEGRADATION AND ITS CONTRIBUTION TO CLIMATE CHANGE: INSIGHTS FROM THE UKRAINE AND 44-DAY WARS Bayram Ibrahimov, Ramil Akhundov 98

EFFECTS OF FOREST FIRES CAUSED BY MILITARY OPERATIONS ON ATMOSPHERIC CO_2 EMISSIONS Aygun Bayramova, Zamina Mashadibeyova 103

THE IMPACT OF MINE EXPLOSIONS ON CULTIVATED SOIL SURFACE AND RELIEF E.A.Gurbanov, T.I.Jafarov, Z.R.Gurbanova....105

NEGATIVE IMPACTS OF WAR-INDUCED FOREST FIRES ON CLIMATE CHANGE S.M.Bashirova, L.V.Ahmadli 107

THE IMPACT OF FOREST FIRES ON CO_2 EMISSIONS IN THE POST-WAR PERIOD AND WAYS OF ECOSYSTEM RESTORATION Nadir Khaligov 109

THE IMPACT OF MILITARY OPERATIONS ON CO_2 EXCHANGE IN THE KARABAKH REGION Akif Habilov, Rukhsara Hasanova 111

COMPARATIVE ANALYSIS OF THE IMPACT OF AERIAL ATTACK SYSTEMS ON ATMOSPHERIC AIR U.N.Rustamova, E.M.Kadyrova 113

MILITARY IMPACTS ON FLORA, FAUNA, AND SOIL RESOURCES IN KARABAKH: ANALYSIS OF FOREST FIRES USING GIS TECHNOLOGIES S.Y.Adigozalova, A.D.Babayeva, A.I.Huseynov, A.M.Gasimov, M.M.Mehdiyev, M.A.Huseynov, Y.V.Mammadov 116

IMPACTS OF MILITARY CONFLICTS ON BIODIVERSITY IN KARABAKH Elshad Mammadov, Tunzala Isgandarova..118

FOREST FIRES, POLLUTION OF WATER AND LAND RESOURCES AS A RESULT OF WARS Solmaz Rzayeva, Muradhasil Gurbanov, Vusala Mirzayeva, Aynura Salimova, Konul Ahmadova 120

THE IMPACT OF MILITARY OPERATIONS ON FAUNA AND FLORA, THE RESULTING FOREST FIRES, AND THEIR ROLE IN CO_2 EXCHANGE Elnara Guliyeva, Khayal Asadov 124

ECOLOGICAL ASSESSMENT OF FOREST COVER IN THE SURROUNDING AREAS OF MILITARY UNITS USING SPACE TECHNOLOGIES Elchin Isgenderzade, Valida Mammadalieva, Ilaha Mammadova............................129

STUDY OF FOREST COVER CHANGES IN CONNECTION WITH MILITARY ACTIONS BASED ON SATELLITE IMAGES Tofik Suleymanov, Valida Mammadalieva, Vusale Nasirova 132

FOREST FIRES, POLLUTION OF WATER AND LAND RESOURCES CAUSED BY MILITARY OPERATIONS Elmir Mammadov, Aprel Babayev 134

FIRES ARE A FACTOR IN THE LOSS OF BIODIVERSITY AND FOREST ECOSYSTEM FUNCTIONS Aynur Heydarova 142

THE CURRENT STATUS OF RELICT, ENDEMIC, AND RARE PLANT SPECIES IN KARABAKH S.G.Garayev, N.P.Mehdiyeva, R.T.Abdiyeva, Kh.J.Khalilova, A.Y.Abdullayeva, K.M.Namazzade, L.I.Babayeva...145

THE IMPACT OF THE FIRST KARABAKH WAR ON THE FLORA OF AZERBAIJAN Nizami Rzayev..148

PURIFICATION OF DIESEL FUEL THROUGH MAGNETIC FIELD-ASSISTED EXTRACTION TO REDUCE ENVIRONMENTAL RISKS IN KARABAKH REGION Babak Abdulov, Alakbar Hasanov 152

IMPACT OF ARMED CONFLICTS ON ECOSYSTEMS: A COMPARATIVE ANALYSIS OF CASE STUDIES (KARABAKH, SYRIA AND UKRAINE) Konul Aghayeva 154

THE DISTANT IMPACT OF REGIONAL WARS ON THE ECOLOGICAL BALANCE OF THE LANKARAN-ASTARA ECONOMIC REGION Rana Garamollayeva 156

IMPACT OF MILITARY CONFLICTS ON THE BIODIVERSITY OF KARABAKH Mahluga Yusifova, Nigar Sultanova 159

SECTION 3. EQUIPMENT AND CHEMICAL MEANS USED IN MODERN MILITARY OPERATIONS 162

CHEMICAL AND BIOLOGICAL APPROACHES TO WHITE PHOSPHORUS REMEDIATION: A COMPARATIVE ANALYSIS H.R.Azizbayli, A.R.Azizbayli..162

LAND MINES IN KARABAKH AND ITS ENVIRONMENTAL IMPACT Kamran Khan 164

REMOTE-CONTROLLED MINE DETONATION SYSTEM F.A.Nasirov, V.M.Abbasov 166

ASPECTS OF THE IMPACT OF CHEMICAL WEAPONS ON THE ENVIRONMENT S.R.Hajiyeva, U.N.Rustamova 168

THE USE OF LASER IN MODERN WARFARE TECHNOLOGY AND ITS ENVIRONMENTAL RISKS E.L.Yuryeva, A.Y.Mammadova 170

THE IMPACT OF MODERN MILITARY TECHNOLOGIES AND CHEMICAL AGENTS ON THE ENVIRONMENT Zarifa Jamilova..172

THE IMPACT OF MILITARY EQUIPMENT, EXPLOSIVES, AND CHEMICAL AGENTS USED IN MILITARY OPERATIONS ON SOIL Turkan Aghazade...174

ENVIRONMENTAL CRISES IN THE 21ST CENTURY: THE IMPACT OF MODERN MILITARY OPERATIONS ON THE ENVIRONMENT Naiba Shamshiyeva..177

PSYCHOLOGICAL PREPARATION OF RESCUE PERSONNEL: ENHANCING STABILITY AND PERFORMANCE Tukazban Hasanova, Jamila Imamaliyeva180

THE IMPACT OF WHITE PHOSPHORUS MUNITIONS ON CIVILIANS AND THE ENVIRONMENT IN ARMED CONFLICTS Elnur Jabrayilov, Aprel Babayev, Arzu Musayev 188

MINE ANTI-MINE ACTIVITIES AND THE ENVIRONMENT IN KARABAKH Gullu Gullarli, Anar Hamidov, Tarana Aliyeva 190

DETECTION OF EXPLOSIVE SUBSTANCES IN CONFLICT ZONES AND THEIR ENVIRONMENTAL IMPACTS: A CASE FOR INTEGRATED MONITORING APPROACHES K.A.Asgarov, S.T.Ahmadova 192

ENVIRONMENTAL IMPACTS OF MODERN MILITARY EQUIPMENT AND CHEMICAL AGENTS IN CONFLICT ZONES Ravana Guliyeva..................193

POSSIBILITIES OF USING OPTICAL WEAPONS IN MILITARY BATTLES Naila Yagubzade, Elvira Huseynova, Rahim Chodarov, Zamina Mashadibayova...195

COMPLEX APPROACHES TO THE ENVIRONMENTAL IMPACT OF ARMED CONFLICTS AND ITS ELIMINATION Mahruza Shatirova 197

THE IMPACT OF MINE EXPLOSIONS ON CULTIVATED SOIL SURFACE AND RELIEF E.A.Gurbanov, T.I.Jafarov, Z.R.Gurbanova 199

ELECTRONIC WARFARE TECHNOLOGIES AND THEIR ROLE IN MODERN MILITARY OPERATIONS Aytan Aslanova, Ilala Ismayilova 201

SCIENTIFIC AND TECHNICAL RESEARCH ON ENHANCING THE EFFECTIVENESS OF TELEMETRY SYSTEMS OF UNMANNED AERIAL VEHICLES UNDER ELECTRONIC WARFARE CONDITIONS
Mukhtar Azizullayev, Nurlan Karimov, Lala Najafova 203

MULTIFUNCTIONAL RADIO-ELECTRONIC JAMMING (MREJ)
Namik Pashayev, Durdana Aliyeva, Aytan Sohbatova 205

REGENERATION OF MOTOR OILS AS AN ELEMENT OF CLIMATE-FRIENDLY RECYCLING Elvira Huseynova 207

THE ROLE OF UNMANNED AERIAL VEHICLES IN ENVIRONMENTAL MONITORING AND SIMULTANEOUSLY IN CAUSING ECOLOGICAL DAMAGE L.V.Ahmadli, A.D.Taghiyev 208

QUANTUM-MECHANICAL RESEARCH OF PENTA ERYTHRITOL TETRA NITRATE AND RDX EXPLOSIVE MINES Arzuman Hasanov, Ashraf Huseynov, Aynura Abdullayeva 210

ASSESSMENT OF THE IMPACT OF MODERN MILITARY EQUIPMENT AND CHEMICAL AGENTS ON ECOSYSTEMS AND MITIGATION STRATEGIES
Ashraf Huseynov, Arzuman Hasanov, Aynura Abdullayeva 215

SECTION 4. RISKS POSED BY MILITARY OPERATIONS TO WATER BODIES, AIR AND SOIL 218

THE COMBINED IMPACT OF WAR AND NATURAL DISASTERS ON AGROECOLOGICAL STABILITY AND ECOSYSTEM SECURITY IN THE SOUTHWESTERN SLOPES OF THE GREATER CAUCASUS
Sona Huseynzade 218

IMPACT OF MILITARY CONFLICTS ON THE AQUATIC ENVIRONMENT
T.N.Kangarli, V.A.Mammadov, H.Kh.Khalilova 221

ECOLOGICALLY EFFECTIVE TREATMENT OF POLLUTED RIVER WATERS
Ayten Samadova, Sevinj Hajiyeva, Islam Mustafayev 224

MONITORING OF LAND, WATER AND VEGETATION IN SOURCES IN THE LIBERATED ZANGILAN DISTRICT (OKCHUCHAY AND SURROUNDING AREAS) A.G.Gaziyev, I.B.Mirjalalli, M.I.Babayev, J.G.Gurbanova 226

ASSESSMENT OF TRANSBOUNDARY ANTHROPOGENIC IMPACT ON THE WATER RESOURCES OF THE OKHCHUCHAY AND ARAZ RIVER BASIN
S.R.Hajiyeva, I.I.Mustafayev, N.T.Shamilov, T.I.Aliyeva, H.L.Rafieva, A.A.Samedova 228

THE IMPACT OF MILITARY CONFLICTS ON RESERVOIRS AND THEIR CONSEQUENCES Emil Gafarov, Nuriyye Abdullayeva 231

THE IMPACT OF RADIATION ON GOLDFISH (*CARASSIUS CARASSIUS AURATUS*) Rovshan Khalilov, Chingiz Mammadov, Alislam Hashimov, Aygun Nasibova, Nuray Akbarova 232

ASSESSMENT OF THE ECOLOGICAL STATUS OF RIVERS AND A RESERVOIR IN THE LIBERATED REGIONS OF AZERBAIJAN
Alakbar Hasanov, Abulfas Allahverdiyev..235

ENVIRONMENTAL RISKS AND CONSEQUENCES OF MILITARY CONFLICTS AND THEIR IMPACT ON GROUNDWATER
Ismayil Mammadov 237

RF-PCER FRAMEWORK: AN INTEGRATED MODEL OF POST-WAR ENVIRONMENTAL SUSTAINABILITY (GEORGIA CASE STUDY)
M.Tsatsanashvili, G.Tatishvili, L.Kvinikadze, M.Gerlini 239

EVALUATION OF ATMOSPHERIC HEAVY METAL DEPOSITION IN THE KARABAKH POST-CONFLICT REGIONS USING LEUCOBRYUM GLAUCUM AS A BIOINDICATOR Rana Khankishiyeva 241

FLOOD DISASTER RISK MANAGEMENT DURING MILITARY CONFLICTS
Habil Huseynov, Aprel Babayev, Maharram Abdullayev 243

THE IMPACT OF MILITARY CONFLICTS ON THE ECOLOGICAL CONDITION OF RIVER BASINS A.Fatdayeva, U.Alasgarova, G.Ahmadova...245

HYDROECOLOGICAL IMPACTS OF MILITARY ACTIVITIES ON WATER STORAGE INFRASTRUCTURE Akif Aghbabali, Hamlet Fatdayev..................247

SPECIES DIVERSITY OF PHYTOPLANKTON IN THE WATER BODIES OF THE KARABAKH REGION AND THE ECOLOGICAL EFFECTS OF THE WAR
Shakar Mukhtarova, Yagut Malikli, Shafiga Umudova 250

IMPACTS OF MILITARY CONFLICTS ON BIODIVERSITY IN KARABAKH
Elshad Mammadov, Tunzale Isgandarova..253

STUDY OF THE ENVIRONMENTAL IMPACT OF MILITARY OPERATIONS
Ruhangiz Guliyeva, Namig Muradov...255

THE IMPACT OF MILITARY OPERATIONS ON WATER RESOURCES AND ECOLOGICAL HAZARDS N.N.Allahverdiyeva, A.M.Aghakishizade...............257

IMPACT OF CONFLICTS ON RENEWABLE NATURAL RESOURCES: FORESTS, SOIL AND BIODIVERSITY Asef Aghayev 258

ECOLOGICAL STATE OF WATER RESOURCES IN THE CONFLICT REGIONS OF AZERBAIJAN Zeynab Talibzade, Elshad Mammadov 261

SECTION 5. ECOLOGICAL REHABILITATION OF WAR-AFFECTED AREAS ..264

MILITARY OPERATIONS NEGATIVE TO LAND SUPERSTRUCTURE EVALUATION OF IMPACT WITH VARIOUS ASPECTS Givami Abbasov ..264

AN ADAPTIVE APPROACH TO SECURING UAV TELEMETRY COMMUNICATION BASED ON ELECTROMAGNETIC ENVIRONMENT ANALYSIS UNDER ELECTRONIC WARFARE CONDITIONS
Mukhtar Azizullayev, Aytan Sohbatova 266

ESTABLISHING INTERNATIONAL COOPERATION FOR THE ECOLOGICAL REHABILITATION OF WAR-AFFECTED AREAS Mirvari Jabrayilova, Sima Valiyeva 268

ELECTRONIC WARFARE SYSTEMS USED AGAINST UNMANNED AERIAL VEHICLES DURING MILITARY OPERATIONS Nurlan Karimov, Mukhtar Azizullayev, Ravana Izzatova..........270

POST-WAR ENVIRONMENTAL DEGRADATION AND ITS LINK TO LOCAL CLIMATE CHANGES N.Kh.Mustafazade, M.G.Valiyeva..........272

THE IMPORTANCE OF INTERNATIONAL COOPERATION IN IMPROVING THE ENVIRONMENTAL SITUATION IN AREAS AFFECTED BY MILITARY OPERATIONS Alisher Orifovich Ochilov 274

KALBAJAR PERLITE FOR ENVIRONMENT REMEDY Nada Edres, Rasim Alosmanov 275

THE ROLE OF BENTONITE CLAYS IN REDUCING RADIOACTIVE CONTAMINATION OF SOIL AND WATER IN AREAS AFFECTED BY MILITARY ACTIONS S.S.Bayramova, A. R.Aliyeva,G.N.Ahmadova\, Ch.S.Aliyev, Z.R.Aghayeva..........277

ESTABLISHING INTERNATIONAL COOPERATION IN THE RECONSTRUCTION OF WAR-TORN TERRITORIES CASE STUDIES OF UKRAINE AND THE PATRIOTIC WAR Yegana Aliyeva 279

In-Sb THIN FILMS IN MILITARY APPLICATIONS N.A.Aliyeva Mammadova, V.A.Majidzade, A.Sh.Aliyev, D.B.Taghiyev..........284

INVENTORY OF FORESTS IN LIBERATED TERRITORIES ....

Alisahib Huseynli, Rukhsara Hasanova 286

ENVIRONMENTAL DAMAGE OF WARS AND ELIMINATION OF ITS CONSEQUENCES Yusif Humbatli..........288

DISPOSAL OF MILITARY TRAINING FORMULAS E.Sh.Mamedov, D.S.Velieva, T.N.Kulibekova, I.R.Rushinaz, Z.S.Safaralieva, S.D.Dadasheva 291

THE ROLE OF ALTERNATIVE ENERGY SOURCES IN THE ECOLOGICAL REHABILITATION OF THE EAST ZANGEZUR ECONOMIC REGION
Shams Alizade..........294

UNEXPLODED ORDNANCE IN THE ECOSYSTEM OF AZERBAIJAN IN THE POST-WAR PERIOD V.H.Khudaverdiev, A.J.Mikailova, R.Mukhtarov 297

SMART VILLAGES, SMART CITIES AND ENVIRONMENT Nargiz Fatahova 300

THE IMPACT OF MILITARY OPERATIONS AND INVASION PROCESSES ON HISTORICAL-ARCHITECTURAL MONUMENTS IN THE KARABAKH REGION AND METHODS OF THEIR RESTORATION Tunzala Majidova 302

POINTS ON ESTABLISHING INTERNATIONAL COOPERATION FOR THE ECOLOGICAL REHABILITATION OF POST-CONFLICT AREAS Gulsum Huseynli, Rukhsara Hasanova..306

MELIORATIVE REMEDIATION AND RESTORATION OF SOIL AFTER MILITARY CONFLICTS Umud Gasimov...310

THE USE OF CHEMICAL AGENTS IN MILITARY OPERATIONS AND THEIR CONSEQUENCES Khudayar Hasanov, Asmat Azizova, Naila Guliyeva, Shimid Gasimov...312

PROBLEMS OF ENSURING SECURITY AT INTERNATIONAL AIRPORTS LOCATED IN THE TERRITORIES LIBERATED FROM OCCUPATION Ruslan Rustamov 314

ECONOMIC MECHANISMS IN THE RECONSTRUCTION OF WAR-AFFECTED AREAS AND ENVIRONMENTAL RESTORATION Roya Amirova 316

SECTION 6. GENERAL ISSUES OF ENVIRONMENTAL IMPACT OF MILITARY CONFLICTS 318

ENVIRONMENTAL DEGRADATION IN THE KARABAKH REGION CAUSED BY MILITARY CONFLICTS IN AZERBAIJAN Kh.J.Mammadova, E.A.Abdullayeva..318

INTEGRATED ENVIRONMENTAL AND BEHAVIORAL MONITORING FOR POST-CONFLICT REHABILITATION IN TRANSPORT INFRASTRUCTURE Shola Shekili 320

IMPACT OF ECOLOGICAL DISASTERS RESULTING FROM MILITARY CONFLICT IN KARABAKH ON CLIMATE CHANGE Sona Osmanova 322

LANGUAGE, EDUCATION, AND ENVIRONMENTAL AWARENESS IN POST-CONFLICT ZONES: BRIDGING LINGUISTIC GAPS IN WAR-AFFECTED TERRITORIES Ahmad Haj Ali...325

ASSESSMENT OF LAND DEGRADATION IN POST-CONFLICT AREAS USING SATELLITE DATA Turkan Mamishova...326

ON THE PREFERENCE OF THE TRANSITION TO A GREEN ECONOMY IN IMPROVING THE QUALITY OF LIFE OF PEOPLE IN THE OCCUPIED TERRITORIES Farhad Mirzayev, Zuleykha Javanshirova, Namig Bakhishov ...328

THE ENVIRONMENTAL IMPACT OF WAR IN THE KARABAKH REGION AND THE RESTORATION OF ECOLOGICAL BALANCE IN THE LIBERATED TERRITORIES A.A.Hasanov, K.S.Abdullayeva, Z.Z.Sharifova 331

THE IMPACT OF ELECTROMAGNETIC WAVES ON THE ENVIRONMENT
R.R.Ahmadova, G.M.Seyidova, G.J.Rustamova..333

RESEARCH INTO THE IMPACT OF WARS ON CLIMATE CHANGE
Gullu Gullarli, Gunel Imraliyeva 335

THE ADVANTAGES AND APPLICATION PROSPECTS OF NEXT-GENERATION MILITARY TECHNOLOGIES AND CHEMICAL AGENTS IN CONTEMPORARY ARMED CONFLICTS Rafig Agamaliev, Nazila Rahimova 337

THE IMPORTANCE OF ESTABLISHMENT OF AN INTERACTIVE GEOINFORMATION DATABASE OF THE ROAD-TRANSPORT INFRASTRUCTURE OF THE REPUBLIC OF AZERBAIJAN
Ilgar Musayev, Aziz Talibov, Magsad Gojamanov, Rauf Nuhov 339

30 YEARS OF OCCUPATION AND THE ECOLOGICAL STATE OF KARABAKH Khasmurad Ismayilzadeh, Khatira Ismayilova 343

ECOLOGICAL REHABILITATION IN POST-CONFLICT ZONES: INTERNATIONAL COOPERATION AND INTEGRATIVE APPROACHES
Firangiz Fataliyeva, Lala Hatamova...345

ASSESSMENT OF RADIOECOLOGICAL RISKS IN THE LIBERATED JABRAYIL DISTRICT Famil Humbatov, Geys Ibrahimov, Gultakin Aslanova, Husniya Nejati Solut, Valeh Balayev, Nisakhanim Karimova, Intizar Karimbeyli, Sabir Osmanov 347

ECOLOGICAL PROBLEMS CAUSED BY MILITARY OPERATIONS
N.U.Alakbarova, A.Z.Abdullazade 351

ENVIRONMENTAL IMPACT OF MILITARY OPERATIONS Imran Gasimov, Sadagat Adigozalova, Gunel Tomuyeva, Latifa Atakishiyeva, Gulnara Asadova....353

MILITARY CONFLICTS, ENVIRONMENTAL DEGRADATION, AND THE URGENCY OF RENEWABLE ENERGY TRANSITION IN RESOURCE-DEPENDENT STATES Rahim Abdinov 356

ASSESSMENT OF ENVIRONMENTAL IMPACT IN THE APPLICATION OF MODERN ARTILLERY SYSTEMS Yashar Ganbar Huseynov..........................360

SORPTION OF HEAVY METALS ON ALUMINOSILICATES IN CONDITIONS OF POST-WAR POLLUTION OF KARABAKH LANDS
Z.R.Aghayeva, V.A.Ismayilova, S.S.Bayramova, H.N.Ilyasova.............................362

THE USE OF TECHNICAL AND CHEMICAL MEANS IN MODERN MILITARY OPERATIONS Muhammad Jafarov 364

MATHEMATICAL MODELING AND CLASSIFICATION OF TOXIC WASTE PREDICTION DURING FERMENTATION Murad Abasov, Ravana Izzatova ..366

CREATION OF SOLAR ELEMENTS BASED ON SILICON DOUBLE-BARRIER NANOSTRUCTURES AND THEIR TESTING FOR RADIATION RESISTANCE Fakhraddin Abbasov 368

INFLUENCE OF GAMMA IRRADIATION ON THE LIFETIME OF A SEMICONDUCTOR BASED ON CdMnSe THIN FILMS N.I.Huseynov, M.A.Mehrabova, O.M.Salamov 369

INFLUENCE OF GAMMA IRRADIATION ON DOUBLE-BARRIER STRUCTURES OF Au-Si(p-n-) DETECTORS OF IONIZING RADIATION AND ELEVATED TEMPERATURES Fakhraddin Abbasov, Oktay Salamov 372

PROMOTING THE KARABAKH VICTORY: THE THEMATIC TOUR EXPERIENCE OF MILITARY HIGHER EDUCATION INSTITUTIONS Mujkan Mammadzade...374

AUTOMATION OF A PATENTABILITY SEARCH FOR SECRET PATENTS AND POSSIBLE DISPUTES Alikhan Rzaguliyev..376

CLASSIFICATION OF EMERGENCY SITUATIONS IN THE MILITARY ACTIONS I.I.Mustafayev, Sh.D.Danyalov, A.H.Ahmadova, Z.E.Habibzade 378

RESEARCH ON FLOOD COVERAGE AREAS IN THE CONTEXT OF CLIMATE CHANGE IN THE REPUBLIC OF AZERBAIJAN BASED ON GIS TECHNOLOGIES Namig Muradov, Boyukkhanim Sharifova 380

OBTAINING THE BROMIDE COMPLEX OF AMIDE OF 5-NORBORNENE-2-CARBOXYLIC ACID AND DETERMINING ITS PHYSICAL-CHEMICAL PROPERTIES E.H.Mammadbayli, V.H.Babayeva, N.M.Mammadova, Z.G.Fataliyeva...383

RADIATION-INDUCED PROPERTY MODIFICATIONS IN $CuTlSe_2$ SINGLE CRYSTALS AND THEIR APPLICATION IN GAMMA-RESISTANT DEVICES R.S.Madatov, R.M.Mamishova, A.Sh.Khaligzade, L.E.Sadigli...............................385

ON THE ROLE OF EDUCATION IN ENVIRONMENTAL PROTECTION F.A.Mirzayev, F.E.Bagishova, Z.Y.Javanshirova 387

RADIOACTIVITY, RADIATION DOSE Akif Mirzayev....................391

SECTION 1. RADIOECOLOGICAL RISKS IN MILITARY CONFLICTS

THE COEXISTENCE OF MILITARY AND ENVIRONMENTAL ACTIVITIES - A MANIFESTATION OF THE CONTRADICTORY NATURE OF HUMAN

Nizami Mammadov[1], Sevda Mammadaliyeva[2]
[1]Russian Academy of Ecology, [2]Corr member ANAS

The central issues of the major international philosophical forums held at the turn of the 20th and 21th centuries were, in one way or another, the question of war and peace, as well as issues related to environmental topics. And this is not accidental. The very existence of humanity – its "to be or not to be" – depends on understanding these issues, formulating them adequately, and finding appropriate solutions.

At first glance, it may seem that these issues represent fundamentally different global problems. In reality, however, they share a common foundation and stem from the very nature of humankind. The possibility of resolving the problem of war and peace, in this regard, can be considered within the context of the humanization and ecologization of the historical process.

It is now widely recognized that the natural, deep-rooted characteristics of human beings are the source not only of anthropological but also of social crises. Nobel Prize laureate Konrad Lorenz argues that one cannot ignore the presence of the aggressive instinct in modern humans [Lorenz, 2023]. In the context of the unprecedented growth of humanity's technological power, this becomes and extremely dangerous factor for civilization. The realization of the need to redirect aggression, along with the widespread implementation of this global program, could become a turning point in the history of humankind [Mamedov 2021].

Knowledge from traditional science makes it possible to create powerful instruments of activity (modern technology), but it does not determine how rational or justified the very goal of that activity is. Based on the same knowledge, one can create both a means that heals people and a weapon capable of destroying them. The use of knowledge for peaceful or military purposes goes beyond traditional science.

With the development of ecology, new possibilities for overcoming this situation have emerged. Ecological knowledge strengthens the humanistic orientation of science and contributes to the harmonization of human life activities and their relationship with nature. This is achieved because ecological knowledge not only explains reality but also performs predictive and normative functions. It can, to some extent, foresee the negative consequences of human activity and warn against the reckless development of technology and the transformation of nature.

A favorable natural environment is necessary for the existence and development of humans. As a result of long-term evolution, a strictly defined range of changes in physical, chemical and biological parameters has been established on the surface of our planet. The human body was formed and acquired its current characteristics by adapting to these conditions. Nevertheless, the human habitat does not remain unchanged. It can be transformed as a result of natural and military disasters, as well as through the transformative activities of humans themselves.

Natural disasters are inevitable – meteorite impact, earthquakes, volcanic eruptions, floods, droughts, and the like. Today, a number of methods are known for predicting and mitigating the effects of certain natural catastrophes on society. For example, areas most prone to particular natural disasters have been identified; earthquake-resistant construction is being implemented; and populations in hazardous regions are alerted to the approach of hurricanes, typhoons, and tsunamis. The global community is also striving to reduce military threats and seeks to resolve conflicts through peaceful means. The likelihood of a new world war has been significantly reduced, although regional conflicts continue to flare. The development of science and technology already makes it possible to create an alternative, peaceful application of military capabilities, directing them toward ensuring society's protection from natural disasters. For instance, schemes are known for preventing large asteroids from striking Earth – they can be destroyed by rockets while still in outer space.

However, humanity today faces an increasing threat from industrial and nature-transforming human activities, which is due to the dual position of humans in this world. On the one hand, as a biological species, humans are an integral part of the nature of our planet; on the other hand, unlike other living beings, humans possess non-biological, so-called socio-cultural needs and mechanisms of development.

Modern society requires a comprehensive justification for and maintenance of ecological security. This primarily entails the formation of a new worldview, a new attitude toward nature, and a new material and spiritual culture based on relevant knowledge. It is necessary to develop and implement a strategy of socio-economic and ecological development that would guarantee the survival of humanity.

It is precisely such a strategy that defines the essence of modern society's transition to sustainable development, which can be regarded as a precursor to the emergence of an ecological civilization [Mamedov, 2024]. In essence, this is a pivotal moment in human history, as it marks the recognition of humanity's direct dependence on the natural prerequisites for existence. Paraphrasing the words of K. Marx, one could say: although people make their own history, from now on they must not make it as they please; they must take into account that their lives are embedded in – and directly dependent on – biospheric processes.

References

1. Лоренц К. «Агрессия, или, так называемое зло». М.: АСТ, 2023, 416 с.
2. Мамедов Н.М. Развитие гуманистических идей как глобальный процесс. //Век глобализации, 2021, №1, с.19-31.
3. Мамедов Н.М. Становление экологической цивилизации – смысл исторического процесса. //Век глобализации, 2024, №4, с.36-51.

A NEGATIVE IMPACT OF LANDMINES AND EXPLOSIVE REMNANTS OF WAR TO THE ENVIRONMENT OF THE REPUBLIC OF AZERBAIJAN

Elnur Gasimov
Mine Action Agency of the Republic of Azerbaijan (ANAMA)

Humanitarian demining is one of the main priorities of Azerbaijan's state policy and considered as a key enabling factor in implementation of The Great Return Program at the liberated territories. The demining is a dangerous and complex chain of activities which has a strategic impact in eliminating a social, economic and environmental threat and isolation posed by mines and explosive remnants of war. For the past 30 years, the liberated territories of the Republic of Azerbaijan have been seriously contaminated by landmines and explosive devices. During demining operations, we witnessed that land mines have been placed in patterned and chaotic manners which makes them to be unpredictable. Landmines are also planted in areas without military necessity: such as cemeteries, parks, in and around residential areas, under and around bridges, hills, riversides, forests and etc. According to estimates, 11.667 km^2 of the liberated territory consists of suspected and confirmed hazardous areas. This area is equivalent to the size of countries such as Lebanon, Qatar and Montenegro. Landmines, ammunition and their fragments are not biodegradable. Areas affected by war and deprived from human care start to degrade. Trees and animals in inhabited certain area have a certain role and benefits, so the violation of that balance can lead to an ecological disaster. Areas desertified, or overgrown, land mines and explosive devices migrated to safe places by rivers and landslides, already damaged and unstable landmines explode and create uncontrolled fires, corroded explosive devices leak chemicals to nature. Also, many white-phosphorus-containing artillery munitions have been used during the former wars. White Phosphorus is known for its toxic properties and ability to burn when contacted to oxygen. If inhaled, it damages lungs. If contacted to body it burns inside the human skin to bones and it is impossible to stop without blocking by water. Spontaneous explosions and fires in forests and dry grasslands lead to emergency situation in those areas. Such fires are hard to stop because firefighters can't enter to dangerous areas. Rivers, lakes and canals, water basins cannot be used because of mine contamination and as a result, orchard are damaged, forests and pastures dry up, agricultural areas become saline. The water, which that does not flow, eventually becomes polluted and turns into ponds. Explosions create craters and eventually those craters form a plate-shape filled with water. That ground becomes unfertile. In the territories liberated from occupation, demining staff encountered animals that had lost their front and rear limbs due to landmines. Territories that have been kept under the occupation for a long time were continuously burned. For this reason, both mine explosions and fires caused the migration of animals. For example: sometimes massive attacks of locusts and mice from occupied territories were observed in Tartar and Aghdam directions, which had a serious negative impact on the ecosystem and agriculture. Water-flushed mines and explosive munitions have a negative impact on hydro ecology. Harmful chemicals contained in explosives cause the death of water habitants, as well as soil poisoning and intoxication of human and other organisms during the consumption of water for agricultural purposes. Until now, ANAMA has detected and neutralized a large number of mines and ammunition in the territory of Tartar's Khachin, Tartar rivers, Agdam's Gargar, Fuzuli's Kondelanchay, Zangilan's Okchuchay, and Goranboy's Goran river. As a result of demining operations conducted from November 10, 2020 to July 28, 2025, 216.301.6ha of the liberated territory were cleared, and a total of 202.657 mines and unexploded ordnance (UXO) were detected and destroyed. Of these, 143.010 were UXOs, 37.655 anti-personnel mines and 21.992 were anti-tank mines. Since November 10, 2020 to July 28, 2025 - 400 people killed and injured by legacy explosive devices. A total of 243 mine incidents were recorded since November 10, 2020 till July 28, 2025. More than 3.400 mine victims have been registered since 1991.

THE IMPACT OF ILLEGAL MINING ACTIVITIES ON THE ENVIRONMENT DURING THE OCCUPATION IN EASTERN ZANGEZUR REGION

Famil Humbatov[1], Aysel Suleymanova-Rahmanli[2]
[1]*Institute of Radiation Problems MSE AR*
[2]*Academy of the Ministry of Emergency Situations*
hfamil@mail.ru, suli_ay@mail.ru

During the period of occupation, the illegal exploitation of gold deposits, military activities, and deliberate modifications of river basins in the Eastern Zangezur region led to significant environmental degradation. This study focuses on the Zod and Vejneli gold mines as case areas. Utilizing satellite imagery, the research identified substantial decreases in vegetation cover, increased soil erosion, and other indicators of ecological disturbance. Deforestation, irregular mining, and improper waste disposal were commonplace, leading to the destruction of vegetation and wildlife, soil erosion, and pollution of water resources. During the occupation, the diversion of river waters, the illegal use of water reservoirs, the use of illegal gold mines, and the use of chemicals and weapons during military operations also caused serious environmental pollution. In this thesis, it will provide information about the damage to the environment and biodiversity in different regions of Eastern Zangezur. The largest and most valuable natural resources of the Eastern Zangezur area are the gold mines located in the Kalbajar and Zangilan area. Especially the Zod and Vejneli gold mines. During the occupation, these gold mines were exploited illegally and the environment was seriously damaged. As a result of the illegal use of gold mines, there were serious effects on the vegetation of the area. For a more accurate assessment of Vegetation in the Kalbajar area the Vegetation Health Index (VHI) was used, and the degree of exposure of plants to environmental stress was studied. It was determined that the area of plant ecosystems with a high degree of stress increased by 7.13% in 2023 compared to 1992. Degree of stress shown below (Figure 1).

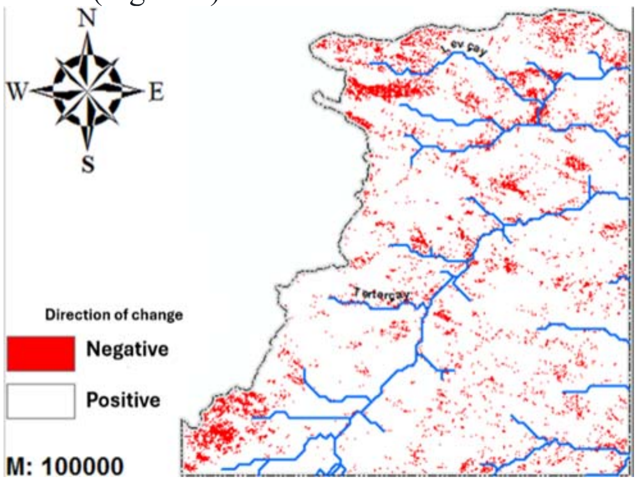


Figure 1. The degree to which plant ecosystems are exposed to stress

As a result, gold mining poses significant environmental and health risks due to the release of harmful substances, including heavy metals such as mercury, arsenic, lead and cadmium, as well as toxic chemicals such as cyanide. As seen in the Zod and Vejneli gold mines, illegal exploitation of mines causes widespread damage to the landscape, serious ecological disturbances, and long-term pollution of soil and water sources. Unregulated expansion of mining areas exacerbates these problems, causing soil degradation and deformation over time. Effective management, stricter regulations and safer mining practices are essential to reduce these harmful effects and protect both the environment and human health.

IS HUMANITY MATURE ENOUGH FOR A PARADIGM SHIFT TO EMBRACE ENVIRONMENTALLY FRIENDLY WARS?

Rahman Khatibi
UK, Azerbaijan University of Architecture and Construction

Environmentally responsive wars may sound oxymoronic as wars are never friendly, but environment-friendly wars are paradoxical for making sense, as wars are unlikely to vanish in the foreseeable future. If wars can be environment-friendly, a transformation of the mindset of decision-makers becomes a necessity in a background where the environment is a common heritage of not only hostile combatant parties but of all species. Mankind has put behind untold wars driven by cold weapons, but in a way, they did not harm the environment, no matter how damaging they were for the domains of the combatant parties. The addition of mechanical weapons and firing arms opened up unsavoury prospects, but more so, the addition of chemical, biological reactants and nuclear weapons puts the environment directly in the spot. No matter how much the environment is omitted from war narratives, sooner or later, it will become imperative to adapt war capabilities to be environment-friendly contexts, as opposed to compelling the environment to adopt to the war impacts. This needs a paradigm shift in the global human culture and the paper aims to bring in some stimulating ideas to the peace discourse.

The subject is treated here in a dispassionate capacity without taking part in the politics of any country and in particular, there is no intention to reinforce or reduce the politics of any country. The mindset requiring no damage to the environment during armed conflicts may be expressed in terms of environment-friendly (minimising harm), environment-sensitive (for fostering careful strategies) or environment-responsive or more appropriately, environmentally responsible (to introduce the responsibility dimension into the actions), as possible steps in the endeavour.

The narrative on environmentally responsible wars is yet to be formed, as it is not topical academic research or a discipline of strategy studies. Conventional strategy studies are likely to consider: monitoring environmental changes, mitigating risks to the environment, promoting active iterative learning, developing cycles of experimentation and feedback, and integration of stakeholders. However, what is overlooked in armed conflicts is existence of strange attractors and repellents in the sense of catastrophe theory. Repellents are inflexibilities arising from fixations of religion, mythology in the form of worshipping ancestors, racism, ideology and conspiracies. These are often disembodied mindsets and have nothing to do with existing realities. Once a country is in the grip of displaying any of these repellents, the environment is out-of-the-window. The attractors require inclusivity deeply rooted in pragmatism and flexibility and these are reinforced by the principles of good governance essential for sustainable development and such other principles as the principle of precaution. The issues amenable to the attractors arise from embodied realities.

The paper illustrates environmentally responsive examples from recent armed conflicts of recapturing Shusha during the 2nd

Karabakh War (27 September – 10 November 2020) and the 13-Day Israel-Iran War (2025), both with precision targeting combatants and their facilities. Environmentally irresponsible wars are still going on in other parts of the world, e.g. the full-scale Russian invasion of Ukraine in 2022 has no provision to protect the environment. The 2nd Karabakh War was the transformation of border incursions to a full-scale war, but Azerbaijan acted with full due care to the environment and when it came to the retake of Shusha, it took the ultimate diligence not to inflict any damage to the city.

The paper will take an overview of the UN initiatives, including a range of human rights concerning the environment, the conventions on protecting the people as a prerequisite for sovereignty and some of the relevant conventions, including the ongoing environmental crimes and initiatives on recognising the necessity for conventions to protect the environment during armed conflicts. These will be outlined with respect to paradigm shifts that each step has caused and identifying existing gaps.

DEVELOPMENT OF PERMEABLE BARRIER SYSTEMS USING NATURAL MATERIALS FOR NUCLEAR SAFETY: MITIGATION OF Sr-90 AND Cs-137 MIGRATION

Sabriye Yusan[1], Sule Aytas[1], Berkay Camgoz[1], Sema Erenturk[2], Ikbal Gozde Kaptanoglu[1], Canan Uraz[3], Senol Sert[1], Ilker Sert[1], Gunseli Yaprak[1], Ozge Elmastas Gultekin[4], Mumtaz Colak[5], Osman Candan[5]

[1]Ege University Institute of Nuclear Sciences, 35100 Bornova-Izmir, Türkiye,
[2]Istanbul Technical University, Energy Institute, Maslak, Istanbul-Türkiye,
[3]Ege University Chemical Engineering Department, Bornova-Izmir, Türkiye, *[4]Ege University Statistic Department, Bornova-Izmir, Türkiye,*
[5]Dokuz Eylul University, Geology Engineering Department, Buca Izmir, Türkiye

Accidental releases from nuclear facilities can mobilize long-lived fission products—most critically ^{137}Cs and ^{90}Sr—into soils and waters, demanding robust in-situ containment. We developed and bench-tested a low-cost permeable reactive barrier (PRB) composed solely of abundant natural sorbents—clinoptilolite zeolite, diatomite, bentonite clay, and sepiolite—configured as a four-layer system (zeolite → diatomite → clay → sepiolite). The PRB design and operating window were optimized using a full factorial design with five factors (pH, influent concentration, particle size, bed volume, and flow rate), with performance evaluated via distribution coefficients and sorption capacities.

Material characterization (XRD/FT-IR/SEM-EDX, BET, permeability) and single-layer column tests showed that pH strongly and positively affected Sr(II) uptake on zeolite, clay and sepiolite, whereas diatomite exhibited a negative pH effect, increasing Sr concentration enhanced diatomite uptake—guiding the multi-layer arrangement. Bench-scale dynamic trials with a ^{137}Cs standard, corresponding to 99.04% removal by the four-layer PRB; layer-specific contributions were ~88% (zeolite), 67% (diatomite), 36% (clay), and 62% (sepiolite). In trials with a ^{90}Sr standard solution, liquid scintillation counting (LSC) indicated adsorption by each layer of 74% (zeolite), 77% (diatomite), 70% (clay), and 45% (sepiolite); considering influent and effluent activities overall ^{90}Sr removal by the four-layer PRB was 99.01%. Dialysis-cell leaching tests indicated limited release, corroborating immobilization and stability.

Overall, the integrated natural-material PRB demonstrated high removal of ^{137}Cs and strong attenuation of ^{90}Sr under realistic flow conditions, with low leachability and favorable radiological risk metrics—highlighting a scalable, locally sourced countermeasure for nuclear-accident preparedness and groundwater protection.

Acknowledgements This research was financially supported by TÜBİTAK Scientific and Technological Research Council of Turkiye (TÜBİTAK) 1003 program (Project No: 118F455)

POTENTIAL FOR SORPTION-BASED EXTRACTION OF HEAVY METAL IONS FROM WATERS CONTAMINATED AS A RESULT OF MILITARY ACTIONS USING CARBONACEOUS MATERIALS OBTAINED FROM SECONDARY WASTE

G.Tatishvili, N.Giorgadze, N.Ananiashvili, L.Kvinikadze, M.Gachechiladze

Rafiel Agladze Institute of Inorganic Chemistry and Electrochemistry of Iv. Javakhishvili Tbilisi State University

Military conflicts are an important factor in the social, political and environmental transformations of humanity, which have a serious and long-term impact on the environment and ecosystems. Modern wars have significantly changed the nature and scale of environmental pollution, which is especially noticeable in terms of the dissemination of heavy metals. As a result of the use and destruction of military equipment, ammunition, explosives, infrastructure, toxic metals such as lead, cadmium, etc., enter the environment. These metals accumulate in soil, water and air, creating a long-term environmental threat and affecting human health [1,2].
Purification of water contaminated with heavy metals is a significant ecological and technological task, which is associated with large economic costs, so the creation of inexpensive, environmentally friendly and effective adsorbents based on waste is relevant.

R. Agladze Institute of Inorganic Chemistry and Electrochemistry of Tbilisi State University have developed a technology that allows obtaining adsorbents from secondary agricultural waste, namely: hazelnut and walnut shells, nectarine kernels, sawdust and others. This technology is applicable to many types of raw materials; the process is single-stage and does not require preliminary processing of raw materials. Carbonaceous materials are obtained from secondary organic waste (in particular, cellulose-containing waste), which are characterized by a high specific surface and porous structure, which determines their good adsorption capacity. In addition, they are notable by their low cost.

It was found out that obtained carbonaceous materials effectively absorb lead, cadmium, copper, cobalt, iron, etc. ions in solution both separately and simultaneously. The absorption efficiency depends on the concentration and pH of the solution, the adsorbent retention time, and the amount of carbonaceous material. The adsorption of heavy metals in polymetallic systems with the simultaneous presence of several metal ions (Pb^{2+}, Cd^{2+}, Co^{2+}, Cu^{2+}, Fe^{2+}) was studied. The purpose of the analysis was to evaluate the effect of ionic interactions between metals on the selectivity of the adsorbent in a complex medium.

It has been established that cellulose-based carbonaceous materials exhibit different adsorption capacity depending on the type of metal ion, which indicates their effectiveness in systems with complex polymetallic contaminants. This technology is a sustainable and promising approach to environmental protection, and the materials used are characterized by high adsorption activity with respect to heavy metal ions.

References

1. Altahaan, Z., & Dobslaw, D. (2024). The Impact of War on Heavy Metal Concentrations and the Seasonal Variation of Pollutants in Soils of the Conflict Zone and Adjacent Areas in Mosul City. Environments, 11(11), 247. https://doi.org/10.3390/environments11110247
2. Williams, O. H., & Rintoul-Hynes, N. L. J. (2022). Legacy of war: Pedogenesis divergence and heavy metal contamination on the WWI front line a century after battle. European Journal of Soil Science, 73(4), e13297. https://doi.org/10.1111/ejss.13297

ASSESSMENT OF THE ENVIRONMENTAL EFFECTS OF MILITARY ACTIVITIES DURING THE WAR IN UKRAINE ON SOIL-PLANT SYSTEMS

V.V.Berezhna, V.I.Sakada, N.K.Kutsokon, N.M.Rashydov
Institute of Cell Biology and Genetic Engineering of NAS of Ukraine

A research team from ICBGE is going to study the effects of different stresses caused by military activities on plants, with a special focus on their productivity. We plan to estimate the impact of soils polluted with heavy metals and explosive chemicals on some physiological, genetic, biochemical, and growth reactions of plants. Coefficients of transferring from soil to plant will be estimated from several species. Based on the results, prospective species for planting in war marginal zones for soil restoration will be proposed as well as fundamental knowledge in plant-stress biology will also be obtained.

Its main lines of research are studying molecular, biological, and genetic mechanisms of plant cell functions with biotechnology methods; developing novel technologies in cell and genetic engineering and investigating the adaptive response of plants to biotic and abiotic stresses. Major research achievements of the Institute include: technologies of plant genetic transformation; production of recombinant proteins using plant systems; a lifespan genetic behaviour in a soil-plant system at the Chornobyl aliened zone under the influence of chronic radiation from nuclide contaminated environment.

Department of Biophysics and Radiobiology was founded over 50 years ago and has previously been a part of the Institute of Plant Physiology, then since 1989 was transferred into ICBGE. The studies of Dept. deal with molecular and biological basics of the processes induced by chronic irradiation in Chornobyl zone and the role of molecular repair pathways in withstanding the plants to anthropogenic factors. The research team investigated some methods for phytoremediation of soil contaminated by radionuclides.

MODERN RADIOECOLOGICAL SITUATION IN THE LIBERATED TERRITORIES OF KARABAKH AND EAST ZANGEZUR

Ch.S.Aliyev, A.R.Aliyeva, F.F.Mahmudova, R.J.Baghirli, Kh.M.Karimli
Institute of Geology and Geophysics MSE AR
aliyev.chingiz47@gmail.com, aliyevaa22@gmail.com, farahveliyeva@gmail.com, rbagirli@gmail.com, xayalkarimli@gmail.com

Establishment and maintenance of ecological balance, which includes the problems of minimizing anthropogenic impact on ecosystems and protecting against global ecological disasters is one of the most important and urgent problems of the 21st century. Studying radioactive fields of the Earth is of particular importance in solving of these problems (1).

Scientific research was carried out by employees of the Institute of Geology and Geophysics in the territories liberated from occupation during 2024-2025 years. During the field research, radioecological monitoring was carried out in the territories cleared of mines and other explosive ordnance. During the monitoring, the equivalent dose rate of external gamma radiation and the volume activity of radon were measured. Gamma-spectrometric measurements were performed on the soil surface. Soil and water samples were also taken from the liberated territories for gamma-spectrometric analysis. Currently, these works have covered almost all of Karabakh and East Zangezur territory.

During the field-survey work, it was determined that the equivalent dose of gamma radiation in the investigated areas was at the level of the natural background, and only a few points recorded its relative high values. However, an anomalous values of equivalent dose of gamma radiation were observed around thermal springs located in Istisu settlement of Kalbajar region (2). Also, an abnormally high volume activity of radon was recorded in the thermal waters located in this area.

Gamma-spectrometric analyzes of the samples taken during the studies were carried out in laboratory conditions. As a result, it was found that natural radioactivity in the studied area, except for Istisu settlement, was formed mainly due to the element 40K (3). But detected anomalies were formed due to the element 226Ra.

On the basis data obtained, an electronic maps of the distribution of equivalent dose of gamma radiation and radon volume activity covering the territory of Karabakh and East Zangazur have been compiled.

The preliminary results of the conducted studies indicate the need for continuous implementation and control of radioecological monitoring in the mentioned areas in accordance with the mine action plan.

This work was carried out with the financial support of the Azerbaijan Science Foundation.

Grant project№ AEF-MQM-QA-2-2023-3(45)-05/03/2-M-03.

References

1. Ч.С.Алиев, Т.А.Золотовицкая, Т.А.Исмаил-заде. Аномалии естественных радиоактивных полей в сейсмоактивных зонах. Геофизика №1, Научно-технический журнал Мин. Природных Ресурсов РФ и Евро-Азиатского Геофизического Общества. 2004. Стр. 54-57.
2. Ch.S. Aliyev, F.Y.Humbatov, F.F.Mahmudova, A.R.Aliyeva, X.M.Karimli. Assesment of modern radioecological situation in Aghdam, Lachin and Kalbajar districts. Journal of Life Sciences and Biomedicine, vol. 4(77), No 2, Baku, 2022. P. 29-34.
3. Ç.S. Əliyev, Ə.R.Əliyeva, F.F.Mahmudova, R.C.Bağırlı, K.M.Kərimli. İşğaldan azad edilmiş Qubadlı, Zəngilan və Cəbrayıl rayonlarında müasir radioekoloji vəziyyət. Azərbaycan Milli Aerokosmik Agentliyinin Xəbərləri, №4 (27), 2024, səh. 40-46.

RADIOACTIVE-INVENTORY-DRIVEN NUCLEAR THREATS AT UKRAINIAN NPPs

Viktor Dolin[1], Yevgeni Yakovlev[1,2], Viktor Smyrnov[3], Oleksandr Kopylenko[4]

[1]State Institution "The Institute of Environmental Geochemistry of the National Academy of Sciences of Ukraine"
[2]Institute of Telecommunications and Global Information Space of the National Academy of Sciences of Ukraine
[3]Petro Mohyla Black Sea National University, Mykolaiv, Ukraine
[4]National Commission for Radiation Protection of the Population of Ukraine

The 2022 Russian invasion of Ukraine has created unprecedented nuclear risks, with over 7.000 metric tonnes of spent nuclear fuel (SNF) stored across Ukrainian nuclear facilities containing 3.02×10^{19} Bq of actinides, 2.18×10^{19} Bq of Cs-137, and 1.58×10^{19} Bq of Sr-90 (Table).

Table.
Key vulnerabilities of radioactive storage at Ukrainian NPPs

Site	Inventory (Bq)	Key Vulnerability	Risk Level
ZNPP	3.15×10^{19}	Occupied; cooling dependency	High
RNPP	4.50×10^{18}	Fuel transfer operations	Medium
SUNPP	2.35×10^{18}	Water intake dependency	Medium
KhNPP	1.57×10^{18}	Storage capacity limits	Low-Medium

This radioactive inventory exceeds historical nuclear disasters by two orders of magnitude. The occupied Zaporizhzhia Nuclear Power Plant (ZNPP) presents the highest risk, with potential pool fire scenarios capable of releasing 590 PBq of Cs-137—seven times the Chernobyl release. Cooling system failure could trigger zirconium ignition within 9-11 hours for recently discharged fuel. The 2023

Kakhovka dam destruction has further compromised ZNPP's structural stability through groundwater depletion and soil liquefaction risks. Current probabilistic safety assessments indicate core damage frequencies exceeding Western European safety standards by two orders of magnitude. Ukrainian NPPs require immediate international intervention including power grid restoration, enhanced physical protection, accelerated fuel transfers to centralized storage, and emergency cooling systems to prevent radiological catastrophe across Europe.

Three and a half years of full-scale warfare in Ukraine have clearly demonstrated the urgent need for significant improvements to the international nuclear safety and security framework. These improvements must include:

- eliminating the influence of financial flows external to the international organizations responsible for nuclear safety and security;
- securing equitable representation for all member states in relevant bodies, independent of financial contributions;
- granting international protection status to nuclear facilities that store spent nuclear fuel, with provisions for UN peacekeeping intervention in the event of nuclear safety threats.

Long-term strategies must prioritize the reduction of global nuclear risks, the restoration of non-proliferation systems, and the resolution of challenges highlighted by the ongoing war in Ukraine.

Acknowledgments: Research supported by MSCA4Ukraine project #1232235, funded by the European Union. The authors thank Professor Rosa Lo Frano (University of Pisa) and Antonio Bulgeroni (JRC Karlsruhe) for technical consultation.

THE IMPACT OF HIGH-FREQUENCY ELECTRO-MAGNETIC RADIATION ON BIOLOGICAL SYSTEMS

Saltanat Aghayeva
Western Caspian University
saltanat.genetic@wcu.edu.az

Keywords: Electromagnetic radiation, serotonin, catecholamines, monoaminergic system, warfare, ecosystems

In recent decades, due to the widespread application of electromagnetic radiation (EMR), the term “electromagnetic pollution” has been officially adopted by the World Health Organization. Research conducted across different scientific fields demonstrates that the influence of low-intensity high-frequency EMR on neurobiological processes leads to alterations in the activity of the monoaminergic MA- system in the brain, disruptions of behavioral and memory functions, and weakening of adaptive mechanisms.

In modern warfare, the intensive use of advanced technologies-particularly radio-electronic warfare systems, unmanned aerial vehicles, and communication devices-significantly increases the impact of EMR in conflict zones. As a result, not only human health but also wildlife and ecosystems are exposed to severe damage. Specifically, the effects of low-intensity high-frequency EMR manifest in neurobiological alterations, behavioral and memory impairments, and reduced adaptive capacities. The aim of this study is to analyze the effects of EMR in the context of functional changes occurring in MA-ergic neurotransmitter systems.

Results and Discussion

- The intensive deployment of EMR sources in war-affected regions leads to disruptions in the neurobiological functions of both humans and animals.
- Imbalances in serotonin and catecholamine systems reduce stress resistance and weaken adaptive responses.

The extensive use of EMR in warfare conditions undermines not only the effectiveness of military operations but also the sustainability of biological and ecological systems. In particular, alterations within the MA-ergic neurotransmitter systems of the central nervous system pose a serious threat to human health. Therefore, comprehensive scientific approaches are required to investigate the effects of electromagnetic pollution and to develop strategies for mitigating its harmful consequences.

The recognition of electromagnetic pollution as a global problem is not accidental, as its impact is clearly evident both in neurophysiological processes and in the stability of ecosystems.

A NEW TECHNOLOGICAL APPROACH FOR REMOTE RADIATION MONITORING IN THE LIBERATED TERRITORIES OF AZERBAIJAN

N.N.Heydarov[1], I.M.Nuruyev[1], M.H.Kazimov[1], A.Z.Sadigov[1], N.S.Babakhanov[2], E.N.Sabziyev[3], A.B.Pashayev[3], N.Y.Suleymanova[1]

[1]Institute of Radiation Problems MSE AR, [2]Institute of Control Systems MSE AR, [3]National Defense University

Introduction

Wars are characterized not only by human casualties and social disruption, but also by long-term and severe environmental and public health consequences. In Azerbaijan, particularly in the liberated territories, the radiation-related risks that have emerged as a result of prolonged military conflicts are of significant concern. The presence of military facilities, remnants of used munitions, destroyed infrastructure and potential radioactive waste can alter the radiation background, posing serious threats to both the public health and post-conflict rehabilitation efforts [1, 3, 5].

This study aims to assess the radiation levels in war-affected areas of Azerbaijan, evaluate potential hazards and enhance existing radiation monitoring methodologies.

To accurately determine radiation levels, various measurement techniques are employed, primarily falling into the following three categories:

1. Stationary monitoring method: Stationary devices are placed in areas of particular importance for continuous radiation surveillance. These devices allow for long-term data collection and can immediately record changes in radiation levels in real time. However, this method is passive in nature and the monitoring area is limited.

2. Manual monitoring method: This method, carried out using handheld dosimeters and gamma spectrometers, allows for high-precision measurements at specific points. While particularly effective for detailed inspections in suspicious areas, it is time-consuming and exposes personnel to potential risks, making it impractical for large-scale surveys.

3. Vehicle-based monitoring method: Dosimeters and GPS systems installed in vehicles allow for data collection in a short period of time across extensive areas. This method minimizes human exposure and is operationally efficient. Nevertheless, it is limited to regions with accessible road infrastructure and may be affected by complex terrain, which can compromise measurement accuracy [2].

The above-mentioned methods are not sufficient for effective monitoring in areas with complex terrain, high radiation contamination and potentially dangerous (mined) areas. Consequently, an innovative solution involving unmanned aerial vehicles (UAVs) has been proposed to facilitate remote, risk-free radiation monitoring.

As part of the research, dosimeters based on a Geiger-Müller counter, spectrometer, LIDAR and GPS systems were integrated onto a quadcopter-type UAV [6]. This type of UAV is suitable for detailed remote research, as it has the ability to maintain a stable position in the air, maneuver at low speeds and land at targeted locations.

The developed detector complex determines the background gamma radiation from a height of 2 ÷ 6 meters (depending on the terrain and vegetation), at the same time measures the altitude from the ground surface using LIDAR technology and records the corresponding GPS coordinates. The collected data is securely transmitted to a ground control center via an encrypted radio link. Specialized software processes this data to generate a visual map of radiation levels based on geospatial coordinates.

If elevated radiation levels are detected, a spectrometer based on micropixel avalanche photodiodes integrated on the drone is sent to the designated coordinates. The drone then lands at specified site and identifies the type and characteristics of the radiation source [7,8].

Conclusion

The technology of remote radiation monitoring based on UAVs creates important opportunities for assessing and mapping radiation risks in hazardous areas without human intervention. The resulting maps visually represent variations in radiation levels, identify radioactive anomalies and delineate potential danger zones. The future widespread adoption of this technology promises to enhance operational efficiency and strengthen radioecological safety protocols in Azerbaijan.

References

1. Axundov, R. Q. (2023). Azərbaycan Ordusunda radiasiya, kimyə və bioloji mühafizənin inkişaf problemləri və onlarin həlli yollari. In *Hərb sənətinin aktual problemləri" beynəlxalq elmi-praktik konfransın materialları* (pp. 137-138). MMU.
2. Fan, J., Xu, J., & Qin, X. (2021). Summary of Application of Vehicle Radiation Environmental Monitoring System. *Open Access Library Journal*, *8*, 1-5. https://doi.org/10.4236/oalib.1107399

3. Geelen, S., Camps, J., Olyslaegers, G., & Schroeyers, W. (2024). Drone-borne dosimetry in a radiological or nuclear scenario. *Radiation Measurements*, *170*, 106170.
4. LIU, J., LIU, Y., NI, N., CHEN, Y., HOU, J., WANG, Z., ZHAO, X., & DING, Y. (2023). Research on Nuclear Radiation Monitoring System of UAV. *Journal of Isotopes*, *36*(6), 565-571. https://doi.org/10.7538/tws.2023.36.06.0565
5. Marques, L., Vale, A., & Vaz, P. (2021). State-of-the-Art Mobile Radiation Detection Systems for Different Scenarios. *Sensors*, *21*(4), 1051. https://doi.org/10.3390/s21041051
6. Nuruyev, I. M., Heydarov, N. N., Nazarov, M. S., Sattarov, R. H., Sadigov, A. Z., & Kazımov, M. H. (2022). Radiation monitoring of oil and gas pipelines. *Colloquium-journal*, *34*(157), 21-27.
7. Ahmadov, G., Ahmadov, F., Holik, M., Berikov, D., Sadygov, Z., Akbarov, R., Nuruyev, S., Sadigov, A., Mammadli, A., Mammadov, R., Kopatch, Y., Pridal, P., Yilmaz, E., Doganci, E., & Zich, J. (2021). Gamma-ray spectroscopy with MAPD array in the readout of $LaBr_3$:Ce scintillator. Journal of Instrumentation, 16(07), P07020. https://doi.org/10.1088/1748-0221/16/07/P07020
8. Holík, M., Ahmadov, F., Ahmadov, G., Akbarov, R., Berikov, D., Mora, Y., Nuruyev, S., Pridal, P., Sadigov, A., Sadygov, Z., & Zich, J. (2020). Miniaturized read-out interface “Spectrig MAPD” dedicated for silicon photomultipliers. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 978, 164440. https://doi.org/10.1016/j.nima.2020.164440

POTENTIAL RADIOECOLOGICAL THREAT TO REMOTE TERRITORIES DURING MILITARY ACTIONS IN NUCLEAR POWER PLANT ZONES

M.E.Gogebashvili[1,2], N.I.Ivanishvili[1,2], S.D.Uchaneishvili[2], S.L.Kalmakhelidze[2]

[1]Iv.Javakhishvili Tbilisi State University, E. Andronikashvili Institute of Physics,Georgia

[2]Beritashvili Center of Experimental Biomedicine, Georgia

gogebashvili@gmail.com, nazikoivanishvili@gmail.com, sofiauchaneishvili@gmail.com, s.kalmakhelidze@tsmu.edu,

The development of the radiation situation following the man-made accidents at the Chernobyl and Fukushima nuclear power plants demonstrated the global nature of radioactive contamination in remote areas. The resulting radioactive clouds spread over vast territories far from the disaster sites, making the “distance factor” a highly relative indicator in radiation incidents.

Unfortunately, the direct shelling of the Zaporizhzhia Nuclear Power Plant during the Russian-Ukrainian war has forced a renewed evaluation of the radiation risks faced by neighboring countries. Radiation monitoring has shown that even after nearly 40 years, radionuclides originating from Chernobyl are still detectable in the territory of Georgia.

In our studies, we used soil samples taken from the Chernobyl zone, as well as soil artificially contaminated with radioactive cesium-137 (^{137}Cs), to model the potential consequences of land contamination. The research focused on radionuclide migration in the soil–plant system, accumulation in different plant organs, dose exposure from consuming contaminated plants, and associated health risks. It was shown that, when soil is contaminated with radiocesium and the radionuclide becomes fixed, factors such as soil acidity and natural potassium content significantly influence its mobility.

For radionuclides to continue migrating through the food chain, key factors include their biological availability and their capacity to transfer into plants. This transfer is typically assessed using soil-to-plant transfer coefficients. The degree of radionuclide accumulation in plants and food products also varies by species.

To study the specific accumulation of radiocesium in culinary herbs commonly consumed in Georgia, we examined coriander (*Coriandrum sativum*), dill (*Anethum graveolens*), parsley (*Petroselinum crispum*), lettuce (*Lactuca sativa*), summer savory (*Satureja hortensis*), garden cress (*Lepidium sativum*), and basil (*Ocimum basilicum*). Based on radiocesium accumulation data and standard consumption rates of these herbs, we generated prognostic assessments of oncological risk from long-term ingestion of contaminated produce.

Considering the global expansion of nuclear energy, there is a pressing need for international agreements that prohibit military operations in the vicinity of nuclear facilities. Our research highlights the significant impact that military incidents in nuclear zones can have on the populations of even distant countries.

THE ROLE OF RADIATION SAFETY IN THE RESTORATION OF ECOLOGY IN LIBERATED TERRITORIES

Sevinj Melikova
Academy of the Ministry of Emergency Situations of the Republic of Azerbaijan
Sevinj.Malikova@fhn.gov.az

Karabakh and the surrounding areas, which were occupied for nearly 30 years, were returned to the control of the Republic of Azerbaijan after the Patriotic War of 2020. Large-scale ecological disasters, pollution of soil and water sources, and destruction of biodiversity are observed in these territories. In order to eliminate these disasters, comprehensive restoration and rehabilitation programs are being implemented at the initiative of the country's leadership. The main focus in this process is on the restoration of ecological balance, protection of natural resources, and ensuring radiation safety. Radiation safety is a system of measures applied to protect people, animals, and plants from ionizing radiation. Radiation contamination of soil, water, air, and flora and fauna can cause long-term and sometimes irreversible consequences. Therefore, monitoring and control of radiation levels is of particular importance in the restoration work carried out in the liberated territories. During the occupation, there is a risk of changes in the radiation background in the territories as a result of industrial waste, military equipment remnants, destroyed infrastructure and illegal exploitation of natural resources. In particular, old equipment, unexploded ordnance and radioactive materials that may be contained in them can be a source of danger to the health of the local population and the environment.

The role of radiation safety in the restoration of ecology:

1. Ecological monitoring and assessment:

As part of radiation safety measures, dosimetry measurements of the territories, analysis of soil and water samples are carried out. This information allows for an objective assessment of the ecological state of the territory and planning of necessary interventions.

2. Identification of hazardous zones:

Zones with high radiation levels are identified and measures are taken to clean up military equipment, recultivate land and prepare it for reuse.

3. Protection of human health:

Radiation pollution affects not only the environment, but also the genetic health, reproductive system and oncological risks of people. Radiation control plays a key role in preventing these consequences.

4. Safety of renewable agriculture and green energy projects:

The radiation background is taken into account during the reconstruction of agriculture in the region and the creation of green energy infrastructures. This serves to ensure long-term sustainable development.

The Ministry of Ecology and Natural Resources of the Republic of Azerbaijan, the Ministry of Emergency Situations, Institute of Radiation Problems and the National Nuclear Research Center are actively working in this area. They carry out regular radiation monitoring in the liberated regions, establish cooperation with international organizations and carry out rehabilitation work in dangerous areas. Ecological restoration is a long-term and complex process. Radiation safety measures play an indispensable role in the successful implementation of this process. Ensuring radiation control is a priority issue in terms of both environmental health and the safe living of the population returning to the region. The steps taken by Azerbaijan in this direction are a guarantee of an environmentally sustainable and safe future.

RADIOACTIVE POLLUTION AND MILITARY OPERATIONS: MODERN CHALLENGES AND SOLUTIONS

S.M.Farajova, A.H.Jafarova
National Aerospace Agency
sistemlerinyaradilmasi@gmail.com

Modern warfare and military operations have increasingly contributed to environmental degradation, particularly radioactive pollution. Among the consequences of such activities, radioactive contamination remains one of the most hazardous and long-lasting effects, with severe impacts on ecosystems and human health [1].

Radioactive pollution refers to the contamination of the environment with radionuclide substances that emit ionizing radiation, potentially leading to cancers, genetic mutations, and ecological imbalance. In contemporary military contexts, sources of such contamination include the use of nuclear and radioactive weapons, bombardment of nuclear reactors and storage facilities, and the application of munitions containing depleted uranium.

The effects of radioactive contamination extend beyond immediate physical damage. Contaminated zones require advanced technologies and significant financial resources for decontamination. Local populations and ecosystems face long-term health risks and recovery challenges. Monitoring and transparency are crucial in conflict zones to track radiation levels and prevent further spread [3].

Historical cases highlight these risks. The 1986 Chernobyl disaster, although not directly linked to military conflict, later became a strategic zone affected by military activity, which disturbed buried radionuclides. Similarly, after the 2011 Fukushima accident in Japan, military forces assisted in rescue operations, but also influenced radioactive material distribution. In both cases, international cooperation and ongoing radiological monitoring have been essential in mitigation.

Closer to Azerbaijan, the Nagorno-Karabakh conflict illustrates the ecological consequences of prolonged warfare. Reports suggest the use of munitions with radioactive or heavy metal components, leading to environmental and public health concerns. Land degradation, water contamination, and rising radiation levels were reported, and the unstable security situation continues to hinder ecological restoration [2].

CONCLUSION

Military activities contribute significantly to radioactive pollution, posing complex challenges that demand scientific, technological, and political responses. Ensuring radioecological safety requires international collaboration, advanced monitoring systems, and public awareness. Cases such as Chernobyl, Fukushima, and Nagorno-Karabakh emphasize the urgent need for comprehensive environmental protection strategies in both post-conflict and high-risk areas.

References
1. "Armed conflict causes long-lasting environmental harms" , Simon et al. (2025), Conflict and Health Journal.
2. "Uranium's hazardous effects on humans and recent developments" , ScienceDirect (2025).
3. "Environmental Warfare – Modern Global Challenge", Ramil Axundov (2024), VI International Scientific Conference Proceedings.

RADIOACTIVE CONTAMINATION OF THE ENVIRONMENT AS A RESULT OF MILITARY CONFLICTS AND INTERNATIONAL LAW

Aysel Hasanova
Ministry of Emergency Situations, State Agency for Regulation of Nuclear and Radiological Activities,
Azerbaijan State University of Economics
aysel.hasanova@fhn.gov.az

Military conflicts and wars have extensive consequences that profoundly and often irreversibly affect the environment. The destruction of habitats, the contamination of ecosystems with toxic substances, and the disruption of natural cycles are among the most visible ecological impacts of armed conflict. It is impossible to ignore that ecological problems no longer concern only individual countries but give rise to new environmental issues that span entire continents or even multiple continents. This, in turn, highlights the urgency of addressing such problems from both national and global environmental security perspectives. The complex relationship between armed conflict and ecosystems has been a growing concern for decades, as wars increasingly impact natural resources and the environment.

Radioactive contamination that may occur during wars or any military operations is one of the most serious and dangerous threats to the global environment and human health. In armed conflicts, nuclear weapons are among the primary sources of radioactive contamination that can have devastating effects on both natural ecosystems and human life and health. Preventing such contamination is a priority issue and requires a comprehensive approach that includes effective international legal, political and environmental measures.

Radioactive contamination is particularly associated with the problems arising from the use of nuclear weapons and other highly hazardous arms. Such contamination can occur in several ways during wartime:

1. Use of nuclear weapons: one of the most evident threats of radioactive contamination is the use of nuclear weapons, which in turn creates heavily contaminated radioactive zones. The explosion of a nuclear device releases a large amount of radiation, which leads to long-term environmental and health consequences for the affected areas.
2. Use of nuclear and other radioactive materials in other forms of weaponry: in addition to atomic bombs, radioactive substances can be used as part of tactical weapons - for example, “dirty bombs”, radioactive devices specifically designed to contaminate targeted areas with radiation.
3. Accidents at nuclear facilities in combat zones: during armed conflict, nuclear installations or reactors may be damaged, resulting in the release of radioactive materials into the atmosphere and their spread over long distances.
4. Use of nuclear technology for peaceful purposes during wartime: During war, certain groups may seize nuclear energy facilities intended for peaceful use, potentially causing radiation leaks. Acts of sabotage and subversion targeting nuclear facilities are also possible, posing additional security risk.

Considering the global nature of these risks, it is necessary to pay attention to the protection system of international law against radioactive contamination. The international system consists of several components, among which the following can be highlighted.

1. International Legal Framework for the Prevention of Radioactive Contamination

1.1. International Humanitarian Law – International humanitarian law regulates the use of force during armed conflicts, aiming to minimize the suffering of the civilian population and to protect the environment.

The Geneva Conventions (1949) and their Additional Protocols I and II (1977) – require minimizing harm to civilians and the environment during military operations. Although Protocol I does not specifically address radioactive contamination, it prohibits the use of weapons that can cause long-term damage to the environment. The principles outlined in these documents can be applied to restrict the use of nuclear weapons and their impact on the environment.

1.2. Treaties on the Non-Proliferation of Nuclear Weapons – the main international treaties aimed at preventing the use of nuclear weapons include the following:

- The Treaty on the Non-Proliferation of Nuclear Weapons (NPT), signed in 1968 – limits the number of countries possessing nuclear weapons and regulates disarmament efforts. It also aims to prevent the use of nuclear weapons in armed conflicts.
- The Comprehensive Nuclear-Test-Ban Treaty (CTBT) (1996) – restricts nuclear testing, helping to prevent radioactive contamination caused by nuclear explosions.
- The Treaty on the Prohibition of Nuclear Weapons (TPNW) (2017) – signed by numerous countries, this convention aims to completely prohibit the development, use and possession of nuclear weapons, thereby directly reducing the risks of radioactive contamination during war.

1.3. Conventions on Environmental Protection

While many international treaties focus on protecting populations from direct military threats, there are also several agreements aimed at protecting the environment during times of war:

- The Convention on the Protection of the Environment during Armed Conflicts (1999) – This convention regulates the protection of the environment during military operations and imposes restrictions on methods of warfare that can cause long-term damage to ecosystems, including radioactive contamination.
- The Convention on Biological Diversity (1992), transboundary water conventions and the 1972 London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, all regulate the protection of nature from radioactive contamination and the impact of radioactive waste. This is crucial, as military operations can cause significant harm to water bodies and natural ecosystems.

2. Mechanisms for Ensuring Compliance with International Requirements

Despite the existence of international legal norms, there are challenges in their implementation and enforcement.

- The International Atomic Energy Agency (IAEA) plays a key role in monitoring compliance with nuclear non-proliferation treaties and in preventing the use of nuclear materials in armed conflicts. However, since the IAEA oversees only the peaceful use of nuclear energy, its role during military conflicts is limited.
- The International Criminal Court (ICC) can also rule on war crimes if radioactive contamination results from violations of international norms.

One of the other challenges is that the implementation of international norms for environmental protection during wartime depends on the political will of states. The application of legal norms is not always effective, especially in large-scale armed conflicts involving multiple parties, where the international community faces difficulties in enforcing mandatory measures.

3. Effects of Radioactive Pollution on the Environment and Health

Radioactive contamination resulting from military activities has long-term effects. It is important to note its impact on health. Radioactive materials such as Cesium-137 or Strontium-90 can cause cancer, genetic mutations, and other serious diseases in exposed populations. These effects can impact not only those directly affected but also future generations.

Environmental damage – Radioactive substances pollute soil, water resources, and the atmosphere, creating long-term impacts on ecosystems. Radioactive contamination can disrupt biodiversity, destroy flora and fauna, and reduce the quality of agricultural land.

The above-mentioned effects form a closely interconnected system, and at the same time, lead to long-term economic losses. Radioactive pollution causes significant economic costs due to the need for ecosystem restoration, decontamination of polluted areas, and support for populations affected by radiation.

4. The necessity of strengthening international efforts

To prevent radioactive contamination during war, the following measures are necessary:

- Strengthening international treaties aimed at banning nuclear weapons, as well as establishing effective mechanisms to monitor and ensure compliance with these treaties.
- Developing and implementing international standards focused on preventing radioactive contamination during military operations.
- Increasing the accountability of states that cause environmental damage during war, including the creation of clear mechanisms for holding states responsible for the use of nuclear weapons.

- Conducting environmental monitoring in the post-war period.
- Carrying out long-term environmental restoration activities in the post-war period.
- Conducting radioecological research.

Preventing radioactive contamination during wartime requires a comprehensive approach that combines international legal, ecologic, and political measures. Despite the existence of current international legal norms, there is a need to strengthen these norms and ensure effective oversight in order to minimize environmental damage and protect the health of future generations.

The thesis emphasizes the importance of a global response to the environmental consequences of war, underlining the role of international cooperation in preventing environmental destruction during conflict and ensuring effective post-conflict recovery. It explores the significance of a comprehensive approach to both security and environmental protection. The main conclusion of the thesis highlights the necessity of an integrated approach and the importance of legal, diplomatic and environmental efforts in promoting sustainable peace and security. It also underscores the need for adaptive legal solutions to address the environmental challenges of future conflicts.

References

1. International legal documents (Geneva Conventions, NPT, ENMOD, etc.)
2. Academic journals on environmental law and ethics
3. Environmental Impacts of Occupation, Center of Analysis of International Relations (AIR Center, Baku 2021)
4. Reports by international organizations (UN, IAEA, United Nations Environment Programme (UNEP)
5. NGO research (Researchgate, Sciencedirect, etc.)

ENVIRONMENTAL RISKS CAUSED BY ILLEGAL EXPLOITATION OF THE VEJNELI FIELD

Famil Humbatov[1,2], Aysel Suleymanova[1], Geys Ibrahimov[1], Gultakin Aslanova[1], Husniya Nejati Solut[1], Valeh Balayev[1], Nisakhanim Karimova[1], Intizar Karimbeyli[1], Sabir Osmanov[3]

[1]Institute of Radiation Problems MSE AR,
[2]Azerbaijan University of Architecture and Construction,
[3]Military Institute named after Heydar Aliyev

During the nearly 30-year occupation, 160 deposits of gold, silver, mercury, copper, lead, coal, colored, decorative stones and other non-ferrous metals in Kalbajar, Lachin, Zangilan, Tartar were ruthlessly exploited by Armenia. During this period, the resources of the occupied lands of Azerbaijan, which were depleted in natural resources, were used as the main source of income for Armenia. It is known that a significant part of the gold, copper, zinc ores and concentrates, as well as concentrates of precious metals, which are among the mining products that occupy an important place in the export of the occupying country, are extracted from the Soyudlu (Zod), Qizilbulag, Vejneli gold, Mehmane polymetal and Demirli copper-porphyry deposits in the occupied territories of Azerbaijan. Of these, the Soyudlu deposits in the Kalbajar region and the Vejneli deposits in the Zangilan region were exploited without taking into account any norms and requirements in order to obtain more income.

This study assesses the risks posed to the environment by Armenia during the exploitation of the Vejneli deposit in the liberated Zangilan region.

The Vejneli deposit is located in the Zangilan region, 4-5 km from the Aghbend railway station. The deposit is a quartz-gold-sulfide vein of geological-industrial type. 25 gold veins have been discovered and evaluated within the deposit. Industrially significant gold reserves are concentrated in 6 veins of quartz-chalcopyrite, quartz-carbonate-pyrite-chalcopyrite composition. All ore veins have a sharp contact with the surrounding rocks and are characterized by their thickness varying from 10 cm to 4.0 m. The main useful component in the ore is gold. It also contains silver, copper, tellurium, and bismuth in additional extractable amounts. The gold ore is large in size, the amount of "free" gold is 9.8%, and in the case of a combination - 85.3%. It is planned to enrich the ores using the gravity-flotation scheme. 96.52% gold, 97.38% silver, 95.9% tellurium and 65% bismuth can be extracted. The deposit is prepared for industrial use [1].

The Vejneli gold deposit located in the territory of the Zangilan region belongs to the vein geological-industrial type with quartz-gold-sulfide composition. The Vejneli deposit was discovered by the Vejneli geological-exploration party in 1959-1962. Geological-exploration and exploration works were carried out in 1962-1971, 1976-1981 and 1983-1984. The Vejneli gold deposit was approved by the Local Reserves Commission in 1984 and was included in the State Balance of Mineral Resources of the Republic of Azerbaijan.

As a result of measurements conducted in the territory of the Vejneli village, it was observed that the average radiation background varied in the range of 6-9 μR/hour. The radiation background inside the production plant, where Armenia is engaged in illegal production, was determined to be 6-8 μR/hour, and in the surrounding areas of the plant - 8-10 μR/hour. Samples were taken from the plant area and production residues and analyzed for elemental composition using AAS methods [2]. The results obtained are presented in table N:1 and figure N:1.

Table N:1

Concentrations observed in the studied samples

Sample	Cr (mg/kg)	Mn (mg/kg)	Ni (mg/kg)	Zn (mg/kg)	Al (mg/kg)	Fe (mg/kg)	Cu (mq/kq)
Produc-tion tail	17.32	301.2	5.47	53.14	34.74	517.23	2146
Factory area	6.94	34.85	2.56	16.21	46.86	362.15	218.36

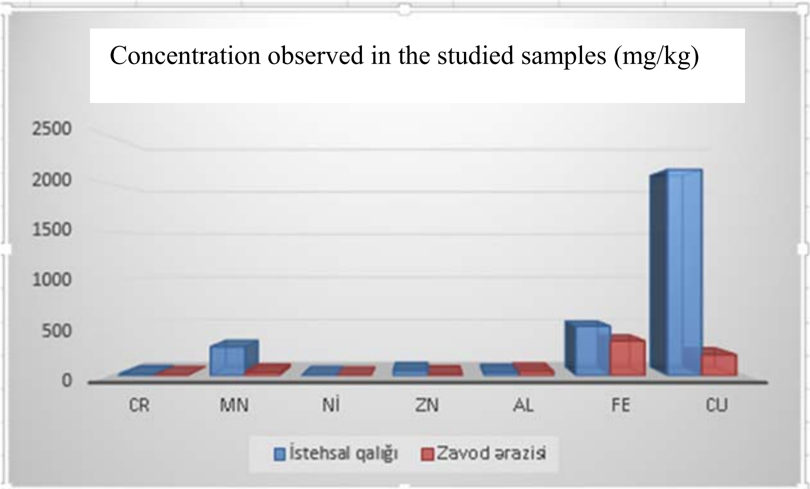


Figure N:1 Graphical representation of the observed concentrations

As can be seen from the table and graphic representation, high concentrations of individual elements were formed both in the production residue and in the plant area during uncontrolled production. As a result of precipitation, there is a possibility that the high concentrations of residues present in the area will spread over a wider area and mix with water sources. Therefore, there is a need for regular monitoring in the area and risk assessment by controlling water quality.

References

1. Azerbaijan Geographical Society. https://gsaz.az/articles/view/92/Azarbaycanin-faydali-qazintilari
2. S.Sh. Mammadzada1, F.Y. Humbatov, I.I. Mustafayev. Assessment of heavy metal pollution in water and surface sediments from Goranchay. Journal of CHEMICAL PROBLEMS 2021 no. 2 (19), pp. 84-93, ISSN 2221-8688

IMPACT OF MILITARY OPERATIONS ON THE RADIOECOLOGICAL SITUATION: CASE STUDY OF THE NAGORNO-KARABAKH CONFLICT

Elshan Hashimov[1,2], Ramil Akhundov[1]
[1]*National Defense University*
[2]*Azerbaijan Technical University*
hasimovel@gmail.com, mr.axundov1@gmail.com

The environmental consequences of military operations extend beyond immediate physical destruction to include long-term effects on radioecological systems. Military operations, particularly in areas with pre-existing contamination or the presence of radioactive materials, can exacerbate the already fragile radioecological situation. This thesis investigates the impact of military activities on the radioecological situation, focusing on the Nagorno-Karabakh conflict as a case study. The study examines the direct and indirect effects of military operations on soil, water, air, and biological systems, paying particular attention to the potential release of radioactive substances and the subsequent environmental risks. Additionally, this paper discusses the implications for public health, environmental recovery, and the measures required for mitigating the radioecological consequences of military conflicts.

Introduction

Military operations in conflict zones frequently lead to significant ecological damage, which can persist for years, if not decades, after the conflict ends. While much focus is given to the immediate impacts of armed conflicts, such as destruction of infrastructure and loss of life, less attention is paid to the longer-term effects on the environment, particularly on radioecological conditions. The Nagorno-Karabakh conflict, a prolonged and intense military confrontation, offers a pertinent example of how military activities can influence the radioecological situation in a region.

Radioecology, the study of radioactive substances in the environment and their impact on ecosystems, plays a critical role in understanding the environmental aftermath of military conflicts. The interaction between military actions and radioactive materials—whether from nuclear arsenals, legacy contamination, or the use of radioactive weapons—can have profound implications for soil, water, air, and human health. This thesis aims to explore the ways military operations can alter the radioecological situation, using the Nagorno-Karabakh conflict to illustrate these processes.

Military Operations and Radioactive Contamination:

Military operations often take place in areas that have been previously contaminated by radioactive materials, either from earlier conflicts or from the presence of nuclear facilities. The Nagorno-Karabakh region, while not directly involving nuclear warfare, has witnessed military activities in close proximity to sites contaminated by the radioactive legacy of the Soviet Union. These sites include military storage facilities, mines, and other industrial areas, where radioactive materials were used or stored.

In the context of the 2020 Nagorno-Karabakh war, the extensive use of artillery, bombing, and rocket strikes in areas with pre-existing radioactive contamination raised concerns about the release of radioactive substances into the environment. Explosions in areas containing radioactive waste can cause the dispersion of radioactive dust and particles into the atmosphere, leading to soil contamination, water pollution, and increased exposure risks for both combatants and civilians. While there are no definitive reports confirming a direct release of radioactive materials during the 2020 conflict, the destruction of industrial sites in the region, such as those near the town of Aghdam, posed a significant risk to the radioecological situation.

Soil and Water Contamination:

One of the most immediate concerns following military operations in regions with radioactive contamination is the degradation of soil and water quality. Radioactive materials released into the environment can contaminate soil, making it unsuitable for agriculture, and potentially rendering it hazardous for human exposure. In the case of the Nagorno-Karabakh conflict, large areas of farmland were affected by military activities, raising concerns about long-term soil degradation and food security.

Furthermore, water resources in the region are highly susceptible to contamination from radioactive particles. Water sources, including rivers and underground aquifers, can become contaminated when radioactive materials leach into the water table, often leading to irreversible contamination. The Tartar River, for instance, which serves as a major water source in the region, faced increased risk during military operations as nearby industrial and agricultural sites were affected by military strikes. The long-term contamination of water resources can have severe consequences for local populations, particularly in the case of radioactive isotopes, which can accumulate in the food chain.

Air Pollution and Biological Impact:

Military operations, especially those involving explosives and heavy artillery, can significantly degrade air quality by releasing dust, particulate matter, and toxic gases, some of which may contain radioactive isotopes. The Nagorno-Karabakh conflict saw heavy use of artillery, airstrikes, and bombing raids, which would have contributed to the spread of pollutants across large areas. While the exact nature of airborne radioactive contamination during the conflict is unclear, the widespread destruction of infrastructure, combined with the release of toxic gases from military operations, posed significant risks to both the immediate and long-term health of residents and combatants.

Biological systems, including plants and animals, are highly vulnerable to radioactive contamination. Radioactive particles can accumulate in the tissues of living organisms, causing genetic mutations, reproductive issues, and mortality. In conflict zones, these effects are amplified due to the destruction of habitats, exposure to contaminants, and disruption of local ecosystems. In the case of

Nagorno-Karabakh, the region's rich biodiversity is at risk due to the combined impact of military activities and the potential spread of radioactive materials.

Public Health and Recovery Challenges:

The public health consequences of military operations on the radioecological situation are profound and long-lasting. The increased risk of cancer, genetic disorders, and other health issues related to radioactive exposure can persist for generations. In the aftermath of the Nagorno-Karabakh conflict, the affected population may face increased rates of radiation-related diseases, requiring significant medical intervention and long-term monitoring.

Environmental recovery following military operations in contaminated regions is a complex and slow process. Restoration efforts must address soil and water decontamination, rehabilitation of natural habitats, and public health initiatives. In regions such as Nagorno-Karabakh, where military activities have disrupted local ecosystems, recovery will require extensive investment in both human and environmental health. Effective strategies will need to include the monitoring of radiation levels, restoration of contaminated lands, and the establishment of public health programs focused on the detection and treatment of radiation-related health conditions.

Conclusion

The impact of military operations on the radioecological situation is a critical concern that must be addressed in the planning and conduct of military conflicts. The case study of the Nagorno-Karabakh conflict highlights the significant risks associated with military activities in areas affected by radioactive materials. To mitigate these risks, it is essential for international organizations, governments, and military forces to develop comprehensive strategies that include the following measures:

Pre-conflict environmental assessments to identify potential sources of radioactive contamination and mitigate risks before military operations begin.

Post-conflict environmental monitoring to assess the extent of contamination and take corrective actions where necessary.

Technological advancements in the cleanup of radioactive sites, including the use of bioremediation and advanced filtration techniques to remove contaminants from soil and water.

Public health initiatives that focus on radiation exposure prevention, early detection, and treatment of related diseases in affected populations.

International cooperation to create binding agreements on the protection of environmental and radioecological resources during and after conflicts.

In conclusion, military operations have profound and often underestimated effects on the radioecological situation. By addressing these impacts in the context of military planning and post-conflict recovery, it is possible to reduce long-term environmental and health risks, ensuring a more sustainable future for regions affected by war.

References

1. Axundov, R.Q. Azərbaycan Ordusunda radiasiya, kimyəvi və bioloji kəşfiyatının əsasları // – Bakı: Hərbi bilik, – 2023. №4, – s. 16-20.
2. Ахундов, Р.Г. Влияние военной деятельности на окружающую среду // – Вестник международной академии наук экологии и безопасности жизнедеятельности (МАНЭБ), – Санкт-Петербург: – 2024. №1(29), – с. 51-58.
3. Axundov, R.Q. Azərbaycan Ordusunda ekoloji təhlükəsizliyin təşkili və təkmilləşdirilməsi // – Bakı: Hərbi bilik, – 2024. №4, – s. 7-15.
4. Axundov, R.Q. Azərbaycan Ordusunda radiasiya, kimyəvə bioloji mühafizənin inkişaf problemləri və onlarin həlli yollari // Ümummilli lider Heydər Əliyevin anadan olmasının 100 illiyinə həsr olunmuş "Hərb sənətinin aktual problemləri"

beynəlxalq elmi-praktik konfransın materialları, – Bakı: MMU, – 3-4 may, – 2023, – s.137-138.

5. Akhundov, R. Military conflicts and environmental safety // Current directions of development of information and communication technologies and control tools. Abstracts of the Fourteenth International Scientific and Technical Conference. – Kharkiv, Ukraine, – 25-26 April 2024, Vol 2, – p.89-90.
6. Akhundov, R. Ecocide in the Nagorno-Karabakh Conflict: An Analysis of Armenia's Environmental Impact on Azerbaijan // Current directions of development of information and communication technologies and control tools. Abstracts of the Fourteenth International Scientific and Technical Conference. – Kharkiv, Ukraine, – 25-26 April 2024, Vol 2, – p.95-96.
7. Akhundov. R The environmental consequences of military activity // 20 years Bulgaria in NATO and NATO in Bulgaria. Abstracts of the Scientific Conference with International Participation. – Sofia, Bulgaria, – 2-4 April 2024, – p.558-570.
8. Akhundov R.G., Talibov A.M. Environmental safety as a component of national security // The latest technologies - for the protection of airspace. Abstracts of the 20th international scientific conference of the Kharkiv National University of the Air Force named after Ivan Kozhedub. – Kharkiv, Ukraine, – 02-03 May 2024, – p.25-27.

ASSESSMENT OF THE RADIOECOLOGICAL CONDITIONS FOLLOWING MILITARY OPERATIONS

Sakit Rasulov, Latifa Kazimova
Azerbaijan State Oil and Industry University,
Industry Safety and Labour Protection Department
latifa.ismaylova@gmail.com
rasulov sakit@gmail.com

In the post-war period, comprehensive investigations of affected areas are of paramount importance. This is particularly critical in regions where various types of weaponry have been deployed, necessitating thorough radioecological studies. These studies are fundamentally based on the collection and analysis of samples from soil, water, and vegetation. This is because soil, plants, and water in the area are directly involved in the human food chain, and any potential pathways for radionuclides to enter the human body must be strictly prevented. It is well established that internal exposure to radiation poses significant risks to living organisms.

Research Methodology. In the absence of monitoring data for certain environmental components, such as food products and biota, radionuclide concentrations in these components are estimated using mathematical modeling methods [Methodological Guidelines, 2014; Kryshev, Sazykina, 1990; Nosov et al., 2010; Romanov, 1993].

Assessment of Population Radiation Doses.

In accordance with established approaches and current methodological guidelines, the calculation of effective radiation doses to the population is carried out as follows:

$$PDN_i = H_{ing,i} + H_{inh,i} + H_{ext,i} \quad (1)$$

Where:

PDN_i— effective radiation dose for the population, $H_{ing,i}$ — dose from ingestion, $H_{inh,i}$ — dose from inhalation, $H_{ext,i}$ — external exposure dose.

The calculation of radionuclide concentrations in environmental components and local products, as well as the effective doses of internal and external exposure to the population, is performed in accordance with current methodological guidelines [Methodological Guidelines, 2014], taking into account relevant publications.

For calculating individual effective radiation doses to the population from the consumption of products grown in contaminated areas, the following expression can be used:

$$H_{ing.i} = \sum_{p=1}^{n} q_{i.p} \cdot R_p \cdot \varepsilon_{ing.i} \cdot B_p \quad (2)$$

Where:

$q_{i,p}$ – concentration of the *i*-th radionuclide in the *p*-th food product (Bq/kg); R_p – annual consumption of the p-th food product (kg/year); $\varepsilon_{ing,i}$ – dose coefficient for radionuclide ingestion (Sv/Bq); B_p – coefficient accounting for radionuclide losses during culinary and technological processing of the p_{th} product.

The following primary pathways of radionuclide ingestion are considered: through the green parts of plants, fruit vegetables, potatoes and root crops, milk and meat, forest products, soil particles, and water.

References

[1] Aliyev, L.A. (2004). Analysis of Radio Ecological Situation in Azerbaijan. In: Zaidi, M.K., Mustafaev, I. (eds) *Radiation Safety Problems in the Caspian Region*. NATO Science Series: IV: Earth and Environmental Sciences, vol. 41. Springer, Dordrecht. https://doi.org/10.1007/1-4020-2378-2_37

[2] Aliyev, Ch.S., & Kazimova, L.A. (2022). Environmental assessment of soil contamination of the oil and gas industry zone. *Nauchnyj Zhurnal "Doklady NAN RK"*, (3), 78-91. https://doi.org/10.32014/2022.2518-1483.160

[3] Aliyev, Ch.S., & Kazimova, L.A. (2023). Reasons for the formation of radionuclides in the soil and radioecological conditions in the oil fields (in Absheron Peninsula). *Visnyk of*

Taras Shevchenko National University of Kyiv. Geology, **4(103),** 98-102. https://doi.org/10.17721/1728-2713.103.12

[4] Aliyev, Ch.S., & Kazimova, L.A. (2024). Assessment of a radioecological situation in Azerbaijan, based on spectral analyses of radionuclides. *Journal of Environmental Engineering and Science*, **19(1),** 1-56. https://www.icevirtuallibrary.com/toc/jenes/0/0

DEVICE FOR CONTINUOUS MONITORING OF RADIATION CONDITIONS

N.M.Muradov, I.R.Hasanov, B.A.Sharifova

National Aerospace Agency

Ministry of Defence Industry of Azerbaijan Republic

ilqar.hesenov.1964@inbox.ru

The article considers the issue of designing a device intended for continuous measurements during the determination of the radioecological situation. It is shown that the proposed device is an improved version of the DRQ-01.Az radiometr. The proposed device for monitoring the radiation environment is designed to search for sources and measure the exposure dose rate of gamma radiation. The device consists of a detection unit that converts gamma radiation quanta into electrical pulses and a registration unit that generates voltage to power the internal circuits. The registration unit is connected to the detection unit by a cable. The control system allows the results of continuous measurements to be collected on a memory card and then processed via a computer. The detection unit contains a photomultiplier with crystals and a high -voltage divider. The registration unit includes an amplifier, a comporator, a frequency-voltage converter and anolog-to-digital converter. The technical characteristics of the device are as follows: Exposure dose rate of gamma radiation- 1 range 0.005-2.000 mR/h, 2 range 0.050-20.00

mR/h, measurement error- 20 %, power consumption- 6 Vt, massa-2 kq. The structural diagram of the detection unit and the general view of the device is shown in fig.1

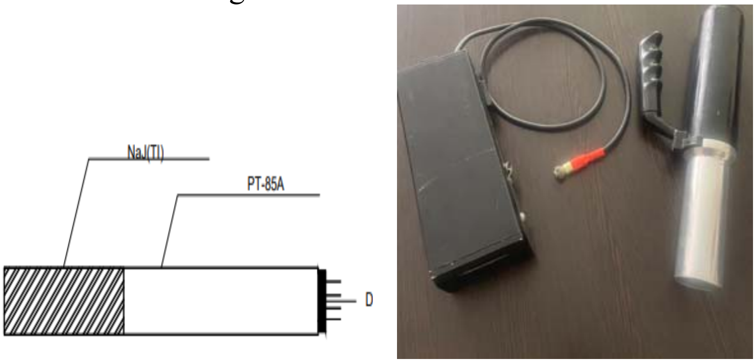


Figure 1. a) The structural diagram of the detection unit ; b) The general view of the device.

The device is designed to determine the degree of radioactive contamination in the air and water environment. The device which is designed to conduct continuous measurements in areas dangerous to human life can be used in mobile robotic devices, quadcopters and floating drones.

References

1. Gamma radiation dosimeter DRQ-01 Az. Pasport. 412112.001 PS. 2009.
2. V.L.Gurachevsky. Radiaton control:physical principles and instrumentation. Minsk.İnstitute of Radiology.2014.
3. Yong Sang. System and Measurements. Dalian University of Technology. 2020.

IMPACT OF MILITARY ACTIONS DURING THE WAR BETWEEN UKRAINE AND THE RUSSIAN FEDERATION ON THE RADIOECOLOGICAL SITUATION OF THE DONETSK REGION

O.Raksh-Slyusareva, O.Slyusarev, P.Kovalenko, Ya.Tur
Donetsk National Medical University, Lyman, Ukraine

The environmental and radiation situation in the Donetsk region is related to the peculiarities of the geological platform of Donbas and the impact of pollution caused by the mining, chemical, and metallurgical industries. The geological platform of the Donetsk region is saturated with radioactive emanations, which causes a constant effect on the biota of low-intensity ionizing radiation due to the presence of isotopes 226Ra, 232Th, 40K. Contamination of soil, air, and water with radioactive elements constantly occurred during the extraction of minerals and agricultural activities. Rock waste dumps located near residential areas, formed as a result of coal mining by mines and the operation of thermal power plants, cause the appearance of radioactive dust and ionizing γ-radiation, which further complicates the radiation situation in the region. In the Donetsk region, 13.000 radioactive spots were formed as a result of radioactive fallout after the Chernobyl accident, with radiation levels sometimes reaching up to 1 curie per square kilometer (1 Ci/km^2). Contamination of raw materials and food products with radionuclides of Chernobyl origin was established. In fact, before the military operations, the Donetsk region was constantly under the influence of the combined effects of man-made and natural radiation and a complex of harmful factors: chemical, metallurgical, mining and mining processing industries.

The purpose of the work was to analyze the ecological and radiation crisis and its impact on the state of the immune system in the region's residents against the background of the ecological and radiation situation in the Donetsk region, in the pre-war period and in 2014-2025 during the Russian aggression.

The work used bibilosemantic, cognitive methods, hematoimmunological studies, supplemented by studies of cytomorphology of cells of nonspecific resistance and immune systems.

Results and discussion. Since 2014, the infrastructure of Donbas has been destroyed as a result of military operations: chemical and metallurgical industry facilities have been damaged, forests and gardens are burning, agricultural lands are being destroyed, rivers, natural and artificial reservoirs, and the Sea of Azov are being polluted. Flooding of mines and adjacent areas led to contamination of groundwater and surface waters with iron, chlorides, sulfates, other mineral salts and heavy metals, as well as radionuclides. The operation of water treatment and drainage facilities was disrupted and stopped, and municipal sewage and water supply networks were damaged. Explosions and shelling in areas of natural radiation lead to the release of radionuclides into the soil, water, and air. An increase in the level of γ-radiation has been recorded since 2014. At the same time, heavy metal pollution is increasing. Only in 2017-2018, the region detected an excess of elements such as mercury, vanadium, cadmium, and non-radioactive strontium by 1.1-1.3 times. In most cases, the content of heavy metals in soil samples taken from military operations exceeded the background value by 1.2-12 times. It has been established that residents of the Donetsk region, both displaced persons from territories not controlled by Ukraine and residents, are experiencing changes in their psycho-emotional state and psychoneuroimmune regulation, which are constantly deepening from 2014 to 2025. Changes in the cells of nonspecific resistance and the immune system indicate its tension at the level of adaptation breakdown, and in the immune system — a tendency towards immunodeficiency and reduced control over the genetic homeostasis of the body.

Conclusions The Russian military aggression that began in 2014 has catastrophic consequences for the economy, natural resources, and ecosystems of the Donetsk region and has a significant negative impact on the health of the population of the Donetsk region.

ASSESSMENT OF THE HISTORICAL TRENDS OF HEAVY METALS FROM FLOODPLAIN SEDIMENT RECORDS IN THE TRANS-BOUNDARY RIVER BASIN, MARITZA–TUNDJA–ARDA

G.Yaprak[1], I.Sert[1], S.Aytas[1], S.Yusan[1], C.Kıncal[2], S.Hakan Sazak[3], O.Candan[2], D.Yasar[4]

[1] *Ege University, Institute of Nuclear Sciences, 35100 Bornova-Izmir, Turkiye*

[2]*Dokuz Eylül University, Engineering Faculty, Department of Geology, Tınaztepe Campus,35390 Buca – Izmir, Turkiye*

[3]*Ege University, Faculty of Sciences, Department of Statistics, Bornova-Izmir, Turkiye*

[4] *Dokuz Eylül University, Institute of Marine Sciences, 35430 İnciraltı-İzmir, Turkiye.*

Sediments are a fundamental, complementary and dynamic part of the aquatic environment and serve as an archive for understanding the environmental processes and fates of pollutants in the aquatic systems such as rivers, estuaries, lakes and marines. As known, the floodplains of Transboundary Rivers are of increasing importance due to the accumulation of nutrients and many pollutants, including heavy metals and pesticides [1-3]. Therefore, in the present study, ^{137}Cs dating methods were applied to floodplain sediments to determine the historical trends of the heavy metal concentrations in the Transboundary River Basin, Meriç, Tunca and Arda.

Sediment cores and surface sediments were collected systematically in the floodplains during 2018. The core length is varied from 50 to 70 cm. The cores were sliced at 1-cm intervals and sediment subsamples were dried at 40-60^{0}C to constant weight, and water content was determined. The dried samples were powdered in a ball-mill for geochemical and radionuclide analysis. In this study, the quantitative determination of ^{7}Be and ^{137}Cs was carried out by HPGe gamma spectrometry. Heavy metal analyses and lead isotopic composition were performed in the AcmeLabs (Bureau Veritas Commodities Canada Ltd.). All physical parameters were also clarified for the sedimentation mechanism. In order to investigate the storage and remobilization of recently eroded sediment, bulk samples of river water (100-150 litres) were collected from the monitoring stations at Kirishane in Edirne. In this study, several reference cores were taken from undisturbed site adjacent to the study field for any excess ^{137}Cs and ^{7}Be on the floodplains. In addition, precipitation samples were also used for the direct measurements of ^{7}Be delivery to study area.

The variations in the ^{7}Be and ^{137}Cs activity concentrations in the suspense sediments were allowed for identifying inputs of recently eroded surface sediment to the river channel. A multiple approach [*SQGs by USEPA, Metal Enrichment Factors (EF) and Geoaccumulation Index(I_{geo})*] should be considered to evaluate the environmental status and sediment contamination. The dated sediment cores were used to sedimentary record of historical heavy metal contamination of the floodplains.

The combination of trace metal analysis, Pb isotopic composition and ^{137}Cs dating as well as statistical data in the floodplain sediments provide vital information on the long-term accumulation of metals in the Transboundary River Basin, Meriç, Tunca and Arda.

Acknowledgements: This Project (Contract No: 117Y093) is financially supported by the TUBITAK (The Scientific Technological Research Council of Turkey).

References

[1] Owen P.N. and Walling D. E. (2003) Hydrobiologia **494**:185-191.

[2] Owens et al. (1999) Catena **36**:21-47; [3] Walling and He. (1997) Catena 29:263-282.

[3] Walling and He. (1997) Catena 29:263-282.

MEASUREMENT OF RADIOACTIVITY ON THE EARTH'S SURFACE

Hokuma Dunyamaliyeva
Western Caspian University
hokuma_98@mail.ru

The application of the achievements of technical progress in a number of areas of the economy in modern times, the observation of various variations in the concentration of pollutants in the composition of atmospheric air as a result of changes in the parameters of the ecological system due to technological progress, as well as the spontaneous use of the earth's natural resources leading to the deterioration of human habitation, changes in climate conditions, a decrease in the amount of stratospheric ozone, the destruction of forest areas, and the widespread expansion of the desertification process have been extensively analyzed in the article.

Keywords: Ecological system, hydrocarbon resources, ecological problems, radioactive aerosols.

In recent years, the country has successfully implemented reforms, economic development and environmental protection, including significant work towards solving ecological problems.

Thus, large-scale state programs and national projects have been implemented in the country to improve the welfare and security of the population and protect their health.

According to calculations, maintaining the current growth rate indicates that the world population will exceed 9 billion in 2030. On the other hand, the extraction of large amounts of hydrocarbon resources and the processing of mining ores seriously affect the physical, chemical and biological properties of the environment, creating conditions for atmospheric air pollution. It is for this reason that the environmental problem has attracted the attention of world scientists, the arsenal of scientific research aimed at monitoring atmospheric pollution has been expanded, and significant achievements have been achieved in the creation of new technical means, the development of complexes and the commissioning of technological lines.

In the globalized world economy, the extraction of hydrocarbon resources and the processing of mining ores have a very serious impact on all characteristics of the environment, creating conditions for environmental pollution of the air. For this reason, conducting scientific research on environmental problems has been set as a goal by world scientists, and significant achievements have been made in creating modern technological equipment, developing complexes that meet environmental standards, and commissioning technological lines in order to overcome environmental problems.

For the Republic of Azerbaijan, an oil and industrial country rich in natural resources, determining the physical nature and mechanism of action of oil and gas fields and radioactive aerosols in the environment is of great importance. In this regard, the research work conducted to identify radon problems in the environmental problems arising during oil and gas production and processing in Azerbaijan is one of the most urgent issues of the day.

References

1. Nuraliyeva R.N., Economic and environmental problems of the

development of the fuel energy complex of Azerbaijan. Baku, 2010, 221 P.
2. Ionizing radiation, radiation safety: Radiation Safety Standards (NRB-99). SP 2.6.1.758-99. Moscow: Ministry of Health of the Russian Federation, 1999. 116 p. The results of measuring the volume activity of radon in Azerbaijan Geophysical processes and the biosphere 2017 Vol. 16 № 3 53
3. El-Taher, A., & Al-Zahrani, J. (2014). Radioactivity measurements and radiation dose assessments in soil of Al-Qassim region, Saudi Arabia. El Mamoney, M., &Khater, A. E. J. J. o. E. R. (2004).
4. Environmental characterization and radio-ecological impacts of non-nuclear industries on the Red Sea coast. *73*(2), 151-168.

POSSIBILITIES OF USING ELECTROMAGNETIC WEAPONS IN INFORMATION WARFARE IN MILITARY CONFLICTS

Elvira Huseynova
National Aerospace Agency of MDI
elvira.q77@mail.ru

Radio frequency electromagnetic radiation (RFEMR) is a new promising means of radio electronic warfare, which developed in the 90s. of the past century and demonstrated the ability to disrupt the functioning of information systems to a high degree. The effectiveness of the use of RFEMR is due to the high density of information flows in the main spheres of activity of modern states in the management of the country's economy, production, and defense. Violation, even short-term, of the functioning of information-management systems can cause serious consequences.

Means of radio electronic attack can also be used by intruders to break electronic locks (including invisible locks!), electronic sealing devices, for short-term blocking of electronic object security systems when entering an object. Active EM-interference can be used by intruders and when breaking into car security systems. For the organization of this type of attack, three types of medium-power (up to 1 GW per pulse) RFCs based on vacuum electron tubes with mesh cathodes can be used - virkators; spiral frequency generators with explosive compression of the magnetic field (explosive magnetic frequency generators —EMFG) [1] and semiconductor generators of nanosecond interference.

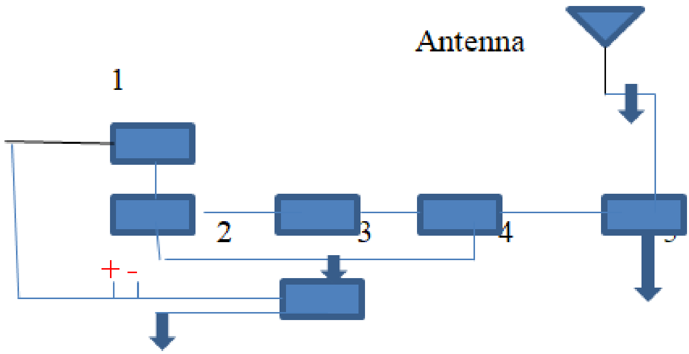


Figure 1. SOS Generator block diagram.

The idea behind the virkator (see fig. 1a) is to accelerate the powerful flow of electrons with a mesh anode. Electrons emitted by the graphite cathode 1 and passing through the anode 2 form a cloud of space charge 3 behind it, which oscillates with frequencies in the microwave range.

It is impossible to detect an attack using virkators without special devices, so in case of failure, criminals can repeat the attempt. The disadvantages of virkators should include, firstly, the narrowband radio emission and tuning to the operating frequency of the attacked devices, which requires preliminary technical reconnaissance of the latter, and, secondly, the relative complexity and high cost of manufacturing technology [1].

The purpose of an electromagnetic attack on electronic devices is the temporary "blinding" of its electronic circuits, caused by overloading of signal and power circuits under the action of radiation-induced current interference and partial degradation of digital and analog semiconductor elements.

The appearance on the market of affordable imported components of power and high-power microwave electronics along with software packages for designing and modeling electronic equipment, in principle allows highly qualified specialists to create individual types of RFEMR .

References

[1]. Bystrov RP, Cherepenin VA. Theoretical substantiation of the possibilities of using the method of generating powerful nanosecond pulses of electromagnetic radiation in the creation of radar systems for combating objects. Bulletin of the Academy of Military Sciences, 2010, 3(32):126-130.

TRANSFORMATION OF TOXIC COMPONENTS IN THE ENVIRONMENT CAUSED BY FUEL LEAKS

Nigar Guliyeva[1], Gulara Imanova[2], Samira Aliyeva[1], Islam Mustafayev[1,3]

[1]*Institute of Radiation Problems MSE AR*

[2]*Azerbaijan State Oil and Industry University*

[3]*Azerbaijan University of Architecture and Construction*

nigarguliyeva64@mail.ru

During military operations, liquid fuels are released into the environment as a result of the destruction of military equipment. In the Karabakh War, thousands of damaged and destroyed vehicles contributed to the release of liquid fuels into the ecosystem, leading to the transformation of their toxic components. At present, petroleum products are recognized as one of the main pollutants of the environment.

In this study, the kinetics and mechanisms of these transformations were investigated under model conditions. Due to human activities, soils near oil fields and pipelines are often contaminated as a result of leaks occurring during oil extraction and transportation. Therefore, the development of innovative methods for eliminating oil spills is of particular relevance today. Since polycyclic compounds exhibit significant environmental toxicity, studying their transformation during oil degradation in the environment is of great scientific and practical interest.

This work presents the results of a study on the transformation of specific PAH groups during the soil degradation of oil extracted from the Surakhani field in the Absheron Peninsula.

The sources of polycyclic aromatic hydrocarbons (PAHs) in the environment are diverse and include both natural and anthropogenic origins, though the majority is linked to human activities. PAHs are released primarily through fuel leaks during transportation and energy production, as well as, to a lesser extent, through industrial waste.

Available data indicate that polyaromatic compounds, including naphthalene, phenanthrene, dibenzothiophene, fluoranthene/pyrene, and benzoanthracene/benzopyrene, accumulate in oil-contaminated soils of Absheron. The concentration of PAHs (calculated as benzopyrene equivalents) exceeds the permissible exposure limit (PEL) by several thousand times.

In view of the potential for developing new technological processes that use ionizing radiation to remediate petroleum-contaminated soils, the effect of gamma radiation on the PAH content in degraded oil was investigated (see table).

Table

Effect of Irradiation on Crude Oil and on the Composition of Hydrocarbon Groups in the Tar Fraction of Oil Degraded in Soil (D = 91.2 kGy)

Fraction	D, kGy	THC (C_{10}-C_{40}) ug/g	UCM (C_{10}-C_{40}) ug/g	Total 2-6 ring PAHs, ug/g	NPD, ug/g	Total EPA 16, ug/g
Tar (from crude oil)	0	523718	422817	20375	18912	1286
	91.2	521521	412187	19448	18133	1587
Tar (from soil)	0	585809	472974	10224	9567	730
	91.2	513250	420280	7950	7429	584

As shown in the table, gamma radiation applied to degraded oils results in a reduction in the concentrations of various groups of polyaromatic compounds.

Investigating the changes in PAHs within fuel spills under the influence of radiation enables the application of radiation-chemical technology in developing methods for remediating oil-contaminated soils.

TECHNOLOGY AND CHEMICAL AGENTS USED IN MODERN MILITARY OPERATIONS

Shahla Hajizade
National Aerospace Agency Institute of Space Research of Natural Resources
Sehlakazimova70@mail.ru

The technology and chemical agents used in modern military operations are highly diverse and are one of the key factors changing the nature of modern warfare. These technologies and agents are used to gain an advantage on the battlefield, neutralize the enemy's forces, and achieve strategic objectives. Furthermore, new military technologies are completely transforming modern warfare, strategic approaches, and the battlefield itself. These new technologies aim to achieve technical superiority and make faster and more accurate decisions on the battlefield. The use of military technology and chemical agents is also regulated by international law, front-line strategies, and the laws of war.

Introduction

The main technologies and chemical agents used can be classified as follows:

1. Military Technology: This includes infantry technology, tanks and armored vehicles, aviation assets, naval forces, rocket and artillery systems, and laser weapons. The use of artificial intelligence in military technology has become a significant part of modern combat systems [1]. The application of artificial intelligence in combat enhances the decision-making ability of soldiers and combat vehicles. With its use, some systems can identify and track targets, allowing urgent decisions to be made without human intervention. Moreover, with the help of artificial intelligence, large datasets are analyzed to predict and determine combat tactics and military strategies through intelligence and data analysis.

2. Chemical Agents: These include chemical weapons, biological weapons, and microwave weapons. Chemical agents can cause severe damage to humans, the environment, and the economy during wars. Chemical weapons have a highly powerful and destructive impact on the battlefield; however, their use is strictly limited by international law. Chemical agents, especially since the early 20th century, have been extensively studied and used by some countries. These agents pose a significant threat to human life and health and create unequal combat conditions in wars.

Chemical weapons can be classified as follows:

- Neurotoxins, which affect the nervous system by disrupting the transmission of messages between nerve cells, leading to muscle paralysis.
- Complex gases, which are some of the most well-known chemical agents, and heavy gases, which can cause death by cutting off oxygen supply.
- Toxic gases and biological weapons.

Chemical weapons are prohibited by the laws of war and international treaties. The Chemical Weapons Convention, adopted in 1993, prohibits the use of these weapons, and significant progress has been made in this field. The aim of the convention is to restrict the production, use, and spread of chemical weapons [2].

However, some countries and non-state actors still use such weapons. The use of chemical weapons also raises ethical and human rights concerns, as their use contradicts the protection of natural life and human health. The impact of chemical weapons is not only physical but also has serious psychological and social consequences. Their use represents a significant danger and disaster for every war. Therefore, the fight against the use of chemical weapons within the framework of international law is crucial, and their prohibition is of utmost importance.

References

1. Feldman, P., Dant, A., & Massey, A. (2019). *Integrating Artificial Intelligence into Weapon Systems.*

2. *The New York Times.* (2024, January 22)."Chemical Weapons in Modern Warfare: A Humanitarian Crisis."

STUDY OF FISH ORGANISMS EXPOSED TO DIFFERENT DOSES OF IRRADIATION

Leyla Kazimli[1], Rovshan Khalilov[1], Nisakhanim Karimova[1], Intizar Karimbeyli[1], Gulay Humbatli[2]
[1]Institute of Radiation Problems MSE AR,
[2]Baku Turkish High School
kazimlileyla@gmail.com

Guppies and swordfish are among the most well-known and widespread fish species in the fishing world [1]. These fish are known for their sexual dimorphism; males are small and colorful, while females are larger and paler [2].

The objects of the study were guppies and swordfish. The main goal of the experiment is to eliminate the consequences of the ecological imbalance that occurred in the territories of Azerbaijan during the occupation period lasting about 30 years, and to determine the reproductive potential of the mentioned fish species. Therefore, we observed the reproductive behavior and other physiological characteristics of these fish species when exposed to different doses of radiation. The experiment was carried out in 3 main groups. For the study, aquariums consisting of fish irradiated at doses of 8 Gray and 15 Gray were prepared, being the first control sample.

Our observations on the direct effect of these doses on the vital activity and reproductive ability of fish continue.

References

1. Magurran, A. E. (2005). Evolutionary Ecology: The Trinidadian Guppy. Oxford University Press.
2. Bashey, F. (2008). Competition as a selective mechanism for larger offspring size in guppies. Oikos, 117(1), 104–113.

THE IMPACT OF PLASTIC MASSES ON THE ECOLOGICAL BALANCE

M.A.Manafov, S.M.Khalilova, G.J.Ismayilova, S.A.Salahova
Institute of Polymer Materials MSE AR
khalilova.leyla@inbox.ru

There is no doubt that environmental pollution by waste has a negative impact on people's lives and health. The solution to the problem of the complex use of recycled raw materials contained in solid household waste is associated with the solution of a number of scientific and technical issues, among which the organization of the volume of recycled raw materials and their supply at the sources of their formation occupy an important place. The effective use of industrial waste and secondary products and the creation of synthesis processes for new polymer materials necessary for the development of the republic's industry are of particular importance for the chemical industry.

Since the middle of the 20th century, the population had an unprecedented impact on the Earth's climate system, which has led to changes on a global scale. Environmental pollution and the increase in the amount of carbon dioxide in the atmosphere lead to an increase in temperature and the gradual destruction of soils. The continuation of wars in the world affects the thinning of the ozone layer. Unsafe products produced in the chemical complex release harmful substances into the atmosphere, biosphere, and hydrosphere. Nowadays, the production of plastic masses is already polluting nature. Since plastic masses do not decompose, or dissolve for a long time, they affect the environment. Currently, one of the main reasons for the deterioration of the environment is the use of millions of tons of plastic masses. It is necessary to adjust the physical and mechanical characteristics of the samples by changing the proportions of plastic masses and fillers in the composition, the color, resistance to environmental influences, etc.

In order to prevent land degradation, desertification, and climate change, awareness-raising activities are being carried out among farmers and local communities in countries around the world on sustainable agriculture and the efficient use of land resources. Also, in many countries, early warning systems for drought are being established, forest areas are being planted to prevent erosion, and greening activities are being carried out.

In modern times, demographic growth, economic development, including industry, and the increase in the level of people's well-being have sharply increased the demand for energy carriers, in parallel with the increase in the demand for vehicles. For a long time, fuels such as coal, oil, and gas have been used as the main energy carriers in the world, and the demand has been met with these fuels, which are widely available in many countries of the world. However, the decline in the reserves of these resources, as well as the instability of fuel prices, and the fact that the use of these fuels plays an important role in disrupting the ecological balance, are increasing interest in renewable energy sources day by day. Reports from international and regional organizations show that significant investments are being made in this area and the share of renewable energy sources in the energy system is rapidly increasing day by day. Research work is being carried out in the field of identifying ways to utilize, neutralize, or recycle petrochemical production waste for environmental protection. For this purpose, new composites have been obtained using natural mineral rocks and polyolefin recycling.

THE ENVIRONMENTAL IMPACT OF PESTICIDES AND MEASURES TAKEN TO REDUCE THEM

Nigar Hashimova
Baku State University
nigar.hashimova@afsa.gov.az, n.hashimova.89@gmail.com

The widespread use of pesticides to intensify agriculture and increase productivity contributes to food security but also poses serious threats to the environment and living organisms. These chemical substances, applied to eliminate pests and reduce crop losses, negatively affect the functional stability of ecosystems. Therefore, the impacts of pesticides not only on agricultural efficiency but also on biodiversity and public health require a multidisciplinary research and management approach.

As a result of pesticide application in agricultural fields, these substances frequently reach aquatic ecosystems, causing pollution in rivers, lakes, and other water bodies. This pollution leads to algal blooms (eutrophication) accompanied by reduced oxygen levels in water bodies, resulting in the death of fish and other aquatic organisms. Additionally, pesticides have long-lasting effects and can accumulate in the food chain (bioaccumulation), increasing the risk of toxic loads at higher trophic levels – such as in birds, mammals, and humans.

The impact of pesticides on soil is also significant. They can remain in the soil for years without decomposing, disrupting the balance of microorganisms, reducing soil fertility, and weakening the regenerative capacity of soil ecosystems. At the same time, the destruction of beneficial insects, especially pollinators, disrupts the biological balance. This not only leads to a decrease in productivity but also threatens the long-term sustainability of agricultural systems. The Republic of Azerbaijan has implemented important institutional and regulatory measures to minimize the environmental impact of pesticides. Within this framework, the Food Safety Agency (AFSA) actively participated in the 2019–2022 project titled *"Management of Pesticide Circulation and Elimination of Persistent Organic Pollutants (POPs) in Central Asian Countries and Turkey."* The main goal of the project was to prevent the spread of unusable and hazardous pesticide stocks into the environment and to strengthen national capacity for proper pesticide management.

Furthermore, AFSA officially banned the import, production, and use of 238 types of pesticide active ingredients across the country. This decision was coordinated with relevant government agencies and incorporated into legislation. The long-term use of these pesticides posed environmental risks, and the ban is considered a significant measure for protecting both the environment and public health.

Analyses show that the environmental impact of pesticides is complex and requires not only technical but also institutional and social approaches. The following recommendations are made:

- Monitoring systems for pesticide use should be expanded;
- Alternative biological and agroecological approaches should be promoted;
- The legal framework should be continuously updated, and enforcement should be strengthened.

References

1. Food and Agriculture Organization of the United Nations. (2019). Managing Pesticides in Central Asia and Turkey. FAO.
2. Republic of Azerbaijan Food Safety Agency. (2020). National Strategy for Pesticide Risk Reduction.
3. Goulson, D. (2013). An overview of the environmental risks posed by neonicotinoid insecticides. J. of Applied Ecology, 50(4), 977–987. https://doi.org/10.1111/1365-2664.12111
4. Aktar, M. W., Sengupta, D., & Chowdhury, A. (2009). Impact of pesticides use in agriculture: Their benefits and hazards. Interdisciplinary Toxicology, 2(1), 1–12. https://doi.org/10.2478/v10102-009-0001-7

5. Damalas, C. A., & Eleftherohorinos, I. G. (2011). Pesticide exposure, safety issues, and risk assessment indicators. Inter. Journal of Environmental Research and Public Health, 8(5), 1402–1419. https://doi.org/10.3390/ijerph8051402

THE ROLE OF THE ZEOLITE MINERAL IN ENVIRONMENTAL IMPACT

Nizami Naghiyev[1], Vagif Mammadov[2]
[1]*Institute of Ecology and Natural Resources MSE*
[2]*Azerbaijan State Agricultural University*
mammedov1948@mail.ru

Keywords: zeolite, ion-exchange properties of zeolites, adsorption, phoiorite mineral, biological properties.

Summary. The adsorption properties of natural zeolites are primarily determined by their structural framework and chemical composition. Among natural zeolites, the mineral *phoiorite* possesses the largest channel entrance diameter—about 9^0A. The zeolite channel systems can be one-, two-, or three-dimensional and may constitute up to 50% of the crystal's total volume. At low temperatures, these channels are typically filled with water molecules. When water is removed, various molecules — such as CO, CO_2, NH_3, hydrocarbons, and other organic compounds — can enter the channels and surfaces of zeolites. Because the dimensions of these channels are comparable to the sizes of the molecules, zeolites are often referred to as **"molecular sieves."** They selectively adsorb or allow the passage of molecules based on their size and shape [1].

The crystal structures of zeolites, known for their remarkable properties, have been investigated using advanced analytical techniques. It has been established that the micropores in the crystal lattices of dehydrated zeolites, with dimensions ranging from 0.3 to 1 nm, occupy up to 50% of the lattice volume, which accounts for their highly active adsorptive properties. The size of these pores determines the selectivity of zeolites in the sorption of various molecules, functioning as a molecular sieve. The ion-exchange properties of zeolites are influenced not only by their crystal structure but also by the chemical compatibility of the ions participating in the exchange process.

The primary purpose of ion exchange processes in zeolites is to swap ions that are incompatible with other techniques for separation.

The ion-sieve effect enables zeolites to adsorb gases and vapors such as N_2, CO_2, SO_2, H_2S, Cl_2, and NH_3 from both gaseous and liquid systems. In addition, it has been demonstrated that zeolites can effectively adsorb radioactive cesium ions, as well as NH_4^+, Cu, Pb, Zn, Cd, Ba, Co, Ag, and other metal ions from wastewater and natural water sources.

Compared with other ion-exchange resins, zeolites exhibit an adsorption capacity that can be up to 30 times higher [2].

The total cation-exchange capacity of zeolites, depending on the type and form of the adsorbed ion, ranges from 1 to 5 mg-equiv per gram of zeolite. This capacity is 5–10 times greater than that of conventional adsorbents.

The application of 0.5–2 tons per hectare of clinoptilolite, a type of zeolite, to soil has been shown to increase wheat yields by 15%, corn yields by 10%, carrot yields by 63%, and apple yields by 28%.

A comparison of the applications of zeolites, which distinguish them sharply from other natural minerals due to their unique properties, demonstrates that zeolites are an indispensable natural resource in modern times. Their remarkable characteristics make them invaluable for addressing human health issues, solving environmental problems, enhancing agricultural productivity, and mitigating the effects of radiation in the environment, especially amid rapid scientific and technological advancement [3].

We believe that the proper evaluation and scientific utilization of this natural mineral is one of the pressing issues of our time.

References

1. M.T. Valiyev, G.I. Alekperov, V.S. Aliyev, *Synthesis of Zeolite Calciners and X-ray Study of Their Structure*, Ganja: GSU, No. 4, pp. 31–32.
2. H.A. Aslanov, *Application of Natural Zeolite Mineral in Agriculture Together with Fertilizers*, Baku, 2015, p. 419.
3. E.I. Ahmadov, S.F. Mammadov, N.A. Rzayeva, *Physical Chemistry*, Baku, 2009, p. 29

ENVIRONMENTAL TERRORISM THROUGH LANDMINES DURING THE ARMENIAN OCCUPATION OF AZERBAIJANI TERRITORIES

Col. (Ret.) Mehman Gadimaliyev
Military Administration Institute of the National Defence University
Mehman.qedimeliyev@mail.ru

1. Brief Statistical Overview

According to official sources, since 1992, a total of 3.500 people have suffered injuries of varying severity due to mine and munition explosions. Of these, 2.900 were injured and 600 were killed. Among the injured, 360 were children and 38 were women.

From November 2020 to May 2023, 44 Azerbaijani citizens lost their lives, and 97 sustained various bodily injuries.

From November 2020 to July 2025, a total of 399 people were injured by landmine and munition explosions.

2. Types of Mines and Unexploded Ordnance Discovered and Cleared from Liberated Territories

During the Soviet era, a factory located in Yerevan, in the territory of the Republic of Armenia, produced anti-personnel mines for the Soviet Army. After the collapse of the USSR, Armenia exploited this facility to continue and expand mine production. Since 1992, these mines—both produced and stored during the Soviet era—have been used to mine Karabakh and other territories bordering Armenia.

In the liberated territories, engineering mines—primarily produced during the Soviet era and more recently by the Republic of Armenia—have been discovered and neutralized. These include mainly anti-personnel mines of the PMN, PMN-2, and PMN-E types, as well as anti-tank mines of the TM-57, TM-62M, and TM-62P types.

The Armenian Army also manufactured and deployed various types of improvised explosive devices (IEDs) on a large scale. During and after the anti-terrorist operations, Azerbaijani Army Engineer Troops discovered and neutralized a significant number of these IEDs.

3. Damage to Flora and Fauna Caused by Mines and Unexploded Ordnance

The installation and subsequent neutralization of mines in the territories have caused significant negative impacts on the soil layer. The placement of mines and other explosive devices by the enemy led to the destruction of existing vegetation. Additionally, explosions have resulted in the burning of both the soil surface and the vegetation growing on it.

Similar to humans, many living beings have been injured by landmine explosions, highlighting the significant harm caused to the region’s fauna.

4. Forecasting Clearance Time for Liberated Territories and Estimating Required Resources

During the operations of the Second Karabakh War, Azerbaijani troops encountered a large number of anti-tank (AT) and anti-personnel mines (APM). While carrying out engineering support tasks during the 44-day Patriotic War, the units of the Engineering Troops and other military forces successfully neutralized numerous AT and APM mines, ensuring the safe advance of our troops.

A major priority for the Azerbaijani state, following the successful completion of the 44-day Patriotic War, is the safe return of former internally displaced persons to their homelands. Immediately after the victory, restoration and reconstruction work began in the territories liberated from occupation in Karabakh and the East Zangezur region and continues in a planned and systematic manner. International airports and hospitals are being constructed, new roads and bridges are being built, and new settlements and schools are being established, alongside other essential infrastructure and development projects.

The Mine Action Agency of the Republic of Azerbaijan, a public legal entity established by the Presidential Decree of January 15, 2021, is pursuing new strategic objectives. Following the victory of the Azerbaijani Army in the Patriotic War, the Agency is responsible for clearing and neutralizing territories liberated from occupation and affected by the conflict, including the removal of mines, unexploded ordnance, explosive devices, and other remnants of war. Currently, organizations engaged in these clearance operations possess highly qualified personnel and a modern material and technical infrastructure.

For the first time since Azerbaijan's glorious victory in the Second Karabakh (Patriotic) War, the IV Azerbaijan International Defense Exhibition 'ADEX' and the XIII International Internal Security, Protection, and Rescue Exhibition 'Securex Caspian' were held at the Baku Expo Center on September 6, 2022, with the participation of President Ilham Aliyev. Organizations involved in clearing liberated territories from mines and unexploded ordnance also actively participated in the exhibitions.

Currently, the neutralization of mines planted by Armenian forces in Karabakh is being successfully carried out by the Mine Action Agency of the Republic of Azerbaijan (ANAMA) and its contractor organizations, special mine clearance units of the Azerbaijani Army's Engineer Troops, engineering and fortification units of the State Border Service, and Special Risk Rescue teams of the Ministry of Emergency Situations. Significant efforts are being made to clear the territories liberated from occupation. Naturally, this gradual process requires not only time but also substantial funding, a sufficient number of skilled specialists, and advanced technical resources. Mine clearance operations are primarily focused on transport routes, critical infrastructure, towns, and villages—that is, throughout all previously occupied territories. The most innovative equipment has been deployed to ensure the effectiveness of these operations.

In modern times, advanced technologies, including robotic systems, are widely used worldwide for clearing territories of mines and unexploded ordnance. Azerbaijan also benefits from the experience of leading countries to ensure the effective clearance of territories liberated from occupation.

Azerbaijan, a strong and technologically advancing state, has joined the global space community in its relatively short history of independence, creating significant advantages for the country. During the Patriotic War, the republic effectively utilized satellite capabilities to locate mined areas, even when the enemy concealed maps. President Ilham Aliyev, speaking at the exhibition held at the Baku Expo Center on September 6, 2022, emphasized: ‘We must use satellite images effectively. They provide additional opportunities both during and after the war, particularly for restoration work. Through satellites, we were able to determine the precise extent of forests destroyed by Armenian forces—54.000 hectares were plundered and sold. Satellite imagery also helps identify areas most contaminated with mines. Therefore, we must use these capabilities efficiently.

The presence of mines not only threatens the right to life of residents but also impedes recovery and development, delaying the return of former internally displaced persons to these territories. Therefore, the urgent clearance of mines and other unexploded ordnance is a top priority. The ongoing efforts indicate that Azerbaijan will soon achieve full demining of the liberated territories, enabling the rapid reconstruction and restoration of Karabakh.

In connection with the above, it is proposed to:

- **widely apply modern demining equipment** to enhance the efficiency and safety of mine clearance operations;
- **increase the number of private demining companies accredited by ANAMA** to accelerate the clearance process and complete it in a shorter time frame.

ASSESSMENT OF TERRITORIES DEGRADED AS A RESULT OF MILITARY IMPACT IN THE TERRITORIES OF OGUZ, AGSU, KHYZY AND HAJIGABUL, USING GIS

Valida Mammadaliyeva, Rovshan Ramazanov, Vusala Nasirova, Nargiz Abilova

National Aerospace Agency, Research Institute of Aerospace Informatics

valide.mamedaliyeva@mail.ru, murad2nasirov@gmail.com

Using GIS technologies, changes in vegetation as a result of the impact of military units on forest cover were studied. This work was carried out in accordance with the principle of geographical dependence and geometric transformation of the image.

Theoretical foundations of geographical dependence and image transformation.

Remote sensing (space and aerospace images) due to its dependence does not provide a real description of the location of data and their objects, their interdependent state and sizes. To obtain such a description, additional processing is required. In general, this processing can be divided into 2 main stages:

- Image transformation. This term refers to a process whose main purpose is to bring the image to a given scale and eliminate offsets arising from the tilt of the image, terrain, curvature of the earth's surface, as well as geographic offsets of the projection.

- Image dependence. This means an accurate determination of the terrain, the surface of the earth reflected in the image, and obtaining for each point of the image a real coordinate that coincides with the coordinate of a given point on the ground.

Military actions, as a specific and widespread type of anthropogenic factors, are considered one of the most serious indicators of degradation. Military impacts play the role of the main anthropogenic-technogenic factor in the deterioration of the environmental situation in the forest cover and the degradation of the landscape complex. The impact of military actions on the ecology of forest cover leads to the disruption of the main soil cover, which is associated with the destruction of vegetation, the impact of heavy equipment and the formation of uncharacteristic erosion processes.

The use of space images to record forest cover disturbances caused by these impacts is of particular importance. Remote sensing data allows us to obtain a fairly objective and accurate picture of forest cover degradation caused by military actions.

As a result, Table 1 shows the territories of military units in the forest cover, the changes that occurred in these territories, as well as the natural factors or causes that caused these changes.

Table 1.

Forest area degradation as a result of military impacts, ha

Existing dynamic processes	Dynamics	Area indicator for different years	
		1980	2016
1 Broken trees	1685	2900	1215
2 Soils subject to displacement	370	1860	1490
3 Areas with sparse vegetation	1350	4250	2900
4 Area of biodiversity subject to variability	2810	6790	3980
5 Soils and rocks with variable properties	1035	5360	4325
6 Area of deformed relief	2025	4150	2125
7 Surface and deep impacts on soils	1730	2780	1050
8 Disturbed land cover	1296	2165	869

9 Altered relief	1320	4280	2960
10 Formation of landslides and artificial pits	1129	3289	2160
11 Destroyed forest areas	1985	4090	2165
12 Disturbed land cover	1390	3260	1870

References

1. Алпенидзе М.Д. География неустойчивого развития: военные конфликты и их экологические последствия (http://konescveta.ucoz.ru/publ/7-1-0-12)
2. Гурвич И.Я. «Послевоенные изменения в географии лесов». Известия Всесоюзного географического общества. 1950. № 4.Вронский В.А. Экология.
3. Ю.Ю.Герасимов, С.А.Кильпеляйнен, А.П.Соколов. Геоинформацион-ные системы: Обработка и анализ растровых изображений. Москва, 2002, 118 с.
4. http://npk-kaluga.ru/CalcNDVI_AGIS.htm
5. http://npk-kaluga.ru/LandsatUSGS.htm

SECTION 2. IMPACT OF MILITARY OPERATIONS ON FLORA AND FAUNA, THEIR ROLE IN FOREST FIRES AND CO_2 EXCHANGE

A BRIEF SUMMARY OF RESEARCH CONDUCTED IN KARABAKH AND NEW STRATEGIES

Sayyara Ibadullayeva
Institute of Botany MSE AR
ibadullayeva.sayyara@mail.ru

In the nearly five years that have passed since the liberation of the Karabakh lands from enemy occupation, unprecedented restoration and construction work has been carried out in the region, ecological terrorism has been inspected with scientifically based monitoring, research has been conducted on the study, restoration, protection and effective use of the biological diversity of the liberated territories, as well as on biosecurity issues. All this necessitates a thorough study of the taxonomic composition of the biodiversity of the Karabakh flora. To identify the species common in the Karabakh flora, a taxonomic spectrum is compiled based on the Fundamental Floras and more than 15.000 specimens belonging to the Karabakh flora stored in Herbarium Fund. It should be noted that this applies not only to vascular plants, but also to lower plants and fungi.

Information booklets have been prepared for a comprehensive study of the ethnobiological basis of the useful plant resources of the Karabakh flora and the conservation of the biological variability of priority-considered species, conducting phytochemical research, including for their use in various areas of industry (medicine, conservation, food additives or perfumery) after studying their effective properties.

Based on the information collected by us from the communities of Karabakh and Eastern Zangazur since 2009, "Forgotten Recipes of Folk Medicine (from the memories of West Azerbaijan, East Zangezur and Karabakh communities)" and "Traditional folk medicine of Azerbaijanis" books have been published and presented to our compatriots who have returned to their ancestral lands. The book contains color photos of plants taken from nature and instructions for their use, including booklets and brochures distributed to the "Great Return" communities in Karabakh. Thus, the fact that the Azerbaijani community of Karabakh has an ancient and deep-rooted cultural and scientific heritage was conveyed to the world scientific community.

A fundamental titanic work (930 pages) "Flora of Karabakh" dedicated to the glorious victory of Karabakh was developed. However, the research does not end there. The following issues were set for study:

- Determination of the taxonomic composition of the Karabakh flora after mine clearance;
- Communication of the ethnobiological use of useful plant resources of the territory's flora to the communities;
- Restoration of protected areas of Karabakh;
- Linking the folk medicine of Karabakh communities with other traditional-household and spiritual cultural spheres;
- Determining the species composition of wild predecessors of plants of the Karabakh flora used for fodder, medicine, food, technical and other purposes, studying their bioecological characteristics and their reproduction;
- Creating a Botanical Garden in Shusha.

All this is our strategy until 2030 and we will do our best to implement it.

ASSESSMENT OF AIR POLLUTION BY HEAVY METALS IN THE AREA OF CITY OF GROZNY, CHECHEN REPUBLIC, USING BIOMONITORING WITH MOSSES

Marina Frontasyeva[1], Zarina Okazova[2]

[1]Frank Laboratory of Neutron Physics, Joint Institute for Nuclear Research, 141980 Dubna, str. Joliot-Curie, Russian Federation

[2]Chechen State Pedagogical University, Grozny, Chechen Republic, Russian Federation

marina@nf.jinrru, okazarina73@mail.ru

The moss biomonitoring method was first applied in the Chechen Republic to assess air pollution in the vicinity of the city of Grozny, one of the largest industrial centers of the Caucasus, where oil production has been taking place since the late 19th century. The difficult environmental situation associated with the war (1994-1996 and 1999-2009) and post-war periods served as a stimulus for the application of the biomonitoring method of atmospheric deposition of heavy metals in this region. Concentrations of 14 macro-, micro- and trace elements (Al, Ba, Cd, Co, Cu, Fe, Mn, Ni, Pb, Sr, V, Zn and S) were determined in moss samples using inductively coupled plasma optical emission spectrometry (ICP-OES). Accumulation factors of individual elements were calculated using background values of their concentrations obtained for a relatively clean northern region of the Russian Federation. The method of multivariate statistical analysis - factor analysis - was used to identify the main sources of pollution located in Grozny and its vicinity. It is shown that the main contribution to Factor 1 is made by Al (0.97), Co (0.84), Cr (0.78), Fe (0.96) and V (0.93), elements attributed to the Earth's crust, which fall on moss together with dust as a result of weathering. Factor 2 includes two toxicants of the first group, lead and cadmium, with a high contribution of Pb (0.80) and Cd (0.96). These two elements, along with tin, are part of the weapons metal, which includes brass, which is a metal alloy based on copper with zinc with additions of other elements, particularly barium (barium carbonate) in the manufacture of electro vacuum products. Copper, zinc and barium give a slight increased contribution to this factor at 0.56-0.65. The greatest contribution to this factor is made by those sampling points where military units were approximately stationed during the military operations in Chechnya. Mn (0.82), Ni (0.74) and Ba (0.73) contribute the most to factor 3. They are also associated with sampling points in the areas of intensive military operations in 1994-2004. The predominant contribution of Mn, Ni and Ba is also related to the role of these elements in weapon metal.

THE IMPACT OF MILITARY OPERATIONS ON FOREST FIRES, WATER POLLUTION, AND LAND RESOURCES: A CASE STUDY OF THE NAGORNO-KARABAKH CONFLICT

Ramil Akhundov[1], Islam Islamov[1,2]
[1]National Defense University, [2]Baku Engineering University
mr.axundov1@gmail.com, isislamov@beu.edu.az

Abstract: Military operations in modern conflicts, particularly in the context of the Nagorno-Karabakh War, have profound and long-lasting environmental consequences. Among the most severe impacts are forest fires, water pollution, and the degradation of land resources, which are often overlooked in the strategic planning of military campaigns. This thesis examines the environmental damage caused by military actions, with a particular focus on the forests, water bodies, and lands affected by the Nagorno-Karabakh conflict, offering insights into the ecological repercussions and potential mitigation strategies.

Introduction

The environmental consequences of military conflicts are increasingly recognized as critical aspects of the long-term sustainability of affected regions. In recent years, armed conflicts have not only led to the loss of human life and infrastructure but have also triggered significant ecological damage, particularly in regions rich in natural resources. One of the most devastating consequences of military actions is the widespread destruction of forests, contamination of water resources, and irreversible degradation of arable land. The Nagorno-Karabakh War (2020) serves as a pertinent case study to examine these issues, offering real-world examples of how military operations have exacerbated environmental destruction in conflict zones.

Forest Fires and Environmental Degradation

Forest fires have become one of the most prominent environmental challenges in conflict zones. In the Nagorno-Karabakh region, military actions, including artillery shelling and airstrikes, triggered numerous forest fires. These fires not only destroyed large swathes of forest land but also contributed to the release of toxic chemicals into the atmosphere. For instance, during the 2020 conflict, extensive forest fires were reported in the areas surrounding the forests of Shushi and Khojavend, resulting in the loss of biodiversity and significant carbon emissions. The environmental impact of such fires is far-reaching, as they alter the ecological balance and lead to soil erosion, which exacerbates flooding risks in the region.

Pollution of Water Resources

Water resources in conflict zones are particularly vulnerable to contamination, and the Nagorno-Karabakh region is no exception. During military operations, water sources often become targets for disruption. Bombing and shelling can destroy infrastructure such as water treatment plants, reservoirs, and irrigation systems, leading to the contamination of drinking water supplies. For example, the Tartar River, which serves as a key water source for both Azerbaijan and

Armenia, experienced significant pollution during the conflict. The destruction of water treatment facilities, coupled with the leakage of hazardous materials from military vehicles and explosives, led to the contamination of water, making it unsafe for human consumption and harming aquatic ecosystems.

Land Degradation and Loss of Agricultural Potential

The degradation of land resources in conflict zones is a common but often underreported issue. In Nagorno-Karabakh, the use of heavy artillery, mines, and explosives has led to the destruction of vast areas of arable land, rendering them unsuitable for future agricultural use. Additionally, the contamination of soil with hazardous materials from military equipment, including oils and chemicals, has further contributed to the degradation of land. As a result, many local communities that depend on agriculture for their livelihood face long-term challenges in restoring their land to productive use. Furthermore, the widespread deployment of landmines in agricultural areas has created hazardous conditions for farmers, rendering large tracts of land inaccessible and unsafe.

Conclusion

The environmental destruction caused by military operations in Nagorno-Karabakh highlights the urgent need for integrated environmental considerations in conflict resolution. While the direct military benefits of these operations are often prioritized, the long-term ecological consequences are less often addressed. Moving forward, it is crucial for international humanitarian organizations, governments, and military forces to recognize the environmental dimensions of warfare and implement strategies to mitigate these impacts.

Some of the strategies include the introduction of post-conflict environmental rehabilitation programs, the use of cleaner technologies in military operations, and the establishment of international agreements to protect natural resources during conflicts. Moreover, efforts should be made to incorporate environmental considerations into military planning and strategy, ensuring that the protection of natural resources is a priority even in times of war.

References

1. Axundov, R.Q. Azərbaycan Ordusunda radiasiya, kimyəvi və bioloji kəşfiyatının əsasları // – Bakı: Hərbi bilik, – 2023. №4, – s. 16-20.
2. Ахундов, Р.Г. Влияние военной деятельности на окружающую среду // – Вестник международной академии наук экологии и безопасности жизнедеятельности (МАНЭБ), – Санкт-Петербург: – 2024. №1(29), – с. 51-58.
3. Axundov, R.Q. Azərbaycan Ordusunda ekoloji təhlükəsizliyin təşkili və təkmilləşdirilməsi // – Bakı: Hərbi bilik, – 2024. №4, – s. 7-15.
4. Axundov, R.Q. Azərbaycan Ordusunda radiasiya, kimyəvə bioloji mühafizənin inkişaf problemləri və onlarin həlli yollari // Ümummilli lider Heydər Əliyevin anadan olmasının 100 illiyinə həsr olunmuş "Hərb sənətinin aktual problemləri" beynəlxalq elmi-praktik konfransın materialları, – Bakı: MMU, – 3-4 may, – 2023, – s.137-138.
5. Akhundov, R. Military conflicts and environmental safety // Current directions of development of information and communication technologies and control tools. Abstracts of the Fourteenth International Scientific and Technical Conference. – Kharkiv, Ukraine, – 25-26 April 2024, Vol 2, – p.89-90.
6. Akhundov, R. Ecocide in the Nagorno-Karabakh Conflict: An Analysis of Armenia's Environmental Impact on Azerbaijan // Current directions of development of information and communication technologies and control tools. Abstracts of the Fourteenth International Scientific and Technical Conference. – Kharkiv, Ukraine, – 25-26 April 2024, Vol 2, – p.95-96.
7. Akhundov, R The environmental consequences of military activity // 20 years Bulgaria in NATO and NATO in Bulgaria. Abstracts of the Scientific Conference with International Participation. – Sofia, Bulgaria, – 2-4 April 2024, – p.558-570.

8. Akhundov R.G., Talibov A.M. Environmental safety as a component of national security // The latest technologies - for the protection of airspace. Abstracts of the 20th international scientific conference of the Kharkiv National University of the Air Force named after Ivan Kozhedub. – Kharkiv, Ukraine, – 02-03 May 2024, – p.25-27.

THE IMPACT OF FOREST FIRES ARISING DURING MILITARY OPERATIONS ON THE STATE OF THE ENVIRONMENT

Narmina Abdullayeva
Institute of Petrochemical Processes MSE AR,
Western Caspian University
ab.narmina@gmail.com

Any war, from the point of view of nature, which is indifferent to human passions and desires, is a violation of the established balance, the destruction of habitats and the death of living things. The global military-industrial complex is responsible for 2% of CO_2 emissions into the atmosphere [1].

During military operations, trees often suffer: they are killed by shell explosions, destroyed during the clearing of territories and the construction of fortifications and crossings. Fires that accompany wars can destroy hundreds of hectares of forest. Forest fires in turn have a negative impact on the Earth's climate. The products of the forest combustion are carbon dioxide and water. Since carbon dioxide is the main cause of the greenhouse effect, fires are one of the natural pollutants of the atmosphere, despite the fact that they also cause no less harm to humans. Forests suffer from fires, and air pollution also damages forests.

The damage caused and the extinction of forests leads to soil erosion, a reduction in the diversity of flora and fauna, and the degradation of river basins. The number of trees that absorb carbon dioxide decreases.

The danger of forest fires lies in the rapid speed of spread, poor controllability, and a large area of damage. From an ecological point of view, forest fires cause the following significant harms:

- Harm to the ecosystem and biodiversity. The habitat and ecosystem of flora and fauna are destroyed. Rare plant species are subject to death; it is almost impossible to restore them. Harm to animals and their living conditions is caused. Rare animal species are forced out of the affected regions and even die, having no chance to escape.
- Forest degradation. Each fire destroys thousands of hectares of trees and vegetation. Quite often, in various forest regions, depending on the zone of military conflict, fires occur, which significantly reduce the quality of some types of forest, including soil fertility and biodiversity.
- Decreased air quality. Trees act as natural air purifiers, releasing oxygen and absorbing carbon dioxide during photosynthesis. Destruction of vegetation has a strong effect on the amount of oxygen in the air. In addition, burning increases the concentration of greenhouse gases in the atmosphere and the amount of smog and smoke.
- Depletion of the soil. Fire also affects the terrestrial environment: it becomes exposed and vulnerable to erosion. The soil loses its fertility and value in terms of natural element compositions and nutrients. Useful soil microorganisms are also destroyed by burning.

References

А.А. Алимов. Экологические последствия современного военного конфликта. Вестник Санкт-Петербургского Университета. // № 2, 2005, с. 135-142

ENVIRONMENTAL DEGRADATION AND ITS CONTRIBUTION TO CLIMATE CHANGE: INSIGHTS FROM THE UKRAINE AND 44-DAY WARS

Bayram Ibrahimov[1,2], Ramil Akhundov[1]
[1]*National Defense University*
[2]*Azerbaijan Technical University*
i.bayram@mail.ru, mr.axundov1@gmail.com

Abstract: Environmental degradation resulting from military conflicts significantly contributes to climate change by accelerating the destruction of ecosystems, releasing pollutants, and increasing greenhouse gas emissions. This thesis examines the impact of military operations on environmental health, with a specific focus on the Ukraine conflict and the 44-Day War between Armenia and Azerbaijan. By analyzing the environmental consequences of these wars, including deforestation, soil degradation, and air and water contamination, this paper highlights how warfare exacerbates the challenges of global climate change. Furthermore, it explores the long-term ecological implications of such degradation and calls for international action to mitigate the environmental impact of military activities.

Introduction

Military conflicts have long been associated with human and economic losses, but their environmental toll is often overlooked. The destruction of natural resources, disruption of ecosystems, and pollution caused by military operations contribute significantly to environmental degradation, which in turn accelerates climate change. In the context of the Ukraine conflict and the 44-Day War, these environmental effects have been particularly pronounced. As both regions have faced intense military operations, they serve as critical case studies to understand how warfare exacerbates environmental degradation and influences climate dynamics.

This thesis aims to explore the relationship between military conflicts and environmental degradation, particularly focusing on the ways these events contribute to climate change. The environmental destruction caused by the wars in Ukraine and the South Caucasus has long-term implications, not only for the immediate regions but also for the global climate. This study provides a comprehensive analysis of the direct and indirect effects of warfare on ecosystems and climate change, emphasizing the need for global awareness and action to address these challenges.

Environmental Degradation in Ukraine and the 44-Day War

In Ukraine, the ongoing war since 2014 and the Russian invasion in 2022 have resulted in widespread environmental damage. The conflict has led to the destruction of forests, pollution of rivers, and severe soil degradation. Military operations, such as artillery bombardments, airstrikes, and the use of heavy machinery, have caused massive deforestation. For example, in the Donetsk and Luhansk regions, large areas of forest have been destroyed or severely damaged, which not only contributes to the loss of biodiversity but also exacerbates the greenhouse effect by decreasing the capacity of these ecosystems to absorb carbon dioxide.

Similarly, the 44-Day War between Armenia and Azerbaijan (2020) caused significant environmental degradation, particularly in the contested Nagorno-Karabakh region. The use of heavy artillery and explosive devices led to widespread deforestation, soil erosion, and the destruction of wildlife habitats. Additionally, both sides targeted infrastructure, such as energy facilities and water reservoirs, which further damaged the environment. In particular, the pollution of the Kura and Aras rivers, which provide water to both Armenia and Azerbaijan, posed serious risks to public health and agricultural sustainability.

Impact on Climate Change

The environmental degradation caused by both conflicts has contributed to the acceleration of climate change in several ways. First, the destruction of forests in both Ukraine and the South

Caucasus significantly reduces the capacity of natural ecosystems to sequester carbon. Forests play a crucial role in mitigating climate change by absorbing large amounts of CO_2 from the atmosphere. The deforestation in conflict zones has released stored carbon into the atmosphere, further enhancing the greenhouse effect.

Second, the pollution of air and water resources from military operations exacerbates the negative effects of climate change. The burning of fossil fuels in military vehicles, as well as the use of explosives and chemical agents, releases harmful pollutants such as carbon monoxide, nitrogen oxides, and particulate matter into the atmosphere. In addition to contributing to global warming, these pollutants harm local ecosystems, affect public health, and reduce agricultural productivity.

Furthermore, the destruction of agricultural land and infrastructure in conflict zones has long-term implications for food security. Soil degradation and contamination from military activities make it difficult for local populations to grow crops, which leads to food shortages and increased pressure on global food systems. The ripple effect of such shortages contributes to rising food prices, further stressing vulnerable populations and increasing the risk of social unrest in the face of climate change.

Long-Term Ecological and Climatic Implications

The long-term environmental impacts of these conflicts are likely to be felt for decades, if not centuries. Ecosystem recovery after such destruction is a slow process, and many of the environmental damages caused by war are irreversible. For example, once a forest is destroyed or a river is contaminated, the regeneration of these ecosystems takes much longer than human lifetimes. The lasting damage to biodiversity further weakens the resilience of ecosystems to climate change, leaving them more vulnerable to future environmental stresses.

Additionally, the acceleration of climate change caused by these conflicts contributes to global warming, which has widespread effects on weather patterns, sea levels, and ecosystems worldwide.

As the effects of climate change become more pronounced, the regions affected by these conflicts will experience increased temperatures, more frequent extreme weather events, and shifts in agricultural zones. These changes will exacerbate existing challenges, such as food and water scarcity, and create new tensions between countries and communities.

Mitigation Strategies

Addressing the environmental impacts of military operations is a critical step in mitigating the long-term consequences of these conflicts on climate change. Several strategies can be implemented to reduce the environmental toll of warfare and promote ecological restoration. These include:

Environmental Protection during Military Operations: International treaties and agreements should emphasize the protection of the environment during armed conflict. The adoption of eco-friendly military technologies, such as electric vehicles and low-emission equipment, can help reduce the environmental footprint of military operations.

Post-Conflict Environmental Rehabilitation: After conflicts, efforts should be made to restore damaged ecosystems, including reforestation, soil rehabilitation, and water purification. International cooperation and support for local restoration projects are essential for rebuilding the environmental health of war-torn regions.

Environmental Monitoring and Accountability: The establishment of environmental monitoring systems in conflict zones can help assess the extent of damage and guide recovery efforts. Furthermore, accountability mechanisms should be put in place to ensure that military operations comply with environmental protection standards.

Climate Change Mitigation and Adaptation: Countries involved in conflicts should prioritize climate change mitigation and adaptation strategies in their post-war recovery plans. This includes transitioning to renewable energy, improving water management, and promoting sustainable agricultural practices.

Conclusion

Military conflicts, particularly the ongoing war in Ukraine and the 44-Day War, have profound and lasting effects on the environment, which in turn contribute to the acceleration of climate change. The destruction of ecosystems, the release of pollutants, and the degradation of land and water resources all exacerbate the challenges of global warming. Addressing these impacts requires coordinated international action, the implementation of protective measures during conflicts, and substantial investment in post-conflict ecological recovery. By recognizing the links between environmental degradation and climate change, the global community can work together to mitigate the harmful effects of warfare on the environment and ensure a more sustainable future.

Reference

1. Axundov, R.Q. Azərbaycan Ordusunda radiasiya, kimyəvi və bioloji kəşfiyatının əsasları // – Bakı: Hərbi bilik, – 2023. №4, – s. 16-20.
2. Ахундов, Р.Г. Влияние военной деятельности на окружающую среду // – Вестник международной академии наук экологии и безопасности жизнедеятельности (МАНЭБ), – Санкт-Петербург: – 2024. №1(29), – с. 51-58.
3. Axundov, R.Q. Azərbaycan Ordusunda ekoloji təhlükəsizliyin təşkili və təkmilləşdirilməsi // – Bakı: Hərbi bilik, – 2024. №4, – s. 7-15.
4. Axundov, R.Q. Azərbaycan Ordusunda radiasiya, kimyəvə bioloji mühafizənin inkişaf problemləri və onlarin həlli yollari // Ümummilli lider Heydər Əliyevin anadan olmasının 100 illiyinə həsr olunmuş "Hərb sənətinin aktual problemləri" beynəlxalq elmi-praktik konfransın materialları, – Bakı: MMU, – 3-4 may, – 2023, – s.137-138.
5. Akhundov, R. Military conflicts and environmental safety // Current directions of development of information and communication technologies and control tools. Abstracts of the Fourteenth International Scientific and Technical Conference. – Kharkiv, Ukraine, – 25-26 April 2024, Vol 2, – p.89-90.

6. Akhundov, R. Ecocide in the Nagorno-Karabakh Conflict: An Analysis of Armenia's Environmental Impact on Azerbaijan // Current directions of development of information and communication technologies and control tools. Abstracts of the Fourteenth International Scientific and Technical Conference. – Kharkiv, Ukraine, – 25-26 April 2024, Vol 2, – p.95-96.
7. Akhundov, R The environmental consequences of military activity // 20 years Bulgaria in NATO and NATO in Bulgaria. Abstracts of the Scientific Conference with International Participation. – Sofia, Bulgaria, – 2-4 April 2024, – p.558-570.
8. Akhundov R.G., Talibov A.M. Environmental safety as a component of national security // The latest technologies - for the protection of airspace. Abstracts of the 20th international scientific conference of the Kharkiv National University of the Air Force named after Ivan Kozhedub. – Kharkiv, Ukraine, – 02-03 May 2024, – p.25-27.

EFFECTS OF FOREST FIRES CAUSED BY MILITARY OPERATIONS ON ATMOSPHERIC CO_2 EMISSIONS

Aygun Bayramova, Zamina Mashadibeyova
National Aerospace Agency, Institute for Space Research of Natural Resources NASA,
aygun.b74@mail.ru

Recent armed conflicts not only affect the death of living beings and the destruction of infrastructure, but also cause serious damage to nature, especially flora and fauna. The impact of military actions on ecosystems leads to forest fires and negatively affects the global carbon cycle. Of particular interest is the impact of burnt-out areas on carbon dioxide (CO_2) emissions and reduced opportunities for natural recovery. Nevertheless, environmental risks must be taken into account when planning post-conflict reconstruction and security [1].

Fires caused by wars not only destroy biodiversity, but also emit huge amounts of CO_2 into the atmosphere. The physical destruction caused by military equipment and explosives is destroying the forest cover. The soils are polluted with chemicals, especially fuel residues and explosives. Erosion is accelerated by reducing the ability of plants to grow and regenerate.

Forest and steppe fires in armed clashes most often occur with the aim of direct missiles and bombs hitting the forest area, sparking equipment or uncontrolled spread of its ignited areas, using deliberate arson tactics (burning the ground, blocking the enemy). Thus, the mass destruction of plants and animals, the decrease in soil fertility and the loss of carbon intensity lead to the fact that it takes many years for ecosystems to fully recover.

Forests and soil act as natural carbon stores. Because of the war:

- When burning forests, large amounts of carbon dioxide are released into the atmosphere;
- The ability of the soil to store carbon and absorb CO_2 is reduced;
- Climate change is accelerating because the natural carbon balance is being disrupted.

Forest fires emit billions of tons of greenhouse gases into the atmosphere. it damages the climate and living organisms. Another reason for the growth of forest fires is the increase in temperature, which occurs against the background of global climate change.

Atmospheric pollution is caused by various means. One of them is natural and anthropogenic factors (gas mixtures released into the atmosphere during forest fires, etc.). A large number of pollutants released into the air react chemically with the components contained in it, and the resulting end products are separated from the air by precipitation (greenhouse effect) and crumble to the ground. Polluted air has a strong negative impact on the lithosphere, hydrosphere, soil and water resources, mainly on public health, and also creates destructive contrasts. These are the most basic functions of the atmosphere [2].

In conclusion, it can be noted that military actions pose a serious threat to ecological systems. Problems such as damage to flora and fauna, increased forest fires and disruption of the carbon cycle affect not only the local, but also the global scale.

In addition, the assessment of environmental complications and their inclusion in post-conflict rehabilitation plans are vital for the safety of future generations.

References

1. Smith, J., and Lopez, M. (2020) – Conflict–Induced Forest Fires and Their Role in Global CO_2 Emissions. Journal of Environmental Studies, 45(3), 221-237.
2. Baku State University (2020) - The impact of war on the environment: ecosystem view, BSU ecological scientific journal, №2, p.38-45.

THE IMPACT OF MINE EXPLOSIONS ON CULTIVATED SOIL SURFACE AND RELIEF

E.A.Gurbanov[1], T.I.Jafarov[1], Z.R.Gurbanova[2]
[1]Azerbaijan University of Architecture and Construction,
[2]Azerbaijan State Oil and Industry University
eldar_qurbanov_54@mail.ru, tariyel.jafarov@azmiu.edu.az,
qurbanova.zumrud17@gmail.com

It is known that all military activities lead to negative processes. In particular, periodic explosions occurring in mined areas contribute to the intensification of exogenous processes on the Earth's surface relief (Aliyev & Gasimov, 2022). Especially in cultivated and irrigated land areas, frequent mine explosions change the relief of the area and mainly the slope of the irrigated area. The change in the slope of irrigated areas causes soil contamination, increasing the potential danger of erosion processes in the area (Makimov & Ibrahimov, 2021). Studies show that in the East Zangezur and Karabakh economic regions, especially in the Jabrayil and Khojavand districts, there are areas with mine explosions. Most of these areas were once used for cultivation and grape plantations.

According to research, in irrigated areas, deepening occurs as a result of water flowing in the created pits. Depending on the slope, linear development occurs in the direction of the pit's slope and also in its upper part. These pits gradually merge, forming the foundation of large ravines. Due to explosions, the parent rock mass emerges from the created depths and mixes with or covers the surface soil. These processes cause damage to the soil in two directions. Firstly, a certain amount of land (0.5-1 hectare) becomes unusable. If this process occurs with every explosion, the loss of fertile soil due to the resulting relief conditions becomes inevitable. It also affects the relief and slope of the surrounding areas (Alizade, 2019). This is clearly proven by Remote Sensing data and GIS software studies. The second direction is the impact on soil fertility and its contamination. During these processes, the specific organic composition of the soil deteriorates, humus loss occurs, and soils become contaminated. To prevent these negative phenomena, mines must be neutralized before they explode. Removed mines should be disposed of in special polygons outside the area.

According to the results of studies carried out with new technologies, the formed ravines double their length in subsequent rainy seasons. The width and depth of these ravines also increase. If natural greening does not occur, its development can increase at any moment. According to calculations, a total of tens of tons of soil are lost per hectare per year. To prevent these losses, a system of various measures must be prepared and implemented. First of all, the grooves formed in the cleared area must be smoothed, and external water flows must be prevented. Perennial forage crops should be planted to increase the soil's resistance to erosion. The resulting dense root system will prevent surface runoff and form water-resistant aggregates. In soils with such a structure, even if the erosion process is not completely prevented, the potential danger is weakened. Thus, negative ecological processes are prevented.

References

1. Aliyev, H.A., & Gasimov, R.S. (2022). Rehabilitation of mined lands and assessment of agroecological conditions in the post-war period (On the example of the Eastern Zangezur and Karabakh economic regions). *Scientific Works of the Institute of Geography, Azerbaijan National Academy of Sciences*, (2), 65–73.
2. Alizade, A. A. (2019). Soil erosion and methods for its elimination. *Proceedings of the Azerbaijan Soil Scientists Society*, (3), 45–52.
3. Makimov, R., & Ibrahimov, R. (2021). Environmental consequences of mine explosions on arable lands in conflict-affected areas: A case study from Nagorno-Karabakh. *Environmental Monitoring and Assessment, 193*(11), 734. https://doi.org/10.1007/s10661-021-09556-3

NEGATIVE IMPACTS OF WAR-INDUCED FOREST FIRES ON CLIMATE CHANGE

S.M.Bashirova, L.V.Ahmadli
National Aerospace Agency
Institute of Space Research of Natural Resources
bashirovasevinc1@gmail.com

Armed conflicts not only cause profound social and humanitarian crises but also lead to severe environmental degradation. Among these impacts, the increased incidence of forest fires during warfare raises particular concern. Such fires, triggered directly by military operations or indirectly by the weakening of environmental governance, result in substantial CO_2 emissions that accelerate global climate change. However, modern international practices and technological innovations offer promising avenues to mitigate these negative effects.

Forests are among the planet's most vital carbon sinks, absorbing atmospheric CO_2 and playing a critical role in maintaining climate stability. During armed conflicts, artillery strikes, bombings, and incendiary weapons often devastate large forest areas, abruptly releasing the carbon stored over years or decades back into the atmosphere as CO_2. This rapid flux significantly increases short-term greenhouse gas concentrations, intensifying global climate change processes.

Nonetheless, it is possible to prevent or at least reduce the scale of these negative impacts. International organizations have launched post-conflict reforestation programs, established new forest belts, and initiated local ecosystem rehabilitation efforts that help to gradually offset war-induced carbon imbalances. Moreover, the integration of satellite monitoring and UAV-based early fire detection systems enhances the capacity to identify and contain wildfires promptly, minimizing their destructive potential.

In addition, provisions within international humanitarian law and conventions on armed conflicts are increasingly reinforcing prohibitions against large-scale environmental destruction. Over the long term, these legal frameworks can limit the ecological consequences of warfare and help curb additional pressures on the climate [1].

In summary, while the contribution of war-induced forest fires to CO_2 emissions and climate change is undeniable, contemporary technologies, international legal instruments, and targeted post-conflict recovery initiatives provide opportunities to mitigate these effects. Future research and projects should focus on strengthening these positive pathways to enhance climate security and restore ecological balance in conflict-affected regions. This dual approach not only supports global climate objectives but also aids the environmental recovery of war-torn landscapes.

References

1. Ganteaume, A., & Jappiot, M. (2017). *What causes large fires in Southern Europe A review.* Forest Ecology and Management, 401, 118–128. https://doi.org/10.1016/j.foreco.2017.06.047

THE IMPACT OF FOREST FIRES ON CO_2 EMISSIONS IN THE POST-WAR PERIOD AND WAYS OF ECOSYSTEM RESTORATION

Nadir Khaligov
National Aviation Academy, AR
nkhaligov@naa.edu.az

Forest fires occurring in the post-war period cause both short-term and long-term impacts on ecosystems. These processes are not limited to the destruction of flora and fauna, but are also accompanied by disruption of the carbon cycle and increased risks of climate change. The amount of CO_2 released into the atmosphere during forest fires increases sharply, and as a result, global warming processes accelerate. In particular, forest areas destroyed and left uncontrolled as a result of military operations are more exposed to the risk of fire. In order to prevent these, first of all, accurate mapping of the risk zone and real-time monitoring of the ecological situation are required. Satellite images, drone technologies and soil biosensors can play an important role in this process.

This presentation assesses the state of forest ecosystems in the South Caucasus, and in particular in the Karabakh region. The analyses conducted show that the number and severity of forest fires have increased in the post-conflict period. This leads to both a decrease in biodiversity and a disruption of the carbon balance. Restoration measures should be implemented through systematic intervention, not just hoping for nature to recover on its own. The proposed approach includes recultivation of forest areas, measurement of CO_2 sequestration capacity, and reforestation. At the same time, environmental education of local communities and behavioral programs for fire prevention should be planned.

Finally, it should be noted that it is difficult to achieve sustainable results in this area without international cooperation and technological integration. Therefore, ecological rehabilitation work carried out in the region should become part of the global climate agenda, and targeted regional policies should be developed to reduce CO_2 emissions. For example, as a result of large-scale fires in the Tartar and Fuzuli regions in 2022, more than 300 hectares of forest were destroyed, and approximately 12 thousand tons of CO_2 were released into the atmosphere (ANAS, 2023). These facts clearly show how forest fires affect climate indicators in the post-conflict period.

The proposed approach is consistent with the UN Sustainable Development Goals (SDG 13 - Combating climate change, SDG 15 - Protecting terrestrial ecosystems) and is consistent with international strategies for ecosystem restoration. It can also play an important role in climate-risk-based regional planning. Future research should also include the long-term impacts of forest fires on biodiversity, as well as changes in soil quality. In addition, the development of AI-based decision support systems for real-time modeling of CO_2 emissions is necessary.

The technologies used in the analysis – satellite observation systems, thermal imaging cameras and biosensors – have shown high efficiency for early detection of forest fires and impact assessment. These technologies allow for more flexible and preventive approaches in the field of ecosystem monitoring. The establishment of regional cooperation platforms for the restoration of forests in post-conflict areas, information exchange and coordination of legal mechanisms are important in terms of ecological security. This can also lay the foundation for the development of ecosystem-based adaptation strategies.

References

1. Szpakowski, D. M., & Jensen, J. L. R. (2019). A review of the applications of remote sensing in fire ecology. *Remote Sensing, 11*(22), 2638. https://doi.org/10.3390/rs11222638

2. Zheng, Y., Zhang, G., Tan, S., & Feng, L. (2023). Research on progress of forest fire monitoring with satellite remote sensing [Review]. *Agricultural & Rural Studies*.
3. Liu, H.-H., Chang, R. Y., Chen, Y.-Y., & Fu, I.-K. (2021). Sensor-based satellite IoT for early wildfire detection [Preprint]. arXiv. https://arxiv.org/abs/2109.10505
4. Afghah, F., Razi, A., Chakareski, J., & Ashdown, J. (2019). Wildfire monitoring using autonomous UAVs in remote areas [Preprint]. arXiv. https://arxiv.org/abs/1905.00492
5. Forest fires push up greenhouse gas emissions from war in Ukraine. (2025, February 24). *The Guardian*. https://www.theguardian.com/...
6. Study details huge emissions resulting from Russia's invasion of Ukraine. (2024, June 13). *Reuters*. https://www.reuters.com/...
7. Forest restoration in a time of fire: perspectives from tall, wet temperate forests. (2021). *Phil. Trans. R. Soc. B*. https://doi.org/
8. Monitoring post-fire vegetation recovery using L-VOD. (2022). *Biogeosciences, 19*, 3317–3330. https://doi.org/

THE IMPACT OF MILITARY OPERATIONS ON CO_2 EXCHANGE IN THE KARABAKH REGION

Akif Habilov[1], Rukhsara Hasanova[2]
Forest Development Service under the Ministry of Ecology and Natural Resources of Azerbaijan [1]
Baku State University [2]
akif.hebilov@mail.ru

The military operations and long-term occupation that occurred in the Karabakh region have caused severe consequences not only in socio-political and geopolitical contexts but also in terms of environmental and ecological degradation. One of the most critical impacts has been the disruption of the region's carbon cycle, particularly the exchange of carbon dioxide (CO_2) within local ecosystems.

During the military operations, intensive wildfires, the deployment of heavy military equipment, the use of explosives, and the deliberate destruction of forested and vegetated areas (including illegal deforestation and removal of shrub cover) led to the release of significant amounts of CO_2 and other greenhouse gases into the atmosphere. These processes not only increased short-term carbon emissions but also severely weakened the region's long-term carbon sequestration potential.

According to available data, approximately 54.328 hectares of forest fund were destroyed—cut down or burned—during the military actions and the period of occupation. Preliminary ecological assessments indicate that an estimated 5,872,328 cubic meters of timber from various tree species were lost. Based on standard environmental calculation methodologies, this level of forest degradation is estimated to have resulted in a total CO_2 loss of approximately 7,320,122 metric tons. This substantial disruption to the carbon sink function has had a significant negative impact on the region's carbon balance and poses a potential contribution to global climate change.

In addition, associated environmental problems such as soil degradation, pollution of water resources, and loss of biodiversity have indirectly affected CO_2 exchange mechanisms. As the soil's capacity to retain carbon diminishes, the overall carbon sink function of the ecosystem is further compromised.

In the post-conflict period, the Government of Azerbaijan has undertaken large-scale restoration and ecological rehabilitation measures aimed at mitigating these adverse effects. The comprehensive environmental programs being implemented in the Karabakh region—including afforestation, reforestation, soil reclamation, and continuous environmental monitoring—play a critical role in achieving the following strategic objectives:

- Restoration and normalization of the carbon cycle,
- Ensuring a stable regional carbon balance,
- Improving public environmental and sanitary health conditions,
- Enhancing the aesthetic and ecological appearance of the region,
- Revitalizing the economic, social, and environmental functions of forests.

The impact of military operations and ecological vandalism during the occupation period on CO_2 exchange in the Karabakh region is both extensive and multidimensional. The weakening of ecosystems' role as a carbon sink not only affects the local environment but also has potential implications for global climate change. Therefore, sustained and scientifically grounded restoration efforts are of paramount importance for the ecological stability and resilience of the region.

COMPARATIVE ANALYSIS OF THE IMPACT OF AERIAL ATTACK SYSTEMS ON ATMOSPHERIC AIR

U.N.Rustamova, E.M.Kadyrova
Baku State University
Ulviya_rn@rambler.ru

Modern military conflicts are characterized by the increased intensity of airstrikes using military aviation, missiles of various types and ranges, as well as drones. The launch, flight, and detonation of air attack weapons are accompanied by the release of large amounts of carbon and nitrogen oxides, hydrogen chloride, heavy metals, soot, and products of incomplete combustion of liquid fuels. These emissions place an additional anthropogenic burden on the environment.

Solid-fuel missiles release hydrogen chloride and aluminum oxides during launch, while liquid-fuel missiles are characterized by emissions of carbon and nitrogen oxides. As a result, the pollutants persist much longer than those released in the lower atmosphere and also have ozone-depleting effects. It is known that chlorine acts as a catalyst in the destruction of ozone. Additionally, soot particles are released into the atmosphere, which trap heat and contribute to climate warming. These soot particles form so-called black carbon, whose presence in the stratosphere can increase the temperature by up to 1.5°C. The launch of a conventional cruise missile results in the emission of approximately 300 to 500 tons of CO_2. In contrast, hypersonic missiles can emit up to 1 ton, while super-heavy rockets such as Starship (SpaceX) can emit 2.500–3.000 tons of CO_2. However, considering the increased frequency of military conflicts around the world, the environmental consequences of armed conflict become evident.

In recent years, the use of drones has become increasingly widespread. The amount of CO_2 emitted varies depending on the drone's range and mass. On average, a drone emits 10–20 kg of carbon dioxide per flight. In the case of mass drone attacks, emissions can reach up to 1 ton of CO_2. The greatest environmental threat from drones arises from their aftermath—fires, especially when targeting oil refineries and logistics hubs. In such cases, CO_2 emissions can reach up to 3 tons. According to scientists' estimates, the destruction of an electrical substation can result in CO_2 emissions of up to 800–1.000 tons during equipment restoration and generator operation. A comparative analysis of the damage caused by different air attack means shows that the highest emissions of carbon dioxide and other pollutants occur during airstrikes (about 3–5 tons/hour). The lowest emissions are associated with drone attacks, but their low cost and mass deployment lead to a cumulative environmental effect. Missile use occupies an intermediate position in terms of environmental pollution. The greatest threat from hypersonic missiles lies not in their CO_2 emissions, but in their release of nitrogen oxides, soot, chlorine, and their destructive impact on the ozone layer.

By early 2025, over 10.000 missiles of various types (ballistic, cruise, etc.) and thousands of drones had been launched over Ukraine. In the summer of this year, conflict escalated in the Middle East as well, involving hundreds of missiles and thousands of drones. All this has inevitably affected the environment. Over three years of warfare in Ukraine, more than 230 million tons of carbon dioxide have been released into the atmosphere. This is comparable to the annual emissions of several small European countries combined, such as the Czech Republic, Slovakia, Austria, and Hungary. This figure includes fuel combustion by military equipment, forest fires resulting from combat, and damage to energy infrastructure. The destruction of forests will have long-term consequences; as natural carbon sinks are lost.

References

1. Осико, С.М. Экологические проблемы ракетно-космической деятельности: влияние ракетного топлива на состояние окружающей среды // Молодой ученый, 2020, №23 (313), с.482-485 - URL: https://moluch.ru/archive/313/71318/.
2. Васянина, А. Ю.,. Швецова, Д. С,. Тонких, А. А и др. Влияние продуктов сгорания жидкого и твердого ракетного топлива на окружающую среду // Актуальные проблемы авиации и космонавтики, Технические науки, 2014, с.211-212

MILITARY IMPACTS ON FLORA, FAUNA, AND SOIL RESOURCES IN KARABAKH: ANALYSIS OF FOREST FIRES USING GIS TECHNOLOGIES

S.Y.Adigozalova[1], A.D.Babayeva[1], A.I.Huseynov[2], A.M.Gasimov[3], M.M.Mehdiyev[4], M.A.Huseynov[5], Y.V.Mammadov[6]

[1]*Institute of Agrarian Problems MSE AR,* [2]*Azerbaijan State Agricultural University,*
[3]*Agrodairy LLC, Head of the Land Management and Cartography Department,* [4]*Ganja State Agricultural College,*
[5]*Head Coordinator, Public Legal Entity for Reconstruction, Construction and Management Service in Jabrayil, Gubadli and Zangilan Districts,* [6]*Tovuz State Socio-Economic College*
sedaqet.adigozalova@mail.ru, baygun@mail.ru, h.efqan@mail.ru, araz_2008@mail.ru, mehmanmehdiyev1979@gmail.com, m.huseynov541@gmail.com, m.yusif@mail.ru

The Karabakh region is one of the areas rich in biological diversity and productive soil resources. However, years of military conflict have severely damaged this ecosystem. Forest fires, the destruction of agricultural lands, and the decline in biodiversity pose significant threats to environmental sustainability. The application of GIS (Geographic Information Systems) technologies is of great importance for detecting and assessing these problems.

Keywords: Karabakh, GIS technology, forest fires, flora and fauna, soil resources, environmental impact, military conflict, ecosystem restoration

Military operations in the Karabakh region have led to the destruction of flora and fauna, with the habitats of rare and endangered plant and animal species being lost. Additionally, soil degradation, erosion, and pollution have been observed. Forest Fires and Their Consequences: During and after the war, forest fires observed in Karabakh caused significant and long-term damage to the region's ecosystem. The fires were caused by various factors, including the use of military equipment and explosives during armed clashes, deliberate ecological sabotage, natural disasters in uncontrolled zones, and human negligence. Satellite images and local observations show that thousands of hectares of forest areas were affected by these fires. The destruction of natural vegetation not only harmed plant life but also endangered hundreds of animal species living in those forests, including rare and protected ones.

As a result of the fires: - Large amounts of carbon dioxide and other greenhouse gases were released into the atmosphere, leading to changes in the region's microclimate; The topsoil was burned, reducing its fertility, weakening its water retention capacity, and increasing erosion risk; Recovery in burned areas is slow and may take many years; The destruction of forests negatively affected the water balance and altered the feeding regime of rivers. The ecological degradation caused by the fires hinders both the use of natural resources and the development of agriculture. Therefore, evaluating the impact of these fires, conducting detailed monitoring through GIS technologies, and planning rehabilitation measures are of utmost importance.

GIS Technologies and Environmental Analysis- Through GIS technologies, the spread of forest fires, changes in land cover, and the degree of biodiversity degradation are analyzed both visually and statistically. Satellite images, drone footage, and geodetic data serve as the main sources in this field. Based on the collected data, rehabilitation plans are prepared for the affected areas. Using GIS tools, the scale, intensity, and impact zones of the fires are accurately identified via satellite imagery and digital maps.

Suggestions and Prospects: Continuous application of GIS-based environmental monitoring systems; Implementation of urgent and systematic rehabilitation measures in fire-affected areas; Establishment of special protected zones to conserve rare and endangered species; Strengthening international cooperation for assessing the environmental consequences of armed conflicts.

Conclusion

The application of modern technologies, particularly GIS systems, plays a crucial role in assessing and restoring the natural resources damaged in the Karabakh region. The analysis of forest fire impacts and the monitoring of the ecological state of soils are key stages for ensuring the region's ecological balance and sustainable development. Recommendations include mapping damaged areas, drafting rehabilitation plans, and implementing regional programs aimed at ecosystem restoration.

IMPACTS OF MILITARY CONFLICTS ON BIODIVERSITY IN KARABAKH

Elshad Mammadov[1], Tunzala Isgandarova[2]
[1,2]Azerbaijan University of Technology, [2]Ganja State University
elshad1952@mail.ru, isgandarova65@mail.ru

Prior to the military conflicts, there were Basitchay State Nature Reserve and Garagol State Nature Reserve in these areas. In addition, Lachin State Nature Prohibition, Gubadli State Nature Prohibition, Arazboyu State Nature Prohibition, and Dashalti State Nature Prohibition, also operated in these areas, all of which played an important role in the protection of biodiversity. Thus, before the military conflicts, a number of valuable species included in the "Red Book" of the Republic of Azerbaijan, including 24 fauna and 69 flora specimens, were protected in a strict reserve regime in all these specially protected areas. The vast majority of them were severely affected or completely destroyed as a result of military operations and ecological vandalism conducted in the region. Up to 2.500 plants grow in these areas, including more than 460 wild trees and shrubs [1]. Before the occupation, the forest fund of Karabakh and the surrounding areas was more than 247352 hectares, of which approximately 13197.5 hectares comprised valuable tree species [2]. Of the more than 460 wild tree and shrub species common in the forests of Azerbaijan, 95 trees (107 species in Azerbaijan), 290 shrubs and 19 subshrub species can be commonly found in the natural forests of Nagorno-Karabakh and adjacent territories located in the center and south of the Lesser Caucasus. During the military conflicts, 261 thousand hectares of forest areas were completely destroyed in our territories. 13 thousand 197 hectares of these are valuable areas. As a result of the military conflicts, 8 valuable forest areas located in our specially protected areas that were occupied were plundered and destroyed. In addition, 152 trees that had been under occupation for nearly 30 years and had the status of natural monuments were brutally destroyed and wiped off the face of the earth as a result of unprecedented and terrible plundering. Of these documented trees, 10 were in the mountainous areas of Karabakh, 4 in Aghdere, 2 in Khojavend, 85 in Aghdam, 14 in Jabrayil, 6 in Zangilan, 10 in Gubadli, 10 in Lachin, and the remaining 11 in the Fuzuli region. As a result of military conflicts, 215 natural monuments, 145 centuries-old, documented, valuable Eastern plane trees with a height of 45 meters, a diameter of 6-8 meters, and an age of 120-2000 years, were ruthlessly cut down and removed. One of the natural monuments that fascinated people with its unparalleled beauty before the military conflicts and had no analogues in the world is the only natural plane forest in Europe with an area of 117 ha located in the Zangilan region in the south of the Lesser Caucasus, in the Basitchay valley. Thus, a large number of centuries-old plane trees have been protected in the Basitchay State Nature Reserve. Those plane trees were also brutally destroyed during military conflicts. In the Kalbajar region, 968 hectares Corylus colurna L., which were included in the “Red Book” of Azerbaijan, were cut down and taken to various countries. Corylus colurna L., which was found very late in other areas of our republic and is 15-20 m high, is a rare, endemic plant species of Azerbaijan. The area is also rich in valuable fauna. Before the occupation, the species that were widespread here (4500-5000 species) constituted up to 20% of the total arthropod population in Azerbaijan. As a result of military operations in the occupied territories, 56 species of insect fauna became rare, endemic and endangered. In conclusion, it should be noted that military conflicts have led to a decrease in biodiversity in the area.

References

1. https://science.gov.az/ru/news/open/15228
2. https://botany.az/az/news/3113

FOREST FIRES, POLLUTION OF WATER AND LAND RESOURCES AS A RESULT OF WARS

Solmaz Rzayeva, Muradhasil Gurbanov, Vusala Mirzayeva, Aynura Salimova, Konul Ahmadova

Institute of Polymer Materials of the Ministry of Science and Education of the Republic of Azerbaijan, Sumgait

ipoma@science.az

In this work the problem of ecological damage caused by wars to forest areas, soil cover and water bodies is considered, as well as it is given information on forest cutting and burning, loss of biodiversity, pollution of water resources, the influence on ecological terrorism and very serious damage to nature and ecosystems. In the text the problems of liquidation of ecological damage in the post-war period, nature recovery, the works to be done for peace and sustainable development in the future, as well as important projects implemented by international organizations are also described.

Historically, the armed conflicts are distinguished not only by human losses and destruction of infrastructure, but also by the serious damage, which they cause to the environment. The forest fires, pollution of water and soil resources and the death of living beings are the main consequences of these influences. The forest fires, pollution of water and soil resources during military operations can occur for various reasons and cause serious consequences from both an ecological and humanitarian point of view.

The use of explosive weapons, artillery fire, rockets, bombs and other explosive weapons during combat operations leads to fires in forest areas. Thermobaric and phosphorous weapons are particularly dangerous, causing extensive fires. Burning of forests leads to the destruction of the humus layer covering the top layer of the soil, which leads to a decrease in its productivity. The effects of forest fires are mainly observed as ecological consequences, destruction of flora and fauna, soil erosion and loss of biodiversity, air pollution and increased carbon emissions. For this reason, the evacuation of civilians and the occurrence of health problems, the contamination of food and water resources, and the burning out of settlements and farms during forest fires create undesirable difficulties.

Since water resources are vital for military and civilian life, the reservoirs are chosen as strategic targets during wars. Water bodies – rivers, lakes, etc., which are one of the most important natural resources for human and living beings, are not only sources of drinking water, but also the basis of agriculture, industry and ecosystem protection. By cutting off the enemy's water supply, it is possible to weaken his fighting ability. During wars, the physical damage to water bodies, the explosion of dams and canals, as well as the dumping of oil and chemicals into the water are widespread methods. This decreases the quantity of water and deteriorates its quality. The chemical and biological pollution of water bodies and destruction of infrastructure lead to ecological disasters. The restoration of reservoirs is a complex and long process requiring a lot of resources and time for water purification and reconstruction of infrastructure. The International law regulates the protection of water bodies during wars to a certain extent. For example, the Geneva Conventions and other international treaties are aimed at protection of the environment, as well as water resources. At the international level, the depletion of water resources, pollution and the collapse of infrastructure lead to the destruction of ecosystems, weakening of the economy and deterioration of human health. Therefore, it is important to create effective mechanisms at the international level for protection of water resources and prevention of their damage, even in war time.

The wars, which bring severe disasters to human society, always lead to countless human losses and social-political changes, and also cause serious and sometimes irreversible damage to natural resources, especially the soil cover. During wars, the soil degradation, loss of fertility, chemical and biological pollution lead to the destruction of vegetation and consequences such as erosion. The shells, rockets and other explosive substances destroy the physical structure of the soil, destroying its natural layers. The movement of machinery compacts the soil and reduces its air permeability. This makes it difficult for water to move through the soil layers, reduces its fertility and makes agriculture impossible. The destruction of infrastructure – roads, irrigation systems and other engineering structures paralyzes economic activity related to the land.

Another problem is a chemical pollution of the soil. As a result of the use of weapons and technologies, various toxic substances, heavy metals and radioactive elements enter the soil. As a result, the chemical substances can completely destroy millions of hectares of forests and agricultural land, causing long-term poisoning of the soil. This pollution makes it impossible to produce nutrients from the soil. This leads to the chain destruction of ecosystem.

The loss of vegetation also leads to the destruction of the soil cover. Deforestation and fires weaken the nature's self-healing mechanisms. The destruction of plants protecting the topsoil from wind and water erosion leads to rapid soil degradation and desertification. This creates not only ecological, but also social and economic problems, and also population migration due to food shortages.

Elimination of these consequences is a long and complex process. After the war, the lands are purified from of mines and chemical substances and become usable again through reclamation. The International organizations – the United Nations Environment Programme (UNEP) and FAO are implementing important projects to restore land cover in war-affected regions.

The deliberate destruction of the environment during the war is in some cases recognized as a war crime by the International Criminal Court.

References

1. Rzayev R.R. “Estimation of damage caused by military actions to forest areas”. Azerbaijan National Academy of Sciences. Journal of Ecology and Natural Resources, (2), 2020. pp. 88-95.
2. Gasimov M.N. “Degradation of land resources as a result of war and problems of reclamation”. Azerbaijan Agrarian Scientific Journal, (3), 2019, pp. 55-62.
3. Gleditsch N.P. Armed conflict and the environment: A critique of the literature. Journal of Peace Research, 35 (3), 1998, p.381-400.

THE IMPACT OF MILITARY OPERATIONS ON FAUNA AND FLORA, THE RESULTING FOREST FIRES, AND THEIR ROLE IN CO_2 EXCHANGE

Elnara Guliyeva, Khayal Asadov
Baku State University
esedov xeyal48@gmail.com, elnara gulieva12@gmail.com

Military operations exert significant and multifaceted impacts on terrestrial ecosystems, particularly forests and biodiversity. These activities cause habitat destruction, species displacement, and ecosystem fragmentation, leading to long-term ecological disruption. A major environmental consequence of military actions is the initiation of forest fires, which release large quantities of carbon dioxide (CO_2) and other greenhouse gases, significantly influencing the global carbon cycle and contributing to climate change. Forests, which serve as vital carbon sinks, lose their sequestration capacity through burning, land degradation, and deforestation caused by combat-related activities. The disruption of fauna and flora, alteration of species composition, and persistent pollution further compound the environmental damage. This paper highlights the complex link between military activity, ecological degradation, and atmospheric CO_2 exchange, emphasizing the urgent need for environmental safeguards during conflicts to mitigate irreversible ecological harm.

Introduction. Military operations have a significant impact on forests and trees. Forests are a major source of wood and a critical component of timber production in many countries. Military activities destroy habitats, cause displacement of species, and affect biodiversity. Ground troops, vehicles, and machinery can damage or destroy large tracts of forest and scrub land, with severe implications for the fauna and flora they support. Military operations also lead to forest fires, which can profoundly affect the CO_2 exchange between terrestrial ecosystems and the atmosphere. Forest fires influence ecosystem structure, biogeochemical cycling, and atmospheric composition. Fire activity is an important factor for ecosystem productivity and influences landscape properties such as albedo. Fires evolve rapidly following ignition and are an efficient releasing process for the carbon stored in terrestrial ecosystems. Forests act as important carbon reservoirs, sequestrating large amounts of CO_2 from the troposphere through photosynthesis. When these forests burn, the amount of carbon released to the atmosphere is redistributed and increases the net carbon emission into the atmosphere every year, especially CO_2 and N_2O. Military activities triggering forest fires thus affect both flora and fauna while amplifying the atmospheric concentration of CO_2 (Cardoso, 2004) (Hantson et al., 2016).

Military Operations and Environmental Disruption. Various armed forces engaged in war or peacekeeping operations perform activities that differ in dimension and structure from civil operations. The destructive effects of military operations on fauna and flora have long been recognized. These disturbances generally result in habitat destruction or degradation and often considerably limit the normal territorial routines of species. Direct destruction of populations and individuals, preventing normal reproduction, is a common effect. History also provides numerous examples of particular military activities causing forest fires and great damage to the air–forest CO_2 exchange. Military operations alter and transform the natural development of an area in several ways. Firstly, they provoke direct destruction of the main environment factors and living species: the species composition may be modified or even changed, and local or distant populations can be exterminated. The network of territories essential for the life cycle of various species can be seriously perturbed. These modifications disturb natural and artificial conditions and may cause the disappearance of species endemic either to the area under influence or to other areas in which the habitants from the impacted enclosure should continue their normal activity. The movement of military vessels or aircraft is capable of creating disturbances over extensive regions, and the disposal of hazardous waste or the unregulated discharge of effluents, whether accidental or deliberate, also affects vast areas (Cranston, 2019). Military operations directed against adversaries are typically sharp, rapid, intense, and capable of delivering significant destruction; properties that suggest the potential for considerable ecological effects on the fauna and flora of the targeted area (Massó i Alemán et al., 2019). Fauna—the collective term for non-human specimens of the animal kingdom—and flora, which represents the entire plant kingdom, are particularly vulnerable under war conditions. Military activities often result in the significant destruction or alteration of habitats, which frequently causes large scale displacement of fauna and considerable damage to, or removal of groups of flora, both of which disrupt the balance of an ecosystem. As ecosystems are connected with one another, the breakdown of one may trigger a chain of destructive effects on others. Moreover, the infringement of habitats precludes the possibility of rapid recovery by the displaced organisms, and the injurious effects of pollution frequently persist long after a conflict has ended. Military operations affect fauna and flora directly in several ways. A common consequence is the destruction of habitats, a crucial factor influencing the composition and diversity of species. In practice, the location of military activities disrupts the existing ecosystem and can also produce hazardous by-products such as chemical waste, increasing the vulnerability of local species. During ground activities, operations need to be performed on the soil, whereas aerial and naval missions take place in the air or water, respectively. Military activities impose direct and indirect effects on wildlife by driving alterations or loss in the natural ecosystems (Massó i Alemán et al., 2019). The characteristics of such activities influence the degree to which local fauna are displaced. Species with restricted ranges or habitat preferences tend to be locally extirpated as they cannot re-establish themselves in alternative locations.

Forest Fires Induced by Military Operations. Military operations frequently generate forest- and bush-fires. During the Vietnam War, extensive use of napalm bombs, tons of thermite bombs, and tens of thousands of crater charges augmented a landscape initially resilient to fire. One extensive 94.000-hectare fire isolated an estimated 56.000 to 112.000 head of large ungulates. Mines planted across areas of unexploded ordnance further restricted fauna and altered land use (Seo & Kim, 2019). Wildfire, defined as any vegetation fire occurring in an unplanned situation, rapidly spreads under conditions of high biomass and intense heat. Such fires periodically affect both forest and vegetated areas on land (Kumar Jhariya & Raj, 2014).

CO_2 Exchange and Climate Implications. Forest ecosystems have the capacity to absorb and store CO_2 from the atmosphere, thereby contributing toward climate regulation and representing a significant carbon sink. Large-scale disturbances, such as those provoked by military conflict, have the potential to disrupt this process substantially. Military operations can trigger atmospheric release of CO_2 through the initiation of forest fires as well as through the removal of forests by logging or land clearing (Lee Gaulin, 2019). Wide-ranging or intense fighting drives up the amount of vegetation lost, which in turn diminishes both the capacity of the landscape to sequester carbon and the biological carbon pool in the affected area. Consequently, military operations influence climatic processes to an extent that warrants further investigation. The specific causal mechanisms can vary according to local social and ecological conditions, particularly in respect of the frequency of conflict, types of activities involved, state of the natural environment, and the extent of ecosystem dependence among the resident human population. In addition to disturbance effects, subsequent recovery rates are a key element determining military impacts because they offset the speed at which the ecosystem can revert to a CO_2-absorbing state. Large-scale disturbances of this kind are therefore bound to affect the long-term distribution of wealth and well-being as well as the time frame associated with general environmental change. (Lee Gaulin, 2019), suggests that armed conflicts can influence the global ecosystem. Military operations distinctly disrupting ecosystems, resulting in habitat disturbance and loss, species displacement, and altered nutrient cycling. Military actions affect both fauna and flora and may trigger large-scale forest fires. Forest fires substantially influence the global carbon exchange and subsequently contribute to global warming. Because forests play a major role in the global carbon cycle, military activities that induce forest fires alter the amount of carbon stored in ecosystems. The resulting carbon emissions can modify regional and global climatic conditions.

Conclusion. Military operations exert a complex influence on terrestrial ecosystems. Activities such as troop maneuvers, convoy movements, and training exercises actively disrupt environmental phases, directly affecting fauna and vegetation by destroying habitats and altering populations, and indirectly instigating other disturbances, including forest fires. The introduction of fire shapes ecosystems and emissions of carbon dioxide (CO_2). War and combat operations inflict multifaceted damage on the environment and biodiversity, including pollution of air, water, and soil, health effects on organisms, and intensified overexploitation of natural resources (Massó i Alemán et al., 2019). CO_2 emission is a key concern from an environmental and climate-change perspective (E. Marler et al., 2012). Forests play a vital role in the global carbon cycle by functioning as a major sink, offsetting anthropogenic emissions and sequestering over four PgC y^{-1} (Cranston, 2019). Forest fires strongly affect CO_2 exchanges and are a major disturbance in many forest ecosystems worldwide.

References

1. Cardoso, M., 2004. Impacts of military operations on forest ecosystems and biodiversity.

2. Cranston, P., 2019. Environmental consequences of warfare and military activities.
3. Hantson, S., et al., 2016 Fire as a global disturbance: Effects on carbon cycle and ecosystems.
4. Kumar Jhariya, M., & Raj, A., 2014. Wildfires and their ecological impacts.
5. Lee Gaulin, J., 2019. Armed conflict and carbon dynamics in forested landscapes.
6. Massó i Alemán, S., et al., 2019. Military activities and ecological degradation: Biodiversity under threat.
7. Marler, E., et al., 2012. CO_2 emissions, ecosystem disturbance, and climate change.
8. Seo, J., & Kim, H., 2019. Forest fires during wartime: Case study of the Vietnam War.

ECOLOGICAL ASSESSMENT OF FOREST COVER IN THE SURROUNDING AREAS OF MILITARY UNITS USING SPACE TECHNOLOGIES

Elchin Isgenderzade[1], Valida Mammadalieva[2], Ilaha Mammadova[3]

National Aerospace Agency, Scientific Research Institute of Aerospace Informatics

isgenderzadeh@rambler.ru[1] , valide.mamedaliyeva@mail.ru[2]

NDVI (Normalized Difference Vegetation Index) - the relative normalization index of vegetation - is a simple quantitative indicator of active photosynthetic biomass (usually called the vegetation index). This is one of the most widely used indices for quantitative assessment of plant cover and problem solving.

It is calculated according to the following formula:

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

Here, NIR is the reflection coefficient in the near-infrared range of the spectrum, µm;

RED – reflection coefficient in the red range of the spectrum, µm.

The NDVI indicator is intended for measuring the ecological and climatic properties of vegetation without artificial measurements, but at the same time it can demonstrate a sufficient correlation with some parameters in a completely different area: productivity (change in time), biomass, humidity and minerality (organically saturated) soil, evaporation (evapotranspiration), precipitation, snow cover and its properties.

The dependence between these parameters and NDVI, as a rule, is not flat and is related to the peculiarities of the studied territory, its climatic and ecological characteristics, in addition, it is often necessary to take into account the reaction of NDVI and various time parameters.

In general, the main advantage of NDVI is the simplicity of obtaining it: no additional data and methods are required to obtain the index, except for space photographs and knowledge of its parameters.

Thus, calculating NDVI in the shortest possible time on the basis of MODIS/Terra data allows you to get operational information about the ecological and climatic situation and track the dynamics of various parameters with a period of up to 1 week. However, its wide coverage allows you to monitor territories corresponding to the size of the whole country and regions. Using the data of high-resolution cameras, such as Landsat, IRS, Aster, it is possible to track the state of objects up to a separate area or forest massif.

A histogram was compiled on the basis of the compiled maps, quantitatively characterizing the changes in different years. With the help of these histograms, quantitative characteristics of forest types were obtained in these years, reflected in Figure 1.

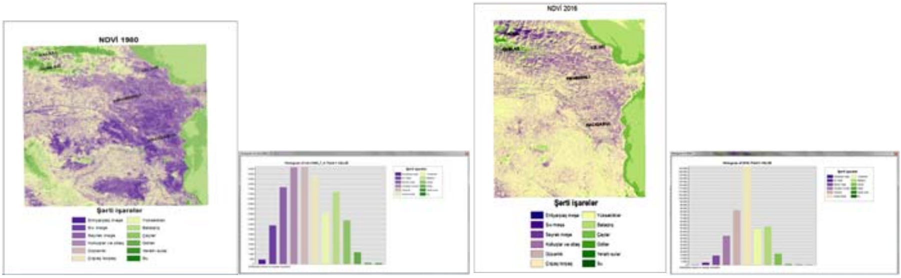


Figure 1 – NDVI map and histogram for 1980 and 2016 based on Landsat-8 data.

References

1. Зонн С.В., Зонн И.С. Экологические последствия военных операций в Чечне //«Энергия» 2002.
2. Гурвич И.Я. «Послевоенные изменения в географии лесов». Известия Всесоюзного географического общества. 1950. № 4.Вронский В.А. Экология.
3. Ю.Ю.Герасимов, С.А.Кильпеляйнен, А.П.Соколов. Геоинформационные системы: Обработка и анализ растровых изображений. Москва, 2002, 118 с.
4. http://npk-kaluga.ru/LandsatUSGS.htm
5. http://gis-lab.info/qa/ndvi.html

STUDY OF FOREST COVER CHANGES IN CONNECTION WITH MILITARY ACTIONS BASED ON SATELLITE IMAGES

Tofik Suleymanov[1], Valida Mammadalieva[2], Vusale Nasirova[3]
Research Institute of Aerospace Informatics of the National Aerospace Agency
valide.mamedaliyeva@mail.ru[2], murad2nasirov@gmail.com[3]

As a result of processing raster images, changes occurring with vegetation in the forest cover in the territories of military operations were studied. The following changes were identified: destruction of soil and vegetation cover, greenery, small shrub vegetation, relief changes, formation of artificial pits and waste heaps, soil displacement, surface and deep impact on the soil, destruction of greenery, vegetation cover, disturbance of soil and vegetation cover, thinning of plants, destruction of tree species, contamination of soil and surface water with fuels and lubricants, runoff, waste, destruction of vegetation and soil cover, loss of biodiversity, increase in soil density, relief deformation, changes in soil and rock properties (in the foothills and mountains), destruction of forests, air pollution, surface and groundwater.

Based on space images, a forecast map-scheme of changes in existing vegetation in forest areas affected by military actions was compiled.

This map-scheme is based on the variability of vegetation in this area as a result of military impacts. As a result, there is the formation of defoliation centers, expansion of bare areas, accumulation of water and salts, surface water sources and local soil pollution, water and wind erosion, changes in the water-air regime of the soil, disruption of natural processes in the soil, soil degradation, changes in vegetation cover and development conditions in the field, surface and upper layers, accumulation of heavy metals, alkalization and depletion of nutrients in the soil, turbidity, salinization, swamping, an increase in landslides, an increase in cliffs, radical changes in various soil properties, soil impregnation with salts, desertification, etc. are shown in Figure 1.

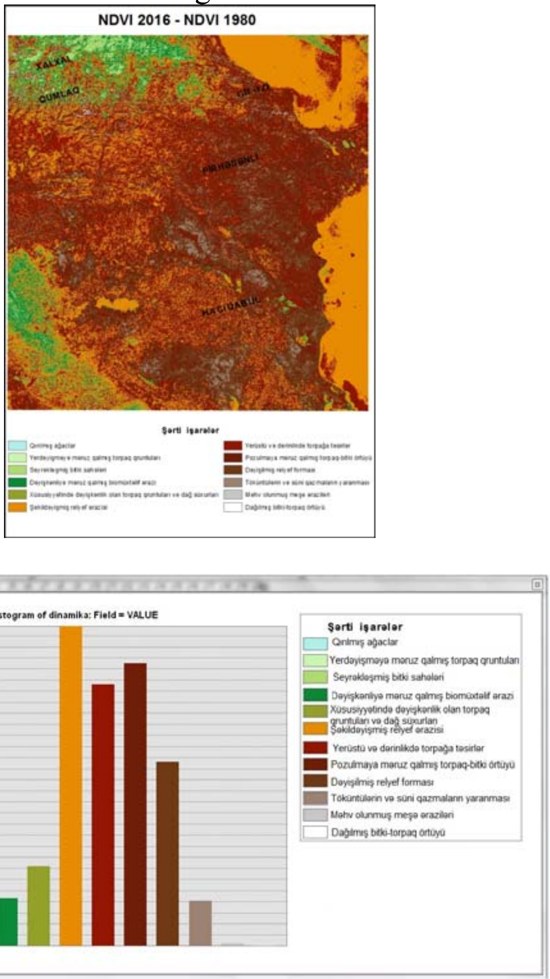


Figure 1. Map and histogram of NDVI dynamics (1980-2016) (36 years) based on Landsat-8 data for the territories of Oguz, Agsu, Khizi, Hajigabul

As a result of using the ArcGIS program with the help of GIS technologies based on space images of different years (1980-2016), the impact of military actions was revealed.

References

1. Jernelov Arne War and the Environment // Project Syndicate, 2003.
2. http://rosecoaudit.ru/2009/01/13/jekologicheskaja_obstanovka_vo_vremja_vojjn_i_voennykh_konfliktov.html.
3. Ю.Ю.Герасимов, С.А.Кильпеляйнен, А.П.Соколов. Геоинформационные системы: Обработка и анализ растровых изображений. Москва, 2002, 118 с.
4. http://npk-kaluga.ru/CalcNDVI_AGIS.htm
5. http://npk-kaluga.ru/LandsatUSGS.htm

FOREST FIRES, POLLUTION OF WATER AND LAND RESOURCES CAUSED BY MILITARY OPERATIONS

Elmir Mammadov, Aprel Babayev
Academy of the Ministry of Emergency Situations of the Republic of Azerbaijan
elmir.memmedov6071@gmail.com

Due to the dynamic development of destructive weapon technologies, modern wars devastate our planet's natural ecosystem to a far greater extent than the wars of the past. The establishment of a sustainable and lasting peace for humanity's secure and ecologically clean future is a necessity now recognized by the international community and nations. Otherwise, the failure to prevent a catastrophic disruption of the ecological balance could bring an end to all life on our planet in the near future.

Keywords: forest fires, military operation, water resources, pollution, land resources

In the modern era, armed conflicts and other military operations have large-scale negative impacts on the environment. These impacts include the destruction of natural ecosystems, the creation of chemical-radioactive contamination zones covering vast areas, air pollution, the rapid loss of biodiversity, deforestation, soil erosion, water contamination, the destruction of wild and domestic animals to gain a military advantage, the acceleration of global climate change, and the degradation of natural landforms. Consequently, this disrupts our planet's long-term ecological stability, which is often irreversible or difficult to restore. Historically, wars have always been accompanied by both human costs, such as casualties and the destruction of infrastructure, as well as the aforementioned damage to the natural ecosystem. However, in the 20th and 21st centuries, particularly destructive military technologies have been developed, which means that as a result of wars has led to the deepening of disasters on an even larger scale.

Impact category	**Impact on flora**	**Impact on fauna**	**Examples**
Habitat destruction	Deforestation, degradation of agricultural lands, destruction of wetlands, alteration of topography, formation of craters.	Loss of habitat, rapid extinction of species, population decline, disruption of food chains.	Agent Orange in Vietnam (3 million acres of forest), the destruction of the Kakhovka dam in Ukraine (600,000 hectares of agricultural land), the destruction of agricultural lands in Gaza.
Chemical pollution	Contamination of soil, water, and vegetation with toxic substances (heavy metals, depleted uranium, dioxins, "forever chemicals") and waste.	Poisoning, reproductive disorders, diseases, death.	Increased birth defects in Fallujah (Iraq) due to toxins, the use of heavy metal munitions in Gaza, pollution caused by the burning of military waste.
Pollution and waste	Contamination of water with sewage and solid waste, air pollution from emissions from military equipment and industrial fires.	Impact on the respiratory system, poisoning, death of aquatic animals (oil spills).	The oil spill in the Persian Gulf (death of 230,000 aquatic animals), air pollution from fires at the Kremenchuk oil refinery.

Loss of biodiversity	Destruction of key plant species, spread of invasive species, degradation of ecosystems.	Accelerated extinction, population decline, disruption of ecological balance, losses in zoos and among domestic animals.	Elephants and gorillas in Africa (poaching), the death of giraffes and elephants in Mozambique (a 90% decline), extinction of species in the Iran-Iraq War.
Climate impact	Reduced carbon sequestration (from forests), greenhouse gas emissions from military operations and fires.	Indirect impact through climate and habitat change.	The war in Ukraine: 120 million tons of greenhouse gas emissions in 12 months; the U.S. military – the largest consumer of oil.
Long-term threats	Contamination of soil and water with unexploded ordnance, soil degradation, desertification.	Death from unexploded ordnance and mines, restricted access to safe areas.	Afghanistan: one of the most mine-contaminated countries; after the war, 40,000 animals in Vietnam have died from mines.

According to various hypotheses, only 200 years of human history have been conflict-free. Despite humanity's rich "conflict experience," in the modern era, there are still no proper and accurate mechanisms for assessing the damage wars inflict on our planet. It is precisely because of this problem that ensuring an effective post-conflict recovery process cannot be fully realized. This, in turn, causes the total damage to our planet to increase. Preventing all of this can be possible through the implementation of just and compassionate policies by world nations to ensure long-term peace and sustainable development worldwide. War has a deep and destructive impact on flora and natural habitats, resulting in irreversible changes to natural landscapes. This impact manifests in various forms, up to the long-term degradation of soil resources. The information below provides some data on the impact of modern wars on our planet's flora, fauna, and climate.

Armed conflicts or military operations result in negative consequences such as the large-scale destruction of forests, contamination of water sources, and degradation of agricultural lands (soil resources). For example, the current conflict in Ukraine has caused "ecocide," with the estimated cost of environmental damage exceeding $57 billion. Forest fires, deforestation, and chemical contamination have affected approximately one-third of Ukraine's territory. The destruction of the Kakhovka dam in June 2022 is considered Europe's largest ecological disaster since Chernobyl, as nearly 90% of the reservoir's water mass flooded thousands of hectares of agricultural and forest lands, causing the region to rapidly turn into a semi-desert. Similarly, in Gaza, almost half of the entire forest cover and agricultural land has been destroyed, with orchards and olive groves being systematically and intentionally targeted. This damage has been described by the UN Environment Programme (UNEP) as "unprecedented" and a "potentially irreversible process." During the Vietnam War, the large-scale use of herbicides like "Agent Orange" led to the defoliation of vast forest areas, destroying over 3 million acres of forest and causing extensive ecological damage, including soil erosion and habitat loss. Military operations also have a significant impact on wetlands. The movement of heavy machinery damages vegetation, soil, and ecosystem components. Wetlands face the threat of destruction as they are used during military training and armed conflicts to improve the mobility of military forces, hinder the movement of enemy vehicles, or provide displaced persons with farmland.

When we think of war, we usually first think of human casualties, destroyed cities, and people leaving their homes. However, the biggest victim of this terrible event is our planet's natural ecosystem. The three main ecological impacts of military operations are forest fires, and the contamination of water and soil resources:

1. **Forest fires.** Military operations create direct and indirect causes for the emergence of forest fires.

- **Artillery and missile strikes:** The high heat and shrapnel from the explosion of shells, missiles, and bombs can instantly ignite dry grass and trees;
- **Use of incendiary weapons:** Prohibited weapons like phosphorus bombs are intended to spread fire over a wider area and make it difficult to extinguish;
- **"Scorched earth" tactics used in combat:** A retreating side deliberately burns forests and fields to hinder the enemy's advance and deny them shelter and resources;
- **Explosion and burning of military equipment:** Destroyed military vehicles (tanks, trucks) can catch fire and ignite the surrounding forested area;
- **Intentional destruction of civilian infrastructure:** Damage to electrical and other communication lines causes short circuits and, consequently, fires.

All these listed causes create negative consequences in three main categories:

- *Destruction of biodiversity:* Forests are home to countless species of plants and animals. Fires destroy the natural habitats (areals) of these creatures, causing many species to perish in masse or be forced to migrate;
- *Soil erosion:* Trees and vegetation protect the soil from erosion with their roots. After a fire, the bare soil is easily washed away by rain and wind, losing its top fertile (humus) layer, and accelerating the process of desertification;
- *Atmospheric pollution:* During large-scale fires, vast amounts of carbon dioxide (CO_2), carbon monoxide (CO), and other toxic gases are released into the atmosphere. This not only locally degrades air quality but also stimulates the acceleration of global climate change.

2. Contamination of Water Resources. In war zones and other areas of combat operations, water bodies (rivers, lakes, groundwater) face a serious threat of contamination for several reasons.

- **Chemical contamination:**
  - ✓ **Fuel and lubricants:** Fuel, oils, and other technical fluids leaking from damaged or destroyed military equipment mix directly with soil and water;
  - ✓ **Remnants of explosives:** Toxic substances like trinitrotoluene (TNT), RDX, and heavy metals (lead, mercury, cadmium) from exploded munitions seep into the water, poisoning it;
  - ✓ **Bombing of industrial facilities:** The destruction of chemical plants, oil depots, and treatment facilities results in tons of toxic waste being discharged into rivers and reservoirs;
- **Domestic and sewage waste:** The breakdown of water treatment plants and sewage systems leads to untreated wastewater flowing directly into water sources. This causes the spread of infectious diseases like cholera and dysentery;
- **Sunken ships and submarines from combat:** Military vessels sunk during naval battles in seas and oceans continue to release fuel, radioactive materials, and other toxic waste into the water for years, poisoning the marine ecosystem.

These listed causes reveal the severity of the damage that military operations inflict on water sources through the following negative outcomes:

- *Drinking water scarcity:* The poisoning of water sources restricts the population's access to clean drinking water and leads to a humanitarian crisis;
- *Destruction of the natural water ecosystem:* Toxic substances lead to the mass death of fish, amphibians, and other aquatic life. The change in the chemical composition of water disrupts the entire food chain;
- *Damage to agriculture:* Lands and crops irrigated with contaminated water become poisoned, which degrades the

quality of agricultural products and poses a threat to human health.

3. Contamination and degradation of soil resources. Soil is the natural resource that suffers the most from armed conflicts. Furthermore, its recovery process can take hundreds of years.

- **Physical damage:**
  - **Craters created by munitions explosions:** The explosions of bombs and shells disrupt the soil structure, destroy the fertile layer, and create deep craters;
  - **Movement of heavy machinery:** The movement of tanks, armored vehicles, and other heavy equipment causes soil compaction. Compacted soil does not allow water and air to penetrate, which hinders plant growth;
  - **Digging of trenches and fortifications:** The digging of trenches over large areas completely destroys the top fertile layer of the soil;
- **Chemical contamination:** As with water contamination, fuel, oils, remnants of explosives, and heavy metals seep into the soil, making it toxic for a long time;
- **Mines and unexploded ordnance (UXO):** Hundreds of thousands of mines and UXO left in combat zones after an armed conflict render the land unusable. Additionally, over time, munitions corrode and leak their toxic chemical components into the soil and groundwater.

These processes lead to the destruction of agricultural lands, disruption of the ecosystem, and the emergence of threats to human health:

- *Destruction of agriculture:* Contaminated and mined lands become dangerous and unsuitable for farming. This deals a serious blow to food security;
- *Ecosystem disruption:* The poisoning of the soil leads to the destruction of vegetation and the death of microorganisms and creatures living in the soil;

- *Threat to human health:* Direct contact with toxic soil, inhalation of dust from it, and consumption of products grown on that land can cause serious health problems (cancer, neurological disorders).

The Republic of Azerbaijan has also been subjected to ecocide by Armenia for a period of about 30 years due to the Karabakh conflict.

- **Forest fires:** During the 30-year occupation and especially after the 2020 war, Armenian armed forces used "scorched earth" tactics while withdrawing from Kalbajar, Lachin, and Aghdam, deliberately burning forests, homes, and farms. As a result, thousands of hectares of valuable forest fund were destroyed;
- **Water contamination:** For years, waste from the mining industry in Armenian territory has been discharged into the transboundary Okhchuchay river without any treatment. This has increased the concentration of heavy metals (copper, molybdenum, iron, zinc) in the river's water many times above the norm and completely destroyed the river's ecosystem;

Soil contamination and mines: The liberated territories are one of the most heavily mined regions in the world. It is estimated that approximately 1.5 million mines have been planted. These mines are not only a threat to human life but are also a major factor rendering the land impossible to use for agriculture and chemically contaminating it.

FIRES ARE A FACTOR IN THE LOSS OF BIODIVERSITY AND FOREST ECOSYSTEM FUNCTIONS

Aynur Heydarova
National Aerospace Agency, MDI AR
heyderova_1974@mail.ru

Forest fires are not only a modern global factor determining the state and functioning of forest ecosystems, having a strong impact on the biogeochemical cycle of carbon, hydrological regime and climate change, but also a historical factor in their formation. Accordingly, when assessing the biodiversity of modern forests and the effectiveness of ecosystem functions, it is necessary to take into account the anthropogenic history, in which fires were the most important factor in the formation of many areas (Whitlock et al., 2010; Aleinikov et al., 2015). Currently, despite fundamentally different technologies in economic activity, the pyrogenic factor remains an acute problem for forest countries, which requires finding solutions to both global climate change and a number of economic issues - the loss of ecosystem services provided by forests, the loss of forests as an important component in the context of the decarburizations of the economy. Based on the data we have, it is argued that fires not only reduce, but also increase the biodiversity of forest ecosystems, and extinguishing large fires is generally not economically feasible (Stephens et al., 2018; Karuk et al., 2021). One of the arguments is that fires occurred before the global impact of humans on nature and are therefore necessary as a factor in the formation of forest ecosystems and even the evolution of biota. However, it should be noted that currently, according to experts, 90 percent of fires that occur due to human error, even in the most remote areas, have significantly increased in frequency, intensity and scale, and this is further aggravated by the impact of climate change.

Our goal is to analyze the consequences of the impact of fires on the main components of forest ecosystems, their biodiversity and functions, and to answer the question of whether fire, as an obvious destructive factor, is sometimes perceived as a factor in increasing biodiversity.

Fire directly or indirectly affects plants, changing their living conditions, completely or partially destroying them. On this basis, short-term and long-term consequences of fires are distinguished. Short-term fires include the heating of forest materials, soil, and the death of aboveground parts of plants or vertebrates and microorganisms. The long-term consequences of fires include pyrogenic transformation of the soil, a decrease in the diversity of soil biota, the drying and destruction of trees, the accumulation of phytomass and the post-fire succession of vegetation.

The most destructive fires for forest plants are crown fires that spread to the tops of trees. Crown fires can be transient and persistent. A persistent fire is a disaster for the entire plant community, as it affects all its components. Forest fires cause sharp changes in microclimatic, hydrological and soil conditions, which in turn lead to the formation of new species, i.e., changes in phytocenoses. Sometimes, due to severe soil burning and the lack of seed sources, vegetation does not immediately recover. In soil fires, lower-tier plants, as well as the dry part and humus horizon, burn partially or completely. Root systems are damaged, fire wounds form on tree trunks. Ground fires can, under certain conditions, turn into crown fires. Fire-damaged and weakened trees are more susceptible to damage by insects and fungi.

Fires, as a powerful factor, trigger positive feedback mechanisms leading to the extinction of species, in connection with which some forest communities have begun to be identified by researchers as pyrogenically dependent. Fires of any intensity affect the functions of the forest ecosystem and all categories of services. In some cases, a short-term increase in the provision of some non-wood products and ecosystem services (berries, mushrooms, medicinal plants, pollination) as a result of an increase in the mosaic of the forest cover is not compensated by the loss of other forest functions and services. It is difficult to assess the scale of economic damage, since the long-term effects of fires on climate, soil formation; water regulation and human health are not taken into account.

In modern forests, it is necessary to constantly maintain and restore the population of endangered animal species, especially large mammals that create zoogenic glades and cracks in the forest cover, and to regulate the density of the forest stand and the mosaic nature of the soil cover.

References

1. *Агапов А. И.* Влияние пирогенного фактора на растения: история и современное состояние проблемы // Горизонты цивилизации. 2019. № 10. С. 24–31.
2. *Макаров В. П., Малых О. Ф., Горбунов И. В., Пак Л. Н., Желибо Т. В., Банщикова Е. А.* Состояние и естественное возобновление сосновых лесов после пожаров в пригородной зоне г. Читы // Успехи современного естествознания. 2016. № 10. С. 79–83.
3. *Gil-Tena A., Brotons L., Saura S.* Mediterranean Forest dynamics and forest bird distribution changes in the late 20th century // Global Change Biology. 2009. Vol. 15. No. 2. P. 474–485.

THE CURRENT STATUS OF RELICT, ENDEMIC, AND RARE PLANT SPECIES IN KARABAKH

S.G.Garayev, N.P.Mehdiyeva, R.T.Abdiyeva, Kh.J.Khalilova, A.Y.Abdullayeva, K.M.Namazzade, L.I.Babayeva
Institute of Botany MSE AR
qarayev.1974@mail.ru

Military conflicts significantly disrupt the integrity of the complex relationships between the long-established natural harmony and the overall ecosystem.

During the 30-year occupation of the Karabakh region, numerous relict, endemic, and rare plant species were eradicated. Forest areas experienced extensive deforestation and burning; pastures were mined; rivers became polluted; and the cultural flora of the majority of rural and urban settlements was entirely destroyed. Consequently, invasive species have replaced many native and economically valuable plants.

The vegetation of the region belongs to the botanical-geographical zones of Azerbaijan's Lesser Caucasus (northern, central, and southern parts) and the Kura lowland. According to recent research, more than 2,000 species of higher plants are found in this area [2].

In the flora of Karabakh, 29 relict tree and shrub species belonging to 16 families and 24 genera have been identified. Among them, 12 species are considered rare.

In forest ecosystems, relict species such as *Taxus baccata* L., *Platanus orientalis* L., and *Punica granatum* L., which are classified as rare plants of Azerbaijan and belong to the subtropical, evergreen Poltava flora, are present. Additionally, 25 species of arctic, deciduous relict trees and shrubs belonging to 12 families and 20 genera of the Turgay flora are found in the region. These include species such as *Pinus kochiana* Klotzsch ex K.Koch, *Castanea sativa* Hill., *Quercus iberica* Stev. ex M.Bieb., *Ficus hyrcana* A.Grossh., *Acer hyrcanum* Fisch. ex C.A.Mey., Betula raddeana Trautv., *Corylus colurna* L., *Tilia begoniifolia* Stev., and Zelkova carpinifolia (Pall.) K.Koch., among the xerothermic relicts formed during the late Tertiary glaciation period, *Quercus boisseri* Reut. (=*Q. araxina* (Trautv.) Grossh.) is considered one of Azerbaijan's rare plant species [3, 4, 5].

Considering the presence of relict, endemic, and rare species in Karabakh, the region can be regarded as a unique ecological area. It is important to note that among Azerbaijan's endemic plant species, several are found exclusively in Karabakh. These include *Carpinus oxycarpa* H.Winkl., *Salvia karabachensis* Pobed., *Alcea sachsachianica* Iljin, *Astragalus zangelanus* Grossh., Psephellus karabaghensis Sosn., *Convallaria transcaucasica* Utk., *Corallorrhiza trifida* Chatel., *Globularia vulgaris* L., *Iris annae* A.Grossh., *Salix pentandroides* L., and *Tulipa karabachensis* A.Grossh., among others the distribution ranges of these species have significantly narrowed, and the number of individuals in their populations has declined [6].

Currently, the expansion of Xanthium strumarium L., X. spinosum L., and Ailanthus altissima (Mill.) Swingle has been observed in areas where fruit orchards and roadside greenery once existed, as well as in the ruins of houses and yards destroyed during the occupation. Species of the genus *Xanthium* L. are annual archaeophytes of North American origin, while Ailanthus altissima is a tree species introduced to Azerbaijan from North-Central Asia in the early 20th century. Unfortunately, the destruction of relict, endemic, rare, and beneficial species through cutting, burning, or drying has created favorable conditions for the invasive activity of such species. This problem can be addressed by restoring the damaged ecosystems with ecologically and functionally significant native species [1].

Following the liberation of the formerly occupied territories, efforts have begun to reconstruct cities and villages, as well as industrial, agricultural, transportation, and energy infrastructure. In parallel with the demining of the area, systematic measures are also being undertaken to restore vegetation cover and establish new forests and orchards. In this context, a key responsibility lies with the country's scientists—to develop scientifically grounded proposals to guide these restoration efforts.

References

1. Abdiyeva R. T. Invasive flora in the ecosystems of the Greater Caucasus (Azerbaijan part). Plant & Fungal Research (2019) 2(1): 15-22 http://dx.doi.org/10.29228/plantfungalres.13
2. Аскеров А.М. Флора Азербайджана / – Баку: ТЭАС Пресс, - 2016, - 444с
3. Гараев С. Г., Сафарова Э.П. Статусы реликтов флоры Азербайджана. Мат. межд. научно-практической конференции, посвященной 125-летию ВНИИЦиСК и 85-летию Ботанического сада «Дерово Дружбы». «Научное обеспечение устойчивого развития плодоводства и декоративного садоводства». 23-27 сентября 2019 года. Сочи. ООО «Просвещение-Юг». Стр.91-99
4. Гараев С. Г., Соколова В. В. Характеристика реликтов третичного периода дендрофлоры Азербайджана по историческим группам // Современная наука: актуальные проблемы теории и практики. Серия: Естественные и Технические Науки. -2023. -№08/2. -С. 22-28 DOI 10.37882/2223-2982.2023.8-2.10
5. Гараев С. Г., Салимов В.С., Гусеинли А.А. Реликты и редкие виды дендрофлоры Восточного Зангезура и Карабахской зоны Азербайджана, их классификация и статус по геологическим периодам. The scientific heritage №133, volume 1, p.10-18, 2024, Budapest, Kossuth Lajos utca 84,1204. DOI: 10.5281/zenodo.10866557 https://www.scientific-heritage.com/wp-content/uploads/2024/03/The-scientific-heritage-No-133-133-2024.pdf.
6. Наиба П. Мехтиева. Биоразнообразие лекарственных растений Азербайджана. Баку: «Савад», 2024, 428 с.

THE IMPACT OF THE FIRST KARABAKH WAR ON THE FLORA OF AZERBAIJAN

Nizami Rzayev
Institute of Radiation Problems MSE AR
rzayevnr@rambler.ru

The flora of Azerbaijan is considered one of the richest countries in the world in terms of the richness of genera and species. There are 4745 plant species in the flora of Azerbaijan, 76% of which are found in the Nakhchivan Autonomous Republic territory, and the first center where many of them originated is precisely this territory (2; 4). Most of these plants have been used in various fields of the folk economy as useful plants. As a result of folk selection over the centuries, many plant varieties suitable for each territory and agroclimatic have been bred.

Many plant varieties have been exported to European countries from Azerbaijan. When the first grain breeding center was established in the USA in 1931, wheat varieties imported from Azerbaijan were widely used in the selection process (8; 9).

The gene pool of agriculturally important plants is the most valuable wealth of every nation. During the Second World War, when Leningrad was under siege, many of the scientists who preserved the genetic fund at the All-Union Institute of Plant Breeding died of hunger, but they preserved the gene pool here. In the genetic fund of Cereal and leguminous plants of the Institute of Genetics and Breeding of the Azerbaijan Academy of Sciences, 22 000 wheat, barley, rye, *Aegilops* varieties, ancient Azerbaijani folk selection varieties and their biotypes separated in different years were collected by academician I.D. Mustafayev and his predecessors, triticologists.(1) In 1986, there have been offered a billion dollars to transfer the genetic fund of cereals, cereal-leguminous, fruit, berry, nut-fruit, medicinal and spice, etc. plants collected at the Karabakh Scientific Research Base to the International Center. However, considering that this fund was in the USSR budget and would not be transferred to Azerbaijan, I.D. Mustafayev refused.

The genetic fund of plants, animals and birds collected at the Karabakh Scientific Research Base was stolen in 1988 and taken to Armenia. This action of the Armenians was a continuation of the series of ecocide policies towards Azerbaijani nature, in order to provide the Basarkecher Scientific Research Base given to them in 1928 with material, to present ancient Azerbaijani folk selection plant varieties as Armenian varieties in the international community. In order to change the name of the one-grain wild wheat (popularly called Ceyran wheat) and the wild two-grain wheat (wild Parinj wheat), which was spread around the village of Asnabirt in Nakhchivan and whose range was first determined by the botanist A.N. Kuleshov in 1922, and to destroy its spreading area in Azerbaijan, they forced the nomadic Kurds to move to that area (1; 2). In 1957, in the book “Fruits of Armenia”, they published the names of the folk selection varieties of Azerbaijani stone fruits, such as, apricot, peach, cherry, and plum in Armenian and Russian, without understanding their names, and noted that the places where they were introduced were mainly the territories of Nakhchivan and Ordubad.

Despite their ecocide attempts in 1986, in addition to collecting these wheat samples again, new spreading areas were also discovered by us in 1990-2003. Some of the spreading areas are now on the contact line of the armies on the border.

After the destruction of the genetic fund stored in Karabakh, a total of 243 samples from the Institute of Genetics and Selection were transferred to the Nakhchivan Scientific Research Base. Our appeal to return the samples from the genetic fund of Azerbaijani plants, which are preserved by the All-Union Institute of Plant Breeding to Azerbaijan, has been unsuccessful. The samples of the genetic fund belonging to Azerbaijan there were also hidden under another name. The local large and small horned animal and bird breeds in the Karabakh Base, the value of which is measured in billions, were seized and taken away by Armenian terrorists.

In 1990-2003, 3642 grain, 152 leguminous, 982 fruit and berry, 443 fodder and technical plants, and more than 500 species of vegetable and melon plants were collected in the genetic fund at the Nakhchivan Scientific Research Base of the Azerbaijan National Academy of Sciences. More than 10.000 herbarium and seed materials of wild plants were collected (7).

In 2003, the Institute Bioresources was established on the basis of the Nakhchivan Scientific Research Base of ANAS. Out of 643 samples planted in the wheat selection nursery in the experimental area, 206 samples were transferred to the Institute of Genetic Resources of ANAS in 2004. These samples were grouped as species-varieties and included in the genetic fund as species-varieties of Nakhchivan origin. Among them, there were 8 durum wheat varieties, 11 soft wheat varieties registered as varieties in Turkey, 22 triticale varieties, 6 wheat varieties submitted for variety testing from the Nakhchivan Scientific Research Base, and promising hybrids obtained as a result of distant hybridization.

We are conducting technological research on the cereals collected in the genetic fund to increase the immunity of military personnel, produce late-stale bakery products, and produce food products with radioprotective properties and polyvitamins.(3;10) We have conducted research on the preparation of drinks (5;6), multivitamin pills, sun and frost protection, treatment of burns and injuries, and cosmetics to help soldiers survive prolonged thirst during combat, using waste-free technology from agriculturally important plants in the genetic fund.

References

1. Mustafayev İ.D. Azərbaycan buğdanın əmələgəlmə vətənidir. Bakı, 1958. 92c.

2. Rzayev N.R. The genus Triticum and Aegilops of the Nakhchivan AR // Scientific & Research Station of Nakhchivan. Ajami, 2002.
3. Rzayev N.R. Buğdanın genetik üzaq hibridlərinin formaəmələgəlmə prosesinə lazer və qamma şüaların təsirinin öyrənilməsi. “Radiasiya və həyat fəaliyyətinin mühafizəsi” konf. Materialları, Bakı, 2008, səh. 58-64.
4. Rzayev N.R. Vavilov buğdasinin təkamülü və genetik müxtəlifliyi. AMEA Botanika İnstitutunun elmi əsərləri, 2012-ci il, cild XXXII.
5. Rzayev N.R., Abdullayev N.M. “Caytikanı” diş məcunu. . İxtira 20160077. 2018. Azərbaycan Dövlət Əqli Mülkiyyətin Qorunması Agentliyinin Sənaye və Əqli mülkiyyətin Sertifikatlaşdırılması İdarəsi.
6. Rzayev N.R., Abdullayev N.M. “Çaytikanı yağı alnmasında meyvələrin tullantısız emalı.”İxtira 2019 0035. Azərbaycan Dövlət Əqli Mülkiyyətin Qorunması Agentliyinin Sənaye və Əqli mülkiyyətin Sertifikatlaşdırılması İdarəsi.
7. Imamaliev G.N., Rzayev N.R. The significance and role Sea buckthorn (Hippophae rhamnoides L.) in the protection of nature. National conference on environmental pollution. Islamic Azad University of Ardabill, 1999, p. 220-221.
8. Вавилов Н.И. Теоретические основы селекции. Москва,Наука,1987, т.1, с.17-74
9. Жуковский Н.П. Культурные растений и их дикие сородичи. Ленинград, 1964.
10. Rzayev N.R., Abdullayev N.M., Kiseleva T.L. , Pavlova L.A, Timochina N.İ. Создание сырьевой базы радиопротекторных и антимутагенных веществ растительного происхождения. The VIII conf. “Radiation Researches and their practical aspects”.2013, Baku 88-91

PURIFICATION OF DIESEL FUEL THROUGH MAGNETIC FIELD-ASSISTED EXTRACTION TO REDUCE ENVIRONMENTAL RISKS IN KARABAKH REGION

Babak Abdulov, Alakbar Hasanov
Azerbaijan State Oil and Industry University
babak001@mail.ru, alakbar48-48@mail.ru

The reconstruction of the Karabakh region has led to a significant increase in diesel fuel consumption, primarily in transportation, construction, and agriculture. The increasing demand for diesel fuel in Azerbaijan, particularly in the Karabakh region, has raised concerns about its environmental impact. Diesel-powered trucks and machinery operating in the area contribute significantly to air and soil pollution, primarily due to the emission of polycyclic aromatic hydrocarbons (PAHs), which are known for their carcinogenic properties (1). These pollutants, formed during incomplete combustion, can accumulate in the environment and enter the food chain, posing serious health risks (2). To address this issue, a study was conducted to improve the quality of diesel fuel by reducing its PAH content using an extraction method enhanced by a magnetic field (3,4). The research focused on purifying diesel fractions obtained from the primary processing of crude oil. N-methylpyrrolidone (NMP) was used as the extractant, and the process was optimized by adjusting parameters such as temperature, mixing speed, and the intensity of the magnetic field. The optimal conditions were found to be a 1:1 ratio of diesel to NMP, a temperature of 25°C, and a mixing speed of 70 rpm. The application of a magnetic field significantly improved the efficiency of the extraction process. At a magnetic field strength of 20 milliTesla, the PAH content in the diesel was reduced from 18.08% to 6%, meeting the Euro-5 standard for diesel fuel. Sulfur content also decreased from 0.0895% to 0.032%, further enhancing the environmental compatibility of the fuel. This improvement is attributed to the magnetic field's ability to alter the structural properties of the mixture, enhancing the interaction between the solvent and the diesel components. The magnetic field creates a more homogeneous and less viscous environment, facilitating better separation of aromatic hydrocarbons. The mechanism involves the formation of a new phase interface that promotes selective diffusion and solubility of target compounds. Additionally, the use of magnetic fields in fuel treatment is energy-efficient and cost-effective, making it a viable alternative to conventional hydroprocessing methods. The study demonstrates that using a magnetic field in combination with NMP extraction is an effective, low-energy method for producing cleaner diesel fuel. This approach not only aligns with environmental regulations but also offers a practical solution for reducing pollution in regions heavily reliant on diesel-powered transportation, such as Karabakh.

References

1. Hi Gyu Moon et al. Assessment of potential ecological risk for polycyclic aromatic hydrocarbons in urban soils with high level of atmospheric particulate matter concentration, Ecotoxicology and Environmental Safety, Volume 272, 1 March 2024, 116014
2. M.A. Mallah et al., Polycyclic aromatic hydrocarbon and its effects on human health: an overeview, Chemosphere, Volume 296, June 2022, 133948
3. B.G.Abdulov, A.A.Hasanov, Study dearomatization of diesel fuel under the influence of magnetic field by IR spectroscopy, International Journal of Modern Physics B, Vol. 35, No. 8, 2150122, 2021
4. B.G.Abdulov, A.A.Hasanov Obtaining of ecologically pure diesel fuel by using N methylpyrrolidone under the influence of magnetic field, AJCN, Vol.2, No. 2, 2020, pp.23 28

IMPACT OF ARMED CONFLICTS ON ECOSYSTEMS: A COMPARATIVE ANALYSIS OF CASE STUDIES (KARABAKH, SYRIA AND UKRAINE)

Konul Aghayeva
Azerbaijan University of Architecture and Construction
Konul.aghayeva@azmiu.edu.az

The article titled "Impact of Armed Conflicts on Ecosystems: A Comparative Analysis of Case Studies (Karabakh, Syria, and Ukraine)" provides an in-depth examination of the often-overlooked environmental consequences of modern warfare. By analyzing three contemporary conflicts—the Second Karabakh War (2020), the Syrian Civil War (2011–present), and the ongoing Russia-Ukraine War (escalated in 2022)—the study presents a comparative overview of how armed conflict disrupts ecosystems, degrades biodiversity, and poses long-term ecological threats.

Each case reveals distinct patterns of environmental damage shaped by geography, scale, and the nature of military operations:

In Karabakh, the conflict led to extensive forest fires, destruction of natural habitats, and landmine contamination, particularly affecting the mountainous forest ecosystems of the South Caucasus. Endangered species lost habitat, and access to large tracts of land became restricted due to unexploded ordnance, limiting both human resettlement and wildlife movement.

In Syria, years of warfare devastated the country's agricultural capacity, led to significant deforestation, and caused widespread soil, water, and air pollution—especially through makeshift oil refining and the burning of oil fields. The collapse of environmental regulation and infrastructure allowed for unregulated waste disposal, compounding the crisis. Several protected natural areas were either abandoned or illegally exploited during the war.

In Ukraine, the environmental impact has been more industrial and transboundary. Bombing and shelling have damaged chemical plants, oil depots, and energy infrastructure, releasing hazardous substances into ecosystems. A major environmental concern is the threat posed by military activities near nuclear power plants, particularly the Zaporizhzhia Nuclear Power Station, raising fears of radiological contamination. Fires in forests and grasslands caused by military action have also impacted Ukraine's biodiversity and carbon sinks.

Across all three cases, the article identifies key common consequences of armed conflicts on ecosystems:

- Destruction of vegetation and forests
- Pollution of water and soil
- Disruption of wildlife and natural habitats
- Loss of biodiversity
- Collapse of environmental governance and monitoring systems

The article emphasizes that environmental damage in war is not only a byproduct of military operations but is often a strategic tool or unintended consequence with long-term effects. Importantly, it critiques the limited role of international legal mechanisms in preventing or punishing environmental crimes committed during wartime. While some international instruments, such as the Rome Statute, address environmental damage as a potential war crime, enforcement remains weak.

In response, the article calls for:

- The integration of environmental protection into post-conflict reconstruction
- Greater use of satellite monitoring and data collection during conflict
- Establishing legal accountability for wartime ecological damage
- Creating international funds and frameworks for environmental restoration in post-conflict zones

Ultimately, the article argues that environmental harm should be treated as a central dimension of armed conflict, not a peripheral issue. Protecting ecosystems is essential not only for the health of the planet but also for long-term peace, food security, and human well-being in post-war societies.

THE DISTANT IMPACT OF REGIONAL WARS ON THE ECOLOGICAL BALANCE OF THE LANKARAN-ASTARA ECONOMIC REGION

Rana Garamollayeva
Baku State University
qarayevarena747@gmail.com

In the modern era, the impact of military conflicts extends far beyond economic disruption, political instability, and the deterioration of social welfare. One of the most overlooked yet critical consequences lies in the long-term, often irreversible, damage inflicted on the natural environment. Particularly during conflicts, the military equipment and weapons used often contain hazardous chemical components that become persistent pollutants, contaminating ecosystems for years or even decades after the cessation of hostilities. Scientific studies have demonstrated that various types of military ordnance contain substances with high toxicity levels, including uranium, phosphorus, and other heavy metals. For example, white phosphorus and depleted uranium (DU) are among the most dangerous compounds used in modern warfare. These substances infiltrate soil, water, and air systems, alter their chemical composition, disrupt microbial activity, and severely hinder ecological restoration processes. The chemical contamination that results from these substances also poses significant public health threats linked to respiratory diseases, cancers, reproductive issues, and genetic mutations. Recent military operations carried out by

Israel in southern Lebanon and the Gaza Strip are notable in this context. Weapons such as the M825A1 White Phosphorus Shell and the M110A2 Howitzer (155 mm WP), which were reportedly used in these operations, have been labeled controversial and, in some cases, illegal by international human rights organizations. The dangers posed by these weapons are not limited to immediate destruction they continue to contaminate the environment for many years. When white phosphorus comes into contact with oxygen, it forms phosphorus pentoxide (P_4O_{10}), which, upon reacting with moisture, converts into phosphoric acid (H_3PO_4). This acidification process degrades soil quality and impairs plants' ability to absorb essential nutrients. Soil and water analyses conducted in southern Lebanon indicate that phosphorus concentrations were found to be 20 to 900 times higher than normal levels. Additionally, alarming quantities of other heavy metals such as mercury, lead, and cadmium were detected. The accumulation of these toxic elements in living organisms can lead to poisoning, organ failure, and weakened immune systems. Human contact with white phosphorus can result in severe burns and long-term toxic effects; in more critical cases, damage to the respiratory system, liver, kidneys, heart, and immune system may occur potentially leading to multi-organ failure and death. Such exposure has also been linked to heritable genetic damage, posing threats not only to individuals but also to future generations. Given the proximity of Azerbaijan to regions experiencing or at risk of military conflict particularly Iran the Lankaran-Astara Economic Region faces a heightened risk of environmental and public health challenges stemming from such confrontations. Prolonged military engagements in neighboring territories may have indirect but profound effects on the ecological integrity and well-being of this region. Lankaran-Astara, characterized by its humid climate and dense population, is particularly vulnerable to airborne pollutants. The region already faces a high incidence of respiratory conditions, including bronchial asthma, chronic pulmonary diseases, and allergic reactions. The introduction of chemical pollutants from military activity would only amplify existing health burdens and negatively impact the quality of life for local communities. It is critical to emphasize that environmental damage caused by war is not confined to the area where the conflict occurs. Due to atmospheric and hydrological circulation, pollutants can transcend borders and impact ecosystems located far from the original source of contamination. Consequently, war-induced environmental degradation should be understood as a regional, and potentially global, crisis. Ecological contamination from conflicts spreads silently and invisibly, threatening the health of future generations and disrupting nature's balance. Therefore, assessments of armed conflict must not be limited to political and economic ramifications alone environmental security must also be considered a fundamental component of strategic evaluations. This issue is not merely local or national in scope; it holds profound implications for the long-term sustainability of the planet and the well-being of all humanity.

References

1. Mammadov, Q.Sh. Ecology, Environment, and Humans. Baku: Elm Publishing House, 2006. (608 pages)
2. Aliyev, A.Q. Radiation Ecology. Baku: Chirag Publishing, 2012.
3. Conflict and Environment Observatory (CEOBS). How Does War Damage the Environment?

IMPACT OF MILITARY CONFLICTS ON THE BIODIVERSITY OF KARABAKH

Mahluga Yusifova[1], Nigar Sultanova[2]
[1]Baku State University, [2]Baku Slavic University
mehluqe_yusifli@mail.ru

Out of more than 460 species of wild trees and shrubs that once grew in the liberated Karabakh region during the 44-day Glorious Patriotic War, 70 are considered endemic. The liberated territories include 6 specially protected natural areas with a total area of 42,997 hectares – 2 nature reserves (Basitchay and Garagol) and 4 wildlife sanctuaries (Arazboyu, Lachin, Gubadli, and Dashalty), where 24 fauna species and 69 flora species listed in the "Red Book of Azerbaijan" are protected [1].

During the occupation, 247,352 hectares of forest land in the Karabakh region, including 13,197.5 hectares of valuable forest areas, were subjected to ruthless and unprecedented plundering by Armenians. Among these were 152 trees recognized as natural monuments (Platanus orientalis, Quercus, Pyrus), 8 especially valuable forest plots, 145 certified oriental plane trees aged between 120 and 2000 years, 6 geological and paleontological sites ("Azykh," "Taghlar," "Khan" caves, etc.), and other natural resources. Seven ecologically important relict lakes (Boyuk Alagol, Kichik Alagol, Zalkhagol, Karagol, etc.) and ten reservoirs suffered significant damage as a result of targeted environmental aggression by Armenians [2].

In the Aghdam district, 6 oriental plane trees aged 150–250 years, 8 trees aged 200–250 years, and 71 trees up to 400 years old—protected as natural monuments—were destroyed. Plane trees on 107 hectares of the Basitchay State Nature Reserve in the Zangilan district were cut down and sold to construction and industrial enterprises [3]. Armenian military units were deployed on 42 hectares of the reserve, and 110 plane trees were uprooted and transplanted to the shores of Lake Goycha and the suburbs of Yerevan. In the Kalbajar district, 968 hectares of walnut trees listed in the "Red Book" were massively cut down and sold abroad. Forests in the protected Topkhana area of Shusha were felled and replaced with buildings, and the Dashalty State Nature Reserve was almost entirely destroyed. In areas called "Garaja Chalan" and "Nargiz Tepe" in the Khojavend district, up to 15,000 hectares of land were burned, leaving no traces of flora and fauna—trees in the area were reduced to ashes [4].

Due to continuous Armenian hunting in the Garagol State Nature Reserve of Lachin district, the number of animals and birds significantly declined, with many species completely wiped out. In the Hajishamli forest within the reserve, red oaks—one of the world's most valuable timber species—were cut down and sold to France, while walnut trees were felled and sold to Iran for furniture production. During the occupation of the Gubadli district, Armenians cut and removed forests, destroyed natural monuments, hunted wild animals and birds in the sanctuary, and valuable fish species in the Bargushad and Hakari rivers disappeared [5].

During military operations, the movement of heavy military equipment through mountainous terrain, widespread scattering of munitions and landmines, dispersion of chemicals during explosions, use of phosphorus bombs, and fires caused serious damage to the soil cover, flora, and fauna of the region. Areas in the Aghdam, Fuzuli, Jabrayil, Tartar, and Khojavend districts located along the line of contact were deliberately set on fire by Armenian occupiers.

When illegally settled Armenian populations left the Kalbajar and Lachin districts, they deliberately cut and burned forests, felled trees, and transported them to Armenia by trucks. In total, as a result of arson deliberately committed by Armenian military forces in Karabakh, 96,000 hectares of pastures, hayfields, green spaces, and forests were burned and destroyed, causing environmental damage amounting to 176 million manats [6].

According to the Rio de Janeiro Declaration on Environment and Development, wars should not have a devastating impact on sustainable development processes, and states must comply with international legal norms protecting the environment during armed conflicts. However, Armenia not only disregards these principles but blatantly violates numerous provisions of more than 300 international conventions aimed at protecting the planet ("Convention on Biological Diversity," "Ramsar," "Bern" and others) [2].

References

1. Yusifova M. & Nuriyeva K. Environmental terror in Azerbaijan's specially protected natural areas liberated from occupation, Proceedings book of III International congress of Applied Sciences, "Year of Shusha- 2022", June 7-10, 2022, Karabagh/Azerbaijan Volume-3, p.186-187
2. https://www.virtualkarabakh.az/az/post-item/26/46/isgal-olunmus-azerbaycan-erazilerinde-ekoloji-veziyyet.html
3. https://mfa.gov.az/az/content/113/environmental-damage
4. https://banco.az/az/news/isgal-olunmus-erazilerin-azad-edilmesi-azerbaycan-iqtisadiyyatina-ne-ved-edir
5. https://sia.az/az/news/social/826181.htmlhttp://supremecourt.gov.az/static/view/168

SECTION 3. EQUIPMENT AND CHEMICAL MEANS USED IN MODERN MILITARY OPERATIONS

CHEMICAL AND BIOLOGICAL APPROACHES TO WHITE PHOSPHORUS REMEDIATION: A COMPARATIVE ANALYSIS

H.R.Azizbayli[1,2], A.R.Azizbayli[1,2]
[1]The Institute of Petrochemical Processes MSE AR
[2]Azerbaijan State Oil and Industry University
afag.azizbayli@asoiu.edu.az, hamida.azizbayli@asoiu.edu.az,
azezizbeylihemide@yahoo.com

White phosphorus (WP) is a highly reactive allotrope of phosphorus that is frequently utilized in military and industrial applications. Its toxicity and tendency to spontaneously ignite pose major challenges for safe handling and disposal. Upon introduction into the environment, WP has the potential to contaminate soil, sediment, and water, thereby causing ecological harm and posing health risks to humans and wildlife [1].

Chemical methods are employed to break down WP into less toxic forms. One common approach involves oxidation, wherein oxidizing agents such as permanganate or hydrogen peroxide convert WP into phosphates. Advanced oxidation processes, which include techniques such as ozone or ultraviolet radiation, have been shown to further accelerate such transformations. Another technique, electrochemical oxidation, involves the application of an electrical current to generate radicals that facilitate the decomposition of WP. Although highly effective and relatively rapid, chemical approaches can produce secondary wastes and require significant energy and specialized equipment.

Bioremediation relies on microorganisms capable of transforming toxic WP into less harmful compounds. Certain bacteria and fungi metabolize WP, converting it into phosphate or incorporating it into microbial biomass. Encouraging these naturally occurring or engineered microbial communities through nutrient addition or environmental controls can promote in situ cleanup. While often more environmentally friendly and potentially cost-effective, biological approaches can be slow, may depend on specific climate and site conditions, and sometimes require ongoing monitoring to maintain optimal environmental parameters. [2].

A comparative analysis was conducted to assess the effectiveness of the two methods. Chemical methods generally offer a more expeditious remediation, but they may also result in the introduction of secondary waste streams. Conversely, biological approaches have the advantage of posing fewer risks to ecosystems over the long term and of being able to integrate naturally with site conditions. However, they tend to be slower and less predictable in harsher environments. A common strategy is to combine both: initial chemical treatment to reduce contamination to safer levels, followed by biological processes to address residual WP and restore ecosystem health.

Conclusion. The selection of the most effective strategy is contingent upon site-specific factors, including contamination level, soil characteristics, climate, and available resources. Thorough site assessment and feasibility studies are essential to ensure effective and safe remediation. Continued research into advanced materials, improved microbial strains, and integrated remediation models will further enhance our capabilities for addressing the challenges posed by white phosphorus contamination.

References

1. Ministry of Public Health. November, 2023. Guideline on White Phosphorus. https://www.moph.gov.lb/en/Pages/0/71629/ministry-of-public-health-health-guidelines-white-phosphorus
2. Crawford, R. L., & Crawford, D. L. (2013). Bioremediation: Principles and Applications. Cambridge University Press.

LAND MINES IN KARABAKH AND ITS ENVIRONMENTAL IMPACT

Kamran Khan
Research Engineer in Pakneftegaz, Islamabad, Pakistan,
Zaporozhye State Technical University, Ukraine
kamrankhan.azerbaijan@gmail.com

The Karabakh region, long entangled in geopolitical conflict between Armenia and Azerbaijan, is among the most heavily landmine contaminated territories in the world. While the human toll of these weapons has been widely acknowledged, the environmental consequences have received comparatively little attention. This abstract explores the long term ecological impact of landmines in the region, emphasizing how these dormant remnants of war disrupt biodiversity, soil quality, land use, and water safety.

Landmines alter ecological balance by creating exclusion zones that limit human activity but paradoxically provide unintended sanctuaries for wildlife. However, this “pseudo-protection” is a double edged sword; while some species thrive in these areas due to the absence of human interference, others face significant risk due to habitat fragmentation and lethal hazards. Moreover, the presence of mines hinders conservation efforts and environmental monitoring.

Soil degradation is another critical concern. The detonation of mines alters the chemical composition and physical structure of soil, reducing fertility and increasing erosion. Explosive residues contaminate the soil with heavy metals and other toxic substances, which can seep into groundwater and nearby water bodies. In agricultural zones, this renders land unusable for years, compounding food insecurity and disrupting local economies.

The table below summarizes some key environmental impacts of landmine contamination in Karabakh:

Environmental Factor	Impact of Landmines
Soil Quality	Contamination, reduced fertility, erosion
Biodiversity	Habitat fragmentation, risk to fauna
Water Resources	Pollution from explosive residues
Land Use	Abandonment of agricultural and forested land

Furthermore, demining activities, though essential, bring their own environmental challenges. Mechanical clearance can damage ecosystems, while chemical neutralization poses contamination risks. Nonetheless, sustainable and ecologically sensitive demining methods are being explored by Mine action agency of the Republic of Azerbaijan.

In conclusion, the environmental repercussions of landmine contamination in Karabakh are profound and long lasting. Effective mine action must integrate environmental considerations alongside humanitarian and political goals. A holistic approach of balancing clearance with ecosystem restoration is essential for the region's ecological recovery and sustainable development.

References

1. GICHD (2022). *Environmental Impact of Landmines: A Study of Affected Regions*. Geneva International Centre for Humanitarian Demining.
2. UNEP (2021). *Post-Conflict Environmental Assessments*. United Nations Environment Programme.
3. ICRC (2020). *Landmines and the Environment*. International Committee of the Red Cross.

REMOTE-CONTROLLED MINE DETONATION SYSTEM

F.A.Nasirov, V.M.Abbasov
Institute of Petrochemical Processes MSE AR
fizuli_nasirov@yahoo.com

There are more than 60 million buried mines in more than 70 countries of the world, which are mostly forgotten traces of wars and conflicts. More than 26,000 people die from them every year, and many more civilians are injured and disabled, and a significant amount of money is spent on their treatment and rehabilitation every year. In addition, mines cause significant socio-economic problems that overshadow peace and security in various regions, cause people to leave their homes and cannot use land for cultivation. Mines remaining underground prevent the normal daily life of more than 22 million people.

Demining in the liberated territory of Karabakh is a very difficult task within the framework of humanitarian operations. Because it is necessary to completely clear every one of these mines and to cultivate the lands for peaceful life. Currently, demining work within the framework of humanitarian operations is carried out by detectors (sappers) or specially trained dogs. Since mine detectors can mainly find metal mines and considering that recently manufactured mines contain very few or no metal parts, mine detectors are not effective in finding them.

In addition to the mine search and mine clearance works used in our time, great importance is attached to the development of new methods. Among these methods, methods that allow mines to be completely cleared in mined areas by detecting and detonating them with various controlled and uncontrolled technical means are given greater importance. However, since these technical means have a very complex structure, they are very expensive, and their preparation requires the creation of special production areas.

The task before us is to create a mine detonation complex with a simple design that reduces the cost of the mine clearance process, increases its effectiveness and safety, and detonates mines in situ in mined areas.

The guided mine-explosion complex we propose consists of an armored or unarmored vehicle with a mine-explosion device attached to it. This complex is designed as a self-propelled mine-explosion device with a hemispherical weighted cylindrical roller at both ends. It is connected to the vehicle by a metal cable passing through a pipe of the appropriate diameter in the roller frame, and the mine-explosion device could be separated from the vehicle at the moment of the mine explosion, and the integrity of the complex is ensured by a metal cable attached to the winch on the vehicle. Having finished clearing mined areas from mines, the guided mine-explosion complex can lift the mine-explosion device (roller) from the ground to a certain height and move freely towards a new mined area.

Unlike known mine detonation complexes used for mine clearance of mined areas, the use of a low-cost, controlled mine detonation system, which has a mine detonator attached to the front of the vehicle through a mechanism, has a simple design, and allows reuse of tanks, armored personnel carriers, and other wheeled or tracked military equipment that have reached the end of their service life, makes it possible to reduce the cost of the mine clearance process, increase its effectiveness and safety.

References

1. Utility model a 2023 0044 (16.03.2023) (Azerbaijan Republic).

ASPECTS OF THE IMPACT OF CHEMICAL WEAPONS ON THE ENVIRONMENT

S.R.Hajiyeva, U.N.Rustamova
Baku State University
Ulviya_rn@rambler.ru

Chemical weapons, as weapons of mass destruction, can spread widely in gaseous, liquid, and solid forms and can easily harm not only enemy forces but also civilian populations. According to the Chemical Weapons Convention (1993), the production, accumulation, and use of chemical weapons and their precursors are globally prohibited. Chemical weapons are used to rapidly destroy vegetation so that enemy forces cannot use it for concealment of personnel, military equipment, or facilities.

During the 44-day Patriotic War, in an attempt to disrupt the offensive operations of the Azerbaijani Armed Forces, separatist forces used white phosphorus shells. This fact was documented by international entities such as the Atlantic Council's DFRLab. When white phosphorus burns in atmospheric air, it generates extremely high temperatures, causing widespread forest fires. In the autumn of 2020, more than 1,800 hectares in the Karabakh region of Azerbaijan were affected by forest fires caused by the use of white phosphorus. Just 0.05 grams of white phosphorus is enough to cause the death of an adult. Exposure to phosphorus smoke causes immediate failure of the gastrointestinal system and suppresses the cardiovascular and respiratory systems. The effects of this chemical agent do not stop there — fragments from phosphorus munitions cause severe burns and skin detachment.

The use of white phosphorus is devastating not only for humans but also for the environment. Under high temperatures (about 800°C), fires break out, and the topsoil is destroyed. Phosphorus particles that fall onto the ground exert toxic effects over a long period, completely disrupting the ecological balance. Since phosphorus does not biodegrade, its presence in the soil leads to long-term chemical pollution. The Karabakh region of Azerbaijan is rich in biodiversity, home to over 6,000 plant species, 153 species of mammals, and 400 species of birds. Due to forest fires and toxic environmental contamination, their survival has come under threat. Experts and international organizations have recognized these incidents as acts of ecocide.

Currently, one of the largest ongoing armed conflicts is taking place in Ukraine and has continued for more than three years. During this period, there have been numerous confirmed instances of chemical agents being used. This information has been confirmed by the U.S. Department of State. International organizations from the United States, the Netherlands, Germany, and the Organisation for the Prohibition of Chemical Weapons (OPCW) have documented the use of choking and riot-control agents such as chloropicrin, CS, and CN gases delivered via drones and grenades — with over 6,000 recorded cases. Restoring ecological balance in such areas may take up to 50 years.

Chemical weapons have also been used in Syria and other conflict zones. The most dangerous environmental threat during chemical attacks comes from nerve agents. It is known that sarin can cause the death of freshwater fish, with high enough concentrations in their tissues after death to pose a threat to humans who consume them. In the event of a chemical attack, nerve agents can pollute bodies of water even in small concentrations. Using water from such contaminated sources can lead to poisoning symptoms. The risk to the environment from mass chemical agent releases due to military actions or terrorist acts remains very real in the future.

References

1. Химическая безопасность. Окружающая среда и здоровье населения: Тез. докл. / Под ред. Н.И. Забродина и др. Ижевск: ИД «Удмуртский университет», 2001,- 157 с.
2. Александров В.Н., Емельянов В.И. Отравляющие вещества. – М.: Военное издательство, 1990. - 268 с.

THE USE OF LASER IN MODERN WARFARE TECHNOLOGY AND ITS ENVIRONMENTAL RISKS

E.L.Yuryeva, A.Y.Mammadova
National Aerospace Agency,
Institute of Space Research of Natural Resources
elina.yuryeva@gmail.com

In the age of rapid technological evolution, laser-based systems have emerged as one of the most significant innovations in modern military applications. Laser technologies, due to their ability to deliver concentrated energy with extreme precision and speed, have become integral components of advanced combat systems. Their uses range from laser-guided munitions and range-finding to high-energy directed laser weapons capable of disabling enemy drones, missiles, and vehicles without conventional explosives [2].

One of the primary advantages of laser technology in warfare is its operational efficiency—providing instantaneous targeting, reduced collateral damage, and enhanced accuracy. These characteristics have made lasers a cornerstone of modern tactical strategies, particularly in asymmetrical and drone-based warfare [1].

However, despite their growing military utility, the environmental consequences of laser deployment are often overlooked. High-intensity laser beams can cause thermal radiation injuries not only to human targets but also to the surrounding ecosystem. The exposure of local flora and fauna to laser-induced heat and radiation may disrupt plant growth, alter animal behavior, or lead to fatal injuries in sensitive species. Moreover, repeated military testing in natural environments has the potential to degrade soil quality, reduce biodiversity, and contribute to long-term ecological imbalances.

From an industrial standpoint, the production, calibration, and maintenance of laser weapon systems involve the use of rare earth elements, hazardous chemicals, and high-energy power sources.

Improper handling or disposal of these materials can result in contamination of water and air, especially near military production facilities and testing grounds [4].

This paper argues that while laser systems have become indispensable for future warfare, their environmental footprint must be critically examined. It proposes a multidisciplinary approach combining military engineering, environmental science, and international law to develop sustainable laser warfare practices. Mitigation strategies, such as regulated testing protocols, environmental impact assessments, and the use of eco-friendly materials in laser construction, are essential for balancing defense effectiveness with ecological responsibility [3].

Ultimately, the study aims to contribute to a broader understanding of how cutting-edge military technologies can be harmonized with environmental preservation in the 21st century.

References

1. Baharov, E. (2021). The Impact of Modern Weapon Technologies on the Environment. Baku: Science and Education Publishing.
2. Mahmudov, R. (2020). Energy-Based Weapons and Environmental Security. Azerbaijan Technical University.
3. NATO Research Group. (2022). Environmental Impact of Directed Energy Weapons. Brussels: NATO Publications.
4. Smith, J. & Palmer, D. (2021). Laser Weapons and the Environment: Risk Analysis in Modern Warfare. Oxford University Press.

THE IMPACT OF MODERN MILITARY TECHNOLOGIES AND CHEMICAL AGENTS ON THE ENVIRONMENT

Zarifa Jamilova
Institute of Radiation Problems MSE AR
zrifcmilova@gmail.com

Military technologies represent advanced tecnical means employed on modern battlefields to achieve strategic superiority.In recent years,parallel to technological advancements, both the variety and the effectiveness of equipment and chemical agents used in military operations have significantly increased. These means, which exert destructive effects not only on human health but also on the environment-including soil, water, air-have become a subject of extensive scientific debate.

As is well known, most military equipment involves the extensive use of chemical substances. These substances are classified according to their harmful effects into groups such as Nerve Agents, Blister Agents, Pulmonary Agents, Blood Agents, Incapacitating Agents, and others. Nerve Agents, including Tabun (Ta), Sarin (GB), Soman (GD), Cyclosarin (GF), and VX Agents are highly toxic organophosphorus compounds that can fatally disturb the nervous system of living organisms. Blister Agents, also known as vesicants, primarily affect mucous membranes and the skin. Substances such as Chlorine, Chloropicrin, and phosgene damage the respiratory tract and can result in suffocation or even death. Blood Agents hinder the ability of cells to utilize oxygen, leading to systematic toxicity in living organisms.

Other chemical agents include herbicides and defoliants. For example, Agent Orange – composed of 2,4-D and 2,4,6-T-used during the Vietnam War, had devastating ecological effects, and caused long-term health issues. Additionally, weapons such as white phosphorous bombs and napalm inflict lasting damage on soil and flora, drastically reducing and productivity. White phosphorous (P_4)

is primarily used militarily to create smoke screens and provide illumination. It was widely used by the U.S. military during the wars in Iraq and Vietnam. Napalm, a mixture of gasoline and thickening agents, is deployed in military operations to destroy shelters through intense combustion. Its modern version, Napalm B, is extremely difficult to extinguish, therefore it spreads to wide areas and seriously damages soil layers and their fertility. Each of these substances also contaminates surface and groundwater resources.

Futhermore, heavy military machinery compacts soil layers,disrupts soil structure ,and impairs both aeration and water circulation. Bombing, shelling, and missile strikes destroy forests, wetlands, and wildlife habitats. Old munitions, abandoned equipment, and nuclear testing residues can leave long-term contamination. The military sector is one of the world's largest greenhouse gas emitters, during warfare, the burning of fuel and explosives releses harful gases into the atmosphere, such as CO_2, NO_x, SO_x. Chemical weapons, depleted uranium, and explosives release toxic substances into air, water, and soil. These effects are not only local but can also be felt at a regional level, ultimately disturbing the balance of ecosystems.

Prior to the deployment of military equipment and chemical agents in armed operations , their potential environmental impacts must be thoroughly assessed. Strengthening international regulatory mechanisms and enhancing technological capacities for effective environmental monitoring are essential. Furthermore, in the post-conflict period, ecological rehabilitation programs should play a central role in mitigating environmental damage and restoring ecological balance.

References

1. Black, R.(2010) Environmental consequences of war. Environmental Science&Technology, 2008-2014
2. Westing, A.H.(1980). Environmental consequences of war.
3. Science Direct

THE IMPACT OF MILITARY EQUIPMENT, EXPLOSIVES, AND CHEMICAL AGENTS USED IN MILITARY OPERATIONS ON SOIL

Turkan Aghazade
Western Caspian University
agazadeturkan741@gmail.com

Just like in ancient times, wars still maintain their relevance today. Like every event, wars also cause serious damage to the environment and nature. Alongside human loss, they lead to air, water, and soil pollution, damage biodiversity, destroy habitats, and cause sick children to be born. In modern warfare, technical explosive chemical substances play a major role. These substances are widely used in munitions, and their main purpose is to achieve maximum destructive power. Soil is highly sensitive to these chemical substances; soil fertility, structural balance, and biological diversity can be severely damaged by these processes.Among the most common chemical compounds in explosives are trinitrotoluene (TNT), hexogen (RDX), octogen (HMX), and ammonium nitrate. Because these compounds have high-energy chemical structures, they do not easily decompose in nature and can remain in the soil layer for a long time, which in turn causes soil pollution, degradation, and a decrease in fertility and productivity. The decomposition of these substances in soil can vary depending on different factors. The decomposition process depends on temperature, humidity, microbial activity, and the mechanical composition of the soil, progressing at different rates. In some cases, TNT and RDX can remain in the soil for decades without decomposing and continue their toxic effects, which is very dangerous for human health.The entry of explosive substances into the soil can change its acidity–alkalinity balance. For example, ammonium-based explosives reduce the soil's pH level and create an acidic environment. As a result of this change, the activity of beneficial microorganisms in the soil weakens, and the process of humus formation stops. On the other hand, some nitrate compounds artificially increase the nitrogen content in the soil, but this nitrogen is not effectively absorbed by plants and mixes with groundwater, creating additional pollution. This pollution, like other types of pollution, causes serious harm to human health.Physically, explosions disrupt the structure of the soil, destroy the fertile top layer, and increase the risk of erosion. As a result, arable soils decrease, and agriculture is affected. Craters and pits created by explosions make soil profile restoration more difficult. Restoring such damage sometimes requires decades.Soil is not only farmland but also a habitat for plants and animals, and not only a collection of mineral and organic substances, but also a rich biological environment. Various microorganisms, fungi, insects, and other living beings live here. The presence of explosive substances in the soil restricts their living conditions. Substances such as TNT and RDX have toxic effects, disrupting microbiological balance and weakening the soil's self-cleaning ability. As a result, the biological productivity of the soil decreases, and its suitability for agriculture declines, which causes serious damage to the country's economy.Soil contamination in areas where military operations take place causes long-term ecological consequences. Firstly, toxic chemical compounds seep into underground water basins and create dangers for human health. Secondly, the decrease in soil fertility makes agricultural activity in these areas difficult, increasing the risk to food security. Thirdly, the reduction of biodiversity disrupts the balance of ecosystems and slows down the natural recovery process.Cleaning the soil from explosive chemical substances is a complex and long-term process. In this field, bioremediation methods, that is, the use of certain microorganisms and plants to clean the soil from harmful substances, are considered promising. At the same time, mechanical restoration of the soil, the application of organic fertilizers, and phytoremediation methods also give certain results. However, since these measures require large financial resources and time, post-conflict ecological recovery processes are often delayed. To protect soil fertility and prevent pollution, peace must be ensured or the impact of war must be minimized, both for nature and for the welfare of future generations.

References

1. Phytoremediation of explosives (TNT, RDX, HMX) by wild-type and transgenic plants. (2012). Journal of Hazardous Materials.
2. Synergetic Toxic Effect of an Explosive Material Mixture in Soil. (2013). Bulletin of Environmental Contamination and Toxicology.
3. TNT and RDX degradation and extraction from contaminated soil using subcritical water. (2014). Environmental Technology.
4. Rylott, E. L., et al. (2011). Engineering plants for the phytoremediation of RDX in the presence of the co-contaminating explosive TNT. New Phytologist.
5. Effects of military training, warfare and civilian ammunition debris on the soil organisms: An ecotoxicological review. (2024). Biology and Fertility of Soils.
6. Əlövsət Quliyev-Praktiki ekoloji qiymətləndirmə və rekultivasiya
7. Əlizadə M. (2017). Torpaqların ekotoksikoloji xüsusiyyətləri və ağır metallarla çirklənmə. Bakı: Nafta-Press.
8. İsmayıl Zeynalov – ekoloji kimya və biotexnologiya sahəsində bioremediasiya üsullarının Azərbaycanda tətbiqi

ENVIRONMENTAL CRISES IN THE 21ST CENTURY: THE IMPACT OF MODERN MILITARY OPERATIONS ON THE ENVIRONMENT

Naiba Shamshiyeva
Azerbaijan National Defence University, Military Institute named after Heydar Aliyev
naibashamshiyeva04@gmail.com

In today's world, the ecological consequences of military operations are becoming an increasingly important issue, not only from a political or strategic perspective but also in terms of environmental impact. Wars and other armed conflicts cause profound and multifaceted damage to the environment, threatening human health, biodiversity, and the sustainability of natural resources. Studying the environmental effects of military operations plays a significant role both in international law and in the national security policies of individual states. It is a reality that military operations cause destructive effects on ecosystems (primarily due to oil fires, the use of chemical weapons, defoliants, and the destruction of transport infrastructure). Ecosystems are damaged in various ways during armed conflicts, and these impacts can be categorized as follows: 1. Pollution of soil and water resources; 2. Destruction of forests (the planet's lungs) and depletion of natural resources; 3. Air pollution and increased carbon emissions; 4. Acoustic and radiological contamination.

Military actions also bring about long-term socio-political and economic consequences, in addition to their global ecological impact. Post-conflict recovery of the environmental elements damaged during warfare requires significant capital, time, and international coordination. Long-term military conflicts of the 20th and 21st centuries - such as the Vietnam War, the Gulf War, the Israel-Palestine conflict, and the war in Ukraine - have accelerated environmental degradation. For example, the use of defoliants during the Vietnam War led to the destruction of millions of hectares of forest. The burning of oil wells during the Gulf War resulted in massive air pollution. In the early stages of the Israel-Palestine conflict, approximately 1.9 million tons of CO_2-equivalent emissions were released, and the subsequent reconstruction phase generated an additional 31 million tons of CO_2 emissions. The war in Ukraine has led not only to humanitarian and political crises but also to a major environmental disaster. The damage is widespread and multifaceted: destruction of forest cover and national parks; contamination of water resources; increased risk of toxic exposure and radiation; air pollution and elevated carbon emissions; damage to industrial and energy infrastructure. Approximately 20% of Ukraine's national parks (around 1 million hectares) have either been destroyed or severely damaged. Fires, explosions, and heavy military machinery have devastated the habitats of rare plant and animal species, reducing biodiversity and disrupting ecological balance. The destruction of the Kakhovka reservoir resulted in 90,000 tons of contaminated sediment, including arsenic, zinc, and nickel, being released into the Dnipro River and the Black Sea. This has caused pollution of drinking water sources, poisoned aquatic life, and posed serious health risks for coastal populations. Groundwater contamination with chemicals requires long-term decontamination efforts. Explosions, the destruction of weapons depots, and attacks on industrial sites have released toxic substances into the air and soil. The potential use of depleted uranium and other heavy metals may lead to carcinogenic effects in the future. Military machinery, explosions, and industrial fires have released massive amounts of CO_2 and other harmful gases into the atmosphere, contributing further to global climate change. Attacks on oil and chemical plants and power stations have caused fuel leaks, fires, and chemical discharges, poisoning both air and soil. These effects go beyond immediate physical destruction and result in long-term ecological, health, and social consequences. In the modern era, recognizing the environmental dimensions of warfare, strengthening international law, and implementing effective recovery programs are critical necessities.

References

1. Koivurova, T., & Pekkanen, J. (2021). *The Environmental Impacts of the War in Ukraine: Legal Perspectives and the Way Forward*. *Finnish Institute of International Affairs*.
2. Mikheieva, O., & Boychenko, M. (2023). *Environmental Consequences of the Russia-Ukraine War: Challenges for Post-War Recovery*. *Journal of Environmental Policy & Planning*, 25(1), 12–29
3. Levy, B. S., & Sidel, V. W. (2016). *War and Public Health* (2nd ed.). Oxford University Press
4. International Committee of the Red Cross (ICRC). (2020). *Guidelines on the Protection of the Natural Environment in Armed Conflict*. Geneva: ICRC.

PSYCHOLOGICAL PREPARATION OF RESCUE PERSONNEL: ENHANCING STABILITY AND PERFORMANCE

Tukazban Hasanova, Jamila Imamaliyeva
Azerbaijan University of Architecture and Construction
ncamila@rambler.ru, tukazban.hasanova@azmiu.edu.az

This study investigates the psychological preparation of rescue personnel in emergency situations, focusing on developing mental stability and professional skills to improve performance during high-stress operations. Using modeled emergency scenarios, we analyze the impact of psychological training on rescuers' efficiency and resilience. Our findings indicate that systematic psychological preparation reduces stress-induced behavioral reflexes and enhances operational effectiveness in real emergency environments. Emergency rescue personnel face significant psychological challenges when operating in extreme and unpredictable conditions. This study examines the impact of a structured psychological preparation program on the mental stability and operational efficiency of rescuers in Azerbaijan. Using simulated emergency scenarios based on QX and DTI modeling, and incorporating verbal influence techniques and group cohesion exercises, we measured the effect of training on stress tolerance, task performance, and psychological resilience. Results indicate a statistically significant reduction in passive-defense reflexes and an improvement in volitional control and motivation, leading to enhanced response effectiveness during real emergencies such as the 2015 fire incident in Baku. These findings support the integration of advanced psychological training methods in emergency preparedness programs to improve rescue outcomes and reduce psychotrauma.

Keywords: Psychological preparation, rescue personnel, stress tolerance, mental stability, emergency response

1. Introduction

Background on emergency response challenges. Importance of psychological readiness in rescue operations. Overview of existing training limitations and the need for improved psychological training.

Objective of the study: To explore methods and outcomes of psychological preparation for rescuers, highlighting novelty in training techniques and psychological modeling. Emergency response teams often operate under extreme stress, facing unpredictable environments such as natural disasters, fires, and industrial accidents. The psychological impact of such conditions can cause anxiety, fear, and cognitive overload, impairing decision-making and performance [1,2]. For example, the multi-storey residential fire on May 19, 2015, in Binagadi District, Baku, not only alarmed residents but triggered widespread psychological shock within the community and rescue teams alike [1]. Such events underline the critical importance of psychological readiness for rescue personnel.

Psychological unpreparedness in emergency responders leads to negative outcomes, including impaired task execution and increased risk of injury or loss [2]. Prior research highlights the need for targeted psychological training to foster mental stability and readiness [3,4]. However, many existing programs focus primarily on physical and technical skills, often neglecting the cognitive and emotional components critical in high-stress scenarios.

This study explores the design and evaluation of a comprehensive psychological preparation system implemented within the Ministry of Emergency Situations (MES) of Azerbaijan. The training aims to develop mental models of emergency actions, enhance stress tolerance, and promote volitional control. By combining simulated environments, verbal and group psychological techniques, and continuous mental conditioning, this program seeks to reduce the effects of psychotrauma and improve operational efficiency during real emergencies.

2. Methods

Description of the psychological training program (simulation exercises, mental image modeling, stress inoculation).

Participant selection: rescue personnel from the Ministry of Emergency Situations of Azerbaijan. Tools and techniques used (QX and DTI simulations, verbal influence, group cohesion exercises). Data collection methods: behavioral assessments, stress measurement, performance metrics during drills and real events.

2.1. Participants

The study involved rescue personnel from the MES of Azerbaijan, including military servicemen and civilian rescuers with varying levels of experience. Participants underwent a 6-month psychological preparation program integrated into their daily service and combat training schedules.

2.2. Psychological Preparation Program

The training protocol consisted of: Simulated Emergency Scenarios:Using QX and DTI modeling, realistic fire and disaster scenarios were created to expose rescuers to novel, high-stress conditions, simulating sensory and operational challenges encountered in the field. Mental Image Modeling: Rescuers were trained to form and rehearse detailed mental action images corresponding to emergency tasks to reduce unpredictability and passive-defense reflexes. Verbal Influence and Group Cohesion Exercises: Commanders and psychological specialists employed verbal persuasion and motivational techniques to strengthen belief in task importance, build collective trust, and instill a sense of duty and courage. Volitional and Emotional Regulation Training: Activities designed to improve willpower, emotional control, and cognitive flexibility, including stress inoculation and voluntary endurance exercises.

2.3. Data Collection

Data was collected at three intervals: pre-training (baseline), mid-training (3 months), and post-training (6 months). The following metrics were used: Stress Tolerance: Measured by physiological indicators (heart rate variability, cortisol levels) during simulated drills. Task Performance: Efficiency and accuracy during emergency operation drills. Psychological Stability: Assessed via standardized questionnaires evaluating motivation, cognitive understanding, emotional control, and volitional effort. Incidence of Passive-Defense Reflexes: Observed behavioral hesitations or freeze responses during novel scenarios.

2.4. Data Analysis

Repeated measures ANOVA tested changes over time across metrics. Qualitative feedback from participants and commanders supplemented quantitative data.

3. Results

Quantitative results showing improvements in stress tolerance and task performance. Examples of reduced passive-defense reflexes and increased volitional control. Psychological stability metrics before and after training.

Enhanced group cohesion and motivational indicators.

Case study: fire incident on May 19, 2015, and how training influenced response efficiency.

3.1. Stress Tolerance

Physiological measures showed a significant improvement in stress regulation. Heart rate variability (HRV) increased on average by 22% ($p<0.01$), and salivary cortisol levels decreased by 18% ($p<0.05$) from baseline to post-training, indicating enhanced autonomic control and reduced stress response.

3.2. Task Performance

Task completion times in complex fire drills improved by 15% ($p<0.01$), with accuracy rates (correct procedures followed) increasing from 78% to 92% ($p<0.001$). Notably, performance under night-time and adverse weather simulations showed the most marked gains. Psychological Stability Index (PSI)

Define a hypothetical quantitative index to measure psychological readiness combining emotional, cognitive, and volitional components.

$$PSI = \alpha E + \beta C + \gamma V$$

Where: E- Emotional stability score (scale 0-1); C- Cognitive preparedness score (scale 0-1); V- Volitional control score (scale 0-1); α, β, γ = Weight coefficients (sum to 1), $\alpha=0.3$, $\beta=0.4$, $\gamma=0.3$

3.3. Psychological Stability and Behavioral Responses

Questionnaire results revealed significant growth in motivational (mean score increase from 3.2 to 4.5 on a 5-point scale), cognitive understanding (3.5 to 4.7), and volitional components (3.0 to 4.6). The frequency of observed passive-defense reflexes (hesitation, freezing) during novel scenario drills decreased by 60%, correlating with improved mental imagery and preparedness.

3.4. Case Study: May 19, 2015 Fire Incident

Retrospective analysis of MES rescue team performance during the Binagadi fire incident revealed that personnel trained under the program exhibited faster decision-making, higher adherence to operational protocols, and lower self-reported anxiety compared to pre-program cohorts. These factors contributed to more effective evacuation efforts and reduced casualties.

4. Discussion

Interpretation of results: how psychological preparation reduces unpredictability and improves response adaptability. The role of willpower, motivation, and cognitive components in operational success. Implications for emergency response training programs globally.

Limitations and recommendations for future research.

The data demonstrates that systematic psychological preparation substantially enhances the resilience and operational efficiency of rescue personnel in extreme conditions. By fostering detailed mental action models and emotional regulation, the program reduces unpredictable reflexes that typically undermine performance. The motivational and cognitive improvements support the premise that psychological readiness involves not only emotional stability but also a clear understanding and acceptance of task goals.

The integration of verbal influence and group cohesion techniques further amplified effectiveness, as trust in leadership and collective unity are essential for coordinated emergency response.

This study fills gaps in emergency training literature by quantitatively linking psychological preparation with measurable performance improvements. However, limitations include reliance on simulated conditions and short follow-up duration. Future research should evaluate long-term psychological outcomes and expand to diverse rescue contexts.

5. Conclusion

Summary of key findings and practical significance.

Call for integration of psychological training in emergency preparedness protocols.

Our findings advocate for the adoption of comprehensive psychological training within emergency response frameworks. Enhanced mental stability, motivation, and volitional capacity improve both individual and team performance during critical operations, ultimately reducing psychotrauma and operational risks. The program applied within the MES of Azerbaijan offers a scalable model for global emergency preparedness initiatives.

The article introduces a novel, integrated psychological preparation program for rescue personnel that combines advanced mental imagery techniques, physiological stress regulation, verbal influence strategies, and group cohesion exercises specifically tailored for extreme emergency scenarios.

Key innovative aspects include:

1. Use of QX and DTI Modeling for Scenario Simulation: Unlike conventional training that relies mainly on physical drills, this program leverages detailed quantitative modeling (QX and DTI) to simulate complex and unpredictable emergency environments. This allows for more precise mental rehearsal and stress exposure, enhancing cognitive adaptation to novel conditions.

2. Multidimensional Psychological Training: The program uniquely integrates mental image modeling, volitional/emotional

regulation, and verbal motivational influence—addressing not just technical skills but deeply rooted psychological mechanisms that govern behavior under stress.

3. Empirical Validation Through Physiological and Behavioral Metrics: The study provides quantitative evidence (e.g., heart rate variability, cortisol levels, performance accuracy) linking psychological preparation directly to improved stress tolerance and operational efficiency, an area with limited prior empirical support.

4. Application and Validation in Real-World Rescue Context: The program's effectiveness is demonstrated retrospectively in an actual emergency event (May 19, 2015 fire in Baku), showcasing practical utility beyond laboratory or theoretical frameworks.

5. Reduction of Passive-Defense Reflexes via Mental Training: Highlighting the specific decrease of freezing and hesitation responses through psychological preparation addresses a common yet underexplored obstacle in emergency response performance.

In summary, the innovation lies in creating a comprehensive, scientifically validated psychological preparation system that improves both mental stability and task performance in emergency rescuers through cutting-edge simulation and integrated psychological techniques, with demonstrated real-world effectiveness.

References

1. http://aile.lent.az/read/11487
2. Ojagov, H.O. (2010). Life Safety in Emergency Situations. Baku: Chashioglu. 398 p.
3. Gozelov, S.S., & Manafov, F.A. (2011). Factors affecting the activity in emergency situations of various nature. News Scientific-methodological Journal of AMI, pp. 44–47. Baku.
4. Zhiganov, K.V., Danilov, P.V., Pronin, A.V., & Titova, E.S. (2017). The effect of fire hazard factors on the rescuer's psyche. Young Student, (2), 693–696.

5. Ojagov, H.O., Gozalov, S.S., & Iskenderov, Y.Ch. (2012). Formation of psychological characteristics of people in emergency situations of various nature. Harbibilik Magazine, (1), 67–72.
6. Aliyev, N.A., & Gozalov, S.S. (2007). Improving the efficiency of the military training process. Military Knowledge Magazine, (4), 70–78.
7. Gozalov, S.S. (2009). The role of psychological service in the activities of personnel in emergency situations of various nature. Military Knowledge Magazine, (6), 56–63.
8. Psychological stability in emergency situations. Course lecture. Part III. (2000). Novogorsk: AGZ Ministry of Emergency Situations of Russia.
9. Shoigu, Yu.S. (Ed.). (2007). Psychology of Extreme Situations for Rescuers and Firefighters. Moscow: Smysl.
10. Chumila, E.A., Bulyga, D.M., Markach, I.I., Gurin, A.A., Voytekhovich, D.R., & Medvedeva, D.V. (2022). About the psychological readiness of rescuers to risk in the conditions of professional activity. Journal of Civil Protection, 6(1), 143–150. [https://journals.ucp.by/index.php/jcp/article/view/]
11. Serrano-Ibáñez, E.R., Corrás, T., del Prado, M., Diz, J., & Varela, C. (2022). Psychological variables associated with post-traumatic stress disorder in firefighters: a systematic review. Trauma, Violence & Abuse, 24(4), 2049–2066.
12. Jha, A.P., Rogers, S.L., Zanesco, A.P., Denkova, E., et al. (2020). Is resilience trainable? An initial study comparing mindfulness and relaxation training in firefighters. Psychiatry Research, 284, 112–120.

THE IMPACT OF WHITE PHOSPHORUS MUNITIONS ON CIVILIANS AND THE ENVIRONMENT IN ARMED CONFLICTS

Elnur Jabrayilov, Aprel Babayev, Arzu Musayev
The Academy of the Ministry of Emergency Situations AR
elnur.cebrayilov992@gmail.com, aprel.babayev@fhn.gov.az, kmelnur2019@gmail.com

White phosphorus, which burns at temperatures of 1200–1300 degrees and is extremely difficult to extinguish — even burning underwater — is frequently used by armies as an offensive weapon. As a result, both soldiers and civilians may be exposed to chemical poisoning. Additionally, it is used to illuminate battlefields, create smoke screens, and as a flammable substance.

The use of white phosphorus munitions, which are considered chemical weapons, was first recorded in warfare in 1916, toward the end of World War I, by the British Army. During various stages of World War II, approximately 20% of the shells used in U.S. 81mm mortars were of the M57 type, which contained white phosphorus. The U.S. forces used M15 model white phosphorus hand grenades to repel German attacks, cause confusion among enemy forces, and clear their positions. In 1944, during the operation to liberate Cherbourg alone, a U.S. mortar battalion fired a total of 11,899 white phosphorus shells — specifically of the M2 and M328 types — from 107 mm mortars into the city.

Over the past 30 years, the Azerbaijani military and civilian population have been exposed to the harmful effects of chemical weapons used by the armed forces of Armenia. By violating the fundamental principles of the United Nations "Convention on Biological Diversity," the Armenian side has caused significant damage to the environment. During these attacks, at least six D-4 type 122 mm artillery shells — each filled with 3.6 kilograms of P-4 substance (white phosphorus) — were used. As a result, the natural resources in those areas were severely damaged and burned. During the April 2016 clashes and in the periods that followed, enemy forces targeted the densely populated village of Askipara in the Tartar district with white phosphorus munitions. Even after the Patriotic War, mortar shells containing white phosphorus were repeatedly discovered in the territories liberated from occupation. These munitions once again demonstrate Armenia's hostile intent toward the civilian population.

The explosion of white phosphorus munitions disperses phosphorus particles with a strong incendiary effect within a radius of 200–400 meters. These particles pose a serious threat not only to military personnel but also to the civilian population living in the area and the environment—affecting water, soil, and the atmosphere—and can cause long-term negative impacts. When these munitions explode in the air, phosphorus and other mixed substances spread over a wide area, damaging the human respiratory tract and lungs. Inhalation of the smoke can injure the airways, cause shortness of breath, and even lead to death. Contact with the skin results in severe chemical burns and can lead to serious conditions such as damage to organs, bones, and bone marrow. Agricultural activities carried out on land contaminated by chemical poisoning may transfer toxic substances to plants, animals, and water sources, entering the human body either directly or indirectly. This can lead to the injuries above and long-term chronic poisoning.

References

1. https://mod.gov.az/az/news/xarici-olkelerin-azerbaycandaki-herbi-attaselerinin-cebheboyu-zonaya-seferi-teskil-olunub-video-12985.html
2. https://mod.gov.az/images/pdf/79be5d384039cb7a3f9ae468051c7d67.pdf
3. Israel/OPT: Identifying the Israeli army's use of white phosphorus in Gaza
4. https://sesqazeti.az/news/mia/499565.html

5. https://kuwait.mfa.gov.az/en/news/3076/statement-on-the-use-of-white-phosphorus-bomb-by-the-armed-forces-of-armenia-against-civilians-and-civilian-objects-of-azerbaijan

MINE ANTI-MINE ACTIVITIES AND THE ENVIRONMENT IN KARABAKH

Gullu Gullarli[1], Anar Hamidov[1], Tarana Aliyeva[2]
[1]*Military Institute named after Heydar Aliyev,*
[2]*Baku State University*
axundzadegullu@rambler.ru, mranarhemidov@gmail.com

The liberated territories of Azerbaijan are littered with mines and explosive remnants of war (ERW), the clearance of which is one of the most important post-conflict priorities. According to the Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on Their Destruction, adopted in Oslo in 1997 and entered into force in 1999, an anti-personnel mine "means a mine designed to be exploded by the presence, proximity or contact of a person and that will incapacitate, injure or kill one or more persons." An anti-vehicle mine or an anti-tank mine are essentially the same thing, except that they are designed to explode when detonated by a vehicle. Together, they fall under the general term "mine," which is defined in the same document as "a munition designed to be placed beneath, on or near the ground or other surface area and to explode on the presence, proximity or contact of a person or vehicle." Additionally, explosive remnants of war are defined as explosive ordnance left behind after a conflict has ended. These include unexploded artillery shells, grenades, mortars, rockets, aerial bombs, and cluster munitions. If such weapons fail to detonate as intended for any reason, they are called unexploded ordnance, while if they have not been used during an armed conflict and have been abandoned by the party that brought them to the battlefield, they are called abandoned explosive ordnance. Cluster bombs or cluster munitions are defined as weapons containing between a few and hundreds of explosive submunitions. They are dropped either from the air or the ground and are designed to explode in mid-air, releasing the submunitions and covering an area that can be as wide as several football fields.

Azerbaijan's mine and ERW contamination is primarily a result of the armed conflict between Armenia and Azerbaijan that effectively began in February 1988 and ended in November 2020 (secondarily, it is also a result of ammunition abandoned by the Soviet military in 1991). The Karabakh conflict can be divided into three main periods: the First Karabakh War, which ended with a ceasefire in May 1994, leaving most of Karabakh and seven surrounding districts temporarily in the hands of separatist ethnic Armenian forces; the period of Armenian occupation that followed; and the Second Karabakh War, which lasted 44 days. Clearing all minefields and ERW in the liberated territories is an integral part of Azerbaijan's commitment to achieving the Sustainable Development Goals, the main outcome of the UN 2030 Agenda for Sustainable Development adopted by world leaders in September 2015. At a minimum, the presence of mines and ERW impedes access to and use of resources and infrastructure, which in turn makes the sustainable resettlement of internally displaced persons in Karabakh virtually impossible, which in turn makes the reconstruction and reintegration of liberated territories into the country's "green growth" economic plans and activities virtually impossible. Technical mine hazard surveys are still ongoing, so it is not yet possible to accurately determine the exact extent of mine and ERW contamination in the former conflict zone, including the former "contact line," which ranged in depth from 3 to 7 kilometers. Two years before the start of the Second Karabakh War, a report by the Azerbaijan National Mine Action Agency (ANAMA) estimated that between 350 and 830 square kilometers of the occupied territories were mined. Mine contamination and explosive remnants of war (ERW) in the former conflict zone have also resulted in enormous loss of life. According to ANAMA, between 1992 and 2021, a total of 3.445 Azerbaijani civilians fell victim to mines: 639 were killed and 2.806 were injured.

References

1. Hacıyeva S.R., Əliyeva T.İ., Güllərli G.H. Kütləvi məhvin törədilməsində silahın rolu// "Azərbaycan ordu quruculuğu və hərb elmi" elmi praktik konf.mat.,2018, s. 17-18
2. Гаджиева С.Р., Алиева Т.И. Конфликт между природой и человеком в период военных столкновений// Проблемы современной науки и образования.,2016,№1(43), с.264-266
3. Гусейнов Р.С., Алиева Т.И., Гюллярли Г.Г., Асланлы А.А. Обеспечение военной безопасности как приоритет внешней политики государства// II International SCIENTITIC conference The army in the ERA of Globalization Georgia. 20-21.09.2019, p. 105-114

DETECTION OF EXPLOSIVE SUBSTANCES IN CONFLICT ZONES AND THEIR ENVIRONMENTAL IMPACTS: A CASE FOR INTEGRATED MONITORING APPROACHES

K.A.Asgarov, S.T.Ahmadova
National Aviation Academy
saidaahmadovabaku@gmail.com

Military operations in conflict zones territories have left behind large quantities of unexploded ordnance, explosive remnants of war, and chemically active residues that pose severe environmental and public health risks. In formerly occupied and war-affected regions like Karabakh, the detection of explosive compounds including TNT, RDX, and their byproducts is crucial not only for safety and demining purposes but also for assessing long-term ecological damage. Explosives degrade slowly in soil and water, releasing toxic derivatives that disrupt microbial activity, poison groundwater sources, and inhibit plant growth. Soil contamination by nitroaromatic compounds alters the carbon and nitrogen cycles, contributing indirectly to climate change. Aquatic ecosystems are especially vulnerable, as runoff from degraded explosives enters rivers and reservoirs, endangering biodiversity and potable water supplies. This paper presents recent advancements in detection technologies, such as portable electrochemical sensors and metal-organic frameworks (MOFs), which enable on-site identification of trace-level explosives. These methods improve environmental risk assessment and can inform remediation strategies.

Furthermore, the paper underscores the need for international cooperation and unified environmental monitoring standards in post-conflict zones. Integrating explosive detection with ecological impact studies will allow policymakers and environmental agencies to implement more targeted rehabilitation efforts and prevent secondary pollution disasters.

This study advocates for an interdisciplinary framework combining environmental science, chemistry, and security technology to address the silent yet persistent threat of explosive-related contamination in post-war regions.

ENVIRONMENTAL IMPACTS OF MODERN MILITARY EQUIPMENT AND CHEMICAL AGENTS IN CONFLICT ZONES

Ravana Guliyeva
Baku State University
rvanquliyeva632@gmail.com

Military operations increasingly rely on advanced technologies and chemical agents that can cause significant environmental harm. This study investigates the types of military equipment and chemical substances deployed in modern conflicts, including incendiary devices, chemical propellants, and explosive residues. The release of hazardous compounds such as heavy metals, persistent organic pollutants, and reactive chemicals into soils, water, and air is a major concern.

These contaminants have long-lasting effects on ecosystems, disrupting soil quality, water resources, and biodiversity. The behavior of these substances in the environment depends on their chemical properties, degradation rates, and interactions with environmental components. This research reviews recent data from conflict-affected regions to identify key pollutants originating from military materials and to assess their ecological risks.

Attention is focused on phosphorus-based incendiaries and metal-containing explosives, which are widely used and highly toxic. The study discusses their chemical pathways in the environment and potential accumulation in flora and fauna. Understanding these mechanisms is critical for designing effective remediation and management strategies.

The findings highlight the urgent need for enhanced environmental monitoring during and after military operations. Moreover, the research supports developing guidelines to minimize environmental damage caused by military activities, promoting the integration of sustainable practices into defense protocols.

References

1. Yilmaz, E., Kaya, S., & Demir, H. (2023). Biosorption of heavy metals from contaminated soils using agricultural wastes: A review. Environmental Science and Pollution Research, 30(15), 41520–41538. https://doi.org/10.1007/s11356-023-27042-x
2. Wang, L., Chen, J., & Li, X. (2022). Radionuclide removal from aqueous solutions by fungal biomass: Mechanisms and applications. Journal of Hazardous Materials, 423, 127123. https://doi.org/10.1016/j.jhazmat.2021.127123
3. Smith, A. J., & Thompson, R. M. (2021). Post-conflict soil contamination and remediation strategies: A systematic review. Science of The Total Environment, 767, 144929. https://doi.org/10.1016/j.scitotenv.2020.144929

POSSIBILITIES OF USING OPTICAL WEAPONS IN MILITARY BATTLES

Naila Yagubzade, Elvira Huseynova, Rahim Chodarov, Zamina Mashadibayova
National Aerospace Agency of MDI RA
naile_yaqub@mail.ru

Currently, the task of creating a combat laser for blinding optoelectronic sensors of surveillance devices on satellites and other aircraft seems more realistic. First of all, let's define the term "blinding", which is found in most publications on laser weapons. With regard to an optoelectronic sensor, this may mean:

1) physical damage to the sensor, which requires replacing the damaged element to eliminate it;
2) jamming, which leads to disruption of the device's operation during the time the interference is active.

In the second case, it would be more correct to talk about "illumination" of the surveillance device, which is what we will do in the future. Illumination of an optoelectronic sensor is currently widely used to protect aircraft and armored vehicles from missiles with infrared guidance heads. The disadvantages of illumination are obvious - this is the restoration of the optosensor's operation after the end of the illumination. Let us first consider the characteristics of a combat laser beam capable of physically disabling (blinding) an optoelectronic sensor at a distance of at least 1,000 kilometers. In [1], it was found that a beam (λ=0.532 μm) load of 163 kW/cm^2 for 0.25 seconds physically destroys the photosensitive black-and-white Sony ICX098BL CCD matrix. For black-and-white CMOS matrices or color CCDs, the beam load of destruction will be 85 kW/cm^2 and 16 kW/cm^2, respectively.

With an increase in the duration of the light pulse to five seconds, the value of the sensor destruction threshold decreases by 20…40%. It is not necessary to completely burn out the light-sensitive matrix of the optical sensor; it is enough to disable 50...70% of the matrix pixels for the sensor to lose its functionality. To evaluate the characteristics of the laser beam, we take the threshold value of optosensor blinding of 80 kW/cm^2. The laser installation with an initial beam of specific power of 2 MW/cm^2, considered earlier, provides a beam load on the optosensor of more than 80 kW/cm^2 at a distance of up to 154 km and 1.390 km for a beam with an initial diameter of D=1 cm and D=3 cm, respectively.

Let's take the initial beam power of 50 kW and a mirror/lens with a diameter of 50 centimeters with a focal length of 5 kilometers. Then, at a distance of no more than 10 meters from the focal point (5 km ± 10 m), the specific power of the light spot on the target will be more than 6 MW/cm^2, which allows free cutting of most construction materials. But already at a distance of three hundred meters or more from the focal point (less than 4.7 km or more than 5.3 km), the light load on the target will be less than 7 kW/cm^2.

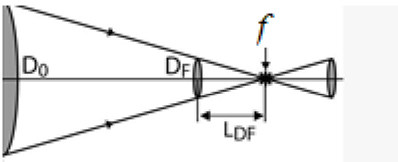


Fig. 1. Change in the diameter of the light spot on the target when shifting from the focal point of the laser beam by a distance LDF.

Thus, a modern laser with a power of ~40 kW and a beam diameter of 50 cm is quite capable of temporarily “illuminating” video surveillance devices at a distance of 1.500 kilometers.

References

Schwarz B. Laser-induced damage threshold of camera sensors and microoptoelectromechanical systems // Optical Engineering. – 2017, 56 (3), 034108.

COMPLEX APPROACHES TO THE ENVIRONMENTAL IMPACT OF ARMED CONFLICTS AND ITS ELIMINATION

Mahruza Shatirova
Polymer Materials Institute MSE AR
mshatirova@mail.ru

Military operations involve the use of explosive and chemical agents that have multifaceted and long-term impacts on the environment and human health. These effects are not limited to the active phase of combat but persist for years after conflicts have ended. Residues of explosives, chemical, and radioactive contamination negatively affect the quality of soil, water, and air resources, reduce biodiversity, and disrupt the overall stability of ecosystems. Soil and water pollution impairs agricultural productivity and renders water bodies unsuitable for drinking, ultimately leading to a decline in the population's living standards and health indicators. Accumulation of heavy metals and toxic compounds in the soil poses long-term ecological risks. One of the major concerns is the entry of these contaminants into the food chain, resulting in toxic, teratogenic, and carcinogenic effects on both humans and animals. Moreover, the loss of biodiversity leads to ecological imbalance. Physical destruction, explosions, and pollution in war zones destroy habitats of rare flora and fauna. Protected areas, reserves, and national parks can also be severely affected, resulting in irreversible ecological and socio-economic losses. The long-term storage of chemical and radioactive waste is another significant hazard. Safe management and disposal of these substances require robust infrastructure, adherence to international protocols, and scientific approaches. Otherwise, leakages and accidental dispersal may lead to severe regional or even global environmental disasters, placing both the environment and nearby populations at risk.

Addressing these problems necessitates integrated and scientifically grounded approaches. First and foremost, physical, chemical, and biotechnological methods should be employed for the rehabilitation of soil and water resources. Techniques such as bioremediation and phytoremediation can support the natural restoration of ecosystems. Water purification methods including filtration, membrane technologies, and chemical neutralization are considered effective. For the recovery of ecosystems and biodiversity, it is crucial to implement nature conservation programs, reintroduce endangered species, expand protected areas, and develop green zones. Cooperation among government institutions, international organizations, and environmental NGOs is vital in these efforts. The safe management of radioactive and chemical waste requires the establishment of isolated storage facilities in accordance with appropriate regulations and technical standards, as well as stabilization and solidification technologies for waste treatment. The participation of highly qualified personnel and the operation of continuous monitoring systems play a crucial role in these processes. Moreover, addressing these issues should not be limited to technological and scientific measures; social, legal, and institutional approaches must also be integrated. Enforcement of environmental protection legislation at both national and international levels and public awareness initiatives are essential. In post-conflict recovery programs, environmental restoration must be prioritized. Ultimately, the environmental impacts of military operations are extensive and multifaceted, and their elimination requires long-term strategies, sustained investment, and multi-sectoral cooperation. These efforts are of critical importance not only from an ecological perspective but also for public health, economic development, and regional stability. Therefore, systematic, well-planned, and science-based measures must be undertaken to restore the environment in post-conflict periods.

THE IMPACT OF MINE EXPLOSIONS ON CULTIVATED SOIL SURFACE AND RELIEF

E.A.Gurbanov[1], T.I.Jafarov[1], Z.R.Gurbanova[2]
[1]*Azerbaijan University of Architecture and Construction,*
[2]*Azerbaijan State Oil and Industry University*
eldar_qurbanov_54@mail.ru, tariyel.jafarov@azmiu.edu.az,
qurbanova.zumrud17@gmail.com

It is known that all military activities lead to negative processes. In particular, periodic explosions occurring in mined areas contribute to the intensification of exogenous processes on the Earth's surface relief. Especially in cultivated and irrigated land areas, frequent mine explosions change the relief of the area and mainly the slope of the irrigated area. The change in the slope of irrigated areas causes soil contamination, increasing the potential danger of erosion processes in the area. Studies show that in the East Zangezur and Karabakh economic regions, especially in the Jabrayil and Khojavand districts, there are areas with mine explosions. Most of these areas were once used for cultivation and grape plantations.

According to research, in irrigated areas, deepening occurs as a result of water flowing in the created pits. Depending on the slope, linear development occurs in the direction of the pit's slope and also in its upper part. These pits gradually merge, forming the foundation of large ravines. Due to explosions, the parent rock mass emerges from the created depths and mixes with or covers the surface soil. These processes cause damage to the soil in two directions. Firstly, a certain amount of land (0.5-1 hectare) becomes unusable. If this process occurs with every explosion, the loss of fertile soil due to the resulting relief conditions becomes inevitable. It also affects the relief and slope of the surrounding areas. This is clearly proven by Remote Sensing data and GIS software studies. The second direction is the impact on soil fertility and its contamination. During these processes, the specific organic composition of the soil deteriorates, humus loss occurs, and soils become contaminated. To prevent these negative phenomena, mines must be neutralized before they explode. Removed mines should be disposed of in special polygons outside the area.

According to the results of studies carried out with new technologies, the formed ravines double their length in subsequent rainy seasons. The width and depth of these ravines also increase. If natural greening does not occur, its development can increase at any moment. According to calculations, a total of tens of tons of soil are lost per hectare per year. To prevent these losses, a system of various measures must be prepared and implemented. First of all, the grooves formed in the cleared area must be smoothed, and external water flows must be prevented. Perennial forage crops should be planted to increase the soil's resistance to erosion. The resulting dense root system will prevent surface runoff and form water-resistant aggregates. In soils with such a structure, even if the erosion process is not completely prevented, the potential danger is weakened. Thus, negative ecological processes are prevented.

References

1. Aliyev, H. A., & Gasimov, R. S. (2022). Rehabilitation of mined lands and assessment of agroecological conditions in the post-war period (On the example of the Eastern Zangezur and Karabakh economic regions). *Scientific Works of the Institute of Geography, Azerbaijan National Academy of Sciences*, (2), 65–73.

2. Alizade, A. A. (2019). Soil erosion and methods for its elimination. *Proceedings of the Azerbaijan Soil Scientists Society*, (3), 45–52.

3. Makimov, R., & Ibrahimov, R. (2021). Environmental consequences of mine explosions on arable lands in conflict-affected areas: A case study from Nagorno-Karabakh. *Environmental Monitoring and Assessment, 193*(11), 734. https://doi.org/10.1007/s10661-021-09556-3

ELECTRONIC WARFARE TECHNOLOGIES AND THEIR ROLE IN MODERN MILITARY OPERATIONS

Aytan Aslanova, Ilala Ismayilova
Azerbaijan National Aerospace Agency, Natural Resources Space Research Institute.
ilale.nesirova@gmail.com

Modern warfare takes place in a high-tech and dynamic environment. Military units are equipped with various electronic systems that enhance the effectiveness of communications, control, reconnaissance, and weapons systems. Electronic warfare (EW) systems provide a strategic advantage by neutralizing the enemy's information and control systems.

The development of technology has increased the role of electronic systems in modern warfare. In particular, electronic warfare means applied to communications, radar, automated control, and unmanned aerial vehicles are an important factor in the successful conduct of operations [1].

Military use of electronic systems: Military units use electronic systems in the following areas: communications, radio and radar systems, automated control, satellite navigation (GPS, GLONASS), technical reconnaissance, and electronic warfare [2].

Analysis and protection against air attack means: The development of enemy air attack means is analyzed, active and passive defense measures are used, especially intelligent methods of electronic warfare.

Electronic Warfare Systems on UAVs: High-tech electronic warfare systems installed on unmanned aerial vehicles provide combat support and improve the effectiveness of operations [3].
Countermeasures to radar systems: The operation of enemy radar stations is disrupted by numerous simulated signals and interference, which reduces the effectiveness of radars [4]. Conclusion: The

development of electronic warfare technologies creates a strategic advantage in modern combat operations. In particular, electronic warfare systems used in UAVs will be further improved using artificial intelligence technologies.

References

1. Grigoryev V.Yu., Syromyatnikov N.I. Fundamentals of radio electronic warfare. Moscow, 2016.
2. Adamy D. EW 101: A First Course in Electronic Warfare. Artech House, 2001.
3. Military Technical Journal of the Ministry of Defense of the Republic of Azerbaijan, 2021.
4. Scientific Journal of the Ministry of Defense of the Republic of Azerbaijan, 2022.

SCIENTIFIC AND TECHNICAL RESEARCH ON ENHANCING THE EFFECTIVENESS OF TELEMETRY SYSTEMS OF UNMANNED AERIAL VEHICLES UNDER ELECTRONIC WARFARE CONDITIONS

Mukhtar Azizullayev, Nurlan Karimov, Lala Najafova
National Aerospace Agency, MDI AR
azizullayevmuxtar27@gmail.com

In modern military and special operations, the widespread use of Unmanned Aerial Vehicles (UAVs) makes the protection of their control and telemetry systems a top priority. Particularly under electronic warfare (EW) conditions, these communication systems face serious threats such as jamming, signal distortion, delays, or complete disruption. These factors significantly impair UAV control and real-time data exchange, potentially leading to mission failure.

This dissertation research is dedicated to the development of scientifically substantiated technological solutions aimed at improving the effectiveness of telemetry systems under the influence of EW. Within the scope of the study, both theoretical and practical methodologies were employed to conduct a comprehensive analysis in the following directions:

Investigation of the impact mechanisms of EW application areas (Electronic Attack, Electronic Protection, Electronic Support) on UAV telemetry;

Comparative analysis of various telemetry modules (LoRa SX1278, XBee PRO S2C, TBS Crossfire, RFD900x, etc.); [1]

Analysis and mathematical modeling of signal quality indicators under electromagnetic interference — including SNR (Signal-to-Noise Ratio), RSSI (Received Signal Strength Indicator), BER (Bit Error Rate), and Path Loss;

Experimental evaluation of protection capabilities of technologies such as FHSS (Frequency Hopping Spread Spectrum) and DSSS (Direct Sequence Spread Spectrum);

The research findings demonstrate that the appropriate application of channel coding and frequency hopping technologies can significantly increase the resilience of telemetry systems under EW conditions. Furthermore, real-world testing has shown that optimal antenna selection (e.g., directional Yagi or Helix-type antennas), effective power management, and integration with a spectrum monitoring system can ensure clean signal reception and transmission. [2]

This scientific research holds strategic significance by addressing the resilience and reliability of UAV telemetry systems under electronic warfare (EW) conditions. Through the analysis of signal degradation mechanisms and the application of technologies such as frequency hopping and channel coding, the study offers practical solutions for maintaining stable communication in hostile environments. The findings contribute directly to the development of secure and robust UAV communication systems, thereby supporting national defense capabilities in the face of electronic threats.

References

1. Hayat, S., Yanmaz, E., & Muzaffar, R. (2016). Survey on unmanned aerial vehicle networks for civil applications: A communications viewpoint. IEEE Communications Surveys & Tutorials, 18(4), 2624–2661. https://doi.org/10.1109/COMST.2016.2560343
2. Gupta, L., Jain, R., & Vaszkun, G. (2015). Survey of important issues in UAV communication networks. IEEE Communications Surveys & Tutorials, 18(2), 1123–1152. https://doi.org/10.1109/COMST.2015.2460343

MULTIFUNCTIONAL RADIO-ELECTRONIC JAMMING (MREJ)

Namik Pashayev, Durdana Aliyeva, Aytan Sohbatova
National Aerospace Agency, Baku, Azerbaijan
namikpasha@rambler.ru

A new method is proposed for suppressing side lobes in the azimuth using data from a multipacks oblique-angle (MPS) synthetic aperture radar (SAR). In MPS SAR, the radar observes the scene from different oblique angles and altitudes during each pass. First, the acquisition geometry for the MPS SAR mode is defined. Then, 2D signals are focused and the images are registered on the main image.

Spatial selection of active jamming is based on their strong spatial correlation and involves compensating for the jamming signal at the input of the main receiving channel.

Spatial correlation characterizes the relationship (similarity) of signals received by different antennas connected to their respective receivers. If this relationship is strong, it becomes possible to construct an auxiliary receiving channel with its own antenna (called a compensating channel) and use its signal to compensate for the jamming in the main channel [1].

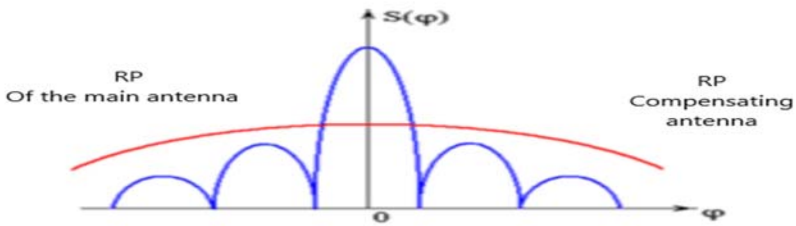


Image 1. Radiation patterns of the main and compensating antennas.

To further explain the elevation processing effect, Figure 2a shows azimuthal profiles of the target on the 2D image, and Figure 2b shows a slice of the 3D image in the azimuth-elevation plane. It can be seen that after elevation processing, the side lobes in different azimuth positions shifted to different elevations. Moreover, parts F and G in Figure 2a were located in incorrect positions due to elevation overlay.[2]

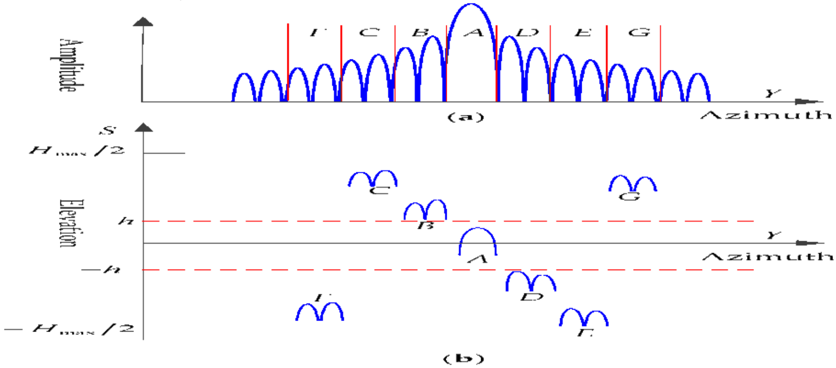


Image 2. Effect of elevation angle processing. (a) Azimuthal profile of the target on a 2D image; (b) Slice of the 3D image in the azimuth-elevation plane.

References

1. Iglesias, R.; Mallorqui, J.J. Side-lobe cancelation in DInSAR pixel selection with SVA. IEEE Geosci. Remote Sens. Lett. 2013, 10, 667–671. [CrossRef]
2. Jun, S.; Yang, L.; Xiaoling, Z.; Ling, F. A novel SAR sidelobe suppression method via Dual-Delta factorization. IEEE Geosci. Remote Sens. Lett. 2015, 12, 1576–1580.

REGENERATION OF MOTOR OILS AS AN ELEMENT OF CLIMATE-FRIENDLY RECYCLING

Elvira Huseynova
Azerbaijan State Oil and Industry University
elvira_huseynova@mail.ru

One of the significant sources of environmental pollution is used motor oils, which contain toxic compounds, thermal destruction products, heavy metals and additive residues. Their uncontrolled disposal or combustion contributes to soil degradation, water pollution and greenhouse gas emissions, directly and indirectly affecting climate change. In this regard, the development of environmentally friendly methods for recycling such waste is of particular relevance.

This paper presents a comprehensive study of ADDINOL Super Light 0546 (SAE 5W-40) motor oil before and after use, as well as after regeneration using chloric acid. IR spectra analysis showed that during operation, the polyolefin base is destroyed, oxygen-containing and unsaturated compounds are formed, and aggressive functional groups (OH, C=C, C=O) accumulate. These changes are accompanied by a shift and disappearance of characteristic absorption bands, a decrease in the intensity of signals associated with additives and hydrophobic hydrocarbons.

After treatment with chloric acid, the restoration of polyolefin structures is confirmed by the return of the C–H-group stretching vibration bands and the disappearance of signals corresponding to compounds with polar functional groups. Also, there are no signs of bisulfates and organophosphorus additives in the spectra, which indicates their removal.

Transmission electron microscopy revealed that during regeneration, a dense carbon-containing sediment is formed, consisting of agglomerates 70–90 μm in size, including additive residues. Elemental analysis (EDX) showed that the sediment consists mainly of carbon (up to 90%) and oxygen, with a minor presence of Ca, Zn, P, Fe, which indicates coagulation and precipitation of ash and adsorbed components. Two sediment phases are distinguished - less and more condensed, differing in the degree of aggregation and elemental composition. In the transparent regenerated phase of the oil, toxic elements are practically absent, which confirms the efficiency of purification and the possibility of secondary use. Treatment with chloric acid does not lead to the formation of difficult-to-utilize tars, and the resulting sediment can be easily removed and utilized.

Thus, the proposed regeneration method allows you to obtain environmentally friendly oil, comparable in quality to the original, and effectively minimize environmental pollution. This contributes to reducing the carbon footprint of petrochemical products and demonstrates how local technogenic flows can be transformed into closed, safe cycles that mitigate the effects of climate change.

THE ROLE OF UNMANNED AERIAL VEHICLES IN ENVIRONMENTAL MONITORING AND SIMULTANEOUSLY IN CAUSING ECOLOGICAL DAMAGE

L.V.Ahmadli, A.D.Taghiyev
Azerbaijan Technical University
lale.ehmedli.1997@mail.ru, tagiyevarzum505@gmail.com

The rapid advancement of modern technologies has significantly expanded the application areas of unmanned aerial vehicles (UAVs). Among these, environmental monitoring and natural resource management hold a prominent place. UAVs are increasingly preferred in ecological studies due to their high maneuverability, unrestricted observation capabilities, and cost-effectiveness.

Through UAVs, numerous environmental assessments are conducted, such as evaluating the condition of forest areas, monitoring biodiversity, analyzing water body pollution levels, and determining the health indicators of agricultural lands. Even in extreme conditions, like mountainous or marshy terrains, the deployment of UAVs often yields more effective results than traditional ground-based observation methods.

However, the use of UAVs also poses certain ecological risks. Frequent flights may disrupt natural animal behaviors, especially in birds, where the acoustic and visual stress caused by flying devices can lead to significant problems. Additionally, in some cases, preparing take-off and landing zones for heavy UAVs requires altering the soil cover, leading to localized ecosystem disturbances.

Moreover, UAVs employed for military or paramilitary purposes—particularly armed or armored variants—can have broader negative impacts on the environment. For instance, drone strikes not only destroy soil structures and vegetation but also leave behind chemical and explosive residues, contributing to long-term ecosystem contamination.

CONCLUSION

Military activities contribute significantly to radioactive pollution, posing complex challenges that demand scientific, technological, and political responses. Ensuring radioecological safety requires international collaboration, advanced monitoring systems, and public awareness. Cases such as Chernobyl, Fukushima, and Nagorno-Karabakh emphasize the urgent need for comprehensive environmental protection strategies in both post-conflict and high-risk areas.

References

1. Anderson, K., & Gaston, K. J. (2013). *Lightweight unmanned aerial vehicles will revolutionize spatial ecology*. Frontiers in Ecology and the Environment, 11(3), 138–146. https://doi.org/10.1890/120150

2. Pimm, S. L., Alibhai, S., Bergl, R., Dehgan, A., Giri, C., Jewell, Z., Joppa, L. N., Kays, R., & Loarie, S. (2015). *Emerging technologies to conserve biodiversity.* Trends in Ecology & Evolution, 30(11), 685–696. https://doi.org/10.1016/j.tree.2015.08.008
3. Hodgson, J. C., Baylis, S. M., Mott, R., Herrod, A., & Clarke, R. H. (2016). *Precision wildlife monitoring using unmanned aerial vehicles.* Scientific Reports, 6, Article 22574. https://doi.org/10.1038/srep22574
4. Mulero-Pázmány, M., Jenni-Eiermann, S., Strebel, N., Sattler, T., Negro, J. J., & Tablado, Z. (2017). *Unmanned aircraft systems as a new source of disturbance for wildlife: A systematic review.* https://doi.org/10.1371/journal.pone.0178448

QUANTUM-MECHANICAL RESEARCH OF PENTA ERYTHRITOL TETRA NITRATE AND RDX EXPLOSIVE MINES

Arzuman Hasanov, Ashraf Huseynov, Aynura Abdullayeva
National Defense University Military Scientific Research Institute
gasqhapk@gmail.com, arzuman.hesenov@mmu.edu.az,
ashraf.huseynov@mmu.edu.az, aynure.abdullayeva@mmu.edu.az

It is known that mines have a huge destructive impact on the environment during and after military conflicts. The most commonly used explosive in mines is Penta erythritol tetra nitrate and RDX are used. Therefore, it is necessary and interesting to study them using quantum mechanical methods. İn the study of penta erythritol tetranitrate (Figure 1) and RDX explosive (Figure 2) a non-empirical quantum mechanics method was used. This method uses the following system of nonlinear algebraic equations:

$$\sum_{q=1}^{m}\left(F_{i,pq} - \varepsilon_i S_{pq}\right)c_{qi} = 0, (p = 1, 2, \dots, m) \quad (1)$$

Here

$$F_{i,pq} = f_i H_{pq} + \sum_{jk\ell} \sum_{rs} c_{rk}^* c_{s\ell} \left(2A_{ij,k\ell} J_{pr,qs} - B_{ij,k\ell} J_{pr,sq}\right) \quad (2)$$

$$S_{pq} = \int \chi_p \chi_q dV \quad (3)$$

has been marked.

Here, ε_i – orbital energy of the i-th electron; f_i - the degree of occupancy of the i - th layer with electrons; c_{qi} - unknown coefficients; χ_p - basis functions; S_{pq} - overlap matrix; H_{pq} - one-electron matrix elements of the Hamilton operator; $J_{pr,qs}, J_{pr,sq}$ - two-electron matrix elements; $A_{ij,k\ell}$ and $B_{ij,k\ell}$ - four-dimensional matrix elements.

To calculate the total electronic energy of the substance under study

$$E = 2 \sum_{ipq} c_{pi}^* c_{qi} f_i H_{pq} + \sum_{ijk\ell} \sum_{prqs} c_{pi}^* c_{rk}^* c_{qj} c_{s\ell} \left(2A_{ij,k\ell} J_{pr,qs} - B_{ij,k\ell} J_{pr,sq}\right) (4)$$

the formula is used.

c_{qi} to find the unknown coefficients, it is necessary to solve the system of equations (1). In this case, the basis functions characterizing the state of the electron inside the atom χ_q are considered known, and therefore the values included in these equations S_{pq}, H_{pq}, $J_{pr,qs}$, $J_{pr,sq}$ $A_{ij,k\ell}$ and $B_{ij,k\ell}$ it is assumed that the numerical values of the matrix elements are known. $F_{i,pq}$ the quantities depend nonlinearly c_{qi} on the unknowns, and therefore the system of equations (1) is a system of nonlinear algebraic equations, and this system of equations can also be written in matrix form as follows:

$$FC = \varepsilon \cdot SC$$

Here, ε - vector of orbital energies of electrons; S - two-dimensional overlap matrix; C - two-dimensional matrix of unknown coefficients; F - two-dimensional Fock matrix, C - depends nonlinearly on the elements of the unknown coefficients matrix. (5) is the generalized eigenvalue equation.

By unitary transformation, the generalized eigenvalue equation (5) can be reduced to the ordinary eigenvalue equation:

$$F'X = \varepsilon \cdot X$$

The usual eigenvalue equation is obtained. To solve equation (6) F' - the method of diagonalizing the Fock matrix is used. As a result ε_i - the values of orbital energies and c_{qi} - coefficients are found, ε_i and c_{qi} using the found values of their values, the total electronic energy of the object under study and the numerical values of other physical quantities can be calculated.

Thus, using a non-empirical method, penta The following results were obtained for the energetic parameters of the explosives penta erythritol tetra nitrate $(CH_2ONO_2)_4C$ and RDX $(CH_2N_2\ O_2)_3$ and the system of equations (6) for the O oxygen, C carbon, N nitrogen and H hydrogen atoms and the corresponding calculations:
Entering Penta erythritol tetra nitrate oxygen E_O =-73.661812907 (a.u.), carbon E_C=-37.089584468 (a.u.), nitrogen E_N=-53.554533091 (a.u.), hydrogen E_H = -0.466581804 (a.u.), the highest level occupied by electrons is ε_{HOMO} = -5.800512 eV and the lowest empty molecular orbital is ε_{LUMO} = 4.925366 eV without electrons. The total electronic energy of penta erythritol tetranitrate (using a small number of basis functions) E_{PETN}=-1291.587304 (a.u.) and the stability energies(table 1)

$\Delta E = E_{EPETN} - (8E_H + 5E_C + 4E_N + 12E_O)$ =-4.2468400897 (a.u.)

and an approximate value of bond length between atoms based on visual model of penta erythritol tetra nitrate explosive $r = 0{,}143857$ nm found.

Entering RDX oxygen E_O=-74.65660027 (a.u.), carbon E_C=-37.58855562 (a.u.), nitrogen E_N =-54.24577486 (a.u.), hydrogen E_H=-0.498232903 (a.u.), the highest level occupied by electrons is ε_{HOMO} =-11.304316 eV and the lowest empty molecular orbital is ε_{LUMO} = 1.022326 eV without electrons, the total electron energy of the RDX explosive (using a large number of basis functions) is E_{RDX}= -1291.587304 (a.u.), stability energies (table 1)

$$\Delta E = E_{RDX} - (6E_H + 3E_C + 6E_N + 6E_O) = \text{-}3.241960598 \text{ (a.u.)}$$

and an approximate value of the bond length between atoms based on a visual model of the RDX explosive $r = 0{,}1332283$ nm found.

The results obtained can be used in the demining of areas[1-3].

Table 1. Calculated values of energetic parameters of Penta erythritol tetra nitrate and RDX explosives

No.	Explosive	ε_{HOMO} (eV)	ε_{LUMO} (eV)	Total energy E(a.u.)	Stability parameter ΔE (a.u.)	Ionization potential I_p(eV)	Band gap energiE_g(eV)	The wavelength of the photon that can be λ questioned (nm)
1	PETN	-5.800512	4.925366	-1291.587304	-4.24684009	5.800512	10.725878	116
2	RDX	-11.304316	1.022326	-892.4112757	-3,241960598	11.304316	12.326642	10 1

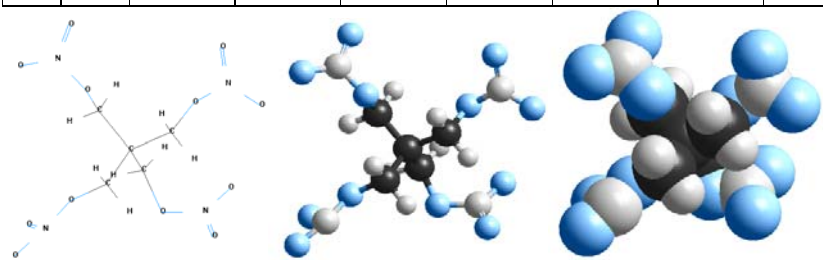


Figure 1. Chemical structure of the explosive Penta erythritol tetranitrate $(CH_2ONO_2)_4C$.

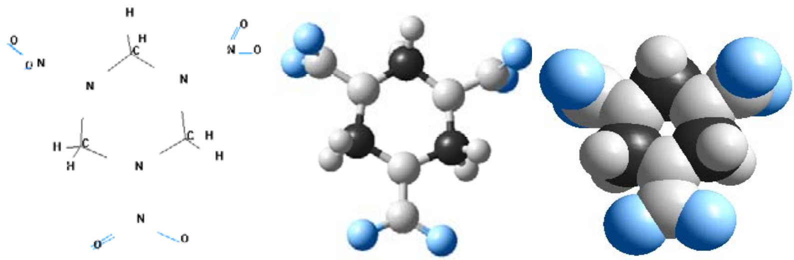


Figure 2. Chemical structure of the explosive RDX $(CH_2N_2O_2)_3$

Reference

1. Pashaev, F., Gasanov, A., Musaev, M., & Abbasov, I. (2021, May). Calculation of One-Electron Wave Functions and Energy Levels of N-Butane Molecule on the Basis of Slater Atomic Orbitals. In Proceedings of the Latvian Academy of Sciences (Vol. 75, No. 3, pp. 229-233). De Gruyter Poland.
2. Bayramov, A.A., Gasanov, A.G. (2021). Mechanical Properties of Materials Based on Graphene C 62 H 20 and Polyethylene (-CH 2-CH 2-) n. Journal of Technical Physics, 66 (3), 416-421.
3. Gasanov, A.G., Bayramov, A.A. (2019). Simulation of the Electronic Structure of Graphene–Polyvinylidene Fluoride Composite Material. Physics of the Solid State, 61 (1), 56-61

ASSESSMENT OF THE IMPACT OF MODERN MILITARY EQUIPMENT AND CHEMICAL AGENTS ON ECOSYSTEMS AND MITIGATION STRATEGIES

Ashraf Huseynov, Arzuman Hasanov, Aynura Abdullayeva
National Defense University Military Scientific Research Institute
huseynovashraf71@yandex.ru, arzuman.hesenov@mmu.edu.az,
aynure-huseynov-2015@mail.ru

Modern military conflicts pose a serious threat not only to human life but also to ecological systems. The use of military equipment and chemical agents during armed operations causes significant and long-lasting damage to soil, water, air, and biodiversity. The scale and intensity of these impacts depend on the type of military technology used and the chemical composition of the weapons applied.

The large-scale movement of armored vehicles leads to soil compaction, structural degradation, accelerated erosion, and destruction of local flora and fauna. Disruption of air and water balance in the soil impairs microbial activity and reduces agricultural productivity.

Additionally, explosive materials containing nitrates, ammonium, and perchlorates contaminate soil and groundwater with toxic compounds [1].

The use of prohibited chemical weapons-such as white phosphorus, napalm, mustard gas, and similar toxic substances-further exacerbates ecological degradation. These substances, when ignited or absorbed into the soil and water, create chemical effects that may persist for decades, with long-term health risks to local populations [3].

During the war in Ukraine, large-scale forest fires significantly increased atmospheric carbon emissions, releasing millions of tons of CO_2 and disrupting the natural carbon balance of ecosystems [2].

Such emissions undermine global climate resilience and accelerate environmental degradation.

Water resources are also severely affected. Leakage of fuel, lubricants, and toxic chemicals from military machinery into rivers and groundwater disrupts aquatic ecosystems and poses a threat to potable water supplies, causing both environmental and public health crises [1].

International practice has developed various legal and technological mechanisms to mitigate the environmental consequences of war. UN and NATO initiatives include environmental impact assessments, drone-based pollution monitoring, and post-conflict rehabilitation programs. Among remediation methods, phytoremediation and bioremediation-based on the use of plants and microorganisms to clean contaminated environments-have shown promising results [4].

Findings:

1. Modern military equipment and chemical agents inflict severe, systematic, and long-term harm on the environment.
2. Soil, water, air, and biodiversity are the most vulnerable components affected by armed conflict.
3. Strengthening international legal frameworks and military environmental protocols is essential for minimizing ecological damage.
4. Post-conflict environmental rehabilitation must prioritize ecosystem restoration through modern technologies.
5. Future military technology development should integrate eco-friendly solutions and green engineering principles.

References

1. UNEP & Environmental Law Institute. Protecting the Environment During Armed Conflict: An Inventory and Analysis of International Law. Nairobi: United Nations Environment Programme, 2009. – 78 p. https://ceobs.org/wp-content/uploads/2018/03/int_law.pdf

2. Damien Gayle. Forest fires push up greenhouse gas emissions from war in Ukraine. The Guardian, February 24, 2025. https://www.theguardian.com/world/2025/feb/24/forest-fires-push-up-greenhouse-gas-emissions-from-war-in-ukraine
3. Wirtu, Y.D., Abdela, U. Impact of War on the Environment: Ecocide. Frontiers in Environmental Science., February 06, 2025. https://www.frontiersin.org/articles/10.3389/fenvs.2025.1539520/full
4. Jensen, D. & Lonergan, S. (2012). *Assessing and Restoring Natural Resources in Post-Conflict Peacebuilding.* https://www.environmentalpeacebuilding.org/assets/documents/e6f94865748f.pdf

SECTION 4. RISKS POSED BY MILITARY OPERATIONS TO WATER BODIES, AIR AND SOIL

THE COMBINED IMPACT OF WAR AND NATURAL DISASTERS ON AGROECOLOGICAL STABILITY AND ECOSYSTEM SECURITY IN THE SOUTHWESTERN SLOPES OF THE GREATER CAUCASUS

Sona Huseynzade
Baku State University
huseynzade sona66@gmail.com

The combined influence of war and natural disasters on agroecological stability and ecosystem security in the southwestern slopes of the Greater Caucasus becomes especially evident when analyzed through statistical data. In particular, the Second Karabakh War significantly exacerbated the extent of environmental degradation in this region. Azerbaijan is considered a high-risk country in terms of natural disasters. According to the 2022 INFORM Risk Index, it ranked 24th out of 191 countries. The country is frequently exposed to hazards such as droughts, earthquakes, floods, landslides, and extreme temperatures. Over the past two decades, the total area under landslide risk has increased sharply. This trend is largely attributed to a combination of intensive rainfall, seismic activity, and human-induced erosion. The southern and northeastern slopes of the Greater Caucasus, as well as the northeastern part of the Lesser Caucasus, are particularly prone to landslides. Currently, 43.29% of Azerbaijan's territory is affected by various degrees of soil erosion. In the southern slopes of the Greater Caucasus, this figure reaches 66.6% of the total land area. Erosive processes result in the loss of fertile topsoil, rendering agricultural lands fragmented and unproductive. According to conservative estimates, the annual economic loss caused by soil erosion and deflation in Azerbaijan is around 10-11 billion AZN. Flooding and flash floods are also common occurrences, especially in rivers originating from the southern slopes of the Greater Caucasus. On average, nearly 10,000 people are affected annually by floods, causing damages estimated at 30 million USD. Deforested areas and overgrazed pastures are particularly vulnerable to such events. Severe meteorological droughts tend to occur approximately every 50 years, but global climate change is expected to increase their frequency. For instance, during the drought of 2014, 12 wildfires damaged approximately 59 hectares of forested land. The Second Karabakh War inflicted unprecedented damage on the already fragile ecosystems of the region, compounding the adverse effects of natural disasters. Reports from the United Nations Environment Programme and other research institutions reveal the scale of environmental harm caused by the conflict. During the war, hundreds of landscape fires occurred, many directly linked to military activities. In the formerly occupied territories, around 260,300 hectares of forest land once harbored more than 460 native species of trees and shrubs, over 15% of which were endemic to the region. Prior to the conflict, protected areas such as the Basitchay and Qaragol state reserves were home to 24 rare animal species and 27 rare plant species. Many of these have been critically impacted by military operations. In fact, armed conflicts have historically been among the most significant factors contributing to the decline of wildlife populations across the Caucasus from 1946 to 2010.Post-war areas are now heavily contaminated with unexploded ordnance, abandoned trenches, military waste, and toxic remnants of warfare all posing substantial threats to human livelihoods and biodiversity. Water security, already a major challenge in the Caucasus region, has become further jeopardized. According to some forecasts, Azerbaijan's water supply may decline by up to 77% by the year 2040, a reduction that may result in a corresponding 77% drop in crop yields. During the war, water infrastructure was also deliberately targeted, exacerbating the risks to water access. Heavy metal pollution has been recorded in key water bodies, such as the Okhchuchay River, due to discharges from copper and molybdenum mining activities and household waste. In certain areas, iron concentrations were found to be 1.5 times above permissible levels, while cadmium exceeded the norm by a factor of 4 Years of occupation and conflict have also led to the collapse of the region's agricultural system. Satellite imagery analysis reveals significant changes in land use and land cover between the 1990s and 2020. The largest loss in arable land approximately 47%was recorded in the Tartar district. Among the major consequences of the conflict are the breakdown of agricultural infrastructure and the acceleration of land degradation, particularly in areas already affected by natural erosion and drought. Statistical data clearly demonstrate the multifaceted and destructive influence of both natural disasters and armed conflict on agroecological stability and ecosystem security in the southwestern slopes of the Greater Caucasus. The Second Karabakh War further deepened existing environmental issues and drastically weakened the region's capacity for natural recovery. The restoration of agriculture in liberated territories, land reclamation, sustainable water resource management, and biodiversity protection demand long-term, integrated efforts. These challenges cannot be addressed solely through local initiatives they also require robust international collaboration and support.

References

1. Nabibeyli, Z.I. Ecology and Emergency Situations. Baku: AZTU Publishing, 2012. (380pages)
2.Aliyev, A.Q. Radiation Ecology. Baku: Chirag Publishing, 2012.
3. The Risk of Cross-Border Pollution and Its Influence on Environmental Health.

IMPACT OF MILITARY CONFLICTS ON THE AQUATIC ENVIRONMENT

T.N.Kangarli, V.A.Mammadov, H.Kh.Khalilova
[1]*Institute of Geology and Geophysics MSE AR*
[2]*Institute of Physics MSE AR*
tkangarli@gmail.com; vmamed@rambler.ru; khalilova@rambler.ru

During military conflicts, along with people, farms and communications, the ecological balance of all ecosystem components, especially water sources, are disrupted. When the military conflict occurred between Azerbaijan and Armenia, a number surface (rivers, lakes, water reservoirs) and ground (springs, wells and mineral-thermal waters, etc.) water resources in Karabakh and Eastern Zangezur with a total area >16000 km^2 covering 14 administrative regions were subjected to physical, chemical, microbiological and radioactive pollution and lost their natural features. As a result of inefficient use of hydrotechnical facilities, i.e., due to the failure to preventive measures, current and capital repair services, their useful working capacity has decreased and they have become a source of danger for surrounding regions. Following the heavy artillery strikes, the dams of most reservoirs were destroyed. Surface washing and erosion processes have been intensified due to the decreasing of water bearing capabilities of the forests with burned and cut trees. Hydrometeorological observations were ceased in 17 hydrological monitoring points. Water of “Istisu” mineral spring were packed and labeled with chemical composition in farsi as a water from Armenian Jermuk residential area.

Both Aras and Okhchuchay are the most polluted rivers in the region. Thousands of tons of sour wastewaters polluted with heavy metal salts and other toxic discharges from Kafan and Gadjaran districts, and the mining enterprises located nearby are running to the Aras river through Okhchuchay and then to the Kura river, which bring these pollutants into the Caspian Sea. As a result, the contents of manganese (Mn), iron (Fe), molybdenum (Mo) and other metals in the water wells around the Aras river were found to be much higher the permissible levels. The content one of the toxic heavy metals – copper (Cu) in the Aras is 25-50 times over the maximum permissible concentration, because the Okhchuchay river brings in industrial runoff from the Gadjaran copper-molybdenum and Kafan copper-ore mines of Armenia. Both microflora and microfauna in the area extended 43 km along the Aras river bank were destroyed. It was revealed that the number of 21 fish species recorded earlier in the river have decreased to 16. The pH value of the Aras river has decreased to 2.4-3.0 and microflora has decreased by 150-200 times. The studies have shown that the content of phenols exceeded the established norms by 200-1100 times, nitrogen-phosphate salts by 26-34 times, chlorides by 25-30 times and oil products by 60-90 times, respectively.

As a result of the Armenia's aggressive policy against Azerbaijan and the occupation of more than 20 percent of the republic's territory, the land reclamation and water management fund located in this region that play an important role in the country's economy has also suffered significant damage. One of the large water objects the Sarsang water reservoir, included in the Tartarchay water management systems and later remained in the occupied territory had 565 million m^3 volume with 13.4 km^2 surface area. Along with this region, the reservoir supplied 92.2 thousand ha land with irrigation water in the bordering districts. Before the occupation, cotton, tobacco, grain and fodder crops, perennial crops, and forests cultivated on these lands were supplied with water taken from the Sugovushan hydroelectric station, which is part of the Tartarchay irrigation system. During the occupation period, the lack of irrigation water for more than 56.000 hectares of land in the Tartar, Barda, Aghdam, Goranboy, Yevlakh and Agjabedi regions that remained outside the occupation caused irreparable damage to the economy of this region of the republic.

125.8 ha of irrigation land were remained in occupied zone including 22 irrigation systems, 16 headwaters, 2 hydro-junctions, 6.426 km of irrigation canals, 330 km of collector-drainage networks, 1.429 subartesian wells, 7.860 hydrotechnical facilities, 88 pumping stations, 9 reservoirs with a total water capacity of nearly 607 million m³, and 14 water reservoirs, as well as other land reclamation and water management facilities.

Majority of these objects became useless during the conflict and other part after occupation due to the lack of necessary technical services. The construction of Khudafarin, Maiden Tower and other hydropower stations and repair and construction of Kondalanchay, Hakari and many other reservoirs are temporarily suspended.

More than 300 kahris (underground water source) need repairing because of remaining in the occupied zone. Many rivers, lakes and springs have been renamed and Armenianized. The liberation of Sugovushan hydropower from occupation made it possible to provide irrigation water to nearly 96,000 hectares of land in 7 regions of the republic (Tartar, Aghdam, Barda, Goranboy, Yevlakh, Agdara and Agjabedi).

In recent years, comprehensive measures have been implemented to restore the water sources and hydrotechnical facilities with disrupted ecological balance to improve sustainable water supply in the region.

References

1. Alekperov A. B., Agamirzayev R. Ch., Alekperov R. A. Geoenvironmental problems in Azerbaijan. Urban groundwater management and sustainability. Springer 2006, p. 39-58
2. Geology of Azerbaijan. VIII issue, Baku “Nafta-Press, 2008, 380 p.
3. Problems of ecological security of water resources of Karabakh. Materials of the Scientific-Technical Conference “Radiological and Chemical risks in the territories liberated from occupation”, 28-29 October, 2022 Baku, p. 84-86.

ECOLOGICALLY EFFECTIVE TREATMENT OF POLLUTED RIVER WATERS

Ayten Samadova[1], Sevinj Hajiyeva[1], Islam Mustafayev[2,3]
[1]Baku State University,
[2] Institute of Radiation Problems MSE AR,
[3]Azerbaijan University of Architecture and Construction,
aytan.samad@gmail.com

The assessment of the environment in areas affected by military conflicts is important and relevant. Continuous monitoring of these territories is extremely necessary. An excessive amount of any parameter in the water can lead to the disruption of the ecosystem. In this regard, rivers that originate from neighboring territories and pass through such areas are of greater importance. At the same time, metals and many chemical parameters must be constantly controlled due to their impact on living organisms [1–2]. To organize the eco-chemical assessment of the Okchuchay River, the dynamics of concentration changes along the water flow in January were studied [3]. It was found that during January, the levels of ions such as manganese, molybdenum, and iron in the Okchuchay River exceeded the permitted limits. Excess manganese disrupts plant development and affects metabolic processes in animals [4]. It makes the central nervous system highly sensitive. When the allowable amount is exceeded, characteristic manganese-induced parkinsonism syndrome is observed in living organisms. It affects the reproductive process of living beings. Additionally, when humans consume water with a high concentration of manganese, it causes intoxication, memory disorders, and disruption of the lymphatic system [5].

The study was conducted on the Okchuchay River within the territory of Azerbaijan (Burunlu village). An Etrex 10 device was used to determine the coordinates of the sampling location. The Mn ion was analyzed in the water sample. The elemental composition was determined using an atomic absorption spectrometer. The research was carried out in accordance with ISO 11885.

The Mn ion was first determined in the collected sample. Subsequently, sorbents were used to reduce its concentration in drinking water. Initially, zeolite was used as a natural sorbent. It was found that its application reduced the concentration by 23 times. Another sorbent used was bentonite clay, and it was observed that this second natural sorbent reduced the manganese ion concentration by up to 45 times. In contrast, the reduction achieved with activated carbon was only up to 2 times—from 363 µg/L to 176 µg/L. Thus, the effectiveness of the natural sorbents used for the removal of manganese ions from freshwater sources increases in the order of activated carbon < zeolite < bentonite clay.

References

1. Sevinj Hajiyeva, Islam Mustafayev, Aiten Samadova. (2025). Eco-chemical study of drinking water pollution (case of Okhchu River). PPOR, Vol 26, N3, p.347-372.
2. Aiten Samadova, Sevinj Hajiyeva, Islam Mustafayev. (2024). Eco-Chemical Study of Freshwater Sources Contaminated with Mining Wastewater. Journal of Baku Engineering University-Advances in Chemistry and Chemical Engineering. Volume 8, Number 1, p.29-34.
3. Samadova Aiten Aftandil, Hajiyeva Sevinj Rafik, Mustafayev Islam Israfil. (2023). Ecological assessment of pollution of the Okchuchay River. National Environmental Priorities and Global Economic Threats: New Challenges, Opportunities and Perspectives. 15-16 december, p.44. (in Azeri)
4. Hajiyeva S.R., et.al. (2021). Chemical ecotoxicology, 288 (in Azeri)
5. Filov V.A. (2004) Chemical pollutants of the environmental, toxicology and information issues. Ros.chem. journal. t. 48. № 2, p.4-8. (in Russian)

MONITORING OF LAND, WATER AND VEGETATION IN SOURCES IN THE LIBERATED ZANGILAN DISTRICT (OKCHUCHAY AND SURROUNDING AREAS)

A.G.Gaziyev, I.B.Mirjalalli, M.I.Babayev, J.G.Gurbanova
Institute of Dendrology MSE of AR
agaziyev@bk.ru

The research was conducted in the surrounding areas of the Okchuchay River, which originates from the Gapijig Mountain (3285 m high) of the Zangezur Range and flows through the liberated Zangilan region. The Okchuchay River, which is extremely polluted with waste from the Gafan and Gajaran mining industries, actually plays the role of a collector that removes industrial waste from the territory of Armenia. The water of the river is so poisoned that no living thing lives here (Abbasov 2005, Pashayev 2006). The soils in the Zangilan region, where its water is used for irrigation, are also at risk of contamination with these substances, and the crops grown there can be a source of danger to the health of the population. As a result of the research conducted in the area, it was determined that the military events had a negative impact on the richness of the local flora. The total amount of chlorophyll synthesized in leaves, which is the basis of life processes in plants, was measured with Chlorophyllometer-SPAD, and the photosynthesis process was studied with a modern Plant Photosynthesis Meter-2021.LI-6400XT system RC-P60 device. The analyses revealed that the total amount of chlorophyll synthesized in plants belonging to the local flora is close to each other. As a result of laboratory analysis of soil samples, it was found that the nutrients that can be absorbed by plants in the samples taken were very poorly supplied with the absorbed ammonia form of nitrogen, moderately supplied with mobile phosphorus, and poorly supplied with exchangeable potassium. The soil environment (pH) is weakly alkaline, with weak salinity. The flora around the Okchuchay River is very rich in terms of biodiversity, and due to its relief structure, it has various climatic factors, so we observed the spread of rare plants. We have recorded the following plants distributed in the area around the Okchuchay River in Zangilan district: *Achillea millefolium* L. (Common yarrow), *Allium ursinum* L. (Bear onion), *Atropa caucasica Kreyer* (Caucasian lady's foot), , *Daphne mezereum* L. (Dwarf birch), *Digitalis ferruginea* L. (Finger foxglove), *Juniperus oblonga* M.B. (Caucasian juniper), *Nasturtium officinale* L. R.Br. (Medicinal fern), Origanum vulgare L. (Black henbane), *Pinus Sosnowsckyi* Nakai (Sosnovsky pine), *Rhamnus cathartica* L. (Murdarcha), *Rosa canina* L. (Dog rose), *Sambucus nigra* L. (Black elderberry), *Thymus nummularius* M.B. (Thyme), *Thymus transcausicus* Ronn (Transcaucasian thyme), *Tilia cordata* Mill (Heart-shaped linden), *Urtica dioica* L. (Stinging nettle), *Vaccinium myrtillus* L. (Blueberry), etc. Each species has its own biological characteristics, and they also form the mechanism of adaptation to climatic and soil conditions to varying degrees. In this regard, species that originally developed in dry climatic conditions preserve and develop their properties. That is why each species has its own characteristic of photosynthesis. Changes in the water-soil environment due to anthropogenic and natural factors are accompanied by serious deviations in their biological characteristics and create problems in the adaptation of species to existing environmental conditions and face the threat of extinction (Mekhtiev, Gul 2006). In this regard, the research carried out is of great importance in the restoration and protection of the richness of the flora of the region against the background of environmental pollution due to military conflicts.

References

1. Sh.M. Abbasov. –Radioactive waste and ecological problems of nuclear energy. ECOINTER, March 2005, p. 14-15.
2. A.Sh. Mekhtiev, A.K. Gul- Technological pollution of the Caspian Sea. Baku "Elm", 2006.
3. A.M. Pashayev et all. - Radioactivity and cosmic rays. Baku "Science" 2006.

ASSESSMENT OF TRANSBOUNDARY ANTHROPOGENIC IMPACT ON THE WATER RESOURCES OF THE OKHCHUCHAY AND ARAZ RIVER BASIN

S.R.Hajiyeva[1], I.I.Mustafayev[2], N.T.Shamilov[1], T.I.Aliyeva[1], H.L.Rafieva[1], A.A.Samedova[1]
[1]*Baku State University*
[2]*Institute of Radiation Problems MSE AR*
aliyevat80@gmail.com

One of the most heavily polluted transboundary rivers in Azerbaijan, the Okhchuchay flows through the Zangilan region and joins the Araz River. Waste from the Kajaran copper-molybdenum processing plant located at the river's source, as well as untreated household waste, is discharged directly into the Okhchuchay. This causes the concentration of heavy metals and other harmful chemical substances in the river to exceed permissible limits. As a result, the pollution of the Okhchuchay leads to the contamination of the Araz River. Although the water volume of the Okhchuchay is approximately 20 times less than that of the Araz, once it flows into the Araz, it can destroy up to 60% of its microflora. This has a severely negative impact not only on the aquatic ecosystem but also makes the water unsuitable for essential human needs and daily use. Starting from the city of Gyumri, the Araz River carries domestic and industrial wastewater from more than 10 industrial cities of Armenia along its course to the border area with Nakhchivan. In particular, tributaries such as the Geder River, Vorotan, and Akhuryan that flow into the Araz from Armenian territory are heavily polluted with toxic substances. Wastewater from industrial facilities in cities such as Razdan, Charentsavan, Abovyan, Yerevan, and domestic sewage from other settlements along the riverbanks is discharged directly into the river. Razdan ranks first in Armenia in terms of water pollution. These rivers contain almost no oxygen; acidity levels, according to recent data, have dropped to pH 2.4[1-5].

Microflora has decreased 200-fold, and even the vegetation along the riverbanks is on the verge of destruction. The results of the analysis of water samples taken from the Araz River are presented in Table 1.

Table 1.
Analysis Results of Water Samples Taken from the Araz River

Indicator	Measurement	Result	Method	Quality standards
pH(20^0 C)	pH unit	7.35	SM 4500-H*B	6.5-9.5
*Turbidity	NTU	40.4	ISO 7027-1	<2.6
*Electrical Conductivity (20^0 C)	µS/cm	2280	SM 2510 B	<2500
*Total dissolved solids (TDS)	mg/L	1475	SM 2540 C	<1000
*Total hardness	mg$CaCO_3$/L	570	SM 2340 C	<350
*Total alkalinity	mmol/L	2.86	ISO 9963	2.8
Carbonate	mg/L	0	ISO 9963	1
Bicarbonate	mg/L	174	ISO 9963	100
*Ammonium	mg/L	<0.1	ASTM D 1426	0.5
*Chloride	mg/L	322	SM 4500 CT B	<350
Nitrite	mg/L	<0.03	SM 4500 NO2-	0.5
Nitrate	mg/L	<0.4	SM 4500 NO3-	<50
*Sulfate	mg/L	451	SM 4500 SO4-	<250
*Arsenic	µq/L	9.1	EPA 200.7	10
*Aluminium	µq/L	<1	EPA 200.7	0.5
Boron	µq/L	98	EPA 200.7	100
Iron	µq/L	8.8	EPA 200.7	200
Manganese	µq/L	1.5	EPA 200.7	50
Zinc	µq/L	22.5	EPA 200.7	500
Nickel	µq/L	<1	EPA 200.7	7
Cobalt	µq/L	3.1	EPA 200.7	10
Chrome	µq/L	<1	EPA 200.7	50
*Molybdenum	µq/L	15.5	EPA 200.7	0.25

Cadmium	µq/L	<1	EPA 200.7	8
Selenium	µq/L	<1	EPA 200.7	10
*Lead	µq/L	7.2	EPA 200.7	10
Beryllium	µq/L	<1	EPA 200.7	0.2
Lithium	µq/L	14	EPA 200.7	-
*Copper	µq/L	5.9	EPA 200.7	1
*Stronsium	µq/L	9	EPA 200.7	7

The results of the physicochemical analyses presented in Table 1 show that the total concentration of certain inorganic substances in the water samples is close to, and in many cases significantly exceeds, the maximum allowable limit for drinking water. In particular, the levels of aluminum, lead, copper, and molybdenum surpass the permissible concentration thresholds, which is a direct result of industrial waste discharged into the Araz River via the Okhchuchay. Additionally, the analysis results indicate that the amount of sulfate ions exceeds the standard limits. This, in turn, affects the biogeochemical processes of carbon, nitrogen, and phosphorus. Sulfate pollution can have toxic effects on aquatic plants and animals, including fish, invertebrates, and amphibians, and it also poses serious health risks to humans.

References

1. Ismayilov, R.A. (2015). *Assessment of the water quality of rivers flowing from the territory of Azerbaijan into the Caspian Sea based on chemical indicators.* Water Problems: Journal of Science and Technology**,** Baku, No. 1, pp. 119–128.
2. Hajiyeva, S.R. (2021). *Water resources of Karabakh: restoration, efficient use, and ecological assessment.* In Proceedings of the online conference "Biodiversity, Land and Water Resources of Karabakh: Past, Present and Future" (Baku: “Elm” Publishing House), pp. 123-124
3. Huseynov, A.B. (2021). *The Ecological Terror of the Okhchuchay River.* In Proceedings of the online conference

"Biodiversity, Land and Water Resources of Karabakh: Past, Present and Future" (Baku: "Elm" Publishing House), pp.74-75
4. Abduyev, M.A. (2007). *Assessment of the Ecological Status of River Basins Based on Anthropogenic Load.* News of ANAS (Azerbaijan National Academy of Sciences), Earth Sciences Series**,** No. 3, Baku, pp. 93–97.
5. Abduyev, M.A. (2010). *Hydrochemical Problems of Azerbaijan's Transboundary Rivers***.** Proceedings of the Geographical Society of Azerbaijan**,** Vol. XV, Baku, pp. 209–211.

THE IMPACT OF MILITARY CONFLICTS ON RESERVOIRS AND THEIR CONSEQUENCES

Emil Gafarov[1], Nuriyye Abdullayeva[2]
[1]*Azerbaijan University of Architecture and Construction*
[2]*Azerbaijan Technical University*
emilqafarov@inbox.ru, abdullayevanuriyye@aztu.edu.az

The rapid development of scientific and technological progress is currently affecting all areas. One of these areas is the military direction. The use of modern weapons, as well as unmanned aerial vehicles, when the Republic of Azerbaijan liberated the territories occupied by Armenia in the 1990s and in 2020, during military operations, showed that in the future wars will be fought with various means provided to us by scientific achievements. Even remotely controlled equipment will be available here. It is known that intercontinental missiles have been tested and they can hit the target accurately in a short time.

In countries where reservoirs exist, they play a major economic role. They are also considered risky and strategic objects. Reservoirs have exceptional services in the development of the country and in flood risk management. There are more than 150 water reservoirs in the Republic of Azerbaijan and they contribute to the country's economy.

During World War II and various military conflicts around the world to this day, water reservoirs were destroyed and serious losses occurred. Most importantly, these incidents resulted in a large number of human casualties.

As we mentioned, modern military equipment can cause major disasters by destroying water reservoirs.

For example, if the Mingachevir reservoir in the Republic of Azerbaijan were to collapse as a result of military conflicts, more than 10 regions and more than 2 million people could become victims of this disaster.

The following consequences may occur when reservoirs collapse as a result of military conflicts:

-Human casualties as a result of flooding
-Ecological risk due to the impact of water on the environment
-Economic damage
-Emergence of social problems, etc.

THE IMPACT OF RADIATION ON GOLDFISH (*CARASSIUS CARASSIUS AURATUS*)

Rovshan Khalilov[1,2], Chingiz Mammadov[2], Alislam Hashimov[2], Aygun Nasibova[2], Nuray Akbarova[2]
[1]Institute of Radiation Problems MSE AR,
[2]Baku State University
hrovshan@hotmail.com; m_chingiz@yahoo.com

The goldfish (*Carassius carassius auratus*) serves a dual purpose as both a popular ornamental fish and a key subject in scientific inquiry. Belonging to the Cyprinidae family, it is prized for its vibrant look and simple maintenance. However, its most significant attribute for research is its pronounced susceptibility to environmental shifts, establishing it as a cornerstone for experiments in ecotoxicology and radiobiology. These fish, which prefer calm, well-oxygenated waters, can live for 15 years, grow to 20–30 cm, and are mainly herbivorous. Their organisms react strongly to stressors, which makes any genetic, physiological, or behavioral alterations readily observable [6, 7].

It is precisely this high degree of responsiveness that qualifies the goldfish as an excellent subject for studying significant environmental dangers like ionizing gamma radiation. Threats from gamma radiation, used in medicine and nuclear fields, and industrial pollutants such as metal nanoparticles, create a substantial risk to aquatic ecosystems. Fish are widely regarded as highly vulnerable to these factors and are therefore frequently employed as bioindicators to assess the health of aquatic environments. Consequently, research into the effects of radiation on fish species represents a vital and timely area of study within modern ecotoxicology and environmental conservation.

Our latest research demonstrated clear behavioral modifications in goldfish following exposure to gamma radiation. As a species that naturally forms schools, their social dynamics served as a crucial metric. Fish subjected to a 3 Gy dose began to exhibit a progressive loss of schooling behavior, though their feeding patterns remained largely unaffected. By contrast, the group that received a 6 Gy dose underwent more severe changes: they ceased schooling completely, and their foraging instincts were suppressed, leading them to feed as individuals.

These findings underscore a key principle: the severity of radiation's effects is contingent upon both the dosage administered and the age of the fish. While some evidence suggests that low radiation doses might induce temporary adaptive mechanisms, higher doses invariably lead to distinct adverse outcomes. The investigation of these phenomena is not new, drawing on decades of important findings from studies on a wide array of organisms, including plants and laboratory animals like rats [1, 2, 3, 4, 5].

The significance of this work extends far beyond aquatic biology. Since fish are a fundamental component of the food chain, these studies have indirect yet crucial relevance for human health. The extensive existing knowledge of their genetics and physiology, coupled with their practicality for laboratory maintenance, confirms their status as superior subjects for toxicological research [6, 7]. By enabling the documentation of responses from the behavioral to the molecular scale, the goldfish offers a robust platform for future investigations. It thus remains an indispensable tool for advancing the fields of radiobiology and biosafety, assessing ecological dangers, and understanding genetic harm.

References

1. Aygun Nasibova, Rovshan Khalilov, Uzeyir Qasumov, Boris Trubitsin, Alexander Tikhonov. EPR signals in plant systems and their informational content for environmental studies. European Journal of Biotechnology and Bioscience. 4(2). P.43-47. 2016.
2. R.I. Khalilov, A.N. Nasibova. Endogenous EPR-detected ferriferous nanoparticles in vegetative objects. News of Baku University. İ.3. P.35-40. 2010.
3. T.S. Kavetskyy, V.N. Soloviev, R.I. Khalilov, V.A. Serezhenkov, L.I. Pan'kiv, I.S. Pan'kiv, A.N. Nasibova, V.I. Stakhiv, A.S. Ivasivka, M.K. Starchevskyy, Y.V. Pavlovskyy, Y.V. Bondaruk, D.A. Dyachok, L.V. Bodnar, S.Y. Voloshanska. EPR study of self-organized magnetic nanoparticles in biomaterials. Semiconductor Physics, Quantum Electronics & Optoelectronics. 25(2). P. 146-156. 2022.
4. N.R. Amrahov, V.Y. Allahverdiyev, Y.I. Agharzayeva, R.B. Mammadova, S.N. Omarova, F.A. Khudayev, A.N. Nasibova, M. Shoaib, R.I. Khalilov, Z.M. Mammadov. Effect of Verticillium wilt on the antioxidant system and formation of

iron nanoparticles in cotton genotypes. JAPS: Journal of Animal & Plant Sciences. 33(6). P. 1322-1332. 2023.
5. A.N. Nasibova, R.I. Khalilov, M.A. Bayramov, M.F. Bayramova, L.T. Kazimli, R.S. Qasimov. Study of some biophysical and biochemical parameters in stress – exposed laboratory rats (Wistar albino). Journal of Radiation Researches. 8(2). P.41-52. 2021.
6. Woodhead, D.S. (2003). "Effects of ionizing radiation on fish." Journal of Environmental Radioactivity, 66(1–2), 19–30.
7. UNSCEAR (2008). Sources and Effects of Ionizing Radiation: Report to the General Assembly, with Scientific Annexes. United Nations Scientific Committee on the Effects of Atomic Radiation.

ASSESSMENT OF THE ECOLOGICAL STATUS OF RIVERS AND A RESERVOIR IN THE LIBERATED REGIONS OF AZERBAIJAN

Alakbar Hasanov, Abulfas Allahverdiyev
Azerbaijan Oil and Industry University
alakbar48-48@mail.ru, Abulfas.allahverdiyev@gmail.com

A comprehensive assessment of the ecological condition of Azerbaijan's liberated territories, particularly the Karabakh region, is essential to facilitate the return of the population to these areas. During the prolonged period of occupation, it was not possible to obtain reliable information regarding the environmental status of natural resources, including river waters and reservoirs. This lack of data posed limitations on the effective utilization of these resources. The present study focuses on the rivers of Karabakh, especially those flowing through the liberated territories. These rivers, which are widely used both for irrigation and as sources of drinking water, were analyzed to assess their pollution levels and ecological suitability.

Following the liberation of these areas, water samples were collected from rivers and reservoirs to determine water quality and its potential for various uses. The samples were analyzed for a range of physical and chemical parameters, including pH, dissolved oxygen, ions (chloride, sulfate, nitrate, nitrite, ammonium, orthophosphate), and heavy metals (iron, zinc, copper, lead, etc.). The results were compared with the maximum permissible concentrations established by national water quality standards.

According to the findings, all analyzed parameters were within acceptable limits, indicating that the rivers in the Karabakh region meet ecological safety standards and are suitable for both agricultural and drinking water use.

It is recommended that environmental monitoring be continued in the rivers and reservoirs to ensure the protection of water quality and to support the sustainable development of the region.

References

1. M.Məmmədov. Azərbaycan Hidroqrafiyası. Bakı. 2012
2. Q.Məmmədov, M.Xəlilov Ekologiya və Ətraf mühitin mühafizəsi. Elm. 2005
3. Е.В. Пименова. Химические методы анализа в мониторинге водных объектов. Пермь, 2011
4. Anuradha Garg, Brijesh K.Yadav, Diganta B.Das, Paul J.Wood Improving the assessment of polluted sites using an integrated bio-physico-chemical monitoring framework. Chemosphere Volume 290, March 2022, 133344, https://doi.org/10.1016/j.chemosphere.2021.133344

ENVIRONMENTAL RISKS AND CONSEQUENCES OF MILITARY CONFLICTS AND THEIR IMPACT ON GROUNDWATER

Ismayil Mammadov
Institute of Geology and Geophysics MSE AR
i.r.mamedov@gmail.com

Military conflicts have a significant impact on the natural environment, particularly on water resources, and are capable of disrupting the natural state of the aquatic environment, including groundwater. Under combat conditions, the probability increases of contaminating aquifers with explosive products, technical fluids, petroleum products and other hazardous substances, destroying water supply infrastructure and altering hydraulic connections between surface and groundwater, as well as destroying infrastructure related to water resource utilization. Such impact can be both direct—through explosions and chemical substance releases—and indirect—through changes in regime, soil erosion, and contaminant migration

The Republic of Azerbaijan, being a region where active military operations have occurred in recent years to liberate approximately 20% of its lands from nearly 30 years of occupation, faces the necessity of comprehensive assessment of the hydrogeological environment and its ecological condition. These occupied territories, being mountainous and foothill parts of the republic, played a very important role in the formation of the most important of all natural resources—groundwater—as these territories served as their recharge areas. It is precisely here that key sources of artesian basin recharge are formed, providing drinking and domestic water supply for a large population [1].

Particularly sensitive to such impacts are the foothill zones in the now-liberated territories, which essentially became battlefields, where horizons of stratified-porous waters of infiltration genesis are widespread. These waters typically have a high degree of vulnerability to contamination, and recovery after anthropogenic impacts occurs extremely slowly. Under foothill conditions, where the hydrogeological situation is complex, such changes can lead to long-term consequences for both the ecological and water balance of the region. This may manifest in water quality degradation, aquifer depletion, and increased risk of water resource deficit [2].

One solution to the aforementioned problems and ensuring sustainable water resource management in the post-conflict period could be the development of a groundwater formation model for foothill zones, where pollution-sensitive stratified-porous waters are predominantly distributed. This will allow identification of the most vulnerable areas that may be subject to anthropogenic factors, including military impacts with the aforementioned consequences, and will also contribute to solving problems of minimizing environmental risks and restoring disrupted natural processes.

References

1. Risk of Emergency Situations in the Areas Liberated from Occupation. Scientific and Technical Conference (21–22 May 2021). Report Abstracts. Baku: Publishing House "Müəllim", 2021. 160 p.
2. Israfilov, Y.G., Panakhov, A.M., & Shakhsuvarov, A.S. Geology of Azerbaijan. Vol. VIII. Hydrogeology and Engineering Geology. Baku: "Nafta-Press", 2008. 380 pp.

RF-PCER FRAMEWORK: AN INTEGRATED MODEL OF POST-WAR ENVIRONMENTAL SUSTAINABILITY (GEORGIA CASE STUDY)

M.Tsatsanashvili[1], G.Tatishvili[2], L.Kvinikadze[2], M.Gerlini[3]
[1]*Georgian Technical University,*
[2] *Rafiel Agladze Institute of Inorganic Chemistry and Electrochemistry of Iv. Javakhishvili Tbilisi State University,*
[3]*University of Siena, Italy*
m.tsatsanashvili@yahoo.com

The 2008 Russian-Georgian war made environmental management and security an important component of the consideration of contemporary military operations. The conflict caused serious damage to the integrity of Georgia's ecosystem. About 950 hectares of forest in the Borjomi-Kharagauli National Park were destroyed by fires, including 230 hectares of a unique forest massif. As a result of the hostilities, agricultural activities in Georgia were forced to cease on about 40% of the territory. This significant risk factor negatively affects the condition and productivity of cultural landscapes. The aquatic ecosystem was damaged. Military actions and destruction of infrastructure led to the pollution of irrigation waters with heavy metals and oil products, which pose a threat to agriculture and public health. (Government of Georgia, Ministry of Foreign Affairs, 2008);

The paralysis of the State Institutions and the lack of security guarantees have significantly limited both local and international mechanisms for environmental monitoring and response. The latest resolution of the UN Environment Assembly (UNEP/EA.6/Res.12) confirms that the restoration of post-conflict ecosystems is the basis for international stability and environmental sustainability. Given that the restoration of ecosystems takes at least two to three decades (Krampe et al., 2025), it becomes obvious that overcoming the damage caused by military conflicts requires interdisciplinary assessments and comprehensive measures based on ethical and legal principles and institutional approaches;

Restoring environmental sustainability in post-conflict situations requires a comprehensive and multi-level approach. For this purpose, the RF-PCER model (Reduced Forested area, protected areas, Carbon sequestration, and Ecosystem restoration) has been developed, compatible with the Georgia Green Policy 2030, national NDC strategies and UNEA-6 (2024) resolution.

The elements of the RF-PCER model are:

- Environmental damage monitoring: assessment of the state of soil, water resources, forests and biodiversity using modern technologies (GIS, remote sensing);
- Socio-economic analysis: employment, poverty, health and social services;
- Legal assessment: revision of regulations, analysis of their compliance and implementation of new mechanisms;
- Mobilization of technological and methodological innovations (GIS, remote sensing, legal modeling).

RF-PCER can become a platform that creates opportunities for international scientific, legal and institutional cooperation in order to achieve post-conflict environmental sustainability.

References

1. Government of Georgia, Ministry of Foreign Affairs. (2008, August). Report on fires caused by the Russian military in Borjomi Forest. Retrieved from https://georgiamfa.blogspot.com/2008/08/
2. United Nations Environment Assembly. (2024). UNEP/EA.6/Res.12 - Environmental assistance and recovery in areas affected by armed conflict. Retrieved from https://docs.un.org/en/UNEP/EA.6/RES.12
3. Krampe, F., Kreutz, J., & Ide, T. (2025). Armed conflict causes long-lasting environmental harms. Environment and Security, 0(0). https://doi.org/10.1177/27538796251323739

EVALUATION OF ATMOSPHERIC HEAVY METAL DEPOSITION IN THE KARABAKH POST-CONFLICT REGIONS USING LEUCOBRYUM GLAUCUM AS A BIOINDICATOR

Rana Khankishiyeva[1,2]
[1]*Institute of Radiation Problems MSE AR,*
[2]*Azerbaijan University of Architecture and Construction*
r.khankishiyeva@irp.science.az

Mosses are well-established bioindicators for atmospheric pollution due to their exceptional capacity to accumulate airborne contaminants. This study presents the results of moss biomonitoring conducted in the Karabakh region to assess air quality in post-conflict zones affected by military activity. Two biomonitoring techniques were used: passive sampling with native moss (***Leucobryum glaucum***) (A) and active moss bag (B) exposure using commercially available moss samples. Sampling was performed across eight locations (Shusha, Karkijahan, Khankendi, Khojali, Asgaran, Vang, Kalbajar, and Agdere). Heavy metals such as Pb, Cd, Cu, As, and Zn were analyzed using ICP-MS following a 59-day exposure period. Results revealed higher heavy metal accumulation in native moss compared to moss bags, suggesting its effectiveness for long-term pollution assessment.

Notably high arsenic concentrations were found in Karkijahan (3.50 mg/kg), while lead peaked in Agdere (0.82 mg/kg). Zinc and copper were also significantly elevated in Shusha (89.6 and 378.5 mg/kg, respectively), highlighting pollution hotspots potentially linked to prior military and industrial activities (Table 1.).

Differences between the two moss types were attributed to exposure duration and moss surface characteristics. This study underscores the value of moss-based biomonitoring for identifying pollution gradients in regions recovering from armed conflict. Such biomonitoring tools are crucial in guiding environmental remediation and supporting sustainable redevelopment. Future work should include long-term monitoring and local moss species adaptation for enhanced reliability.

Table 1.

Results concentrations of heavy metals in ppm

Samples	Collected area	Pb		Cd		As		Zn		Cu	
		A	B	A	B	A	B	A	B	A	B
1	Shusha	0,57	0,41	0,038	0,035	0,47	0,51	89,6	35,4	378,5	178,7
2	Karkijahan	0,78	0,65	0,055	0,034	3,50	0,51	99,7	68,2	96,5	20,4
3	Khankandi	0,81	0,41	0,065	0,058	0,62	0,25	98,6	98,7	28,5	3,5
4	Khojali	0,78	0,67	0,051	0,034	1,90	0,62	9,7	10,7	5,6	7,5
5	Asgaran	0,79	0,73	0,065	0,041	0,74	0,62	87,5	18,7	10,5	3,7
6	Vang	0,75	0,74	0,037	0,032	0,22	0,17	62,5	52,5	46,7	26,7
7	Kalbajar	0,75	0,39	0,034	0,028	0,62	0,18	102	38,1	68,0	11,5
8	Agdere	0,82	0,67	0,054	0,048	0,61	0,54	198,7	63,2	54,5	4,2

References

Smith, J. A., & Brown, L. M. (2020). Mosses as Bioindicators of Air Pollution. Environmental Monitoring Journal, 45(3), 123-130.

FLOOD DISASTER RISK MANAGEMENT DURING MILITARY CONFLICTS

Habil Huseynov, Aprel Babayev, Maharram Abdullayev
The Academy of the Ministry of Emergency Situations
habil.huseynov.98@gmail.com, aprel.babayev@fhn.gov.az, abdullayevmeherrem10@gmail.com

Armed conflicts pose significant risks to the environment, essential infrastructure, and public safety. This research explores the possible consequences and effects on flood disaster risk management stemming from a military-related failure of the Mingachevir Reservoir dam in Azerbaijan. As we know it is an important water infrastructure system in the South Caucasus. Given Azerbaijan's history of armed conflict, especially in the Karabakh region, there is increasing concern about the potential intentional or accidental harm to critical infrastructure.

Utilizing flood modeling tools and risk assessment, the research identifies the regions that may be impacted by flooding, the at-risk populations, and the possible damage to infrastructure in the Kura River basin. It highlights the heightened dangers that arise during wartime, such as failures in communication, diminished efficiency in emergency responses, displacement of populations, and restricted access to technical resources. Furthermore, the research examines international case studies where military conflicts have coincided with disasters impacting water infrastructure, providing comparative insights. The findings underscore the critical need for coordinated civil-military disaster preparedness, safeguarding vital water infrastructure in accordance with international humanitarian law, and creating contingency plans suited to conflict situations. This research enhances the understanding of how to address environmental security and disaster resilience in areas facing both natural and human-made threats.

References

1. International Committee of the Red Cross (ICRC). (2004). *Protection of Water Infrastructure During Armed Conflicts*. Geneva: ICRC. https://www.icrc.org
2. UNESCO. (2009). *Risk Reduction of Extreme Floods: Sustainable Flood Management Strategies*. Paris: United Nations Educational, Scientific and Cultural Organization.
3. United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA). (2021). *Water Under Fire: Emergencies, Development, and Peace in Fragile Contexts*. https://www.unocha.org
4. https://azertag.az/en/xeber/missiles_fired_from_armenia_into_mingachevir_intercepted-1610247
5. https://ukraine.un.org/en/249742-kakhovka-dam-destruction-inflicted-us14-billion-damage-and-loss-ukraine-government-ukraine
6. BBC News. "Ukraine Dam Collapse: What We Know about the Kakhovka Dam Breach." *BBC News*, June 6, 2023. https://www.bbc.com/news/world-europe-65818705

THE IMPACT OF MILITARY CONFLICTS ON THE ECOLOGICAL CONDITION OF RIVER BASINS

A.Fatdayeva, U.Alasgarova, G.Ahmadova
Azerbaijan Ministry of Defense Industry, National Aerospace Agency, Institute of Ecology
fetdayev.hamlet@gmail.com, gunel.ahmedova89@mail.ru, ulkerelesgerli1995@mail.ru

One of the natural ecosystems directly affected by all types of military conflicts is rivers and their drainage basins. During this period, their ecological condition is affected by multidimensional and long-term ecological consequences. Explosions from the use of weapons, the dispersion of harmful waste from military equipment, the destruction of industrial and infrastructure facilities in the basin, as well as the hydrographic network and forest cover, and the forced displacement of the population occur. As a result of explosions and bombings, riverbeds are deformed and even the direction of water flow is altered. Residues of ammunition, fuel leaks and the operation of military equipment lead to contamination of river waters with heavy metals and chemicals. It is no coincidence that during the 30-year occupation of certain territories, the irrigation and water management infrastructure of our Republic was completely destroyed, the water regime of the rivers flowing through those areas was disrupted and as a result, the entire ecosystem balance in the Lesser Caucasus region was altered. It must be noted that during the occupation, there were 9 water reservoirs, 7 water bodies, 6426 km of irrigation networks, 2 hydrological junctions, 330 km of collector-drainage networks, 8003 hydraulic structures, 88 pumping stations, and 1429 subartesian wells under enemy control. In Azerbaijan, 125800 hectares of irrigated land were occupied. According to some sources, the economic damage caused to our country by the occupation of these territories for nearly thirty years exceeded 100 billion USD.

On the other hand, the deliberate deforestation in military conflict zones has intensified soil erosion, which in turn has increased sediment flow into rivers. As a result, the use of water for drinking purposes in downstream areas has become more difficult. All rivers flowing through the conflict zone are tributaries of either the Kura or Aras rivers. Such events have abruptly altered the habitat for fish and other aquatic life that have lived in these rivers for thousands of years, thereby leading to a decline in biological diversity.

Political tensions have further complicated the distribution and management of water resources over border rivers shared by conflicting parties. The disruption of transboundary water management cooperation has resulted in the ecological condition of these rivers being left without oversight.

During the 30-year occupation, the extent of damage caused by military conflicts to rivers and their drainage basins varied across different hydrological regions. Globally, statistical indicators of the impacts of military conflicts on river basins are as follows: deterioration of water quality is observed in 50–90% of rivers; a decline in biodiversity places 30–70% of species at risk; the costs of cleaning and restoration range from millions to billions of dollars and hundreds of water infrastructure facilities are reported to have sustained damage.

Thus, the upper reaches of the hydrography of the Lesser Caucasus have undergone severe degradation over the 30 years of enemy exploitation. The reckless and chaotic use of water bodies has led to drastic changes in many hydro-ecological parameters. Therefore, all water resources in these areas must be comprehensively re-examined in accordance with modern requirements, and new recommendations for their regulation must be developed. In this regard, the use of aerospace methods and satellite data will enable the acquisition of results that stand out for their informativeness and accuracy.

References
1) Araz Qurbanov Azərbaycan Respublikasının Prezidenti yanında strateji araşdırmalar mərkəzi: "Hidroböhran, Hidromünaqişələr və Hidrostrategiya" Bakı 2013
2) Z.S.Musayev, K.M.Məmmədov, M.S.Zərbəliyev "Su Ehtiyatlarının İnteqrasiyalı idarə olunması" Bakı 2009

HYDROECOLOGICAL IMPACTS OF MILITARY ACTIVITIES ON WATER STORAGE INFRASTRUCTURE

Akif Aghbabali[1], Hamlet Fatdayev[2]

[1]*Ministry of Science and Education of the Republic of Azerbaijan, Baku State University*

[2]*Azerbaijan State Water Resources Agency, Scientific Research Institute of Water and Amelioration*

fetdayev.hamlet@gmail.com

Water bodies play a vital role in environmental protection and the sustainable development of the agricultural sector. In recent years, it has become increasingly common for water resources to be exploited during military operations to exacerbate hydro-ecological tensions and exert pressure on the opposing side. In 2016, the Parliamentary Assembly of the Council of Europe (PACE) adopted a resolution entitled "Inhabitants of frontier regions of Azerbaijan are deliberately deprived of water", highlighting this issue. The impact of military operations on water bodies manifests not only through environmental consequences but also through legal and political implications. Under international humanitarian law, the deliberate targeting of civilian infrastructure constitutes a war crime. In general, the targeting of water bodies can further escalate international conflicts.

The risks associated with military operations affecting water bodies (such as dams, reservoirs, lakes, rivers, etc.) are multidimensional, encompassing agroecological and socio-economic consequences. One of the most prominent among these is the ecological risk. During military operations, water pollution occurs as explosives, fuel, and other chemical substances infiltrate aquatic systems, posing serious threats to both human health and ecosystems. This contamination accelerates environmental degradation-including the destruction of flora and fauna due to flooding and soil erosion-and leads to significant disruptions in agriculture and food security. Agricultural productivity and food security are particularly vulnerable to these disturbances. The deliberate destruction of irrigation systems or manipulation of water supply regimes disrupts agricultural water availability, resulting in reduced yields and food shortages. Physical damage to water infrastructure and systems during hostilities can lead to downstream flooding, inundation of land, and even loss of life.

During the Karabakh conflict, the control and use of water resources gained strategic significance from both military and political standpoints. The conflict extended beyond territorial and ethnic disputes to encompass issues related to access to and control over water supplies. The water resources in the territories liberated from occupation comprise approximately 780 million m^3, accounting for 20% of Azerbaijan's domestic water reserves. During the occupation, Azerbaijan was deprived of access to major rivers such as the Tartar and Hakari, resulting in serious challenges in supplying drinking water and irrigating farmlands, especially during the vegetation period. Armenian forces engaged in acts of ecological terror by obstructing the natural flow of these rivers to the foothill regions.

The Sarsang reservoir, which had the capacity to supply irrigation water to nearly 100,000 hectares of agricultural land in six Azerbaijani districts, came under the control of Armenian armed forces during the conflict. Over the years, the Azerbaijani side observed that water from the reservoir was not released in a planned manner. As a result, the region experienced severe droughts in the summer and destructive floods in the winter. The release of water was weaponized to inflict damage on agriculture and the environment, thus functioning as a form of agroecological and hydro-ecological pressure. Moreover, the sudden release or withholding of water posed serious threats to downstream settlements.

In this context, during the occupation period, water resources were systematically employed as tools of military and political coercion. The deliberate destruction of irrigation systems, mining of dams and canals rendered the use of water resources perilous. These practices led to widespread agroecological disruption, including the devastation of cultivated lands, decreased productivity, and a breakdown of agricultural-economic life in the region. The scarcity of drinking water also contributed to social unrest in various districts. Ecological changes such as swamp formation or desiccation were frequently observed in the affected ecosystems.

Following the 44-day Patriotic War, during which Azerbaijan restored its territorial integrity, numerous water infrastructures, including the Sarsang reservoir, returned to Azerbaijani control. This development has opened up significant opportunities for improving water supply, irrigation, and the overall ecological situation in the region.

References

1. Resolution No. 2085 of the Parliamentary Assembly of the Council of Europe (PACE). 26.01.2016
2. S.Ə. İsmayılova. İşğaldan azad olunmuş ərazilərin su ehtiyatları. “Azərbaycanın su təsərrüfatı sektorunun inkişafı Ümummilli lider Heydər Əliyevin adı ilə bağlıdır” mövzusunda elmi-praktiki Konfrans materialları. Bakı, 5 may 2023-cü il. Səh.105-109.
3. https://ordu.az/az/news/144368

SPECIES DIVERSITY OF PHYTOPLANKTON IN THE WATER BODIES OF THE KARABAKH REGION AND THE ECOLOGICAL EFFECTS OF THE WAR

Shakar Mukhtarova, Yagut Malikli, Shafiga Umudova
Institute of Botany MSE AR
shakar.mukhtarova@mail.ru, malikliyaqut3@gmail.com, ushafiga@gmail.com

Algae are one of the most important components of aquatic ecosystems. They play a key role in oxygen production and the formation of the food chain. At the same time, algae have an important function in water purification and maintaining the balance of the ecosystem. During wars, rivers, lakes and groundwater resources are severely damaged by weapons, explosives and various chemical pollutants. This pollution and physical destruction negatively affects the environment in which algae live. As a result, the mass destruction of algae and a sharp decline in their populations are observed. The decline of algae leads to a decrease in oxygen levels in the aquatic environment, which negatively affects the vital activity of other aquatic organisms. Furthermore, the extinction of algae causes a chain reaction in the aquatic ecosystem, leading to a reduction in biodiversity. Pollution caused by war limits the access of algae to light and nutrients needed for photosynthesis. These factors prevent the healthy growth and reproduction of algae. Thus, wars threaten the sustainability of aquatic ecosystems and cause long-term consequences by disrupting ecological balance. At the same time, rivers have historically been among the most sensitive aquatic ecosystems to anthropogenic changes.

Before the war, the Okhchuchay and Basitchay rivers, located in the Karabakh region and known for their rich biodiversity and ecosystems, were dominated by algae species belonging to various taxonomic groups. However, as a result of research conducted after the war, it was determined that the species diversity in these rivers has significantly decreased. This decline has seriously damaged the structural and functional integrity of aquatic ecosystems. Microalgae (phytoplankton, phytobenthos) and aquatic macrophytes, which form the basis of the trophic chain of various water bodies, are sensitive to changes in abiotic and biotic environmental conditions and respond to numerous anthropogenic impacts in aquatic systems. The war has a significant impact on algae and marine ecosystems, primarily through pollution and physical destruction. After the liberation of the occupied territories, physico-chemical and biological monitoring was carried out in connection with the restoration of the Okhchuchay and Basitchay rivers. As a result of observations in the studied water bodies, it was determined that the species diversity of phytoplankton is formed mainly due to representatives of the Chlorophyta and Bacillariophyta divisions. The species diversity of other taxonomic groups was found to be considerably low. Overall, the phytoplankton composition in these water bodies was poor and characterized by low biodiversity. Although the phytoplankton species composition in the studied water bodies was poor, some species were dominant in the community. The main share in the structure of phytoplankton was represented by species belonging to the division Bacillariophyta, such as *Navicula cryptotenella* Lange-Bertalot, *Caloneis silicula* (Ehrenberg) Cleve, *Pinnularia viridis* (Nitzsch) Ehrenberg, *Nitzschia linearis* W. Smith, *Cymbella cymbiformis* C. Agardh, and *Ulnaria ulna* (Nitzsch) Compère. In addition, *Oscillatoria limosa* C.Agardh ex Gomont and *Oscillatoria margaritifera* Kützing ex Gomont belonging to the Cyanophyta were also observed to have an important place in the flora. The dominance of these species can be considered a significant indicator reflecting the trophic state of the ecosystem and the biophysical characteristics of the environment.

References

1. Azərbaycan Milli Elmlər Akademiyası mərkəzi Nəbatat Bağının Elmi Əsərləri, VIII cild 2011: 123-127

2. Караева Н.И., Мухтарова Ш.Дж. (1987) Редкие для СССР и новые виды пеннатных Диатомовых водорослей (Bacillariophyta) Азербайджана. Ботан. журн., т. 72, 2011 - № 7 –С.943-948
3. Мухтарова Ш.Дж. (2000) Материалы об альгофлоре водоёмов южных / склонов Большого Кавказа. «Biologiyanın müasir problemlari» mövzusunda elmi konfransın materialları. BDU, Bakı: -2000-s.169
4. M.A. Müseyibov Azərbaycanın fiziki coğrafiyası. Bakı-1998 - s: 156-195
5. S.K. Cəfərova., Ş.C. Muxtarova Azərbaycan Şirin sularının Diatom yosunları (məlumat siyahısı, sinonimləri, ekologiyası və yayılması). Bakı "Elm" – 2018 s: 4-10
6. Yaqut Malikli, İsmayilli rayonunun kontinental su hövzələrininin alqoflorasina dair VII international scientific conference of young researchers,2023 s 320-321
7. Голлербах М.М., Косинская Е.К., Полянский В.И ю определитель прес-новодных водорослей СССР: В 14-ти выпусках. Вып 2: Синезеленые водоросли – Москва: Советская наука, 1953, 327 с
8. Zoe, V.F, Benjamin. K. (2010) Silica Use Through Time: Macroevolutionary Change in the Morphology of the Diatom Fustule Geomicrobiology Journal volume 27.
9. www.algaebase.org

IMPACTS OF MILITARY CONFLICTS ON BIODIVERSITY IN KARABAKH

Elshad Mammadov, Tunzale Isgandarova
Azerbaijan University of Technology
elshad1952@mail.ru, isgandarova65@mail.ru

Prior to the military conflicts, there were Basitchay State Nature Reserve and Garagol State Nature Reserve in these areas. In addition, Lachin State Nature Prohibition, Gubadli State Nature Prohibition, Arazboyu State Nature Prohibition, and Dashalti State Nature Prohibition, also operated in these areas, all of which played an important role in the protection of biodiversity. Thus, before the military conflicts, a number of valuable species included in the "Red Book" of the Republic of Azerbaijan, including 24 fauna and 69 flora specimens, were protected in a strict reserve regime in all these specially protected areas. The vast majority of them were severely affected or completely destroyed as a result of military operations and ecological vandalism conducted in the region. Up to 2,500 plants grow in these areas, including more than 460 wild trees and shrubs [1]. Before the occupation, the forest fund of Karabakh and the surrounding areas was more than 247352 hectares, of which approximately 13197,5 hectares comprised valuable tree species [2]. Of the more than 460 wild tree and shrub species common in the forests of Azerbaijan, 95 trees (107 species in Azerbaijan), 290 shrubs and 19 subshrub species can be commonly found in the natural forests of Nagorno-Karabakh and adjacent territories located in the center and south of the Lesser Caucasus. During the military conflicts, 261 thousand hectares of forest areas were completely destroyed in our territories. 13 thousand 197 hectares of these are valuable areas. As a result of the military conflicts, 8 valuable forest areas located in our specially protected areas that were occupied were plundered and destroyed. In addition, 152 trees that had been under occupation for nearly 30 years and had the status of natural monuments were brutally destroyed and wiped off the face of the earth as a result of unprecedented and terrible plundering. Of these documented trees, 10 were in the mountainous areas of Karabakh, 4 in Aghdere, 2 in Khojavend, 85 in Aghdam, 14 in Jabrayil, 6 in Zangilan, 10 in Gubadli, 10 in Lachin, and the remaining 11 in the Fuzuli region. As a result of military conflicts, 215 natural monuments, 145 centuries-old, documented, valuable Eastern plane trees with a height of 45 meters, a diameter of 6-8 meters, and an age of 120-2000 years, were ruthlessly cut down and removed. One of the natural monuments that fascinated people with its unparalleled beauty before the military conflicts and had no analogues in the world is the only natural plane forest in Europe with an area of 117 ha located in the Zangilan region in the south of the Lesser Caucasus, in the Basitchay valley. Thus, a large number of centuries-old plane trees have been protected in the Basitchay State Nature Reserve. Those plane trees were also brutally destroyed during military conflicts. In the Kalbajar region, 968 hectares Corylus colurna L., which were included in the "Red Book" of Azerbaijan, were cut down and taken to various countries. Corylus colurna L., which was found very late in other areas of our republic and is 15-20 m high, is a rare, endemic plant species of Azerbaijan. The area is also rich in valuable fauna. Before the occupation, the species that were widespread here (4500-5000 species) constituted up to 20% of the total arthropod population in Azerbaijan. As a result of military operations in the occupied territories, 56 species of insect fauna became rare, endemic and endangered. In conclusion, it should be noted that military conflicts have led to a decrease in biodiversity in the area.

References

1. https://science.gov.az/ru/news/open/15228
2. https://botany.az/az/news/3113

STUDY OF THE ENVIRONMENTAL IMPACT OF MILITARY OPERATIONS

Ruhangiz Guliyeva, Namig Muradov
National Aerospace Agency of Azerbaijan Ministry of Defense Industry
ruhengizq@mail.ru

The Karabakh economic region is located in the historical Karabakh lands of Azerbaijan, covering mountainous and plain areas in the southeast of the Lesser Caucasus. The widespread use of destructive weapons and heavy equipment in war zones has caused severe damage to the nature of the area, which has increased the amount of damage to the environment in the fragile mountainous areas of the Lesser Caucasus with thin soil layers and slopes prone to erosion, and has further aggravated the consequences. Studies show that irreversible mutations occur during the use of firearms, similar to radioactive radiation. The use of such weapons has a negative impact on the environment. The negative impacts on the landscape during the war can be summarized as follows:

1) Mechanical damage to the environment

When heavy machinery moves, the soil cover is torn off and compacted in places where sand is located, which leads to the development of erosion and loss of soil fertility. Heavy military equipment destroys the soil cover. So, for example, when a column of 10 tracked vehicles passes through a field 1 km long, about 4 thousand m2 of land is destroyed. Numerous trenches, trenches, and shell fragments spoil the view of infrastructure facilities.

2) Chemical pollution of the environment

Chemical pollution of the landscape is caused not only by toxic substances, but also by a number of heavy metals contained in the shells and other ammunition used. Soil samples were taken near the test site to determine the amount of heavy metals in the soil cover. Monitoring of soil contamination was carried out in an accredited and certified laboratory using the X-ray fluorescence method. A quantitative chemical analysis of the soil sample was carried out for the content of heavy metals: arsenic, lead, zinc, cobalt, nickel, copper, chromium, manganese, strontium, iron and titanium. The results of the study are shown in table 1.

Table 1.
Analysis results of tests carried out to determine the content of heavy metals and acidity (pH) in the soil

Name of chemical element	Measurement results. mg/kg									
	pH	**Ti**	**Fe**	**Cr**	**Ma**	**Ar**	**Pb**	**Ni**	**Cu**	**Zn**
Amount on city streets	7,8	4100	61,9	105,0	777,8	24300,0	18,5	33,2	43,8	194,2

The measurement results show that the amount of chromium, cobalt, arsenic and lead exceeds the norm. The fact that the amount of lead in soil samples exceeds the norm is explained by the long-term use of tetraethyl lead accumulated in the soil as an additive to the fuel of military vehicles.

3) Pollution of the environment with oil products

It is impossible to imagine a modern army without the use of fuels and lubricants. Internal combustion engine combat and special vehicles and other technical devices consume significant amounts of gasoline, diesel fuels, oils and lubricants. The amount of fuel consumption of modern armored vehicles was investigated in our study.

THE IMPACT OF MILITARY OPERATIONS ON WATER RESOURCES AND ECOLOGICAL HAZARDS

N.N.Allahverdiyeva, A.M.Aghakishizade
National Aerospace Agency
Institute of Space Research of Natural Resources
nigarsadiyeva66@gmail.com

The risks created by military operations in water reservoirs (dams, reservoirs, lakes, and rivers) and their sediments are multifaceted and dangerous. These risks can be assessed from ecological, technical, and human safety perspectives.

Unexploded ordnance remaining in open water bodies poses a direct threat to humans and wildlife. Such ordnance can settle on the seabed or lakebed, remaining active for years and potentially detonating upon accidental contact. Additionally, explosive substances and chemical components in ammunition (such as TNT, RDX, etc.) seep into the water and sediments, exerting toxic effects. These substances negatively impact fish, microorganisms, and other aquatic life.

The Karabakh region has suffered severe damage to natural resources, especially water resources, due to over 30 years of military operations. Although the main focus during the conflict was human safety, water reservoirs and their sediments as ecological systems have also been severely affected.

One of the main water reservoirs in Karabakh is the Sarsang Reservoir, which is critically important for irrigation and drinking water supply in the region. However, during the war, the usage and water flow of this reservoir were deliberately restricted. As a result, more than 100,000 hectares of farmland in districts such as Tartar, Barda, Aghdam, and Aghjabadi have suffered from water shortages. This has significantly impacted the agricultural sector, local economy, and daily life of the population [1].

Military operations in the Karabakh region have created multifaceted and profound risks to water reservoirs and their sediments, causing serious problems in terms of ecological, technical, and human safety. Unexploded ordnance and toxic chemical residues in water bodies endanger aquatic life, disrupt agricultural activities, and pose risks to the health of the local population. Pollution of water resources leads to the disruption of ecological balance, long-term health issues, and economic difficulties.

References

Ministry of Ecology and Natural Resources of Azerbaijan. (2021). Status of Water Resources in the Karabakh Region and the Impact of the Conflict. Baku.

IMPACT OF CONFLICTS ON RENEWABLE NATURAL RESOURCES: FORESTS, SOIL AND BIODIVERSITY

Asef Aghayev
Azerbaijan Architecture and Construction University
Asaf.aghayev@azmiu.edu.az

Armed conflicts profoundly impact renewable natural resources—particularly forests, soil, and biodiversity—causing environmental degradation that often persists long after hostilities cease. While war is typically analyzed in terms of human casualties and political disruption, its ecological footprint is significant and frequently overlooked. This extended summary outlines the primary ways in which conflicts damage these three critical natural systems and explains the long-term consequences for environmental recovery and sustainability.

1. Forests: Strategic Targets and Collateral Victims

Forests are frequently situated in contested or remote regions and often become battlegrounds or strategic zones during armed conflicts. They suffer from both intentional destruction—such as through scorched-earth tactics or targeted deforestation—and collateral damage from shelling, wildfires, and bombings. The collapse of governance during war also enables illegal logging and unsustainable harvesting of wood for fuel and construction.

Examples from countries like Vietnam, Syria, and parts of Central Africa show how war not only causes deforestation but disrupts forest ecosystems, endangering wildlife and accelerating climate change through carbon release. The breakdown of forest management programs during conflict further reduces resilience to environmental threats like flooding and erosion.

2. Soil: The Hidden Casualty

Soil degradation is a less visible but equally devastating impact of war. Explosions, military vehicles, and infrastructure damage disrupt the structure of soil, causing erosion, compaction, and the loss of fertility. In addition, chemical contamination from weapons, fuel leaks, and destroyed industrial sites introduces toxic substances into the ground.

In conflict zones like Iraq, Syria, and Ukraine, warfare has contributed to the desertification of arable land. Agricultural collapse due to damaged irrigation systems and land abandonment compounds the problem, undermining food security and threatening long-term land productivity. Rehabilitating damaged soils can take decades and requires major investments in ecological restoration.

3. Biodiversity: Collateral Damage to Ecosystems

Biodiversity—defined as the variety of living organisms within ecosystems—is highly vulnerable during war. Habitat destruction, unregulated poaching, and pollution severely disrupt species populations and ecological balance. Conservation programs and protected areas often cease to function during conflict, exposing wildlife to human exploitation and displacement.

Species loss is not only a local concern but has global implications, especially when conflict affects regions of high biodiversity. In places like the Democratic Republic of Congo or Yemen, armed groups, displaced civilians, and survival economies lead to the decline of endangered species, from large mammals to marine life. War-related pollution, including oil spills and untreated sewage, further contaminates habitats and waterways.

4. Mechanisms of Environmental Harm

The damage to renewable resources occurs through multiple, overlapping mechanisms:

- Direct destruction: from bombings, fire, and chemical use.
- Resource exploitation: timber, wildlife, and minerals are harvested unsustainably to fund war efforts.
- Neglect and collapse of governance: environmental regulations and monitoring are suspended or ignored.
- Displacement of populations: leading to unsustainable pressure on ecosystems in new areas.

These processes undermine the natural regenerative capacities of forests, soil, and wildlife systems, often pushing them beyond the point of recovery.

5. Long-Term Consequences and Need for Recovery

The environmental costs of war continue long after peace agreements are signed. Forests may take decades to regenerate; contaminated soil may never fully recover; and lost species may be gone forever. Furthermore, post-conflict reconstruction often overlooks environmental priorities, focusing instead on rapid economic and infrastructural development.

To mitigate these effects, post-war recovery plans must include environmental restoration, landmine clearance for ecological access, and stronger legal accountability for environmental war crimes. Integrating ecological security into peacebuilding efforts can help ensure sustainable development and prevent resource-driven conflicts in the future.

Conclusion

Conflicts can turn renewable resources into non-renewable ones by destroying the natural systems that allow them to regenerate. Forests, soil, and biodiversity are interconnected pillars of environmental health that suffer immense damage in war zones. Without targeted environmental protection during and after conflict, the damage can become irreversible—threatening food systems, water resources, climate stability, and the well-being of future generations. Recognizing and addressing this dimension of conflict is essential for sustainable peace and ecological resilience.

ECOLOGICAL STATE OF WATER RESOURCES IN THE CONFLICT REGIONS OF AZERBAIJAN

Zeynab Talibzade, Elshad Mammadov
Azerbaijan University of Technology
z.talibzade@atu.edu.az, e.memmedov@atu.edu.az

During armed conflicts, various components of the environment suffer significant damage. Water resources, as an integral part of the ecosystem, also play a vital role in human life and activity. In such periods, water infrastructure is destroyed, and transboundary rivers become polluted. The prolonged conflict between Armenia and Azerbaijan similarly caused numerous negative ecological effects on the water resources in the Nagorno-Karabakh region.

The areas where military operations occurred are among the regions with the richest water resources in the country. The river network here consists of tributaries flowing into the Kura River, such as the Tartar, Khachinchay, and Gargarchay Rivers, as well as those flowing into the Aras River, including the Ishkhan and Hakari Rivers. Approximately two billion cubic meters of water resources are accumulated annually in the region. Around 70% of Azerbaijan's freshwater resources originate from transboundary rivers, which further highlights the strategic importance of the Karabakh region in meeting the country’s water demand.

There were also approximately 120 mineral water wells with high therapeutic potential in the conflict zone. These include Bagirsag and Keshdek in Upper and Lower Kalbajar, Iligsu and Minkend in Lachin, and Turshsu and Shirlan in Shusha, among others. This region accounts for about 9.6% of Azerbaijan’s total mineral water reserves.

Improper management of water resources in the region has led to several issues. Unplanned and inefficient exploitation, poorly coordinated water release schedules, irregular water distribution, and lack of technical maintenance have all contributed to the degradation of the system. Furthermore, the destruction of hydro-meteorological monitoring stations in the area has made access to accurate water data nearly impossible.

The primary water supply system in the region is the Sarsang Reservoir, which has a storage capacity of 565 million cubic meters. The reservoir was constructed in 1976. Mismanagement of the Sarsang Reservoir has resulted in a number of ecological problems. Due to the lack of consideration for climatic factors, the water level has declined. Additionally, a reduction in aquatic flora and fauna, a drop in fish populations, disruption of bird migration patterns, desertification of surrounding lands, and ultimately, a disturbance of the ecosystem's balance have been observed. Water from the Sarsang Reservoir is used for irrigation and potable water supply in the districts of Tartar, Aghdam, Barda, Goranboy, Yevlakh, and Aghjabadi. Consequently, water scarcity has been frequently reported in these areas.

Okhchuchay, a left tributary of the Aras River, is 83 km in length. It originates from the Zangezur mountain range in Armenia and passes through the Zangilan district of Azerbaijan. In 2021, Azerbaijan conducted a water quality assessment of the Okhchuchay. The results revealed high concentrations of heavy metals such as cadmium, lead, nickel, iron, molybdenum, and zinc in the surface water and sediments. The main sources of this pollution are believed to be the Kajaran Copper-Molybdenum Plant and the Kapan Ore Processing Plant in Armenia. The contamination of the river poses a serious threat not only to the aquatic ecosystem but also to human health. Consumption or use of this polluted water can lead to gastrointestinal, kidney, cardiovascular, and nervous system disorders. Furthermore, the environmental degradation of the Okhchuchay directly impacts the water quality of the Aras River as well.

The Aras River plays a crucial role in meeting the agricultural and domestic water needs of the country, and any decline in its quality may lead to serious socioeconomic and ecological problems.

In the post-conflict period, consistent efforts have been made toward ecosystem restoration and the sustainable use of water resources. The core components of this policy include water monitoring, digital mapping of water resources, and alignment with the green energy transition concept. Ensuring the ecological stability and national security of Azerbaijan's water resources remains one of the country's key environmental priorities.

SECTION 5. ECOLOGICAL REHABILITATION OF WAR-AFFECTED AREAS

MILITARY OPERATIONS NEGATIVE TO LAND SUPERSTRUCTURE EVALUATION OF IMPACT WITH VARIOUS ASPECTS

Givami Abbasov
Azerbaijan University of Architecture and Construction
qivamiabbasov1@gmail.com

The military units of the Armenian state, which occupied 20% of the territory of the Republic of Azerbaijan for 30 years, brutally destroyed all the infrastructure, cultural and historical monuments, residential buildings, as well as other buildings, and carried out large-scale mining operations in these areas, which caused the degradation of the top layer of the soil. has been

On both sides of the war (unfortunately, the war was fought on our territories) defensive deep trenches (picture 1), barricades, ditches, bunkers, dams, as well as heavy military equipment in the active phases of the First and Second Karabakh Wars, were built on our territories. especially the movement of tracked machinery and the destructive effect of the shock wave caused by the shells during the intensive bombing of the areas (picture 2) ruined the superstructure of the land.

Figure 1.

Figure 2.

In general, the negative effects of military operations on the superstructure of the lands of our territories freed from occupation can be evaluated in terms of the following aspects:

- from an ecological point of view (pollution of land resources with destroyed buildings and construction remains of facilities, including the remains of destroyed military equipment and the fuel separated from them, soil degradation on the slopes as a result of military erosion);
- from the geomorphological point of view (a sharp disturbance of the relief, which is the sum of all the unevenness of the earth's surface due to the interaction of endogenous and exogenous forces);
- from an engineering-geological point of view (disruption of simple shaped relief and uncut lithological stratigraphic sections, transformation of simple engineering-geological conditions that regularly change along the depth into very complex engineering-geological conditions with a sharply divided relief and a high degree of gender in soil properties).

It is clear from this that the military operations caused serious environmental damage to the top structure of the land, as well as by disrupting the geomorphological structure and engineering-geological conditions of the areas, created risk factors that are difficult to manage for the future activities of people in these areas (1). It is worth noting only one fact that large-scale leveling works in the damaged superstructure of the soil and the variety of geological-engineering conditions in depth and uneven compressibility in the design of the ground base of the buildings and facilities to be built should be done with reference to the specific construction norms and rules.

Reference

G.D. Abbasov. Materials of the Scientific-Technical conference on "Emergency risks in areas freed from occupation", Baku, May 21-22, 2021, pp. 65-66.

AN ADAPTIVE APPROACH TO SECURING UAV TELEMETRY COMMUNICATION BASED ON ELECTROMAGNETIC ENVIRONMENT ANALYSIS UNDER ELECTRONIC WARFARE CONDITIONS

Mukhtar Azizullayev, Aytan Sohbatova
National Aerospace Agency
aytansohbatova@gmail.com

In recent years, the increased reliance on Unmanned Aerial Vehicles (UAVs) in both military and civilian operations has underscored the critical importance of ensuring uninterrupted and secure telemetry communication. However, under electronic warfare (EW) conditions, UAV telemetry systems are highly susceptible to electromagnetic interference, signal jamming, and data corruption, which may compromise mission success and lead to a complete loss of control over the aerial platform. [1]

This research thesis proposes a novel adaptive telemetry protection model that dynamically adjusts transmission parameters based on real-time analysis of the electromagnetic environment. By integrating environmental awareness into the communication protocol, the system actively responds to signal degradation caused by intentional or unintentional interference, ensuring resilient and continuous data exchange between the UAV and ground control stations. [2]

The study encompasses the following research directions:

1. Modeling of signal degradation mechanisms in hostile electromagnetic environments, including path loss, noise figure, and SNR variations under EW attacks;
2. Development of adaptive frequency selection and power control algorithms based on real-time RSSI and SNR monitoring;
3. Implementation of software-level reconfigurable communication protocols on telemetry modules such as LoRa SX1278 and XBee PRO S2C using STM32 microcontrollers;

4. Design of experimental testbeds simulating various electronic warfare scenarios to evaluate the robustness of the proposed telemetry scheme;

5. Comparative analysis of signal integrity metrics (SNR, BER, RSSI) before and after adaptive techniques are applied.

Experimental results confirm that adaptive telemetry communication—driven by real-time environmental feedback—can significantly reduce the impact of electronic jamming and interference, thereby enhancing system performance and ensuring mission reliability. Moreover, the proposed approach enables flexible reconfiguration of transmission parameters without human intervention, which is particularly vital for autonomous UAV operations in unpredictable or hostile settings.

This research makes a substantial contribution to the development of next-generation UAV telemetry systems by offering a scientifically grounded and practically validated solution for secure and resilient data communication under electronic warfare conditions. The findings are particularly relevant for national defense technology programs focused on building robust autonomous platforms that can withstand adversarial electronic threats.

References

1. Shakeri, H., Sadeghi, M., & Aghaei, M. (2022). A review on electronic warfare threats and countermeasures in UAV communication systems. IEEE Access, 10, 89712–89730. https://doi.org/10.1109/ACCESS.2022.3197805
2. Kovacs, G., & Molnar, L. (2021). Security challenges of unmanned aerial vehicle systems in jamming environments. Sensors, 21(11), 3789. https://doi.org/10.3390/s21113789

ESTABLISHING INTERNATIONAL COOPERATION FOR THE ECOLOGICAL REHABILITATION OF WAR-AFFECTED AREAS

Mirvari Jabrayilova, Sima Valiyeva
National Aerospace Agency Institute of Space Research of Natural Resources, NASA
veliyevasima1994@gmail.com

The ecological devastation caused by armed conflicts requires urgent and coordinated international efforts to restore environmental integrity, ensure sustainable recovery, and protect human health and biodiversity in war-affected regions.

Armed conflicts result in deforestation, soil degradation, water contamination, loss of biodiversity, and air pollution, leaving long-term ecological scars.

The scale and complexity of environmental damage often exceed national capacity, making international support and expertise essential. [1]

Institutions like the United Nations Environment Programmed (UNEP), World Bank, and international NGOs play a critical role in funding, planning, and implementing environmental recovery projects. International environmental law and humanitarian principles can guide countries in holding perpetrators accountable and

Cross-border collaboration fosters the exchange of eco-rehabilitation technologies, scientific research, and best practices.

Environmental restoration contributes to long-term peace by rebuilding livelihoods, supporting agriculture, and reducing resource-based conflicts. [2]

Soil and water pollution due to explosives, chemicals, and military equipment. Deforestation and decertification because of troop movements and bombings. Collapse of agricultural systems and biodiversity loss. Long-term effects on public health (e.g. due to heavy metals, landmines, or toxic waste) Challenges to international Cooperation. Political tensions and lask of trust between counters. Insufficient funding or unequal distribution of resources. Lask of reliable data from conflict zones. Climate change is an additional stressor.

Ecological restoration in war-affected areas is not only an environmental necessity, but a humanitarian and peacebuilding imperative. International collaboration ensures a more effective, inclusive, and sustainable recovery. A global framework for environmental peacebuilding must be institutionalized and funded.

References

1. United Nations Environment Program (UNEP)Protecting the Environment During Armed Conflict. An Inventory and Analysis of International Law, UNEP.2009
2.Weir, Doug. Conflict and the Environment. Toxic Remnants of War Project 2017
https// ceobs.org

ELECTRONIC WARFARE SYSTEMS USED AGAINST UNMANNED AERIAL VEHICLES DURING MILITARY OPERATIONS

Nurlan Karimov, Mukhtar Azizullayev, Ravana Izzatova
National Aerospace Agency
Nurlan.Karimov@nasa.az

In the modern era, Unmanned Aerial Vehicles (UAVs) are widely used in various fields such as military operations, security, and civilian applications. The increasing deployment of UAVs necessitates the development of new and effective electronic warfare technologies to neutralize them. This study discusses limiting the enemy's use of UAVs during military operations by interfering with their space-based radionavigation systems (GPS, GLONASS, Galileo, BeiDou), telemetry, and radio communication channels. [1]

Detection Technologies

The following systems are used for the detection of UAVs:

- Signal detection and direction-finding via radio monitoring and reconnaissance systems (RTR complexes);
- Radar stations (primarily active radars);
- Electro-optical surveillance systems;
- Acoustic direction-finding systems.

Main Methods of Neutralizing UAVs:

Kinetic impact — destruction via fragments from anti-aircraft shells or missiles;

- Interception by a fighter drone (i.e., neutralization through drone-to-drone engagement);
- Destruction of the UAV's structure using laser beams;
- Disruption of UAV electronics through powerful microwave radiation;
- Disabling UAV electronics using an explosion-based generator that emits electromagnetic pulses (EMP);
- Use of Electronic Warfare (EW) systems

When discussing Electronic Warfare (EW) systems, it is important to note that various types of jamming show different levels of effectiveness against UAVs. All modern EW systems typically use frequency-hopping jamming generators controlled by Radio Technical Intelligence (RTI) systems, since there is a growing trend toward the use of non-standard frequencies in UAV communication and surveillance systems. [2]

In other words, structured jamming is optimized to suppress communication and navigation channels with known parameters — both in terms of frequency and the structure of the targeted channel.

Electronic Protection (EP): Safeguarding one's own communication and detection systems from enemy EW attacks.

This study presents significant results in terms of the localized and portable application of electronic attack systems aimed at UAVs and contributes to the development of new technologies in the field of Electronic Warfare.

References

1. Yu, A. Y., Kolotylo, I., Hashim, H. A., & Eltoukhy, A. E. E. (2025). Electronic warfare cyberattacks, countermeasures and modern defensive strategies of UAV avionics: A survey. arXiv.
2. Bekmezci, I., Sahingoz, O. K., & Temel, Ş. (2013). Flying ad-hoc networks (FANETs): A survey. Ad Hoc Networks, 11(3), 1254–1270. https://doi.org/10.1016/j.adhoc.2012.12.004

POST-WAR ENVIRONMENTAL DEGRADATION AND ITS LINK TO LOCAL CLIMATE CHANGES

N.Kh.Mustafazade, M.G.Valiyeva
National Aerospace Agency
Institute of Space Research of Natural Resources
nm_609@mail.ru

In contemporary times, armed conflicts pose serious threats not only to human lives but also cause substantial damage to the natural environment. Environmental degradation observed during post-war periods—particularly the destruction of soil cover and the deterioration of water and air quality—stands among the primary factors that can lead to local climate changes. Consequently, it is of critical importance to scientifically analyze the interrelationship between ecosystem disturbances and local climate indicators in post-conflict scenarios [1].

Changes in the environment due to anthropogenic impacts have long been a focus of scientific research. However, the degradation of natural resources following military conflicts and its effects on microclimate systems remains an insufficiently explored field. Fires, explosions, the movement of heavy military machinery, and the destruction of infrastructure during wars deliver severe blows to the ecological state of the environment, accelerating processes such as carbon emissions and soil erosion. These disruptions directly affect local climate parameters, including temperature, humidity, and air circulation [3].

The main forms of degradation commonly observed in post-war territories include:

- disruptions of heat balance, resulting in altered evaporation rates;
- decreased soil heat retention capacity and increased surface runoff intensity;
- disturbances in local hydrological cycles;

- intensified emissions of carbon dioxide and other greenhouse gases into the atmosphere.

As an example, during the Gulf War in the 1990s, the burning of oil fields in Kuwait led to the formation of massive smoke clouds that lowered local air temperatures by obstructing solar radiation from reaching the Earth's surface. Similarly, extensive military operations in the Balkans and the Middle East caused large-scale forest destruction and converted lands into non-agricultural use, thereby inducing microclimatic changes in those regions. For this reason, post-war recovery measures must be not only humanitarian and social but also explicitly ecological and climate-oriented—an area in which the National Aerospace Agency is currently conducting focused research [2].

Our specialists have collected long-term statistical data across the liberated territories, enabling the identification of correlations between meteorological parameters and climate factors, and allowing for an assessment of the dynamics of environmental change. In these studies, landscape structure parameters have been employed as primary indicators of contamination, and a classification of degradation levels under the backdrop of climate variability has been developed.

As a result of this research, the next stage envisages the creation of electronic maps that will directly characterize the relationships between ecological stress conditions and climate variations. These maps are expected to serve as essential tools for supporting effective environmental management and sustainable restoration strategies in post-conflict areas.

References

1. Əliyev, A.M. (2021). *Ekoloji təhlükəsizlik və iqlim dəyişmələri: geocoğrafi yanaşmalar.* Bakı: Elm və Təhsil Nəşriyyatı, 232 s.
2. Həsənov, R.Ş. (2020). *Ətraf mühitin mühafizəsi və dayanıqlı inkişaf: nəzəri və praktiki aspektlər.* Bakı: Adiloğlu nəşriyyatı, 198 s.

3. Qasımova, S.R., İsmayılov, T.R. (2022). *İqlim dəyişmələri və insan fəaliyyətinin ekosistemlərə təsiri*. Bakı: Bakı Dövlət Universiteti nəşriyyatı, 176 s.

THE IMPORTANCE OF INTERNATIONAL COOPERATION IN IMPROVING THE ENVIRONMENTAL SITUATION IN AREAS AFFECTED BY MILITARY OPERATIONS

Alisher Orifovich Ochilov
Karshi State University, Uzbekistan
alisherochilov69@mail.ru

International cooperation plays a decisive role in improving the environmental situation in combat zones. Wars and armed conflicts have a devastating impact on the environment: For example, destruction of infrastructure and industrial facilities (air, soil, and water pollution); leakage of hazardous substances (oil, chemicals, heavy metals); mass deforestation and desertification; destruction of biodiversity and ecosystems; water and soil pollution by unexploded ordnance and mines; disruption of waste treatment facilities and waste management systems. Soil and water bodies are polluted, forests and agricultural lands are destroyed, hazardous substances leak, and biodiversity suffers. In such circumstances, the efforts of one country, especially one affected by the conflict, are often insufficient. These consequences can last for decades and affect not only one country, but also neighboring ones - polluting rivers, soils, and the atmosphere.

International cooperation is an integral component of effective environmental restoration in war zones. It unites the efforts of states, the scientific community, international organizations, and the civil sector.

Formats of international cooperation: Interstate agreements on joint monitoring and restoration. International organizations and NGOs: UNEP, UNDP, ICRC, WWF, Greenpeace. Scientific consortiums and knowledge exchange: publications, joint research, conferences. Financing and technical assistance: World Bank, GEF, EU, USAID.

Here are the key aspects of the importance of international cooperation:

- Pooling of resources and technologies.
- Legal framework and compliance with international law.
- Environmental assessment and restoration.
- Investment attraction and long-term assistance.

The environmental consequences of wars are not limited to the areas of military action - they affect neighboring regions, transboundary water bodies, and the atmosphere. Therefore, improving the environmental situation in such areas is impossible without coordinated international efforts. Only joint actions can restore the environment and ensure sustainable development in post-conflict regions.

KALBAJAR PERLITE FOR ENVIRONMENT REMEDY

Nada Edres[1], Rasim Alosmanov[2]
[1]Khartoum University, 406, Sudan
[2]Baku State University
r_alosmanov@rambler.ru, nanobaku2023@gmail.com

The Kalbajar region consider one of the extremely rich area in Azerbaijan with significant industrial minerals and metals such as gold, chromium, mercury, deposit clays. Perlite one of the interesting deposit minerals that used around the area as filler in production of concrete and stone that distinguished with its light weight and high thermal insulator, also in agriculture perlite add to soil to improve water retention and aeration[1]. Moreover, perlite exploit as effective adsorbent to filter various fluid specially water and oil from impurities and chemicals this refer to the perlite's porous structure of high adsorption capacity[3]. Recently industry use different grades of perlite such as expanded perlite that can be obtain in pyrolysis of perlite ore around 850°C to 100°C and the chemically modified perlite that they show more reactive structure which enhance the industry performance of perlite in various fields even in medical[2,4]. Still studies in chemical and physical modification of perlite structure are carry out to increase its reactivity and performance.

In simple experiment trail in our laboratory, we tried to modified expended perlite with ZnS nanoparticles using SILAR method, structure analyzed by UV-vis and XRD. The obtained ZnS/expanded perlite observed high photocatalytic activity and degraded high percentage of the carcinogenic dye (Crystal violet) from water in comparison to nonmodified expanded perlite.

Table: Photocatalysis oxidation of 0.4 mg/l crystal violet using Expanded perlite, ZnS/Expanded perlite

Sample	0 min	5 min
Expanded perlite	11 %	78%
ZnS/Expanded perlite	11 %	88%

References

1- Svetlana Turyalay & Elchin Hajiyev. Impact of the War on the Environment. Azerbaijan International (2.3), 1994. p. 57.
2- Dzięcioł, J., Szlachetka, O., Rodrigues Tavares, J.M. From Volcanic Popcorn to the Material of the Future: A Critical Review of Expanded Perlite Applications and Environmental Impacts. Sustainability. 2025.
3- Ruhallah Mortazavi, S., Sarrafi, A. H. M., Alihosseini, A., & Niazi, A. Investigating the absorption and biodegradation of spilled oil on water using expanded perlite loaded with oil-eating bacteria. Energy Sources, Part A: Recovery, Utilization, and Environmental Effects. 2024.
4- Ali Reza Taheri Fard. Application of advanced composite modified perlite for degradation of particle size and turbidity in treatment of sewage water. Drink.WaterEng.Sci. 2018.

THE ROLE OF BENTONITE CLAYS IN REDUCING RADIOACTIVE CONTAMINATION OF SOIL AND WATER IN AREAS AFFECTED BY MILITARY ACTIONS

S.S.Bayramova[1], A. R.Aliyeva,[2] G.N.Ahmadova[1], Ch.S.Aliyev[2], Z.R.Aghayeva[1]
[1]*Institute of Catalysis and Inorganic Chemistry MSE AR*
[2]*Institute of Geology and Geophysics MSE AR*
laboratoriya4@inbox.ru

Military conflicts are often accompanied by the destruction of infrastructure, fires and many undesirable phenomena. For example, the use of explosives and a number of other life-threatening materials, also containing radioactive materials, leads to large-scale pollution of the environment, especially soil and water bodies. In this regard, an important task in the conditions of post-war restoration of the territory of Karabakh is the development of effective methods for the rehabilitation of contaminated territories. One of such methods is the use of a natural mineral for these purposes - bentonite clays, which have high sorption and barrier properties. This paper examines the effectiveness of bentonite in reducing radioactive contamination in war-torn areas, which not only cause human and economic losses but also cause enormous environmental damage. Destruction of infrastructure, the use of ammunition and incendiary substances, explosions and leakage of hazardous materials contribute to the release of radioactive substances into the soil and water bodies. This problem is especially relevant for regions where military conflicts took place near industrial facilities or military bases containing radioactive materials. During the research it was established that one of the suitable and promising materials for the reclamation of contaminated territories are bentonite clays - rich in montmorillonite, which has a high capacity to absorb ionic pollutants, including radionuclides. It was established that bentonite clays have a number of properties that make them effective in combating radioactive contamination due to their high sorption capacity, colloidal activity, chemical inertness, and barrier function. It has been shown that they can be used in areas affected by military actions in several forms: when added to the soil, when used in sorption barriers and for cleaning wastewater and surface water during the rehabilitation of water bodies. Also, in areas affected by armed conflicts, the use of bentonite clays can be part of a comprehensive environmental rehabilitation program. Field and laboratory studies show that adding 5-10% bentonite to the mass of contaminated soil reduces the mobility of radionuclides by 70-90%, while improving the soil structure and reducing the risk of secondary contamination of aquifers.

Based on the conducted research, it was concluded that bentonite clays are an effective, affordable and environmentally safe material when used to reduce radioactive contamination of soil and water in areas affected by military action. Its use can significantly accelerate the restoration of ecosystems and reduce risks to public health. And the introduction of technologies based on bentonite clays is highly relevant and practical.

References

1. Khan S.A. // Sorption of the long-lived radionuclides cesium-134, strontium-85 and cobalt-60 on bentonite./Journal of Radioanalytical and Nuclear Chemistry, Vol. 258, № 1, September 2003, pp. 3–6.
2. Ismayilova, I.I. Mustafayev // Primenenie rentgenovskoy fotoelektronnoy spektroskopii dlya issledovaniya bentonitovoy gliny iz mestorozhdeniya Alpoid v Respublike Azerbaydzhan./ Khimicheskaya bezopasnost, № 6(2), Dekabr 2022, str. 258–264.

ESTABLISHING INTERNATIONAL COOPERATION IN THE RECONSTRUCTION OF WAR-TORN TERRITORIES CASE STUDIES OF UKRAINE AND THE PATRIOTIC WAR

Yegana Aliyeva
National Defence University, MDI AR
aliyevayegana14@gmail.com

Abstract: Reconstruction of war-torn territories is a complex and long-term process that requires coordinated international efforts to rebuild infrastructure, restore communities, and revive local economies. This thesis explores the role of international cooperation in the reconstruction of regions devastated by conflict, with a specific focus on Ukraine and the Patriotic War. The study examines the challenges and opportunities presented by post-conflict reconstruction, including issues related to funding, technical expertise, and political coordination. Drawing on lessons from the ongoing reconstruction efforts in Ukraine and Azerbaijan's Patriotic War, this paper argues for the importance of a collaborative international framework that integrates both governmental and non-governmental organizations to ensure sustainable recovery and development in war-affected regions.

Introduction

War causes devastation that extends far beyond the immediate loss of life, with long-lasting consequences for infrastructure, the environment, and socio-economic systems. Rebuilding war-torn territories is a monumental task that requires not only the resources of the affected country but also the involvement of international actors. Reconstruction efforts involve repairing physical infrastructure, revitalizing economies, restoring essential services, and addressing social and psychological trauma. However, the effectiveness of these efforts depends significantly on the level of international cooperation. This thesis explores how international cooperation can be leveraged in the reconstruction of war-torn territories, specifically focusing on Ukraine and the Patriotic War, and highlights the role of both international organizations and bilateral partnerships in facilitating recovery.

Challenges of Reconstruction in War-Torn Territories

The challenges of rebuilding after war are multifaceted and often insurmountable without external support. The first major challenge is securing adequate financial resources. In both Ukraine and the Patriotic War, the costs of reconstruction are immense. In Ukraine, for example, the 2022 Russian invasion caused widespread destruction of critical infrastructure, including residential areas, industrial facilities, power plants, and transportation networks. The World Bank estimates that the cost of rebuilding Ukraine could exceed $500 billion. In the case of the Patriotic War, Azerbaijan faces similarly substantial costs to rebuild the territories in Nagorno-Karabakh that were devastated during the 2020 conflict, including cities, villages, and vital infrastructure.

Alongside financial challenges, reconstruction also requires technical expertise, human resources, and political stability. War often displaces populations, leaving behind a shortage of skilled workers and professionals, making it difficult to rebuild efficiently. In addition, political instability can hinder reconstruction efforts, especially when multiple stakeholders with competing interests are involved.

The Role of International Cooperation in Reconstruction

International cooperation plays a critical role in overcoming these challenges by providing the necessary financial support, expertise, and political coordination. In Ukraine, international partners have provided extensive support in the form of loans, grants, and technical assistance. The European Union, the United States, and other countries have committed to providing financial aid to help rebuild Ukraine's infrastructure, with the EU pledging billions of euros for reconstruction. In addition, technical expertise from international organizations such as the United Nations Development

Programme (UNDP) and the World Bank has been essential in helping Ukraine rebuild critical infrastructure, particularly in war-torn eastern regions.

Similarly, the post-Patriotic War reconstruction efforts in Azerbaijan have seen significant international involvement. After the 2020 ceasefire agreement, Azerbaijan began rebuilding the territories recaptured from Armenia, with the assistance of international partners and financial institutions such as the Asian Development Bank (ADB). Azerbaijan has also received support from Turkish and other regional actors in rebuilding infrastructure, including roads, schools, and healthcare facilities, which were heavily damaged during the conflict.

These examples demonstrate that international cooperation in reconstruction efforts can facilitate more effective recovery by pooling resources and expertise, particularly in areas where the affected country lacks the capacity to address the scope of the damage.

The Role of International Organizations

International organizations, such as the United Nations, the European Union, and the World Bank, have played key roles in post-conflict reconstruction in both Ukraine and Azerbaijan. The UN has been instrumental in coordinating humanitarian aid, providing emergency relief, and facilitating the rebuilding of public infrastructure. For example, in Ukraine, the UN's Office for the Coordination of Humanitarian Affairs (OCHA) has worked to provide displaced populations with essential services, including food, shelter, and medical care.

The World Bank has also supported Ukraine in post-war reconstruction through the provision of loans and grants, focusing on rebuilding critical infrastructure such as energy systems, water and sanitation networks, and transportation infrastructure. The European Union has similarly played a pivotal role in Ukraine's reconstruction, not only by providing direct financial support but also by helping to align Ukraine's recovery with broader EU integration goals, ensuring that reconstruction efforts are sustainable in the long term.

In the case of Azerbaijan, international organizations have helped coordinate efforts to rebuild infrastructure in the newly liberated territories. The World Bank and the European Investment Bank (EIB) have been involved in financing reconstruction projects, while regional organizations such as the Organization of Turkic States have provided additional technical support, particularly in sectors such as education, health, and agriculture.

The Importance of Bilateral Partnerships

Bilateral partnerships between countries also play a significant role in the reconstruction process. For Ukraine, cooperation with countries like the United States, the United Kingdom, and Poland has been crucial in rebuilding military infrastructure, providing logistical support, and addressing security challenges. Similarly, Azerbaijan has benefitted from bilateral cooperation with Turkey, which has supported the reconstruction of destroyed infrastructure, such as bridges, roads, and schools. Turkey's expertise in rapid infrastructure rebuilding and its historical and cultural ties to Azerbaijan make it an essential partner in the post-conflict recovery process.

These bilateral efforts, when combined with the assistance from international organizations, create a multi-layered approach to reconstruction, ensuring that the recovery process is both efficient and sustainable. It also fosters stronger diplomatic relations between countries, further promoting regional stability and cooperation.

Conclusion

The reconstruction of war-torn territories requires robust international cooperation to address the multifaceted challenges of rebuilding physical infrastructure, restoring social services, and reviving local economies. The case studies of Ukraine and the Patriotic War illustrate how international actors, including governments, organizations, and financial institutions, can collaborate to support post-conflict recovery. Through coordinated efforts, war-torn regions can rebuild more effectively, ensuring that recovery is sustainable and inclusive. However, for international cooperation to be most effective, it must be guided by principles of mutual respect, transparency, and long-term commitment to the affected regions. By prioritizing these values, the international community can support the reconstruction of war-torn territories and help restore stability and prosperity to regions recovering from conflict.

References

1. Axundov, R.Q. Azərbaycan Ordusunda radiasiya, kimyəvi və bioloji kəşfiyatının əsasları // – Bakı: Hərbi bilik, – 2023. №4, – s. 16-20.
2. Ахундов, Р.Г. Влияние военной деятельности на окружающую среду // – Вестник международной академии наук экологии и безопасности жизнедеятельности (МАНЭБ), – Санкт-Петербург: – 2024. №1(29), – с. 51-58.
3. Axundov, R.Q. Azərbaycan Ordusunda ekoloji təhlükəsizliyin təşkili və təkmilləşdirilməsi // – Bakı: Hərbi bilik, – 2024. №4, – s. 7-15.
4. Axundov, R.Q. Azərbaycan Ordusunda radiasiya, kimyəvə bioloji mühafizənin inkişaf problemləri və onlarin həlli yollari // Ümummilli lider Heydər Əliyevin anadan olmasının 100 illiyinə həsr olunmuş "Hərb sənətinin aktual problemləri" beynəlxalq elmi-praktik konfransın materialları, – Bakı: MMU, – 3-4 may, – 2023, – s.137-138.
5. Akhundov, R. Military conflicts and environmental safety // Current directions of development of information and communication technologies and control tools. Abstracts of the Fourteenth International Scientific and Technical Conference. – Kharkiv, Ukraine, – 25-26 April 2024, Vol 2, – p.89-90.
6. Akhundov, R. Ecocide in the Nagorno-Karabakh Conflict: An Analysis of Armenia's Environmental Impact on Azerbaijan // Current directions of development of information and communication technologies and control tools. Abstracts of the

Fourteenth International Scientific and Technical Conference. – Kharkiv, Ukraine, – 25-26 April 2024, Vol 2, – p.95-96.
7. Akhundov, R The environmental consequences of military activity // 20 years Bulgaria in NATO and NATO in Bulgaria. Abstracts of the Scientific Conference with International Participation. – Sofia, Bulgaria, – 2-4 April 2024, – p.558-570.
8. Akhundov R.G., Talibov A.M. Environmental safety as a component of national security // The latest technologies - for the protection of airspace. Abstracts of the 20th international scientific conference of the Kharkiv National University of the Air Force named after Ivan Kozhedub. – Kharkiv, Ukraine, – 02-03 May 2024, – p.25-27.

In-Sb THIN FILMS IN MILITARY APPLICATIONS

N.A.Aliyeva Mammadova, V.A.Majidzade, A.Sh.Aliyev, D.B.Taghiyev
Institute of Catalysis and Inorganic Chemistry MSE AR
vuska_80@mail.ru

InSb-based materials are promising candidates for a wide range of civilian and military applications, from magnetism to optics [1-2]. Indium antimonide is a crystalline semiconductor made from indium and antimony. It is a III-V group, narrow-bandgap semiconductor material. It is a type of microbolometer sensor material used in some cooled thermal imaging cameras. Detectors made from indium antimonide are sensitive in the 1-5 μm wavelength range. InSb sensors must be cryogenically cooled and have much lower temperature requirements. Unlike microbolometer type detectors, which are photostable for uncooled thermal imaging cameras, InSb detectors are photoelectric and operate in the mid-wave infrared range of 3-5 μm. This means that they detect heat rather than light, generating a small voltage when exposed to radiant thermal energy. This means that they detect heat rather than light, generating a small voltage when exposed to radiant thermal energy. InSb is one of the first types of materials that have many military and scientific applications. Military applications include the use of IR sensors, including long-range night vision thermal imaging cameras for reconnaissance and surveillance, often using wavelengths of 3-5 µm, scientific applications include IR detector arrays in telescope sensors for astronomy and IR detectors for spectrometers and radiometers [3].

The purpose of this work is to obtain thin InSb semiconductor films by electrochemical deposition. In_2O_3 was used as a source of indium ions, and Sb_2O_3 as a source of antimony ions. The samples were obtained by galvanostatic or potentiostatic electrolysis modes in different current or potential ranges. During the experiments, the electroreduction of indium and antimony was investigated separately, and their reduction region was determined (Fig.1 and 2).

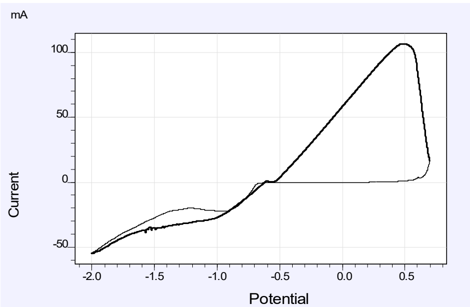


Fig.1. Cyclic polarization curve of the process of electroreduction of indium ions.

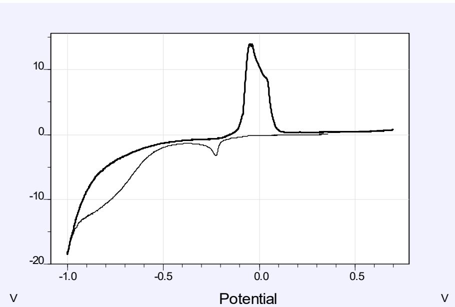


Fig.2. Cyclic polarization curve of the process of electroreduction of antimony ions.

References

1. Pham Van T., Do Thi P.D., Nguyen Vu T., Tran Quang D., Nguyen Thanh N., Nguyen Van T. Effect of thickness on InSb thin film properties grown onto silicon heated substrates by pulsed laser deposition, Journal of Military Science and Technology, 2022, no. 84, p. 109–118.

2. Salwa A.S., Abd. El-Sadek M.S., El-Sayed A. Thermally Deposition of InSb Thin Films with High Infrared Nonlinear Impact: Optical Approach. Internatıonal Journal of Scıentıfıc and Technology Research, 2020, Vol. 9(3), p. 5800-5805
3. Hnida K., Mech J., Sulka G.D. Template-assisted electrodeposition of indium–antimony nanowires – Comparison of electrochemical methods. Applied Surface Science, 2013, Vol. 287, p. 252-256

INVENTORY OF FORESTS IN LIBERATED TERRITORIES

Alisahib Huseynli[1], Rukhsara Hasanova[2]

Forest Development Service under the Ministry of Ecology and Natural Resources of Azerbaijan [1]
Baku State University [2]
alisahib1013@gmail.com

Proper and efficient management of forest resources, ensuring their sustainable utilization, critically depends on forest inventory activities. Within forestry operations, such inventory data serves as the foundation for planning interventions such as various types of tree cuttings, afforestation, assistance to natural regeneration, replacement of low-value tree species with more valuable ones, and the regulation of economic, ecological, and social use mechanisms. Overall, multipurpose and functional forest management is based on the results of forest inventory.

The Eastern Zangezur and Karabakh regions of the Republic of Azerbaijan remained under Armenian occupation for approximately 30 years. During this period, not only the national economy and social infrastructure, but also the natural resources and forest areas in this region suffered significant damage. According to estimates, around 54,328 hectares of forest land were destroyed to varying degrees—completely, severely, or partially—during the occupation. Moreover, the suspension of forestry activities—including planting and restoration efforts—for 30 years further exacerbated the magnitude of the damage.

Within the framework of the "Great Return I" State Program, a range of measures have been planned for the restoration and development of forest management in the territories liberated from occupation, and the implementation of these efforts has been entrusted to the Forest Development Service.

Following the liberation of these areas, monitoring of forest lands was initiated, preliminary clarification activities were carried out, and optimal forestry decisions were made based on the findings. In the initial phase, forest-planning (forest inventory) work was conducted over the following areas:

- Zangilan district: 19,395 ha
- Kalbajar district: 35,553 ha
- Gubadli: 17,015.1 ha
- Jabrayil: 5,151.6 ha
- Khojaly and Khankendi: 44,319.7 ha
- Shusha: 10,008.8 ha
- Khojavand: 35,303.2 ha

In total, 166,726.5 hectares were covered in this phase. In the next phase, similar measures are planned for Lachin and Aghdere districts.

Considering the danger of landmines and unexploded ordnance, inventory operations were primarily carried out using remote sensing methods and, to some extent, ground-based techniques.

During the forest-planning operations, the forest fund was clarified: boundaries of forested areas, the dominant tree species present, their reserve volumes, and annual growth rates were identified. Additionally, areas of tree cutting, zones in need of natural regeneration, lands designated for planting and sowing, and planned forestry activities for future periods were assessed and documented.

ENVIRONMENTAL DAMAGE OF WARS AND ELIMINATION OF ITS CONSEQUENCES

Yusif Humbatli
Baku State University
yhumbatli@gmail.com

War can heavily damage the environment, and warring countries often place operational requirements ahead of environmental concerns for the duration of the war. Some international law is designed to limit this environmental harm. War and military activities have obvious detrimental impacts on the environment [1, 2]. The events of international life that surround us by their essence cause multi-faceted, complex and effective effects, and of course, the management of these processes and their regulation is not an easy task [3]. Critically, environmental damage has implications for people, as well as ecosystems. This means that protecting civilians first requires that we protect the environment that they depend upon. Therefore, studying the damage caused by wars to the environment and eliminating its consequences is one of the actual problems of the modern era.

The environmental impact of wars begins long before them. Creating and maintaining a military force consumes a large amount of resources. These can be common metals or rare earth elements, water or hydrocarbons. Maintaining military readiness means training, and training consumes resources. Military vehicles, aircraft, ships, buildings and infrastructure all require energy, and most of the energy is oil and energy efficiency is poor. The CO_2 emissions of the largest armies are greater than that of many countries in the world combined. We estimate that the military is responsible for 5.5% of all greenhouse gas emissions globally, but reporting military emissions to the UN Framework Convention on Climate Change is weak. Military training creates emissions, disruption to landscapes and terrestrial and marine habitats, and creates chemical and noise pollution from the use of weapons, aircraft and vehicles. Historically, vast quantities of surplus munitions were also dumped at sea.

The environmental impact of conflicts themselves vary greatly. Some international armed conflicts may be brief but highly destructive. Some civil wars may last for decades but be fought at low intensity. High intensity conflicts require and consume vast quantities of fuel, leading to massive CO_2 emissions and contributing to climate change. Large scale vehicle movements can lead to widespread physical damage to sensitive landscapes and geodiversity, as can the intensive use of explosive ordnance. Severe pollution incidents can be caused when industrial, oil or energy facilities are deliberately attacked, inadvertently damaged or disrupted. In some cases, deliberate attacks on oil or industrial facilities are used as a weapon of war, to pollute large areas and spread terror. Other scorched earth techniques include the destruction of agricultural infrastructure like canals, wells and pumps and the burning of crops. Tactics like these threaten food security and livelihoods, increasing the vulnerability of rural communities. Whether unintended or deliberate, these large-scale pollution incidents can lead to transboundary impacts from air pollution or through the contamination of rivers, aquifers or the sea. In some instances, these even have the potential to affect weather or the global climate.

Militarized responses to security issues can create more serious environmental harm than civil responses would.

As noted above, from a legal point of view, environmental protection during war and military activities is partially addressed by international environmental law. Additional sources are also found in areas of law such as common international law, the laws of war, human rights law, and the local laws of each affected country. However, this article focuses mainly on the environment, and as the two countries battle it out, the issue becomes one of international concern. Thus, international environmental law as applied by the United Nations Security Council is the focus here. The law of armed conflict is not so developed compared to other areas of international law. Only the United Nations Security Council has the authority and jurisdiction to regulate its development and implementation or to monitor compliance with it.

Conclusion: Several United Nations treaties, including the Fourth Geneva Convention, the 1972 World Heritage Convention and the 1977 Environmental Modification Convention have provisions to limit the environmental impacts of war or military activities.

UN General Assembly Resolution 47/37 (1992) provides: [4] "[D]estruction of the environment, not justified by military necessity and carried out wantonly, is clearly contrary to existing international law.""Warfare is inherently destructive of sustainable development. States shall therefore respect international law providing protection for the environment in times of armed conflict and cooperate in its further development, as necessary": Principle 24 1992 Rio Declaration → paragraph 39.6 of the Agenda 21: "measures in accordance with international law should be considered to address, in times of armed conflict, large-scale destruction of the environment that cannot be justified under international law".

References

1. "EarthTrends: Feature - Armed Conflict, Refugees, and the Environment". March 8, 2006. Archived from the original on 8 March 2006.
2. International Environmental Law and Naval War: The Effect of Marine Safety and Pollution Conventions During International Armed Conflict
3. Mammadov Rahim Kamil oglu, "INTERNATIONAL LAW-1", lecture texts from the subject, Baku 2021.
4. "A/RES/47/37 - E - UN General Assembly Resolution 47/37 (1992)". undocs.org.

DISPOSAL OF MILITARY TRAINING FORMULAS

E.Sh.Mamedov, D.S.Velieva, T.N.Kulibekova, I.R.Rushinaz, Z.S.Safaralieva, S.D.Dadasheva
Institute of Catalysis and Inorganic Chemistry MSE AR
ziba.sefereliyeva@rambler.ru

The irrational use of natural resources and the current situation in the field of industrial waste causes significant economic damage, leads to environmental pollution and, at the same time, these wastes are valuable raw materials for obtaining various substances on their basis for secondary use in industry. Today, one of the examples of a negative impact on the ecology of the environment is the storage of various training formulas used during exercises in military warehouses. Due to long-term storage, these components acquire a substandard state (lose activity) and then there is a need to dispose of them.

Recycling is any method of disposal, as a result of which waste materials are processed, making them suitable for reuse in various areas of the national economy.

Recycling of materials contributes to the provision of raw materials at the national and international levels. The economic incentive for development is that the use of secondary raw materials allows improving the efficiency of investments than the use of primary resources. In addition to economic benefits, waste disposal also contributes to environmental protection, reduces the emission of toxic substances into the atmosphere.

Thus, recycling is modern environmental technologies plus real savings.

To train military personnel in practical skills of conducting combat operations in conditions of the use of toxic substances (TS), special training recipes are developed to simulate the effects of toxic substances on the environment, living organisms and military equipment. The main condition imposed on them is the versatility and safety of using these recipes. Over time, the shelf life and, accordingly, the activity of the recipes decreases and there is a need to dispose of them.

Currently, some military facilities have accumulated a significant amount of unused stocks of training recipes-simulators, the production of which has been suspended due to their high toxicity. Such simulators include the IV-B, IV-2 recipes, which are a mixture of neutral substances with substances that have a strong irritating effect on a living organism. Substances with an irritating effect are called irritants, and depending on the effect on a living organism are divided into: tear-inducing (lacrymates), sneezing (sternites) and painful (algogens). They are used to suppress and eliminate riots that pose a public danger.

The disposal of toxic substances is reduced either to their complete destruction (burning, burial) or chemical treatment. The first two methods are unacceptable from an ecological and economic point of view. The third method should be reduced to the simplicity of the technological process of decomposition to low-toxic compounds used in industry

The training formula IV-2 is also prepared on the basis of crystalline chloroacetophenone in green oil mixed with chloropicrin and turpentine. As can be seen, the main components of both formulas (chloropicrin, chloroacetophenone), causing an irritating effect and simulating the effect of "Mustard gas", are the same. The third component designed to enhance the toxicity of the formulations is sulfate turpentine, which not only functions as a solvent, but also gives the formulation an unpleasant garlic smell.

Carbon tetrachloride is a non-flammable solvent.

Petroleum bitumen imitates the appearance of persistent toxic substances, imparts the necessary viscosity. Green oil is a solvent that imparts stability to the formulation, it is a mixture of high-molecular aromatic hydrocarbons.

The conversion of toxic substances of military training formulations IV-B and IV-2 into non-toxic ones is carried out by means of a reaction of destruction of chloropicrin and chloroacetophenone until complete decomposition.

Various methods of surface cleaning are used to remove toxic substances (TS) from the surface of contaminated objects, military equipment and weapons, personal protective equipment for skin and terrain. Reagents that enter into chemical interaction with toxic substances and convert them into non-toxic or low-toxic compounds are called degassing agents.

For degassing of weapons and military equipment, exposed areas of human skin, equipment, uniforms, polydegassing formulations RD-2 and RD-A are used. The degassing formulation RD-2 has a wide temperature range from + 40 ° C to - 60 ° C and is used in winter conditions. RD-2 is used to neutralize such toxic substances as "Iprit", "Zoman". When utilized, the compounds included in RD-2: chlorobenzene, kerosene, isobutyl alcohol, ethyl cellosolve, oxyphos - 1 are subjected to fractional distillation.

The degassing formulation RD-A is intended for degassing small arms, for partial degassing of armored vehicles and equipment at temperatures from + 40 ° C to – 37 ° C.

The constituents of RD-A: gasoline B-70, n-butyl alcohol, ethylenediamine, ethyl cellosolve are also subjected to fractional distillation.

The isolated adducts are widely used in the national economy. Thus, oxyphos is used in the leather and fur industries, as a filler for wetting, degreasing and cleaning agents with an antiseptic effect, as a dispersant for magnetic tapes in the manufacture of magnetic varnish, as an inhibitor of asphalt - resinous and paraffin deposits during the transportation of oil through pipelines. Ethyl cellosolve is used as an antifreeze in aviation fuel to prevent the water contained in it from freezing. Thus, ethylenediamine is used in the production of dyes, emulsifiers, stabilizers, fungicides. Kerosene is used in various ways. It is used as a combustible component of rocket fuel, as a fuel for firing porcelain and glass products, in household lighting and heating devices, etc. Sulfonic acid is also used in the production of inhibitors, in the cleaning of paraffin, asphalt-resin deposits in oil pipelines. The resulting sulfonic acids do not have toxic properties.

THE ROLE OF ALTERNATIVE ENERGY SOURCES IN THE ECOLOGICAL REHABILITATION OF THE EAST ZANGEZUR ECONOMIC REGION

Shams Alizade
Baku State University
alizade.shams@mail.ru

The East Zangezur economic region is one of the important strategic territories of the Republic of Azerbaijan. As a result of being under occupation for many years, the ecological balance in this region has been seriously disrupted, natural resources have been exploited without control, forest areas have been destroyed, soils have been degraded, and water resources have been polluted. Currently, within the framework of the restoration and reconstruction work carried out in this region, improving the ecological situation and ensuring sustainable development are among the main priorities.

The ecological rehabilitation of the region should not be limited only to the restoration of the landscape but should also include the application of environmentally clean and sustainable energy sources. In this regard, the role of alternative energy sources - solar, wind, biomass and small hydroelectric power stations - is of particular importance.

The natural and geographical conditions of East Zangezur create favorable opportunities for the production of solar and wind energy. The number of annual sunny hours in the region is more than 2,600, which is an important indicator for the widespread use of solar panels. The installation of solar panels in newly built settlements, public facilities and agricultural farms allows for environmentally friendly energy supply.

At the same time, the foothills and high relief areas of the Zangilan, Gubadli and Lachin regions have wind energy potential. In these regions, it is possible to generate electricity using small and medium-power wind turbines using medium and high-speed winds. This can serve both to meet local demand and to increase energy export potential.

Types of bioenergy – in particular biomass and biogas – make it possible to direct organic waste generated as a result of widespread agricultural and livestock activities in the region to energy production. Biogas production from manure, plant residues and other biological waste creates conditions for both waste reduction and the provision of alternative heat and electricity. This also prevents environmental pollution.

The construction of small hydroelectric power stations at the expense of mountain rivers and springs can also play a significant role in the energy supply of the region. These plants can contribute to the provision of electricity to remote villages, efficient use of local resources and reduction of carbon emissions, provided they are not disturbed by the ecosystem.

The application of alternative energy sources has a number of advantages not only from an environmental perspective, but also from a socio-economic perspective. Thus, as a result of new projects and infrastructure construction in this area, the employment level in the region increases, new professional fields are formed for the population, and the social well-being of the region increases. At the same time, the application of renewable energy technologies also strengthens the country's energy security and independence.

However, there are also certain difficulties that slow down development in this area. Among the main problems are high initial investment requirements, limited access to modern technologies, and a lack of qualified personnel. Internationalon, in addition to state support, cooperation with international organizations and the involvement of the private sector in the process are of particular importance.

Consequently, the application of alternative energy sources is of strategic importance in the context of the ecological rehabilitation of the East Zangezur economic region. These types of energy are indispensable in terms of restoring ecological stability and ensuring the long-term sustainable development of the region. In this regard, the widespread application of alternative energy sources plays an important role in ensuring a green and sustainable future for East Zangezur.

References

1. Azərbaycan Respublikasında alternativ və bərpa olunan enerji mənbələrindən istifadə olunması üzrə Dövlət Proqramı (Azərbaycan Respublikası Prezidentinin 2004-cü il 21 oktyabr tarixli 462 №-li sərəncamı ilə təsdiq edilmişdir).
2. Energetikanın Problemləri jurnalı, AMEA, 2004, № 1, Məqalə: Azərbaycan külək enerjisindən istifadənin inkişaf perspektivləri, Bakı, 2004.
3. Azərbaycan Respublikasının Alternativ və Bərpaolunan Enerji Mənbəələri üzrə Dövlət Agentliyinin rəsmi internet saytı, Geotermal enerji bölməsi
4. https://respublika-news.az/az/news/serqi-zengezur-alternativ-ve-berpaolunan-enerji-menbeleri

UNEXPLODED ORDNANCE IN THE ECOSYSTEM OF AZERBAIJAN IN THE POST-WAR PERIOD

V.H.Khudaverdiev[1.2], A.J.Mikailova[1], R.Mukhtarov[2]
[1]Institute of Radiation Problems MSE AR,
[2]National Aviation Academy
vx5357484@gmail.com

Military conflicts not only harm infrastructure and human life, but also lead to serious environmental consequences. One of the most destructive factors for the environment is ammunition — their use in battles and unexploded combat elements that remain after that. The impact of these ammunition on ecosystems and the results of demining occupy an important place in Environmental Research.

Ammunition has a varied chemical composition, which largely determines its effects on the ecosystem. The composition of these materials depends on the type of ammunition (artillery shells, bullets, missiles, mines, aerial bombs) and the targets they carry out [1, 2]. Some of these substances are toxic, carcinogenic and can remain in the environment for a long time, disturbing the ecological balance and threatening human and animal health.

The Karabakh region of Azerbaijan has been the scene of intensive hostilities in recent decades and has long become a territory subject to significant environmental damage due to the use of various types of ammunition. After the end of hostilities in Karabakh, there were many areas left contaminated with unexploded ordnance, including artillery shells, mines and missiles, as well as chemical components of combat materials.

Most ammunition contains explosives designed to destroy the target. Explosives are made up of chemical compounds that, when detonated, release a large amount of energy, which causes the material to disintegrate.

Ammunition is classified according to the method of action: high explosive (main damaging factor - explosive wave and resulting fragments), impact (designed to destroy a target on direct contact), fragmentation (aimed at defeating a target with fragments formed during an explosion), Kumulative (used to pierce armor due to the directional effect of the explosion), cassette (contains many damaging elements scattered over a large area), incendiary (used to create a fire), Shooting and target designation (used to regulate fire), agitation (special ammunition for the distribution of campaign materials) [1, 2].

One of the most widely used explosive components in the military industry is TNT [3]. TNT consists of benzene and nitrobenzene, which makes it dangerous for the ecosystem, since toxic substances can be released during its decomposition. When it enters soil and water bodies, TNT can have a toxic effect on living organisms, including microorganisms that provide vital biochemical processes. He also includes ammonite, an explosive commonly used in artillery shells and Mines based on nitrates and carbon materials [3]. Ammonite is less resistant to the external environment compared to TNT, but its chemical components can also penetrate into the soil. The high content of nitrogen and ammonia can contaminate water bodies and soil, disrupting the balance of ecosystems and threatening aquatic organisms.

Many ammunition, especially bullets and artillery shells, contain heavy metals such as lead, cadmium, barium and Mercury. These elements are extremely dangerous for the environment due to their ability to accumulate in soil and water bodies and in the biological chain.

It should be noted that during the Karabakh War, the Armenian military also used various types of incendiary ammunition, such as white phosphorus [4]. It is a chemical that, when burned, releases toxic gases and causes long-term damage to ecosystems. After using phosphorus shells, residues of this substance remain in the soil, which leads to pollution of the Earth and water bodies, as well as the destruction of vegetation in large areas.

Environmental problems caused by hostilities can last for decades, and the restoration of territories requires considerable effort and resources. According to experts, Azerbaijan only needs 30 years and 25 billion US dollars to clear its territories from mines [5]. Demining methods currently in use, such as Metal detectors, manual demining, and the use of robots, are important, but not always effective, for cleaning large areas such as Karabakh. Some demining technologies, especially if chemicals are used to neutralize mines, can lead to additional contamination of the soil. One of the promising areas in this area may be the impulse effect on anti-personnel mines with a shock wave of sufficient load to activate them.

All of the above emphasizes the importance of stricter environmental standards and safe technologies aimed at minimizing the environmental damage caused by military conflicts.

References

1. А.В. Бабкин, В.А. Велданов, Е.Ф. Грязнов, Н.А. Имховик; «Боеприпасы»: Учебник. Под общ. ред. В.В. Селиванова. // Москва: МГТУ им. Баумана, Т.1, 2016. 506 с.
2. А.В. Бабкин, В.А. Велданов, Е.Ф. Грязнов и др.; «Средства поражения и боеприпасы»: Учебник. под общ. ред. В. В. Селиванова. // М.: Изд-во МГТУ им. Н.Э. Баумана, 2008. 984 с.
3. А.Ф. Беляев, В.К. Боболев, А.И. Коротков и др. «Переход горения конденсированных систем во взрыв» // М.: Наука. 1973.
4. https://ru.trend.az/azerbaijan/politics/3327476.html
5. https://ru.trend.az/azerbaijan/society/3935368.html

SMART VILLAGES, SMART CITIES AND ENVIRONMENT

Nargiz Fatahova
Azerbaijan University of Architecture and Construction
nargiz.fatakhova@azmiu.edu.az

Smart Cities. The concept of a smart city involves more effective management of urban infrastructure and services through modern technologies (Caragliu et al., 2011; Giffinger & Gudrun, 2010). Here, the quality of life of city residents is improved by using information and communication technologies (ICT). The main goal of smart cities is to optimize the use of energy, water and other resources, regulate transport, reduce waste and ensure security. Advanced ICT systems in these cities allow for easier monitoring and management of city services (Kitchin, 2014). For example, smart lighting systems save energy by turning on street lights only when needed. At the same time, smart transportation systems reduce traffic congestion and organize traffic flow more efficiently. This approach benefits not only city dwellers, but also the environment, as the waste of natural resources is reduced.

Smart Villages. Smart villages involve the application of technology in rural areas (European Network for Rural Development, 2018). This approach aims to ensure that rural residents live a better and more sustainable lifestyle. Smart villages use more modern methods in agriculture and animal husbandry. Soil productivity and irrigation processes are managed more efficiently using sensors and data analysis. In smart villages, the improvement of the internet and technology increases the education and job opportunities of rural residents. By providing smart solutions for industrial and agricultural development in villages, environmental protection is helped. For example, environmentally friendly and resource-conserving technologies are applied in agriculture. These approaches strengthen the economy of villages and at the same time protect natural resources.

Environmental Impact. Smart cities and villages have a positive impact on environmental protection. Smart cities use energy more efficiently, reduce waste and implement activities that meet environmental requirements. This reduces environmental pollution and ensures less use of natural resources (Caragliu et al., 2011). Thanks to smart transportation systems, the number of cars is reduced, which in turn reduces atmospheric pollution. Smart villages contribute to environmental protection through environmentally friendly agriculture and efficient use of water (European Network for Rural Development, 2018). Fewer chemicals are used in agriculture and soil erosion is prevented. These approaches help protect the environment in rural areas and improve the living conditions of the rural population. Smart cities and villages show how technology and sustainable development can play an important role in environmental protection (Kitchin, 2014). These approaches benefit not only urban and rural residents, but also the planet as a whole. In the future, expanding these systems and applying them to more areas will be important steps for a more sustainable and environmentally friendly world.

References

1. Caragliu, A., Del Bo, C., & Nijkamp, P. (2011). Smart cities in Europe. *Journal of Urban Technology*, 18(2), 65–82. https://doi.org/10.1080/10630732.2011.601117
2. European Network for Rural Development. (2018). *Smart Villages: Revitalising Rural Services*. Publications Office of the European Union.
3. Giffinger, R., & Gudrun, H. (2010). Smart cities ranking: An effective instrument for the positioning of the cities? *ACE: Architecture, City and Environment*, 4(12), 7–25.
4. Kitchin, R. (2014). The real-time city? Big data and smart urbanism. *GeoJournal*, 79, 1–14. https://doi.org/10.1007/s10708-013-9516-8

THE IMPACT OF MILITARY OPERATIONS AND INVASION PROCESSES ON HISTORICAL-ARCHITECTURAL MONUMENTS IN THE KARABAKH REGION AND METHODS OF THEIR RESTORATION

Tunzala Majidova
Western Caspian University
tunzalemecidova62@gmail.com

Monuments in Karabakh have suffered serious damage not only from natural influences, but also from wars, occupations, and violations of ceasefires. Examples of such damaged historical and architectural monuments include Shusha Fortress, Askeran Fortress, Khudaferin Bridges, Khudavang (Dadivank) Monastery, Gandzasar Monastery, Aghoglan Temple, Yukhari Govhar Agha Mosque, Ashagi Govhar Agha Mosque, Saatli Mosque, Mardinli Mosque, Khan Qizi Spring, Shusha Caravanserai, Barda Mausoleum, Qutlu Saray Mausoleum, Agdam Mausoleums, Khurshidbanu Natavan's House, Uzeyir Hajibeyli's House, and others. The architectural examples mentioned are considered pearls of Azerbaijani culture and art. The damage caused by the enemy to historical and architectural monuments in our lands liberated from occupation has been investigated and observed so far. This article examines the names, locations, materials of historical and architectural monuments in the Karabakh region, the impact of military operations and occupation processes on them, and the existence of ways to restore them.

Keywords: historical monument, artillery, destruction

The Karabakh region is one of the oldest cultural centers of Azerbaijan. Historical and architectural monuments of various periods are located here - mosques, churches, fortresses, bridges and cemeteries. To date, various researchers, architects, archaeologists have studied the types and materials of historical and architectural monuments in the Karabakh region and determined the damage caused. These monuments are mainly made of natural building materials - stone, brick, wood, plaster and sometimes marble. However, wars and military operations have had a serious impact on these materials, in many cases leading to the partial or complete destruction of the monuments[1].

The greatest damage occurred during the First and Second Karabakh Wars between Armenia and Azerbaijan. The subsequent occupation and brutal plundering actions of the Armenians damaged important pearls of cultural heritage in those lands. Therefore, the study, damage and resuscitation of such important historical and architectural monuments have become an important issue[2]. In order to restore these monuments, it is necessary to first determine their materials, the area where they are located, and the effects of military operations. The restoration of ancient architectural monuments damaged by the war in Karabakh and in general requires both a practical and scientific approach, mainly 3D printers, laser scanning, reinforcement with nanomaterials and virtual restoration methods will play a significant role in the restoration of these monuments[3].

Several stages need to be completed to restore ancient historical and architectural monuments. Initially, a damage assessment should be applied. In the first stage, the real condition of the monuments is documented by archaeologists, architects, conservators and restorers. Mapping of existing remains is carried out using photos, 3D scans, and drone footage. Cracks, burn marks, disintegrations, and corrosion in materials (stone, brick, wood, metal) are analyzed[4]. Then, historical documents are examined. Archival photographs, drawings, traveler's notes, and UNESCO information about the previous appearance of the monument are studied. Oral history is collected among the local population. Then, the stage of restoration and adaptation of materials begins. And this stage is grouped as follows:[5]

- Stone monuments: Filling of cracks by selecting suitable stone from local quarries, restoration without damaging the original architectural style.

- Brick and tile monuments: New bricks are made using traditional technologies and matched to the old ones.
- Wooden elements: Damaged wooden parts are replaced with materials made of the same type of wood, protected by varnish and conservation methods.
- Frescoes and patterns: Stabilized with chemical conservation agents, colors are restored to match the original[6].

Finally, modern technologies are applied. 3D printers and laser scanning allow for accurate copying of old parts. Reinforcement with nanomaterials is used to prevent the collapse of stone and brick. Virtual restoration is the preparation of digital models for monuments that cannot be fully restored. Legal, international and local support is important in this regard. As a legal and international support, the restoration process should be carried out in accordance with the recommendations of UNESCO, ICOMOS and other organizations. The local population, students, and artisans should be involved in the restoration work so that both traditional art lives on and a sense of ownership of the monument increases[7].

As a result, the restoration of Karabakh monuments is not just the reconstruction of stone walls, but also the restoration of historical identity, cultural memory, and national heritage. This work can be carried out with the unity of science, technology, and the people. It is proposed that the restoration of historical and architectural monuments can be organized using 3D printers, laser scanning, reinforcement with nanomaterials, and virtual restoration methods[8].

Reference

1. Əliyeva S. "Müharibə dövründə mədəni irsin mühafizəsi məsələləri" Qafqaz Universiteti Elmi Əsərləri, cild 15, səh 88-99, 2020.
2. Hüseynov E. "Azərbaycan tarixi-memarlıq abidələrinin qorunması problemləri" Bakı: Elm və Təhsil, 2018.

3. Məmmədov R. "Qarabağ abidələrinin müharibədən sonrakı vəziyyəti" Azərbaycan Memarlıq və İncəsənət Jurnalı №4, səh. 25-39, 2021.
4. Quliyev T. "Daş materiallı abidələrin dağıntılara qarşı dayanıqlığı" Azərbaycan Milli Elmlər Akademiyası Xəbərləri, Memarlıq və İncəsənət Seriyası №2, səh 55-63, 2019. Khalaf M.N.
5. "Traditional Building Materials in the Middle East: Vulnerability to War Damage" International Journal of Architectural Conservation, pp 201-220, 2020.
6. Smith J. & Brown L. "Preservation of Historical Monuments under Armed Conflicts" Journal of Cultural Heritage, pp 45-58, 2019.
7. Thompson P. & Watson D. "Sulfur Removal in Wastewater Treatment: A Critical Review of Techniques" Environmental Technology & Innovation, pp 135-145, 2018.
8. UNESCO "Damage Assessment of Cultural Heritage Sites in Conflict Zones" Paris: UNESCO Publishing, 2017.

POINTS ON ESTABLISHING INTERNATIONAL COOPERATION FOR THE ECOLOGICAL REHABILITATION OF POST-CONFLICT AREAS

Gulsum Huseynli[1], Rukhsara Hasanova[2]
Ministry of Ecology and Natural Resources of Azerbaijan [1]
Baku State University [2]
gulsum.huseynli@eco.gov.az

Introduction: **The Environmental Consequences of War** - This document examines the deep and often overlooked link between armed conflict and environmental degradation, emphasizing the urgent need for stronger international cooperation. War not only brings human suffering and infrastructure collapse but also causes long-term harm to ecosystems — including deforestation, pollution of natural resources, and biodiversity loss. Existing legal frameworks offer some protection, yet remain insufficient to effectively prevent or address the environmental damage caused by warfare. This study aims to promote dialogue and support the development of more effective strategies to mitigate these impacts.

The Role and Influence of International Organizations and Conventions in Post-Conflict Recovery - Through environmental analysis, governance support, and resource management initiatives, **UNEP** serves as a crucial actor in ecological rehabilitation efforts in conflict-affected regions. After conducting environmental assessments, UNEP can support the following outcomes in affected areas: analysis and recycling of waste materials, reclamation of degraded lands, conservation of biodiversity through the reintroduction of endemic species, and facilitation of ecological restoration projects by establishing connections with donor organizations.

The **IAEA** also offers support in setting up radiological monitoring systems, mobile laboratories, and training for personnel. In this context, the IAEA has installed four monitoring stations to measure background radiation levels in the Lachin, Kalbajar, Gubadli, and Zangilan regions.

In post-conflict contexts, **FAO** also plays a vital role in the restoration of forests in conflict-affected areas. This includes the physical rehabilitation of land and forest areas—such as reforestation and soil erosion control.

WWF is promoting nature-based solutions integrating environmental sustainability into reconstruction and climate resilience planning. Beyond restoration, WWF supports ecosystem and community resilience — including forest rehabilitation, biodiversity protection, and sustainable livelihoods contributing to lasting peace and ecological stability.

The **Convention on Biological Diversity (CBD)** plays a crucial role in post-conflict zones by promoting biodiversity conservation, sustainable use of resources, and equitable benefit sharing, which can contribute to peacebuilding and sustainable development. The CBD framework emphasizes national strategies, capacity building, and traditional knowledge, which are vital for rebuilding ecosystems and livelihoods in conflict-affected areas.

By ratifying the **Minamata Convention**, a country can facilitate the implementation of environmental assessments in post-conflict areas, support the identification of mercury-related risks, and enhance access to grants and project-based assistance in this regard. The Minamata Convention can make a significant contribution to post-conflict recovery and environmental assessment processes.

Work can be done on the assessment and management of toxic wastes and POPs under the UNEP **Stockholm** and **Basel Conventions**. Azerbaijan, in accordance with the Basel Convention, is actively establishing safe management systems for hazardous waste, including asbestos and war debris, with the support of the United Nations. A joint project initiative with UNEP, GEF and SEPA (Sweden) under the Stockholm Convention can be done: the aim is to map, monitor and develop a cleanup plan for POPs residues in post-conflict areas.

Conclusion - To mitigate the long-term ecological consequences of armed conflict, environmental recovery must be a core pillar of post-war reconstruction strategies. By strengthening multilateral collaboration and investing in nature-based and community-driven solutions, the international community can turn ecological damage into an opportunity for **resilience**, **sustainability**, and **peace**.

Key words: international cooperation, hazardous waste, ecosystem, environmental assessments, convention

References

- https://www.unep.org/cote-divoire/post-conflict-environmental-assessment#:~:text=Upon%20request%20of%20the%20Government,the%20C%C3%B4te%20d'Ivoire%20coastline.
- https://www.zsl.org/news-and-events/news/conservationists-call-impact-armed-conflict-biodiversity-be-acknowledged
- https://www.nicolefound.org/programmes/unep-post-conflict-environmental-recovery-guidance
- https://www.unep.org/resources/assessment/sudan-post-conflict-environmental-assessment
- https://sdg.azstat.gov.az/en/indicators/608/number-of-parties-to-international-multilateral-environmental-agreements-on-hazardous-waste-and-othe#:~:text=The%20Republic%20of%20Azerbaijan%20accedes,Republic%20ware%20developed%20and%20approved.
- https://wedocs.unep.org/bitstream/handle/20.500.11822/40746/environmental_impact_Ukraine_conflict.pdf?sequence=3&isAllowed=y
- https://enb.iisd.org/basel-rotterdam-stockholm-conventions-brs-cops-2022-summary
- https://www.iaea.org/topics/response/nuclear-safety-security-and-safeguards-in-ukraine/assistance?

- https://www.neimagazine.com/news/belarus-receives-iaea-radiological-monitoring-equipment-7948742/
- https://www.iisd.org/system/files/publications/conflict_peace building.pdf
- https://openknowledge.fao.org/home
- https://openknowledge.fao.org/server/api/core/bitstreams/23b 8936f-163f-4fbb-9607-93226645a8b2/content
https://www.wwfmmi.org/?8199916/httpswwfuanaturebasesolutions#:~:text=After%20the%20onset%20of%20the,context%20of%20post%2Dwar%20recovery
- https://wwf.panda.org/wwf_news/?5985466/Environmental-NGOs-call-for-a-green-post-war-reconstruction-at-Ukraine-Recovery-Conference
- https://www.kfw-entwicklungsbank.de/PDF/Evaluierung/Ergebnisse-und-Publikationen/IKI-Evaluierungen/IKI_Kaukasus_Naturwald_2017_E.pdf?
https://minamataconvention.org/en/projects/establishing-functional-environmental-information-system-synergistic-implementation
- https://ejeba.com/index.php/journal/article/view/62/48
- https://ceobs.org/how-does-war-damage-the-environment/#:~:text=The%20use%20of%20explosive%20weapons,such%20as%20water%20treatment%20plants.
- https://pmc.ncbi.nlm.nih.gov/articles/PMC5101266/
- https://www.unep.org/topics/disasters-and-conflicts/response-and-recovery#:~:text=Helping%20partners%20prepare%20for%20crisis,Press%20release

MELIORATIVE REMEDIATION AND RESTORATION OF SOIL AFTER MILITARY CONFLICTS

Umud Gasimov
Azerbaijan State Water Resources Agency Water and Reclamation Scientific Research Institute
umud.qasimov@smeti.gov.az

Military conflicts have complex negative effects on the structure, chemical, and biological properties of soil. Artillery fire, explosive munitions, and heavy machinery disrupt the mechanical structure of soil layers, causing dispersion and compaction of soil masses. This leads to a reduction in soil porosity, alteration of hydro-physical characteristics, and destruction of microstructures, ultimately deteriorating the soil's hydromeliorative indicators (permeability, water retention, drainage capacity). As a result of military conflicts in the Karabakh region of Azerbaijan, the meliorative condition of the soil has changed significantly. Given the diverse geomorphological and meliorative conditions of the region, the impact of conflict on soil varies by zone. In mountainous areas such as Lachin, Kalbajar, and Shusha, the intensive movement of tanks and armored vehicles has seriously disrupted soil structure and destroyed natural and forest cover. In these zones, soil porosity and water retention capacity have decreased by 35–40%, accelerating erosion processes. In lowland areas, including Fuzuli and Jabrayil, artillery fire and landmines have caused soil subsidence and seriously degraded hydro-physical properties. The destruction of irrigation systems has intensified salinization and alkalinization processes, reducing agroecosystem productivity by 25–30%. In mineralized and steppe zones, military operations have drastically decreased biological productivity, reducing microorganism populations by up to 50%, thus disrupting the functional stability of the soil biosphere.

To normalize the hydro-physical properties of soil, mechanical methods such as aeration, cultivation, fertilization, and the application of organic matter are widely used. To eliminate structural degradation in compacted soils, multilayer repair and preventive leaching techniques are applied, which increase infiltration capacity by 20–30%, restoring water balance. For chemical contamination, immobilization of pollutants is achieved using phosphate- and calcium-based modifiers. Alongside neutralization processes, bio-remediation techniques involving microorganisms—especially bacteria and fungi—as well as the phytoremediation potential of plants are used to reduce soil toxicity and restore biological activity. In Karabakh, the application of bioremediation methods has restored soil microflora activity by about 40%. Reconstruction of destroyed irrigation and drainage infrastructure is a core component of hydromeliorative rehabilitation. The repair of hydraulic structures and optimization of irrigation norms help regulate soil irrigation regimes and reduce water stagnation and salinization issues. Modernization of drainage systems in Karabakh has led to a 15–20% reduction in erosion processes. Additionally, innovative tools such as Geographic Information Systems (GIS), remote sensing, and sensor technologies are widely used in soil reclamation. These technologies not only enhance the effectiveness of meliorative measures but also ensure the sustainability and adaptive management of restoration processes. Scientific studies indicate that innovative approaches can increase soil productivity by at least 25%.

References

1. Aliyev, J.A. Methods of Improving the Reclamation Condition of Soils. Baku: Elm Publishing House, 2014.
2. Ministry of Ecology and Natural Resources of the Republic of Azerbaijan. Report on the Ecological Condition and Assessment of Land Resources in the Karabakh Region. Baku, 2022.

THE USE OF CHEMICAL AGENTS IN MILITARY OPERATIONS AND THEIR CONSEQUENCES

Khudayar Hasanov[1,2], Asmat Azizova[1], Naila Guliyeva[2], Shimid Gasimov[1]
[1]Azerbaijan Medical University, [2]Western Caspian University,
x.qasanov58@gmail.com

Chemical weapons are one of the most dangerous means of mass destruction used in military conflicts. Despite international prohibitions, they continue to be used in a number of local wars. The relevance of the topic is due to the high degree of destructiveness of chemical agents, their impact on public health, the environment and the moral and psychological state of society. The purpose of this work is to consider the nature of the use of chemical weapons, their consequences and international control measures. The first mass use of chemicals occurred during the First World War (1914–1918), when chlorine, phosgene, and mustard gas were used. Later, chemical weapons were used in the conflict between Iraq and Iran, in the civil war in Syria, and in terrorist attacks. Brief examples of use: 1915, Ypres — use of chlorine by the German army, 1980s, Iran–Iraq — mass use of mustard gas and sarin, 2013–2018, Syria — cases of sarin and chlorine use against civilians have been recorded [1]. Chemical substances used for military purposes are divided into several categories according to the nature of their effect: asphyxiants (chlorine, phosgene): affect the respiratory tract, causing pulmonary edema, nerve agents (sarin, VX): affect the nervous system, causing paralysis and death, vesicants (mustard gas): cause chemical burns of the skin and mucous membranes, general toxic (hydrocyanic acid): disrupt cellular respiration processes, irritants (CS, CN): used to suppress protests, temporarily incapacitate. The impact of chemical agents is extremely destructive for both the armed forces and the civilian population: mass poisoning and death of people, long-term consequences: oncological and neurological diseases, congenital pathologies in offspring, pollution of water, soil and air with toxic substances, psychological trauma: fear, panic, post-traumatic syndrome, disruption of medical infrastructure and humanitarian aid in the affected area. Following the horrific consequences of the use of chemical weapons during the First and Second World Wars, the international community began to develop treaties to ban chemical weapons. Key international documents prohibiting the use of chemical weapons in military operations: The Geneva Protocol (1925) - a ban on the use of suffocating and poisonous substances, the Chemical Weapons Convention (1993) - a ban on the development, production, stockpiling and use of chemical weapons. The Organization for the Prohibition of Chemical Weapons was created, which carries out control. As of 2024, 193 countries have joined the convention. Despite this, violations are recorded in a number of cases, for example, in Syria and Iraq [2].

Despite the efforts of the international community, chemical weapons continue to pose a threat to global security. They violate humanitarian norms and cause long-term damage to people and nature. Only strict control, collective measures against violators and the constant development of protection technologies will help prevent a repetition of the tragic events of the past.

References

1. Chemical weapons: history, classification and consequences / Ed. S. A. Kulikov. - M.: Military publishing house. 2021. P.346.
2. Chemical and Biological Weapons: Use in Warfare, Impact on Society / L. K. Park. – Oxford Press, 2020.

PROBLEMS OF ENSURING SECURITY AT INTERNATIONAL AIRPORTS LOCATED IN THE TERRITORIES LIBERATED FROM OCCUPATION

Ruslan Rustamov
National Aviation Academy
rrustamov@naa.edu.az

In modern times, the increasing trend of large-scale acts of terrorism and unlawful interference are forcing states to implement a number of countermeasures. Combat measures taken to ensure the security of their citizens have become a pressing problem for states. The measures are mainly aimed at ensuring the security of highly dangerous, life-saving and strategic facilities of particular importance in the international and national spheres, especially airports with a large flow of people. As terrorist acts committed at international airports have caused high public resonance, protecting civil aviation from acts of unlawful interference remains an ever-important issue. A perfect security and guarding system is required for the areas and facilities on the balance of airports with complex security zones. Protecting civil aviation facilities from acts of terrorism and unlawful interference is considered a preventive measure to ensure aviation security. To prevent possible acts of unlawful interference, it is essential to detect intruders at an early stage.

The priority issue of aviation security is the implementation of a set of measures to protect passengers, flight crew, ground personnel, aircraft and other civil aviation facilities from acts of terrorism and unlawful interference on the ground or in flight, in order to ensure the safety, regularity and efficiency of flights. The implementation of this set of measures at the international and national levels is carried out by involving the human and material resources of states and airlines. The importance of creating an airport security complex in this direction is reflected in the relevant standards and recommended practices of Annex 17 to the Chicago

Convention, as well as in the "State Program on Aviation Security" and the "Rules for Ensuring Aviation Security".

The security of strategically important facilities begins with perimeter protection, which plays an indispensable role in their reliable protection. Currently, a wide range of technical systems are used in perimeter guarding. However, it is difficult to find technical means that can physically work effectively in any location and under any conditions. When choosing a system, the main considerations should be the type of protective barrier (e.g., the type of fence) and the type of intrusion that is likely to occur. In addition, it is important to pay attention to many natural and technical factors when choosing a perimeter security system. It is important for security systems to have automated technical means that are highly efficient and capable of performing flexible operations and can be integrated into the existing infrastructure of the airport's guarding complex. To ensure reliable, sustainable and effective implementation of the above requirements, integrated automated guarding warning systems with remote control of the perimeter are used.

A timely, reliable, and sustainable response to anticipated threats depends on the level of integration of guarding warning systems of strategically important facilities. Stable and reliable operation allows guarding warning systems to receive information about possible threats at an early stage, regardless of environmental influences. Along with the advantages, the main disadvantages of these systems are that they do not use special intelligent algorithmic software capable of distinguishing between humans and small targets (animals and birds). In order to eliminate the shortage, it is advisable to use capacitive sensors in the guarding warning systems of international airports located in the liberated territories. Because capacitive sensors have the ability to detect an intruder approaching the airport perimeter from a relatively long distance, regardless of the ambient temperature and geometric dimensions. Capacitive sensors are mainly used in various types of guarding fences, such as tall fences, wide gates, etc. covering large areas, and can effectively detect intruders in these locations.

ECONOMIC MECHANISMS IN THE RECONSTRUCTION OF WAR-AFFECTED AREAS AND ENVIRONMENTAL RESTORATION

Roya Amirova
The Academy of the Ministry of Emergency Situations
roya.amirova@fhn.gov.az

The economic recovery and ecological reconstruction of regions devastated by war are interdependent processes. The restoration of ecosystem services—such as water, soil, and air—is a fundamental prerequisite for reviving agriculture, tourism, and industrial activities in these regions. International experience shows that sustainable post-war economic development must be built on the principles of a green economy.

Several key economic mechanisms play a crucial role in the economic and environmental restoration of post-conflict territories. One such mechanism is public-private partnership (PPP). Through such collaboration, especially environmentally focused projects are financed. For instance, initiatives in renewable energy are supported by green funds and facilitated through tax incentives provided by the state. A practical example of such collaboration is the “Smart Village” project (e.g., Aghali village in the Zangilan district), where ecological and sustainable agricultural technologies are applied, and farmers are supported through government subsidies.

International donor mechanisms also play a significant role in post-conflict recovery. Financial instruments provided by institutions such as the Asian Development Bank (ADB), the World Bank (WB), the Global Environment Facility (GEF), the Green Climate Fund (GCF), and the European Bank for Reconstruction and Development

(EBRD) are directed toward sustainable environmental restoration and infrastructure rebuilding (Del Castillo, 2008).

Additionally, domestic financing tools ensure the efficient use of local resources. These include the reinvestment of land tax revenues, issuance of reconstruction bonds, and ecology-based insurance mechanisms. Such instruments create conditions for the independent economic revitalization of war-affected areas (Makdisi & Soto, 2023). Land tax exemptions, concessional loans to farmers, and support from ecological funds contribute to economic revitalization in the regions (Kravchenko, 2024)

Ultimately, the principles of the green economy and circular economy form the foundation of sustainable recovery. Within this framework, investment projects aimed at waste reuse, biodiversity conservation, and carbon emission reduction gain special significance. Green investment funds and the implementation of environmental technologies are actively encouraged (Tokarchuk et al., 2024). Therefore, the recovery process requires not only technical and social efforts but also strong economic planning and financing mechanisms. These mechanisms collectively serve as strategic tools to support the economic, social, and environmental revitalization of post-war regions.

References

1. Del Castillo, G. (2008). *Rebuilding War-Torn States: The Challenge of Post-Conflict Economic Reconstruction*.
2. Makdisi, S., & Soto, R. (2023). *Economic Agenda for Post-Conflict Reconstruction*.
3. Kravchenko, K. et al. (2024). *War Consequences and Urban Reconstruction*.
4. Tokarchuk, D. et al. (2024). *Green economic approach to Ukraine's reconstruction*.

SECTION 6. GENERAL ISSUES OF ENVIRONMENTAL IMPACT OF MILITARY CONFLICTS

ENVIRONMENTAL DEGRADATION IN THE KARABAKH REGION CAUSED BY MILITARY CONFLICTS IN AZERBAIJAN

Kh.J.Mammadova, E.A.Abdullayeva
National Aerospace Agency,
Institute of Space Research of Natural Resources
xuraman.mammadova88@gmail.com

This thesis explores the severe environmental degradation in the Karabakh region of Azerbaijan as a result of prolonged military conflicts. It focuses on key environmental consequences such as forest fires, soil contamination, and the pollution of freshwater sources caused by the deployment of heavy artillery, landmines, and other military activities. By analyzing satellite imagery, official environmental assessments, and post-conflict ecological data, the study outlines both the immediate and long-term impacts of war on the region's ecosystem. The research also proposes measures for environmental restoration and sustainable post-conflict resource management [2].

The Karabakh conflict between Armenia and Azerbaijan dates back to the late 1980s and intensified into full-scale war during the early 1990s and again in 2020. Throughout these periods, military operations were conducted across forested, agricultural, and urban areas. The use of explosives, trench warfare, and infrastructure sabotage left behind a legacy of land degradation, unexploded ordnance, and chemical contamination. Environmental issues were not prioritized during hostilities, leading to long-term damage to natural habitats [1].

One of the most visible and devastating consequences of the conflict was the extensive destruction of forests. Military shelling, incendiary weapons, and deliberate burning led to the loss of thousands of hectares of forest in Karabakh.

The use of heavy military machinery, explosive ordnance, and chemical agents contaminated both surface and underground water sources. Polluted rivers and lakes have had a detrimental effect on agriculture and human health.The contamination of water sources also had cross-border implications, affecting neighboring ecosystems and human settlements downstream [3].

Since the end of active hostilities, the Azerbaijani government, in collaboration with international partners, has begun large-scale environmental assessments in the liberated territories.

The Karabakh conflict illustrates how military operations can lead to long-lasting environmental degradation. Forest destruction, pollution of vital resources, and the collapse of local ecosystems are not only ecological tragedies but also obstacles to sustainable development and peacebuilding. This study underlines the importance of environmental accountability in conflict zones and calls for more robust international mechanisms to prevent and mitigate ecological damage in future conflicts.

References

1. United Nations Environment Programme (UNEP). (2009). Protecting the Environment During Armed Conflict: An Inventory and Analysis of International Law. United Nations. https://www.unep.org/resources/report/protecting-environment-during-armed-conflict
2. International Committee of the Red Cross (ICRC). (2020). When Rain Turns to Dust: Understanding and Responding to the Combined Impact of Armed Conflicts and the Climate and Environment Crisis on People's Lives. https://www.icrc.org/en/publication/4494-when-rain-turns-dust
3. Carius, A. (2006). Environmental Peacebuilding: Managing Natural Resource Conflicts in Post-Conflict Societies. In Environmental Change and Security Program Report, Issue 12, 4-11. https://www.wilsoncenter.org/publication/environmental-peacebuilding

INTEGRATED ENVIRONMENTAL AND BEHAVIORAL MONITORING FOR POST-CONFLICT REHABILITATION IN TRANSPORT INFRASTRUCTURE

Shola Shekili

National Aviation Academy of Azerbaijan
shekily1977@gmail.com

Post-conflict zones affected by military operations face not only physical destruction but also deep ecological imbalances. Traditional environmental rehabilitation efforts tend to overlook the crucial dimension of human behavior and infrastructural interaction in recovering these territories. This paper proposes a novel approach combining environmental monitoring and behavioral profiling to support the sustainable recovery of dual-use transport zones, particularly those near former conflict areas.

While post-conflict ecological recovery strategies are increasingly discussed in environmental literature (e.g., reports by UNEP, 2021), there remains a significant gap in integrating human behavior as an operational factor within ecological risk models. Existing frameworks rarely account for the psychosocial consequences of prolonged militarization, nor do they incorporate infrastructural behavior patterns that may indicate environmental misuse or future instability (Meloy, 2016). This paper attempts to bridge that gap through a multidimensional risk-based approach.

Using a cross-disciplinary methodology, we outline a framework integrating remote sensing, CO_2 emission tracking, and infrastructure-based behavior analytics. The model emphasizes the detection of environmental hazards such as chemical residues, deforestation, and soil destabilization, alongside monitoring of human movement patterns, unauthorized access, and insider threats in rehabilitated airports and logistic hubs. The inclusion of behavioral data allows for a more precise risk assessment and prioritization of ecological restoration measures.

Furthermore, the paper advocates for international cooperation in the post-conflict ecological rehabilitation of strategic infrastructure zones, aligning environmental goals with security protocols. By treating transport-related sites not just as passive victims of war, but as active agents in recovery, the proposed framework opens new avenues for resilience-building and environmental stewardship in formerly militarized landscapes.

This integrative approach is particularly relevant in regions like the South Caucasus and Eastern Europe, where post-conflict zones coincide with critical civil and military transport corridors. The methodology includes satellite data analysis, on-site biosensor deployment, and predictive behavior modeling supported by AI-free analytics (see recent work in *behavioral risk mapping* by Meloy, 2016; WMO climate resilience reports, 2023). The behavioral component includes heatmap-based analysis of foot traffic, identification of anomaly clusters in access logs, and semi-structured observational protocols implemented in cooperation with local monitoring agents. Such synergy between environmental science and security profiling ensures not only ecological stabilization but also safeguards against illicit activity, radicalization, and infrastructure misuse during the recovery period. The framework thus contributes to both sustainable development goals and conflict prevention in fragile, strategically important ecosystems.

In future applications, the proposed model may be integrated into smart environmental governance platforms, enabling real-time decision-making across post-conflict regions. Its modular structure allows adaptation to various scales and ecological contexts, potentially becoming a cornerstone for global cooperation in climate-security interfaces.

IMPACT OF ECOLOGICAL DISASTERS RESULTING FROM MILITARY CONFLICT IN KARABAKH ON CLIMATE CHANGE

Sona Osmanova
Baku State University
osmanova-sona@mail.ru

The Karabakh region, with its rich natural resources, unique biodiversity, and significant water reserves, constitutes one of the key ecological systems of the South Caucasus. However, the long-lasting military conflicts, especially during the period of occupation by Armenia and the Patriotic War of 2020, have severely disrupted the region's ecological balance. These disruptions have both direct and indirect impacts not only on local ecosystems but also on regional climate change.

According to NASA's MODIS (Moderate Resolution Imaging Spectroradiometer) satellite observations, the average annual temperature in the region has increased from 0.7^0C to 1.2^0C. While the average annual temperature in the early 2000s was around 11.2^0C, by the 2020s this figure had risen to approximately 12.4^0C. The most significant temperature increases have been observed during the summer and spring months. Although the average annual precipitation remains around 450-550 mm, in the 2020s this indicator dropped to 390-420 mm in some areas, representing an overall decrease of 8-12%. The most pronounced reduction in precipitation levels has occurred around Shusha, Khojavend, and Fuzuli. In the 2000s, the active growing season for plants typically began in late March or early April; however, in the 2020s, it has shifted approximately 10-14 days earlier, being recorded in mid-March. As a result, vegetation has developed earlier, but due to a lack of soil moisture, overall productivity has declined. The number of drought days per year has increased on average by 18-22 days. Previously, drought periods during summer lasted around 30-35 days, but in recent years this figure has exceeded 50 days in some cases. During the military conflicts in Karabakh, over 20000 hectares of forest, shrubland, and pasture were either destroyed by fire or damaged by machinery. This has led to a 15-20% reduction in the region's carbon storage capacity, disruption of soil structure, and changes in the water balance.

Since 1992, the Sarsang Reservoir (with a capacity of 560 million m^3 and an area of 14.2 km^2), which was held under occupation by the Armenian armed forces, has for many years been used as a means of geopolitical pressure and as an ecological weapon. Under normal operating conditions, this reservoir was supposed to supply irrigation water to six districts along the Tartar River (Aghdam, Tartar, Barda, Goranboy, Yevlakh, and Aghjabadi). However, this regime was deliberately disrupted by Armenia. In the summer months, the withholding of water resulted in irrigation problems across more than 100000 hectares of farmland. In the winter months, sudden and uncontrolled releases of water caused irrigation canals and drainage systems to fail, leading to flooding of agricultural lands and increased waterlogging and salinization processes. Between 1995 and 2010, the area of saline soils in Aghjabadi and Tartar districts tripled, increasing from 7500 hectares to 22000 hectares. Observations indicate that the water's acidity level (pH) decreased from 7.2 to 6.4, while the concentration of ammonia due to wastewater increased from 1.2 mg/l to 4.8 mg/l. The discharge of industrial and military waste into rivers and lake basins led to a 40-60% reduction in aquatic fauna populations. The biodiversity of aquatic organisms (especially fish species) declined, with at least 17 species either disappearing or migrating. Due to irregular water supply, the vegetation period was disrupted, leading to the destruction of 35-40% of the plant cover and an increase in the surface temperature of the soil by 1.1-1.4^{0}C. The Karabakh region is home to nearly 60 endemic and rare species (including the Karabakh oak, Karabakh kharybulbul, and Eastern plane tree). Approximately 25-30% of these species have changed their distribution range.

The pollution of soil, water, and air resources, the loss of biodiversity, and the destruction of forest cover have severely disrupted the ecological balance of the region. Therefore, sustainable restoration, ecosystem-based approaches, and climate adaptation measures are of critical and strategic importance in Karabakh.

References

1. Ministry of Ecology and Natural Resources of the Republic of Azerbaijan. (2021). Report on the assessment of the environmental situation in the liberated territories. Baku
2. Babayev A.M. (2020). Degradation of land and water resources in the Garabagh region and its connection with climate change. Bulletin of the Geographical Society of Azerbaijan, No. 3, pp. 45-53
3. International Committee of the Red Cross (ICRC). (2020). When rain turns to dust: Understanding and responding to the combined impact of armed conflicts and the climate and environment crisis on people’s lives. Geneva: ICRC
4. Mammadova S.A. (2021). Impact of forest fires in Garabagh on forest ecosystems and the regional climate. Ecology and Sustainable Development, No. 2, pp. 61-68
5. Gasimov R.F. (2023). Intentional environmental degradation and climate risks during the Karabakh war. Proceedings of the Institute of Geography, National Academy of Sciences of Azerbaijan, No. 1, pp. 24-32

LANGUAGE, EDUCATION, AND ENVIRONMENTAL AWARENESS IN POST-CONFLICT ZONES: BRIDGING LINGUISTIC GAPS IN WAR-AFFECTED TERRITORIES

Ahmad Haj Ali
Western Caspian University
Teacherahmad2025@outlook.com

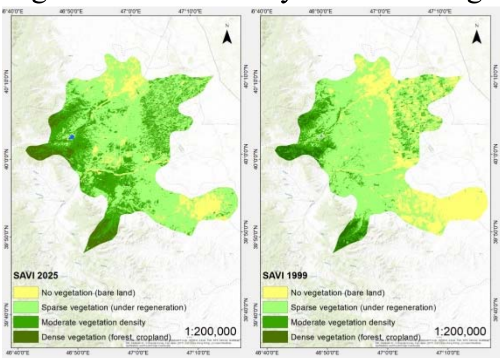
Military conflicts often leave lasting damage to ecosystems, but their effects extend far beyond the environment. One of the most significant consequences is the disruption of communication and education systems, which are essential for raising environmental awareness and fostering international cooperation in post-conflict recovery. This paper examines the intersection of applied linguistics, environmental communication, and education in post-conflict regions, focusing on the linguistic and educational challenges that impede effective environmental recovery. In many affected areas, linguistic diversity poses a challenge to the accessibility of environmental information, as key messages are often conveyed only in dominant or official languages, leaving marginalized communities unable to engage with crucial data or recovery efforts. Furthermore, the disruption of education systems during and after conflicts exacerbates this problem, as environmental education is often neglected or underdeveloped in curricula, which hinders long-term sustainability efforts. This paper advocates for the integration of multilingual and contextually relevant environmental education in post-conflict zones, emphasizing the importance of including local languages and cultural knowledge in educational materials and environmental campaigns. By incorporating diverse linguistic and educational perspectives, recovery efforts can be more inclusive and effective, empowering local communities to actively participate in rebuilding both their environments and societies. Ultimately, this paper calls for international organizations and NGOs to prioritize

linguistic inclusivity and educational strategies that foster both environmental literacy and social resilience in war-affected regions.

ASSESSMENT OF LAND DEGRADATION IN POST-CONFLICT AREAS USING SATELLITE DATA

Turkan Mamishova
Baku State University
Turkan.memishova@gmail.com

The main objective of this study is to analyze post-war land cover changes based on satellite data and to assess the level of land degradation. The study area is the Aghdam district of the Republic of Azerbaijan. Since Aghdam remained under occupation for a long period, the reduction in anthropogenic activity and the deformation of the landscape during the occupation have led to significant changes in land cover.

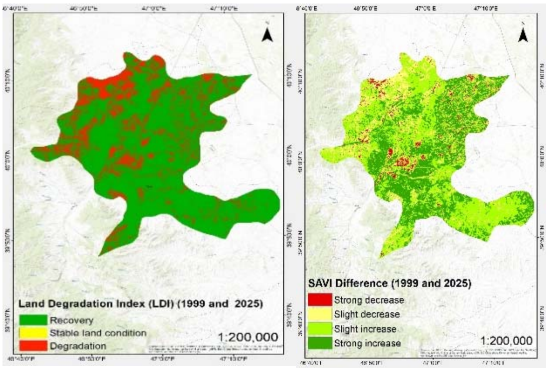


The research utilized Landsat 5 (1999**)** and Landsat 9 (2025) satellite imagery, as well as Sentinel data, focusing on imagery captured in June**.** Through this data, the Land Degradation Index (LDI) and Soil Adjusted Vegetation Index (SAVI) were calculated to evaluate changes in land quality across the region [1, 2].

Furthermore, a SAVI difference map (comparing 1999 and 2025) was developed to visualize the dynamics of vegetation change more clearly. This map allowed for the spatial analysis of changes in vegetation levels, identifying areas with both increases and decreases in coverage. Notably, some previously degraded areas have shown signs of vegetation recovery, while others have experienced further degradation of land surface.

In addition, the LDI was employed to assess the severity of land degradation. The LDI map revealed that several parts of Aghdam exhibit moderate to high levels of degradation, indicating that natural regeneration processes are weak in those areas and that active intervention may be necessary.

In conclusion, analyses based on satellite data demonstrate that LDI and SAVI are effective tools for monitoring land conditions, estimating recovery potential, and supporting land-use planning in post-conflict environments. The study further highlights that land cover changes following conflict are heterogeneous, and satellite-based assessments play a crucial role in identifying and understanding these dynamics. The findings of this research provide valuable information for land restoration efforts, ecosystem rehabilitation, and the development of sustainable land management policies at the regional level.



References

1. Bai, Z.G., Dent, D.L., Olsson, L., & Schaepman, M.E. (2008). Proxy global asses sment of land degradation. *Soil Use and Management*, 24(3), 223–234.
2. Huete, A.R. (1988). A soil-adjusted vegetation index (SAVI). *Remote Sensing of Environment*, 25(3), 295–309.

ENVIRONMENTAL IMPACT OF MILITARY CONFLICTS,
International conference dedicated to the year of Constitution and Sovereignty,
September 10-12, 2025, Baku, Azerbaijan

ON THE PREFERENCE OF THE TRANSITION TO A GREEN ECONOMY IN IMPROVING THE QUALITY OF LIFE OF PEOPLE IN THE OCCUPIED TERRITORIES

Farhad Mirzayev, Zuleykha Javanshirova, Namig Bakhishov
Baku State University
farhad_1958@mail.ru, shabiyeva.zuleyxa@gmail.com,
namigbm@hotmail.com

This paper explores the role of transitioning to a green economy in improving the quality of life in the liberated territories of Azerbaijan. Post-conflict reconstruction in these regions presents both significant challenges and unique opportunities. The green economy framework is essential for ensuring ecological restoration, sustainable development, and socio-economic well-being. Azerbaijan has launched initiatives such as the creation of "green" villages and towns, the application of renewable energy resources (solar, wind, hydro), and measures to restore forests and agricultural lands destroyed during occupation. The findings indicate that by adopting green economic principles, Azerbaijan can simultaneously restore ecological balance, improve living standards, create new jobs, and reduce poverty in the liberated territories. Moreover, the integration of advanced technologies and international cooperation is vital for achieving long-term sustainability and resilience in these regions.

The lands of Azerbaijan, which have been under occupation for nearly 30 years, have suffered serious ecological damage. Deforestation, pollution of water resources, and the chemical and physical deterioration of the lands have led to a disruption of the ecological balance in these areas. In addition, the abandonment of agricultural lands, the destruction of industrial infrastructure, and the presence of mined areas have had a negative impact on the quality of life of people. Currently, the Azerbaijani state is carrying out large-scale restoration and construction work in the liberated lands within the framework of the "Great Return" program. One of the main directions of this program is the application of the green economy model. This is very relevant in terms of both minimizing environmental risks and ensuring the social well-being of the population. The purpose of the study is to analyze the role of the green economy in improving the quality of life in the liberated territories; to study the measures taken to restore the ecological environment in these areas; to assess the possibilities of implementing green energy projects, alternative energy sources, and innovative technologies; and to evaluate Azerbaijan's transition strategy to a green economy, taking into account international experience. Green economy is considered a key tool for sustainable development. According to the definition of the United Nations Environment Programme (UNEP), a green economy aims to increase human well-being and social equity, while minimizing environmental risks and depletion of natural resources. The Karabakh and East Zangezur regions of Azerbaijan have been declared "Green Energy Zones". Solar, wind and hydropower projects are planned to be implemented here. "Smart village" and "green city" projects in accordance with ecological principles are being implemented in the liberated areas. Aghaly village in Zangilan district is an example of this. Demining, forest restoration, protection of water resources and development of agriculture on ecological grounds are among the main directions. The establishment of transport systems powered by alternative energy, waste management and the application of environmentally friendly production technologies are envisaged. According to the State Statistical Committee, the volume of carbon dioxide emissions in Azerbaijan remained stable and sometimes increased in 2005–2022. This indicates the importance of the transition to a green economy. New technologies applied on liberated lands will allow for waste reduction. Clean air, restoration of water resources, increasing soil fertility and the creation of new jobs, education and health infrastructure are key aspects for improving the quality of life.

Alternative energy production, development of ecotourism, expansion of income opportunities of the local population are envisaged as economic factors. The analysis shows that the implementation of a green economy will create conditions for eliminating the consequences of the ecological disaster in the liberated territories, developing sustainable agriculture and alternative energy sectors, improving the social well-being of the population, increasing the economic potential of the region, and forming a new development model in accordance with international environmental standards. As a result, the transition to a green economy acts as one of the main strategies for ensuring not only the ecological, but also the social and economic security of Azerbaijan.

References

1. Gilmundinov V. M., Kazantseva L. K., Tagaeva T. O., Kugaevskaya K. S. Environmental Pollution and Public Health in Russia. Bulletin of Novosibirsk State University, 2012.
2. Anufriev V.P., Anufrieva E.I., Petrunko L.A. Enhancing the Competitiveness of Regions and Enterprises through the Green Economy. Bulletin of Ural Federal University, 2014.
3. Carter N. The Politics of the Environment: Ideas, Activism, Policy. 3rd ed., Cambridge University Press, 2018.
4. Dövlət Statistika Komitəsi. https://www.stat.gov.az
5. Azərbaycan Respublikasında "Böyük Qayıdış" və "Yaşıl Enerji Zonaları" üzrə rəsmi sənədlər.

THE ENVIRONMENTAL IMPACT OF WAR IN THE KARABAKH REGION AND THE RESTORATION OF ECOLOGICAL BALANCE IN THE LIBERATED TERRITORIES

A.A.Hasanov, K.S.Abdullayeva, Z.Z.Sharifova
Azerbaijan State University of Oil and Industry
alakbar-48-48@mail.ru ,abdullayeva.kamala@asoiu.edu.az

The impact of the environment on human health has always been a priority topic. One of the factors that negatively affect the environment is war. This article explores the adverse environmental impacts of war. War is the root cause of many diseases and can have significant and tragic consequences for individuals' lives. The article investigates the negative effects of war and occupation on the environment in the Karabakh region, the resulting losses, and the damage caused by the use of phosphorus bombs. Additionally, it examines the ways to eliminate the arising ecological problems.

This article examines the severe environmental damage caused by war and occupation in the Karabakh region. As a result of the conflict, the chemical and physical structure of the soil was disrupted, forests were destroyed, water resources were polluted, and biodiversity suffered significant harm. The use of heavy military equipment, chemical weapons, and phosphorus bombs caused long-term and devastating impacts on ecosystems.

Before withdrawing from the liberated territories, Armenian armed forces deliberately set fire to homes, forests, and infrastructure, carrying out what can be termed "ecological terrorism." These actions, which violated international law, led to the destruction of many rare plant and animal species.

Furthermore, Armenia's use of phosphorus bombs during the war posed serious threats to human health and the environment. These bombs cause deep burns, organ damage, and respiratory issues. The use of such chemical weapons is strictly prohibited under the Chemical Weapons Convention.

The article also highlights Azerbaijan's efforts to restore the environment in the liberated territories, including reforestation, water restoration, and ecosystem rehabilitation. However, full recovery may take decades, and the return of some species might not be possible.

In conclusion, the authors emphasize that the environmental destruction should be recognized as "ecocide" and that those responsible must be held legally accountable. War does not only harm people, but also causes irreversible damage to the planet's ecosystems.

References

1. Günümüzün savaşlarında çevre konusuna ilişkin bir değerlendirme. / Tarık Ak / İstanbul Aydın Üniversitesi Dergisi 32, (2016) (17-26)
2. "International Law Protecting the Environment During Armed Conflict: Gaps and Opportunities"/ Bothe M. / International Review of the Red Cross, Vol 92,Number 879, 574, September 2019.
3. "Silâhlı Çatışmalarda Doğal Çevrenin Korunması"/ Topal A. H. / MHB, 29, (1-2), 2009.
4. Kimyasal Savaş Ajanları: Tarihçeleri,Toksisiteleri, Saptanmaları ve Hazırlıklı Olma/ Pınar Erkekoğlu, Belma Koçer-Gümüşel / Hacettepe University Journal of the Faculty of Pharmacy Review Article Volume 38 / Number 1 / January 2018 / pp. 24-38
5. Ganesan K, Raza SK, Vijayaraghavan R: Chemical warfare agents./Journal of Pharmacy and Bioallied Sciences 2019, 2(3):166-178.
6. Биологическая деградация белого фосфора: осуществимость и перспективы/ Миндубаев, Антон Зуфарович, Волошина Александра Дмитриевна и Яхваров Дмитрий Григорьевич/ Butlerov Communications. 2013. Vol.33. No.2. P.1-17.
7. Исследование микробной детоксикации белого фосфора – компонента зажигательных боеприпасов/ Миндубаев А.З., Волошина А.Д., Бабынин Э.В., Минзанова С.Т.,Миронова Л.Г., Сапармырадов К.А., Бадеева Е.К./2018

THE IMPACT OF ELECTROMAGNETIC WAVES ON THE ENVIRONMENT

R.R.Ahmadova, G.M.Seyidova, G.J.Rustamova
Sumgayit State University MSE AR
gulnara.rustamova@sdu.edu.az, rahila.ahmadova@sdu.edu.az

Keywords: Electromagnetic waves, electromagnetic pollution, radioactive radiation, ionization, isotope**,** physical pollution, environmental protection, technogenic impact.

Summary. This thesis investigates the effects of electromagnetic waves and radioactive radiation on the environment and human health. It is shown that the widespread use of electrical and radiotechnical devices leads to the formation of electromagnetic fields, which in turn causes ionization and pollution of the environment. Exposure to electromagnetic fields and radioactive isotopes can lead to cellular-level disorders in humans, resulting in various diseases, particularly radiation sickness. Furthermore, the damage caused by electromagnetic waves to soil and vegetation can transfer harmful effects through the food chain to humans and animals. Therefore, it is crucial to observe ecological and sanitary-hygienic standards when placing devices that generate electromagnetic fields. The thesis also emphasizes the necessity of developing and implementing preventive technical and organizational measures to minimize these harmful effects.

It is well known that electrical and radiotechnical devices, which increasingly penetrate human life, simultaneously pollute the natural environment with electromagnetic radiation. The main sources of electromagnetic pollution include radio and television broadcasting devices, high-voltage power lines, electric vehicles, and radiocommunication equipment. These devices and their equipment generate powerful electromagnetic fields in the areas where they are located. These fields produce radioactive radiation, which in turn leads to the formation of charged particles (ions and electrons), resulting in ionization and pollution of the environment [1].

Recently, several modern technical and technological systems have employed devices with radioactive properties for operational purposes—such as radioactive level gauges, roentgen spectroscopes, static charge neutralizers, and certain equipment in nuclear power plants. These devices primarily operate using radioactive isotopes. As these isotopes decay, they emit radiation and contaminate the environment. In ionized environments, chemical reactions occur at the cellular level within human organisms, disrupting normal physiological functions and leading to radiation sickness [2].

Electromagnetic waves are absorbed by the soil and cause significant damage to plants. Moreover, radiation-affected plants can transmit these harmful effects to humans and certain animals. Currently, the harmful impacts of electromagnetic fields on humans and living organisms are being closely studied, and regulatory limits are being established. During the planning and construction of facilities generating electromagnetic fields, the location of residential areas, recreational zones, and arable lands must be considered [3].

Some industrial enterprises also use devices associated with radioactive isotopes. The radiation generated around such devices poses significant health risks. It should be noted that the placement guidelines for such modern and hazardous equipment, as well as protective measures against their physical impacts, have not yet been sufficiently developed. In recent years, discussions around these harmful sources have increased, and protective measures have started to be implemented. In the past, such concerns were rarely mentioned—the only focus was producing large quantities of high-quality products [5].

Today, all sources capable of polluting the environment through chemical or physical means are being recorded. Their harmful effects are being studied, and extensive work is being conducted to eliminate, neutralize, or minimize them. A technical action plan has been prepared and is expected to be implemented in the near future.

References

1. Mammadov R.A. – Ecology and Environmental Protection, Baku, 2018
2. Aliyev M.G. – Impact of Electromagnetic Fields and Safety Regulations, Baku Technical Publishing, 2017
3. Huseynov A.F. – Use and Protection Methods of Radioactive Isotopes, Sumgayit State University, 2020
4. World Health Organization (WHO) – Recommendations on the Impact of Electromagnetic Fields on Human Health, WHO Report, 2019
5. Guliyeva S.T. – Technogenic Impacts and Environmental Pollution, Baku, 2021
6. Ministry of Ecology and Natural Resources of the Republic of Azerbaijan – Regulatory Documents on Environmental Protection, 2022

RESEARCH INTO THE IMPACT OF WARS ON CLIMATE CHANGE

Gullu Gullarli, Gunel Imraliyeva
Military Institute named after Heydar Aliyev
axundzadegullu@rambler.ru

Any military weapon has a devastating effect on the environment, especially if this process is long-term and covers a large area. However, with the use of modern means, even a short-term military conflict can lead to serious consequences. The deliberate impact of man on nature and the environment with the help of military ammunition is called environmental warfare. Currently, weapons of mass destruction can be nuclear, chemical and bacteriological. People, like all components of the environment, are powerless against these types of weapons. Nuclear weapons are characterized by their power and diverse effects: shock waves, radiation, radioactive and electromagnetic radiation in the environment. Shock waves have a huge destructive effect on unprotected people and animals, causing severe injuries and even death. During war, when the wave pressure exceeds 50 kPa, forests are completely destroyed, trees are uprooted, people's bones are broken and internal organs are destroyed. Light radiation causes severe burns to exposed parts of the body and blindness. From the effects of radiation, from the lethal effects of neutrons and γ-rays - people and animals develop radiation sickness, the severe form of which leads to death.

"Nuclear winter" is a global ecological catastrophe, a factor leading to the collapse of the Earth's ecosystem and the catastrophe of humanity. Chemical weapons are used in missiles, mines, bombs and other military means. Chemical poisons pose a high toxic threat to the human body throughout the trophic chain. Chemical weapons were most often used in World War I and in Vietnam. The combat poisons used in 1914-1918 (mainly mustard gas) took the lives of 10 thousand people and crippled 1.2 million. Currently, new classes of combat toxic substances have appeared, especially those with a neuro-telepatholytic effect (sarin, tabun, soman, etc.), as well as toxic substances with a psychogenic, general toxic and asphyxiating effect. Chemical weapons have a very strong negative impact, causing massive destruction of natural ecosystems, vertebrates, plants and humans.

References

1. Hacıyeva S.R., Hüseyinli A.Q., Rüstəmova Ü.N.,Hüseynov F.E. Ekologiyanın əsasları və təbiətin mühafizəsi// Bakı 2018, 258 s.
2. Гаджиева С.Р., Алиева Т.И. Конфликт между природой и человеком в период военных столкновений// Проблемы современной науки и образования.,2016,№1(43), с.264-266

THE ADVANTAGES AND APPLICATION PROSPECTS OF NEXT-GENERATION MILITARY TECHNOLOGIES AND CHEMICAL AGENTS IN CONTEMPORARY ARMED CONFLICTS

Rafig Agamaliev, Nazila Rahimova
National Aerospace Agency, Institute for Space Research of Natural Resources, NASA
n-allahverdiyeva@mail.ru

Modern military operations have evolved and become increasingly complex due to technological advancements. In contemporary warfare, alongside high-precision weapon systems and unmanned aerial vehicles (UAVs), innovative tools such as electronic warfare systems and robotic technologies are also widely used. In some cases, the use of chemical agents—prohibited by international law—has been observed. Chemical weapons are employed to cause both fatal and psychological effects on people. A key characteristic of modern warfare is that not only physical force but also information and technological superiority play a decisive role. Therefore, the effective and responsible use of military technology, along with adherence to international conventions, is crucial in managing modern conflicts. Technical superiority is a crucial factor in determining the outcome of battles in modern warfare. UAVs, armored vehicles, robotic systems, electronic warfare tools, and cyber-attack and defense systems are among the primary technological assets used in today's military operations. Additionally, modern infantry fighting vehicles and tanks are outfitted with heavy armor and advanced weaponry. Robotic technologies can replace the human presence on the battlefield, helping prevent casualties and resulting in fewer deaths. One of the most significant advantages of modern warfare is the deployment of electronic warfare and cyber-attack and defense systems, which provide information superiority on the battlefield. As a result, the digital era has set the stage for technical superiority and a crucial factor in determining the outcome of battles in modern warfare. UAVs, armored vehicles, robotic systems, electronic warfare tools, and cyber-attack and defense systems are among the primary technological assets used in today's military operations. As a result, the digital era has set the stage for wars to shift into a virtual realm domain war to shift into a virtual realm domain.

The use of chemical agents and weapons was banned by the Geneva Protocol of 1925 and the Chemical Weapons Convention of 1993. Still, there have been documented cases of illegal use of these weapons in some conflicts. Agents like sarin, chlorine, and mustard gas, used in these cases, burn the skin, damage the respiratory system, and result in mass casualties. Chemical substances in aerosol and gas form cause panic among civilians and are often used to swiftly evacuate areas. Therefore, under international law, using chemical agents in warfare is considered a war crime and is strictly forbidden.[1]

In conclusion, modern military operations are carried out not only with traditional weapons but also with systems based on advanced technologies. To regulate modern conflicts and ensure that armed forces act according to ethical principles, compliance with international legal standards is essential.[2]

References

1. Mammadov, M. A. (2020). "The Role of Information and Technology in Modern Wars". Baku" Elm və Təhsil".
2. Ahmadov, E. M. (n.d.)."Modern Military Strategies and Technologies"– Baku, 2018

THE IMPORTANCE OF ESTABLISHMENT OF AN INTERACTIVE GEOINFORMATION DATABASE OF THE ROAD-TRANSPORT INFRASTRUCTURE OF THE REPUBLIC OF AZERBAIJAN

Ilgar Musayev[1], Aziz Talibov[1], Magsad Gojamanov[2], Rauf Nuhov[1]
[1]National Defence University Military Scientific Research Institute,
[2]Baku State University
ilgar2533@gmail.com, aziztalibov@mail.ru, mgodja@yandex.ru, enrio2904@gmail.com

Along with air, sea and rail transport, road transport also occupies an important place in the economy of the Republic of Azerbaijan. Road transport infrastructure includes all categories of roads, bridges, tunnels, cargo terminals, parking lots, overpasses, road signs and other elements.

Since elements of road transport infrastructure are located on the ground, information about their name, coordinates, size and shape is usually taken from the terrain. Data obtained on the terrain, as well as statistical data obtained from other data sources, are provided to users for their purpose after processing in geographic information systems (GIS) programs.

The establishment of an interactive geographic database of the road infrastructure of Azerbaijan in order to meet the needs of integration into international road transport organizations, as well as to facilitate the growing information needs of road transport within the country and abroad is an urgent task today.

The article examines the importance of establishing an interactive geoinformation database of the road transport infrastructure of Azerbaijan and presents a variant of the database's structural model.

Conversion coefficients from the distance measured on the map to the curvilinear distance in the area [1]

Terrain type	**Correction factor for maps of different scales**			
	1:50 000	**1:100 000**	**1:200 000**	**1: 500 000**
Plain	1,00	1,00	1,05	1,05
Hilly	1,05	1,10	1,15	1,20
Mountain	1,15	1,20	1,25	1,30

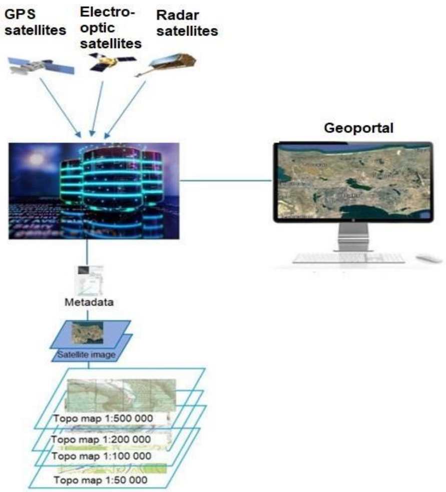


Figure 1. Structural sheme of the interactive geoinformation database of road infrastructure (***Note:*** *Author of the model – Ilgar Musayev*)

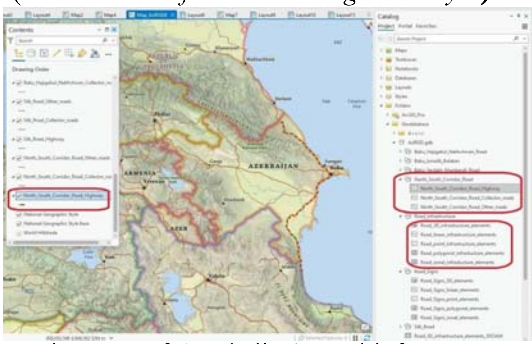


Figure 2. Interactive map of Azerbaijan's road infrastructure developed in ArcGIS Pro database (fragmentary image) (***Note:*** *The interactive geographic database was developed by Ilgar Musayev, using ArcGIS Pro software)*

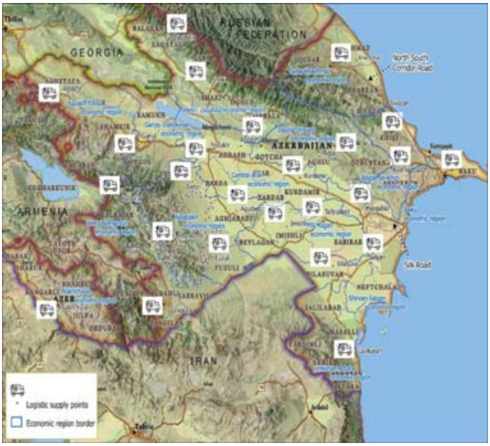


Figure 3. Map of logistics support points in the Republic of Azerbaijan (variant)
***(Note:** The map was prepared by Ilgar Musayev based on a basemap from the ArcGIS Pro software*)

Figure 4. The main corridor of the trans-European transport network (TEN-T). The ways. Map of the connection of Azerbaijan highway Silk Road to TENT-T main corridor roads
***(Note:** The map was prepared by Ilgar Musayev based on the "Roads connecting European region" map)*

References

1. M. H. Godjamanov, B.A. Aliyev, M. SH. Suleymanaov. Military Topography / Baku: 2008, Hərbi Nəşriyyat, page 12, 232 pages.
2. Условные знаки, образцы шрифтов и сокращения для топографических карт масштабов топографических карт масштабов 1:25 000, 1:50 000, 1:100 000. Военнотопографическое управление генерального штаба / Москва -1963, Редакционноиздательский отдел Военно Топографической Службы, страницы 16-19, 68 стр.
3. Rob O'Byrne, What is Transportation? Is it the same as transport? / Electronic resurce, URL: https://www.logisticsbureau.com/what-is-transportation/
4. European Court of Auditors. Roads connecting European region / European Union, May 2019, page 15, pages 15. Electronic resurce, URL: https://www.eca.europa.eu/lists/ecadocuments/ap19_08/ap_connecting_roads_en.pdf
5. Po Ve Sham, Muki Haklay. GIScience, Citizen Science & Environmental Information. The source of the assertion that 80% of all organisational information is geographic. , Electronic resurce, URL: https://povesham.wordpress.com/2010/02/22/the-source-ofthe-assertion-that-80-of-all-organisational-information-is-geographic/

30 YEARS OF OCCUPATION AND THE ECOLOGICAL STATE OF KARABAKH

Khasmurad Ismayilzadeh[1], Khatira Ismayilova [2]
[1]Istanbul Gedik University, Istanbul
[2]Institute of Petrochemical Processes MSE AR, Baku
Xatire19667@gmail.com

In modern times, the environmental damage caused by wars affects the whole world. In the 21st century, along with the death of people during wars, the amount of damage to the environment has also increased. During wars, more and more industrial enterprises are being destroyed in order to collapse the enemy's economy.

During these attacks, industrial chemicals affect the civilian population. Every Azerbaijani who has been at war with Armenia for many years knows this well. At the same time, every Azerbaijani has seen with his own eyes the ecological terror carried out by the aggressor Armenia in our territories. As we can see, wars have a devastating impact on the environment. We know this very well. Over the course of 30 years, as a result of the Armenian occupation, dozens of cities and villages of Azerbaijan have been destroyed, a number of cities have been completely razed to the ground and demolished to the last stone. The once beautiful city of Agdam has been completely destroyed. Due to the scale of the destruction, Aghdam was called the “Hiroshima of the Caucasus” of Azerbaijan. In addition to the destruction of our cities and villages over the past 30 years, the ecological situation has also been devastated. The forest reserves in those regions and their rare fauna, flora, and rich resources in the rivers were destroyed by Armenian vandals. In short, the ecological terror carried out by Armenians in the occupied territories of Azerbaijan destroyed the ecosystem, nature, and resources of the region. In the protected areas such as the Basitchay and Garagol reserves, the Arazboyu, Lachin, Gubadli, and Dashalti nature reserves under the occupation of Armenia, most of the 60 fauna and 70 flora species included in the "Red Book", as well as the use of phosphorus bombs, which were banned during the war, destroyed all the vegetation in this area.

The rare endemic forests of the Zangilan region were cut down by the invaders, irrigation systems in the Jabrayil and Fuzuli regions were completely destroyed, springs and wells were destroyed, rivers were polluted, hundreds of kilometers of Azerbaijani lands were turned into trenches and military shelters. During the 30-year occupation, Armenia caused long-term and irreversible damage to the environment of the Republic of Azerbaijan. For many years, the hated enemy illegally exploited the national resources of Azerbaijan, benefiting both its own country and its foreign supporters. However, after the victory over Armenia, Azerbaijani environmental activists held a peaceful protest on their lands, on the Lachin road connecting Armenia with part of Karabakh, demanding environmental monitoring in the region and preventing the illegal exploitation of Azerbaijan's natural resources, and achieved their goals.

The Azerbaijani people, who liberated their lands from Armenian occupation, are currently engaged in restoring the environment in Karabakh. Thus, important steps are being taken to restore the ecological situation in that region. Thousands of different types of trees, mainly Eastern plane trees, have been planted in the territories of Fuzuli, Zangilan and Aghdam districts, and seeds of oak and other forest trees have been sown. Tree planting campaigns are also continuing in Gubadli, Jabrayil and other liberated districts.

References

1. Bizim Yol.info. Müharibə ətraf mühiti necə məhv edir, 24 mart, 2022
2. Milli.Az. Müharibələrin, silahların ilk qurbanı, 20 May 2014
3. Xalq qəzeti. Qarabağa sağlam ətraf mühit və minasız həyat 08.12.2023

ECOLOGICAL REHABILITATION IN POST-CONFLICT ZONES: INTERNATIONAL COOPERATION AND INTEGRATIVE APPROACHES

Firangiz Fataliyeva, Lala Hatamova
Institute of Ecology, National Aerospace Agency, Ministry of Defense Industry of Azerbaijan
lale.hatamova@gmail.com, firengizfeteliyeva606

Wars not only take a heavy toll on human lives but also cause long-lasting and sometimes irreversible damage to the environment. This issue extends beyond the natural restoration of ecosystems; it holds strategic significance for human health, economic development, and regional security. Experience shows that international cooperation plays a critical role in addressing such challenges.

International practice demonstrates that in post-conflict regions such as Kosovo, Bosnia and Herzegovina, Iraq, and Afghanistan, ecological rehabilitation has been possible not only through local resources but also with the support of international institutions and donor organizations.

The territories of Azerbaijan recently liberated from occupation (particularly the Karabakh and Eastern Zangazur economic regions) were left unmanaged for an extended period, resulting in significant ecological problems. Serious threats include deforestation, contamination of water bodies, loss of rare biodiversity, soil erosion, and extensive landmines. Addressing these issues requires a comprehensive approach, with the establishment of international partnerships as a key condition.

The following cooperation opportunities and recommendations should be considered:

Utilizing the technical and practical experience of international organizations such as HALO Trust and UNDP in mine clearance.

Engaging institutions such as UNEP, the European Bank for Reconstruction and Development (EBRD), and the Islamic Development Bank (IsDB) in ecological mapping and monitoring activities.

Implementing joint projects with special donor programs for the South Caucasus region (e.g., EU4Environment) to restore biodiversity.

Receiving technical support under the Bonn Convention and the United Nations Sustainable Development Goals (SDG-13 and SDG-15) frameworks to combat climate change and soil degradation.

Establishing cooperation with foreign universities and research institutes to facilitate training and technology transfer, ensuring the capacity building of local specialists.

Thus, ecological rehabilitation processes can be carried out more effectively and sustainably not only based on national capabilities but also through global experience and support. In this regard, Azerbaijan must strengthen its cooperation with donors and international environmental organizations and create an exemplary model for post-conflict rehabilitation. This will ensure ecological stability within the country and contribute to sustainable development goals at the regional level.

References

1. Mammadova, S. (2021). *Post-münaqişə ərazilərinin ekoloji reabilitasiyası: Beynəlxalq təcrübə və regional çağırışlar.* Bakı: Elm və Təhsil Nəşriyyatı.
2. Aliyev, R. (2022). *Qarabağda mina təhlükəsi və ekoloji nəticələr: HALO Trust və ANAMA-nın fəaliyyəti.* Azərbaycan Ekologiya Jurnalı, №3, s. 17–24.

ASSESSMENT OF RADIOECOLOGICAL RISKS IN THE LIBERATED JABRAYIL DISTRICT

Famil Humbatov[1,2], Geys Ibrahimov[1], Gultakin Aslanova[1], Husniya Nejati Solut[1], Valeh Balayev[1], Nisakhanim Karimova[1], Intizar Karimbeyli[1], Sabir Osmanov[3]
[1]Azerbaijan Institute of Radiation Problems MSE AR,
[2]Azerbaijan University of Architecture and Construction,
[3]Military Institute named after Heydar Aliyev
hfamil@mail.ru

Jabrayil district is one of the 66 districts of Azerbaijan. It is located in the south-west of the country and belongs to the East Zangezur Economic Region. The district borders the districts of Khojavend, Fuzuli, Gubadli, Zangilan, and the Islamic Republic of Iran. Jabrayil region is located in the south-east of the Lesser Caucasus mountains, in the Gayan plain and the Karabakh range. The region borders the Islamic Republic of Iran along the Araz River in the south. Its area is 1050 square kilometers [1]. The soils of the Arazboyi plains are dark chestnut soils with high productivity. Before the Armenian occupation, there were 118 kahriz (kahriz - is an underground facility system created in arid zones to collect groundwater, and in some cases surface water, and bring it to the surface with its own flow) and 99 springs, 107 subartesian wells and Hasanli and Maral canals, which take their source from the Araz river, in the region. There are 58.686 hectares of land suitable for agriculture in the region, of which 12.509 hectares were irrigated land. Jabrayil region, which was under Armenian occupation for nearly 30 years, not only the villages and settlements, residential areas, but also its natural resources, forests, springs, water reservoirs were razed to the ground, purposeful changes were made in the area. The surrounding environment has been subjected to serious ecological impacts and changes. The deliberate alterations to the district's territory, the plundering of natural resources, and the use of various types of weapons, ammunition, and military equipment during the war have exposed the area to pollution and led to the disruption of ecological balance, creating conditions for the contamination of existing water sources. For this reason, the radioecological assessment of the region is of particular importance.

In the article of this research, radiation measurements were conducted in mine-safe areas for the assessment of radioecological risks in the liberated Jabrayil district. Water samples were taken from the rivers in the district for the evaluation of water quality. It is known that physical-chemical processes occurring in river systems vary depending on water parameters.That's why, continuous monitoring of these parameters for both monitoring and scientific research purposes can be considered significant. Additionally, the potential use of the researched water sources as sources of drinking water underscores the necessity for complex analyses to be conducted on them.

During the radioecological monitoring in the Jabrayil district, measurements of gamma radiation exposure dose rate were conducted using the IndetiFINDER-2 dosimeter-spectrometer device. The measurement activities were carried out in accordance with the requirements of the standard operating procedure, and based on the observed radiation background values, a characteristic average value of 3.76 μR/h was determined for 85 measurement points, with a minimum of 0.8 μR/h and a maximum of 11.6 μR/ho (Figure.1). It should be noted that relatively high radiation background was observed around Khudafarin bridge.

Water samples taken from the district area were analyzed for various parameters (pH, conductivity (Cond.), total dissolved solids (TDS), salinity (Sal.), dissolved oxygen (DO), temperature (T), radiation background (R)) to determine the quality. Then, after undergoing respective preparation stages, the samples were analyzed for metal composition via atomic absorption spectrometry, and the determined concentrations were compared with the permissible limits for drinking water provided by the World Health Organization (WHO).

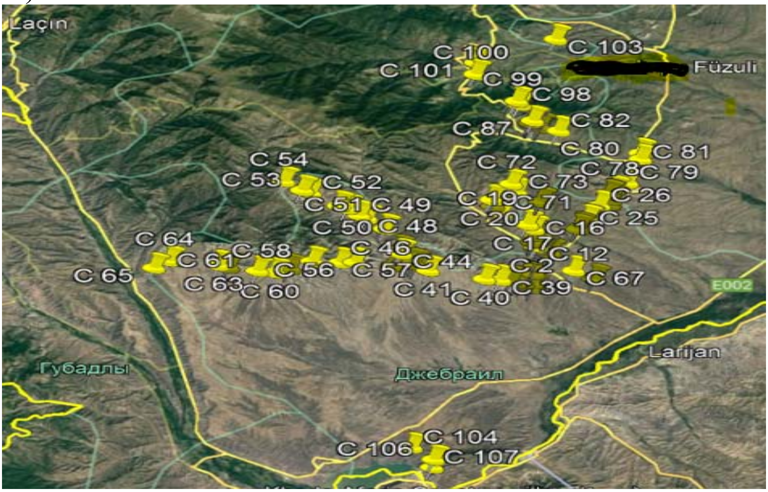


Figure 1. The measurement of radiation background was carried out in the areas of Jabrayil district.

To measure water quality parameters, water samples were taken from 5 points of Jabrayil region. These areas include Jabrayil district Dostlug spring, Dashkasan village (artesian water), Minbashili village, Gumlag village and Khudafarin village. Studies have shown that the conductivity levels at several sampling points exceeded the WHO guidelines for drinking water, indicating high mineralization. A high conductivity in water indicates that the water contains significant amounts of dissolved ions such as salts, minerals, or metals that can carry an electrical charge. This makes the water, particularly from the sampling points in the Jabrayil region, Dashkasan village (artesian water), Minbashili village, Gumlag village, and Khudafarin village, unsuitable for drinking. If the WHO standard for conductivity is set at 400 µS/cm, the conductivity of water samples at these points exceeds 550 < µS/cm. This indicates that these water sources are highly mineralized and are not suitable for use as drinking water.

Additionally, the collected samples were analyzed using the Varian SpectrAA 220FS Atomic Absorption Spectrometer to determine the metal composition [2]. The results of the analysis were compared with the WHO standards. Most metals, including copper, manganese, nickel, and zinc, were within safe limits set by WHO. However, iron levels at one location Gumlag village were significantly above the recommended level, indicating that this water source should not be used for drinking without treatment. Thus, there are many reasons for the high amount of Fe in the water basin, including:

Use of explosives and military equipment during war and occupation

1. Natural Sources: Iron is abundant in the Earth's crust and can leach into rivers from rocks and soils, especially in areas rich in iron-bearing minerals.
2. Industrial Pollution: Industrial discharges, particularly from mining, metal processing, or wastewater from factories, can introduce significant amounts of iron into nearby water bodies
3. Agricultural Runoff: Fertilizers or chemicals used in agriculture may contribute to increased iron levels in water through runoff.

Iron is an essential nutrient for humans, and excessive intake through drinking water can cause health problems such as iron overload, which can damage organs such as the liver, heart, and pancreas. Also, iron concentrations can harm aquatic organisms by affecting water chemistry and reducing oxygen availability for aquatic organisms. Although the average concentration of iron in rivers is reported to be 0.7 mg/L, after treatment, the concentration of Fe in water is typically kept below 0.3 mg/L for drinking purposes. Therefore, it is not recommended to use the mentioned water source directly as drinking water.

References

1. Akif A. Alizadeh, Ibrahim S. Guliyev, Fakhraddin A. Kadirov, Lev V. Eppelbaum. Geosciences of Azerbaijan, Volume I: Geology, Springer International Publishing Switzerland 2016, p.237
2. S.Sh. Mammadzada1, F.Y. Humbatov, I.I. Mustafayev. Assessment of heavy metal pollution in water and surface sediments from Goranchay. Journal of CHEMICAL PROBLEMS 2021 no. 2 (19), pp. 84-93,ISSN 2221-8688

ECOLOGICAL PROBLEMS CAUSED BY MILITARY OPERATIONS

N.U.Alakbarova, A.Z.Abdullazade
Azerbaijan Ministry of Defence Industry, National Aerospace Agency, Institute of Ecology
nermin.elekberova.86@mail.ru, murselzade_ayten@mail.ru

One of the technogenic disasters that has dealt a heavy blow to nature is war in its various forms. The territories that remained under enemy occupation for 30 years and the 44-day war have caused serious damage to the unique natural biogeoecological system of Karabakh. In the occupied territories, the fertile layer of soil that had formed over centuries was destroyed, significant damage was done to the flora and fauna, plant and animal species were eradicated, and forest cover was burned, turning the area into a desert. According to the results of conducted monitoring, it has been determined that oriental plane trees aged 1600, 900, and 500 years were destroyed in the territories of Gubadli, Fuzuli, and Jabrail districts. During the battles for the liberation of the lands, more than 1000 pieces of equipment running on liquid fuel and fuel depots were destroyed. As the occupiers retreated from the territories, they set fire to these depots, residential areas, and forests.

Forest plants are responsible for breaking down carbon dioxide through the process of photosynthesis. The destruction of forests leads to numerous problems. As a result, the water cycle weakens, its sources disappear, soils undergo severe erosion, large gullies form over vast areas, and dry winds prevail. The destruction of forests leads to the loss of carbon dioxide absorption channels, alters the circulation of energy, water, and biogenic elements of the global biological cycle, affects the chemical composition of the atmosphere, and causes drastic changes in climate conditions at local, regional, and global levels.

During the occupation period, Azerbaijan's hydrological environment was poisoned, reaching the brink of an ecological crisis. Nearly all of the rivers originating from the territory of Armenia flow into Azerbaijan's Kura-Aras rivers and from there into the Caspian Sea.

For years, rivers such as Okhchu, Zangi, Aras, Aghstafa and others flowing from the territory of this country have polluted Azerbaijan's rivers with their waters. Harmful substances discharged into the Okhchu river from the Gafan molybdenum deposits have contributed to this pollution.

The water used in Armenia's nuclear power plant was later discharged into rivers that flow into Azerbaijan. During the course of the military operations, large amounts of petroleum products were released into the environment, contaminating the soil and water bodies.During the war, the enemy used weapons that are prohibited by international conventions. The use of such weapons poses a danger to human health and may lead to radioecological problems in the future. Modern, technological, and innovative methods are being used to detect landmines during the demining of the liberated territories. For this purpose, robots and drones are being utilized. In order to analyze ecological risks and hazards, it is advisable to implement the following essential measures.

1. The geochemical characteristics of degraded landscapes should be studied from an ecological perspective during field research of the area.
2. The quantity and distribution areas of carcinogenic toxic substances formed in the soil and water as a result of ecological terror should be identified.
3. The distribution areas of radioactive elements in the area should be identified, and chemical and spectral analyses of soil and water samples should be conducted.

President has noted that there is every opportunity to establish a green energy zone, develop solar and wind energy sources in the liberated territories. He also stated that new construction works will commence, and alongside infrastructure projects, the transportation and technology sectors will also remain a focus of attention.

References
1. Əhmədov Ş., Sadıqov R., Tətbiqi Ekologiya. Bakı-“Sabah” 2019, 321 s
2. Əliyeva R., Mustafayev Q.,Hacıyeva S. Ekologiyanın əsasları.Bakı, 2006,536 s.

ENVIRONMENTAL IMPACT OF MILITARY OPERATIONS

Imran Gasimov, Sadagat Adigozalova, Gunel Tomuyeva,
Latifa Atakishiyeva, Gulnara Asadova
Institute of Bioresources of the MSE (Ganja)
penahova.shahnaz@mail.ru

As a result of military operations, very serious negative effects occur in the environment — including a decrease in biodiversity and the emergence of irreversible processes leading to its destruction. These include soil, water, and air pollution, destruction of forests, displacement of animals, and damage to ecosystems. Due to the use of military technologies and weapons, the soil can become polluted with heavy metals, fuel, and other harmful substances. This slows down the development of vegetation and leads to the extinction of species.

One of the main documents of the UN is the Environmental Modification Convention (ENMOD), which prohibits the use of environmental modification techniques for military or hostile purposes by manipulating natural processes that affect the dynamics, composition, or structure of the Earth — including the biota, lithosphere, and hydrosphere.

Wars, military exercises, and tests also have negative impacts on ecological integrity and contribute to the planet's pollution. According to experts, wars in ancient times did not have significant effects on the global ecological condition. However, recent wars have inflicted harsh damage on nature and the environment.

According to Swiss scientist Jean-Jacques Babel, 14,513 wars have taken place in the last 600 years. The impact of small aerial bombs disrupts the normal climatic conditions within 16 days. A single military helicopter’s missiles can cause cracks in the soil layer that never heal again. If it rains, the area turns into a “dead zone” in 15 days; if it doesn’t rain, in 9 days. For the next 20 years, nothing grows in that zone, and nearby areas see a 2.5 times increase in tuberculosis syndrome. This shows that weapons directly contribute to the destruction of biodiversity.

The nearly 30-year occupation of Azerbaijani territories led to the destruction of cities and villages, as well as the devastation of civilian life and the flora and fauna of the region. Since the military conflict and war occurred solely within Azerbaijani territory, our atmosphere, water, air, and soils were subjected to biological, chemical, radiological, and physical pollution.

Armenia, besides being an occupying force that carried out ethnic cleansing across the Caucasus region, has also been identified as a state supporting and engaging in terrorist acts against civilians. It has been confirmed that the Armenian military used various types of prohibited munitions against civilians during the conflict. In October and November 2020, ballistic missiles such as the OTR-21, Tochka, and Scud—whose use is internationally prohibited—were launched at civilian settlements (Ganja, Mingachevir, Barda, Tartar).

Armenian armed forces violated international environmental protection standards, legal frameworks, and laws in the occupied territories. Monitoring conducted in the liberated areas revealed widespread exploitation of natural resources and illegal logging of centuries-old valuable trees in the forests. Armenian military personnel and equipment were directly involved in this destruction. In areas along the Murov Mountain range in Gazakh and the Talysh forest zone in Aghdara, over 100 hectares of valuable trees such as pistachio, mastic, hackberry, pine, and oak were cut down and damaged by the occupying forces.

From September 21–23, 2021, during an online seminar held by the Lithuanian Armed Forces within the framework of the Eastern Partnership, foreign participants were informed about Armenia's acts of ecological terror against Azerbaijan. Armenia was highlighted as not only a threat to the South Caucasus but to global environmental security due to its eco-terrorist actions. As a result of Armenia's aggression and occupation, the environmental damage and loss of natural resources inflicted on Azerbaijan is estimated to be $265 billion.

References

1. Bakı döyüşü, Muğan hadisələrı, Aprel işğalı (Türkiyənin müharibəsi), Əfqanıstan müharibəsi (4979-1989), Qarabağ Müharibəsi (May hadisələri).4-iyun Gəncə qiyamı.Tovuz döyüşləri. İkinçi Qarabağ Müharibəsi.
2. İşğaldan azad edilmiş şəhər və kəndlərimiz Azərbaycan 2020-12-30 tarixində arxivləşdirilib.
3. General–mayor Mayıs Bərxudarov: Düşməni sona qədər məhv etmək uğrunda vuruşaçağıq. Azərbaycan Müdafiə Nazirliyi. 2021-ci il arxivinə əsaslanıb.

4. Большая советская энциклопедия (БСЭ) Третье издание вышедший издательством Советская энциклопедия в 1969-1978 г. 30 том.
5. Словарь военных терминов-Военное изд-во, А.М. Плехов, С.Т. Шанкин, Москва: 1988 г.

MILITARY CONFLICTS, ENVIRONMENTAL DEGRADATION, AND THE URGENCY OF RENEWABLE ENERGY TRANSITION IN RESOURCE-DEPENDENT STATES

Rahim Abdinov
Western Caspian University
rehim.abdinov98@gmail.com

Military conflicts create not only humanitarian crises but also profound environmental degradation, from oil spills and toxic pollution to deforestation and ecosystem collapse. These impacts are particularly severe in resource-dependent states, where oil and gas infrastructure is both an economic lifeline and a frequent military target. This paper explores the intersection of war, environmental security, and renewable energy transition. It argues that renewable energy investment is not only a climate policy priority but also a post-conflict recovery strategy that enhances resilience and supports sustainable development. Drawing on case studies from Kuwait, Ukraine, Rwanda, and Azerbaijan, the paper examines how fiscal and budgetary mechanisms can attract renewable investment in fragile contexts. It concludes that embedding renewable energy transition within post-war reconstruction frameworks is essential for reducing vulnerability, diversifying economies, and fostering long-term peacebuilding.

Keywords: Military conflicts, renewable energy, environmental degradation, fiscal strategies, post-conflict recovery, resource dependence, sustainable development.

Military conflicts are not only humanitarian tragedies but also profound environmental crises. Armed confrontations destroy ecosystems, pollute natural resources, and release hazardous substances into the air, soil, and water. These ecological costs are particularly severe in resource-dependent states, where oil and gas infrastructure is both the backbone of the economy and a frequent target of attacks. The vulnerability of such states highlights the urgency of diversifying energy systems through renewable alternatives, which can provide greater resilience and sustainability in the aftermath of war.

Wars leave behind a legacy of ecological destruction. The 1991 Gulf War, in which Iraqi forces set fire to Kuwaiti oil wells, remains one of the most devastating examples of environmental damage, with massive oil spills and toxic smoke polluting land and sea. More recently, the war in Ukraine has demonstrated how attacks on energy facilities cause oil leaks, explosions, and radioactive risks. Similarly, the Nagorno-Karabakh conflict in the South Caucasus resulted in deforestation, polluted rivers, and widespread land degradation. Beyond immediate destruction, conflicts undermine governance, weaken environmental monitoring systems, and encourage unsustainable exploitation of natural resources. This double impact—direct damage combined with weakened institutions—creates long-term ecological and economic vulnerability.

For resource-dependent economies, these challenges are magnified. Heavy reliance on hydrocarbons exposes them to what is often called the resource curse: weak institutions, lack of diversification, and heightened vulnerability to external shocks. When wars erupt, oil wells, pipelines, and refineries are often targeted, causing economic collapse alongside environmental harm. Without a diversified economic base, recovery becomes slow and fragile. In such contexts, renewable energy transition is not simply a matter of climate change mitigation—it becomes a critical strategy for survival, recovery, and long-term resilience.

Renewable energy offers strategic advantages in post-conflict contexts. Unlike centralized hydrocarbon infrastructure, renewable systems—especially solar and wind—are decentralized and less vulnerable to attack. They provide energy security, support environmental restoration, and stimulate non-oil economic sectors. Rwanda's post-genocide development strategy illustrates this approach: investments in hydropower and solar supported recovery and growth. Ukraine's expansion of solar and wind since 2014 has been driven not only by climate goals but also by the need to strengthen resilience against external threats. Azerbaijan's 2030 strategy to expand renewable projects, particularly in Karabakh and Nakhchivan, demonstrates how resource-dependent states can link green transition to reconstruction.

Financing these transitions requires innovative fiscal and budgetary strategies. Governments can attract investment through tax exemptions, subsidies, feed-in tariffs, and public–private partnerships. Issuing green bonds or dedicating parts of recovery funds to renewable infrastructure provides sustainable financing mechanisms. International organizations such as the World Bank, the EBRD, and UNDP have played critical roles in funding renewable energy projects in fragile states, offering not only capital but also institutional credibility that encourages private sector participation.

Despite these opportunities, multiple barriers remain. Investors are often deterred by security risks, political instability, and weak governance capacity. Post-war governments face competing priorities, from housing and healthcare to defense spending, that can overshadow renewable energy. Financing gaps persist due to limited fiscal space, and regional tensions complicate cross-border cooperation in energy systems. Addressing these challenges requires integrating environmental recovery into peace agreements, earmarking recovery funds for renewables, and designing fiscal frameworks that prioritize sustainable investment. Strengthening institutional capacity and promoting regional cooperation will also be critical to long-term success.

Military conflicts reveal the fragility of resource-dependent economies and exacerbate environmental degradation. The destruction of oil and gas infrastructure not only cripples fiscal stability but also devastates ecosystems. Renewable energy transition, therefore, should be understood as both an environmental imperative and a peacebuilding strategy. By embedding green priorities into fiscal and budgetary policies, resource-dependent states can reduce vulnerability, diversify their economies, and chart a more resilient path forward. In the aftermath of war, placing renewable energy at the center of reconstruction is essential for moving from ecological destruction to sustainability and from dependency to resilience.

References

- Bebbington, A. (2013). Natural resource dependence and post-conflict recovery. World Development, 45, 63–79.
- Crawford, A., & Church, C. (2019). War and the environment: The long-term impacts of armed conflicts. International Review of the Red Cross, 101(911), 493–520.
- International Energy Agency (IEA). (2021). Renewables in post-conflict reconstruction. Paris: IEA.
- World Bank. (2020). Fiscal strategies for sustainable recovery: Lessons from fragile states. Washington, DC: World Bank.
- United Nations Environment Programme (UNEP). (2009). Protecting the environment during armed conflict. Nairobi: UNEP.

ASSESSMENT OF ENVIRONMENTAL IMPACT IN THE APPLICATION OF MODERN ARTILLERY SYSTEMS

Yashar Ganbar Huseynov
National Defense University, Nakhchivan Military College
yhuseynov131@gmail.com

Modern artillery systems are technological tools that have a significant impact on the course of war and military operations. In addition to providing strategic advantages on the battlefield, they are also known as weapons systems with high destructive power (Hasanov, 2018). However, the application of artillery weapons is not limited to military purposes; the impact of their operation on the environment has also become an increasingly relevant field of research.

This article analyzes the environmental impacts of modern artillery systems, including their harmful effects on soil, air, water resources, and wildlife, in a scientific, pedagogical, and strategic context. The aim is to assess the effectiveness of artillery systems as well as their use in terms of environmental sustainability and safety.

Modern artillery systems — self-propelled howitzers, rocket systems, and long-range missiles — have high explosive power and a wide radius of action. The following environmental impacts are observed as a result of the use of these systems:

- Soil degradation and erosion: The craters and blast waves created by artillery shells in the soil change the structure of the earth, accelerate the erosion process and reduce its suitability for agriculture.

- Air pollution: When explosives burn, nitrogen oxides, carbon monoxide and other toxic gases are released into the atmosphere. This reduces air quality and poses a threat to human health in nearby areas.

- Water pollution: In areas where artillery exercises are conducted, underground and surface water sources can be contaminated by the leakage of explosives and heavy metals. This puts drinking water supplies at risk.

- Impact on wildlife: Sound waves, thermal shocks and chemical pollution have a negative impact on the flora and fauna living in the area. The extinction of rare and protected species in particular can lead to a disruption of the ecological balance (Aliyev, Mammadov 2020).

These impacts can have long-term effects on military training areas and sometimes even beyond combat zones. Thus, the environmental assessment of artillery use is an important part of modern military ethics and strategic planning.

In order to minimize environmental damage, modern armies are implementing a number of technological and organizational measures. The main one is the ecological monitoring of training ranges. At the same time, soil and water analysis is conducted before and after modern artillery exercises, and the ecological situation is monitored. This data serves as the main basis for risk assessment. The next step is the introduction of less environmentally harmful shells, where new generation shells are now made with less toxic components. This technological innovation helps both to protect the environment and to facilitate post-operational recovery work. It is of primary importance in decontamination programs. After artillery use, cleaning and restoration plans are developed for unused shells and contaminated areas. These programs accelerate the ecological recovery process (Mammadova, 2022).

Environmental monitoring, innovative missile technologies, legal mechanisms, and restoration programs should be implemented to mitigate environmental impacts. This approach serves both military-strategic goals and allows Azerbaijan to fulfill its international obligations in the field of environmental security.

References

1. Aliyev, G.A., Mammadov, R.H. (2020). Environmental protection and ecological safety. Baku: “Science and Education” publishing house.

2. Hasanov, E.A. (2018). Ecological aspects of modern weapons systems. Scientific Works of Azerbaijan Technical University, No. 2, pp. 45–52.
3. Mammadova, Z.T. (2022). Environmental monitoring and assessment during the operation of artillery systems. Baku State University Scientific News, Ecology series, No. 1, pp. 59–65.

SORPTION OF HEAVY METALS ON ALUMINOSILICATES IN CONDITIONS OF POST-WAR POLLUTION OF KARABAKH LANDS

Z.R.Aghayeva, V.A.Ismayilova, S.S.Bayramova, H.N.Ilyasova N.V.Valiyeva

Institute of Catalysis and Inorganic Chemistry MSE AR

agayeva-zenfira@mail.ru

Armed conflicts have a significant impact on the environment, especially on soil cover. Following military actions in Nagorno-Karabakh, as a result of the destruction of infrastructure, the use of military equipment and explosives, significant areas of the soil in this region were contaminated with heavy metals such as cadmium (Cd), lead (Pb), zinc (Zn), copper (Cu), mercury (Hg) and a number of others. It should be noted that these elements are highly toxic and can accumulate in food products, posing a threat to human health and ecosystems. The use of aluminosilicates on contaminated lands in Karabakh has significant potential for reducing environmental impacts and restoring soil fertility. To successfully implement this problem, it is necessary to conduct field studies taking into account the specifics of the soil and climate of the region, as well as integration with other remediation methods, including biological stabilization. One of the effective approaches to remediation of such contaminants is the use of aluminosilicate sorbents. In this aspect, the use of aluminosilicates on the contaminated lands of Karabakh has significant potential for reducing the environmental burden and restoring soil fertility, and the cleaning of the contaminated lands of Karabakh after the war with heavy metals using aluminosilicates is a topical issue in the environmental sense and, at the same time, a significant scientific and practical topic. One of the most promising and economically viable ways to reduce the concentration of heavy metals in contaminated soils is the use of aluminosilicates - natural minerals with high sorption capacity, such as zeolites, montmorillonite bentonite clays. It should be noted that aluminosilicates - natural or modified mineral compounds - are widely used as effective sorbents in the extraction of heavy metals from soils and waters due to their porous structure and negative surface charge. They effectively bind heavy metal ions, reducing their mobility and toxicity. The successful solution of many practical problems is determined by the choice of sorbents with the optimal porous structure, surface chemistry, physicochemical properties and cost for these purposes.

The aim of the study was to investigate the efficiency of heavy metal sorption by aluminosilicates for the purpose of rehabilitating contaminated soils in Karabakh. The work uses data from laboratory and field studies published in the scientific literature. It was found that the studied aluminosilicates have high selectivity for heavy metal ions, especially in the pH range of 5.5–7.5. Nanostructured bentonite clays, due to their porous structure and negatively charged surface, show the best results in the sorption of Pb^{2+} and Zn^{2+}, and modification of aluminosilicates can significantly increase the sorption capacity. The use of aluminosilicates is a promising method for remediation of post-war soils in Karabakh. For practical implementation, additional research is necessary, taking into account regional soil characteristics, microclimate and the nature of pollution.

References
1. Méndez, A., Terrones, M., & Fernández, J. R. (2018). Adsorption of heavy metals on modified montmorillonite and kaolinite. *Applied Clay Science*, 148, 114-121.
2. Anurov S.A., Belevich A.A., Yattara B. Ochistka stochnykh vod ot tyazhelykh metallov mineralnymi poglotitelyami // Sovremennye naukoemkie tekhnologii. 2018. № 2. S. 9-14.
3. Wang, S., & Peng, Y. (2010). Natural zeolites as effective adsorbents in water and wastewater treatment. *Chemical Engineering Journal*, 156(1), 11-24.

THE USE OF TECHNICAL AND CHEMICAL MEANS IN MODERN MILITARY OPERATIONS

Muhammad Jafarov
Azerbaijan Sports Academy
savekk19@gmail.com

In the contemporary era, the nature of warfare has undergone a profound transformation. Traditional weapons and battlefield tactics have increasingly been replaced by technologically advanced systems and scientifically grounded military strategies. In particular, the application of technical and chemical means has become a decisive factor in gaining superiority on the battlefield.

Unmanned Aerial Vehicles (UAVs) have emerged as a central component of modern combat systems. These platforms are used for both reconnaissance and offensive purposes. Systems such as the Bayraktar TB2 and the MQ-9 Reaper are capable of transmitting real-time imagery and delivering precision strikes. Their deployment reduces personnel casualties and offers significant tactical advantages (NATO Review, 2021).

In addition, electronic warfare (EW) systems play a crucial role in disabling enemy communication and radar networks. These systems function both offensively and defensively. EW platforms such as Koral and Krasukha-4 are employed to minimize the adversary's technical capabilities (Asgarov, 2022). Moreover, the integration of artificial intelligence and automated command systems enhances the operational planning and analytical capabilities of modern armed forces.

Satellite and navigation technologies, particularly GPS-based systems, are indispensable for the precise coordination of military operations. These tools enable accurate targeting, route calculation, and effective command of personnel on the battlefield.

Chemical weapons, historically used in various conflicts, pose serious threats to human health and the environment. Nerve agents (e.g., Sarin, VX), choking agents (e.g., Chlorine, Phosgene), and blistering agents (e.g., Mustard Gas) have devastating effects. Although the use of chemical weapons is prohibited under international conventions, these bans have been violated in some conflicts.

Protective equipment such as gas masks, specialized clothing, and detection devices significantly improve the survival rates of military personnel during chemical attacks (Tucker, 2006). Additionally, protective shelters and civil defense systems are essential for safeguarding civilian populations against such threats.

In conclusion, the effective and coordinated use of technical and chemical tools is essential for success in modern military operations. These means must be employed not only as instruments of technological power but also within frameworks of scientific preparedness, ethical responsibility, and legal regulation.

References

1. Əsgərov, R. (2022). *Hərbi təhlükəsizlik*.
2. NATO Review (2021). *Drones and AI in warfare*.
3. Tucker, J. B. (2006). *War of Nerves*.

MATHEMATICAL MODELING AND CLASSIFICATION OF TOXIC WASTE PREDICTION DURING FERMENTATION

Murad Abasov, Ravana Izzatova
Azerbaijan National Aerospace Agency
murad.abasov54@gmail.com

The classification of the anaerobic fermentation decomposition of agricultural waste has been reviewed, taking into account the use of electrophysical methods for the preliminary treatment of bio-gas installations. The study focused on the specification of the problem in developing mathematical models that allow for the prediction of the amount of toxic waste in the outlet gas and condensate during the operation of a gas condensate tank.

Development Trends of the "Green Economy" in Agriculture. Azerbaijan's climatic conditions (temperature, abundance of sunlight, and long vegetation period) make it possible to specialize in the cultivation of many valuable agricultural crops. The main directions of agricultural production are grain growing (wheat), cotton growing, winemaking, horticulture, tobacco growing, tea cultivation, vegetable growing (especially early vegetables), and livestock farming.

The leadership of Azerbaijan attaches great importance to climate change issues. The main development directions of the "Azerbaijan 2030: National Priorities for Socio-Economic Development" aim to align the specific volume of carbon dioxide emissions per unit of GDP with the level of energy intensity and carbon intensity observed in the countries of the Organization for Economic Co-operation and Development (OECD). In 1990, the volume of carbon dioxide (CO_2) emissions in Azerbaijan amounted to 73.3 million tons, while it is planned to reduce the volume of greenhouse gases by 35% by 2030 [1].

In accordance with the new concept for the development of organic matter anaerobic fermentation technology, it is possible to expand the structural scheme of the classification of biogas installations.

At the input: the temperature of the air supplied for combustion and the unit volume of fuel required for combustion.

At the output: the temperature of the water directly; the temperature of the exhaust gases; heat loss with the exhaust gases, due to incomplete combustion and external cooling; the volume and composition of the flue gases; the volume and composition of the condensate formed, as well as its hydrogen index and temperature [2].

However, the factor needed for the calculation is the amount of recoverable heat energy transferred from the condensed water vapor to the water supplied to the boiler in the condensation heat exchanger.

This value depends on the material from which the heat exchanger itself is made, the shape of its surface, its thickness, and the surface area of its walls. The heat flow can be expressed by formula

$$Q_{rec1} = \frac{t_1 - t_2}{\frac{1}{\alpha_1 F_1} + \frac{\delta}{\lambda_1 F_1} + \frac{1}{\alpha_2 F_2}}$$

Here, t_1 və t_2 are, respectively, the condensation temperature of the counterflow and the temperature of the water, in °C; α_1 and α_2 are the heat transfer coefficients of the outer and inner walls, in W/(m·K); F_1 and F_2 are the surface areas of the outer and inner walls, in m^2.

References

1. Алиев А.Р., Гулиев И.А. Энергопереход как фактор развития устойчивой энергетики стран Каспийского региона: Монография. – М.: Издательство «Аспект Пресс», 2022
2. Катков, Д. С. Обоснование оптимального режима эксплуатации конденсационного котла / Д. С. Катков // Научное обозрение: научный журнал. – Вып. 9. – Саратов: ООО «Буква», 2014. – Часть 2. – ISSN 1815-4972.

CREATION OF SOLAR ELEMENTS BASED ON SILICON DOUBLE-BARRIER NANOSTRUCTURES AND THEIR TESTING FOR RADIATION RESISTANCE

Fakhraddin Abbasov
Institute of Radiation Problems, MSE AR
fpabasof@gmail.com

Developed two - barrier structures with a nanostructured base based on silicon. Exposed to gamma radiation at the ^{60}Co facility and analyzed the photoelectric properties of the resulting structures and proved that the use of these structures improves the photoelectric properties of traditional photovoltaic structures and creates a high integral sensitivity in the short-wavelength region of the spectrum. The effect of irradiation on the occurrence of leakage current both at the Schottky barrier and at the p-n junction was studied. It is shown that the two-barrier structure makes it possible to improve photoelectric receivers. It is also shown that double-barrier structures are superior in photoelectric parameters to photoconverters of single-barrier structures, and it is recommended to use them as solar cells. The probability of exposure to radiation due to the occurrence of a leakage current has been studied both for a random type of Schottky barrier and for p-n junctions. It is shown that, in terms of photoelectric parameters, double-barrier structures are superior to photoconverters for use as solar cells. It is also shown that the two-barrier structure allows the improvement of photoelectric receivers. The effect of incident ionizing radiation on the appearance of current and charge carriers is studied both for the Schottky barrier type and for p-n- junctions. It is shown that, in terms of photoelectric parameters, double-barrier structures are superior to photoconverters for use as solar cells.

The effect of gamma radiation on the mechanism of current generation and transfer in a barrier structure of the Schottky type and in p-n junctions has been studied. It was found that the two-barrier structure makes it possible to improve the photoelectric parameters of the photoconverting structure. Double-barrier structures of photoconverters with high sensitivity in the short-wavelength region of the spectrum with a silicon-based nanostructured fabric have been developed. An increase in overall sensitivity and an increase in spectral sensitivity is one of many factors. The reliability of the operation of a double-barrier structure under conditions of increased radiation, as a converter of solar energy into electricity, as well as the study of resistance to the effects of ionization rays of solar radiation, is an urgent task and is the subject of our study. The influence of radiation on the mechanism of excitation of electric current at p-n junctions and on the effect of the structure as a whole is also being studied. It is shown that two-barrier structures have extremely high characteristics of conventional photovoltaic structures.

INFLUENCE OF GAMMA IRRADIATION ON THE LIFETIME OF A SEMICONDUCTOR BASED ON CdMnSe THIN FILMS

N.I.Huseynov, M.A.Mehrabova, O.M.Salamov
Institute of Radiation Problems MSE AR
nizamiphys@gmail.com, m.mehrabova@science.az

The investigation of recombination processes is a critical stage in studying the physical properties of semiconductor materials and the devices based on them. Charge carrier recombination mechanisms play a decisive role in defining the characteristics of photoelectric, luminescent, and injection phenomena, which form the foundation for most practical applications of semiconductors. This paper focuses on the investigation of charge carrier recombination processes.

To determine the recombination mechanism, the parameters of recombination centers, and the processes of electronic transitions in CdMnSe thin films, a combination of stationary and kinetic research methods was employed. For the acquisition of kinetic characteristics, the semiconductor samples were illuminated using short LED pulses ($t \sim 10^{-6}$ s). The photoelectric signal, generated by changes in the semiconductor potential under pulsed illumination, was amplified using a broadband transistor amplifier and fed to an oscilloscope, with data subsequently recorded by a computer. The time resolution of the selective measurement system was no worse than 10^{-8} s, enabling signal detection within a time range of $10^{-8} \div 10^{-2}$ s [1, 2].

Radiation defects in CdTe-based semiconductors emerge upon exposure to fast particles. These thermodynamically nonequilibrium defects can significantly alter the electrical properties of CdTe. The primary types of radiation-induced defects include vacancies, interstitial atoms, dislocations, and other point defects. Gamma irradiation of the samples was performed using a Co-60 source at 300 K. During irradiation, the crystals were cooled with nitrogen vapor, maintaining their temperature below 290 K.

The analysis of nonequilibrium photoconductivity relaxation curves under laser radiation further confirms the presence of two distinct recombination channels in CdMnSe: intrinsic and impurity-related [3]. Photocurrent relaxation proceeds through both fast and slow recombination channels. The fast relaxation time (τ = 15–35 μs) corresponds to intrinsic transitions, while the slower relaxation time (τ = 100–200 μs), which is dependent on the irradiation dose, is attributed to impurity excitation. To better understand the current transport mechanisms in the heterostructure, dark VAC and photoconductivity at room temperature were examined.

The results indicate that CdMnSe-based thin film semiconductors have promising potential as solar energy photoconverters. The observed radiation-induced changes in photosensitivity arise from both alterations in the lifetime of nonequilibrium holes—due to defect restructuring in the crystal's band gap—and variations in the concentration of photosensitivity centers, and their hole filling. The energy levels of the radiation-induced defects responsible for photoconductivity were found to be in the range of 0.17–0.22 eV, with concentrations of $10^{13} \div 10^{15}$ cm^3. Thus, the study of CdMnSe photoelectric characteristics reveals that gamma irradiation significantly affects the concentration of localized levels, including n-centers of photosensitivity.

References

1. M.A. Mehrabova, N.I. Guseynov, A.A. Abdullayeva, R.M. Sadiqov, Recombination Processes in CdTe/CdFeTe Thin Film Heterojunction. \International Scientific-Practical Conference on; The Fourth industrial revolution and innovative technologies; 3–4 may 2023 Ganja.
2. M.A. Mehrabova, N.I. Huseynov, A.A. Abdullayeva, R.M. Sadigov. Electrical Properties of Thin-Film CdTe: CdFeTe Heterojunctions. AJP FIZIKA 2023 section C: Conference H.A. Aliyev. pp. 67–70.
3. N.I. Huseynov, M.A. Mehrabova, O.M. Salamov, A.M. Alakparov, R.M. Sadigov, F.P. Abasov, Study of recombination centers in CdTe/$Cd_{1-x}Fe_xTe$ (x=0.08) thin film by photoconductivity relaxation, J. Radiat. Res., Vol.11, No.1, 2024, Baku, pp. 54–60

INFLUENCE OF GAMMA IRRADIATION ON DOUBLE-BARRIER STRUCTURES OF Au-Si(p-n-) DETECTORS OF IONIZING RADIATION AND ELEVATED TEMPERATURES

Fakhraddin Abbasov, Oktay Salamov
Institute of Radiation Problems MSE AR
fpabasov@gmail.com

In this work, the task of creating highly sensitive detectors of ionizing radiation was set; double-barrier structures of photoconverters with high sensitivity in the short-wave region were developed thanks to a nanostructured film based on silicon for use as a detector of ionizing radiation. In order to create highly sensitive ionizing radiation detectors, double-barrier photo converter structures with high sensitivity in the short-wave region were developed using a nanostructured silicon-based film for use as an ionizing radiation detector.

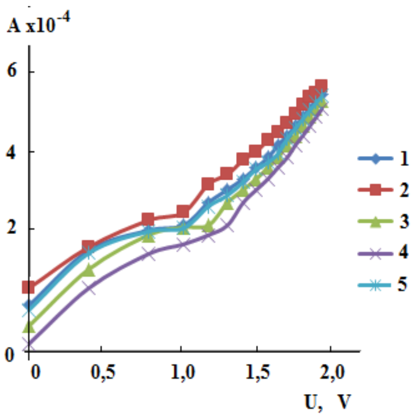


Fig. 1. I-V characteristic of a two-barrier structure when reverse bias is applied. 1- before irradiation of the structure, 2- after irradiation with gamma quanta. Dγ = 10kGy. 3. Dγ = 20kGy., Dγ = 60kGy. Volt-ampere characteristics of p-n-junction. Annealing results are in significant.

Double-barrier structures of photoconverters with high sensitivity in the short-wavelength region of the spectrum with a nanostructured film based on silicon have been developed for use as a detector of ionizing radiation. To increase the overall sensitivity and increase the spectral sensitivity, Schottky barriers were created, acting in parallel with the p-n junction, which is one of the important factors for increasing the speed of the detector. The reliability of the operation of a double-barrier structure under conditions of increased radiation, as a converter of solar energy into electrical energy, as well as the study of resistance to the effects of ionizing rays of solar radiation, is an urgent task and is the subject of our research. The influence of radiation on the mechanism of excitation of electric current in p-n junctions and on the structure as a whole is also studied. It is shown that double-barrier structures have exceptionally high characteristics of traditional photovoltaic structures. The investigated double-barrier structures with a nanostructured film based on silicon were exposed to irradiation at different doses and the results obtained show that the Schottky transition between a metal and a semiconductor is often modified to achieve the required barrier height for a specific application. Such modification can provide lower leakage current, higher breakdown voltage and better stability. It is known from the literature that the modification is achieved by using various organic and inorganic materials. The investigated double-barrier structures with a nanostructured film based on silicon were exposed to irradiation at different doses and the results obtained show that the Schottky transition between a metal and a semiconductor is often modified to achieve the required barrier height for a specific application. Such modification can provide lower leakage current, higher breakdown voltage and better stability. It is known from the literature that the modification is achieved by using various organic and inorganic materials.

PROMOTING THE KARABAKH VICTORY: THE THEMATIC TOUR EXPERIENCE OF MILITARY HIGHER EDUCATION INSTITUTIONS

Mujkan Mammadzade
National Defence University Military Scientific Research Institute
mujkan@mail.ru

In the autumn of 2020, the brilliant Karabakh Victory achieved by the Azerbaijani Armed Forces left an indelible mark on the nation's collective memory—not only in military and political terms, but also ideologically, spiritually, and culturally. This victory plays a crucial role in shaping the younger generation, especially future officers and military leaders. To ensure that this historic triumph is transmitted accurately to future generations, thematic tours organized by military higher education institutions to the Karabakh region have become important experiences for enhancing patriotic spirit and forming historical consciousness.

The Karabakh Victory is not merely a success in reclaiming territory; it is also a triumph of national unity, strategic governance, and military professionalism. The 44-day Patriotic War marked the beginning of a new era in Azerbaijan's history. Promoting this victory is not limited to media channels—it has also become a vital component of education, particularly within military training and moral instruction.

Teaching historical facts on-site, analyzing events within their geographic context, and honoring the memory of fallen heroes directly strengthen both the sense of historical responsibility and professional patriotism among young cadets.

The main objectives of the thematic tours organized by military academies to Karabakh include:

- Familiarization with historical sites: First-hand exploration of operational zones in regions such as Jabrayil, Fuzuli, Shusha, Hadrut, and Zangilan (Həsənov, 2021).

- Patriotic education: Strengthening moral and national values through visits to martyr cemeteries, memorial complexes, and visible remnants of battles.
- Professional preparedness: Practical analysis and field-based discussion of tactical operations.
- Reinforcement of collective memory: Preserving historical memory and cultivating national responsibility in future military personnel (UNESCO, 2020).

These tours are not merely excursions—they have become an integral part of military education programs.

The impact of thematic tours on military education can be assessed from several perspectives. Psychologically and morally, young officers are more deeply affected when directly confronted with the realities of sacrifice for the homeland. Leadership skills are enhanced through the analysis of real battle zones, promoting decision-making and a sense of responsibility. Strategic thinking is developed through the on-site study of military operations, allowing cadets to approach events not only theoretically but also practically. Teamwork and mutual understanding are also strengthened during these shared experiences.

All of these components help shape future officers into more professional, patriotic, and responsible military personnel.

Thematic tours to the Karabakh region organized by military higher education institutions are not only tools for historical promotion; they are also effective methods of instruction, essential instruments of ideological education, and integral parts of practical military training (Biggs & Tang, 2011). Their role in shaping young officers is undeniable. In the future, expanding this practice and enhancing the thematic and academic depth of such tours can yield even more effective outcomes.

References

1. Həsənov, T. (2021). "Qarabağ döyüş bölgələrində yerində tədris təcrübəsi." *Azərbaycan Hərbi Təhsil Jurnalı*, 2(1), 36–45.
2. UNESCO. (2020). *Education and Memory: Strengthening National Identity through Curricula*. Paris.
3. Biggs, J., & Tang, C. (2011). *Teaching for Quality Learning at University* (4th ed.). Open University Press.

AUTOMATION OF A PATENTABILITY SEARCH FOR SECRET PATENTS AND POSSIBLE DISPUTES

Alikhan Rzaguliyev
Western Caspian University
Alixan.rzaguliev@gmail.com

Abstract: Secret patents are subject to state-imposed restrictions and considered as war materials. While secrecy will always limit transparency, systematic AI-assisted search can provide more reliable novelty and inventive step assessments. Retaining machine-generated evidence of search might also reduce the scale of future disputes, supporting both innovation security.

Keywords: Patentability, patent search, patent law, secret patents, war materials, inventions, utility models, automated search, artificial intelligence, automation.

Introduction:

Secret patents are secretly granted patents by the IP offices. Those documents are not published and therefore, not public. While it is necessary for national security, it raises a serious protection problem. Patent examiners and applicants may not be able to access relevant prior art. Which means examiners might grant patents that should not have been issued, because secret prior art was overlooked. Future disputes and litigations might also happen when/if those documents will become public. Same invention could be protected in two different countries.

Literature review:

According to the law of the Republic of Azerbaijan, the subjects of patents can be inventions, utility modes and industrial designs. The patentability conditions for the inventions are novelty, inventive step and industrial application [1].

Secret patents are granted in many countries, including Azerbaijan, Russia, USA, etc. This law permits the granting of secret patents for inventions related to war materials or defence technologies. Rights cannot be transferred, and publication is banned unless authorization is granted [2].

Automation can reduce, though not eliminate, these risks. It would make search faster. However, secret data would stay secret. In potential conflicts, automated search could play an unbiased role. There could also be AI based database for patent examiners. This would reduce human bias. However, considering secret patents are mostly related to military equipment. It’s unlikely.

References

[1] Patent haqqında Qanun “AZƏRBAYCAN RESPUBLIKASININ QANUNU,” Maddə 7, Gov.az. https://patent.copat.gov.az/files//26290292722835030361312-IQ%20Patent%20haqq%C4%B1nda%20(2).pdf. [Accessed: 08-Mar-2025].

[2] “WIPO Lex,” Secret Patents Act, 1989, Wipo.int, https://www.wipo.int/wipolex/en/text/126351 (accessed Aug. 20, 2025).

CLASSIFICATION OF EMERGENCY SITUATIONS IN THE MILITARY ACTIONS

I.I.Mustafayev, Sh.D.Danyalov, A.H.Ahmadova, Z.E.Habibzade
Azerbaijan University of Architecture and Construction

War is one of the most severe tests for human society. Its consequences extend far beyond the battlefield, profoundly affecting the daily lives of civilians, the economy, and the governance system of the state. The emergency situations that arise during wartime are complex and multifaceted, and their accurate classification is of great importance for preventing threats and mitigating their consequences.

The Karabakh region of Azerbaijan has long faced extraordinary challenges resulting from war and occupation. Thousands of people lost their lives, while hundreds of thousands were displaced from their ancestral lands. Hundreds of villages, towns, and historical and cultural monuments were destroyed, and economic activity in the region was brought to a complete standstill.

From an ecological perspective, vast areas of Karabakh have been mined, forests have been cut down, and water resources have been polluted. The socio-economic consequences are reflected in the difficult living conditions of the population as internally displaced persons, as well as in the restricted access to education and health care. This example of classification once again demonstrates that emergencies during wartime are not only short-term threats but also produce consequences that endure for many years.”

Emergency situations are classified into two major categories by their origin: military and non-military. Military emergencies include missile, artillery, and aviation strikes, explosions, fires, and the use of chemical, biological, or nuclear weapons. Non-military emergencies, on the other hand, may arise from industrial accidents, failures of energy or communication systems, transport accidents, or environmental disasters.

Emergency situations can be classified as local, regional, or nationwide in scale. Local emergencies occur within a limited area, regional emergencies affect several administrative regions, and nationwide emergencies have an impact on the overall security and governance system of the country.

Depending on the object of impact, emergency situations may affect the military, civilian, or economic spheres. Incidents at military facilities undermine the combat readiness of soldiers, while those at civilian facilities — such as schools, hospitals, and residential buildings — expose the population to direct danger. At economic facilities, failures at industrial enterprises, power plants, or transport networks can seriously undermine the economic stability of the country."

Due to the nature of their consequences, emergencies during wartime result in human, material, socio-economic, and environmental impacts. Human consequences include loss of life and mass displacement of people. Material consequences manifest in the destruction of buildings and infrastructure. Socio-economic challenges appear in the form of food and medicine shortages, unemployment, and disruptions in health care and education. Environmental consequences are reflected in the pollution of soil, water, and air, as well as the spread of epidemics and diseases."

Thus, emergencies during wartime manifest themselves in diverse forms, and their proper classification is crucial for preventing threats, effectively planning civil defense measures, and ensuring the safety of the population. The example of Karabakh demonstrates that overcoming such consequences requires long-term state policy, comprehensive reconstruction efforts, and systematic preparation of the population for security measures.

RESEARCH ON FLOOD COVERAGE AREAS IN THE CONTEXT OF CLIMATE CHANGE IN THE REPUBLIC OF AZERBAIJAN BASED ON GIS TECHNOLOGIES

Namig Muradov, Boyukkhanim Sharifova
National Aerospace Agency Special Design Bureau of Space Instrumentation
kcmkb@mdi.gov.az, namiq.m7312@gmail.com

On the basis of various time space images and GIS technologies, electronic maps of areas where flooding occur frequently in the Republic of Azerbaijan, the structure of the information support system created in the GIS software environment of courtyards and buildings under the Kura River floods, RGB(4,3,2) band combination of Landsat satellite images were also provided.

In connection with global climate changes, an inventory of thermal emissions in Azerbaijan was carried out, and it was determined that the share of this indicator per capita is higher than the global indicator. Lidar data and GIS technologies were used to assess the damage for selected areas where floods, flooding occur. The procedure stages of the proposed method were presented, the Coordination of GeoEye satellite data with Lidar data for October-November was carried out, thereby it was possible to calculate the total area of the flooded area. Using the Spatial Analyst module, a single Digital Terrain Model (DTM) was created for the construction of a 3D model of the flooded areas, separated by the contours of the Araz River on the basis of Lidar data. On the basis of Modis Terra data, Geoinformation analysis was carried out on the example of Murselli village of Sabirabad region, using topographic maps of 1:50000 scale, it was determined that the area was completely submerged. In addition, technological methods were applied to determine the water protection zones of Saatli and Sabirabad districts, and it was determined that meander formation processes were activated.

Since the flood emergency is a process that varies in location and time, different timed Landsat satellite image processing procedures have been involved, and RGB (red, green, blue) combinations of individual bands were created to visually present of the obtained results.

The results of the assessments carried out with different approaches showed that climate changes are not only affected by natural conditions, but also the tourism sector, Water Resources, etc., which are sensitive to such changes. It has a serious impact.

References

1. Qarib Mammadov, Mahmud Xalilov. Ecology, Environment and man, Baku, ‹‹Science ››, 2006
2. Telman Xalilov, Maya Zenalova. Global Environmental Problems, Baku, MBM, 2013
3. Alizade V.M., Mehdiyeva N., İbrahimova S. (2016). Predicting the risk of extinction of threatened and rare species of Azerbaijan flora. GPPC 2016 Conference, Missouri Botanical Garden, USA http://www/missouribotanicalgarden/org/things-to-do/events/gppc-2016- conference.aspx
4. Farzaliyev V. & Aronin A. (2016). Prognostication of plantation possibilities of Pinus eldarica Medw. by use of geoinformational technologies J. Applied Ecology and Environmental research, 14 (4): 121-131, IF 1,82
5. Climate change and agribusiness conservation training program6. Global Warming vs. Climate Change. NASA. (9 August 2010 archived in history)
7. Cronin, Thomas Nş Paleoclimates: understanding climate change past and present. New York: Columbia University Press. 2010. ISBN 978-0-231.14494.0
8. E.R. Alaskarov. Object-oriented classification of soil cover using LIDAR data // Journal of Qafqaz University, Mathematies and Computer Sciense, Bakı, 2013, №2 (1), pp. 189-198

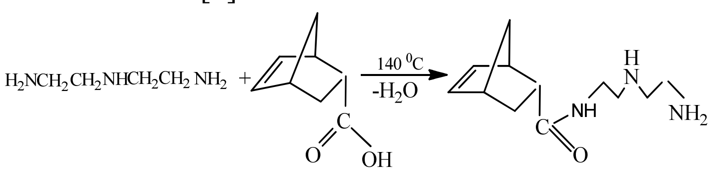
9. E.M.Aliyev. Problems related to lands of water fund during implementation of real estate lands // Journal of “European Applied Sciences”. ORT Publishing, German (Stutgart), 2012 (№2), February, pp. 186-190
10. Ağayev A.T. №D modeling in the environment of Geographic Information Systems Baku State University, materials of the IV scientific-practical conference on “XXI century: innovations in Geodetic and cartographic science”. Baku 2012, pp. 146-150
11. Ağayev A.T. Programming of g=damage to settlements as a result of river flooding based on remote sensing data and geographic information technologies // Azerbaijan University of Architecture and construction Journal of Ecology and Water Management. Baku, Politex MMC, 2016, №3, pp. 94-99.

OBTAINING THE BROMIDE COMPLEX OF AMIDE OF 5-NORBORNENE-2-CARBOXYLIC ACID AND DETERMINING ITS PHYSICAL-CHEMICAL PROPERTIES

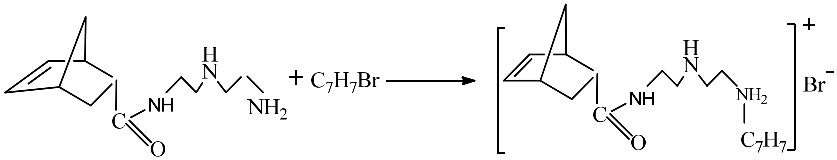
E.H.Mammadbayli[1], V.H.Babayeva[1], N.M.Mammadova[1], Z.G.Fataliyeva[2]
[1]*Institute of Petrochemical Processes MSE AR*
[2]*SOCAR Baku High Oil School, Baku*
nuraybabayeva2008@gmail.com

One of the widespread problems in the world is corrosion phenomena occurring in various industrial sectors, including agriculture, the national economy, and the defense industry. The corrosion process causes great losses and poses a serious threat [1]. Many methods and means are used to combat corrosion. The most convenient of these methods is the application of corrosion inhibitors. Inhibitors used to combat corrosion are added in small quantities to the environment where corrosion occurs, and they sufficiently reduce the corrosion rate of the metal in contact with the environment. For this reason, the application of corrosion inhibitors is considered one of the most superior methods against the corrosion process observed in metal equipment [2]. The presented work is devoted to the synthesis and determination of the properties of the inhibitor used as a corrosion inhibitor.

At the initial stage of the study, amide (NDA) was synthesized based on 5-norbornene-2-carboxylic acid and diethylenetriamine. The synthesis of amide was carried out at a temperature of 130-140°C for 1.5-2 hours [3].



Then, benzyl bromide was added to the amide to form its complex in a 1:2 molar ratio. The reaction was carried out for 2.5-3 hours at a temperature of 50-60ºC [4].



The physico-chemical parameters of the obtained complex were determined and shown in the table.

Table

Physico-chemical properties of NDA+C_7H_7Br complex

Conventional name of the complex	Ratio, (mol)	Density, q/cm^3	Refractive index,(n_D^{20})	Specific resistance, R, Ohm•m	Specific electrical conductivity, σ, S/cm
NDA+C_7H_7Br	1:2	1.8080	1.4390	$1.85\cdot10^2$	$5.4\cdot10^{-3}$

References

1. Abbasov V.M., Mammadbayli E.H., Mahmudova L.A., Tahirova F.F., Babayeva V.H., Abbasova Kh.A. Effect of inorganic complexes of imidazoline based on synthetic petroleum acids and triethylenetetramine against carbon dioxide corrosion. Chemical Problems. 2017, No. 4 (15), pp. 364-369.
2. Soomro A.A, Mokhtar A.A, Kurnia J.C, Lashari N, Lu H, Sambo C. “Integrity assessment of corroded oil and gas pipelines using machine learning: A systematic review”, Eng. Fail. Anal. 2022, 131, 105810.
3. Mammadbayli E.G., Babayeva V.H., Agamaliyeva D.B. Study of the bactericidal properties of allyl bromide complex of amide obtained from norbornene carboxylic acid against biocorrosion. PPOR, 2025. Vol. 26, No. 1, pp. 144-153.
4. Mammadbayli E.H., Babayeva V.H. Norbornene-containing imidazolines. Baku “Elm”, 2023.

RADIATION-INDUCED PROPERTY MODIFICATIONS IN $CuTlSe_2$ SINGLE CRYSTALS AND THEIR APPLICATION IN GAMMA-RESISTANT DEVICES

R.S.Madatov[1,3], R.M.Mamishova[1,2], A.Sh.Khaligzade[1], L.E.Sadigli[1]

[1]*Institute of Radiation Problems MSE AR,*
[2]*Azerbaijan University of Architecture and Construction,*
[3]*National Aviation Academy*
rexsane@yandex.ru

This study focuses on the analysis of structural and electrophysical changes induced by gamma irradiation in $CuTlSe_2$ single crystals and evaluates the potential of these changes for applications in radiation-resistant optoelectronic devices [1]. The research is motivated by the growing interest in complex chalcogenide compounds as promising materials for energy-sensitive and radiation-tolerant technologies.

$CuTlSe_2$ single crystals were structurally characterized using DTA and EDS analysis, confirming crystallization in the tetragonal system with lattice parameters a = 4.08 Å, c = 8.16 Å, and z=2 [2]. Electrical and photoelectrical measurements were conducted in the 100–300 K temperature range under gamma irradiation doses from 0 to 400 krad. Activation energies and photocurrent spectral distributions were analyzed to understand the impact of radiation-induced defects.

Temperature-dependent electrical conductivity measurements revealed two distinct activation energies: 0.01 eV in the low-temperature range (100–250 K) and 0.22 eV in the high-temperature range (250–300 K). At low irradiation doses (D_γ<500Gy), donor-type radiation defects partially compensated the initial acceptor-type defects, leading to a decrease in conductivity. At higher doses (D_γ>500Gy), acceptor-type defects dominated, resulting in increased conductivity. Photoresponse behavior also exhibited a two-stage character: weak photocurrent increase in the 110–250 K range, followed by a more rapid increase from 250–300 K. Spectral distribution curves showed a blue shift of the photocurrent peak at lower temperatures, consistent with band theory predictions. These changes were attributed to the formation and transformation of radiation-induced recombination centers, whose concentration and behavior depend on temperature and irradiation dose.

The results demonstrate that the electrical and photoelectrical properties of $CuTlSe_2$ single crystals can be effectively modulated by gamma irradiation. The type and concentration of radiation-induced defects vary with the irradiation dose, enabling control over material characteristics. These findings highlight the potential of $CuTlSe_2$ as a base material for the development of gamma-resistant optoelectronic and electronic devices.

References

1. Madatov R.S, Mamishova R.M, A study of the effect of γ-radiation on the current-carrying mechanism in the p-CuTlS2 single crystal, Modern Physics Letters B (2024) 2450295, https://doi.org/10.1142/S0217984924502956
2. Rahim Madatov, Rakshana Mamishova, Adila Abasova and Shamsaddin Alahverdiyev, Diferential-thermal analysis and a microscopic study of the effect of γ-radiation on $CuTlSe_2$ single crystal, International Journal of Modern Physics B (2023) 2350265, DOI: 10.1142/S021797922350265X

ON THE ROLE OF EDUCATION IN ENVIRONMENTAL PROTECTION

F.A.Mirzayev, F.E.Bagishova, Z.Y.Javanshirova
Baku State University
farhad_1958@mail.ru, aliyevafatma2901@gmail.com,
shabiyeva.zuleyxa@gmail.com

This article discusses the environmental problems that are leading humanity to an unknown end in modern times. The importance of education to minimize these environmental problems is emphasized, and the analyses conducted and reviewed for this purpose are discussed.

Environmental protection is a major issue. Until the 1970s, it was barely discussed in many parts of the world. Few knew that the construction of large enterprises, the destructive wars that led the world to disaster, and the extremely disgusting treatment of nature by man would sooner or later cause alarm throughout the world. And so it happened. All of humanity began to realize the bitter consequences of these events, and the progressive elite of the world, caring about future generations, decided to gather at the level of presidents and prime ministers, and finally this meeting took place.

In 1992, at the World Conference on Environment and Development held in Rio de Janeiro (Brazil), in response to the growing problems caused by the violation of the ecological balance in the world, the main directions of ensuring environmental security were discussed, which became a priority in the national security strategies of many countries. Later events, such as the Kyoto and Copenhagen symposia, also showed that the determining role of the human factor in the violation of the ecological balance is undeniable.

It is obvious that the rapid and dynamic development of scientific and technological progress in the 21st century, the integration of ICT, the Internet, robotics, nano-biotechnology in all spheres of human life require the formation in the consciousness of society of a creative and careful, non-harmful to nature, its resources, flora and fauna. At present, specialists in this field come to the conclusion about the need to form a new type of culture in humanity - an ecological one. Otherwise, the negative, destructive attitude and careless attitude of people to living nature and its resources will not change, but will only deepen. Specialists in this field consider it very important that the formation of ecological culture, thinking, consciousness, upbringing and education in people has already become a requirement of the day. Our century requires from the entire population of the planet the development of a concept, program and implementation of a strategy for the continuous development of environmental education and environmental consciousness as the main direction of cultural progress. Leading experts in the field of world ecology believe that environmental education and environmental awareness should begin from the first moments of personality formation, from childhood, and that its foundation should be laid in the family, in preschool institutions - that is, in kindergartens, in elementary school, and fully formed in secondary, secondary specialized and higher educational institutions.

By the way, in recent years, attention to environmental issues, ways to solve them and environmental literacy has increased significantly in our country. Planting millions of trees in the country in 2010 by Mr. President Ilham Aliyev, creation of new parks, forests and forest belts, as well as participation of the head of state in this campaign can be considered an indicator of special attention to this area. Along with all this, environmental problems that have accumulated over many years and are awaiting their solution were analyzed, national and state programs aimed at their comprehensive solution and based on the principles of sustainable, balanced development were approved and implemented. The areas of existing reserves and wildlife sanctuaries were expanded, national parks were created, various measures were taken in this direction. No matter how many state programs are adopted and no matter how much financial support is allocated, it is necessary to conduct explanatory work, public condemnation and the use of fines in order to minimize the elimination of emerging environmental problems. We will not be mistaken if we say that the formation of a caring attitude towards nature and environmental thinking depends on the level of environmental education and culture of the entire population and the younger generation. Today it is very important to pay immediate attention to environmental education, therefore everyone, regardless of status and social background, should acquire environmental knowledge, an environmental worldview should be formed among the entire population, the implementation of environmental education at all levels of education should be ensured, special attention should be paid to environmental education of children in preschool institutions, and the continuity of the educational process should be ensured.

It is necessary to carry out educational work on land protection, prevention of deforestation by using alternative energy and management of water used in everyday life and for drinking. It would be good if every TV channel broadcasted at least one or two-hour program on ecology once a week, NGOs and government agencies should organize conferences and trainings, and many brochures should be prepared. Lessons and campaigns should be held for this purpose. The Ministry of Ecology and Natural Resources has prepared many brochures for the education of schoolchildren, students and the general public. Among them are a collection of environmental information, geography of river basins, efficient use of water and water conservation, water in life and ecology, protection of water quality, Hirkan National Park, etc. Since 1993, our country has joined more than 20 international environmental conventions. In recent years, the use of plastic bags has been reduced in our country, it is recommended to replace them with paper, woven or fabric bags, and many businesses are trying to follow this example. It is recommended to sort waste and throw it into special containers, for which special places have been allocated and containers have been installed in cities and regions. In developed countries, the use of personal cars is reduced and preference is given to public transport, while in some countries, benefits are provided to those who use public transport and bicycles. The paper we use is made from forest materials, and the forest is also our source of air, so both sides of the paper should be used, and unused paper materials should be collected as waste paper, for this purpose, recycling should be started, paper collection points should be opened and accepted. Energy conservation is a very important issue in protecting the environment, for this purpose it is important to turn off the light when it is not needed. It is necessary to protect green spaces, plant trees, and not waste drinking and technical water. It is very important to hold various events in schools, universities and enterprises every year, at least tree planting campaigns, timed to coincide with dates such as “March 15 — Waste Recycling Day”, “May 22 — International Day for Biological Diversity”, “March 21 — International Day of Forests”, “March 22 — World Water Day”, “September 16 — Ozone Layer Protection Day” and “June 5 — World Environment Day”. Despite numerous reforms carried out in this area in the world and in Azerbaijan, the average temperature in our country has increased by 0.4–1.3˚C.

One of the goals set for our country at last year's COP-29 was to create a "net zero emissions" zone in the liberated territories by 2050. In this sense, we must all mobilize as citizens and contribute to this cause.

References

1. S.Ə.Əhmədov, F.Ə.Mirzeyev Umumi ekologiya, Baki, 2005, Muəllim nəsriyyati, 100s.
2. Чернышева Охрана окружаюшей среды:методическая указания, Краснодар, КубГАУ, 2021, 74c

RADIOACTIVITY, RADIATION DOSE

Akif Mirzayev
National Aerospace Agency

Radioactivity. In 1896, the French scientist A. Becquerel discovered that uranium salts emit specific rays spontaneously, without any external influence. He found that the intensity of this radiation depends solely on the amount of uranium present and is independent of the chemical compound in which the uranium exists. Later, Marie and Pierre Curie discovered polonium and radium and termed this phenomenon **radioactivity**, referring to the spontaneous emission of radiation. In the Mendeleev periodic table, all chemical elements with atomic numbers greater than 83 are radioactive.

Radioactive Rays. An experiment was conducted to study the composition of radioactive radiation. A radium preparation was placed at the bottom of a narrow channel cut into a piece of lead, with a photographic plate positioned in front of the channel. The radiation emitted from the channel was subjected to a strong magnetic field, with the field lines oriented perpendicular to the direction of the rays. The entire apparatus was maintained in a vacuum. Under the influence of the magnetic field, the rays were separated into three distinct groups, which were designated as **α (alpha), β (beta), and γ (gamma) rays.**

α-Rays: The positive component of α-rays consists of helium nuclei, which have a charge of +2 and a mass number of 4. α-rays have the lowest penetrating power, are weakly deflected by electric and magnetic fields, and travel at approximately 1/15 the speed of light.

β-Rays: β-rays are streams of electrons moving at speeds close to that of light. They are strongly deflected by electric and magnetic fields and are only moderately absorbed by matter.

γ-Rays: γ-rays are the most penetrating component of radioactive radiation. They consist of very short electromagnetic waves with wavelengths ranging from 10^{-8} to 10^{-11} cm. γ-rays have the highest penetrating ability among the three types of radiation.

Radioactivity is the process in which certain atomic nuclei transform into other nuclei through the emission of various particles.

The fission of uranium nuclei was discovered in 1938 by the German scientists O. Hahn and F. Strassmann. They observed that when uranium is bombarded with neutrons, elements such as barium, krypton, and other mid-periodic table elements are produced. However, the correct interpretation of this phenomenon—as the fission of a uranium nucleus that had captured a neutron—was provided in early 1939 by the English physicist O. Frisch and the Austrian physicist L. Meitner.

The process of nuclear fission occurs when the rest mass of a heavy nucleus exceeds the sum of the rest masses of its resulting fragments. The specific binding energy of heavy atomic nuclei ($A > 200$) is approximately 1 MeV lower than that of nuclei in the middle of the periodic table ($A \approx 100$), where 1 MeV (megaelectronvolt) equals 1,000,000 eV. Consequently, the fission of a heavy nucleus releases energy on the order of 200 MeV.

Radioactivity is the spontaneous emission of **α-particles** (helium nuclei), **β-particles** (electrons), and **γ-quanta** (high-energy photons) from atomic nuclei. In addition to these common types of radiation, other rare forms have been discovered, such as spontaneous fission of nuclei, double β-decay, and cluster decay. α-particles and γ-quanta are emitted as a result of radioactive transformations; their nuclei pass from one energy state to another, taking on discrete values. The distribution of emitted particles and quanta according to their energies is called a **radiation spectrum**.

The decay rate of a radioactive substance is calculated using the following formula:

$$\mathbf{A} = \frac{dN}{dR} = -\lambda \mathbf{N}$$

A – decay rate (activity), **N** – number of radioactive nuclei, **λ** – radioactive decay constant, **R** – radius of the nucleus.

Since 1975, the SI unit of radioactivity has been the **Becquerel (Bq)**, defined as 1 Bq = 1 disintegration per second. Non-SI units are also used; for example, **1 Curie (Ci) = 3.7 × 10^{10} Bq.**

Marie Skłodowska Curie discovered the radioactive element **radium**, which is significantly more radioactive than uranium and has a higher decay rate. The second radioactive element she discovered was **polonium**, named after her homeland, Poland. In 1910, the International Commission adopted the first **radium standard** prepared by M. S. Curie, consisting of 21.99 mg of highly pure radium chloride stored in a thin, sealed tube. The Commission also adopted the **Curie** as the unit of radioactivity for radon.

1 Kg = 1 radon

Radiation Dose: The effect of radiation on living organisms is determined by a physical quantity known as the **radiation dose**. The **absorbed dose** of radiation is defined as the amount of energy deposited by ionizing radiation per unit mass of the irradiated material.

$$\mathbf{D} = \frac{E}{m}$$

Here, **E** is the energy of the absorbed radiation, **m** the mass of the irradiated substance, and **D** the absorbed dose.
The SI unit of absorbed dose is the **Gray (Gy)**.

$$[\mathbf{D}] = \mathbf{1}\frac{C}{kq} = \mathbf{1Q_r} = \mathbf{1}\frac{m^2}{san^2}$$

If 1 kg of a material absorbs 1 joule of energy from ionizing radiation, the absorbed dose is **1 Gray (Gy)**. For humans, a **short-term whole-body exposure** of approximately **3–10 Gy** is considered **potentially fatal**, depending on the duration of exposure and the part of the body affected.

In practice, a **non-SI unit** called the **roentgen (R)** is often used. This unit characterizes the **ionizing ability of X-rays and γ-**

rays in air. 1R is defined as the amount of radiation that produces **3 × 10^{-10} coulombs of positive and negative charge** in 1 cm^3 of dry air at **0°C and 760 mmHg**. This corresponds to the formation of approximately **2 × 10^9 ion pairs**. For reference, **1 R ≈ 0.01 Gray (Gy)**.

The equivalent dose is used to evaluate the impact of ionizing radiation on living things, taking into consideration the varying biological consequences of different radiation types and intensities. The SI unit of equivalent dose is the **Sievert (Sv)**. Since the **absorbed dose** can be difficult to measure directly, the **exposure dose** is often used to estimate both the absorbed and equivalent doses. The **exposure dose** quantifies the ionization produced in air and is measured in **roentgens (R)**. 1R corresponds to the ionization of **1 cm^3 of air at 0°C and 760 mmHg**, producing approximately **2.08 × 10^9 ion pairs**. The **half-lives of radionuclides** are presented in Table 1

Table 1

Radionuclides	**T½.year**	**Natural isotopic abundances of elements (%)**
^{235}U	$7.0 \bullet 10^8$	0.72
^{232}TH	$1.4 \bullet 10^{10}$	100
^{40}K	$1.3 \bullet 10^9$	0.0117
^{87}Rb	$4.9 \bullet 10^{10}$	27.8
^{150}Nd	$5.0 \bullet 10^{10}$	5.6
^{147}Sm	$1.6 \bullet 10^{11}$	15.07
^{176}Lu	$3.6 \bullet 10^{10}$	2.6
^{138}La	$1.0 \bullet 10^{11}$	0.089
^{238}U	$4.5 \bullet 10^9$	99.27

The first three radionuclides — **^{238}U, ^{235}U, and ^{232}Th** — are considered **primary radionuclides**. The activity of primary radionuclides can be expressed by the formula

A=A0(1−e−λt)

- **A** – activity of the primary radionuclide
- $\mathbf{A_0}$ – initial activity of the radionuclide in the parent rock
- **λ** – decay constant of the primary radionuclide

In most modern nuclear reactors, ^{235}**U** is enriched because its half-life is shorter than that of ^{238}**U**, making it more suitable for sustaining a chain reaction. To ensure continuous reactor operation, fuel containing approximately **3%** ^{235}**U** is sufficient.

Artificial radionuclides are introduced into the environment through **nuclear weapons testing, nuclear explosions, and the disposal of nuclear industry waste**. Natural uranium deposits in Oklo and Bangome (Gabon) contain the isotope ^{1238}U at an abundance of approximately 17%.

Sources of **man-made radioactive waste** include accidents involving artificial satellites, incidents at nuclear power plants, and nuclear weapons tests (both underground and aboveground), as well as the resulting radioactive residues. Notable nuclear accidents—such as the **Ozersk (Mayak) nuclear facility** in Russia (September 29, 1957), the **Chernobyl nuclear power plant** in Ukraine (April 26, 1986), and the **Fukushima Daiichi nuclear power plant** in Japan (March 11, 2011)—have significantly increased the overall radioactive background on Earth. Additionally, **large amounts of liquid radioactive waste** and **decommissioned radioactive materials** are discharged into seas and oceans annually, further contributing to environmental radioactivity.

Nuclear Weapons: After World War II (since 1945), the major world powers—the Soviet Union, the United States, France, Great Britain, and China—began actively competing to expand and strengthen their nuclear arsenals.

The Nuclear Age - On July 16, 1945, the world's first atomic bomb was detonated in the Alamogordo Desert, New Mexico, USA. Subsequently, on August 6 and 9, 1945, the United States dropped two atomic bombs, each with a yield of approximately 20 kilotons, on the Japanese cities of Hiroshima and Nagasaki. The Soviet Union conducted its first atomic test on August 29, 1949, at the

Semipalatinsk test site in Kazakhstan. Nuclear tests were carried out in various regions worldwide. In the Soviet Union, testing occurred in Semipalatinsk and the northern Novaya Zemlya islands. France conducted tests in French Polynesia and the Sahara, while the United States carried out tests in the Hawaiian Islands (Johnston Atoll), the Marshall Islands (Vicki and Eniwetok Atolls), Christmas Island in Polynesia, and in the states of Nevada, Alaska, and Mississippi. Military exercises involving nuclear weapons were also conducted in the USA and the USSR. Specifically, the USSR carried out two military nuclear exercises: in 1954 at the Troitsky test site (Orenburg region) and in 1956 at Semipalatinsk. The USA conducted eight such operations between 1946 and 1957. The vast majority of the world's population resides in urban areas, where the spread of pollutants—including artificial radionuclides—significantly impacts human health. Among natural radioactive substances present in the urban environment, uranium, thorium, and potassium predominate. Radon-222 (including radioactive decay products of U-238) contributes most to the radiation dose received by urban populations. Radon has a half-life of 3.8 days, and its emission rate and spread depend on soil composition, moisture, and porosity, allowing it to disperse over several kilometers within a few days. In large cities, natural radioactivity in the lower atmosphere shows diurnal variation: it typically increases in the morning during peak traffic hours and decreases in the evening.

EXECUTIVE COMMITTEE:

Ravan Mehdiyeva – Executive director IRP
Famil Humbatov – Head of the laboratory IRP
Saltanat Aghayeva – WCU
Famin Salmanov – Chief Researcher IRP
Vugar Khudaverdiyev - Head of the laboratory IRP
Namig Heydarov – Group leader IRP
Ali Mammadov – Scientific worker IRP
Emil Gafarov – AUAC, Ass. Prof
Rana Khankishiyeva- Senior Researcher IRP

Financial manager:	Abulfaz Azizov
Manager on Logistics:	Amina Mikayilova
Technical operators:	Aliha Huseynova Saida Amirova Zargalam Nabizade

CONTACT
Institute of Radiation Problems of MSE
Azerbaijan Republic
AZ1143, B.Vahabzadeh 9, Baku,
Republic of Azerbaijan

Tel: (+99412) 538 32 24 (109),
(+99412) 510 05 92

E-mail: office@conferencerpi25.az