

---

## **METHODOLOGY FOR CONTAMINATED SITES OF MILITARY ACTIVITY TERRITORIES RESTORATION**

*D. P. Khrushchov<sup>1</sup>, Yu. V. Yushchenko<sup>2</sup>, S. B. Shekhunova<sup>1</sup>*

*<sup>1</sup> - Institute of Geological Sciences, Kiev, Ukraine*

*<sup>2</sup> - Ministry of Environment Protection and Radiation Safety  
Kiev, Ukraine*

### **ABSTRACT**

Major part of Eastern Europe countries meet environmental problems related to sites of military activity. Major part of these sites is characterised with degradation of natural landscapes and contamination of geological environment with toxic and hazardous waste representing actual and potential danger for population and environment. Actual danger is caused with localisation of toxic waste, hazardous materials and waste which are preventing normal land use. Potential danger is related to successive dispersion of contamination in biosphere as well as origin of new derivatives and products having toxic and hazardous properties. The list of such sites and objects comprises bases of land, air and naval forces. These objects include a network of infrastructures: storages of fuels and lubricants (surface, underground), filling stations, pipe lines, reparation stations, garages, decontamination stations, underground storages of different purposes, depots (for ammunition, chemical products), hospitals, constructions, firing grounds (tank, artillery, aircraft bombing etc.) and waste disposal sites. Special programs aimed at military industries and bases contaminated sites remediation have been carrying out in developed countries (USA, United Kingdom, Germany etc.). This experience was used in the frames of joint programs having been founded in several countries of Central and Eastern Europe (Chesh republic, Slovakia, Lithuania etc.).

Key words: geological environment, military activity contamination, restoration methodology, remediation

There exist technologies for geological environment remediation and sites restoration having been introduced in the frames of programs and projects mentioned above.

Methodology for contaminated sites remediation is based upon general contamination typisation, analysis of main contaminants behaviour in geological medium and consideration of technologies available.

---

Negative constituents of military objects major part impact upon the environment intended for removal areas follows: mechanical and chemical contamination of geological media and natural landscapes degradation. Mechanic contamination comprise operational and domestic waste, residues of constructions and ammunition, useless constructions and buildings, construction debris etc.

Chemical (physical-chemical) contamination from the functional point of view comprise: fuels for transport, domestic fuel, lubricants, conservants, solvents, galvanic waste, residues of chemical weapon, desactivation matter. Very toxic are rocket fuel components (samine, nitric acid etc.). Hazardous matters of physical-chemical group include explosive and inflammable materials- shells, bombs, mines, incendiaries, smoke boxes etc.

From the point of view of chemical composition main types of contamination represent the following groups. Fuels for transport means and lubricants are the products of oil, i.e. hydrocarbons. Sometimes fuels content very toxic admixtures (tetramethyle lead). Hydrocarbon pollution is usually represented with oil products and their components or derivatives. Separate group form chloric hydrocarbons, which represent major part of solvents.

Chemical mycrocomponents of pollution are represented with heavy metals ( Cd, As, Pb, Zn, Hg, Tl etc.).

Chemical combinations mentioned above differ in forms of localisation and behaviour in geological medium. Liquid hydrocarbons (oil, oil products, chloric hydrocarbons) exist in free phase and emulsions. These forms can be easy extracted. Oil and oil products usually are hydrophobic, bat if there are organic solvents in the halo of contamination oil products may be dissolved. Certain part of organic combinations may be adsorbed.

Inorganic toxicants (heavy metals, salts etc.) form solid phases, solutions, suspensions and sorptive phases.

General scheme of contamination spread is under control of two factors: migration and retard. The retard of contamination takes place in barriers of geological media. Main types of barriers are: mechanical (filtrative), physical-chemical and biological. Forms of localisation for main types of contamination are as follows. Fuels of oil origin form bodies of complicated bed-lenslike and lenslike character in uppermost parts of aquifers and dispersed concentrations. In the case of lateral underground water flow the halo of contamination takes oblong shape being directed to drainage zone. Behaviour of solvents depends upon their density. Heavy solvents intrude into aquifers, that accelerates their migration. Contamination of inorganic contaminants in unsaturated zone is of spotted, dispersed and stream like character, in aquifers forms halos controlled by water flow. Behaviour of explosive and inflammable matters is defined by their physical-chemical properties. Mechanical contamination is formed mainly with metallic and synthetic materials waste.

*R e s t o r a t i o n* is the complex of operations aimed at remediation (clean-up, decontamination) of polluted geological environment and remediation of natural landscapes according to initial (or projected) land use conditions.

Remediation (clean-up, decontamination) comprises complex of operations aimed at removal or neutralization of contaminants in geological medium (soils, rocks, underground and superficial waters) in the degree which meets safety standards and provides entire safety of population and environment at subsequent land use of the territory.

The organisation of R&D for military activity sites restoration is preceded with evaluation of landscape degradation and geological media contamination. Degradation of landscape is

---

evaluated by means of remote (aerospace) methods interpretation and surface measurements.

Methodology for chemical geological medium contamination evaluation comprises direct and indirect methods use. The use of direct methods is based on registration of contamination impact upon landscapes and geological surroundings. Direct methods include surface and underground studies. Surface studies comprise atmospheric and hydrochemical survey, surface geophysical methods and laboratory tests. Underground studies include boreholes drilling and sampling, hydrogeological tests, boreholes logging and geophysical investigations, laboratory tests.

The strategy and selection of technologies for sites remediation is based upon the data of contamination evaluation considering main regularities of contaminants behaviour in geological medium.

The whole complex of R&D for geological medium remediation comprises two approaches: contamination containment and remediation.

Operations of long term action include the foundation of underground barriers aimed at contamination isolation from dispersion in aquifers. There exist two types of barriers: unpermeable and semipermeable. For short term containment technologies of hydrodynamic control (pumping) and ground freezing are used.

Remediation (clean-up, decontamination) of geological medium is realised by two approaches: with excavations of contaminated components and in situ. Clean-up with excavation is used for underground waters, soils and rocks. Excavation of water is realised by means of boreholes pumping or drainage overtake. Water is treated in special surface units. There exist two technological directions of underground water treatment: oil products removal and clean-up from inorganic chemical contamination (and heavy hydrocarbons). Clean-up with excavation for rocks and soils is the most efficient method but it needs significant power and financial expenditures. There exist two directions of excavated soils and rocks treatment: soil washing and treatment in special integrated facilities (incinerators etc.). Integrated facilities are used for decontamination of any soils and rocks being contaminated with PCB, anions, mercury, uranium, lead and other heavy metals. There exist efficient technologies aimed at heavy metals and radionuclides extraction from soils basing on principles of hydroclone, centrifugal gravity separation, flotation, magnetic separation, air separation etc.

Remediation of geological medium in situ is carried out in two directions: chemical or physico-chemical treatment and bioremediation.

After completion of operations for geological medium remediation a system of monitoring has to be introduced.

Remediation of natural landscapes comprises removal of human made damages and restoration of landscape. There are two approaches for this task realization: restoration of initial landscape and completion of planned modification of landscape.

Realization of measures connected with restoration of military activity territories is a heavy economic and financial burden for any country and especially for countries being suffered of political collisions and hostilities. Meanwhile the problems of environment pollution arising from military activity pose certain danger for international community. Hence the realisation of national programs aimed at military activity territories restoration need and are worth of international assistance in the frames of special programs of international and regional co-operation.