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*Biotechnology*

# Technology for the Elimination of Explosives from Soil and Water

**Giorgi Kvesitadze[*] and David Sujashvili[**]**

[*]*Academy Member, Georgian National Academy of Sciences, Tbilisi, Georgia*
[**]*Scientfic-Resaerch Institute of Law and Criminology, Grigol Robakidze University, Tbilisi, Georgia*

**The international community is actively trying to solve ecological problems in different ways society should still look for ways to solve this problem in the ability of mother nature to regenerate itself. We consider it expedient to establish a research center by the civilized world, authoritative international organizations, where leading specialists will actively study the ways of nature's self-regeneration to develop technologies that will be used to solve eco-problems. In addition to chemical technologies attention is paid to biological technologies, namely, to plants and microorganisms of different taxonomic groups (bacteria, mycelial fungi, actinomycetes, and yeasts). The aim is the development of a novel technology for phytoremediation of TNT and RDX of contamination sites. Primary transformation of TNT and RDX by selected rhyzosphere (soil) microorganisms of different taxonomic groups in soil or water polluted with the contaminants. The main function of this stage is the transformation of TNT and RDX into partially oxidized or reduced compounds, easily utilized by plants roots. Disposal of TNT and RDX and/or products of their partial transformation from soil or water by plants previously selected specifically for this purpose.** *© 2021 Bull. Georg. Natl. Acad. Sci.*

Soilbiodegradation, phytoremediation, bio utilization

While at the beginning of the new millennium the UN identified hunger, poverty and ecology as the main problems of mankind, for leading specialists in the field of strategic planning of global security, the core problem was and remains the geopolitical stability of the world.

The world's consumption-oriented growing population, who consumes more than it needs, has caused the pollution of the earth by such wastes that nature recycles for a long period. If the amount of production waste exceeds its recycle time it will ultimately instigate irreparable damage to the bio-space (Table 1). To the above-mentioned processes, we should add the ongoing conflicts/hostilities in the different regions of the world, military exercises, and the recently activated process of creating a new weapon. Countries interested in this field spend a lot of resources and compete with each other in the creation of crushing weapons [1,2], but unfortunately, there is little research conducted to study the damage done by these weapons to nature (Table 2).

At the same time if we take into consideration the growing possibilities of modern terrorism (Strategic objects are mostly managed by high technologies, which are becoming more and more dependent on

cyberspace. Terrorists may not carry out a direct attack on a nuclear power plant, but they may detonate an explosive device or otherwise disrupt the vehicle, thereby transporting the radiation-carrying product or attacking the radiation product depot) and their interest in causing as much damage as possible to the civilized world. Having this in mind the danger remains quite real.

**Table 1. Agricultural and forest land decline** [1]


Between 2000 and 2018, slight declines in the shares of agricultural land and forest land in land area translated into 78 million ha less of agricultural land and 89 million ha less of forest land.

**Table 2. Countries which reported armed clashes between state forces and/or rebels in 2020** [2]

The long-term influence of natural climatic and especially anthropogenic factors on the environment determines changes in different levels of the ecosystem, sometimes of vital importance: such as the invasion of infections by alien, uncharacteristic species; in the field conditions partially converted, but still toxic intermediates of explosives finally getting in food chain. The influence of these factors on the environment is also expressed in the accumulation in ecosystems of a large quantity of toxic, technogenic compounds, which have an extremely negative effect on the functional activity of all organisms.

It can be said that the civilized world has taken certain steps in legal terms.

- Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD); 5 October 1978;
- Article 35 (3) of the Additional Protocol to the Geneva Conventions of 12 August 1949, which deals with the protection of victims of international armed conflict (Protocol I, 06/08/77), prohibits the use of military weapons that "cause widespread, long-term, and severe damage to the natural environment."
- Protection of the environment in times of armed conflict, Adopted 1992, 25 November.
- United Nations Convention to Combat Desertification – UNCCD; Paris, 1994.

The international community is actively trying to solve ecological problems in different ways, but in our opinion, society should still look for ways to solve this problem in the ability of mother nature to regenerate itself. Based on the above mentioned, we consider it expedient to establish a research center by the civilized world, authoritative international organizations, where leading specialists will actively study the ways of nature's self-regeneration to develop technologies that will be used to solve eco-problems.

The aim was to develop the possible ways of TNT (2,4,6-Trinitrotoluene) and RDX (Hexa-hydro-1,3,5-trinitro-1,3,5-triazin) elimination from soil and water reservoirs, explosives, widely distributed and existing in ammunition of all military units in the world. In carried out in the laboratory and field experiments it was established that these explosives undergo just partial natural transformation in soil but definitely require complete elimination. According to the existing information in addition to chemical technologies attention was paid to biological technologies, namely, to plants and microorganisms of different taxonomic groups (bacteria, mycelial fungi, actinomycetes, and yeasts). As a result of

long-term investigation, by using the variety of plants and microbial strains, it was detected that the above mentioned explosives and their partially transformed products could be completely isolated from soil by the following three steps of technology.

The aim is the development of a novel technology for phytoremediation of TNT and RDX of contamination sites. Below the short description of the stages are presented:

- **Rhizosphere biodegradation**

Primary transformation of TNT and RDX by selected rhyzosphere (soil) microorganisms of different taxonomic groups in soil or water polluted with the contaminants. The main function of this stage is the transformation of TNT and RDX into partially oxidized or reduced compounds, easily utilized by plants roots.

- **Phytoextraction and phyto transformation** (Table 3)

Disposal of TNT and RDX and/or products of their partial transformation from soil or water by plants previously selected specifically for this purpose.

- **Bio utilization**

Bioconversion of plant biomass by basidial fungi strains by enzymes having lignolytic and cellulolitic activities. Using this approach, it might be reached the maximum (complete) level of TNT and RDX degradation (oxidation to $CO_2$, or to the level of standard cell metabolites).

**The most perspective plants to be used in technology:**

Ryegrass *(Lolium multiflorum)*
Maize *(Zea mays)*
Chickling vetch *(Lathyrus sativum)*
Chickpea *(Cicer arietinum)*
Alfalfa *(Medicago sativa)*
China bean *(Vigna sinensis)*
Mung bean *(Vigna radiata)*
Soybean *(Glycine max)*

**Table 3. Potential of microorganisms to degrade TNT and RDX** [3]

| The amount of analyzed strains | Selected for TNT | Selected for RDX |
|---|---|---|
| Microscopic fungi (250) | 14 strains | 11 strains |
| Actynomycetes (86) | No | No |
| Bacteria (500) | 16 strains | 9 strains |
| Yeasts (159) | 1 strain | 2 strains |

It was detected that the following hydrolytic enzymes participate in process of explosives degradation, lignolitic enzymes: laccase, manganese-dependant peroxidase; cellulases: endoglucanase, β-glucosidase, cellobiohydrolase [4].

Finally, it could be concluded that using biological, friendly to nature technology, based on the use of plants and microorganisms, could be reached the complete elimination from any type of soil and water the native forms of TNT and RDX, as well as products of their partial transformation. In practice the use of this technology would avoid the application of usually accompanied for detoxification process, critical conditions such as: acids, alkali's, high temperatures, other aggressive solutions and save the soil full value productivity.

*ბიოტექნოლოგია*

# ნიადაგიდან და წყლიდან ამაფეთქებლების მოშორების ტექნოლოგია

გ. კვესიტაძე* და დ. სუჯაშვილი**

**აკადემიის წევრი, საქართველოს მეცნიერებათა ეროვნული აკადემია, თბილისი, საქართველო*
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