REMEDIATION OF URANIUM CONTAMINATED SITES: CLEAN-UP ACTIVITIES IN SERBIA

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ABSTRACT

One of the serious environmental problems in Serbia represent sites contaminated with depleted uranium (DU) during past war activities. According to UNEP reports and our findings there are two types of contamination: (i) localized points of high, concentrated contamination where DU penetrators enter the soil, and (ii) low level of widespread DU contamination, which indicates that during the conflict DU dust was dispersed into the environment. Remediation of these sites is an urgent need because they represent a permanent threat to the population living in this area. Here we give a brief description of approaches commonly used in remediation of DU contaminated sites, and an overview of current clean-up activities performed in Serbia.

Key words: depleted uranium (DU), decontamination, soil remediation

1. Introduction

During the 1999 war activities, several sites in Serbia were struck with depleted uranium (DU) ordnance, a single site in Montenegro and numerous sites in Kosovo [1, 2]. Immediately after the air strikes all sites in Serbia were identified for DU contamination, signed and fenced-off and cleaned from unexploded DU penetrators from the surface [3]. This was necessary in order to protect people who live near by from accidentally entering the contaminated sites and picking up DU penetrators. All removed penetrators and surrounding contaminated soil are stored at the interim storage for low- and intermediate-level radioactive waste at the Vinca Institute of Nuclear Sciences. The Laboratory for Radiation and Environmental Protection is responsible for this storage which also is under supervision of the International Atomic Energy Agency (IAEA).

However, the amount of unexploded DU penetrators found on the surface is small compared to the total amount of DU ordnance that had struck these locations. Some of them that hit a hard surface exploded and were transformed into DU dust but the ones that hit soil did not explode and are still in the ground.

Therefore, further, more extensive clean-up activities with soil excavation were necessary for complete site decontamination, followed by soil remediation.

2. Assessment of environmental behaviour of DU by UNEP mission

In autumn of 2000, the United Nations Environment Programme (UNEP) carried out the first-ever international assessment of environmental behavior of DU following its use in a real conflict situation in Kosovo [1]. A second phase was carried out in Serbia and Montenegro with a field mission in October 2001. This study investigated five sites in Serbia (including the Bratoselce and Pljackovica locations) and one in Montenegro (Cape Arza) [2]. Their detailed field and laboratory analysis of soil samples revealed: (i) low level of widespread DU contamination which indicates that during the conflict DU dust was dispersed into the environment, (ii) localized points of concentrated contamination where the DU penetrator entered the soil (contamination points), (iii) traces of DU contamination were detected in the air at two sites two years after the conflict, through a modern air sampling technique, and (iv) no DU contamination was detected in drinking water and groundwater samples.

At contamination points (near penetrators) the concentration of DU can be very high from 0.01 - 10 g DU/kg soil, but the contamination is very localized (within the radius of 1 - 2 m) [2]. The depth of contaminated soil below contamination point is in the range of 10 – 20 cm but could be more. Since the majority of penetrators are still buried in the ground this has important implications for future risk of groundwater contamination. The penetrators recovered by the UNEP team, two years after the conflict, had decreased in mass by 10-15 % due to corrosion.

The third UNEP mission was carried out in Bosnia and Herzegovina in 2002 and their assessment of environmental behavior of DU following its use in a real conflict situation was recently reported [4].

Kosovo (war activities 1999) [1, 5]:

- 1.5 years after the conflict
- penetrators decreased in mass by 5 - 10 %
- no DU contamination was detected in drinking water

Serbia and Montenegro (war activities 1999) [2]:

- 2 years after the conflict
- penetrators decreased in mass by 10 - 15 %
- no DU contamination was detected in drinking water

Bosnia and Herzegovina (war activities 1994-5) [4]:

- 7 years after the conflict
- penetrators decreased in mass by about 25 %
- for the first time, DU could be clearly identified in one drinking water sample.

Presented data pointed to a strong correlation between the time period of corrosion of penetrators, measured by percentage of penetrators decreased in mass and time of contamination of drinking water. Those results strongly point out the urgent need for remediation of these sites in order to protect the population living in this area and prevent contamination of groundwater and, ultimately, drinking water supplies.

3. Remediation strategies for DU contaminated sites

Remediation strategies for DU contaminated sites depend heavily upon environmental conditions, aqueous chemistry and physical setting of the site, and will involve a combination of:

- physical removal and,

- chemical treatment.

A combination of sieving, gravity separation and soil washing can be used to remove actinides, coupled with simple bulk removal and disposal for extremely hot spots. Pump and treat method can be used to capture groundwater contamination and above-ground removal methods such as ion-exchange or mineralization can be used to strip the water before re-injection or disposal. An in-situ permeable reactive barrier (PRB) can provide a low-cost alternative to pump and treat methods for remediation of groundwater if the hydrology is suitable [6], or can be used as a barrier to prevent contamination from entering specific down gradient wells, water supplies, or wetlands that may be at risk, as is the case in Bosnia and Herzegovina [4].

After hot spots have been removed and general activities are below acceptable levels, either natural processes will act to slowly transport the remaining amounts of uranium (depending on the geochemical and hydrology characteristics of the site) or, alternatively broad site treatments can be applied, such as mixing in soil amendments [7-9], establishing wetlands, planting specific vegetation for uptake and stabilization, etc.

4. Clean-up activities in Serbia

From 11 investigated sites in Serbia, DU penetrators were found at four: Bratoselce, Pljackovica, Reljan and Borovac. The cleaning up activities on the first location Bratoselce were performed in 2002 and completed in 2003. The cleaning up activities on the second location, Pljackovica started in August and should be completed in October, 2004. At present, the problem is that 5 years after the air strikes, due to corrosion and weathering, it would be more difficult to detect DU penetrators. Decontamination at the remaining locations is planed for next year but will depend on funding since the Serbian government alone has financed all these activities.

Investigation of the profile around the penetrators at Bratoselce revealed that contamination of the soil in the close vicinity of the penetrators is high (>250 kBq/kg), rapidly decreasing with distance. Soil contaminated with DU dust has 80-90 kBq/kg [10-12].

As a first phase of complete soil remediation, simple bulk removal and disposal was performed for decontamination of sites in Serbia. Depleted uranium residues and contaminated soil resulting from decontamination are stored at the interim storage for low- and intermediate-level radioactive waste at the Vinca Institute of Nuclear Sciences. UNEP team and IAEA representatives inspected the barrels containing DU residues at the interim repository for solid radioactive waste at the Vinca Institute. According to their findings the DU residues are in a stable physical and chemical form, all the containers are in very good condition, provide sufficient containment and the radiological risk to the environment and the general population from the residues of depleted uranium stored at Vinca is negligible [2]. Since the residues are in a stable form and well contained they could be easily immobilized if necessary.

However, the capacity of the temporary waste storage at Vinca is sufficient for a maximum of only 3 to 4 years, and a plan to build a new permanent repository for low- and intermediate-level radioactive waste is being prepared. Such a facility would provide a long-term solution to the storage of radioactive waste including the residues of depleted uranium.

Complete site decontamination is very difficult to achieve only by excavation and physical removal. This is especially case when contamination is created by exploded DU munitions. At single DU contaminated site Cape Arza in Montenegro, the UNEP team was still able to detect low-level contamination, even that comprehensive decontamination undergone on this site, involving the removal of two tons of rock, soil and humus [2]. Also the UNEP team detected low level, but widespread surface contamination by micro-particles of DU dust generated by exploded DU

munitions, and traces of airborne DU particles two years after the conflict [2]. In addition, it is important to recognize that special care must be taken to prevent the spread of contamination when removing or burning vegetation or disturbing soil at contaminated sites.

5. Conclusions

Presented data strongly pointed out the need for continuation of the remediation activities in Serbia, in order to protect food and water resources located in the vicinity of the DU contaminated sites. It is also obvious that there is no single approach which could provide a sufficient level of remediation. For this reason, in future remediation activities attention must be paid to appropriate selection of remediation techniques and their combination.

6. Acknowledgement

This research was supported by The Ministry of Science and Environmental Protection of the Republic of Serbia, under Project 1985 and Project 2016.

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