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Original scientific paper

Impact of Depleted Uranium Weapons Use on the Quality of the Environment in Kosovo

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Abstract: During the bombing campaign of the then Federal Republic of Yugoslavia there was a significant deterioration of environmental quality, especially in Kosovo: causing significant disturbance to the health of the population, disturbance of the natural balance of the environment, polluting land, air, water and underground water courses, damaging flora and fauna, degrading the natural ecosystems and biodiversity in general, etc. It is certain that the consequences of the bombing with DU will be long and that they caused significant threats to the environment not only on local but also on regional and global levels.

The use of DU ammunition can be considered ecological disaster, with long-lasting and unpredictable consequences for the population and the environment. When it comes to our living space, it is certain that the environmental rehabilitation today is a challenge of a wider Balkan region and if the problem is not quickly fixed the whole area will become hazardous for living.

Keywords: Depleted uranium, military use, ecological consequences, monitoring

Introduction

Uranium (U, Latin - uranium) is a radioactive chemical element of III group B, 7 of the periodic system of elements (Actinides). It was discovered by German chemist Klaprot in 1789, and he named it after the planet Uranus which had been discovered earlier. It is a silvery white metal of unusually high density (nearly two-thirds higher than the lead). Among the elements that occur naturally on earth, it has the highest atomic number - 92 and relative atomic mass 238.029. It consists of three radioactive isotopes U-238 or UI (99.27% in natural uranium), U-235 or aktinouranium (0.72%) and U-234 or UII (0.006%). Obviously, natural uranium contains a very small amount of more radioactive U-235, while containing a significantly higher percentage of less radioactive U-238. To obtain a more useful U-235, a special method is used to enrich natural uranium (the process of separation) during which the percentage of U-235 increases to 3 - 90%, with a significant reduction in the percentage of isotope U-238. Less enriched U-235 is used in nuclear power plants as a fuel to run the submarine, while 90% U-235 is used for production of nuclear weapons. U-238 is used as a raw material for obtaining plutonium-239, which still serves as fissile material. Artificial uranium isotope U-233 is obtained by bombardment of thorium-232 with neutrons (Housecroft & Sharpe, 2008). Uranium is a highly radiotoxic and cancerous. Its compounds are highly toxic and have a cumulative effect (Parkes & Phil, 1973).

Depleted Uranium (DU) is a by-product of uranium enrichment process and is highly dangerous radioactive waste (Rajković, 2001). This means it is a less radioactive isotope U-238, devoid of other components of the two isotopes, and is essentially waste material that arises during the process of production of nuclear fuel. The percentage of isotope U-238 in DU is a minimum of 99.8%. Nearly one hundred thousand

tons of this waste had been accumulated for decades in special warehouses in the U.S. until the early seventies when it was applied in ammunition production. Depleted uranium is built into the tops of conventional grain of non-nuclear missiles. Each missile has approximately 350 grams of DU and that part of the missile is called a "penetrator" (Fig. 1). For the safety of the operator these projectiles are coated with an aluminum sleeve on the outside. Almost twice as dense as lead (19.06 g/cm^3), projectiles filled with DU easily pierce the dome of modern tanks and other armored vehicles. Due to the high penetration power, this type of ammunition is called a "silver bullet". In addition to this "efficiency", the other reason for the use of DU shells filling is that it is completely free.

Military use of DU

Depleted uranium munitions have been used in multiple conflicts. In the Persian Gulf War in 1991, 300 tons of DU ammunitions were used in Iraq and Kuwait (NATO, 2010). Approximately 950.000 DU bullets were used by American military during the 1991 Gulf War (Aitken, 1999).

About 10.800 DU rounds (approximately 3,3 tons of DU) were fired during NATO air strikes in Bosnia and Herzegovina in 1994 and 1995, mainly around Sarajevo (Global Security org., 2010).

According to NATO information, about 30.000 rounds of DU were fired from A-10 planes in Kosovo, corresponding to about 10 tons of DU. Total of 112 sites in and close to the border of Kosovo were hit with DU ammunition (NATO, 2010).

During the 2003 Iraq invasion from March to May, approximately 100 – 200 tons of DU ammunition was used by U.S and U.K forces (Fahey, 2010). In Afghanistan, over a 1 year period between October 2001 and October 2002, an estimated 500 to 600 tons of DU ammunition was used by the U.S military (Herold, 2010). Although this war is ongoing, more recent estimates are difficult to ascertain.

Fig. 1. PGU-14 (Armour Piercing Incendiary)

Environmental consequences of DU use

After the attack by DU-missiles, DU will be stored on the surface in the form of dust, metal pieces or in the form of oxide uranium powder, if the penetrator gets burned (Bleise et al., 2003). It is estimated that one third of the penetrator, when hitting the target transforms into dust (uranium and its oxides), covering the soil and the objects. Stored particles move easily, the wind carries them for kilometers contaminating the environment. However, the highest concentration of DU is stored up to 100 m from the target hit. A majority of penetrators which miss the target usually penetrate the soil intact up to the 50 cm in depth, where they can stay for a longer period. In such case, a small percentage of DU passes into a phase of dissoluble aerosols. Metal uranium will be found in the soil where reaction with water is possible. Depending on the geological situation, the pollution of underground waters is quite probable. The depth of penetration into the soil depends on the chemical composition and the characteristics of the soil (porosity, humidity, pH etc.). Thus, in sandy soil DU from the penetrator easily "moves", due to the weather conditions (showers, snow melting etc.) and in such a way, underground waters may be contaminated. If the main ingredient of the soil is clay or organic matter, the mobility of uranium dust is considerably reduced thus making environment pollution less possible. The pollution of underground waters due to the decomposition of whole penetrators or their large parts presents a potentially big ecological problem (UNEP., 2001). As DU has a half-life of 4.5 billion years, it can be concluded that the areas bombed with the munitions are and will be contaminated with carcinogens, radioactive element, practically forever.

Chemical process of the transport of DU in soil and underground water

When the penetrator hits the target it breaks and starts burning. As metal uranium has thermal-chemical instability in terms of oxide forms U(IV) and U(VI), it is clear that when the contact with the earth atmosphere emerges, oxide uranium will be created. Primary product of oxidation is U(IV)-oxide, UO_2. Further oxidation leads to the mixed U(IV) and U(VI)-oxides. Uranium gained by water falling off the fragments and dust of DU transferred to the soil or water appears as uranyl (U_2^{2+}) ion.

Migration of uranium depends on physical and chemical properties of soil and water, as well as oxidation products OU. Mobility of dissolved uranium will depend on pH values and presence of certain complex compounds in underground waters. In these complexes, carbonates and phosphate are usually found as ligands. U(VI) is more mobile than U(IV), which is explained by considerably higher solubility of U(VI)-compounds. Dissolved U(VI) easily makes complex compounds with OH^-, CO_3^{2-}, PO_4^{3-}, F^-, SO_4^{2-} and some organic ligands. These reactions lead to the reduction of the uranium concentration in the underground and surface waters. In pH values lower than 4, uranyl ion is present in the complex with fluoride ligand. If pH value is between 4 and 7, 5, uranyl ion makes complexes with phosphates and with higher pH values with carbonate ligand (UNEP/UNCHS., 1999).

Decomposition of the remaining penetrator mainly causes corrosion and hydrated UO_3, highly soluble in water. Acid soil reduces concentration of uranium in the soil. Also, the soil with a high quantity of carbonate has the least concentration of uranium, probably due to the forming of very soluble uranyl carbonate. Also, uranyl ion ties to many iron minerals which considerably reduces uranium migration through the soil (Erikson et al., 1990).

Dissolved uranium in water currents will find its way through the ground to the underground water.

The quality of uranium which enters underground waters dictates a degree of contamination of water currents. Normal concentration of uranium in underground waters is 0,1 – 12 mg/l.

Test results of UNEP in Kosovo

In November 2000, a field mission of UNEP *(UN program for the protection of environment)* visited 11 of 112 sites in Kosovo, hit by ammunition with DU. This team, consisting of 14 scientists from several countries, collected soil, water and plant samples and did the testing of the samples taken from the buildings, destroyed army vehicles and remaining DU bullets. The total sum of 355 samples was analyzed as followed: 249 soil samples, 46 water samples, 37 plant samples, 13 samples taken from buildings and vehicles, 3 samples of milk, 4 jackets (parts of ammunition), 2 penetrating bullets and 1 fragment of penetrating bullet (UNEP., 2001)(UNEP/UNCHS., 1999).

UNEP mission has used so called RESRAD computer code in its research, developed in *Argon National laboratory*. The code was designed for doses and risk estimation on the basis of measured concentration of radioactive substance in the environment (Yu et al., 1993).

In the near vicinity of the impact, a law level of radiation was detected and mild contamination caused by DU dust near the aimed targets. Beside U-238 isotope, which makes up the largest part of DU, penetrators consisted of both isotope of uranium U-236 and isotope plutonium Pu-239/240. According to the results of UNEP, a quantity of trans-uranium isotope is very law and does not have to be of an importance in terms of its overall radioactivity.

In addition, according to UNEP, a widely spread contamination was not found in areas covered by the research. Therefore, respective chemical and radiological risks are not of considerable importance.

Results of the field research of UNEP mission in Kosovo, point to the fact that the majority of 10 tons DU penetrators ended deep in the soil. One of the possible effects which DU could have on the local population is an increase of uranium concentration in water, due to the decomposition of the penetrator and its presence in the water currents. Data from the USA tests point to the fact that each penetrator could, in soft soil penetrate to 7-8 meters of depth and each of them could contaminate 1 m^3 of soil. Having taken into account that the depth of the tested underground waters in tested locations in Kosovo is 2 - 25 meters, it is clear that there is a high possibility of water contamination. In these considerations, processes in nature which could slow down the transport of uranium (hydro-meteorological processes and composition of the soil) must be taken into account.

Research results show that the DU particles can be detected in the soil samples and in sensitive biological indicators such as lichens or fungi.

According to the warnings of the Serbian experts, there is an attempt of reducing the evident danger to some already recognized and harmless parameters, in the conclusions of UNEP report.

Representatives of UNEP mission, in their report, admitted existence of considerable scientific ambiguities, especially in the case of water safety. The remaining penetrators and jackets several meters hidden under the earth, as well as those above it, present a risk of future DU contamination of underground waters as well as tap water.

Conclusion

The use of DU ammunition can be considered as an ecological catastrophe, with long-lasting and unpredictable effects on the population and the environment. As far as our environment is concerned, it is certain that ecological recovery today, presents a challenge of a wider region of the Balkans, and if the problem is not solved soon, the whole area will become of a great risk for people's lives.

Decontamination procedure should contain an elaborate research and the removal of the remains of the DU ammunition jackets. At least half a meter of surface layer of contaminated soil should be removed and stored in protected containers. The only way of removing DU is by continuous effects of rain and snow melting. Therefore, it would probably take several hundred of years before the contamination ceases.

All locations identified as DU bombardment targets were decontaminated and recovered by 2002. But monitoring of DU effects on the environment should be continued in future for a long period of time. It is necessary to conduct a continous monitoring of radiation of every location and its surroundings following the elaborate Programe of radioactivity testing (water and soil samples, bioindicators – lichen and moss, food and the like).

References

Aitken M. (1999). Gulf war Leaves Legacy of Cancer. British Medical ournal, 319, 401.

Bleise A., Danesi P. R., Burkart W. (2003). Properties, use and health effects of depleted uranium (DU): a general overview, Journal of Environmental Radioactivity, 64, 93 – 112.

Erikson R. L. et al. (1990). A review of the environmental behavior of uranium derived from depleted uranium alloy penetrators, Washington.

Fahey D. (2010). The Use of Depleted Uranium in the 2003 Iraq War, (accessed August 12, 2010).

Global Security org. (2010). Depleted Uranium (DU) History, (accessed August 12, 2010).

Herold M. W. (2010) Uranium Wars: The Pentagon Steps up its Use of Radioactive Munitions, (accessed August 12, 2010).

Housecroft C. E., Sharpe A. G. (2008). Inorganic Chemistry, 3rd, Prentice Hall.

NATO. (2010). Depleted uranium, (accessed August 11, 2010).

NATO. (2010). Depleted uranium, (accessed August 12, 2010).

Parkes, G. D., Phil, D. (1973). Mueller modern inorganic chemistry, Nuučna books - Belgrade.

Rajković Miloš B. (2001). Uranium, radioactivity and legal regulations, Chemical Industry, 55, 167 - 182

UNEP / UNCHS. (1999). Balkans Task Force, DU Report.

UNEP. (2001). Depleted Uranium in Kosovo, Geneva.

Yu C. et al. (1993). Data collection handbook to support modeling impacts of radioactive material in soil, Argonne National Laboratory, Illinois.

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