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**Serhii Krasovskiy PhD student gr.183A-20-2**

**Scientific supervisors: Oleksandr Kovrov professor, Iryna Klimkina associate professor, Hermann Heilmeier professor.**

*(Dnipro University of Technology)*

## **ENVIRONMENTAL IMPACT OF METALS RESULTING FROM MILITARY ACTIVITIES: UKRAINE**

Heavy metals accumulate in the soil during military operations with the use of small arms, mortars, artillery and rockets. Military projectiles have different metals in their composition. Each metal has its own physico-chemical properties, so it is difficult to predict their reactions in the environment. Due to its specific chemical composition, it is difficult to predict their migration in the environment. The chemical composition of military projectiles includes the following elements: Ld, Sb, Cu, As, Zn and W. Military projectiles typically consist of a steel penetrator followed by a Pb/Sb slug jacketed with an alloy of Cu, Zn, and Pb, although not all small arms projectiles have a Cu alloy jacket such as some handgun and shotgun cartridges, which contain bare slugs, balls, or pellets is an example of a typical small-arms projectile [1]. In addition, large-caliber weapons such as mortars and artillery are used in the war in Ukraine. These projectiles consist of 95% iron and manganese, all other metals are copper, zinc, lead and aluminum present in the rotating strip. Some shells have powdered metals instead of explosive filler, such as Ba, Cu, Mn, K, Sr for pyrotechnics. In the experiments that took place at the military training grounds, after the use of these shells, an increased concentration of such elements Al, Mn, and Ni were recorded, but it did not exceed the maximum permissible [2].

It is now even impossible to fully assess the impact of war on the environment due to the lack of accurate information. In the first days of the full-scale invasion, Russian troops moved within the existing infrastructure. The hostilities have dragged on — and that is why the Russians are changing tactics and preparing for prolonged confrontations. For this purpose, they form bases and fortifications. This means that they move deep into the natural territories: they occupy forests and territories of the nature reserve fund. The movement of heavy equipment, the construction of fortifications, and military actions damage the soil cover. This leads to the degradation of the vegetation cover and increases wind and water erosion. According to the Ministry of Environmental Protection and Natural Resources, according to preliminary estimates, as of March 1, 2022, the aggressor is conducting combat operations on the territory of 900 objects of the nature reserve fund with an area of 12,406.6 square kilometers, which is about a third of the area of the nature reserve fund of Ukraine. Also, the Russian troops, while destroying our forests, use wood to build fortifications, lay infrastructure, heat and cook.

A number of chemical compounds are formed during the detonation of rockets and artillery shells: carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>), water vapor (H<sub>2</sub>O), brown gas (NO), nitrous oxide (N<sub>2</sub>O), nitrogen dioxide (NO<sub>2</sub>), formaldehyde (CH<sub>2</sub>O), vapors of cyanic acid (HCN), nitrogen (N<sub>2</sub>), as well as a large amount of toxic organic matter, the surrounding soils, wood, sod, and structures are oxidized. During an explosion, all substances undergo complete oxidation, and the products of the chemical reaction are released into the atmosphere. The main ones, carbon dioxide and water vapor, are not toxic, but harmful in the context of climate change, since both are greenhouse gases. In the atmosphere, sulfur and nitrogen oxides can cause acid rain, which changes soil pH and causes plant burns, to which conifers are particularly sensitive. Acid rain also has a negative impact on the human body, other mammals and birds, affecting the condition of mucous tissues and respiratory organs. Metal shrapnel from projectiles entering the environment are also not safe and completely

inert. Cast iron with steel admixtures is the most common material for the production of ammunition shells and contains not only standard iron and carbon, but also sulfur and copper. These substances enter the soil and can migrate to groundwater and eventually enter food chains, affecting both animals and people [3].

For an accurate analysis of the impact of military operations on the environment, it is necessary to constantly take control of soil and water samples that have been subjected to military influence.

#### References:

1. Agency for Toxic Substances and Disease Registry (ASTDR), 2005. Public Health Statement for Tungsten. Accessed. [www.atsdr.cdc.gov/php/phs.asp?id=4804&tid=4157](http://www.atsdr.cdc.gov/php/phs.asp?id=4804&tid=4157) ;
2. Jay L.Clausena, Nic Korteb , 2009 *Environmental fate of tungsten from military use*. Science of The Total Environment. V.407.P.2887-2893;
3. Datta, S., Vero, S.E., Hettiarachichi, G.M., Johannesson, K., 2017. Tungsten contamination of soils and sediments: current state of the science. Landerber. Pol. <https://doi.org/10.1007/s40726-016-0046-0>.