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ABSTRACT

RESTORATION OF AGRICULTURAL LANDS EXPOSED TO MILITARY IMPACT BY PHYTOREMEDIATION WITH CABBAGE OILSEEDS

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Military actions that took place in the de-occupied territories and those that are taking place in the occupied territories have led to significant contamination of the soil cover and soil horizons, namely, physical, chemical, mechanical and biological degradation of soils.

To date, it has been established that soil contamination as a result of hostilities significantly affects its structural parameters and the functioning of soil microbial communities, reducing its biological activity, and the accumulation of heavy metals, explosive residues, and their metabolites. Sulfur and phosphorus contamination, arsenic contamination, and arsenic contamination in soil after explosions are observed in excess of permissible levels. Excessive concentrations of benzopyrene, high concentrations of lead, sulfur, titanium, copper, chromium, strontium, zinc, and cadmium were recorded in the surface soil layer at the sites of leakage and combustion of fuels and lubricants. All of these substances are inherently carcinogenic, persistent, and can remain in the soil for a long time, making it impossible to grow crops due to their high phytotoxicity and the ability of plants to accumulate these elements during cultivation.

There are almost no accredited analytical agricultural laboratories in Ukraine that are fully capable of assessing the impact of toxic elements of explosives, heavy metals, polychlorinated biphenyls and polyaromatic hydrocarbons, and the physical and chemical indicators of soil quality. The Ukrainian Laboratory of Quality and Safety of Agricultural Products (NULES of Ukraine) is accredited according to the international standard DSTU ISO/IEC 17025:2019, which contains requirements for measuring laboratories, compliance with which ensures technical competence and the ability to obtain reliable results of measurements and research.

Preliminary studies show that after explosions, pollution with sulfur and phosphorus increases, which may be by-products of explosives phlegmatization. Arsenic contamination is a critical environmental problem, with arsenic levels in the soil after explosions exceeding permissible limits. The source of arsenic is weapons, as arsenic and arsenic trioxide are used in the production of chemical warfare agents, lead alloys and smoke generators in shells. It is a very dangerous reactive soil contaminant that is capable of vertical migration through penetration to groundwater, horizontal transport by runoff, and aerial transport with dust particles.

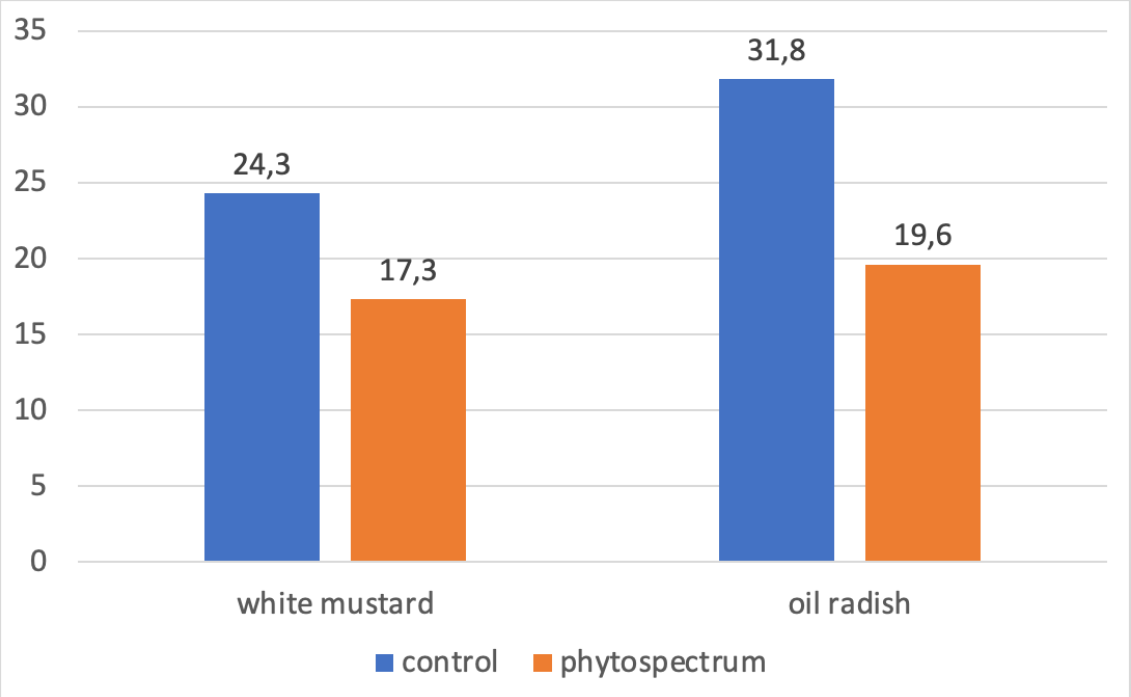
We also observe that soil contamination with cadmium negatively affects the microbiological activity of the soil, disrupting the absorption of basic nutrients by the root system and inhibiting plant growth. In the areas where hostilities

were conducted, the content of iron, manganese, copper, nickel, and chromium increases, but their content is within the MPC limits. Such a preliminary conclusion can be made, but it is impossible to determine the impact of these elements based on one-year data because sampling is difficult in the area of hostilities and access to the areas that are being romanized, etc. is limited.

However, as for a complete and comprehensive soil survey for explosive residues, our capabilities are to some extent limited by the availability of a database of metabolites of nitroammonium compounds of explosives, a system of autosamplers and digestors for sample preparation.

The National University of Life and Environmental Sciences of Ukraine, as the leading agricultural university in the country, and its structural unit have launched a study to determine the impact of different types and levels of soil contamination on the growth, development and yield of such cabbage crops as mustard and oil radish. These crops are good phytoremedies and are not susceptible to phytotoxicity by heavy metals and explosive residues.

The influence of various types of pollution on the phytotoxicity of certain types of cabbage crops, the effect of the use of bacterial fertilizers and fertilizers containing trace elements on improving seed germination and germination of the studied crops - mustard and oil radish (Fig. 1). It was found that the use of this agricultural measure helps to reduce the impact of pollution on germination, which is further reflected in the growth and development of the studied crops.



Soil phytotoxicity in the cultivation of white mustard and oil radish, %, 2024

Given that after the demining of agricultural land, it is necessary to have a clear answer as to the use of arable land, namely, what crops to grow with minimal accumulation of harmful substances in the main products, and how to use them in the future.

One of these crops is winter rape, which is also a good phytoremedial, and which occupied large areas in the currently occupied territory and on the combat line. However, the issue of the accumulation of polutants in its main products remains poorly understood, which will determine its use. In Ukraine, this crop is grown on an area of more than 1.0 million hectares, providing production of 3.7-4.0 million tons, the lion's share of which (about 90%) is exported. And secondary metabolites of explosives are generally poorly understood and can

potentiate the risks of negative impact on environmental and human health.

For export, only the parameters of oil content, erucic acid, glucosinolates and residues of certain pesticides are considered. However, rapeseed (mustard) grown in areas that are mined, where military operations were conducted (filled craters, foci of spillage and burning of fuels and lubricants, etc.) can accumulate heavy metals and explosive metabolites, which, when processed into oil, can remain in it and have a negative impact on the end consumer. Since this area has not been studied, the issue of accumulation of heavy metals, explosive residues and their metabolites by rapeseed plants and their accumulation in the final product remains open. There is also a need to increase the effectiveness of phytoremediation and the use of fundamentally new elements in their cultivation technology that improve the biological activity of the soil and are capable of neutralizing polutants, increasing the productivity of rapeseed (mustard), monitoring growth and development processes, in order to improve cultivation technologies by making certain decisions at certain stages of organogenesis that will ensure the quality of seeds that do not exceed the maximum permissible levels of concentrations of heavy metals and explosive residues. However, this is a complex and time-consuming process based on soil and plant sampling during the growing season, monitoring the accumulation of polutants during the growth and development of rapeseed (mustard), and screening for chemical compounds subject to hygienic regulation.

Thus, there is a need for a comprehensive study of the above factors, which will make it possible, in addition to cleaning up contaminated areas of agricultural land, to use the main products (seeds for oil production) in the national economy, depending on their quality - for food consumption, for biodiesel production or as technical oil.