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ASSESSMENT OF ENVIRONMENTAL POLLUTION RESULTING FROM THE DESTRUCTION OF CIVILIAN PETROLEUM STORAGE FACILITIES DURING MILITARY OPERATIONS

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Abstract

The publication examines a topical issue related to the impact of military actions on the state of one of the fundamental components of the environment – the soil layer both within the aeration zone and the collectors of the first aquifers from the surface. The massive destruction of oil processing and storage facilities in Ukraine caused by Russian aggression, not only on the battle lines but also deep in the rear, creates a significant long-term danger to environmental components and human economic activity. At one of the technogenic disaster sites destroyed by Russian missiles (oil depot in urban settlement Kalynovka, Kyiv region) specialists from the IGS of NAS of Ukraine have begun practical and theoretical work to create a methodological basis for assessing the impact of pollution on the environment and develop measures to minimize such impact.

Key words: *impact of military operations, soils, petroleum products, environmental damage, assessment methodology, groundwater.*

It is well known that one of the most vulnerable components of the environment in the area of military activity was and remains the soil, as evidenced by daily illustrations from the theaters of military operations of the Russian-Ukrainian war. In addition to the visually recorded impact on the fertile layer (violation of the integrity of the soil and vegetation cover, pollution with hazardous substances, etc.), there are other dangerous aspects, the negative effects of which have a hidden or delayed effect. They can not only manifest and have a long-term impact after a certain time, but also change the location and type of impact on various components of the environment, which is difficult to predict.

We are talking about leaks of significant volumes of liquid pollutants, in particular petroleum products, which enter the soil not only during military operations, but also as a result of missile/UAV strikes on civilian infrastructure facilities deep in the rear [1]. In addition to contamination of the fertile soil layer there is a risk of oil products leaking deep into the soil layer and entering underground horizons. In accordance with the geological and hydrogeological conditions of the territories and the

physicochemical properties of pollutants, their accumulation occurs on the surface of groundwater and water-resistant layers of rocks. This causes complex negative consequences, including contamination of underground aquifers and migration ("spreading") of the liquid phase of pollutants over large areas. And this, in accordance with the geomorphological conditions of the area, can lead to the discharge of pollutant flows into surface water reservoirs and the creation of long-term problems for aquatic organisms, drinking water intakes, and irrigation areas.

Solving of such problems requires significant expenditure on localizing pollution and developing measures to minimize/remove it, and first of all, on carrying out research on the diagnostics of polluted environments, their properties in interaction with pollutants, concentrations of accumulated pollutants, and forecasts of impact on the environment.

In the pre-war period research team of IGS of NAS of Ukraine investigated the consequences of the impact of military and civilian activities on the environment, in particular, such objects as military airfields and oil depots, as well as civilian airports [2]. For such objects, an assessment of the state of pollution of the geological environment was carried out (Fig. 1), sources and routes of pollution distribution were identified, geofiltration mathematical models were created, the impact on adjacent components of the environment was determined, and recommendations for the management of contaminated areas were developed. The developed scientific approaches allow us to perform high-quality similar work on pollution hotspots that appeared as a result of Russian aggression.

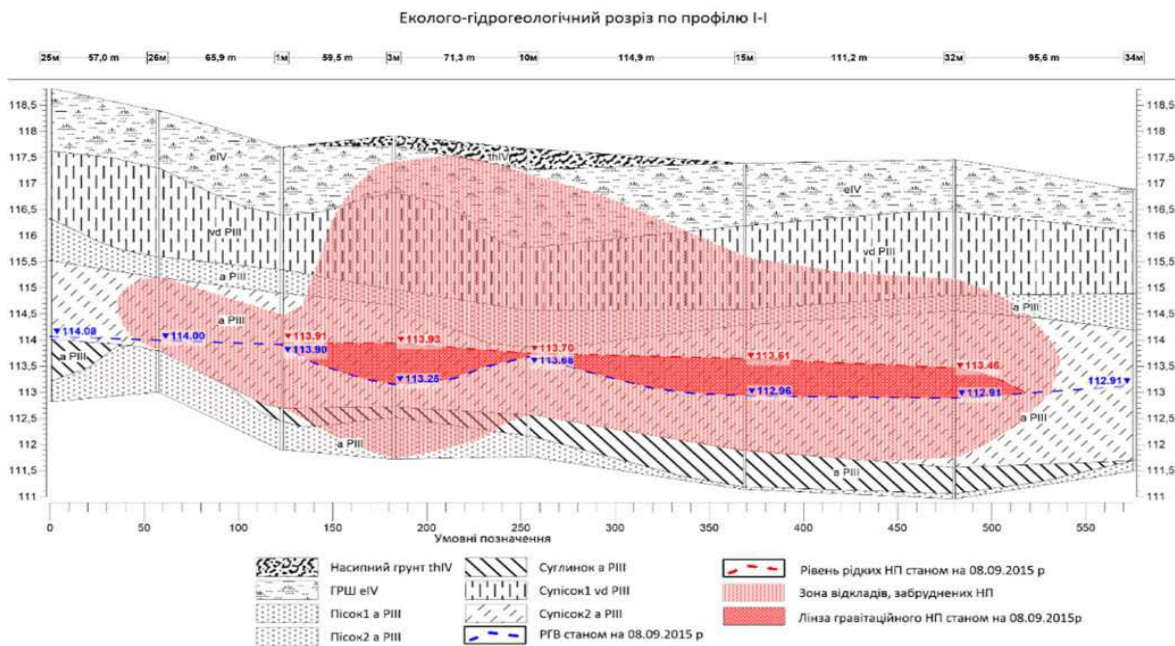


Figure 1. Example of a schematic model of liquid petroleum product migration through different strata of the geological cross-section (fuel and lubricants storage area, Boryspil Airport)

The development of a methodological framework for assessing the consequences of petroleum contamination in the geological environment, based on practical experience [3], can significantly reduce the time and financial costs associated with such assessments. Given the large number of facilities destroyed by Russian forces and the limited resources available in Ukraine for environmental research, this will have a notably positive impact

One of the most serious incidents occurred near the village of Kalynivka (Kyiv region), where a missile attack destroyed large fuel tanks (Fig. 2), leading to uncontrolled leakage of petroleum products into the soil and groundwater. The pollution has spread to the local river system, affecting

tributaries of the Irpin River and creating long-term risks to ecosystems, water resources, and human health.



Figure 2: *Civilian oil depot destroyed by a Russian missile attack
Kalynivka urban settlement, Fastiv district of the Kyiv region)*

The situation was worsened by the destruction of the concrete protective cushion at the site of the tanks and the protective concrete barrier around their perimeter. As a result, petroleum products entered the soil at the oil depot site and spread to nearby areas.



Figure 3. *Documented contamination of the
geological environment in the area
of the destroyed oil depot based on drilling results*

The first field studies in the area of the destroyed oil depot showed the formation of a zone of intensive contamination of the geological environment with liquid petroleum products along the river bank (Fig. 3).

It is assumed that oil products could have entered the river from the site of the destroyed oil depot as a result of rapid overflow through the underground structures of the drainage system. The river is part of the cascade of water bodies of Kozhukhivka village and belongs to the Irpin River basin. Large-scale pollution of the river during 2022-2025 did not decrease in intensity. In the near future, in the absence of nature restoration measures, this will affect not only the ecosystem of the river and the adjacent territory, but also the environmental objects and economic activities downstream.

We are determining the degree and spatial distribution of hydrocarbons contamination of the geological environment (soil, groundwater, bottom sediments of adjacent surface water ponds) (Fig. 4). Planning of further field work will be based on the need to forecast the spread of pollution from the site of the petroleum products leak in the geological environment and assess the risks of impact on the social sphere (water intakes, surface water ponds for various economic purposes) and biotic groups of nearby natural reserve fund objects. Both the completed and planned field work consists of surveying the oil depot area, identifying pollution hotspots; sampling soils, bottom sediments of water

ponds, groundwater and surface waters to determine the content of pollutants within the designated areas, inter alia by drilling exploratory wells.



Figure 4. *Contaminated aeration zone sediments with discoloration (left) and contaminated surface waters of a small river (right), June 2024*

The laboratory studies will include comprehensive analysis of soil samples (natural properties and contamination status). The analysis of the obtained results will involve the development of a conceptual model for predicting the spread of contamination in the geological environment, including its extent and affected area.

The forecasting of contamination plume transformations using mathematical modeling will include, in particular, scenarios of petroleum product interactions within the 'water–petroleum product–soil' system, as well as a risk assessment of their impact on social and environmental assets.

Conclusions

The combination of field research and laboratory work using modern equipment, the use of mathematical models and the creation of databases within the framework of the local task will allow the formation of algorithms for approaches to assessing and solving the problem as a whole. Defining the instrumental and technological components of the research will contribute to the development of an optimal methodological framework for improving the management of petroleum-contaminated zones within the geological environment caused by Russian aggression. Conducting these studies in the scientific and practical plane will contribute to the creation of a methodological basis for working out similar centers of pollution in other locations affected by Russian aggression.

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**ОЦІНКА ЗАБРУДНЕННЯ ДОВКІЛЛЯ ВНАСЛІДОК РУЙНУВАННЯ ЦИВІЛЬНИХ ОБ'ЄКТІВ
ЗБЕРІГАННЯ НАФТОПРОДУКТІВ В ХОДІ ВІЙСЬКОВИХ ДІЙ**

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Анотація

В публікації розглянуто актуальне питання, пов'язане з впливом військових дій на стан одного з основоутворюючих компонентів навколишнього середовища – шару ґрунтів як в межах зони аерації так і колекторів перших від поверхні водоносних горизонтів. Масові руйнування об'єктів переробки та зберігання нафтопродуктів в Україні, спричинені російською агресією, не тільки на лініях бойового зіткнення, але й глибоко в тилу, створюють суттєву довготривалу небезпеку для складових довкілля та господарської діяльності людини. Фахівцями ІГН на базі одного з об'єктів техногенного лиха – зруйнованої ракетами росіян нафтобази в с. Калинівка Київської області, розпочато практичні та теоретичні роботи зі створення методичної бази для проведення оцінки впливу забруднення на довкілля та розробки заходів з мінімізації такого впливу.

Ключеві слова: вплив військових дій, ґрунти, нафтопродукти, шкода навколишньому середовищу, методика оцінки, ґрунтові води.