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**UDC 504.05:631.95:504.062.2**

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## USE OF PHYTOREMEDIATION TECHNOLOGIES TO REDUCE SOIL POLLUTION BY OIL PRODUCTS

Soil contamination with oil products is one of the most serious environmental problems arising from the intensive activities of oil production, refining and transportation infrastructure. Such contamination causes significant degradation of soil ecosystems, reduction of their fertility, loss of biodiversity, and negative impact on water resources. Traditional methods of soil treatment, including mechanical and chemical methods, are often expensive, require significant resources and can have secondary negative impacts on the environment. Given the current challenges associated with sustainable development, the use of environmentally friendly technologies is of particular importance [1, 3].

Phytoremediation, which is based on the ability of plants to cleanse the soil of contaminants, is a promising alternative to traditional methods. This technology not only effectively reduces pollution, but also helps restore soil structure and biological activity by integrating the principles of nature-based solutions [2, 4].

Phytoremediation involves the use of plants and associated microorganisms to remove, stabilize or degrade pollutants in the soil. The main mechanisms that ensure the cleanup of oil-contaminated soils are absorption of pollutants by plants through the root system with their subsequent translocation to the aboveground;

decomposition of pollutants by enzymes secreted by plants or rhizosphere microorganisms; absorption and release of volatile compounds into the atmosphere through transpiration; stimulation of microbiological activity in the root system zone, which promotes the decomposition of pollutants; reduction of pollutant mobility in the soil, preventing their migration to groundwater [5, 7].

The study of the effectiveness of different plant species for phytoremediation of oil-contaminated soils showed that the best results are demonstrated by Table 1.

**Table 1: Plant species for phytoremediation**

| Plant name | Benefits in herbal medicine |
|---|---|
| *Helianthus annuus* | Developed root system, high tolerance to oil pollution, rapid biomass growth |
| *Medicago sativa* | Enriches soil with nitrogen, creates favorable conditions for microbiological decomposition of oil products, has a deep root system |
| *Festuca arundinacea* | Effective for soil stabilization, maintains high microbial activity in the rhizosphere, and is resistant to drought |
| *Lolium perenne* | Fast-growing cereal with a high ability to adapt to adverse conditions, forms a dense turf |
| *Vicia faba* | Effectively cleans the soil even in areas with medium and high levels of oil pollution, reduces soil phytotoxicity |

In the course of the laboratory experiments, the effectiveness of phytoremediation at different levels of soil contamination with oil products (5%, 10%, 15%) was investigated. The parameters evaluated were seed germination, biomass growth, phytotoxic effect, and soil cleanup efficiency [1, 8].

The results showed that the cleaning efficiency was 73.87% at 5% contamination, 66.83% at 10% contamination, and 46.50% at 15% contamination. Statistical processing confirmed the significance of the difference between the variants (at P=0.95).

It was found that phytoremediation parameters vary depending on the level of pollution: The maximum purification efficiency (77.0%) was recorded at a final concentration of oil products of 2.3%. The biomass growth reached the highest rates (245.0%) at medium concentrations. The optimal zone for effective phytoremediation was a concentration of 2.3-2.5%.

Phytoremediation is an effective, economically feasible and environmentally friendly technology for cleaning soils contaminated with oil products. Experimental studies have shown that the cleaning efficiency can reach 70-75% during one growing season with an optimal choice of plants and agrotechnical measures.

The advantages of phytoremediation are minimal interference with natural ecosystems, no secondary pollution, and relatively low cost compared to traditional methods. In addition, phytoremediation helps to restore soil structure and biological activity, increasing its fertility.

The use of phytoremediation technologies has significant potential for implementation in the remediation of areas contaminated by oil products,

especially in conditions where traditional methods of cleanup are economically unfeasible or environmentally hazardous.

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**UDK 614.8**



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## RISK MANAGEMENT AND ENVIRONMENTAL MONITORING AS COMPONENTS OF OIL AND GAS INDUSTRY FACILITIES SAFETY OPERATION

Safety is a paramount requirement in oil and gas facilities. Numerous risks in such facilities are typically having high hazard potentials for major accidents. Our ongoing research aims at: (a) establishing linkages between common set of leading and lagging indicators of oil and gas facilities and (b) benchmarking the safety management system (SMS) components to the effectiveness of safety