# INFLUENCE OF INDUSTRIAL WASTE ON SOIL PROPERTIES
# ВЛИЯНИЕ ПРОМЫШЛЕННЫХ ОТХОДОВ НА СВОЙСТВА ПОЧВЫ

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**Abstract.** The article substantiates the need to implement soil protection, pollution reduction, and reclamation measures. The obtained results are important for improving the environmental monitoring system and ensuring sustainable development in agriculture.

**Keywords:** industrial waste, soil pollution, heavy metals, agroecological state, soil fertility, chemical composition, anthropogenic impact, degradation.

**Аннотация.** В статье обосновывается необходимость внедрения мер по защите почв, снижению загрязнения и рекультивации. Полученные результаты важны для совершенствования системы экологического мониторинга и обеспечения устойчивого развития сельского хозяйства.

**Ключевые слова:** промышленные отходы, загрязнение почв, тяжелые металлы, агроэкологическое состояние, плодородие почв, химический состав, антропогенное воздействие, деградация.

Waste generated by industrial enterprises has a serious negative impact on the composition and quality of the soil. In various scientific sources, the main aspects of this process are described as follows: Industrial waste often

contains a high content of heavy metals (for example, lead, copper, zinc, cadmium), petroleum products, acids, alkalis, and other toxic substances. They accumulate in the soil layer, disrupting its natural chemical balance. Toxic substances entering the soil pass through plants into the food chain. Therefore, it enters the human and animal body in sufficient quantities, causing various chronic diseases.

Sources of industrial waste are mainly metallurgical, chemical, oil refining, thermal power plants, and mining enterprises. In these processes, hazardous wastes are released into the air, water, and ground, resulting in long-term pollution.

Reclamation of soils contaminated with industrial waste is a complex, but feasible process. Below is detailed information on the main methods of reclamation of contaminated soils, how they work, and their practical results. One of such main methods of soil regeneration is biological methods (Bioremediation), which include soil cleaning using living organisms - mainly bacteria, fungi, and plants. They are considered environmentally safe and economically efficient.

By adding special bacterial strains to the soil, pollutants are neutralized. For example, scientists of the Institute of Microbiology of the Academy of Sciences of Uzbekistan implemented an innovative project for the restoration of saline soils. In experiments conducted on a farm in the Dangara district of the Fergana region, with the help of biopreparations using microorganisms, water consumption was reduced by 30%, and the consumption of chemical fertilizers by 50%, as a result of which the cotton yield increased by 20%.

In the restoration of soils contaminated with cadmium (Cd), a joint association of “Enterobacter ludwiigi”, “Bacillus simplex”, and “Bacillus licheniformis” bacteria showed high effectiveness. These bacteria not only reduce cadmium toxicity but also stimulate the growth of plants like wheat.

In phytoremediation, plants are used to restore the natural state of contaminated soils, and they are cleaned with the help of plants. Some plants (special species such as “Sedum alfredi”) have the ability to accumulate heavy metals (zinc, cadmium, lead) in the soil in their roots, stems, and leaves. By planting these plants, it is possible to remove pollutants from the soil along with their biomass. Along with biological methods, chemical methods are also used to restore the natural state of soils. Chemical methods are mainly aimed at reducing the harmful effects of pollutants by adding chemical substances to the soil composition. Currently, one of the widely used chemical methods is the chemical melioration method, which is mainly used to improve the chemical properties of soils. Chemical methods such as liming, gypsum plating, acidification, and immobilization (preservation) are also used. While liming is used to reduce acidity in acidic soils and eliminate the effects of harmful hydrogen and aluminum ions, gypsum plastering is used to reduce the sodium content in saline (alkaline) soils and improve their physical properties. In this case, the calcium in the gypsum displaces sodium ions from the soil.

The acidification method is used to neutralize the soil environment in soda saline soils by adding substances such as sulfuric acid or sulfur, while the immobilization (preservation) method involves adding special sorbents (such as activated carbon, zeolites) to the soil to bind heavy metals and other toxic substances, preventing their transfer to plants and groundwater.

These methods are aimed at removing pollutants from the soil or neutralizing them. In addition to the above useful methods, there are several other methods designed to restore the natural state of contaminated soils. Today, depending on the degree of soil contamination, one of the methods is used, such as soil washing (Soil Washing), thermal cleaning, and electro-kinetic remediation. This method is based on the removal of harmful substances (in particular, heavy metals) by washing contaminated soil with

special solutions. The EU-funded project **ReSoil** is one of the most advanced technologies in this field. ReSoil technology allows for the efficient extraction of lead and other toxic metals from the soil. The biggest advantage of this method is that the water and chemical reagents (EDTA) used in the process are processed in a closed cycle, as a result of which no liquid waste is formed. . This allows for soil purification while preserving it as a natural resource. Thermal Desorption. Method of evaporating and then retaining petroleum products, mercury, and other volatile organic compounds by heating the soil to a high temperature.

Electrokinetic remediation. Passing low-voltage electric current through the soil. In this case, heavy metals and other charged pollutants move towards the electrodes and are collected.

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These results show that soil regeneration brings great benefits not only from an ecological, but also from an economic point of view. Microorganisms contribute to the transition to sustainable agriculture by improving soil composition, increasing water retention capacity, and increasing plant resistance to drought.

The most effective approach to the restoration of contaminated soils is often the combined use of several methods. For example, improving the soil environment through chemical melioration, followed by phytoremediation or

the application of microorganisms, yields high results. Innovative technologies, such as the European ReSoil project, based on the principles of waste-free production, allow for soil preservation and cleaning. Practical research conducted in Uzbekistan shows that there are ample opportunities for applying environmentally friendly and economically beneficial methods in this area. Industrial waste disrupts the natural composition of the soil, reduces its fertility, harms flora and fauna, and poses a threat to human health. Therefore, it is important to reduce waste, strengthen waste recycling and environmental control systems.

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