# Effects of pollution of saline soils with oil and oil products on soil physical properties

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**Abstract.** In the article, pollution of saline soils with oil and oil products, physical and water-physical properties depending on the level of salinity are studied. As a result of the research, it is scientifically based that the increase in the level of contamination of the soil is subject to the decrease in water permeability, and the decrease in the level of pollution is subject to the law of the increase in water permeability. In the article, weakly, moderately, strongly and very strongly contaminated soils with oil were studied. According to the results, it was determined that the water permeability of the soil was observed in 25, 45, 45, 37, 5, 3, 2 minutes, and it carried 75, 26, 44, 45, 540, 1050, 1200 ml of water, respectively, for 90 minutes. The amount of water transfer compared to the control soil for 90 minutes was less in 1%, 2%, 5% contaminated soils, and very high in 15%, 25% and 37.5% contaminated soils. The increase in the level of pollution is explained by the deterioration of water permeability and moisture retention. Also, due to the fact that oil is a viscous organic pollutant, the changes of 0.25, 0.5, 1, 3, 5, 7, 10 mm microaggregates, which are important for soil fertility, as a result of pollution, and changes in the amount of these microaggregates were also determined. It was found that the soils around the South Mirshodi oil field were previously contaminated and the amount of microaggregates smaller than 0.25 mm, 0.25 mm, 1 mm, 2 mm and 3 mm in the irrigated soils increased as the distance from the source of contamination increased. This is explained by the decrease in the concentration of oil in the soil. The amount of 5 mm, 7 mm and 10 mm aggregates has decreased. A similar situation was observed around the Kumkurgan oil base. The effect of petroleum hydrocarbons is more noticeable in microaggregates with a diameter of 10 mm.

## 1. Introduction

The increase in oil-contaminated areas in the world is explained by the increase in demand for oil and oil products. In oil-producing countries, the level of soil pollution with oil products is high [1]. Pollution occurs in the areas of oil production and processing due to technical failures, fires in mines and warehouses, accidents in the process of oil transportation, and the spilling of oil water from mines and other related substances into the environment. Oil and oil products spilled into the environment have a negative impact on all components of the ecosystem, especially the properties of the soil. This situation leads to soil and plant mutation, reduced productivity and lack of food [2]. Pollutants such as cycloalkanes, n-alkanes and polycyclic aromatic hydrocarbons cause serious problems in the environment and public health. Oil and oil products spilled on the soil, oil water in the oil extraction process lead to deterioration of soil density and structure, decrease of water permeability, change of nutritional conditions of plants as a result of accumulation of salts [3].

During an experiment on saline and oil-contaminated soils, it was found that the strain of Exiguobacterium alkaliphilum B-3531D bacteria reduces contamination by 30% and salinity by 11% [ 4]. One promising method for bioremediation of hydrocarbons is the propagation of biosurfactant-producing microorganisms that recycle wastewater into culture media. This method helps to reduce costs [5]. In the soil contaminated with oil and gasoline in the amount of 5%, when applying the microbiological preparation "Baikal EM-1" in different amounts, the soil was cleaned by 39% compared to the control sample. Petroleum hydrocarbons have short-term and long-term effects on soil, water

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and human health. Petroleum hydrocarbon affects the growth of plants, reduces the productivity of agricultural land, reduces the fertility of the soil and makes it unusable [6].

Decontamination of soils contaminated with oil and oil products is very important. Today, one of the most economical and environmentally friendly methods of soil restoration is the phytoremediation method, which consists of cleaning with the help of algae and plants. Petroleum hydrocarbons also have a negative impact on soil and water sources [7–10].

Petroleum hydrocarbons reduce the germination of plant seeds and the transformation of nutrients, reduce the activity of plants. This leads to a decrease in productivity. Using organic manure, compost, plant hormones and biochar, moisture conservation and microbial remediation, phytoremediation can reduce oil hydrocarbons, improve morphological and physiological properties of plants, and increase productivity [5, 11–13]. These methods reduce the biological activity of the soil and slow down the rate of decomposition of petroleum products in the soil [14–16].

The number of microorganisms in the soil reaches its maximum level in spring, and this increases the efficiency of cleaning the soil from oil and oil products [26]. Particles of oil and oil products impair the process of water supply to the roots of plants, and this leads to physiological changes. Due to the increase in the concentration of carbon residue in the soil profile, there is a violation of the oxidation-reduction reaction and an increase in the mobility of humus components [7, 21]. As a result of pollution, the liquid and plastic limit and plasticity index of soils increase, the specific gravity decreases with the increase of oil content, the amount of MgO, $Al2O3$, CaO and $Fe2O3$ decreases, $Na2O$ and the pH of the environment increase [17,18]. Morphological characteristics and color of soils (depending on the degree of oil pollution) change [20].

Oil and oil products are quickly adsorbed and remain in the soil for a long time [18]. Living in oil-contaminated areas is dangerous for humans. Because pollutants also enter the food chain. This situation has been identified in many oil-rich countries. An increase in the level of pollution has a negative effect on soil properties and disrupts biological, chemical and physical processes in the soil. The physical properties of the soil deteriorate, and small aggregates are replaced by large aggregates. As a result, the physical properties of water deteriorate, the ability to retain moisture decreases [19,20].

## 2. Study Area and Methods

The study area is located in the Surkhandarya region in the southern part of Uzbekistan (North point is N 39°03”8” north latitude, E 67°97”0” east longitude, south point is N 37°18”76” north latitude, E 67°26”78” east longitude, East point is N 38°19”49” north latitude, E 68°40”25” east longitude, west point is N 37°38”07” north latitude, E 66°51”51” east longitude, picture 1), and the irrigated gray grassland soils around the oil field and the irrigated light gray soils around the Kumkurgan oil reservoir are distributed. Soil sampling, storage and laboratory experiments were carried out according to the international standard GOST: 17.4.3.01–83 [21–24]. The chemical and physical properties of the soil were carried out on the basis of methodological manuals entitled "Conducting chemical analysis of soils", "Agrochemical analysis of soils and plants of Central Asia" [30].

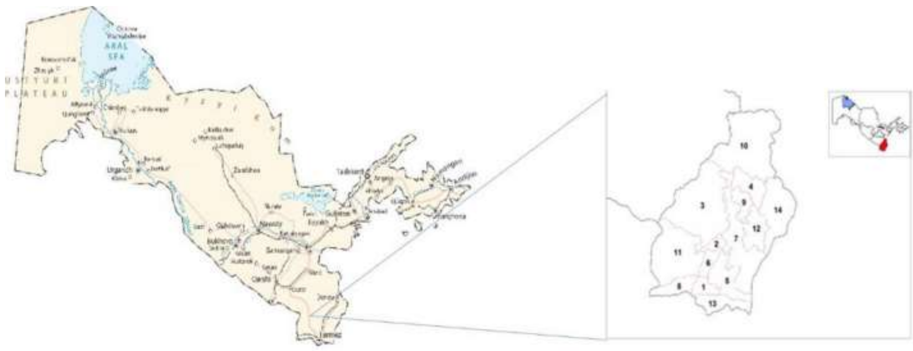

**Fig. 1.** Geographical location map of the study area

Physical properties of soil samples taken from the study area were determined for different soil layers. The specific gravity of the soil was determined by the Kaczynski gravimetric method, the volume mass by the cylinder method, and the porosity by determining the ratio of the volume mass to the specific gravity [23, 25].

## 3. Results and Discussion

In the process of determining the water permeability of the soil according to the degree of pollution, it was observed that the increase in oil concentration has a different effect on the water permeability property (Fig. 2).

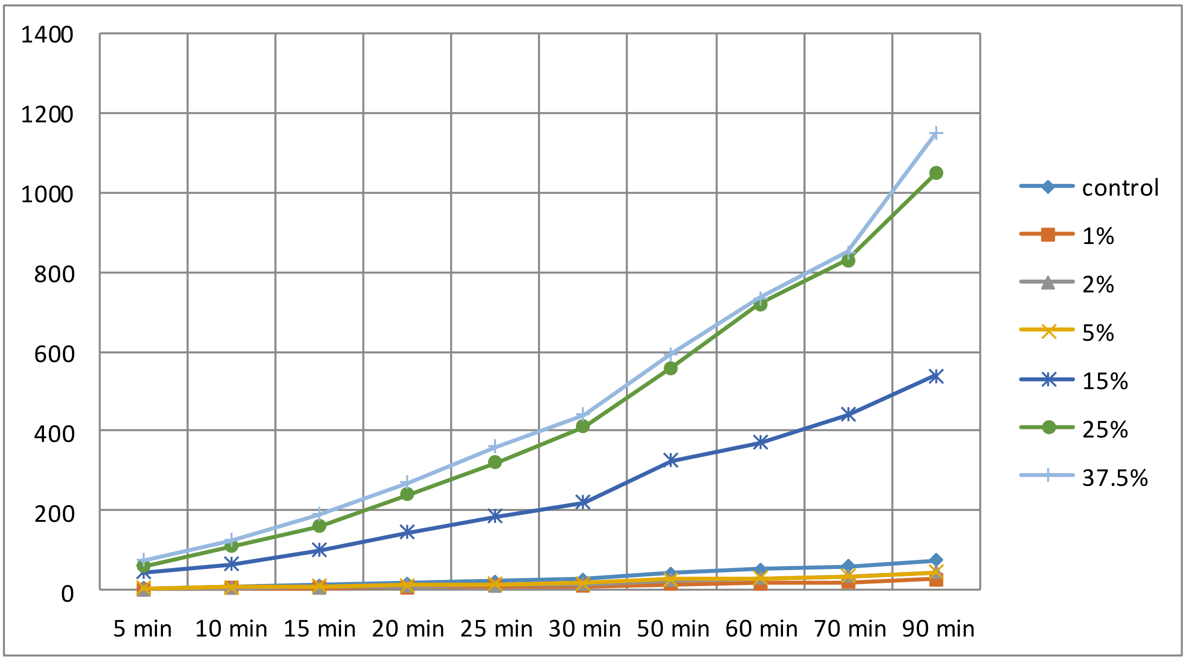


**Fig. 2.** Water permeability of soils contaminated with oil and oil products

At 1 percent, 2 percent, and 5 percent pollution levels with weak and moderate oil concentration, the water permeability of the soil decreased compared to the control sample, and at 15 percent, 25 percent, and 37.5 percent pollution levels with high oil concentration, the water permeability increased sharply. In the control sample, perfusion continued for 25 minutes and perfused 75.0 ml for 90 minutes. In 1% contaminated soil, permeation lasted 45 minutes and 26.0 ml of water was transferred in 90 minutes. The amount of water transfer during 90 minutes was 44.0 ml in 2% polluted soil, 45.0 ml in 5% polluted soil, 540.0 ml in 15% polluted soil, 1050.0 ml in 25% polluted soil, and 1200.0 ml in 37.5% polluted soil. Soil contamination with oil and oil products affects their water properties, and the strength of this effect is directly related to the degree of contamination. Soil porosity and maximum water holding capacity are reduced as a result of oil hydrocarbon pollution [17, 33]. Maximum density and optimal moisture content decreased in gasoline-contaminated soils [32]. Soil pollution with petroleum products significantly increased water permeability [5], caused changes in physicochemical properties [13]. Also, the pH level changed, soil moisture, total organic carbon, nitrogen and phosphorus content decreased [10]. An increase in the level of pollution caused an increase in water permeability [34].

It was found that pollution with oil and oil products has a different effect on soil pH and electrical conductivity. The study area had a high pH environment due to the salinity of the soils. The fall of oil and oil products into the soil has led to a decrease in the pH of the environment (Table 1).

**Table 1.** Changes in physicochemical properties of soils with different levels of salinity and oil contamination

| Soil weight, grams | Oil pollution level, % | pH | Ec | P.p.m | TEMP |
|---|---|---|---|---|---|
| 200 | Control | 8,04 | 235 | 118 | 16,3 |
| 200 | 1 | 8,04 | 235 | 122 | 16,3 |
| 200 | 2 | 7,95 | 255 | 125 | 15,9 |
| 200 | 5 | 7,84 | 322 | 161 | 15,8 |
| 200 | 15 | 7,72 | 331 | 225 | 15,7 |
| 200 | 23 | 7,65 | 359 | 179 | 15,7 |
| 200 | 40,5 | 7,32 | 324 | 169 | 15,8 |

According to the results, the pH of the soil in the control sample was 8.04, and the pH did not change at 1% contamination. At 2 percent contamination, the index was 7.95, at 5 percent contamination, 7.84, at 15 percent contamination, 7.72, at 23 percent contamination, 7.65, and at 40.5 percent contamination, 7.32. That is, the pH environment of the soil changed from alkaline environment to neutral environment with the increase of pollution level. In other regions, as a result of oil pollution, the pH environment, water permeability, temperature, and inorganic ions of the soil have significantly changed [11]. Also, oil pollution causes the pH of the soil to become alkaline, the amount of humus to increase, and the structure to change to medium sand [6].

The 0.25-10 mm aggregates, which are important in soil fertility, also change under the influence of pollution. There is no single law in the increase or decrease of aggregates, and as a result of pollution, the chemical content of oil, the type of oil product, the type of soil, the mechanical composition, and the degree of pollution change in different ways depending on the duration (Fig. 3 and Fig. 4).

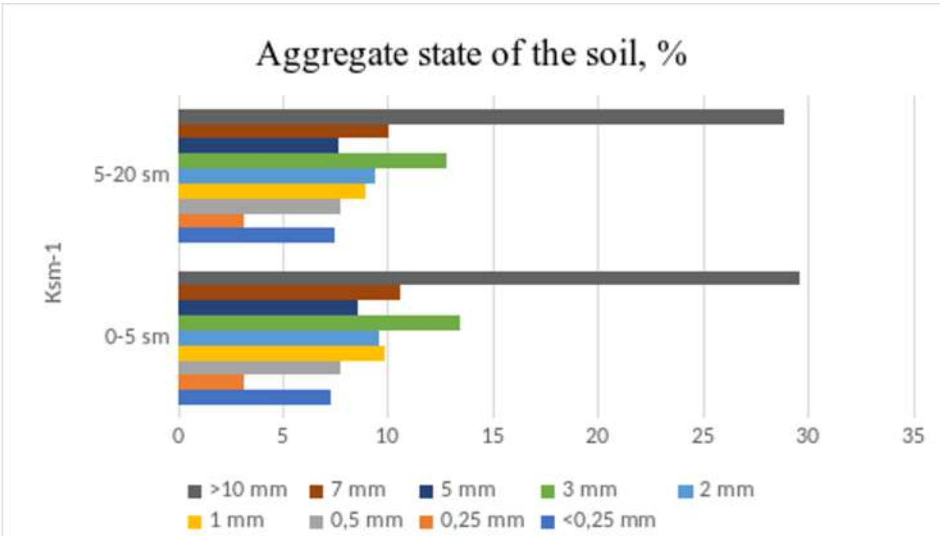


**Fig. 3**. Aggregate state of the soil around the South Mirshodi oil field

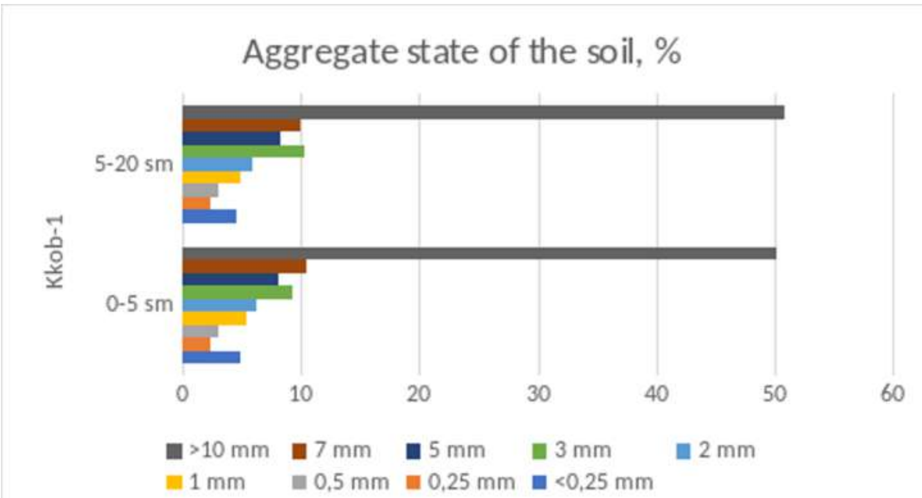


**Fig. 4**. Aggregate state of the soil around the Kumkurgan oil base

It was found that the soils around the South Mirshodi oil field were previously contaminated and the amount of microaggregates smaller than 0.25 mm, 0.25 mm, 1 mm, 2 mm and 3 mm in the irrigated soils increased as the distance from the source of contamination increased. This is explained by the decrease in the concentration of oil in the soil. The amount of 5 mm, 7 mm and 10 mm aggregates has decreased. A similar situation was observed around the Kumkurgan oil base. The effect of petroleum hydrocarbons is more noticeable in microaggregates with a diameter of 10 mm.

Oil and oil product pollution affected soil physical properties, particularly bulk density and porosity (Fig. 5 and Fig. 6). The amount of porosity was 49.44% in the soils near the oil field (500 meters away), and 48.08% in the farthest (8000 meters away) soils. The indicator was also reduced in the samples taken from other sections. This situation is explained by the appearance of aggregates in the form of "oil+soil" in the soil, and the enlargement of small particles.

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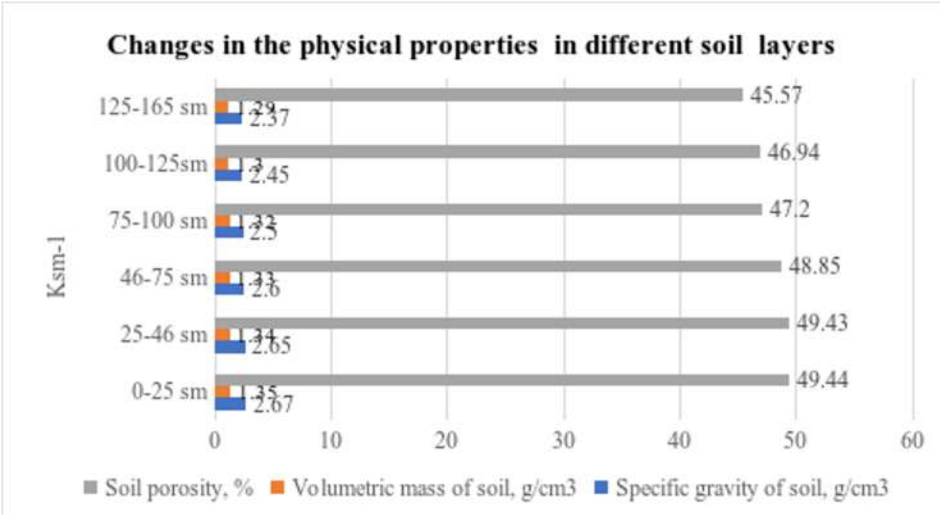


**Fig. 5.** Changes in the physical properties in different soil layers of the soil around the South Mirshodi oil field.

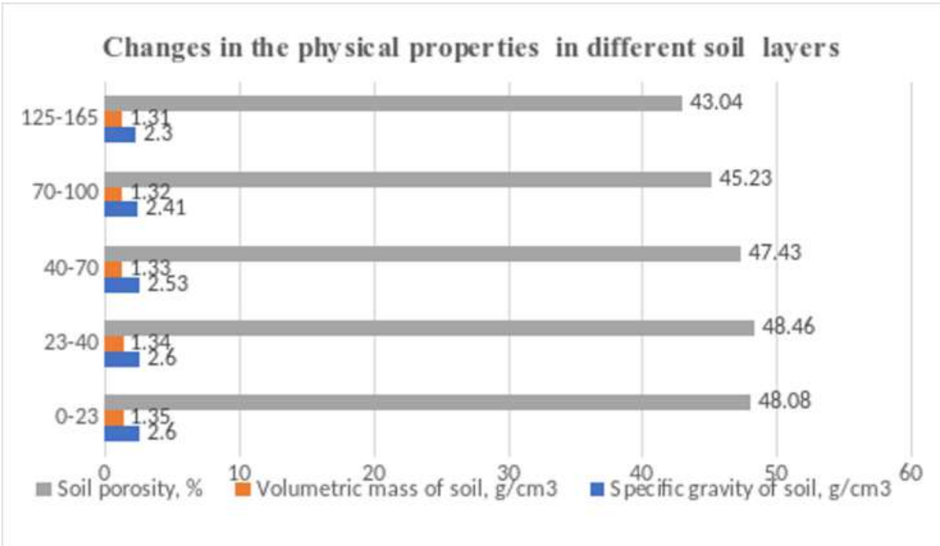


**Fig. 6.** Changes in the physical properties in different soil layers of the soil around the Kumkurgan oil base.

Oil and oil products fall into the soil and enlarge the small particles in it. As a result, soil porosity increases and water properties deteriorate. This reduces the ability of the soil to retain moisture.

## 4. Conclusion

Soil pollution with oil and oil products has an increasing and decreasing effect on their physical and water physical properties. This pollution adversely affects soil fertility and creates unfavourable, stressful conditions for plant nutrition. Soils with mild and moderate, i.e., 1 percent, 2 percent, or 5 percent contamination levels had reduced water permeability compared to the control area. Water permeability increased at 15 percent, 25 percent, and 37.5 percent contamination levels with higher oil concentrations. The pH of the soil was 8.04 and remained unchanged at 1% contamination. This figure was equal to 7.95 for 2% pollution, 7.84 for 5-phase pollution, 7.72 for 15% pollution, 7.65 for 23% pollution and 7.32 for 40.5% pollution. That is, the pH of the soil has changed from alkaline to acidic. Changes have also occurred in soil microaggregates. It was found that the soils around the South Mirshodi oil field were previously contaminated and the amount of microaggregates smaller than 0.25 mm, 0.25 mm, 1 mm, 2 mm and 3 mm in the irrigated soils increased as the distance from the source of contamination increased. This is explained by the decrease in the concentration of oil in the soil. The amount of 5 mm, 7 mm and 10 mm aggregates has decreased. A similar situation was observed around the Kumkurgan oil base. The effect of petroleum hydrocarbons is more noticeable in microaggregates with a diameter of 10 mm. In conclusion, when studying soil pollution with oil and oil products, it is recommended to pay attention to changes in physical properties of soil and to take this into account in agriculture.

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