Investigation of the process of penetration of petroleum products into the ground during construction work

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Abstract. There are many sources of pollution on the territory of the city: enterprises, transport, and also a large negative impact is during the construction work. The article examines the impact of construction machinery and works on the soil, namely soil contamination with oil-containing products. To minimize such an impact, the process of penetration of the most common oil-containing substances into the soil was simulated in laboratory conditions. To minimize such an impact, the process of penetration of the most common oil-containing substances into the soil was simulated in laboratory conditions. In order to obtain a more accurate result, the granulometric composition of the soil of the urban area was determined at the initial stage. further studies were carried out with a similar soil. Kerosene, diesel fuel and gasoline were used as oil-containing liquids in the studies. A methodology for conducting laboratory tests was developed. To identify the dependence of the volume of liquid entering the ground surface and the depth of penetration, its studies were carried out for three volumes: 50 ml, 100 ml and 150 ml. A series of experiments (at least 10) was conducted for each liquid and each volume of liquid under study. The results of the studies were recorded for 48 hours at the same intervals in each series. The results of the experiments were recorded in tabular form, then analyzed statistically and graphically. During the analysis, it was found that gasoline and kerosene penetrate into the ground faster and reach half of the maximum penetration depth in the first 30 minutes. Diesel fuel penetrates more slowly and more evenly throughout the entire time of fixing the penetration depth due to its higher density. Based on the results of the research, recommendations were formulated for the use of contaminated areas after the completion of construction work, and measures were proposed to minimize the negative impact of pollution on the ecosystem.

1 Introduction

In the process of urban development, the transformation of all spheres of urban activity is taking place, including the redevelopment of the private sector, the demolition of outdated

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and dilapidated low-rise buildings, the expansion of the roadway, the construction of road interchanges, etc. During construction work, local air pollution occurs by construction machines and mechanisms, bulk construction materials, as well as dusting zones that occur during the dismantling of buildings and structures. Settling pollutants have an impact on nearby territories and nearby residential areas, concentrate on the ground surface and can lead to the destruction of vegetation cover [1-4]. Liquid pollutants, such as gasoline, diesel fuel, oils and others, are added to the pollutants coming from the surface layer of the atmosphere, the sources of which are directly construction mechanisms [5-7].

Concentrated pollutants on the soil surface lead to degradation processes not only of the upper soil layer. Under the influence of atmospheric precipitation, pollution penetrates into the thickness of the soil, negatively affects vegetation and living soil organisms. In the process of penetration of pollution, they change the chemical composition, mechanical parameters, reduces soil fertility, and eventually fall into groundwater.

According to the research of various scientists [8-11], the urban soil is characterized by a high concentration of various pollutants, including petroleum products. The presence of oil pollution in the soil leads to the formation of a completely different ecological situation, leads to a significant change in natural processes, a decrease in the biodiversity of soil organisms, suppression of vegetation activity [12-14]. The process of restoring the territories contaminated with petroleum products is slower (fig.1).

Such soils are not suitable for the arrangement of recreational areas, cannot be used for private sector planting, can lead to changes in the physical and chemical properties of the soil, which must be taken into account when planning and designing structures and objects of the urban environment. Over time, high concentrations of petroleum products in the soil occur, which causes irreversible changes in the landscapes. The thickness of the soil in which changes occur depends on the granulometric composition of the soil, its type, the thickness of the precipitation layer and the amount of petroleum products that have fallen on the soil surface.

When operating construction machines and mechanisms, various liquids are used: gasoline, diesel fuel and kerosene. These liquids have different properties and behave differently in the ground. The greatest pollution is observed with repeated intake of petroleum products into the ground, which can be observed on dirt roads and construction sites. It is also necessary to take into account that the decomposition of petroleum products is a long process, therefore, for the most rapid restoration of the soil, measures should be carried out in a timely manner.

Fig. 1. Typical construction site (dismantling - construction)

2 Methods

Soil studies were carried out in two stages. During the first stage, the initial degree of contamination of the soil with petroleum products on the territory of the city was determined. For this purpose, samples of the top layer of soil were taken at different points of the city territory. The studies were conducted according to the approved methodology in a licensed laboratory. Soil samples must have been pre-prepared: drying in a drying cabinet, grinding, sifting and determination of fractions.

Also, within the framework of laboratory studies, the type of soil of urban soils and their granulometric composition were determined. Soil sampling points were planned on the sampling area (construction sites were selected). An example of the location of the selection points is shown in Figure 2. Soil samples were taken by the envelope method. At each site under study, a control soil sample was taken at a distance from the main array of points. According to the results of the determination of the granulometric composition of the soil, it was found that the soil in percentage composition and particle size is close to river sand. Therefore, in accordance with the similarity theory, sand was used to study the penetration of petroleum products in subsequent studies.

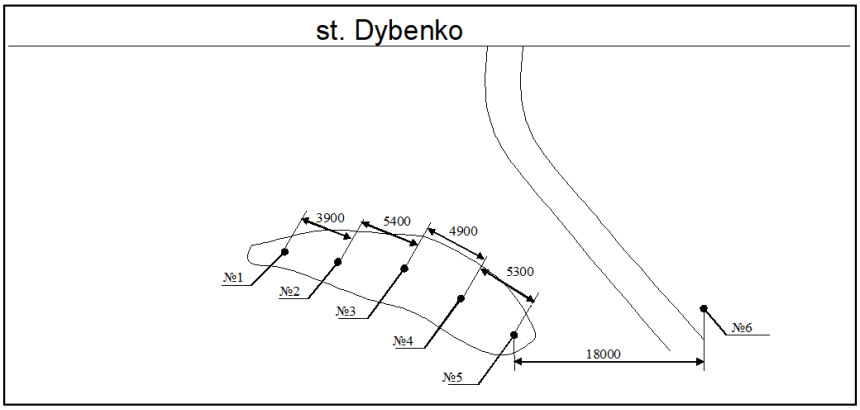

Fig. 2. Scheme of soil sampling at the site №1

The second stage of research included the study of the penetration of petroleum products into the ground. Liquids such as resin, bitumen, fuel oil, solara, synthetic masses and lubricants, gasoline and others can be used on construction sites. Some of the listed liquids have a high viscosity, they can be attributed to sedentary. Such substances, when they hit the ground, concentrate on the surface and practically do not penetrate into its thickness. The intensity of contamination transfer depends on the density of liquids, the solubility of its components and the ability to biodegradate. Therefore, gasoline, kerosene, diesel fuel were used as widely used liquids in construction that can penetrate into the ground.

A transparent plastic container with a diameter of 10 cm and a height of about 25 cm was used for the experiments. Each container was numbered. A homogeneous soil (sand) was placed in the container, which was compacted in layers. A measuring container with the liquid under study was placed above the ground (figure 3). With the help of a measuring cup, the volume of the liquid under study was measured for each series of experiments. The liquid was evenly poured onto the ground surface. The experiments were carried out with volumes of 50, 100 and 150 ml. With the help of a stopwatch, the time of liquid penetration into the ground was detected. The depth of liquid penetration was recorded through 1, 3, 5, 10, 15, 30 minutes, and also after 1, 2, 3, 6, 12, 18, 21 hours and a day later.

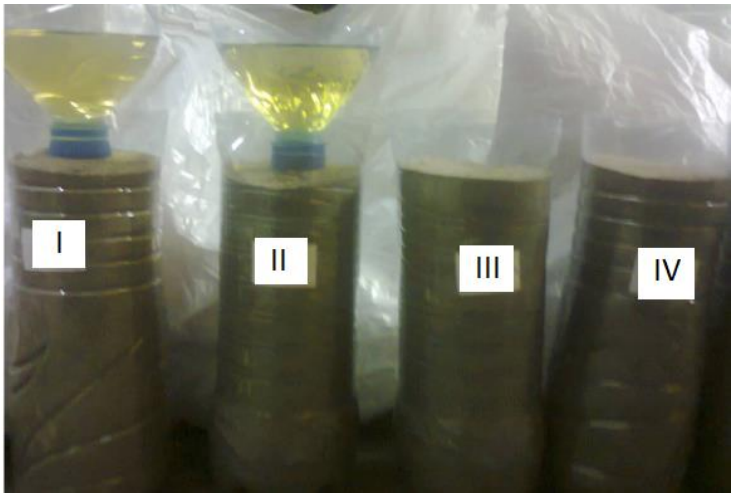

Fig. 3. The penetration research process

3 Results and discussions

The results obtained were reflected in the tables (tab.1-3). The data was then statistically processed to exclude random data. Based on the results of the analysis of laboratory studies, a graph was constructed characterizing the penetration of each of the studied volumes of a specific liquid into the ground. An example of such graphs is shown in Fig.4. The processed averaged data were compared depending on the volume and type of liquid.

Table 1. Results of tests for petrol penetration (50 ml volume).

Test No.	Penetration depth, cm						
	After 1 min	After 2 min	After 5 min	After 10 min	After 15 min	After 30 min	After 24 hours
1	4	6	8	10,5	11	12,5	15,5
2	4,5	7	8,5	10	11,5	13	17
3	5	7,5	9	11	12	14	17
4	4	6	7,5	9,5	11	12	16
5	4	6,5	8	10	11,5	13	16,5
6	5	7	9	11,5	13	15	18

Table 2. Results of tests for petrol penetration (100 ml volume).

Test No.	Penetration depth, cm						
	After 1 min	After 2 min	After 5 min	After 10 min	After 15 min	After 30 min	After 24 hours
1	5	6	7,5	9	10	12,5	20
2	6	7	8	9	10	11	21
3	5,5	6	8	10	10,5	11	20,5
4	6	7,5	9	10,5	12	14	19
5	8	9	10	12	12,5	15	19
6	7	8,5	9,5	11	13	15	18

Table 3. Results of tests for petrol penetration (150 ml volume)

Test No.	Penetration depth, cm						
	After 1 min	After 2 min	After 5 min	After 10 min	After 15 min	After 30 min	After 24 hours
1	6	10	15	21	22	22	22
2	6	9	13	21	21,5	21,5	22
3	6	9,5	14	21	21	22	22
4	6	10	13	21	21,5	22	22
5	6	12	13	21	22	22,5	22,5
6	6	9,5	12	20,5	21	21,5	22

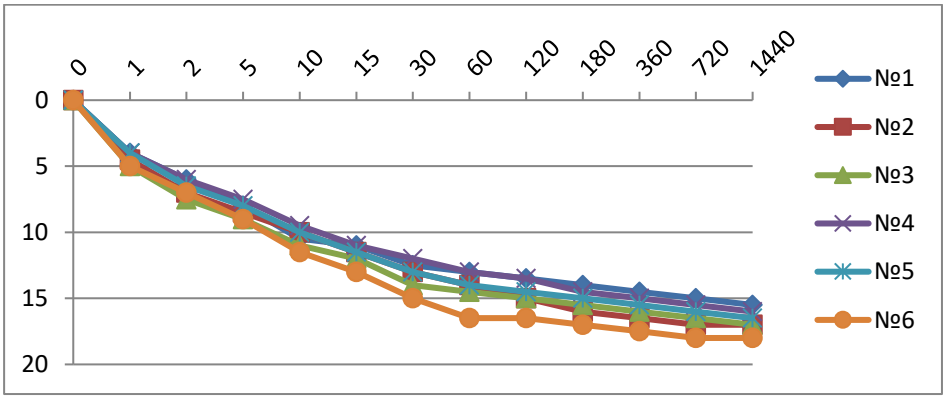

Fig. 4. The results of a series of experiments to study the penetration of gasoline (volume 50 ml). Vertically – penetration depth in cm, horizontally – observation time in minutes.

The graphs showed that the penetration of the smallest investigated volume of gasoline into the ground occurs most intensively in the first minute, then the process becomes smoother. Gasoline reaches the maximum penetration depth (17-18 cm) after 20 hours, no further changes were noted. The penetration of 100 ml of gasoline into the ground also occurs most intensively in the first minutes, then proceeds smoothly enough and reaches an average depth of 20 cm during the day, then the process slows down and stops. Over the next 2-3 days, the depth of penetration of gasoline into the ground almost did not change. The highest penetration rate is observed in the first 30 minutes and ranges from 5 to 8 cm . With an increase in the volume of liquid (150 ml), the penetration rate of gasoline in the first minutes increases sharply (in 1 minute it is 6 cm) and by 10 minutes reaches a depth of 20-21 cm. After that, the process begins to slow down.

When comparing the process of penetration of different liquids, the fastest penetration of kerosene is noted: with the smallest volume studied in 1-2 minutes, the depth of contamination is about 5 cm, with a volume of 100 ml – 6 cm, and with 150 ml – up to 9 cm. With further penetration, a faster attenuation of the penetration process is noted: at 50 ml, the maximum average penetration depth after 24 hours is 14 cm, at 100 ml, the maximum depth is 19 cm. Kerosene in a volume of 150 ml reaches a depth of 21 cm after 10 minutes of research.

Diesel fuel behaves more inert. In the first minutes, the penetration is the smallest compared to other liquids: with a volume of 50 ml – 3-4 cm, with 100 ml – 4-5 cm, with 150 ml – the penetration was 4-5 cm. Further, diesel fuel penetrates also slowly, but this process is longer than that of other liquids under study: at all volumes, after 24 hours, the

penetration depth reaches 21 cm, the further process slows down even more, but does not stop.

Conclusions

The soils of urban areas, including construction sites, are polluted by a variety of solid and liquid substances. Among the pollutants there are petroleum products that lead to the emergence of degradation processes in soils and fertile soil layers, pollute groundwater and water bodies of urban areas. Soil contamination at a construction site can occur repeatedly, which increases the negative impact on the soil.

To determine the degree of one-time contamination, studies of the penetration of various oil-containing liquids were carried out. Gasoline and kerosene showed the fastest penetration of oily substances into the soil, which can be explained by the lower density of the liquid and the lowest viscosity of these liquids. The penetration of denser liquids (diesel fuel) proceeds more inertly, but at the same time shows the greatest penetration depths.

To minimize the negative impact of pollution, it is necessary to carry out additional landscaping work in a timely manner. as measures, it is possible to propose the removal of contaminated soil on the territory of construction sites, taking into account the depth of possible penetration of used liquids. To minimize the negative impact of pollution, it is necessary to carry out additional landscaping work in a timely manner. as measures, it is possible to propose the removal of contaminated soil on the territory of construction sites, taking into account the depth of possible penetration of used liquids.

In addition, as noted in a number of sources [15-17], when carrying out works on the improvement of the territory after the completion of construction work, it is necessary to carry out territory planning, arrangement of sidewalks and internal roads, parking spaces on the sites of the greatest elevation during construction, and the allocation of plots for playgrounds in the territory with minimal contamination with petroleum products.

According to the results of the conducted studies, the following values can be taken as the recommended capacity for removing the soil layer contaminated with petroleum products to ensure the subsequent minimal negative impact on the ecosystem: 20 cm when contaminated with kerosene and gasoline, up to 25 cm when contaminated with diesel fuel (additional soil studies are necessary for non-repeated contamination).

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