The methodology of geo-information monitoring system of oil pollution distribution in sandy soils near fuel station

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Abstract. This article considers the results of studies of possible permeability coefficient in sandy soils of oil products sold in bottling at fuel stations. Based on the results of the obtained data, a method of geo-information monitoring of the environmental condition of the existing or newly built fuel station of the environment is created to minimize the risk of possible pollution of the environment (soils, above-ground and underground waters).

1. Introduction
This work was carried out within the framework of the scientific study implemented in the Moscow State University of Civil Engineering.

River sand was used for the study, which in its composition and physical and mechanical characteristics is close to natural sand masses existing in the Moscow area of Russia.

Of the total variety of petroleum products sold at fuel stations, gasoline and diesel fuel are the most likely to enter the environment. For this study, gasoline [1] was taken with octane numbers 92 and 95 (according to the RON system), which were mixed in a ratio of 1:1 to produce gasoline with average characteristics. Diesel fuel [2] at the time of the study at filling stations was sold only “summer” varieties with Cetane (n-Hexadecane) number 48-51 without anti-frost additives.

2. Studies of the permeability of various sandy soils with petroleum products
This article presents the results of the study on the permeability of sandy masses of different sizes with petroleum products, such as gasoline and diesel fuel. Permeation modeling was performed in laboratory conditions in accordance with the requirements of GOST 25584-2016 [3] in the permeability device of “PKF Souzdornii” at constant pressure gradient.

River sands were taken for the study. Sands for the study were carefully prepared. The sands were first sieved through a 2mm cell laboratory sieve to remove coarse particles and foreign material. Then, all the sieved sands in batches were placed in a drying furnace to obtain a moisture ratio of 0 to 0.3, i.e., to produce low-moisture sands.

The sands were then sieved through a set of laboratory sieves on shaker apparatus to be fractionated. A screen with the number 01, the number “mesh” 150, is used to produce fine sand of 0.1 mm fraction. To obtain the average sand of 0.25 mm fraction, a sieve with the number 025, the number “mesh” 60, is used. Mesh number 05, number “mesh” 32, is used to produce 0.5 mm coarse sand.

After sieve analysis, some of the sands remain low-moisture, and pure water is added to the remainder of the sands by full water absorption. Thereafter, the control pieces of sand and water were placed in a drying oven to determine the degree (coefficient) of humidity. Moisture degree
(coefficient) was 0.8-0.9, which corresponds to water-saturated sands. Names of sand fractions and degree (coefficient) of their humidity were taken in accordance with GOST 25100-2011 [4].

Experiments on oil permeation of sandy soils were divided into two series.

2.1. The first series.
The first series of experiments were carried out with sands of low moisture.

First, an experiment was conducted to determine the sand permeability coefficient of low-moisture fractions 0.1 mm, 0.25 mm and 0.5 mm without adding petroleum products. Next, an experiment was conducted to determine the sand permeability coefficient of low-moisture fractions 0.1 mm, 0.25 mm and 0.5 mm with the addition of gasoline. Next, an experiment was conducted to determine the sand permeability coefficient of low-moisture fractions 0.1 mm, 0.25 mm and 0.5 mm with the addition of diesel fuel. The results of the test are shown in Table 1 and Figure 1.

**Table 1. Results of the first series of experiments**

| Type of the studied sand                                      | Coefficient of permeability, m/days |
|----------------------------------------------------------------|------------------------------------|
| Sand of fraction 0.1 mm low-moisture                         | 158.59                             |
| Sand of fraction 0.25 mm low-moisture                        | 211.45                             |
| Sand of fraction 0.5 mm low-moisture                         | 761.23                             |
| Sand of fraction 0.1 mm low-moisture with addition of gasoline| 114.19                             |
| Sand of fraction 0.25 mm low-moisture with addition of gasoline| 152.25                             |
| Sand of fraction 0.5 mm low-moisture with addition of gasoline| 548.09                             |
| Sand of fraction 0.1 mm low-moisture with addition of diesel fuel| 45.31                              |
| Sand of fraction 0.25 mm low-moisture with addition of diesel fuel| 60.42                              |
| Sand of fraction 0.5 mm low-moisture with addition of diesel fuel| 217.50                             |

![Figure 1. The result of the first series of experiments](image-url)
2.2. Second series of experiments
The second series of experiments was carried out with water-saturated sands.

First, an experiment was conducted to determine the sand permeability coefficient of the water-saturated fraction 0.1 mm, 0.25 mm and 0.5 mm without adding petroleum products. Next, an experiment was conducted to determine the sand permeability coefficient of the water-saturated fraction 0.1 mm, 0.25 mm and 0.5 mm with the addition of gasoline. Then, an experiment was conducted to determine the sand permeability coefficient of the water-saturated fraction 0.1 mm, 0.25 mm and 0.5 mm with the addition of diesel fuel. The results of the test are shown in Table 2 and Figure 2.

| Type of the studied sand | Coefficient of permeability, m/days |
|--------------------------|----------------------------------|
| Sand of 0.1 mm water-saturated fraction | 105.30 |
| Sand of 0.25 mm water-saturated fraction | 140.41 |
| Sand of 0.5 mm water-saturated fraction | 505.46 |
| Sand of fraction 0.1 mm water saturated with addition of gasoline | 5.07 |
| Sand of fraction 0.25 mm water saturated with addition of gasoline | 6.77 |
| Sand of fraction 0.5 mm water saturated with addition of gasoline | 24.36 |
| Sand of fraction 0.1 mm water saturated with addition of diesel fuel | 11.10 |
| Sand of fraction 0.25 mm water saturated with addition of diesel fuel | 14.80 |
| Sand of fraction 0.5 mm water saturated with addition of diesel fuel | 53.29 |

![Figure 2. The result of the second series of experiments](image-url)
3. Creation of a geo-information monitoring system for gas stations

Geo-information Systems (GIS) have appeared very long ago, but only for the last 20 years they have begun to be actively used in construction. In GIS construction, these are primarily digitized geographic maps with cloud-based databases [5].

Today’s geo-information systems combine traditional database operations, which are now stored on remote servers (using cloud technology), with the benefits of full visualization and geographical (spatial) analysis that the map provides. Previously, geo-information systems were referred to as geographic information systems and the database was manually compiled using the Paradox and Oracle technologies [6].

GIS is also used in various fields of science indirectly related to construction. For example geology and ecology. Many scientific studies have been carried out in these fields by various authors, in particular S.V. Kozlowski, A.V. Konoplev, I.S. Kopylov, P.A. Krasilnikov, I.V. Kustov, G.K. Lobacheva, A.V. Goldov, I.Zh. Guchanova, M.Z. Ermolitskaya, M.V. Solovyova, M.A. Romamentyeva, O.V. Morozova [7, 8, 9, 10, 11].

In order to establish an environmental monitoring system in GIS, it is necessary to formulate very precisely the task to be solved by the project. Environmental monitoring in this work refers to the observation and forecasting of the possible process of pollution of oil products with the environment. In particular, pollution from underground storage facilities of fuel of surrounding sand mass by transfer of gasoline and diesel fuel particles by underground waters.

The structure of the environmental monitoring system is shown in Figure 3.

![Figure 3. Structure of environmental monitoring](image)

Regional geological and geodetic maps must be digitized before the project can be created. It is also necessary to carry out the necessary surveys, and in the laboratory to determine the main characteristics of soils. All this information is included in the GIS monitoring project and database system (“Cloud”).

After that, 2D or 3D model of the area of construction of the petrol station in GIS is built and zones are indicated with various colors. In these areas it is possible to contaminate sandy soils with
petroleum products due to an accident at underground storage facilities at filling stations. Zones of possible accident are built according to hydraulic gradient of groundwater flow.

The speed of permeability of gasoline and diesel fuel depends on the degree of moisture content of the sand. The results of these experiments are described in paragraph 2 of this article. The results obtained can be considered as reference results. If the soil properties differ from the reference sands, the results are corrected by interpolation and extrapolation. All received data are displayed in the GIS project and project databases.

If there is an accident at oil storage facilities of filling stations, its results are displayed in the GIS project. Comparing the time that has passed since the beginning of the accident with the reference time, it is possible to conclude the direction and area of distribution of oil pollution. All this data in automatic mode will be shown in the GIS project on digital maps.

After the economic damage from pollution has been calculated, it is necessary to prepare draft measures to eliminate the consequences of the accident of their petrol and diesel fuel storage facilities. The implemented project is also displayed in the GIS project and database for subsequent adjustment of the environmental monitoring system for the surrounding mass.

Figure 4 shows such an implemented environmental monitoring project of one large Russian city.

4. Conclusions
The article presents the results of the study on the penetration of sandy masses by gasoline and diesel fuel of different degrees of humidity. These results can be considered reference results. The article also presents the methodology for the creation of an environmental monitoring system behind the surrounding filling station with dirt mass.

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