Assessment of soil pollution by petroleum products in cities of Karaganda region

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Abstract. The article is devoted to assessing soil pollution with petroleum products in the cities of the Karaganda region and developing recommendations for its improvement. The environmental survey consisted of determining the content of petroleum products in the soil. The article presents the results of the analysis of 40 soil samples at 20 points in the city of Karaganda and 12 soil samples at 6 points in the city of Temirtau (at a depth of 0-5 and 5-20 cm) for the content of petroleum products. In addition, studies of the influence of roads on soil cover were carried out by analyzing soil samples taken near the Karaganda-Temirtau highway. Analysis of the results obtained showed that there is an almost universal excess of the maximum permissible concentration for petroleum products in the cities of the Karaganda region. The data obtained served as the basis for the recommendations proposed in the article for improving soil quality in the region under study.

1 Introduction

Currently, the influence of technogenic activity and industrial production has a significant, negative impact on the components of the environment. In large settlements, cities, and urbanized areas, pollution with dust, heavy metals, and gaseous substances is usually observed. In recent decades, with the increase in the number of public utility vehicles and those in personal use by the population, the share of their impact on the environment has also increased: not only by emissions into the atmospheric air, but also by soil contamination as a result of the ingress of petroleum products - fuel, lubricants, etc.

In this work, the territory of the cities of Karaganda and Temirtau is taken as the object of studying. The purpose of the study is to assess soil contamination with petroleum products, the sustainability and possibility of self-healing to improve its quality in the Karaganda region (an example of the Karaganda and Temirtau).

Research task:

- selection of model sites in various regions of Karaganda and Temirtau;
- analysis of field measurements of soil pollution with petroleum products to assess the pollution situation;
- development of recommendations for improving soil quality in Karaganda and Temirtau.

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In general, the problem of contamination of soil and land resources with oil and petroleum products is relevant, especially in oil-producing regions. In [1,2] it is noted that the current environmental problem in the republic is the pollution of the natural environment with oil and its products. Soil contamination with oil and petroleum products inhibits the vital activity of soil microflora: the physical and chemical properties of the soil and the structure of biocenoses change, and the water-air regime deteriorates. All this generally leads to imbalance in ecosystems and negatively affects all links of the ecological chain. A large share of soil pollution with petroleum products occurs in the western part of Kazakhstan (Atyrau, Aktobe, West Kazakhstan, Mangistau regions). The total area of oil contamination in this part of Kazakhstan is 194 thousand hectares, and the volume of spilled oil is more than 5 million tons. Thus, studies in the Atyrau region showed that the highest levels of soil pollution with oil products were found near the Makat field. In heavily oil-contaminated areas, the maximum content of oil products reaches 172,480 mg/kg, while the maximum permissible concentration of oil in Kazakhstan is 100 mg/kg [3]. High levels of soil contamination with petroleum products were recorded near the Dossor, Komsomolskoye, Tanatar, Tentexor, Iskene fields, which range from 24 to 138.

A large number of studies, including those conducted in the Republic of Kazakhstan, have been devoted to the topic of soil contamination with petroleum products in places of extraction and transportation of oil and its refined products [4,5]. However, these sources do not provide information and analysis of soil pollution with petroleum products in settlements and cities located in regions not related to the oil industry and caused by the operation of transport.

Thus, in [6], the quality of atmospheric air in the large industrial city of Karaganda was assessed, and emissions from its industrial facilities were analyzed. In selected model areas of Karaganda, exposed to industrial enterprises and transport, studies were conducted on the level of atmospheric air pollution. Excesses of the maximum one-time content of carbon monoxide, phenol, formaldehyde, hydrogen sulfide, and methyl mercaptans in the air of Karaganda were revealed. The indicators of the air pollution index for substances exceeding the maximum one-time content were calculated. Proposals have been developed to improve the quality of the environment for the studied areas of Karaganda. In [7], a generalized analysis was carried out and environmental protection measures were developed to stabilize the quality of the environment in the Karaganda region. To determine the degree of atmospheric air pollution in the Karaganda region, measurements were taken of suspended particles (dust), suspended particles PM-2.5, PM-10, sulfur dioxide, soluble sulfates, carbon dioxide, carbon monoxide, nitrogen dioxide, nitrogen oxide, ozone, hydrogen sulfide, phenol, hydrogen fluoride, chlorine, hydrogen chloride, hydrocarbons, ammonia, formaldehyde [8].

However, it should be noted that there are practically no works on soil pollution in the cities of Karaganda and Temirtau in general, and with oil products in particular.

2 Materials and methods

To assess the degree of soil contamination with oil products in Karaganda and Temirtau, soil samples were taken in various areas of the cities under study: industrial areas, near highways, residential areas.

The content of chemical elements, including petroleum products, in the soil at different depths makes it possible to estimate their long-term entry into the soil. The content of the studied substances in the soil shows both the geological features of the soil structure and the features of soil formation under the influence of environmental conditions, in particular the entry of chemical elements into the soil from the air (dust fall) or with precipitation.

The difference in the content of elements on the soil surface (0 - 5 cm) and in deeper layers shows the intensity of the introduction of petroleum products in recent years. Samples were taken using an envelope method measuring 1x1 m (one collective sample of 5 points, in the corners and in the center of the envelope), from a depth of 0-5 cm and a depth of 5-20 cm. The weight of the combined sample sent to the laboratory was 0.2 kg.

Determination of the state of soil and vegetation cover was carried out according to current state standards. The samples were tested using the atomic emission method, and the gross content of petroleum products was determined.

3 Results and discussion

In Karaganda, 40 soil samples were taken from 20 different points in the city. A map of the location of sampling points is presented in Figure 1. The results of sample analysis are given in Table 1. For soil sampling, places where the soil layer was preserved were selected - under trees, in areas of public gardens, in areas free of asphalt.

Fig. 1. Soil sampling locations in Karaganda.

Of the analyzed soil samples, an excess of the safe level of oil product content was not found only in 3 points in the area of residential buildings near the reservoir (sample No. 6), in the area of the central mosque (sample No. 9), in the Bolshaya Mikhailovka station (sample No. 12) and a relatively uncontaminated area is Victory Park (sample No. 17). It can be noted that in those residential buildings where there are multi-storey buildings and a

concentration of a large number of private vehicles in the courtyards, the concentration of petroleum products is high.

Table 1. Content of petroleum products in soils of Karaganda, mg/kg.

№	Sampling location	Content in sample, mg/kg, at depth	
		0 – 5 cm	5 – 20 cm
1	Industrial zone site 1	177	49.1
2	Industrial zone site 2	69.7	32.6
3	Residential zone 1 (near the industrial zone)	145	163
4	Residential zone 2 (Maikuduk area)	72.8	78.8
5	Residential zone 3 (private houses)	916	200
6	Residential zone 4 near the reservoir	22.2	19
7	Residential zone 5 (30 microdistrict)	125	21.7
8	Residential zone 6 (densely populated area with a lot of personal transport)	613	140
9	Location of the central mosque	22.3	14.1
10	Residential zone 7 (South-East)	110	46
11	Residential zone 8 (near industrial zones of Fedorovsky district)	91.8	52.4
12	Residential zone 9 (Bolshaya Mikhailovka station)	35.2	25.5
13	Residential zone 10 of the old part of the city	6700	2071
14	Residential zone 11 (район Михайловки)	1500	756
15	Hospital town (Mikhailovka)	469	464
16	Sports stadium	302	423
17	Victory Park (recreation area)	78.7	26.8
18	Residential zone 12 (32nd quarter)	1207	184
19	Central Park (recreation area)	108	93.1
20	Hospital town (Prishakhtinsk)	51.7	38

To determine the influence of roads on the soil cover, soil samples were taken at a depth of 0-5 cm and at a depth of 5-20 cm near the Karaganda-Temirtau highway. The selection was carried out according to the following scheme: next to the road embankment; further at a distance of 5, 10, 20, 50, 100 m from the embankment (Table 2, Figure 2).

Table 2. Content of petroleum products in the area of the Karaganda – Temirtau route.

№	Sampling location	Content in sample, mg/kg, at depth	
		0 – 5 cm	5 – 20 cm
1	Near the road embankment	9364	4730
2	At a distance of 5 m	8455	2354
3	At a distance 10 m	7840	823
4	At a distance 20 m	1306	424
5	At a distance 50 m	256	41.2
6	At a distance 100 m	208	33.5

The results obtained show a clear dependence of the concentration of petroleum products in the soil on the road. At a distance of 100 m in the top layer of soil, the concentration of petroleum products remains at a level unacceptable for plant growth.

An analysis of soil contamination with petroleum products was also carried out in the city of Temirtau. Sampling locations are shown in Figure 3. The results of the analysis are shown in Table 3 and Figure 4.

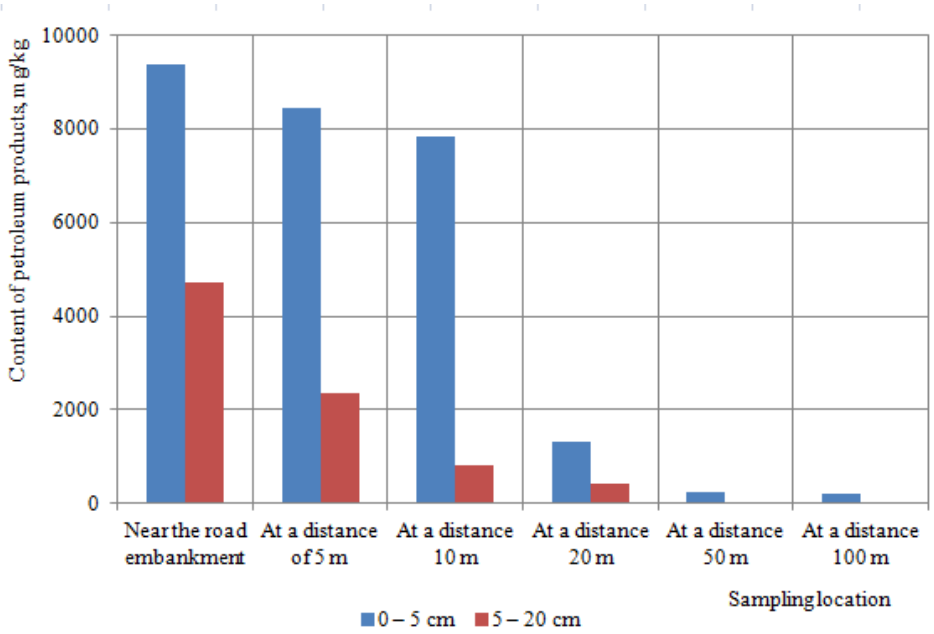

Fig. 2. Concentration of petroleum products in the soil, depending on the distance from the route

Fig. 3. Soil sampling locations in Temirtau.

Analysis of the data obtained shows that at almost all soil sampling points the content of petroleum products exceeded the permissible norm. Almost everywhere there is an excess of the safe level of petroleum products, both in the soil of Karaganda and Temirtau, and along the Karaganda-Temirtau highway. It can be assumed that this fact is directly related to the activities of motor transport. Petroleum products enter mainly in places where vehicles accumulate. Petroleum products can enter the soil either from the air during emissions of exhaust gases (under-combustion products) and evaporation from fuel tanks, followed by precipitation on the soil with condensation or precipitation, or directly from

spills of fuel and lubricants. A decrease in concentration with depth indicates the penetration of petroleum products from the upper layers of the soil to the lower ones. The results obtained are of interest not only for conducting a comprehensive assessment of the condition of soils in the study areas, but also form the basis for developing recommendations for improving the condition of soils in Karaganda and Temirtau.

Table 3. Content of petroleum products in the soil of Temirtau.

№	Sampling location	Content in sample, mg/kg, at depth	
		0 – 5 cm	5 – 20 cm
1	Industrial zone	259	180
2	Bread Factory District	106	56.3
3	Bus station area	214	33.4
4	School District	399	625
5	Residential zone (Sots city area, near the industrial zone)	40.3	26.7
6	Central Highway area	1157	205

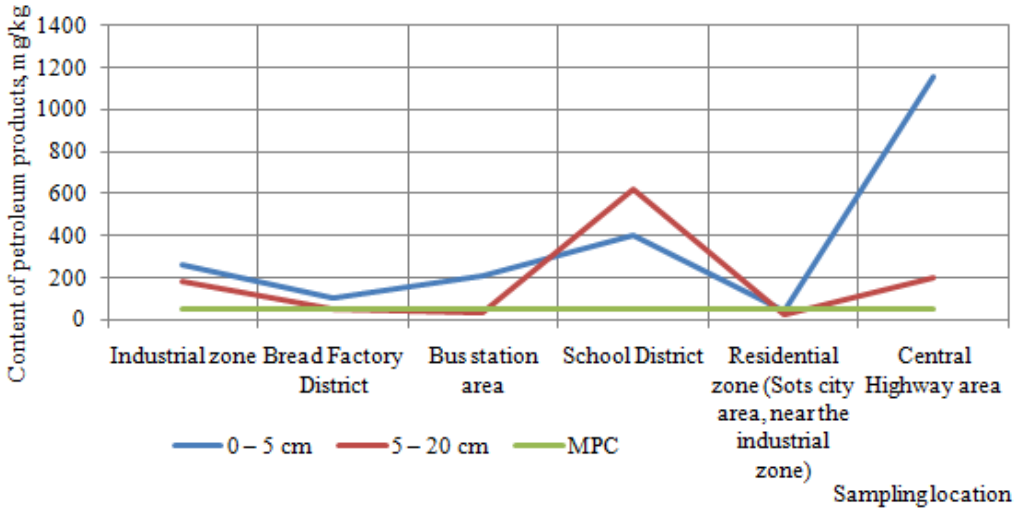

Fig. 4. Content of petroleum products in the soil of Temirtau.

The action plan to improve soil health includes measures such as:

- greening of transport, which requires a whole range of measures: improving fuel parameters, gasification of vehicles, restoring the trolleybus fleet, tightening requirements for technical control of vehicles, increasing the number of electric vehicles, etc.;
- optimization of the infrastructure of car parking and traffic in the city;
- improvement of the environmental monitoring system.

4 Conclusion

Analysis of soil samples revealed such environmental problems as the almost universal excess of petroleum products in them. Karaganda and Temirtau. Currently, there is no MPC of petroleum products in the soil in Kazakhstan. In this regard, these studies are being conducted to assess oil pollution. There is an increased content of petroleum products along the Karaganda-Temirtau highway in comparison with other ananalyzed areas. It should be noted that it is advisable to conduct such studies on an ongoing basis, for example, once every 2–3 years, in order to analyze the pollution picture and prevent its further increase. It

is necessary to increase the frequency of monitoring in areas most susceptible to contamination. Comprehensive monitoring should be carried out not only on the territory of industrial enterprises, but also on residential areas, taking into account their geo-ecological features.

Based on the results of geoecological monitoring, recommendations were developed to improve the condition of soils in Karaganda and Temirtau. In addition, the results of the study of soil conditions will make it possible to further optimize the monitoring system in the cities of the Karaganda region, identifying priority areas for its implementation. When conducting further monitoring studies (air basin, water resources, etc.), the results obtained can be used to develop a comprehensive program for improving the environmental situation of cities not only in Karaganda, but also in other regions of Kazakhstan.

References

1. National Report on the State of the Environment and the Use of Natural Resources of the Republic of Kazakhstan for 2020 (Ministerstvo ekologii, geologii i prirodnykh resursov Respubliki Kazakhstan, Astana, 2021)
2. National Report on the State of the Environment and the Use of Natural Resources of the Republic of Kazakhstan for 2022 (Ministerstvo ekologii, geologii i prirodnykh resursov Respubliki Kazakhstan, Astana, 2023).
3. Saparov A.S., Shimshikov B.Ye., Dosbergenov S.N., Asanbayev I.K., Pochvovedeniye i agrokhimiya. S. 56-62 (2009).
4. Sabirova A.R., Adil'khanova A.K., KazKKA Khabarshysy, **5 (66),** 263-266 (2010).
5. Tomina T.K., Dosbergenov S., Saparov G.A., Abdresheva M.B., Boychenko I.N., Pochvovedeniye i agrokhimiya, **4**, 22-28 (2010)
6. Ye.Tseshkovskaya, E.Golubeva, N.Tsoy, A.Oralova, Yu.Obukhov, A.Ahmetova E3S WoC, **265**, 02006 (2021)
7. Mukasheva M.A., Nurlybayeva K.A., Arymbekova A.K., Starikova A.Ye. International Journal of Applied and Fundamental Research, **1-1**, 85-88 (2017); URL: https://applied-research.ru/ru/article/view?id=11100
8. Nurlybayeva K.A., Mukasheva M.A., Surzhikov V.D., Mukasheva G.ZH., Starikova A.Ye. Vestnik Karagandinskogo universiteta. Seriya «Biologiya. Meditsina. Geografiya». **2(90)**, 35-39 (2018).