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REMEDICATION OF PETROLEUM CONTAMINATED SOIL AND ITS PHYSICAL AND AGROCHEMICAL PARAMETERS

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Keywords: agrochemical properties of soil; oil-contaminated soil; remediation; residual oil content.

Abstract: The authors studied physical and agrochemical parameters of remediated oil-contaminated soils. It was found that the remediated areas do not differ from the background ones in agrochemical and physical indicators. The residual oil content of 5 g/kg after remediation of soil proved to have no negative effects on physical and agrochemical parameters of soil.

The Stavropol Territory is an area of crude oil production, with a number of companies operating in it. Their economic activities often result in emergency conditions in the form of oil spills causing soil contamination with petroleum products.

According to literary sources, oil contamination leads to bonding of soil particles and, as a consequence, to violation of aeration, inhibition of soil biota and plants. Soil tends to lose absorption capacity, and have less moisture content; it has a lower hygroscopic moisture, water permeability, moisture content and moisture capacity than background soils. In addition, it results in decreased soil dispersity, soil pedality, the degree of aggregation, and reduced water filtration coefficient.

Oil contamination worsens agrochemical properties of soil, reduces the content of mobile forms of nitrogen and phosphorus and the content of nitrate nitrogen [1, 2]. According to I. M. Gabbasova [3], with worsening of aeration there occurs accumulation of ammonia nitrogen up to 20...40 mg/kg caused by filling of the pore space with oil and the development of recovery processes

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in the soil; at the same time, the content of nitrate nitrogen reduces to a trace amount and the number of mobile phosphorus decreases as well (from 2 to 9 times). On the background of strong salinity the authors note an increase in the content of mobile phosphorus.

The aim of the research was to evaluate physical and agrochemical parameters of planting media of remediated oil-contaminated soils.

To achieve this, the following **tasks** have been created:

- obtaining data on soil texture;
- evaluating soil-absorbing complex (**SAC**) and the impact of oil on the degree of salinity;
- evaluating the content of absorbed cations Ca, Mg, Na;
- evaluating the nutrient content in soils of remediated areas and background areas.

Characteristics of the object of the study: The object of the study is planting media of the Neftekumsk district the Stavropol Territory. According to the agro-climatic zoning, the above areas are located in Zone I and, partly, Zone II distinguished by the content of moisture (dry and very dry); vegetation cover is mainly semi-desert steppe.

Materials and methods. During the field work we examined 16 sample plots containing remediated oil-contaminated soils and 14 sample plots that were not affected by anthropogenic impact. The number of samples was taken from each sampling site, depending on the homogeneity of the soil. If the soil cover of the area was different in the content of oil products (by visual assessment), the combined sample was taken from the most contaminated areas.

Analytical studies were performed using conventional methods in soil science [4–6] by an independent accredited laboratory «Research and Production Environmental and Agrochemical Centre of «Stavropolsky», accreditation certificate ROSS RU 0001 515 028 (issued 19 June 2009, valid until 19.06.2014).

Preparation of soil samples was carried out in compliance with GOST 17.4.4.02–84 “The Nature Conservancy. Soil. Methods of sampling and sample preparation for chemical, bacteriological and helminthological analysis” [7].

The results of research. The studied planting media of the Neftekumsk district the Stavropol Territory included black alkali, chestnut, meadow-chestnut, meadow and alluvial soils of different salinity. According to the findings on grain size distribution, the examined soils were characterized by a high content of clay fraction. In view of the steppe type of soil formation and natural soil salinization all the examined soils were characterized as loam and clay of varying weight. In many soil samples the content of physical clay was greater than 40 %.

It should be noted that some remediated soils had a reduced grain size distribution compared to that of the background ones (samples No. 1, 5, 7–9). These changes are connected with the remediation works.

The characteristics of soil-absorbing complex (**SAC**) were evaluated; the content of absorbed cations Ca, Mg and Na was studied in the selected soil samples. The obtained data are presented in Table 1.

Table 1

Physical and chemical properties of soils

№ SAC	Absorbed cations, mEq / 100 g of soil						The amount of cations	
	Ca ²⁺		Mg ²⁺		Na ⁺			
	RA*	Ground	RA	Ground	RA	Ground	RA	Ground
1	11.00	9.70	2.6	3	2.65	1.7	16.25	14.40
3	9.40	10.60	3.2	0.9	2.4	1.44	15.00	12.94
4	12.40	13.50	4.7	7.6	5.2	7.59	22.30	28.69
7	10.90	11.90	4.4	2.7	1.5	0.13	16.80	14.73
8	12.70	13.20	2.4	4.2	4.5	2.13	19.60	19.53
10	13.80	11.90	4.3	5.2	5.25	1.26	23.35	18.36
11	14.30	11.90	6.3	5.2	4.9	1.26	25.50	18.36
5	8.10	10.80	8.7	2.3	11.2	0.94	28.00	14.04
6	41.90	10.80	16	2.3	12.05	0.94	69.95	14.04
9	12.10	10.00	6.4	4.1	1.45	4.35	19.95	18.45
12	12.90	9.00	4	3.3	1.6	1.3	18.50	13.60
13	54.50	13.20	14.4	3.7	2.7	0.85	71.60	17.75
14	19.80	9.60	8.3	6.1	1.54	10.3	29.64	26.00
15	18.70	23.40	8	3.7	3.4	0.18	30.10	27.28
16	17.40	17.90	6.6	6.3	1.65	1.3	25.65	25.50

* RA – Remediated Areas.

Proportion of Na ions in the SAC, %

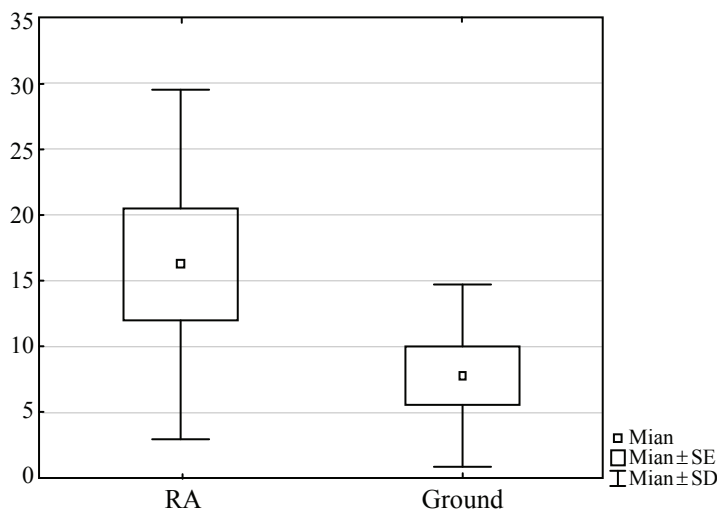


Fig. 1. The proportion of sodium ions in the SAC

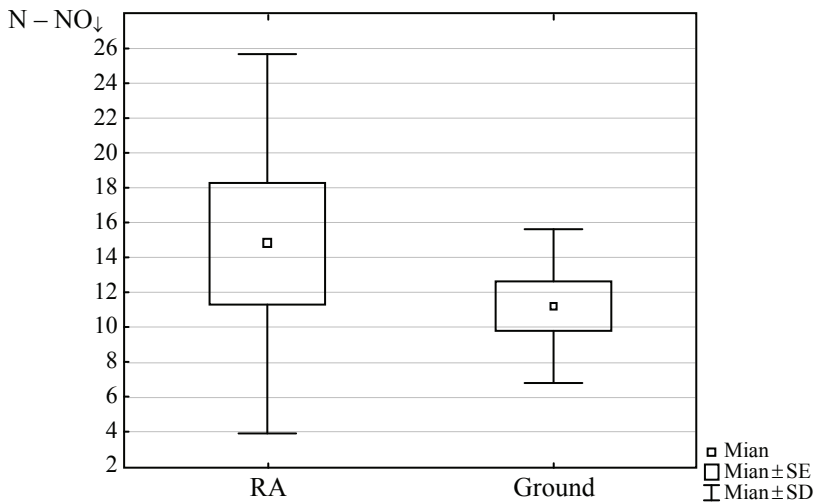
The evaluation of the oil impact on the salinity of the samples was evaluated in terms of the proportion of Na ions in the SAC (Fig.1).

In order to identify the authenticity of the observed differences we used the one-way ANOVA test. The calculation results showed that the average value of the content of sodium ions in the SAC differed insignificantly, $F(1, 18) = 3.177, p = 0.0916$.

The findings suggested that the current regulations of PRPO (permissible residual products and oil) did not lead to salinization of the soils and qualitative deterioration of its physical characteristics.

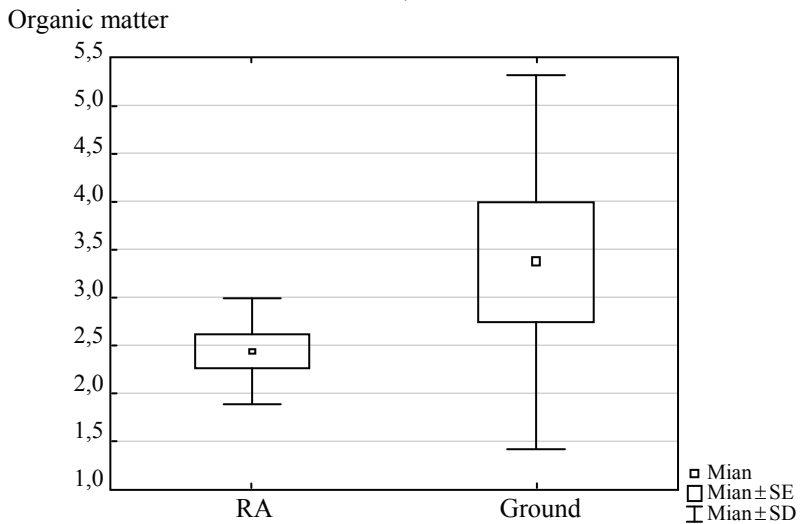
According to the «RN-Stavropolneftegaz» remediation works of oil-contaminated sites, which were carried out in 2012, included the application of some doses of mineral fertilizers. In the selected soils we studied major agrochemical parameters. As of 2013, the examined remediated soils were characterized by low content of mobile forms of phosphorus and potassium in comparison with the background soils.

The average content of ammonium nitrogen and organic carbon in remediated soils did not differ from baseline values (Fig. 2).



$N - NO_3: F(1;18) = 0.9139; p = 0.3517$

a)



Organic matter: $F(1;18) = 2.0768; p = 0.1667$

b)

Fig. 2. The content of plant food compounds in the soil of remediated areas and background areas:

a – ammonium forms of nitrogen; b – organic carbon

In order to identify the authenticity of the observed differences in the values obtained for RU and Background we used the one-way ANOVA test. The calculation results showed that significant differences were observed for the concentrations of available phosphorus and potassium ($p < 0.05$). The average values of P_2O_5 and K_2O in the soil of remediated areas were characterized by lower values than those in the background. These changes may be linked to the activities of microorganisms of biological product «SOILEX» applied at the biological stage of remediation. The content of nitrate nitrogen and organic matter in soils of remediated areas had much in common with background values.

Conclusions. The experimental results of the study of soil in the Neftekumsk district the Stavropol Territory showed that the examined remediated areas did not differ from the background soils by agrochemical and physical parameters.

Thus, the residual oil content of 5 g/kg in remediated soils had no negative effects on physical and agrochemical parameters of planting media. The remediated soils can fulfill one of the main ecological functions of soils related to its physical properties, such as the habitat of living organisms.

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Влияние рекультивации после нефтезагрязнения на состояние физических и агрохимических показателей почв

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Ключевые слова: агрохимические свойства почвы; нефтезагрязнение почв; остаточное содержание нефтепродуктов; рекультивация.

Аннотация: Изучены физические и агрохимические показатели почв земельных участков, рекультивированных после нефтезагрязнения. Установлено, что исследованные рекультивированные участки практически не отличаются от фоновых по агрохимическим и физическим показателям. Остаточное содержание нефтепродуктов 5 г/кг после проведения рекультивационных работ не оказывает негативного воздействия на физические и агрохимические показатели почв.

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