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STUDY OF THE CHARACTERISTICS OF PHYSICAL AND CHEMICAL PROPERTIES OF SOILS OF THE COASTAL ZONE OF THE CASPIAN SEA IN THE AREA OF THE SUBURB OF AKTAU

BADANIE CHARAKTERYSTYKI WŁAŚCIWOŚCI FIZYKOCHEMICZNYCH GLEB STREFY PRZYBRZEŻNEJ MORZA KASPIJSKIEGO NA PRZEDMIEŚCIACH MIASTA AKTAU

***Abstract*:** The results of the stages of research of the marine part of the Caspian Sea and the coastal zone in the area of Akshukur village (a suburb of the city of Aktau) are presented. It is a coastal zone. Field studies were carried out during 25–28 May, 2018 at research sites (RS). Soil samples were taken according to the generally accepted method in soil science at 0–20 cm depth, with a sampler, using the envelope method. Determination of the amount of humus in the soil was performed by the Nikitin method with an Orlov-Grindel colorimetric ending. Mobile forms of heavy metals were determined using AAS MGA-915 (Lumex Russia). The soils in the surveyed area are characterized by a low content of organic matter, an alkaline reaction of soil solutions, salinity and weak resistance to anthropogenic influences. When increasing the distance from contaminated soils on RS-2 up to 9.5 km, the soils on RS-4 (background), the soils are not contaminated with heavy metals, the exception was arsenic metalloid, the excess of which is natural. The Kruskal-Wallis test is statistically significant only for Cu (0.047) ($p < 0.05$) and As (0.042) ($p < 0.05$). The highest rank sums relative to the content of copper Cu and cadmium Cd are characterized by the samples for RS-2 (33.5) and (29.0), respectively..

***Key words*:** Caspian Sea, coastal zone, soils, monitoring, heavy metals
***Słowa kluczowe*:** Morze Kaspijskie, strefa przybrzeżna, gleby, monitoring, metale ciężkie

Introduction

Currently, despite numerous studies of the Caspian Sea, there are still areas of the sea, the degree of study and coverage of direct observations of which are extremely small [Cambier, P. Michaud et al. 2019]. In these areas, a number of fundamental and applied issues arise that require a regional approach to study the state of soils in the coastal zones of the Caspian Sea. This situation has been particularly aggravated in the last three decades, when there has been a sharp decline in the number of scientific studies of this problem. One of these areas is the eastern coast of the Middle Caspian Sea, namely the sea area in the area of the regional center of the Mangystau region, Aktau, and its suburban territories. In addition, the port of Aktau is the only port in Kazakhstan used for international transportation of crude oil and petroleum products. In this regard, studies of the Caspian Sea and the coastal zone of the regional center are relevant and timely [Kenzhetaev G.Zh et al. 2013].

Materials and methods of research

At the end of May 2018, work was carried out on monitoring the marine part of section 1 (stations 14, 15, 16 and 17), and field studies were carried out in the coastal zone opposite these stations, in the area of the village of S. Shapagatov. Field studies were conducted by the route method. 4 research sites (RS), RS-1, RS-2, RS-3 and RS-4 (background) were laid to monitor the state of soils in the area of the suburban territory of Aktau opposite the hydrological stations HS-14 – HS-17 (Fig. 1).

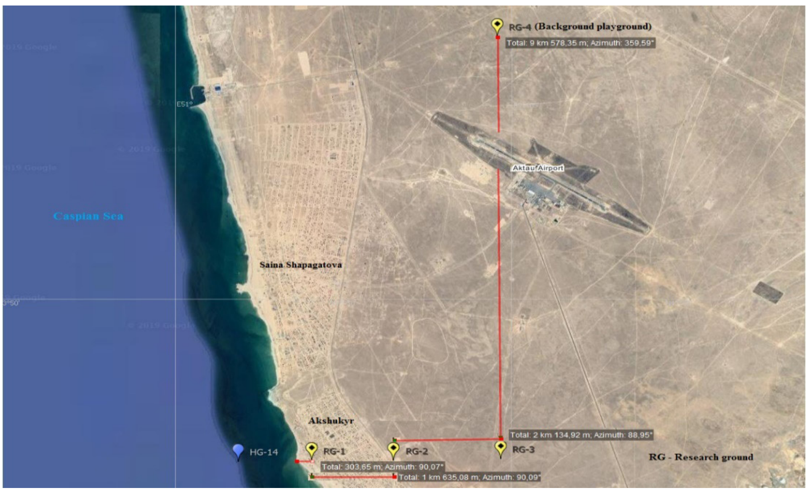

Fig. 1. Map-diagram of research sites for monitoring the state of soils made in the SAS Planet environment

Ryc. 1. Mapa-schemat stanowisk badawczych do monitorowania stanu gleb wykonanych w środowisku Sas Planet

Source: own study.

Źródło: opracowanie własne.

Selection of soil samples. Samples were taken according to the generally accepted method in soil science. At the test sites RS-1,2,3 and 4 (background), soil samples were taken from a depth of 0-20 cm, using an envelope sampler. The method represents the selection of a mixed sample at the rate of 1 sample per 100 m2 (site 10×10 m). The mixed sample consisted of 5 soil samples taken in a 5-point envelope. An average sample weighing 300–400 grams was selected. In general, the samples are mixed samples with 20 points, that is, 5 points by 4 [Abdel-Saheb J. A. et al. 2014].

Determination of humus in the soil. To study the soil samples the following methods were used: color – scale Munsell, granulometric composition – according to Kachynski, the humus (TS) – by Tyurin, the gross nitrogen – Kjeldahl, mobile compounds of phosphorus and potassium by Chirikov (for calcareous soils – in Machine) [Kenzhetaev G. Zh et al. 2015]. Determination of the amount of humus in the soil was performed by the Nikitin method with a colorimetric ending according to Orlov--Grindel, based on wet ozolation of organic compounds of the soil.

Determination of heavy metals in the soil was conducted by atomic absorption spectrometry with plasma atomization using AAS MGA-915M (Lumex, Russia) in an accredited laboratory of the Department of Ecology of the Mangystau region, according to the method (M-MVI-80-80-2008) [Kenzhetaev G. Zh et al. 2014]. Due to the fact that the total content of detectable heavy metals (HM) in the soil was high, the mobile forms of the following elements were determined: Pb, Ni, Cr, Hg, V, Cu, Fe, Zn [Badalova A. N et al. 2012]. Certain concentrations of heavy metals (HM) were compared with the available maximum permissible concentrations (MPC).

Methods of geoinformation technologies (GIT). The cartographic material of the research area was performed using satellite images and using GIS family programs (Google Maps, SAS Planet). Editing of schematic maps, as well as diagrams and graphs, is performed using CorelDRAW 11 and Paint programs [Kroshenko A.N. et al. 2018].

Statistical processing of the results. The received data are processed in the environment of the analytical software interface Statistica 10. The choice of the analysis method using Kruskal-Wallis ANOVA criterion statistics was determined by a small volume of study samples with different distribution laws. The statistics of the Kruskal--Wallis criterion are mostly similar to parametric one-factor analysis of variance, but this criterion is based on ranks rather than averages [Alca N. et al. 2014].

Results and discussion

In the soil cover of Akshukur village and the farther from it in the direction of the airport, there are the most widely brown desert soils. According to the depth of the upper saline horizon, the soils are saline [Kenzhetaev G. Zh et al. 2014]. The humus content in the upper horizon of these soils varies from 1.18 to 2.62%. Lower in the profile, it decreases to 0.42–0.97%. The content of biogenic elements is low. Total phosphorus in the surface horizons is contained in amounts of 515.17–2004 mg / kg.

The content of carbonates in the range of 1.77–3.11%. The total nitrogen content varies in the range of 0.26–0.39% [Kenzhetaev G. Zh et al. 2015]. As a rule, the heavier the granulometric composition, the higher the exchange capacity. The exchange capacity varies from 9.62 to 32.15 mg-eqv/100g of soil. In the soil-absorbing complex, there is a stable predominance of exchangeable magnesium (40–80% of the exchange capacity) [Kenzhetaev G. Zh et al. 2013]. The reaction of water suspensions in soils is slightly alkaline or close to neutral (pH 6.85–7.41). Physical and chemical properties of soils according to the results of monitoring are shown in Table 1.

Table 1.

Physical and chemical properties of soils at the Research Sites

Tabela 1.

Fizyczne i chemiczne właściwości gleb na badanych terenach

Physical and chemical characteristics of soils	Research Sites (monitoring of soil conditions)			
	RS-1	RS-2	RS-3	RS-4 (background)
Humus, (%) Total	1.18	1.39	1.47	2.62
nitrogen, (%)	0.26	0.34	0.39	0.27
Phosphorus (gross), mg / kg	1660.30	472.5	515.17	2004.0
Carbonates, (%) Exchange	3.11	1.77	1.82	2.75
capacity, mg-eq/100 g of soil	9.62	22.85	24.15	32.15
Exchange calcium, mg-eq/100 g of soil	1.5	4.0	5.0	1.3
Exchange magnesium, mg-eq/100 g of soil	7.11	17.0	18.45	11.7
Exchange sodium, mg-eq/100 g of soil	0.61	0.93	0.97	16.13
The amount of salts	0.57	1.06	1.30	0.2
pH	7.39	7.10	7.41	6.85

Source: own study.
Źródło: opracowanie własne.

The soil cover on all RS, except RS-4 (background) is subject to severe disturbances directly on the territory of private buildings and on adjacent plots.

The content of heavy metals in soil RS. May 2019. If the excess of copper in soil RS-1 (1.06 MAC), RS-2 (of 1.56 MPC), RS-3 (1.2 MPC), the background RS-4 less than the MPC =0,7. The excess of copper in the soils of the RS-1, 2 and 3 is mainly due to the transport emissions involved in the construction of the private sector and transport of materials. The excess of nickel by RS-2 (1.32 MPC) is associated with the impact on the soil of various paint containers, as well as vehicles running on fuel oil (tractor equipment). No excess of the MPC values for zinc was recorded [Suyunova A.B. et al. 2016].

There is an excess of arsenic metalloid, at RS-1 (1.45 MPC), at RS-2 (2.45), at RS-3 (2.1 MPC), and the greatest at the background RS-4 (3.65 MPC).

This situation is explained by the fact that the increased content of arsenic in the Mangystau region is natural in nature and is also associated with natural processes of accumulation and migration. The excess of cadmium was recorded only on RS-2 (1.88 MPC), which is associated with the operation of diesel transport in the area of the warehouse and transportation of construction and road materials.

The concentration of chromium does not exceed the MPC value on all RS. For lead, the excess over the MPC was also found on RS-2, which is explained by the influence of exhaust gases of transport and tractor equipment and motor graders [Kazem Darvish Bastani et al. 2015]. The content of copper, nickel, zinc, arsenic, cadmium, chromium and lead, showed that the soils of RS-2 (the area of an open warehouse of road construction materials, near the highway) are subject to the greatest pollution, the least soil of the background RS-4 (Table 2).

Table 2.

Content of heavy metals in the soils of the study sites, mg / kg

Tabela 2.

Zawartość metali ciężkich w glebach badanych stanowisk, mg/kg

Date of soil sampling	No. of samples see	Heavy metals and their content in soils, mg / kg						
		Cu	Ni	Zn	As	Cd	Cr	Pb
MPC, mg / kg		3.0	4.0	23.0	2.0	5.0	6.0	32.0
RS-1. Coordinates: N43°47'55,63''. E52°02'01,76''								
May 2018 г.	0–20	3.2	3.6	12.4	2.9	3.6	4.3	15.9
RS-2. Coordinates: N43°47'55,54''. E51°03'15,02''								
May 2018 г.	0–20	4.7	5.3	19.7	4.9	9.4	5.3	36.17
RS-3. Coordinates: N43°47'56,80''. E51°04'50,66''								
May 2018 г	0–20	3.6	3.8	6.9	4.2	4.1	3.5	14.1
RS-4(background). Coordinates: N43°53'22,34». 51°04'46,75»								
May 2018 г.	0–20	2.1	2.5	8.5	7.3	3.7	2.8	6.3
Mean ± *SD*								
May 2018. RS-1 (*n* = 3)		2.96±0.51	3.72±4.36	11.3±2.71	2.11±0.41	2.54±1.75	3.85±0.71	15.1±13.7
May 2018. RS-2 (*n* = 3)		4.16±1.04	5.11±3.27	16.1±3.73	3.60±0.73	8.45±2.05	5.11±1.03	34.9±10.2
May 2018. RS-3 (*n* = 3)		2.93±0.10	2.56±3.16	6.13±4.49	3.69±0.85	2.81±3.65	2.99±1.78	12.7±11.6
May 2018. RS-4 (background)(*n* = 3)		1.83±1.09	2.45±1.50	7.86±5.19	7.11±0.97	2.91±3.81	2.41±1.93	6.15±13.1

Source: own study.
Źródło: opracowanie własne.

Statistical processing of research results

Table 3, according to Table 2, presents the results of the analysis of research data in the Statistica 10 environment.

Table 3.

The average content of heavy metals, arsenic for a layer of 0-20 cm in the soils of the studied area at RS-1, RS-2, RS-3 and RS-4 (Background) and the results of statistical processing in the Statistica 10 environment

Tabela 3.

Średnia zawartość metali ciężkich, arsenu dla warstwy 0-20 cm w glebach badanego obszaru na RS-1, RS-2, RS-3 i RS-4 Wstęp) oraz wyniki opracowania statystycznego w Statistica 10

Substance	Research sites in the soil monitoring area				Criteria Kruskal-Wallis ANOVA	Sum of ranks and average of rank
	RS-1 (*n* = 4)	RS-2 (*n* = 4)	RS-3 (*n* = 4)	RS-4 (background)	p	
Cu	2.96±0.51	4.16±1.04	2.93±0.10	1.83±1.09	0.047	33.5 (11.1)
Ni	3.72±4.36	5.11±3.27	2.56±3.16	2.45±1.50	0.084	25.5 (8.5)
Zn	11.3±2.71	16.1±3.73	6.13±4.49	7.86±5.19	0.256	27.0 (9.0)
As	2.11±0.41	3.60±0.73	3.69±0.85	7.11±0.97	0.042	22.0 (7.5)
Cd	2.54±1.75	8.45±2.05	2.81±3.65	2.91±3.81	0.842	29.0 (8.33)
Cr	3.85±0.71	5.11±1.03	2.99±1.78	2.41±1.93	0.135	23.5 (9.83)
Pb	15.1±13.7	34.9±102	12.7±11.6	6.15±13.1	0.532	22.0 (7.33)

Source: own study.
Źródło: opracowanie własne.

Processing of data on the analysis of the content of HM and arsenic metalloid in the soils of the studied RS, in the medium Statistica 10, showed that the Kruskal-Wallis criterion is statistically significant only for Cu (0.047) ($p < 0.05$) and As (0.042) ($p < 0.05$). Table 3 shows that the highest rank sums relative to the content of copper Cu and cadmium Cd are characterized by the samples for RS-2 (33.5) and (29.0), respectively. These substances make the maximum contribution to the differences in the content of these elements between all groups [Liu S et al. 2015; Zgłobicki W., Telecka M. et al. 2018].

Conclusions

The humus content in the upper soil horizon of the studied sites varies from 1.18 to 2.62%. Lower in the profile, it decreases to 0.42–0.97%. The content of biogenic elements is low. Total phosphorus in the surface horizons is contained in the amounts of 515.17–2004 mg / kg. The content of carbonates in the range of 1.77–3.11%. The total nitrogen content varies in the range of 0.26–0.39%. As a rule, the heavier the granulometric composition, the higher the exchange capacity [Yifei Zhao et al. 2018].

The soils in the surveyed area are characterized by a low content of organic matter, an alkaline reaction of soil solutions, salinity and weak resistance to anthropogenic influences [Xiaohu Wen et al. 2019]. The excess of copper in soils at RS-1 (1.06 MPC), RS-2 (1.56 MPC), RS-3 (1.2 MPC), and at the background RS-4 less than the MPC value=0.7, is explained by emissions of transport involved in construction and transportation of materials.

There is an excess of arsenic metalloid, at RS-1 (1.45 MPC), at RS-2 (2.45), at RS-3 (2.1 MPC), and the greatest at the background RS-4 (3.65 MPC). This situation is explained by the fact that the increased content of arsenic in the Mangystau region is natural in nature and is also associated with natural processes of accumulation and migration [Xiaohu Wen et al. 2019].

The content of copper, nickel, zinc, arsenic, cadmium, chromium and lead, showed that the soils of RS-2 (the area of an open warehouse of road construction materials, near the highway) are subject to the greatest pollution, the least soil of the background RS-4. Processing of data on the analysis of the content of HM and arsenic metalloid in the soils of the studied RS, in the medium Statistica 10, showed that the Kruskal-Wallis criterion is statistically significant only for Cu (0.047) ($p < 0.05$) and As (0.042) ($p < 0.05$) [Luis R. et al. 2018; Cipullo S. et al. 2018].

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Streszczenie

W artykule zajęto się badaniem właściwości fizycznych i chemicznych gleb w strefie przybrzeżnej Morza Kaspijskiego na obszarze przedmieścia Aktau. Wyniki wykazały, że gleby na badanym terenie charakteryzują się niską zawartością materii organicznej, zasadowym odczynem roztworów glebowych, zasoleniem gleby oraz słabą odpornością na oddziaływanie człowieka, co wymaga podjęcia decyzji. Występuje również nadmiar metaloidu arsenowego. Sytuację tę tłumaczy się tym, że podwyższona zawartość arsenu w rejonie Mangystau jest naturalna i wiąże się również z naturalnymi procesami akumulacji i migracji.