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ELEMENTAL COMPOSITION IN THE SOIL LAYERS OF THE DRIED BOTTOM OF THE ARAL SEA AND BALANCE THEIR AMOUNTS ON THE BASIS OF EQUIVALENT RATIOS

Abstract. Every year, up to one hundred million tons of toxic salt and dust mixture is carried by the winds from the dried bottom of the Aral Sea. Most of it settles in the nearest territories, but millions of tons are carried away thousands of kilometers away. The results of the analyzes show that the migration of toxicants infects the environment and pollutes plant products. Based on the results of the research, approaches have been developed to balance the ions in a layer of 0–20 cm to create the development of plants according to biological properties.

Keywords: Aral Sea, soil, heavy metals, calcium, then magnesium, sodium, B, Cu, Zn and Mn, dried bottom.

Introduction

The Aral region attracts great attention of scientists as an object that is experiencing drastic changes in the natural environment and caused the deterioration of the ecological situation.

The dried bottom of the Aral Sea is a global threat to the environment. From this, one can imagine what a global difficult task faces scientists who are looking for possible ways to lay a dried-up seabed and help the natural process to fix sandy areas containing toxicants and devoid of vegetation [1–3]. A toxic salt-dust mixture is carried by the winds around the Aral Sea and its adjacent territory [2–4].

Heavy metals are inhibitors of many physiological processes as toxic substances [5; 6]. Therefore, at present, the problem of protecting the environment from pollutants, which is closely related to the need to obtain a large number of environmentally friendly agricultural products through the use of intensive technologies, is very relevant. The literature contains rather contradictory information about the migratory ability of the most dangerous toxicants, about the quantitative parameters of their accumulation in the natural environment, as well as about the factors influencing this process [5–13].

Our research work is related to the study of toxicants in the salt-sand layers of the dried seabed and the attempt to neutralize where resistant species/varieties or seed materials are planted.

Objects and methods

To study toxicants and their migration, the south-eastern latitudes of the Aral Sea from the Muynok region were chosen as the object of study. The selected territory of the Aral Sea is located from the 80th kilometer from Muynak. Although this territory belongs to the drylands of the 60 s, 70 s and 80 s, samples of soil layers and plant products grown in areas and areas adjacent to the territory of the island were taken for analysis.

Soil samples and plant products were taken in an amount of 200 mg on an analytical balance (FA220 4N) to prepare for elemental analysis. A mineralization device (MILESTONE Ethos Easy, Italy) was used to mineralize the sample. To do this, in a test tube with a device. The whole mixture was then mineralized at 180 °C for 40 min.

After completion of the mineralization process, the mixture in the test tube is diluted with distilled water (BIOSAN, Latvia) to 25 ml in a separate conical volumetric flask and placed in test tubes of the MILESTONE Ethos Easy microwave instrument hopper. Samples were prepared for analysis in a microwave device after a specified time interval.

The prepared sample was analyzed on an Avio200 ISP–OES optical emission spectrometer with inductively coupled plasma (Perkin Elmer, USA). The level of accuracy of the device is high and allows you to measure the elements contained in the solution, with an accuracy of up to 10^{-9}g.

Results and discussion

It has been established that the composition of soil samples taken from the layers of the dry bottom of the island consists mainly of mineralized sandy layers (Table 1).

Table 1.– Mineral composition of soil layers of the dried bottom of the Aral Sea

Electrical conductivity (mS/sm	Normal amount mg/100 g	0–20 sm	20–40 sm	40–60 sm	60–90 sm
1	**2**	**3**	*4*	*5*	*6*
	0–0.6	1.48	1.134	2.309	1.589
pH	6–7.5	7.87	7.59	7.05	7.35
NO_3^--N mg/l	3.1–4.0	0.314	0.439	0.41	0.603
NH_4^+-N mg/100 g	4.6–6.0	0.394	0.733	0.362	0.319
P (mg/100 g)	4.6–6.0	0.476	0.385	0.33	0.506
K (mg/100 g)	30.1–40.0	34.6	23.0	34.59	32.95
S (mg/100 g)	20.5–40.0	2.79	2.96	8.16	5.605
Cl^- (mg/100 g)	28.4–54.8	569	352	254	341
Ba (mg/100 g)	0.7–8.7	0.039	0.069	0.088	0.026
Co (mg/100 g)	2.0–3.0	0.03	0.03	0.029	0.031
Sr (mg/100 g)	0.2–7.0	1.592	1.268	8.634	0.567
B (mg/100 g)	0.06–0.10	0.217	0.087	0.138	0.178
Zn (mg/100 g)	0.23–0.41	0	0	0	0
Fe (mg/100 g)	7.4–11.0	0.04	0.04	0.041	0.045
Cu (mg/100 g)	0.47–1.28	0.042	0.042	0.039	0.043
Mn (mg/100 g)	0.6–10.0	0.03	0.032	0.032	0.032
Cr (mg/100 g)	1.5–7.0	0.037	0.037	0.037	0.037
Ca (mg/100 g)	100–200	88.93	91.27	351.74	68.76
Li (mg/100 g)	0.7–20	0.075	0.036	0.077	0.065
Hg (mg/100 g)	0.003–0.01	0.02	0.019	0.018	0.019
Mo (mg/100 g)	0.03–0.05	0.057	0.039	0.043	0.044
Sn (mg/100 g)	0.001–0.22	0.014	0.012	0	0.014
Ag (mg/100 g)	0.001–0.1	0	0	0	0

1	2	3	4	5	6
Pb (mg/100g)	0.001–0.1	0.047	0.048	0.045	0.049
Na (mg/100 g)	59	262.4	172.13	324.3	304.82
Cd (mg/100 g)	0.001–0.1	0.032	0.031	0.031	0.031
Sb (mg/100 g)	0.02–0.03	0.010	0.008	0.014	0.017
Mg (mg/100 g)	65.0	82.22	42.8	74.7	75.35

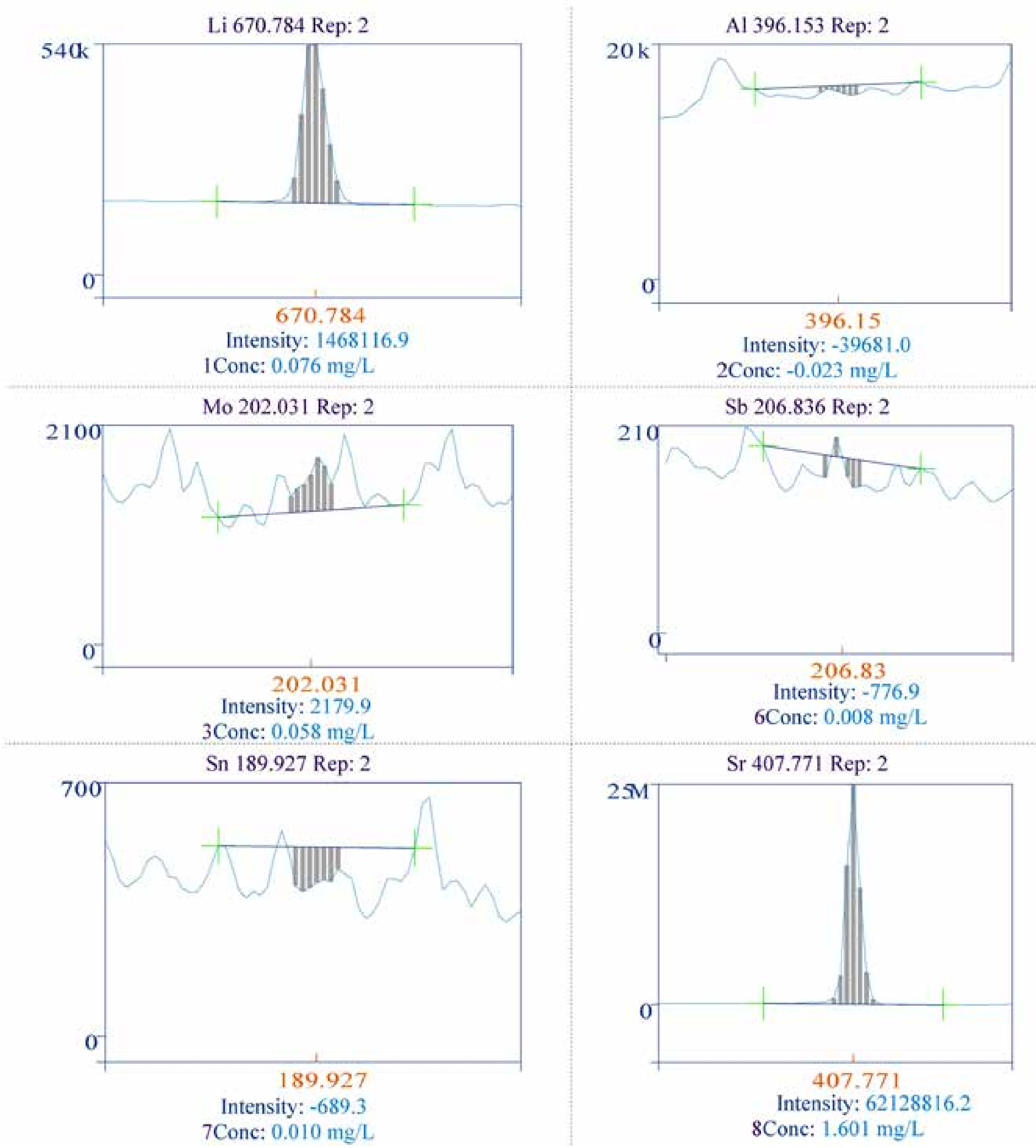


Figure 1. Results of analyzes of metals in the composition on an Avio 200 ICP-OES optical emission spectrometer with inductively coupled plasma (Perkin Elmer, USA)

Salt content in the upper layer ranges from 15–20%, including chlorine 10–15%, sulfates 5–10%. The sharp excess of chlorine content over sulfate ions is explained by the accumulation of salts in soils under conditions of stagnant highly mineralized chloride-type groundwater. So in a layer of 20–40 cm, the salt content in the paid residue decreases by 10–20%. In these horizons, the content of chlorine is 5–8% and sulfates – 2–3%. The value of dense remains from 40 cm to a depth of 90 cm varies mainly within 5–6%. The type of chemistry up to 60 cm is sulfate-sodium chloride alternating with sodium chloride. The increased moistening of the deep layers of the soil is a distinctive feature of saline.

The absorption capacity of clay saline soil under crust up to 60 cm is characterized by low and varies in examples 0–20 cm per 100 g of soil. The composition of the base in the soil layer up to 60 cm is dominated by calcium, then magnesium, sodium. The presence of sodium in the soil-absorbing complex indicates a sign of alkalinity, however, this phenomenon is not significant, since it is closely related to the content of silt particles on the profile of sections up to 90 cm, which content or varies between 2–12%. A pronounced saline feature in the soil is manifested when the content of silt particles in the composition of 50 cm is more than a percent.

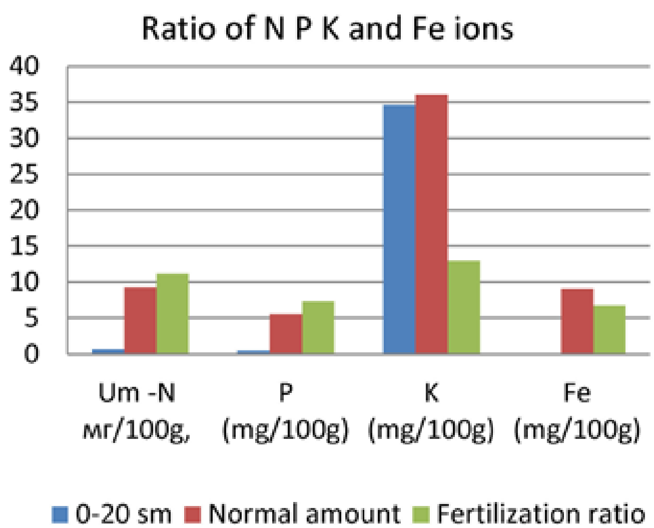
Also soil in the layers of metals Sb, Cd, Pb, Sn, Mo, Hg, B and other trace elements and toxic heavy metals are above the specified norm and not at the level of quantitative and equivalent norms. This has a negative effect on the absorption of appropriate nutrients by plants and on their growth and development.

Accordingly, in order to regulate the amount of elements in the soil in an equivalent ratio to the growth and development of plants, we tried to balance the composition of the soil of the seedling and seed planting site with nutrients in the plant development stage.

We calculated the number of elements in an equivalent ratio for adding per 100 g of soil: ammonium nitrate 171 mg/100 g; Ammophos 206 mg/100g; potassium sulfate 140 mg/100g; Cobalt sulfate 5.5 mg/100g; Boric acid 39 mg/100 g; Zinc sulfate 7.8 mg/100g; Ferrous sulfate 242 mg/100 g; Copper sulfate 15.6 mg/100g; Manganese sulfate 163 mg/100 g; Calcium sulfate 2700 mg/100g.

$Ca(NO_3)_2$ was used to improve the ratio of Ca and Na ions in the soil. The initial ratio of elements Ca and Na is 4.5 : 9.

After applying calcium fertilizers, the equivalent ratio of Ca and Na ions is 36 : 9.



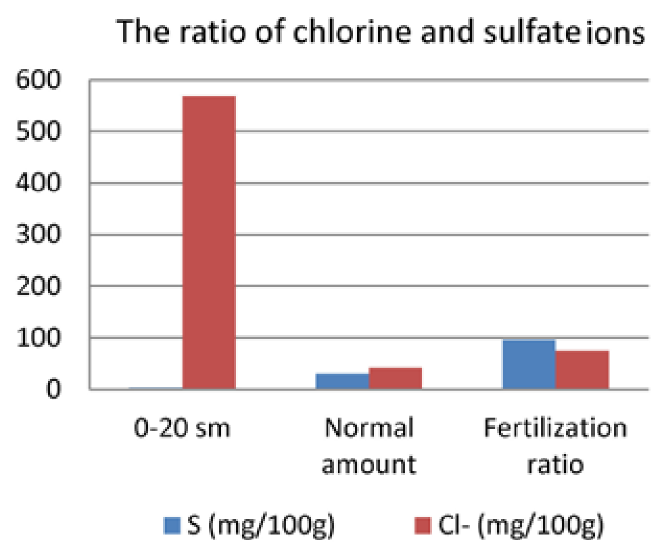
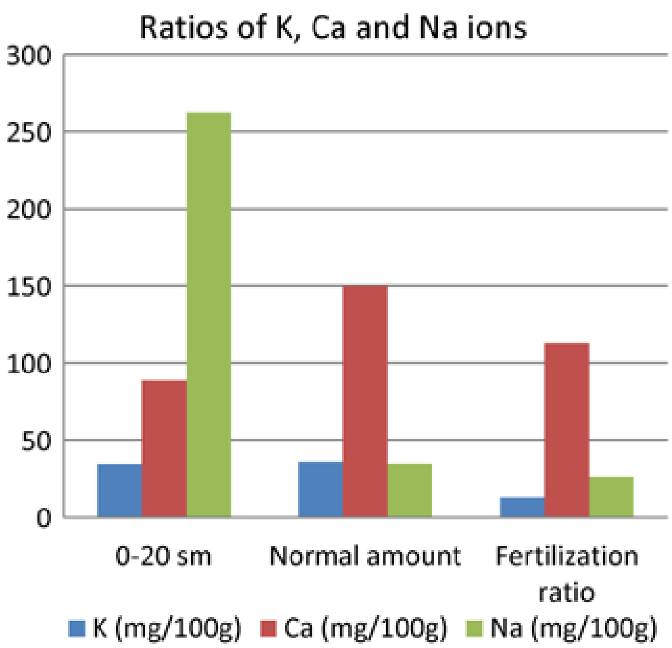


Figure 2. The results of the balance ions of NPK and Fe (A), Cl and SO_4 in the 0–20 cm layer of the dried bottom of the Aral Sea based on equivalent ratios

Since monovalent elements destroy the soil structure, as a result of the introduction of additives, the concentration of Na^+ and Cl^- ions decreases

Due to the relatively low nitrogen content in the soil, 171 mg of ammonium nitrate, 206 mg of ammonium phosphate fertilizer due to lack of phosphorus, 140 mg of potassium sulfate to equalize the amount of potassium, 242 mg of Fe_2SO_4 salt to normalize the amount of iron ions were applied to the soil. This amount of added salts is calculated to improve the condition of 100 g of soil compared to the Na ion in the soil.

According to the analysis of samples, it was found that the proportions of chlorine and sulfate ions differ from the norm. To equalize the quantitative ratios of these ions, sulfate salts of Ca and trace elements, which are absent in some soils, were used.



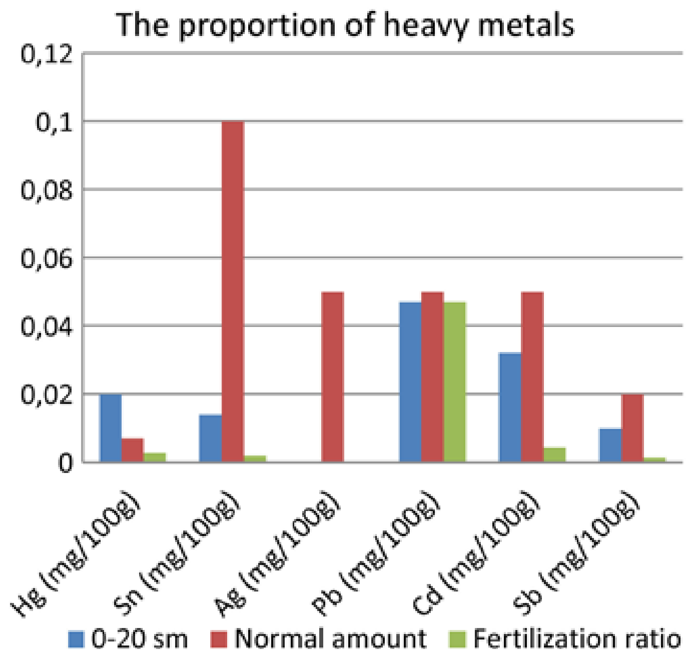


Figure 3. The results of the balance ions of K, Ca, Na (A) and heavy metals (B) in the 0–20 cm layer of the dried bottom of the Aral Sea based on equivalent ratios

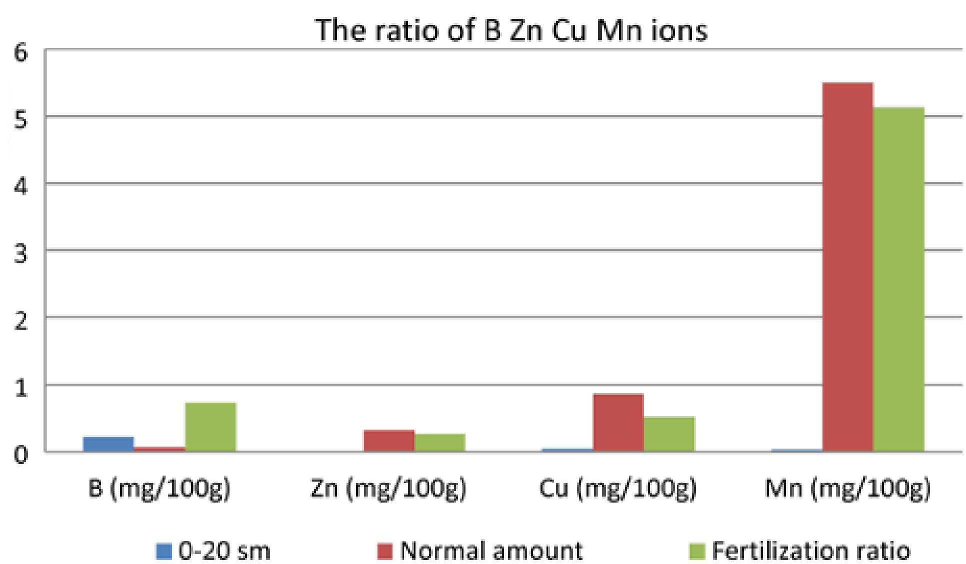


Figure 4. The results of the balance of B, Cu, Zn and Mn ions in the 0–20 cm layer of the dried bottom of the Aral Sea based on equivalent ratios

As a result of the analysis of mobile ions of potassium, calcium and sodium, it was found that sodium ions are 7–8 times higher than the norm. Accordingly, as a result of the addition of Ca and K salts, the quantitative ratios of cations were equalized. That is, calcium sulfate (2700 mg) and potassium (140 mg) salts were used.

The elements boron, zinc, copper and manganese are known to be vital trace elements. According to the results of the analysis, it was found that these elements are a little out of the norm. Therefore, to enrich the amount of boron, boric acid (39 mg) was added, and to enrich zinc (7.8 mg) and copper (15.6 mg) and manganese (163 mg), sulfate salts of these elements were added.

Based on the biological properties of plant species, the salts of the necessary elements, calculated by equivalent ratios, were gradually added to the soil composition. This served as an important basis for ensuring their growth and development based on the absorption of nutrients from the soil.

Conclusions

Analysis of the soil layers on the dried bottom of the Aral Sea showed that the salt content in the upper layer ranges from 15–20%. To correct the amount of elements in the soil in the equivalent ratio of plant growth and development, we tried to balance the soil composition of the seedling planting site and seeds with nutrients at the stage of plant development.

Calculated the number of elements in an equivalent ratio for adding per 100 g of soil: ammonium nitrate 171 mg/100 g; $(NH_4)_3PO_4$ 206 mg/100g; K_2SO_4 140 mg/100g; $CoSO_4$ 5,5 mg/100g; H_3BO_3 39 mg/100 g; $ZnSO_4$ 7,8 mg/100g; $FeSO_4$ 242 mg/100 g; $CuSO_4$ 15,6 mg/100g; $MnSO_4$ 163 mg/100 g; $CaSO_4$ 2700 mg/100g to create nutrition for plants in developmental stages.

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