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Content of Zinc in Soils of the Alakol Hollow

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There were explored the soils of the Alakol hollow and there were defined their basic physical and chemical properties. There was given the evaluation of the level of zinc concentration. There was considered its character inside the profile allocation. There were calculated the coefficients of the correlating dependence of zinc content on the indices of physical-chemical properties of soils. There were received the data on the content and accumulation of the researched element reflecting the regularity of allocating zinc in semi-deserted and deserted soils of the Alakol hollow.

Key words: soil, chemical elements, heavy metals, zinc, gross content, background content.

Soil is a specific component of the biosphere, a poly-phase, multi-component, poly-disperse and poly-functional open system possessing significant buffering due to the aggregation of natural properties including chemical pollution by heavy metals[1]. Metals being accumulated in soil are slowly removed during desalinations, consumption by plants, erosion and weathering. According to the calculation of Jimura[2] and others, the first period of semi-removing (i.e., removal of half from the initial concentration) of heavy metals for soils in a lysimeter conditions varies greatly: for zinc – 70-100 years.

Many scientists remark a great biologic importance of zinc and its necessity for the plants[3,4]. The deficit of zinc in plants causes the violation of the carbohydrate, phosphate and protein exchange, worsening of the reproductive function, reduction of stability of the plants under unfavorable factors of the environment. Zinc fulfills many biochemical functions in living organisms. The most significant of them is the share in the structure of various ferments in the metabolism of carbohydrates, proteins and phosphates.

Increased concentrations of zinc have toxic effect on living organisms. As zinc is a carcinogen for humans it causes nausea, vomiting, respiratory failure, pulmonary fibrosis[5]. Studies on toxic metals effects on human body include the effects of high concentrations of zinc, which alter the composition of blood and may result in cancer[6,7].

The natural sources of zinc are maternal rocks and atmospheric precipitation. Besides natural ones, technical genetic sources of zinc have also much importance[8]. The content of heavy metals in soil-forming rocks, soils and plants of the Eastern-Kazakhstan region is examined in the works of M.S. Panin (1999) and others.

Soil covering of the Alakol hollow is diverse but its elemental and chemical composition

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is poorly explored and requires ecological and geochemical research because of economical and recreational importance of the territory. Soils of the Alakol hollow are used mainly as a land for pasture and haying.

The purpose of this research is the studying inside the profile and spatial distribution of zinc in soils of Alakol hollow.

Objects and Methods of Research

Alakol hollow occupies the inter-mountainous lake hollow between the mountainous system of Tarbagatay, Barlyk and Zhetysu (Dzhungar) Alatau in the eastern part of Kazakhstan. In the west the hollow is attached the eastern part of Lake Balkhash, in the south-east - to the foundation of Lake Ebinor, situated in China.

The objects of research are soil-forming rocks and the spreading soils of Alakol hollow: brown, meadow-brown and grey-brown soils, grey soils (sierozems), meadow saline soils. Also there were researched half-durable ringe-uneven sands, overflow-marsh soils lying on low-lying banks of the lake Alakol. The soil cover of Alakol hollow is represented mostly by deserted types.

Element concentration was analyzed according soils profiles. Gross content and concentration of moving forms of lead in soils were defined by atomic absorption analysis with spectrometer “AAS KVANT-2A”, moving forms were extracted from soils by acetate-ammonium buffer solution pH 4.8. Physical and chemical properties of soils were defined by methods accepted in soil science.

Data obtained by research were statistically processed by the method developed by N.A. Plokhinski[9] in Microsoft Excel.

The following statistic statistical quantities were used in data processing: n-number of samples; $\bar{x} \pm S\bar{x}$ - arithmetic mean and its error, (mg/kg); C_V – variation coefficient (%); lim – divergence limits (mg/kg); σ – standard deviation (mg/kg); r – correlation coefficient.

RESULTS AND DISCUSSION

The surface of alluvial plain of the Alakol hollow is composed of: clay, loam, sand and in the less degree pebble-cobble material. Foot-hill plain of the ridges of Barlyk and Maily is composed mostly of boulder- pebbled deposits mixed with crushed-stony sands and also in the Alakol hollow there are sands, which are usually composed of the sorted medium- and small grainy quatz-field spar sands.

The gross content of zinc in soil-forming rocks of the Alakol hollow changes from 26.97 till 92.91 mg/kg, the average content of the studies element in all soil-forming rocks is 52.51 mg/kg, that is lower than its Clark in the lithosphere (83 mg/kg). Low levels of zinc content are discovered in the soil-forming rocks of light-loamy and sandy structure - at the average 31.97 mg/kg and 36.99 mg/kg accordingly. The most content of zinc is typical of loamy and heavy-loamy deposits. The content of zinc in loamy deposits is equivalent to

Table 1. Content of the gross zinc in soil cover of the Alakol hollow

#	Soils	n	lim	$\bar{x} \pm S\bar{x}$	σ	CV, %
			Mg/Mg			
	1	2	3	4	5	6
1	Meadow-brown light-loamy soils	5	43.95-69.95	58.14±5.54	12.42	21.36
2	Brown medium-loamy soils	5	64.91-92.91	80.62±5.70	12.78	15.85
3	Brown loamy soils	5	70-92.41	81.70±3.87	8.68	10.62
4	Light-loamy grey soils	3	31.97-68.92	46.79±11.29	19.53	41.75
5	Meadow-brown sabulous soils	5	53.42-63.95	55.95±2.02	4.52	8.07
6	Grey-brown highly skeletal sabulous soils	3	57.95-86.40	76.58±9.33	16.14	21.07
7	Overflow-marsh soils	3	25.79-38.48	29.83±1.83	4.48	15.03
8	Ringe-uneven half-durable sands	4	34.88-36.99	35.65±0.49	0.99	2.76
9	Sands desert-steppe durable	5	51.96-58.94	56.35±1.20	2.68	4.75
10	Meadow heavy sabulous saline soils	4	28.97-53.47	36.78±5.70	11.40	30.99

85.38 mg/kg.

Most authors express their unanimous opinion and state that the gross background content of heavy metals depends on physical-chemical properties of soil (physical clay, humus, the sum of the absorbed foundations and others) and on the near and far transfer of substances[1].

As the results of the research showed, the average content of humus in the soils of the Alakol hollow in the horizon (A) is 1.52 %; varying within the limits of 0.10- 3.41 %. The content of carbonate in the humus horizons varies within the limits of 0.53-18.55 %. The reaction of the soil solution in the upper horizons is strongly alkaline (pH water within the limits of 8-9.8). The average content of the muddy fraction on the whole profile of the soils is 12.82 % and varies within the limits of 0.16-30.86 %.

The gross content of zinc in the soils in humus- accumulating horizon varies from 39.94–92.41 mg/kg, at the average making up 61.74 mg/kg. The coefficient of variation of the gross zinc in soils of the Alakol hollow is 28.45 %. The found average content of zinc is close to the content of approximately permissible concentration (APS) of sandy and sandy-loam soils. The content of zinc in the soils of Russia is regulated by the following normative (mg/kg): APS (gross) in different sandy and sandy-loam soils – 65, in loamy and clay (acid) – 110, in loamy and clay (neutral) – 220 [10]. The gross content of zinc in the humus layer of the soils of the studied territory is lower than in the soils of Western Siberia, close to the content of zinc in the soils of dry steppes and semi-deserts and deserts of the former USSR[1].

In soil profiles of Alakol hollow the gross zinc is distributed rather evenly. In most studied soils the tendency of biogenetic accumulation is observed. Brown medium-loamy and grey-brown loamy soils reach the level of the content of the elements of soil-forming rocks.(Fig. 1).

The average content and the limits of varying of zinc in soil cover of the studied territories are presented in Table 1.

As it is seen from table 1, the maximum average content of gross zinc is characteristic of the brown medium-loamy soils, the minimum - for the marshy soils.

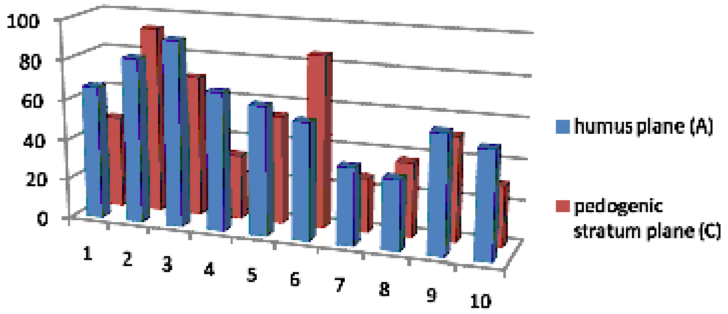

Fig. 1. Gross zinc content in humus plane (A) and pedogenic stratum plane (C) diagram for Alakol hollow.1 – Meadow-brown light-loamy soils; 2 - Brown medium-loamy soils; 3 - Brown loamy soils; 4 – Light-loamy grey land; 5 - Meadow-brown sabulous soils; 6 – Grey-brown highly skeletal sabulous soils; 7 - Overflow-marsh soils; 8 - Ringe-uneven half-durable sands; 9 - Sands desert-steppe durable; 10-Meadow heavy heavy sabulous saline soils

Overflow-marsh soils lie on the low banks of Lakes Alakol, Sasykol, where they are formed within the limits of the reedy mace places which are under the water for the most part of the year. The soil profile is stratified, the peat or semi-peat horizon is usually seen on the surface, under which the humus horizons and layers are distributed in different amounts. The gross zinc in flood-land marshy soils varies from 25.79 till 38.48 mg/kg, variation coefficient is – 15.03%, average content is 29.83 mg/kg.

Brown soils in the studied territory occupy a big area; they are formed on the proluvial deposits, of the loamy loamy-sandy mechanical structure under the cover of the wormwood vegetation. In brown loamy soils the reduction of the content of the element down the profile from 92.41 till 70 mg/kg is observed, the interrelation is observed with the reduction of the humus content. Humus (r=0.96) has a great influence of the medium force on the conduct of the element in the studied soils.

Meadow-brown soils are formed among brown deserted soils in low relieves. The average content of zinc in meadow-brown soils is equivalent to 55.95; the coefficient of variation for meadow-brown loamy-sandy soils is 8.07%.

Grey-brown highly skeletal sabulous soils are attached to weak wavy sloping plain of the foot-hills of Barlyk. They are formed under greatly thinned out poor deserted vegetation on the nearly laid pebbled deposits. The gross zinc in grey-brown highly skeletal soils varies from 57.95 till 86.40 mg/kg, variation coefficient is 21.07%, and average content is 76.58 mg/kg. The content of the element reduces on the profile, the reverse strong correlation with humus (r=-0.85) is observed.

Grey soils are formed under ephemeral wormwood vegetation on the sloppy hills and higher parts of Alakol hollow with 350-750 meters high, where they occupy big areas. In grey soils the gross zinc varies from 31.97 till 68.92 mg/kg, the variation coefficient is equal to 41.75%, the average content is 46.79 mg/kg.

Ringe-uneven half-durable sands refer to semi-lumped territories or lumped relieves covered by various grassy-wormwood or grass-bushy vegetation. The morphological profile of the sands is characterized by weakly separate genetic horizons, structurelessness, and friable composition. In the sands there is observed even B content of the element on the profile. The gross zinc in the sands varies from 34.88 till 36.99 mg/kg, the average content is equal to 35.65 mg/kg, and the coefficient of the variation is 2.76%.

Meadow heavy sabulous saline soils are formed under the influence of much mineralized soil waters 1.5 meters deep under the cover of the salt-sustained vegetation on medium and heavy loamy soil-forming rocks. The content of the gross zinc in meadow heavy sabulous saline soils varies from 28.97 till 53.47 mg/kg; the medium content is 36.78 mg/kg. The concentration of zinc directly depends on humus (r=0.99).

On the value of the coefficient of correlation between the gross zinc and the content of humus the soils form the following reducing row: meadow, saline soils (r=0.99), grey soil (r=0.99), brown loamy (r=0.96), meadow-brown loamy sandy (r=0.93), meadow-brown light loamy (r=0.89), marshy soils (r=0.73), ringe-uneven half-durable sands (r=0.43).

Correlative connection between zinc and muddy fraction in most soils is reverse to that of weak, medium and strong one. The correlative dependence between zinc and carbonate in most cases is reverse to the medium and strong force. According to Panin[1], the carbonate horizon does not have a significant influence on the redistribution of zinc on the profile of the studied soils and its functions as biochemical barrier are supposed to be small.

There was also made the analysis on the content of the moving forms extracted by acetate-ammonium buffer with pH 4.8. Moving forms represent the ecological danger because they possess high migration capability and accessible to plants. The concentration of the moving form of zinc in soils varies within the levels of 0.04 – 0.70 mg/kg; the average content of this form is 0.29 mg/kg. The average concentration of the moving zinc in the soils of the explored territory is 1.5 times higher than in the soils of the middle part of the Eastern Kazakhstan. The low levels of the content of the moving zinc are discovered in the half-durable and desert-steppe sands desert-steppe durable - on the average 0.08 mg/kg and 0.16 mg/kg accordingly. The most content of the moving zinc is typical of meadow-brown, marshy soils - on the average 0.51 mg/kg and 0.47 mg/kg accordingly. The soils of light grading are less provided with moving zinc than the soils with heavier grading structure. On the revealed content of moving form of zinc, soils of the Alakol hollow may be referred to the soils with very low content of this metal, less than 23 mg/kg for all explored soils[9]. The explored region may be referred to the biogeochemical province with low deficit of moving zinc. The least indices of the content of the moving form of zinc are discovered in the sands and meadow-brown loamy soils - 0.10 mg/kg. The most content of the moving zinc is characteristic of meadow-brown light-loamy 0.51 mg/kg and marshy soils - 0.47 mg/kg.

The correlative dependence between the moving form of zinc and its gross quantity in most soils (r–from -0.23 till -0.78), carbonates (r–from -0.29 till -0.94) is of reverse weak and strong force. The correlative connection between the moving zinc and pH of the environment in most soils is positive of medium and weak force (r–from 0.08 till 0.64), the exclusion is for meadow-brown loamy soils, where the connection is of medium force (r=-0.58) and marshy soils, where the connection is negative and of strong force (r=-0.81). Between humus and moving zinc we observe the positive connection of the medium force, in meadow-brown loamy-sandy soils (r= 0.70) and marshy soils (r= 0.40). In all the rest cases the connection is reverse to the medium and strong force. The content of the moving zinc has an authentic reverse connection of the medium significance with muddy fraction in most explored soils except for brown medium-loamy soils (r=-0.90), meadow-brown loamy sandy soils (r=-0.38) and marshy soils (r=-0.40).

CONCLUSION

The first thing, which has an impact on the content of chemical elements in soils, is parent rock material belonging to the different geochemical provinces. Geochemical provinces of chemical elements are territories where the chemical elements are contained in superficial portion of earth crust in different amounts (reduced or increased). Relatively low concentration of lead for most soils of analyzed region may be explained by light grading of soil of most of researches soils. According to M.S. Panin[1], brown and grey brown soils are often sabulous and sandy and low concentration of heavy metals is typical for such soils. They had been formed on ancient alluvial sands with the lowest content of heavy metals in all pedogenic stratum of the region. In addition, a low assay of zinc is associated with physical and chemical properties of the soil. According to Lindsay[11], an important factor of zinc concentration deficits is low organic matter concentration in the soil, while having a high content of carbonates and pH value over 7.

Resume

1. Research of gross zinc content and its moving form in pedogenic stratum and soils of the Alakol hollow. Environmental and geochemical evaluation of pedogenic stratum and soils is provided.
2. Average gross content of zinc in the soils of the explored territory does not exceed the generally accepted approximately possible concentration; lower than its Clark in the lithosphere.
3. Content and distribution of the gross zinc in the soils and the correlate dependence on the uliginous fraction, carbonates, pH environment in most cases has a reverse character or has the relation of the weak force.
4. In moving fund of zinc compositions the part os moving form is 0,53% of gross content.

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