Ecological and biogeochemical studies of the soil cover from the mercury province Aydarken (Kyrgyzstan)

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Abstract
Currently, Kyrgyzstan is one of the leading in the world antimony-mercury provinces and has significant potential to increase these metals. However, the problem of mercury safety is an ecological and social problem. The distribution, transport, and transformation of mercury in ecosystems require special attention. This article presents the results of physical and chemical studies on the sites of the mercury province of Aydarken, Batken region, the Republic of Kyrgyzstan. Collection and research of the sample carried out in 2013-2017. The types of soils and the mechanical components of the soil above sea level at an altitude of 1684 m to 2078 m are determined. The results of the mercury in the soil cover by the atomic absorption method presented. It was found that in all studied areas the concentration of mercury in the soil cover more than in the background plots and maximum allowable concentration (MAC), and their values depend on the remoteness of the pollution source, especially in the area of the tailing dump and the metallurgical plant.

Keywords: mercury, soil cover, tailing dump, biogeochemistry, maximum allowable concentration

1 Introduction

MERCURY possesses unique geochemical, biogeochemical, and toxicological properties due to the variety of forms of its migration and the specifics of transformation in natural conditions, and increased possibility of redistribution, and biotransfer in the environment, as well as a wide and diverse range of negative effects on living organisms. According to the literature, the most dangerous and critical environmental situations were associated precisely with the pollution of the environment with mercury. In recent years, extensive zones of technogenic pollution with this toxic metal identified in Germany, Russia, Kazakhstan, Kyrgyzstan, and Ukraine (Ermakov 2010), (Scheuhammer et all. 2007).

One of the most important problems of geochemical ecology is the study of the chemical composition of environmental objects in the conditions of natural and technogenic biogeochemical provinces. In the biogeochemical cycle of mercury, the soil is one of the important components and is not only a depositing medium for mercury and its compounds but also a source of input into other components of ecosystems. Anthropogenic influence significantly disrupts the normal biogeochemical cycle of mercury (Yanin 1992), (Kabata-Pendias 2007). The main sources of pollution in the investigated mercury province of Aydarken are the mining plant and the tailings dump.

Purpose of the study. To study the ecological and biogeochemical features of the soil cover Aydarken mercury province of the Alai ridge.

Research objects. The Aydarken mercury biogeochemical province stretches from east to west from the Meting Bel pass to the Sokh River by 24 km, 12 km wide with an average altitude of 1360-2360 m above sea level. The objects of our ecological and biogeochemical studies are the soil cover of the mercury province of Aydarken.

2 Materials and methods

The survey of the territories was carried out according to the methods developed in the Institute of Biology of the National Academy of Sciences of the Kyrgyz Republic. Soil samples were taken following the standards from horizon A with a depth of 0-20 cm. Scientific research was carried out from 2013 to 2017 at 8 sites, taking into account the distance from the source of pollution in the territory of the mercury province of Aydarken (Table 1). Determinations of the amount of mercury in the objects under study (soil) were carried out by the atomic absorption method (with a hydride attachment) on an MGA-915 spectrometer, and in some samples - on an RA-915M mercury analyzer (Djenbaev and Kaldybaev 2014).

Chemical analyzes for elements of fertility (gross content of nitrogen, phosphorus, and potassium, hummus, absorption capacity, carbonate content, pH) and analyzes for the mechanical composition of soils were carried out in the laboratory of the Republican Soil-Agrochemical Station of the State Polytechnic Institute "Kyrgyzgiprozem" under the Ministry of Agriculture of the Kyrgyz Republic.

3 Results and discussion

In the studied province, we identified dark Turanian light soils at points AMP 1, AMP 2, AMP 3, AMP 4, AMP 5, and brown dry steppe mountain soils at points AMP 6, AMP 7, AMP 8 (Table 1). Altitude above sea level ranged from 1684 m to 2078 m. With an increase in altitude above sea level, mountainous brown dry steppe soils are formed (Imatali kyzy 2015), (Imatali kyzy and Djenbaev 2016). To assess the physicochemical composition of the soil cover of the mercury province, agrochemical soil analyzes were carried out.

The results of the study showed that, the humus content varies in the range of 1.46-4.58%. The total nitrogen content varies from 0.070 to 0.125%, and the total phosphorus content is 0.120-0.170%, which in all cases is less than the typical values for soils. The gross potassium content is very low in sierozem (samples AMP 1, AMP 3, AMP 5) - 0.66-0.90%. On the upper soil layer, carbonates are much higher (5.28–12.3) on the territory of the tailing dump and the metallurgical plant.

We have determined the nutrient elements of the upper layer of the soil cover of the province, according to the

values they correspond to the Turanian dark gray soils on average throughout the republic. For example, there is a small amount of phosphorus - up to 3 g / kg of dry matter, K_2O - from 5 to 15 g / kg, and oxides of other macronutrients are characteristic of mountain brown dry steppe sierozem soils.

TABLE 1
Places of sampling of soils, and soil type

Sample code	Collected place	Soil type
AMP 1	Tailing dump	sand, Turan light soils
AMP 2	Upper part of the tailing dump	Turan light soils dark sandy
AMP 3	Lower part of the tailing dump	Turan light soils dark sandy
AMP 4	Lower part of the tailing dump	Turan light soils dark sandy
AMP 5	Metallurgical factory, 20 m from the road	Turan light soils dark light clay sandy
AMP 6	1 km from the metallurgical factory, 100 m from the road	Mountainous brown dry sandy light soils
AMP 7	Eastern border of the Aydarken, 100 m from the road	Mountainous brown dry light soils
AMP 8	On the Aydarken pass, 100 m from the road	Mountainous brown dry sandy light soils

The main element in this province, mercury, was determined by atomic absorption (with a hydride attachment). In Figure 1 the results of the content of mercury in the soil cover by years are presented. The dynamics of these indicators in the soil cover depends on many factors, therefore, from 2013 to 2017, the data changed. The highest value for mercury in the area of the tailing dump was observed in 2014, with a subsequent decrease in 2015. In 2015, the amount of precipitation was above normal, therefore, the concentration of mercury in the soils of the tailing dump is slightly lower, but on the contrary, the highest value of mercury was observed in the vicinity of the metallurgical plant. With precipitation and gravitational settling, its amount in the atmosphere decreases. This enriches the soil and hydrosphere.

On the territory of the metallurgical plant in 2014, the minimum values for mercury in the soil cover revealed in other periods. As reported in the report on the socio-economic development of the Kyrgyz Republic, in 2014 the drop in mercury production was 34.5%. And this was due to the flooding of the lower horizons of the "Vspomogatel'naya" mine.

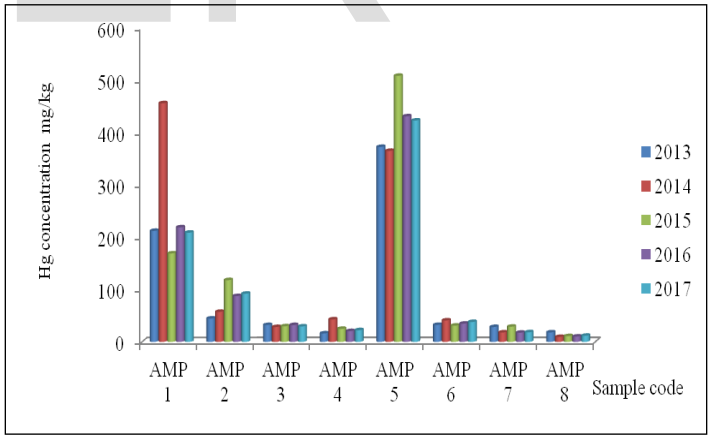

Fig. 1. Dynamics of the mercury content in the soil cover by years.

According to the results of data over some years, the average content of mercury in the soil cover of the mercury province of Aydarken is 191 times higher than the MAC (MAC= 2,1 mg/kg) on the territory of the metallurgical plant and 101 times on the territory of the tailing dump, at the Aydarken pass (conditionally control area) by 6 times (Fig 2).

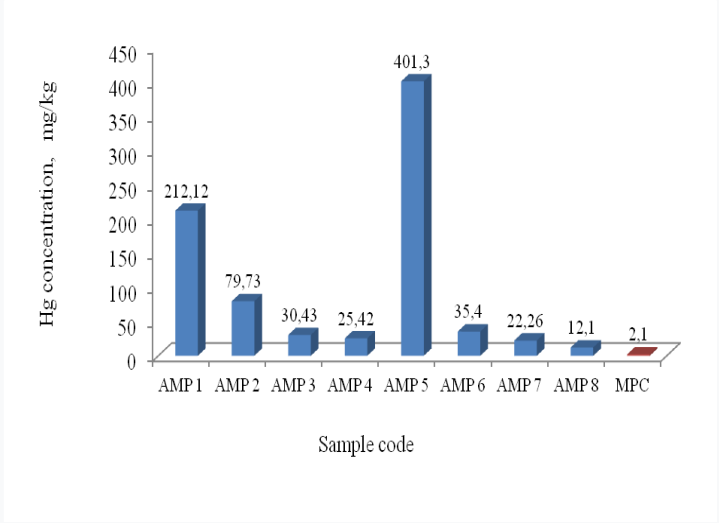

Fig. 2. The average content of mercury in the soil covers during 2013-2017.

4 Conclusion

In general, the obtained data on mercury in the soil and vegetation cover of the province are significantly higher than in the background plots and MAC, their amounts depend on the distance to the source of pollution. The metal concentration in the samples is higher in the summer than in the spring. The density of mercury is greater than that of soil. In summer, there is less precipitation and as the temperature rises, mercury evaporates and rises to the topsoil. The dynamics of the content of mercury in the soil cover depends on many factors, therefore, in the period from 2013 to 2017, the results obtained are not the same. On the territory of the metallurgical plant in 2014, we found the lowest mercury content in the soil cover, which is explained by a drop in production and other factors. We have established the highest levels of mercury concentration in the area of the tailing dump (up to 456 mg/kg) and the metallurgical plant (up to 508.4 mg/kg), the MAC of mercury in the soil is 2.1 mg/kg.

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