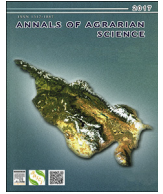


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About rationing of the heavy metals in soils of Georgia

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ABSTRACT

In Georgia, there are no approved standards that determine the values of Maximum permissible Concentrations (MPC) for heavy metals in soils. Taking into account the experience of normalizing the gross content of heavy metals in the EU countries, it is proposed to select the MPC's for Georgia, taking into account the environmental hazards of each of the metals, which is determined by the maximum permissible additives (MPA), according to the data of Dutch ecologists. In Georgia, for the highly dangerous Cd, it is proposed to use the minimum value of the MPC used in the EU. For low-risk metals - Zn and Pb – is used the maximum values of MPCs used in the EU. For moderately hazardous - Cu, Ni – is used the average value of the MPC used in the EU.

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Introduction

Soil pollution by heavy metals remain in a number of pressing environmental problems [1,2]. At present, three main types of soil pollution by heavy metals are accepted: global, regional and local (impacted).

Global pollution is associated with global trends in the movement of pollutants, which is not permanent, it varies markedly with time. This type of pollution is largely determined by global climate transformations. Regional pollution is analyzed by changes in the composition of river, lake and marine sediments. Local soil contamination has three different forms.

The most common is pollution of soils from emissions of stationary sources and cars [3,4]. However, after establishing strict standards for air pollution by heavy metals in the soils of the EU and North America pollution has declined significantly. Air pollution has also decreased in Russia. Now the problem is the restoration of soils contaminated near industrial centers in the XIX-XX centuries [5]. In Asian countries: China, India, Kazakhstan, Iran, aerial

contamination of soils continues.

Less common is the hydrogen contamination with heavy metals of alluvial and floodplain soils [6,7]. The surface waters of rivers are often contaminated by mining waste from mining operations. Thus, the most fertile floodplain soils are removed from circulation.

In connection with urbanization in the world, the scale of the hydrogenic contamination of terrestrial areas around landfills near major cities is increasing. Heavy metals along with organic pollutants spread with the flow of groundwater.

The third source of local pollution is the flow of heavy metals together with organic pollutants, for example, in case of oil spills [8,9], getting into the soil from fertilizers, means to improve the soil, etc. This type of contamination with heavy metals is relatively weak.

The solution of pollution problems largely depends on adequate standards for the content of heavy metals in soils [10]. The most important standard is the maximum permissible concentration (MPC) in the soil. But in Georgia, the meaning of their MPCs has not yet been legislated. Probably, the experience of normalization of heavy metals obtained in the EU countries can be transferred to Georgia.

In the world, the practice of using as MPC the gross content of heavy metals, despite the obvious drawback - the gross content includes the proportion of metal (often significant) in the

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composition of inert compounds, mainly silicates, which do not affect vegetation. To eliminate this drawback, attempts have been made in Russia and the Czech Republic to introduce mobile (active) forms of heavy metal compounds as standards [11]. But in recent years, their defectiveness as a norm has been shown, due to the dependence of the mobility of heavy metals on humidity at the time of sampling [12].

But, at the same time, the gross content does not depend on the soil moisture at the time of sampling. Therefore, in most countries, the maximum permissible concentration of heavy metals in soils has been adopted [13,14]. As another disadvantage, we point out the inability of MPC of the gross composition to divide the content of heavy metal into natural and anthropogenic shares.

In the future, we will only discuss the maximum permissible concentration of heavy metals. Often these values of MPC are assigned differentially, depending on the properties of the soils. For acidic and light in the grain-size composition of soils, the MPC values are set lower than for neutral and heavy soils [15]. This is due to the fact that in acid and light soils heavy metals are more mobile and potentially more toxic to living organisms [15].

Soil contamination in Georgia

Data on soil contamination of Georgia with heavy metals are presented in Refs. [15,16].

Soil pollution from atmospheric air at 9 km from the village Kazreti, where the Madneuli Ore Mining and Processing Enterprise is located, was found contamination of pasture soils and vegetation with heavy metals: Cu, Zn, Pb [17]. In addition, significantly increased the content of these metals in the blood and milk of cows and in dairy products: cheese, matzoni. In the area of the Madneuli Mining and Processing Plant, which processes sulfide ores, the arsenic content close to the background values was almost in all soils. The maximum is noted near the ore-processing plant. In vegetable food products contaminated zone, the arsenic content is markedly increased, but besides the rare exceptions did not exceed the MPC [18–20];

Hydrogen pollution of soils. Long-term studies were conducted in the Mashavera river basin [21–23]. The chemically extracted forms of heavy metals and the entry of metals into plants in irrigated, heavily contaminated chestnut soils of the valley of the river were determined. Mashavera to the south-east of Georgia. In the fertile irrigated chestnut soils of the valley of the river Mashavera has a high yield potential. However, the waters of the river are polluted with mining waste - quarries of copper and gold mines in the mountains in the middle reaches of the river Mashavera. As a result, most agricultural irrigated soils are highly enriched with heavy metals. The concentration of total copper, zinc and cadmium increases with the intensity of land use and the degree of irrigation. It reaches a maximum in arable land, somewhat lower in periodically flooded meadows, plantings of vegetables, vineyards, orchards. The content of heavy metals exceeds the safety thresholds for plants, animals and humans. So, the content of copper in soils is 200 times higher than the norms of the European Union (60 mg/kg) and amount to 12,000 mg/kg; the content of zinc in soils is 15 times higher than the norms of the European Union (200 mg/kg) and amount to 3000 mg/kg; the content of cadmium in soils is 1.5 times higher than the norms of the European Union (11 mg/kg) and amount to 17 mg/kg; An increased risk of contamination of plant products with heavy metals is established.

The receipt of heavy metals with fertilizers. It is determined the content of heavy metals in phosphorus and organic fertilizers [24] and in the soils of Georgia: chernozem, meadow brown and brown carbonate [25]. The content of heavy metals in these soils differs little from the background.

MPC of heavy metals in EU countries

Considering the maximum permissible concentrations of heavy metals established by the legislation of European countries - Austria, Czech Republic, Denmark, Finland, France, Germany, Italy, Norway, Spain, Sweden, United Kingdom, Russia.

In Georgia, twice - in 2006 and 2017, a comparative analysis of MPC indicators in European countries was carried out. In 2017, the National Environment Agency of the Ministry of Environment and Natural Resources Protection of Georgia conducted an analysis of the MPC values of a number of EU countries, including Bulgaria, Czech Republic, Estonia, Hungary, Lithuania, Poland, Romania, Serbia, Montenegro, Slovakia, Slovenia, and Russia [26–48]. In the publication of 2017, the standards of countries that have not been noted earlier are considered, including Bulgaria, Estonia, Hungary, Lithuania, Slovakia, Slovenia, Latvia, Poland, Romania, Serbia, Montenegro, Slovenia. In 2006, the standards of countries that were not analyzed in 2017, including Austria, Denmark, Finland, France, Germany, Italy, Norway, Spain and Sweden were discussed. In Table 1 the values of MPC for soils of 11 countries of Europe and Russia are summarized.

We note an important circumstance. The data presented in Table 1, the MPC values refer to the most diverse chemical elements. They differ in many properties. Among them, a very dangerous, although light metal, beryllium ($n = 4$), and a very dangerous heavy metalloid arsenic ($n = 33$). The remaining 9 elements are heavy metals, although of varying degrees of danger. Our choice of MPC values for Georgia depends on the degree of danger of a particular heavy metal.

There are several gradations of heavy metals in terms of their environmental hazards. The most reliable are the standards developed in the Netherlands [49,50]. The Netherlands environmentalists have established maximum permissible additives (SDA), above which the receipt of heavy metals becomes dangerous. The SDA values were obtained as a result of numerous and diverse ecotoxicological studies: a great deal of work was done to establish the toxicity of 17 heavy metals and metalloids [49]. These studies included the effect of water extracts from soils polluted by chemical elements on different types of organisms (at least four): plants, representatives of soil fauna (earthworms, arthropods) and microorganisms. In addition, the biological effect of heavy metals passing into solution (in laboratory experiments with suspensions) and in natural conditions in groundwater and surface waters was taken into account. It is very important that the Dutch ecologists took into account the toxic effect on soil biota, rather than the direct exposure of heavy metals to human health by inhaling dust and drinking water. The final specifications were obtained after the mathematical harmonization of a large number of experimental works (100 titles) on the effect of heavy metals on biota and plants.

Using the MPC for soils of the European Union and assessment of the risk of heavy metals in soils according to the values of SDA, try to offer indicative values of MPC for soils in Georgia.

Proposed values of MPC for heavy metals for soils in Georgia

We have proposed equilibrium values of the equilibrium ecological state for heavy metals in the soils of Georgia, taking into account their MPC in the EU and the degree of danger of each metal. Taking into account the experience of normalizing the content of heavy metals in the EU countries, it is proposed to select the MPC for Georgia, taking into account the ecological danger of each of the metals in the soils. As a criterion of danger, the data on the maximum permissible additives (SDA) of heavy metals determined by Dutch ecologists were used.

In terms of SDA values, all heavy metals studied by Dutch

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