GEOCHEMICAL FEATURES OF SOILS IN THE INDUSTRIAL AREA OF THE MINING COMPLEX

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Abstract

The content of microelements Cu, Zn, Sr, Pb and Cr in arable layer of chernozems in the vicinity of the mining enterprises and under the similar landscape conditions, but at a considerable distance from them, was studied. The comparison of their concentrations with clarkes of soils, maximum permissible and approximate permissible concentrations and regional background concentration was conducted. It was found that the processes of concentration for Cu, Zn and Pb in soils are typical and for Cr and Sr - scattering. All studied elements, except chromium, are in concentrations significantly below the MPC. In the most variants the background concentrations of the studied trace elements are exceeded.

Keywords

The KMA region, heavy metals, clarkes of concentrations, maximum allowable concentration, regional background concentration.

1 Introduction

The KMA region is located in the steppe zone, where the soil cover was initially heterogeneous: chernozems were formed under the steppe vegetation, under oakery – grey forest soils. From the standpoint of soil-geographical zoning, the territory of the Starooskolsko-Gubkinsky mining area belongs to the Donetsko-Oskolskiy area of grey forest soils and to the Seimitco-Oskoletskiy micro-district of the chernozems typical, which is included in the Central district of chernozems typical and leached middle thick low-, middle humus and grey forest soils of the Central Russian forest-steppe province. The location of the Yakovlevsky mine refers to the Somoksco-Verhnevorsclovscy micro-district of the West soil district of chernozems typical andf leached and medium low humus, which is included in the West soil district of chernozems typical and leached thick and medium and powerful humus, and gray forest-steppe soils of the Ukrainian forest-steppe province [1].

The problems of the soil cover condition in the vicinity of mining enterprises are widely reported in the literature. First and foremost, this concerns the size of the immediate destruction of the soil cover due to quarry- dump activities and identifying the extent and nature of soil contamination in the vicinity of mining enterprises, especially heavy metals [2,3,4]. At the same time, little is known about the nature of the contamination of soils by heavy alkaline earth metals (Sr, Ba), due to the difficulty of their diagnosis [5].

Geochemical aspects of the soils transformation of these areas were reviewed by us in the series of publications [6,7,8]. In assessing the degree of soil contamination the MPC is often used or the total index of pollution Zc. At the same time, the MPC norms do not take into account the partial nature of the pollutants genesis, therefore the danger is overstated on the areas of positive geochemical anomalies, and it is underestimated the area of negative anomaly, therefore it is necessary to consider regional and provincial natural conditions for determining the extent of soil contamination [5]. In this regard, in our research [9] we have been calculated the excess of the regional background concentrations in arable layer of soils of agricultural lands of the Belgorod region.

The aim of our research was the comparison of the geochemical conditions in the vicinity of the mining enterprises and in similar landscape conditions, but at the considerable distance from them.

2 Materials and methods

The basis of the study was the materials of database of geochemical conditions in the mining areas of the region KMA of the Belgorod region [10] and the results of field and laboratory studies that were conducted at the experimental site of the „Belgorod research Institute of agriculture“, located in the Belgorod region in the valley of the river Erik. Common features of the studied sites are slope of the plots is the nature of the terrain, the predominance of loess-like loams and loamy composition, of chernozems, their agricultural use as arable land. At each site 8 soil samples.were studied.

Determination of the trace elements contents was conducted on x-ray fluorescence spectrometer SPECTROSCAN MAX – GV. The patterns of accumulation of Cu, Zn, Sr, Pb and Cr are discussing in this article.

To identify trends of the elements content in the studied soils the comparison of their concentrations with clarkes of soil by A. P. Vinogradov [11], MPC/APC [12,13] and the regional background concentration was conducted [14]. The last calculation was performed for the 4 elements, as for Cr the data of the background values in soils in Belgorod region do not exist.

3 Results and discussion

Copper in soils, as a rule, is accumulated in the upper horizons, which reflects the bioaccumulation of this element, as well as modern anthropogenic influence [15]. It refers to moderately hazardous elements (2 class of danger), has good migration ability [16]. In the Belgorod region the Cu content in arable soils is 13.5 mg/kg, 6.5 mg/kg below clarke [17].

Zinc is especially dangerous element (1 class of danger), many of its compounds are toxic. It has high migration ability, especially in an acidic medium [16]. This is an important trace mineral that is actively involved in many biochemical processes [18]. In the Belgorod region the content of zinc in arable soils is 44 mg/kg, 6 mg/kg below clarke [17].

Strontium – low risk element (belongs to 3 class of danger), it has good migration ability [16]. Its content in soil and subsoil can vary within wide limits [19.] The background Sr concentrations in the arable layer of soils of the Belgorod region is equal to 53.6±7.2 mg/kg [20].

Lead is dangerous heavy metal, but the soil it is strongly inactivated and loses its toxicity [5], it refers to particularly dangerous elements (1 class of danger). In arable soils in Belgorod region the content of Pb is 14.3 mg/kg, which is above the clarke 4.3 mg/kg [17].

Chrome, according to [21], creates a high ecological danger of pollution of natural ecosystems. The pollution of chromium strongly influences upon soil biological activity, however, it is missing in the national list of dangerous elements [5], it belongs to moderately hazardous elements (hazard class 2) [16]. In the arable layer of soils of the Central Russian upland, the content of Cr is 44...130 mg/kg [22].

The diagrams of the of elements contents in the studied soils in comparison with the clark of the soil are presented on the Figure 1.

The studied elements can be divided into 3 groups: 1 – with contents below the clark of soil (Sr and Cr); 2 – with the content at the level of the clark of soil (Zn); 3 – contents are generally higher Clark of the soil (Cu and Pb). It is obvious that the contents of all studied elements in the soils of the industrial zone of the mining enterprises is not higher than in the soils of the site, remote from such facilities.

With 95% probability we can be argue that the content of copper and zinc in the topsoil of the soils of the site at a considerable distance from mining is higher than at the site near the open-pit mining of iron ore. Similarly, for strontium, lead and chromium we can be argue that their content in the arable layer of soils of the site at a considerable distance from mining is higher than for the area near the underground extraction of iron ore. Comparison of sites with open and underground mining shows that the content of strontium and chromium in the arable layer of soil was significantly higher near the quarries.

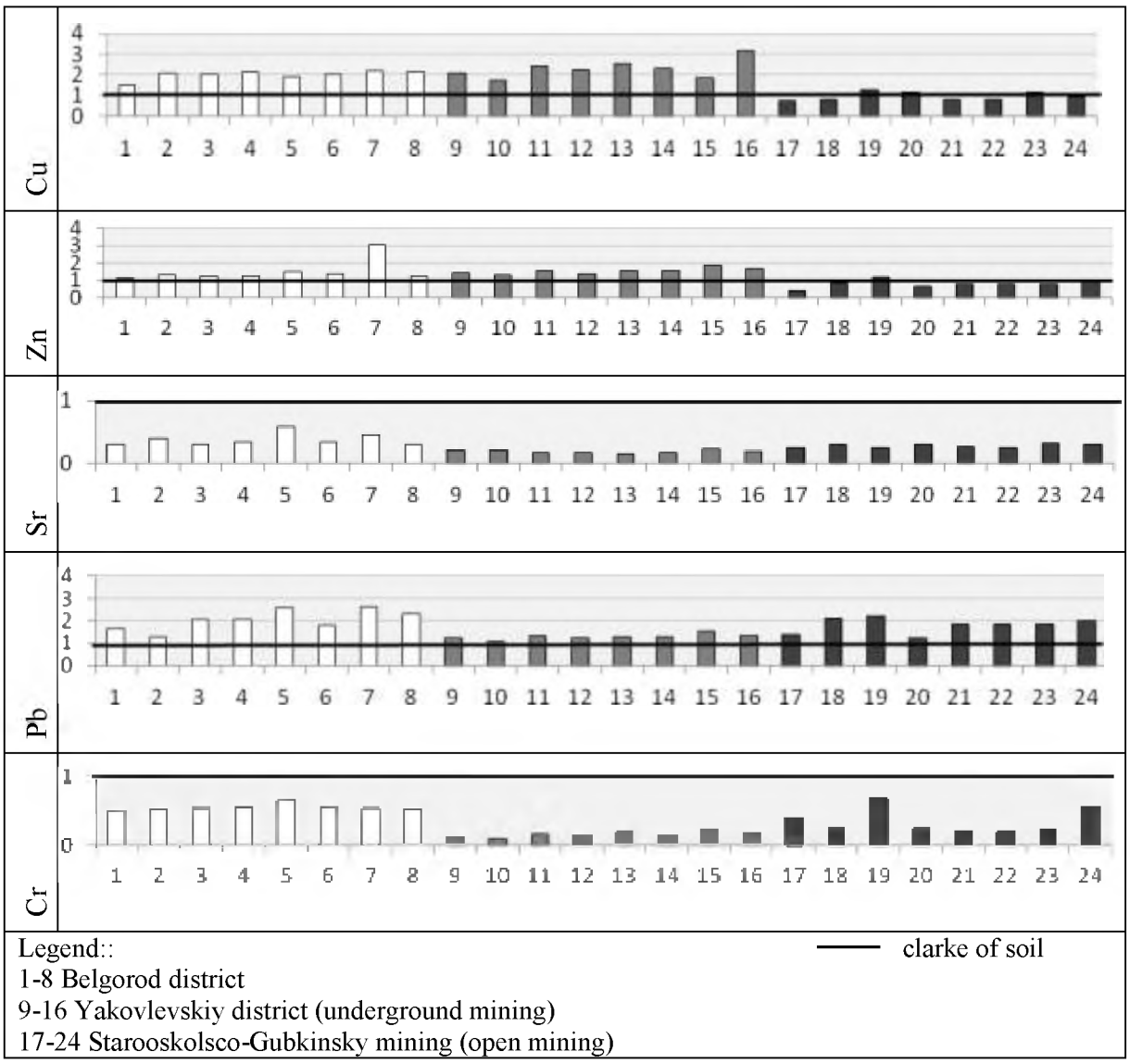

Fig. 1: The coefficient of the elements concentration (CC) in the studied soils in relation with the clarke of soil (after A. P. Vinogradov)

Figure 2 shows the concentration of elements in fractions of MPC/ APC in the studied soils. The indicator „maximum permissible concentration“ (MPC) or approximate permissible concentration (APC) is widely used in Russia to assess the degree of soil contamination with chemical substances.

The results of the evaluation showed that all the studied elements, except chromium, are in concentrations significantly below the MPC. Noteworthy, that it is the clear contradiction between the background gross chromium content in soil and maximum permissible concentrations of this element. As noted in [21], clarke of chromium in soil is 2 times higher than the MPC values.

Figure 3 shows the excess of the regional background concentration in the topsoil of the studied soils. The 3 variants of the ratio of concentrations are clearly distinguished:

1. The contents of the elements below background concentrations are typical for Cu and Zn in the topsoil of the soils close to the pits, the average values of the ratio between concentrations and background are 0.95 and 0.86, respectively.

2. The contents of elements at the level of background concentrations was determined for Sr in soils in the vicinity of the mine, the average value of the ratio between concentration and the background is 1.03.

3. The contents of elements above background concentrations are presented in all remaining versions of elements distribution in the soils of the plots. The average values of the ratio of concentrations and background are varied from 1.37 to 2.27.

The only element that significantly exceeds the background at all three sites is the lead. Obviously, this is due to the impact of transport.

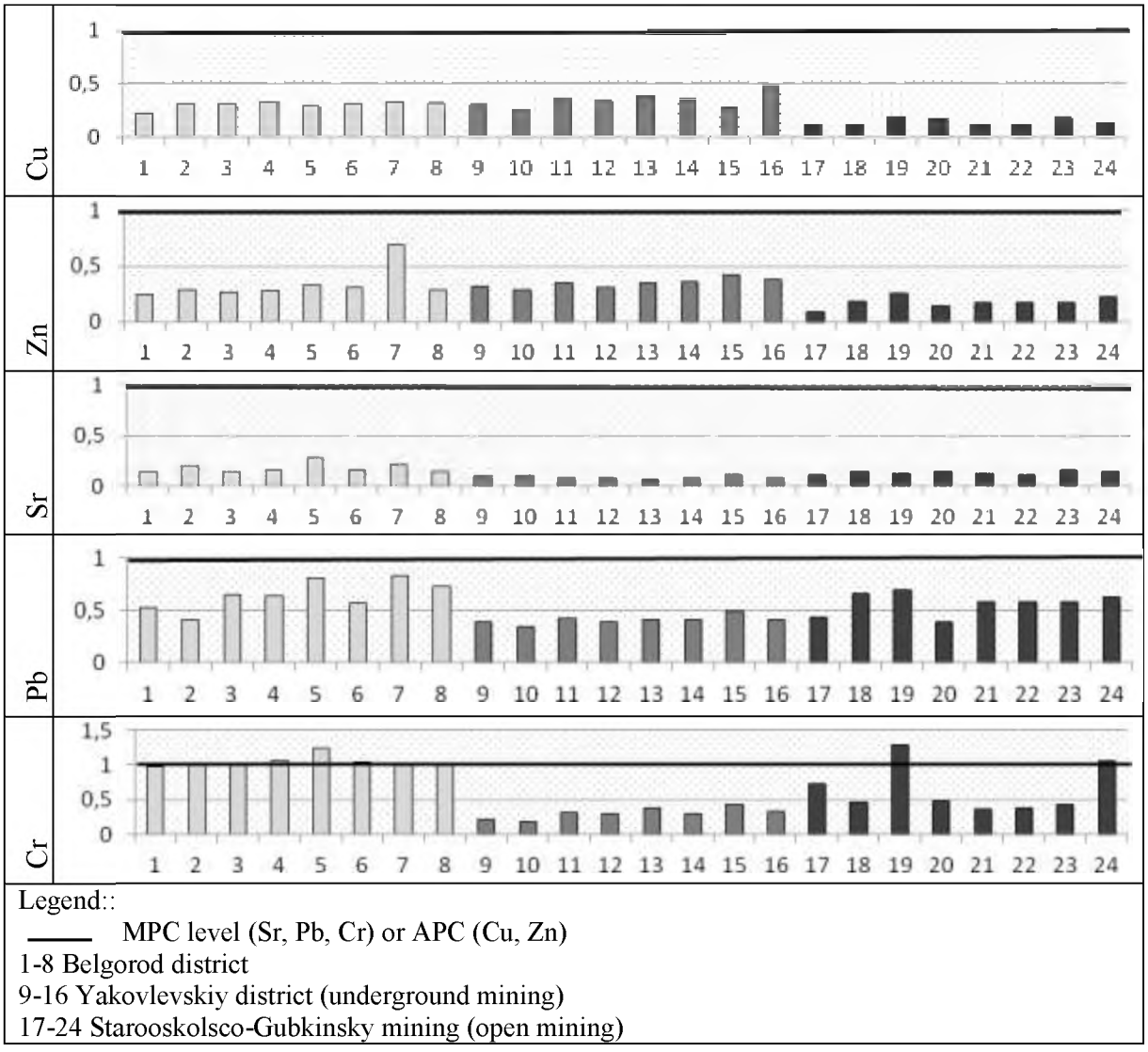

Fig. 2: The contents of Cu, Zn, Sr, Pb, and Cr in parts of MPC/APC in the studied soils

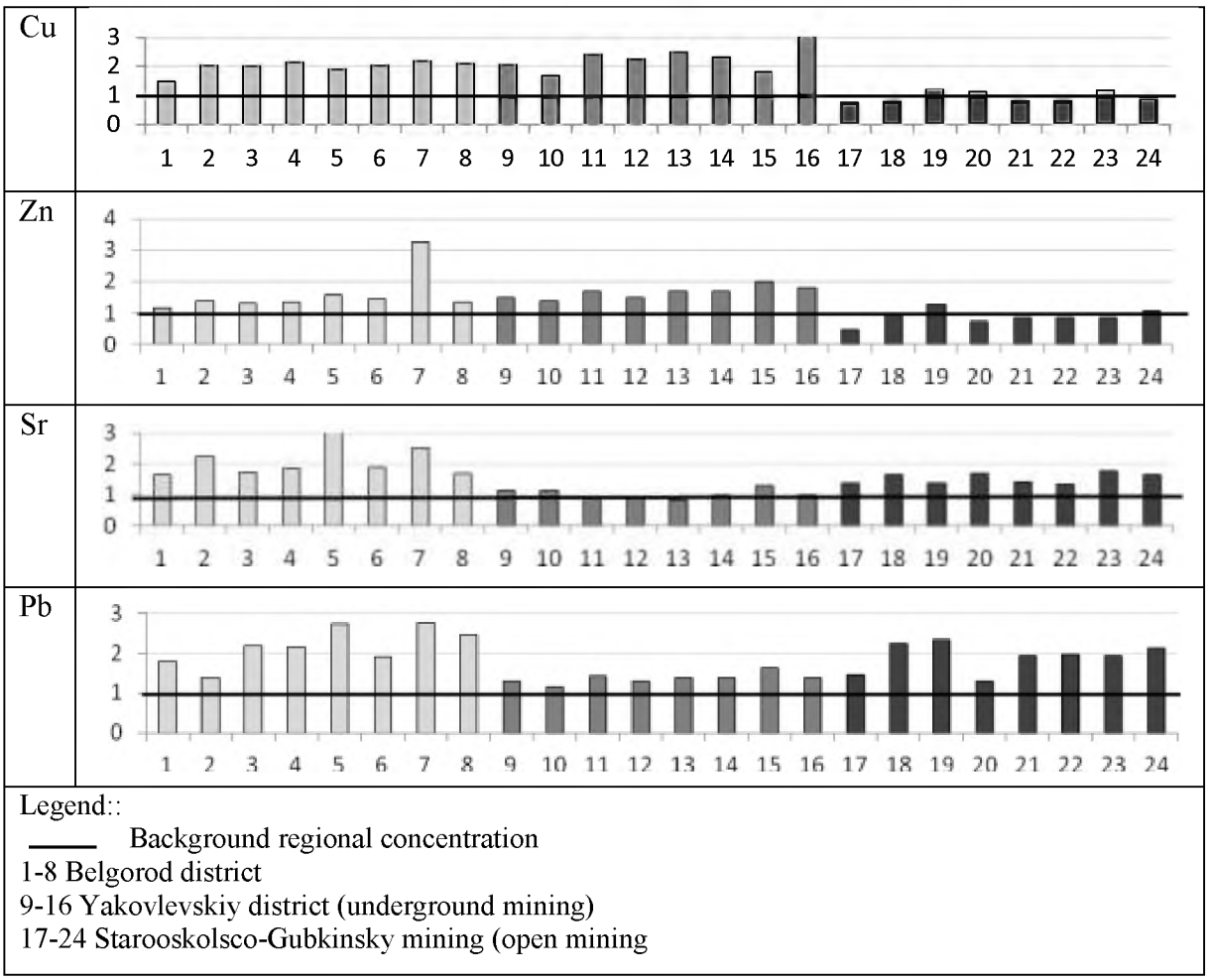

Fig. 3: Exceeding of the regional background concentrations in the arable layer of the studied soils

Conclusion

Thus, the comparison of the geochemical conditions in the soils for elements Cu, Zn, Sr, Pb, and Cr at sites remote from the mining enterprises and located in close proximity to underground mining or quarries, shows that processes of concentration are typical for Cu, Zn and Pb and for Cr and Sr - scattering.

The significant excess of elements in the arable layer of soil on the site significantly remote from the mining enterprises was revealed: copper and zinc (in comparison with the site near the open-pit mining of iron ore), strontium, lead and chromium (in comparison with the plot with underground mining of iron ore).

All studied elements, except chromium, are in concentrations significantly below the MPC.

At the same time, in the most of the options the background concentrations of the studied trace elements were exceeded. Lead stands out; it considerably exceeds the background of all three sites.

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