BIO Web of Conferences **95**, 02010 (2024) https://doi.org/10.1051/bioconf/20249502010
CIBTA-III-2024

Atmospheric air pollution of a mining town in the Kuzbass region by toxic metals

Natalia Rogova[1*], *Nadezhda* Rizhakova[1], *Elena* Pokrovskaya[1], *Maria* Tatarincheva[1], and *Ksenia* Tailasheva[1]

[1]TPU, Tomsk, Russia

Abstract. The paper analyses the results of active biomonitoring of atmospheric air pollution in the mining town of the Kuzbass region by the most toxic metals. The epiphytic moss Pylaisia polyantha (Hedw.) B. S. G. was used as a bioindicators; determination of metal content in moss samples was carried out using neutron activation analysis and atomic emission spectrometry methods. Based on the results of the study, spatial distributions for pollution levels of the most toxic metals were plotted and their sources were identified.

1 Introduction

Coal dust and emissions from coal industry enterprises contain a large amount of metals [1-3]. Prolonged exposure of the human body to metals combined with their ability to accumulate in tissues and organs can be one of the main causes of various serious diseases. For example, increased content of cadmium in the body leads to lung damage, bone softening, kidney damage; lead - to brain dysfunction, anaemia, nephropathy; arsenic - to diabetes, cancer, arrhythmia, encephalopathy; chromium - to fibrosis and lung cancer; etc.

It is known that metals can be divided into two main groups: essential (vital or biologically important) and toxic and poorly studied trace elements [4]. However, it should be borne in mind that the effect on the human body not only of toxic but also of biologically important elements depends on their dose. Therefore, some essential trace elements are also included in the lists of toxic elements under the condition of long-term exposure to the human body, vegetation, and foodstuffs. These include Fe, Co, Ni, Mn, Cu, Mo, Se, Cr, Zn high concentrations for some of them were determined in our study. Among the little-studied elements is uranium, found in large quantities in the study area. Even in small doses, this element and its radioactive decay products have not only toxic, but also radiation effects. Rare earth metals Lu, Nd and Eu, high concentrations of which have been detected at some observation points, can also be included among the poorly studied elements. The following metals are included in the Codex Alimentarius of the Joint Commission of the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO), among the components controlled in international food trade: Cd, Pb, As, Sr, Zn, Fe, Sb, Ni, Cr, Al, Sm. These metals also enter the food supply from atmospheric air through food chains.

* Corresponding author: rogova@tpu.ru

The aim of the study is to investigate the spatial distributions of the level of atmospheric air pollution in the mining town of Berezovsky, Kemerovo region, by metals belonging to the toxic group. The results were obtained by transplantation of epiphytic moss *Pylaisia polyantha*; the content of toxic elements in moss samples was determined by neutron activation analysis (NAA) and atomic emission spectrometry (AES) methods.

2 Materials and methods

Atmospheric air quality in accordance with regulatory documents [5] is determined by comparing the values of average (average monthly, average annual) and maximum concentrations of harmful substances with the standards adopted in the Russian Federation - maximum permissible concentrations (MPC). In most cases, the content of suspended particles, some gases (nitrogen and sulphur dioxides, carbon monoxide) and organic compounds (phenols, formaldehyde, ben(a)pyrene, etc.) is monitored, the concentrations of which are measured at stationary air quality control stations. The level of atmospheric air pollution by metals is practically not controlled due to difficulties in measuring average and maximum concentrations of metals in the air using traditional instrumental methods. The possibility of assessing the levels of atmospheric air pollution by metals is provided by the method of bioindicator mosses, which provides sufficiently large temporal exposures [6-8]. The natural content of metals in mosses measured in background samples can be used as MPC in this case. The coal industry is the main industry in the region. The study area includes the Beryozovskaya, Barzasskoye Comradeship, and Chernigovskaya coal preparation plants, the Beryozovskaya and Yuzhnaya mines, and the Chernigovets coal mine with an area of more than 30 km^2 (Figure1).

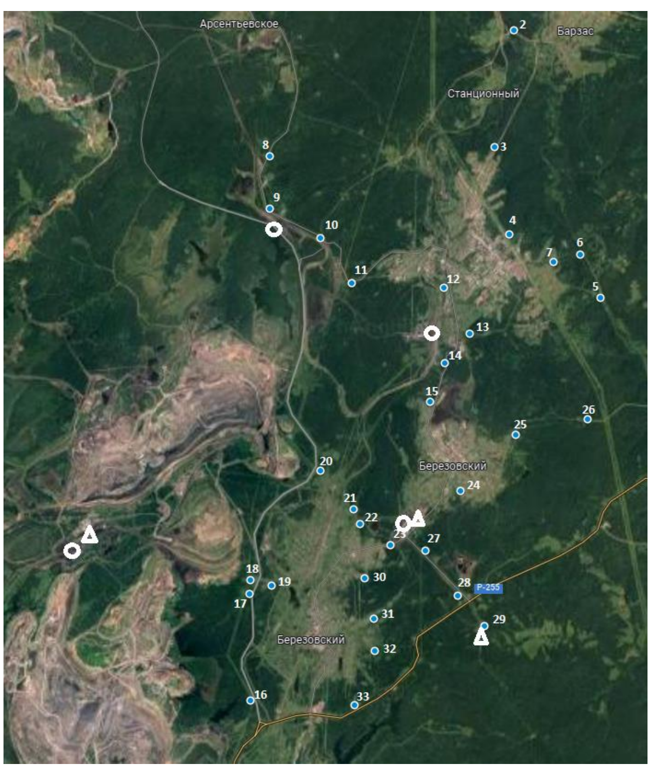

Fig. 1. Sampling map, triangle – mines, circle - concentrating plants.

According to climatic conditions determining the atmospheric dispersion capacity from low pollution sources, the study area belongs to unfavourable ones [9]. The method of active biomonitoring was used in the work; the methodology of the method is described in [10]. Figure 1 shows the scheme of moss-transplants placement. Metal concentrations in moss samples were determined by highly sensitive methods - NAA and NPP, the error of determination for NAA does not exceed 10-15%, for AES - (20-40) %. All moss samples were prepared for analysis according to the previously developed methodology for epiphytic moss [10]. This method includes washing in distilled water by dipping, drying at t=40˚C, and grinding in a porcelain mortar.

3 Results

Table 1 presents the results of measurements of concentrations of toxic metals obtained by the NPP method, concentrations of other metals, which are classified as toxic (Ba, Co, Cr, Cr, Eu, Fe, Hf, Lu, Mo, Nd, Sb, Sm, Sr, U, Zn,) are measured using NAA and are given in [10].

Table 1. Minimum, maximum, average, background concentration values, μg/g.

element	min/max	Mean/background	element	min/max	Mean/background
Al	1072/3340	1850/1386	As	0.37/2.21	1.23/0.44
Cd	0.15/3.54	0.56/0.14	Cu	4.2/20.9	6.6/4.2
Mn	420/1225	745/486	Ni	3.2/8.3	5.5/5.2
Pb	2.28/6.91	4.63/3.24	Se	0.07/5.03	0.76/0.22

4 Discussion

Analysis of the concentrations of metals determined in this study by AES, as well as metals determined by NAA, showed that the main sources of toxic elements are coal concentrating plant and coal mine. The highest U concentrations were found in the territory adjacent to mines, concentrating plants and coal mine; Ba - to the coal mine and concentrating plants "Beryozovskaya", "Chernigovskaya"; Mo - to concentrating plants "Beryozovskaya", "Barzasskoye Comradeship"; Sb - to the coal mine and Beryozovskaya coal concentrating plant; Co - to the coal mine and Beryozovskaya and Chernigovskaya coal concentrating plants; Sr - to Beryozovskaya and Barzasskoye Comradeship coal concentrating plants, etc. Concentrations of Fe, Ni, Mn, Pb, Cr and Al in most sample sites belong to the background range; concentrations of Ba, Zn, Co, Sm, Sr, Nd and Hf exceed the background on average 2...2.5 times. The ratio of concentrations averaged over all observation points to background values for As, Cd, Se, Eu belongs to the range from 3 to 4. Figures 2-4 shows the spatial distributions of As, Cd and Se as an example. The greatest contribution to the atmospheric air pollution of the study area is made by Sb, Lu, U and Mo, for which the ratio of mean concentrations to background concentrations is 4.9; 5.3; 9.5 and 11.5, respectively; spatial distributions for these elements are given in [10].

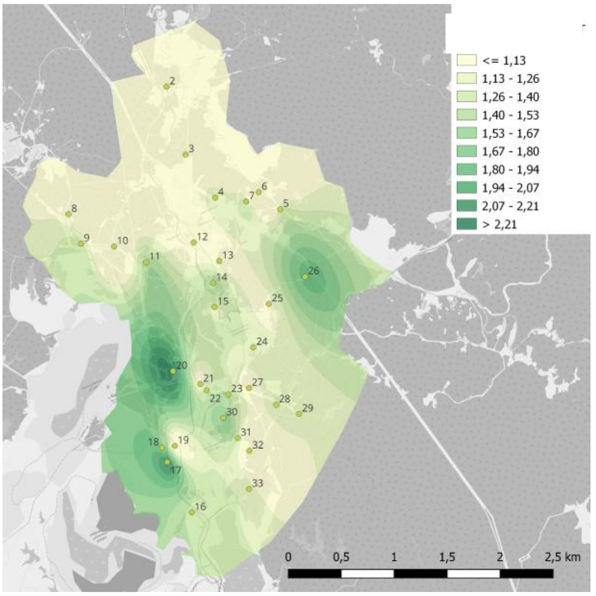

Fig. 2. Distribution of As concentrations (Berezovsky city), µg/g.

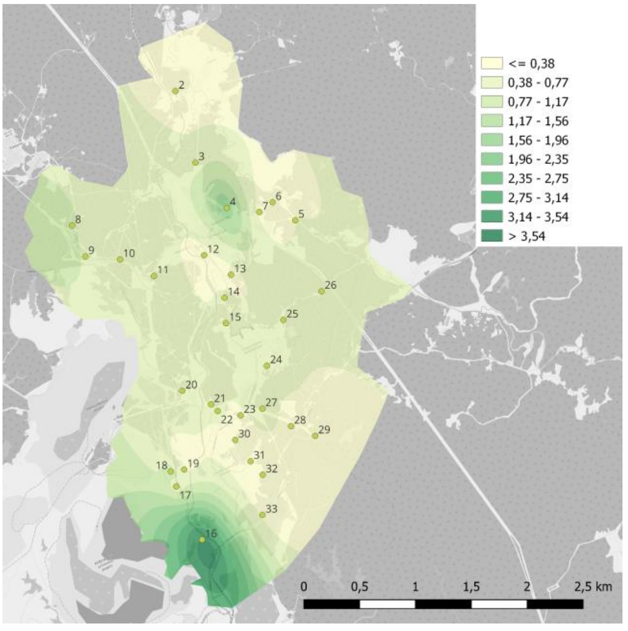

Fig. 3. Distribution of Cd concentrations (Berezovsky city), µg/g.

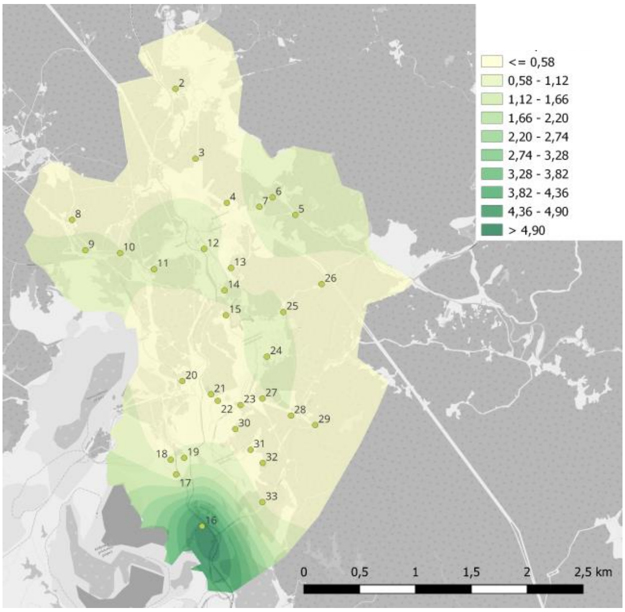

Fig. 4. Distribution of Se concentrations (Berezovsky city), µg/g.

5 Conclusion

Concentrations of Fe, Ni, Mn, Pb, Cr, and Al do not differ significantly from background values; the content of Ba, Zn, Nd, As, Cd, Se, and Eu is several times higher than background values. Antimony, lutetium, uranium and molybdenum make the greatest contribution to air pollution in Beryozovsky, Kemerovo Oblast, with average concentrations 5 and more times higher than background values. The highest concentrations, tens of times higher than background concentrations, were found for uranium and molybdenum. Molybdenum belongs to the second class of hazard in terms of toxicological effect; uranium is not only toxic but also radiation hazardous metal. The main sources of molybdenum are concentrating plants, uranium - mines, concentrating plants, coal mine.

Acknowledgement

The research is funded by the Russian Science Foundation (RSF) Grant Number 23-27-00186.

References

1. L.G. Shutko, L.L. Samorodova, Coal, **9, 1146**, 46-50 (2021)
2. Ya.E. Yudovich, M.P. Ketris, Coal Prod. Process. Techn., 48–73 (2015)
3. Ako, https://ako.ru›upload/medialibrary/a7b/doklad_2020.pdf
4. A.M. Prohorov, Biogenic elements (Soviet Encyclopaedia, Moscow, 1969-1978)
5. GOST 58577-19. Rules for establishing standards for permissible emissions of pollutants by projected and operating economic entities and methods for determining these standards

6. M. Rajfur, A. Stoica, P. Świsłowski, W. Stach, F. Ziegenbalg, E. Mattausch, Atmos., **15(1),** 102 (2024)
7. I. Zinicovscaia, O. Chaligava, N. Yushin, D. Grozdov, K. Vergel, C. Hramco, Arch. Environ. Contam. Toxicol., **82,** 355–366 (2022)
8. A. Baczewska-Dąbrowska, B. Gworek, W. Dmuchowski. Environ.l Prot. Nat. Resour., **34(2),** 19-30 (2023)
9. RD 52.04.667-2005, Documents on the state of atmospheric pollution in cities for informing state bodies, public and population (2005)
10. N. Rizhakova, N. Rogova, A. Borisenko, E. Pokrovskaya, M. Tatarintseva, E3S Web Conf., **463**, 02015 (2023)