

Evaluation of heavy metal pollution in bogs of Tomsk region on change in biogeochemical activity of ericaceous shrubs

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Abstract. The article discusses the change in biogeochemical activity of plant species in bogs under the influence of various types of human impact (roads, cities, drainage of mires, fire). It has been established that ericaceous shrubs, depending on the species, react with varying degrees of intensity to anthropogenic influences. The biogeochemical activity of species increased by 2.5 to 4.8 times in polluted sites.

1. Introduction

Bogs are unique ecosystems that are the habitats of highly specialized species. The supply of mineral nutrition to plants in such bogs is very low; the main source of elements is atmospheric precipitation [1, 2]. Currently, the three main sources of metals in soils are industrialization, urbanization and agricultural practices. Heavy metals in the soil from anthropogenic sources tend to be more mobile and hence bioavailable than those from lithogenic soil formation [3]. The absorption and accumulation of heavy metals by plants depends on the chemical form of metal compounds, soil factors and characteristics of the plant [4, 5, 6]. Mires have very low environmental buffer capacity and therefore their response to atmospheric pollution is more pronounced than in many other ecosystems [7, 8]. It is necessary to know the levels of metals in peat and plants to assess potential environmental damage and develop mitigation strategies [9]. Large areas of bogs are characteristic of the Tomsk region, an area which is swamped by different sources, from 39.5% to 50% [10]. Significant areas of mires are affected by pollution as a result of the influence of the Tomsk–Seversk industrial agglomeration, roads, drainage, fires, peat extraction, oil and gas. Mires located near settlements are often used to discharge sewage.

2. Method and data

Taking into account the listed anthropogenic factors, 19 mire sites which are affected by one or more of these factors were selected. As a background, 13 bog sites significantly removed from pollution sources were selected. Previously conducted studies have shown that the content of heavy metals in plants of the mires is within or below background concentrations for the study region [11]. The research was conducted from 2014 to 2016, in mires located in Tomsk, Shegarsky, Bakcharsky, Kozhevnikovsky, Kolpashevsky, Kargasoksky and Parabelsk districts of the Tomsk region (figure 1). To study the effect of heavy metal contamination four kinds of shrub widespread in bogs of the Tomsk region, were selected: *Andromeda polifolia* L., *Chamaedaphne calyculata* (L.) Moench, *Ledum palustre* L. and *Vaccinium uliginosum* L. For all the investigated sites, plant and peat samples were selected in July 2015 for the determination of Zn, Cd, Pb and Cu. In plants of each of the species studied, a mixed sample of



shoots of the current year was selected from an area of 10×10 m. Samples of peat were selected in the root layer. Determination of the content of heavy metals in plants and peat was conducted by inversion voltammetry in the laboratory analytical centre of the Siberian Research Institute of Agriculture and Peat. Statistical analysis was performed on the basis of StatSoft Statistica for Windows 6.0 and Excel 7.0. Comparison and significant differences between the samples were set using the nonparametric Mann–Whitney test. To determine the influence of pollution on the accumulation of heavy metals the coefficient of biological absorption (CBA), which reflects the ratio of the element content in plant ash to its content in peat [12], and the biogeochemical activity of the species (BAS) which is the sum of the CBA of the elements under consideration were calculated [13].

3. Results

When comparing the absolute values of the heavy metal content in plants it was found that not all of the elements investigated had a significantly increased concentration in plants from sites prone to anthropogenic impact. In *A. polifolia* an increase in the content of Zn and Cu was observed, in *V. uliginosum* the concentration of Zn, Cu and Cd increased, and the content of Zn, Pb and Cu increased in *C. calyculata*. Only in *L. palustre* was the concentration of all the elements studied increased from contaminated sites: Zn, Cd, Pb and Cu, when compared with similar areas of bogs remote from pollution sources.

Absolute values of the concentration of elements in plants do not take into account the influence of the content of heavy metals in peat. However, when comparing not absolute but relative indicators, for example the CBA, there were differences in all elements between background and contaminated sites ($U = 5$; $p < 0.05$).

The BAS level also significantly increased in sites prone to anthropogenic impact ($U = 85$, $p < 0.001$). In addition, the spread of values was much larger for the disturbed sites (figure 1).

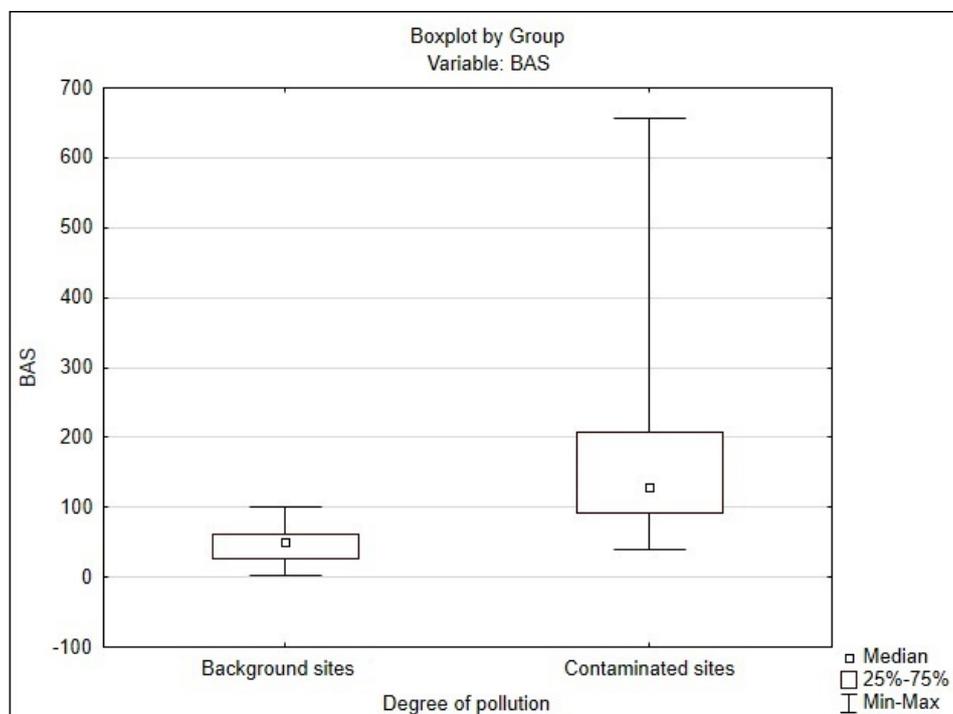


Figure 1. Differences in the distribution of BAS values for background and contaminated sites.

The biogeochemical activity of all the species studied significantly increased in the disturbed mire sites. In the background sites the biogeochemical activity was the same for different species of shrub. In areas subject to anthropogenic effects the equilibrium is violated so the biogeochemical activity of various species has increased unevenly. For *C. calyculata* and *L. palustre* biogeochemical activity of the species increased approximately 3-fold, while *A. polifolia* and *V. uliginosum* biogeochemical activity of the species increased 7-fold (figure 2).

Thus, *A. polifolia* and *V. uliginosum* were species most sensitive to changes in the microelemental composition of the environment.

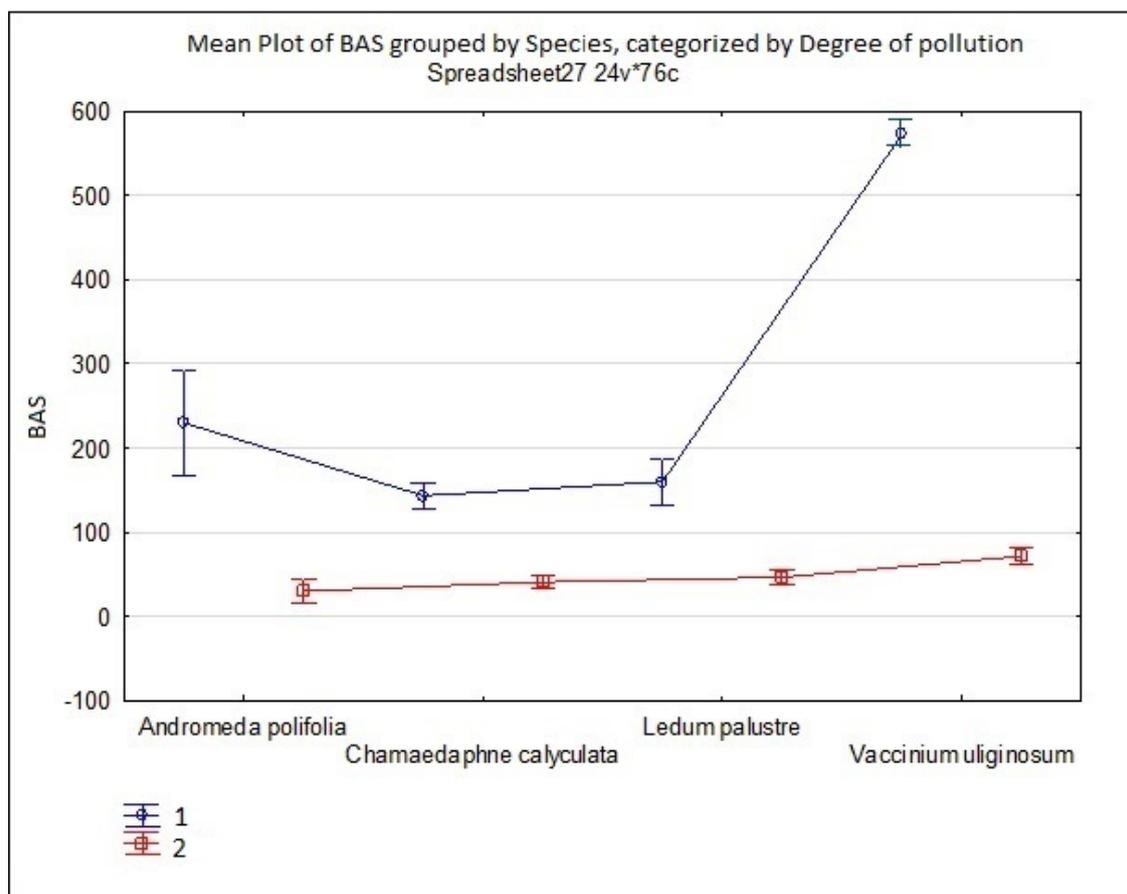


Figure 2. Comparison of biogeochemical activity values of species in sections 1 – subject to anthropogenic impact – and 2 – remote from pollution sources.

The biogeochemical activity of the species data obtained also showed a dependence on the type of pollution. There was an increase in biogeochemical activity of the species of approximately 2.5 times in areas affected by roads compared with the background values. In dry areas of mires, biogeochemical activity of the species increased by 4.3 times and in the zone of city influence by 4.6 times in comparison with uncontaminated areas. In mires exposed to fire, biogeochemical activity of the species increased on average by 4.8 times (figure 3).

The differences in the increase in the types of biogeochemical activity are due to different levels of contamination and varying availability of trace elements for plants. On mires affected by the city and roads the main source of pollution is atmospheric transport of elements from vehicles and industrial plants. On the drained bogs the degree of peat decomposition increases; as a result of this the availability of trace elements for plants is increased. After a fire in the mires the amount of mobile trace elements in peat also increases.

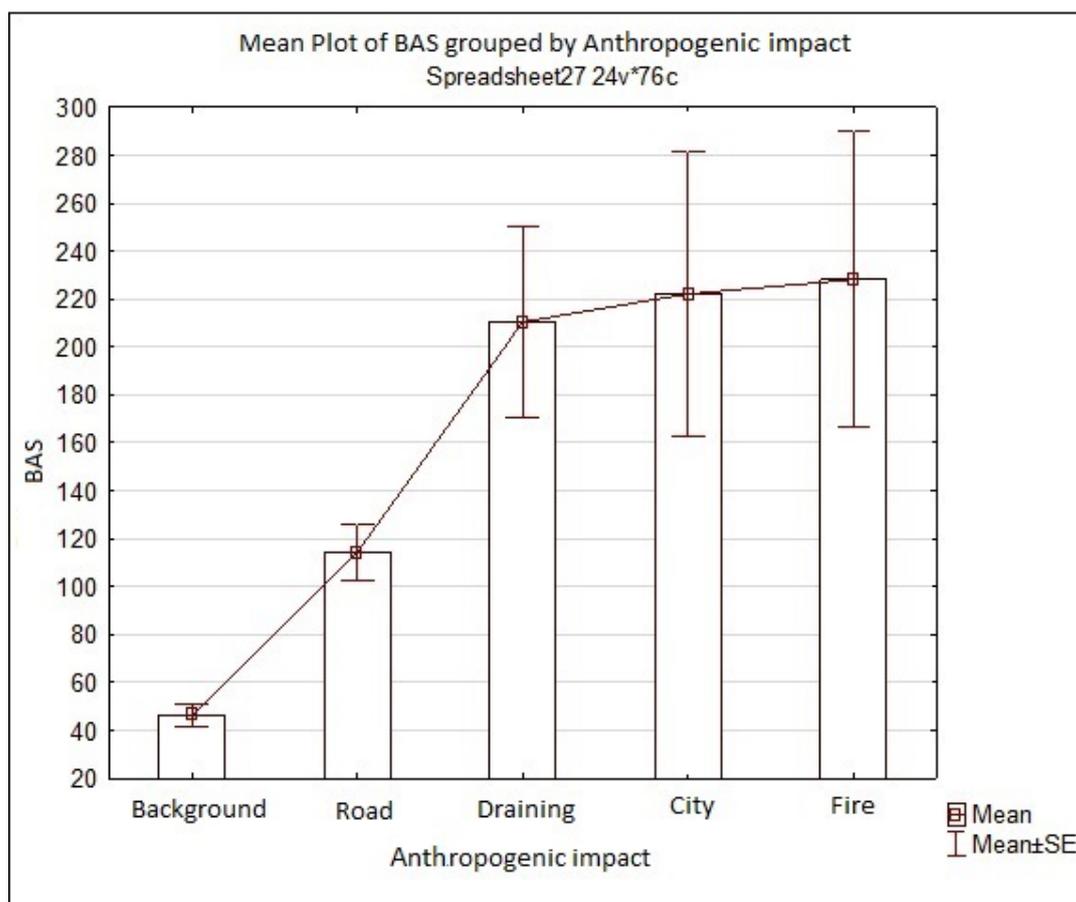


Figure 3. Influence of different types of anthropogenic impact on the change in biogeochemical activity of the species.

4. Conclusions

As a result of the study, it can be concluded that ericaceous shrubs can serve as indicators of pollution of mires with heavy metals. The most sensitive species to contamination with heavy metals from the environment were *A. polifolia* and *V. uliginosum*. Despite a slight increase in heavy metal content in contaminated sites bog plants had a sharply increased intensity of biological absorption under anthropogenic influence. Therefore, in determining the degree of pollution, instead of comparing the absolute values of the content of elements in plants and peat, it is more indicative to compare the biogeochemical activity of the species.

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