European Journal of Sustainable Development (2014), **3**, 4, 269-276 ISSN: 2239-5938
Doi: 10.14207/ejsd.2014.v3n4p269

Pollution of bogs in Tomsk region (Western Siberia, Russia) as an indicator of sustainable development

By Mezhibor A.M.[1]

Abstract
Wetlands play a key role in the climatic balance of our planet. Thus, their protection from anthropogenic pollution is an important target for sustainable development of environment. Wetlands have a special significance for the Siberian region of Russia where they take great territories. Peat bogs, being unique ecosystems among wetlands, have properties to save the history of atmospheric pollution. The particularity of peat bogs is determined by their nutrition - they receive chemical elements mostly from the atmosphere. Some peat bogs in Siberia (Tomsk region, Russia) were studied to determine the degree of environment pollution during the last century and the change of geochemical composition of peat in time. These studies determined the increase of pollution in the region from the middle of 20th century because of the sharp industrial development. The data on the pollution of peat bogs allow concluding that the geochemical peculiarities of different parts of Tomsk region influenced by different types of industry: nuclear facility, coal-burning power stations and oil refineries. This method can be used together with other methods implemented for the detection of anthropogenic pollution and the results can be used as indicative parameters in environmental change. The results of the studies can be used for the development of recommendations in the decrease of the industry influence for the sustainable development of Siberian region.

Keywords: upland peat, air pollution, Tomsk region, indicators of sustainable development

1. Introduction

Environmental sustainability is one of the main directions for the sustainable development of our planet. Thus, for the sustainable development of the environment criterions for the estimation of environmental quality should be worked out. These criterions can include various indicators, which are individual for different territories and geographic regions. Such indicators measure the degree of the environmental change under the anthropogenic influence indicating a positive or negative direction of sustainable environmental development.
Nowadays we have solid evidence of climate change, with projections pointing to an increase in extreme environmental events with potentially devastating consequences for the systems that support human life and society (Strange & Bayley, 2008). Most of deteriorations in environmental ecosystems and climate balance are connected with the anthropogenic impact. Indeed, the accumulation of a number of bad habits and

[1] Tomsk Polytechnic University, Tomsk, Russia.

"unsustainable" practices seems to have led to critical stresses on societies and the environment (Strange & Bayley, 2008).

Atmospheric pollutants from energy transformation and energy consumption, but also from industrial processes, are the main contributors to regional and local air pollution. Major concerns relate to their effects on human health and ecosystems. Human exposure is particularly high in urban areas where economic activities are concentrated. Air pollution may also damage ecosystems, buildings and monuments, for example through acid precipitation and deposition (Towards sustainable development, 1998).

When estimating the air quality it is important to choose appropriate method for this estimation. The use of peat deposits for air pollution estimation has obtained wide application because of some advantages:

- wide spreading of bogs in the temperate climate zone of the northern hemisphere where contaminants are mainly concentrated;
-a property of peat to keep different chemical elements, that hinders from their migration;
- an opportunity to obtain representative data using only some peat sections.

Because of a property of peat keep pollutants inside and annual peat formation, peat bogs can save the history of atmospheric deposition and this feature can be also used to predict future accumulations on the data of industry development.

Peat bogs play a significant role in climate balance, serving as a huge buffer of carbon. Their protection in this case help to keep natural equilibrium.

Peat bogs as an indicator of sustainable development presented here relate to the following criterions:

- pollutants emissions (representing as chemical elements) and changes of their composition over time, as well as emission intensities expressed as quantities emitted per unit (mg per one kg of dry matter), presented with related changes in economic growth and fossil fuel supply. These indicators should be however supplemented with information on the acidity and chemical composition of rain and snow in selected region, and the excess of critical loads in soils and waters which reflect the actual contamination of the environment.
- air quality expressed as trends in annual chemical elements concentrations for selected territories. In the longer term, indicators should focus on population exposure to air pollution. They should be additionally complemented with information on known air pollutants.

These two criterions can be combined in an indicator of atmospheric pollution through bog pollution.

In Tomsk region peat bogs play a significant role in the ecosystems balance, thus, it is very important to estimate their role in the sustainability of the region environment.

Many data on bog research testify about the increase of anthropogenic load during the last century (West, 1997; Aubert, 2006; Mezhibor, 2011; Bao, 2014). Thus, beat bogs serve as a simple and cheap method for the estimation of environmental change, intensity of anthropogenic load, and sustainability of environment.

2. Methods

Some peat bogs in Tomsk region were sampled for the study. Tomsk region has huge territories of wetlands that allow using them for various environmental studies. The location of studied bogs was determined in view of the concentration of main enterprises-polluters and a background territory was also estimated for the comparison. Peat samples were collected from three bogs near Tomsk city and its town-satellite Seversk (bogs PR, CH, V). These settlements are combined by the name of Tomsk-Seversk industrial agglomeration (TSIA). There the main polluters are nuclear facility in Seversk, petro-chemical plant between Tomsk and Seversk, and coal-fired power stations in Tomsk and Seversk. The second industrial area for the study was the region of oil and gas exploration in the western part of Tomsk region. Also three bogs from this area were sampled (bogs I, ZM, O). And the third group of samples from one bog was collected in a background territory in the south of Tomsk region far from the influence of any anthropogenic sources (bog MI). The location of sampling is represented at the Figure 1. The peat samples were analyzed by the method of neutron activation analysis (INAA) at the Geochemical laboratory of the Department of Geoecology and Geochemistry of Tomsk Polytechnic University. This laboratory is certified and the INAA method has high quality of trace elements detection in peat.

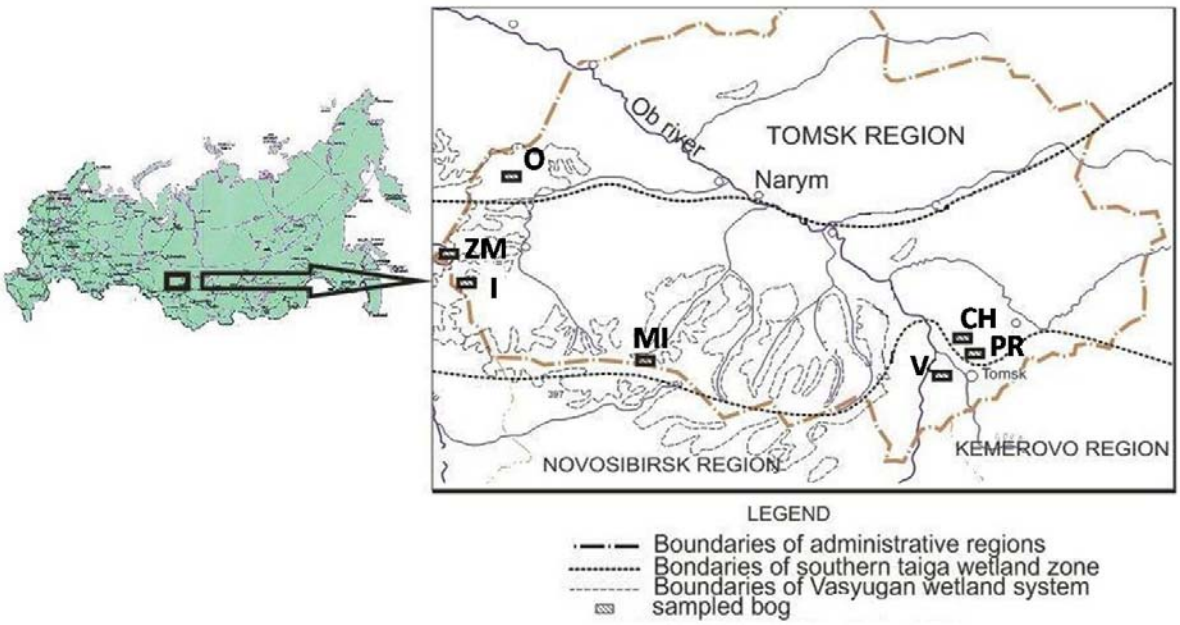

Fig. 1. *Location of the studied region and sampled bogs*

3. Results and discussion

In total 23 chemical elements were detected in the peat. Table 1 represents the concentrations of major and trace elements in the studied upland bogs. It is obvious that

the concentrations of the majority of chemical elements in the peat from the TSIA zone, especially in the bog PR, are considerably higher than in other studied bogs.
As we can see from the figures of the distribution of some chemical elements in peat sections (figures 2-5), the bogs located close to the industrial area of TSIA are more polluted. For example, a bog located in the predominant wind direction, has high ash yield in the upper part of bog (up to 13%), that can be explained by the considerable increase of dust load.
For the region of oil and gas deposits exploration we observe lower concentrations of chemical elements, but they are higher than in the background region. For the peat samples from this region higher concentrations of some metals (Sc, Ar, Co, Sb, Ba, La, Yb), in comparison with the background, were found.

Table 1. Mean contents of chemical elements in the 50-cm layer of upland peat of some bogs in Tomsk region.

Elements	Element concentration in bogs, mg·kg^{-1}						
	MI	I	ZM	O	CH	V	PR
Na (%)	0,03	7,71	0,04	0,03	0,04	--	***0,09***
Ca (%)	0,24	0,34	0,29	0,31	***0,73***	--	***0,43***
Sc	0,33	0,22	**0,76**	0,34	0,53	0,49	***1,61***
Cr	3,3	0,4	***11,2***	6,4	***11,9***	9,1	***14,7***
Fe (%)	0,12	0,23	0,28	0,16	0,18	0,17	***0,46***
Co	0,34	***1,29***	***1,10***	0,78	***1,18***	0,81	***2,77***
Br	6,8	7,7	3,7	7,8	***10,5***	7,1	4,6
Rb	6,9	--	7,4	4,1	--	--	***11,4***
Sb	0,17	0,06	***0,39***	***0,33***	***0,56***	***0,35***	***0,39***
Cs	0,14	0,22	0,33	0,20	0,24	0,19	***0,92***
Ba	35,0	0,2	***62,4***	35,8	31,7	--	***117,0***
La	0,88	0,06	***1,42***	0,03	***2,41***	***2,22***	***3,74***
Ce	1,7	1,5	4,4	2,3	3,4	2,2	***9,1***
Sm	0,17	0,34	0,28	0,20	0,30	0,33	***0,69***
Eu	0,04	0,06	0,09	0,05	0,09	0,08	***0,17***
Tb	0,02	0,04	0,05	0,03	-	0,04	***0,11***
Yb	0,09	***0,16***	***0,15***	***0,11***	-	***0,13***	***0,37***
Lu	0,02	0,02	0,02	0,02	-	0,01	***0,05***
Hf	0,09	0,19	0,31	0,14	0,19	***0,30***	***0,76***
Ta	0,03	--	0,05	0,09	-	--	***0,21***
Au	0,004	0,02	0,04	0,02	-	0,01	0,004
Th	0,25	0,4	0,55	0,23	***0,69***	0,33	***1,7***
U	0,12	0,02	0,11	0,06	-	***0,24***	***0,66***

Notice: - no data, -- element concentration is lower than detection limit. The letters mean the names of bogs: MI – Malaya Icha, I – Iksinskoe, ZM – Zapadno-Moiseevskoe, O – Ozernoe, CH – Chistoe, V – Vodorazdelnoe, PR – Petropavlovsky Ryam.

In the regions with industrial development the environmental state has changed during the period of industrial development. Many changes are characteristic for TSIA location. Since the period of intensive economical and industrial development of Tomsk in the 50th of the XXth century the concentrations of many chemical elements had sharply increased. We can observe it from the depth of 23 cm of the bog PR (Figures 2-5). At present this area is under the level of unsustainable environmental state. According to the anthropogenic load in comparison with background region, concentrations of the majority of trace elements 2-8 times exceed the background concentrations.

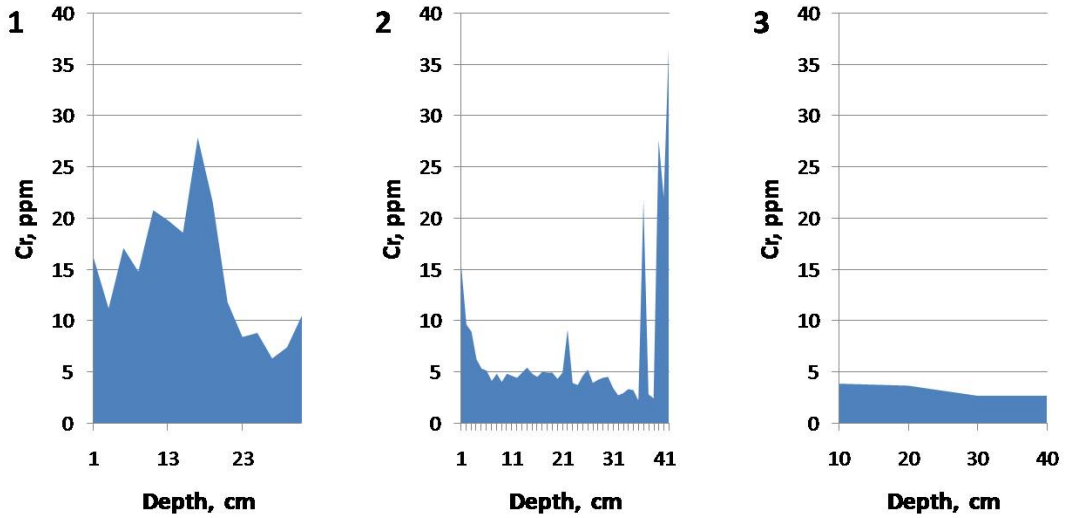

Fig. 2. *Dynamic of chromium change in peat sections, reflecting air pollution (bogs: 1 – PR, 2 – ZM, 3 – MI)*

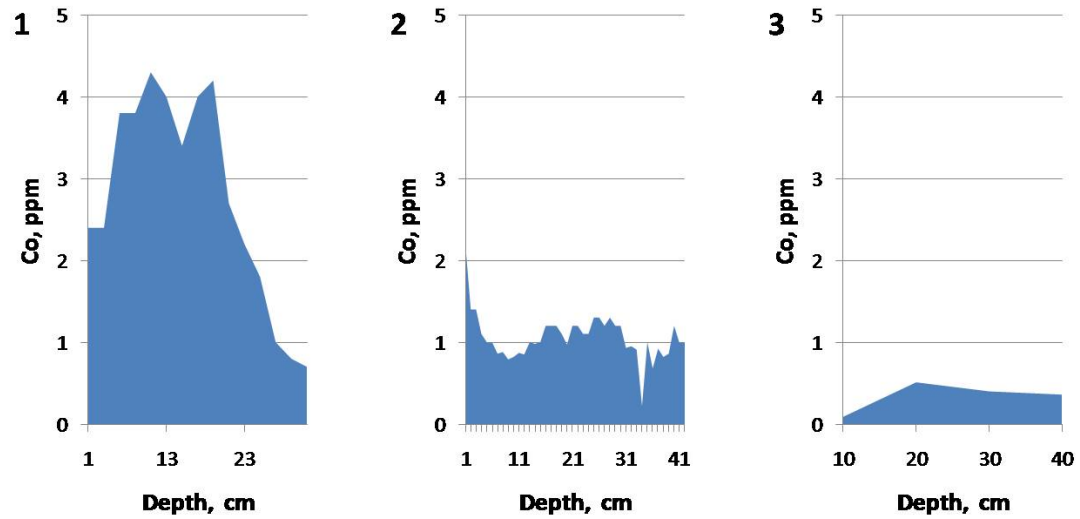

Fig. 3. *Dynamic of cobalt change in peat sections, reflecting air pollution (bogs: 1 – PR, 2 – ZM, 3 – MI)*

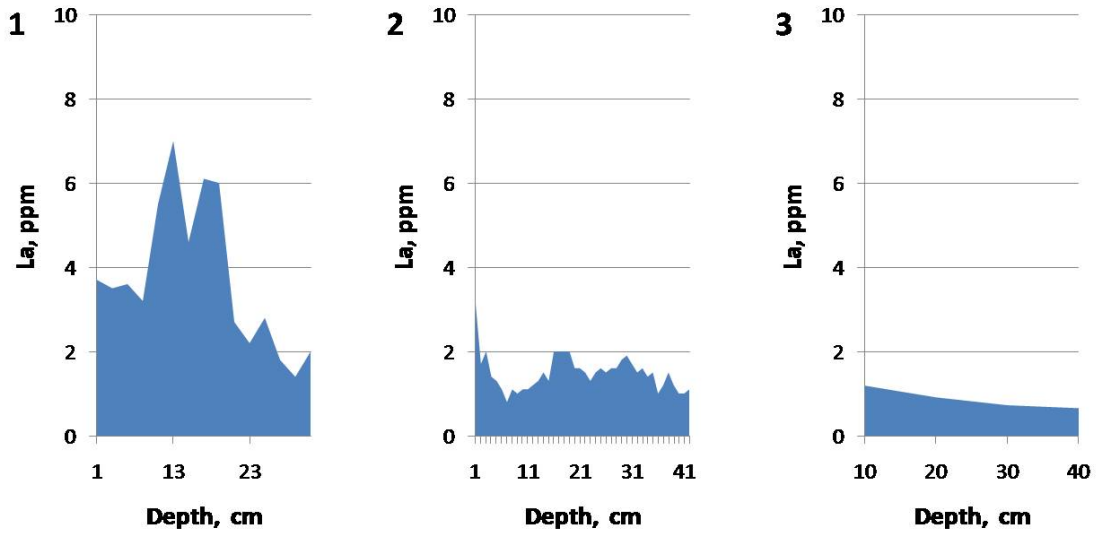

Fig. 4. *Dynamic of lanthanum change in peat sections, reflecting air pollution (bogs: 1 – PR, 2 – ZM, 3 – MI)*

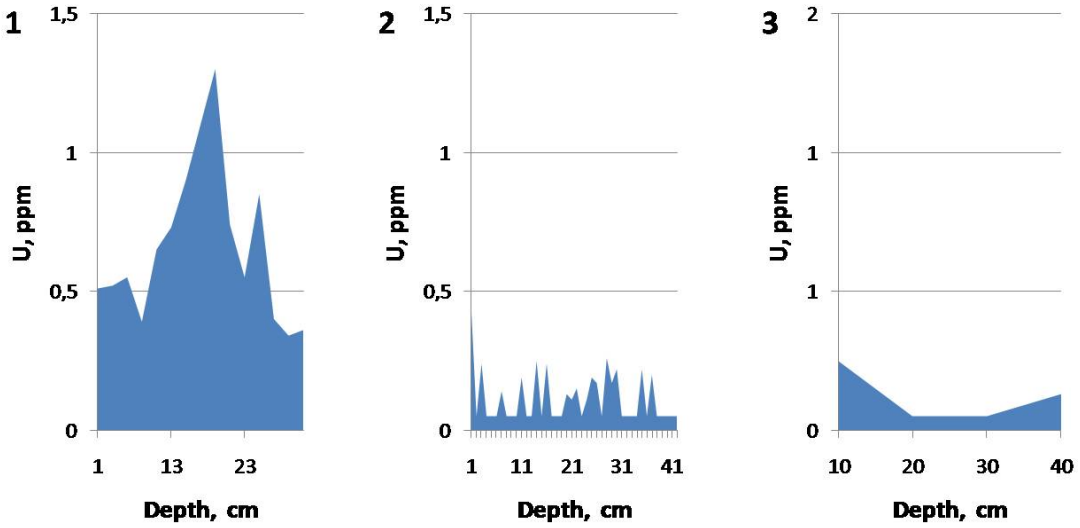

Fig. 5. *Dynamic of uranium change in peat sections, reflecting air pollution (bogs: 1 – PR, 2 – ZM, 3 – MI)*

Thus, in the background territory we do not observe sharp changes in the geochemical composition of peat accumulated in different time periods. When we examine peat sections from the region of oil exploration, we can observe moderate increase in concentrations of chemical elements. And in the zone of Tomsk-Seversk industrial agglomeration we observe a sharp increase of the elements concentrations, connected with the industrial influence. So, peat deposits can represent fast and complex information about the industrial load on environment. These data can be used also for the prognosis of people health, because peat deposits allow defining pollutions by a wide

range of chemical elements: metals, rare and radioactive which have a definite influence on human health.

Conclusion

The results of this research showed, that in the vicinity of Tomsk city peat bogs are contaminated with many trace elements. They are different metals, including rare earth and radioactive elements. In the region of oil and gas industry of Tomsk region we can also observe high concentrations of some chemical elements in comparison with the background territory. Peat of the studied bogs reflect the degree of atmosphere pollution and therefore peat can be used as an indicator for sustainable environmental development in Tomsk region, where peat bogs occur overall.

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