

Geochemical characteristics of peat from two raised bogs of Germany

A M Mezhbor

Department of Natural Resources, Tomsk Polytechnic University, 30 Lenin Avenue,
Tomsk, Russia

amezhbor@gmail.com

Abstract. Peat has a wide range of applications in different spheres of human activity, and this is a reason for a comprehensive study. This research represents the results of an ICP-MS study of moss and peat samples from two raised bogs of Germany. Because of the wide use of sphagnum moss and peat, determining their geochemical characteristics is an important issue. According to the results obtained, we can resume that the moss samples from Germany are rich in Cu, As, Y, Zr, Nb, and REE. The geochemical composition of the bogs reflects the regional environmental features and anthropogenic influence.

1. Introduction

Peat is an organic substance forming by weak decomposition of the mosses growing in wetlands. Peat has a wide range of applications in different spheres of human activity, including its use as a fuel. Because of the great importance of peat for humans, it is necessary to determine the chemical composition of peat from different regions. When peat deposits are located in areas under the influence of anthropogenic activity, determining their geochemical features is even more necessary for a subsequent peat use.

The geochemical features of raised peat deposits (ombrotrophic bogs) are defined, first of all, by the mineral composition of the underlying grounds and by the surrounding dry lands. The wind soil erosion is also an important provider of atmospheric dust (clay minerals) in the bogs. Chemical elements, as components of various substances, are deposited on the bog surface by wet deposition and by dry or cloud (fog) water deposition. Because of weak decomposition, the sphagnum mosses forming the peat deposits can save the falling from the atmosphere particles *in situ*. Usually the chemical elements entering bogs from the atmosphere are not subject to significant post-depositional dislocations because of the properties of sphagnum moss to retain them by its “air cells” and accumulations in the root air spaces [3, 5].

There is lack of data on the bog geochemistry of Germany. The concentrations of some chemical elements in the peat in Germany were estimated in a bog from the Black forest [2] and in sphagnum mosses from 8 bogs [6]. The estimates made in [2] relate to the rare earth elements (REE) and do not include some chemical elements presented in this work. The results for 8 bogs of Germany [6] relate only to living sphagnum moss. The objective of this study is to characterize the geochemical features of peat from two bogs of Germany (central part) with the aim to determine the accumulation of chemical elements by sphagnum mosses and peat. The results of the study can be used in different



spheres of human activity and for other studies connected with the research of peat and sphagnum moss.

2. Sampling sites and methods

For the present research two raised bogs located in the central part of Germany were sampled in September 2011: Strohn Maarchen (Eifel region) and Rotes Moor (Hassian Rhoen) (Figure 1). The central part of Germany has temperate-oceanic climate with relatively cold winters and warm summers. Strohn Maarchen bog is located in an agricultural and touristic region at the foot of a former volcano within the Eifel volcanic field. The underlying magma rocks are enriched in light REE, Zr, Nb, Rb, Ba, U, and Th [7]. Rotes Moor is located in a mountain region without direct anthropogenic influence. The underlying rocks in this area are generally composed by sandstones [4].

Samples of moss and 5-cm of peat were taken with a stainless knife (to exclude any contamination of peat samples) and put into plastic airproof bags. The samples were transported to a laboratory and dried at room temperature for obtaining a constant weight. After that the samples were milled into powder using an electrical stainless grinder. Peat samples of 100 mg weight were studied by mass-spectrometry with inductively-coupled plasma (ICP-MS) at a laboratory of the Chemistry Department of Vladimir State University (analyst I. Podkozlin) with an equipment called ELAN DRC II (PerkinElmer). The ash yield was determined additionally. The samples were weighted, and then dried in a muffle furnace at a temperature of 500°C during four hours. After stabilization of the ash mass, the percent of the ash yield was calculated.



Figure 1. A scheme of location of the bogs:
1 - Strohn Maarchen, 2 - Rotes Moor.

3. Results and Discussion

When comparing the results obtained for chemical element concentrations in moss and peat, we observe a similar character of the distributions of chemical elements in the bogs (Figure 2).

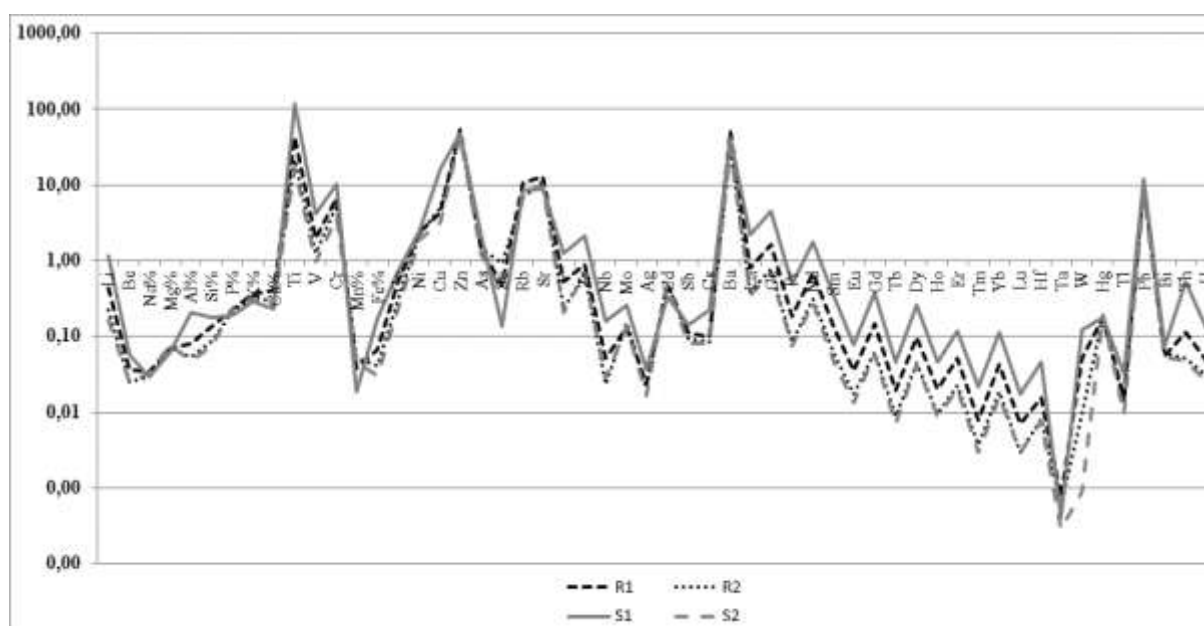


Figure 2. Concentrations of chemical elements ($\text{mg}\cdot\text{kg}^{-1}$) in moss (R1 – Rotes Moor, S1 – Strohner Maarchen) and peat (R2 – Rotes Moor, S2 – Strohner Maarchen) of the bogs.

Higher concentrations of the chemical elements were found in the moss from Strohner Maarchen in comparison with the moss from Rotes Moor. The concentrations of some chemical elements in the moss of Strohner Maarchen are two and more times higher for Li, Al, Ti, V, Fe, Cu, Y, Zr, Nb, Mo, Ag, Cs, REE, Hf, W, Th, and U (Table 1). The results for the mosses of these bogs have shown close values compared with mean estimates of some chemical elements (Ca, Al, Fe, K, Mn, Ni, Pb, Rb, S, Ti, Zn) in 8 bogs of Germany [6], except for Ti in the moss of Strohner Maarchen. The Ti concentration is 2.7-7 times higher than that given in [6]. High Ti contents were also obtained for some moss samples of Germany [2], where Ti concentration in living moss was $90.09 \text{ mg}\cdot\text{kg}^{-1}$. The mean concentration of Ti in the mosses of Germany according to [8] is $21.8 \text{ mg}\cdot\text{kg}^{-1}$.

Comparing the above-obtained results with the mean element concentrations in the moss of Germany (according to [8]), we note that the following chemical elements have higher concentrations: Cu, W, Ti – about 2 times, Li – 3.6 times, Al, U – 4.5 and 4.3 times, Ti, Y, Th, La – 5.3-5.9 times, Cr – 7.4 times, and As – 9.1 times in Strohner Maarchen, and Ti, La, Ce – about 2 times in Rotes Moor. Estimates made in [2] allow comparing the concentrations of REE in the bogs being studied. High concentrations are noted for Er – 4.6 times, Ho, Nd, Pr, Sm, Eu, Ce, La, Dy – 5.0 - 5.9 times, Gd, Tb – 6.6 times in Strohner Maarchen, and La, Ce, Nd, Sm, Er, Tm – 2 times, Eu, Gd, Dy, Ho, Tb – 2.2-2.7 times, Yb, Lu – 1.5 and 1.8 times for Rotes Moor.

The peat samples of the bogs being studied have similar values for the chemical elements except for Se. The concentration of Se in Rotes Moor is 2.2 times higher than the value for Strohner Maarchen. Comparing with REE estimates for a 4-cm peat in [2], there are higher concentrations only for Ce – 3.4 and 2.6 times for Rotes Moor and Strohner Maarchen, respectively.

The ash yield of moss samples in Strohner Maarchen is higher than that in the peat. This may indicate a higher dust load in the recent years of moss growth. Perhaps, higher concentrations of some chemical elements (Ti, Cu, Fe, Cr, As) in the moss samples of Strohner Maarchen are of anthropogenic origin. The region of Strohner Maarchen is influenced by the closely located auto roads and agriculture fields. The location of this bog in the center of an industrially developed territory can also be a reason of the high element concentrations, for example, metals. The great difference in the accumulated REE of the moss of Strohner Maarchen in comparison with the values from [2] allow concluding that the dust load in 2011 was higher than before. The higher ash yield in moss (2.5) than

in peat (1.4) also confirms this. The rate of peat accumulation in Europe is quite slow [1], and this explains the similarity of the REE values for the peat samples. Another source of chemical elements (Al, Ti, Zr, Nb, REE, Th, and U) is the dust input from the surrounding ground, whose composition is determined by the composition of the underlying rocks (vulcanites).

Table 1. Concentrations of chemical elements ($\text{mg} \cdot \text{kg}^{-1}$) in moss and peat of the bogs being studied.

Elements	R1	S1	R2	S2	Elements	R1	S1	R2	S2
Li	0.43	1.14	0.23	0.16	Cd	0.49	0.33	0.51	0.49
Be	0.04	0.06	0.03	0.02	Sb	0.11	0.14	0.09	0.08
Na, %	0.03	0.03	0.03	0.03	Cs	0.10	0.22	0.08	0.08
Mg, %	0.07	0.06	0.07	0.08	Ba	50.6	41.3	32.0	30.4
Al, %	0.08	0.21	0.05	0.05	La	0.79	2.19	0.39	0.35
Si, %	0.13	0.18	0.09	0.07	Ce	1.65	4.42	0.76	0.68
P, %	0.23	0.19	0.22	0.24	Pr	0.19	0.49	0.08	0.08
K, %	0.36	0.29	0.31	0.32	Nd	0.69	1.76	0.32	0.27
Ca, %	0.41	0.23	0.29	0.28	Sm	0.13	0.34	0.06	0.05
Ti	42.7	117.1	21.8	16.8	Eu	0.036	0.077	0.017	0.013
V	1.9	4.2	1.24	0.95	Gd	0.14	0.38	0.06	0.06
Cr	6.7	10.3	5.35	3.69	Tb	0.019	0.046	0.009	0.007
Mn, %	0.04	0.02	0.05	0.04	Dy	0.097	0.258	0.044	0.042
Fe, %	0.07	0.17	0.04	0.03	Ho	0.020	0.045	0.009	0.009
Co	0.55	0.74	0.31	0.24	Er	0.052	0.119	0.023	0.020
Ni	2.34	2.45	2.19	1.90	Tm	0.008	0.021	0.004	0.003
Cu	4.2	16.2	4.9	3.2	Yb	0.04	0.11	0.02	0.02
Zn	54.0	48.32	46.8	44.3	Lu	0.007	0.017	0.003	0.003
As	1.5	2.24	1.45	1.21	Hf	0.02	0.05	0.01	0.01
Se	0.47	0.13	0.92	0.41	Ta	0.0008	0.0004	0.0006	0.0003
Rb	10.5	8.5	6.89	7.10	W	0.051	0.122	0.009	0.001
Sr	12.6	8.7	10.9	9.8	Hg	0.18	0.18	0.18	0.19
Y	0.54	1.23	0.23	0.21	Tl	0.015	0.032	0.013	0.009
Zr	0.89	2.10	0.69	0.68	Pb	9.91	11.68	9.2	7.6
Nb	0.05	0.16	0.02	0.03	Bi	0.06	0.07	0.06	0.05
Mo	0.13	0.26	0.15	0.14	Th	0.11	0.52	0.05	0.05
Ag	0.02	0.04	0.02	0.02	U	0.05	0.12	0.03	0.03
Ash yield, %	3.0	2.5	6.2	1.4	Th/U	2.2	4.3	1.7	1.7

Comments: R1, R2 - Rotes Moor moss and peat, respectively, S1, S2 - Strohner Maarchen moss and peat, respectively.

4. Conclusions

The results of the present research showed that the regional geochemical features and anthropogenic activity are essential factors influencing the geochemical characteristics of moss and peat in the central part of Germany.

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