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ANALYSIS OF THE IMPACT OF NATURAL PROCESSES AND FACTORS ON ECOLOGICAL AND GEOCHEMICAL SITUATION IN LANDSCAPES OF THE BREST POLESIE

ANALIZA WPŁYWU NATURALNYCH PROCESÓW I CZYNNIKÓW NA EKOLOGICZNE I GEOCHEMICZNE ŚRODOWISKA W KRAJOBRAZACH POLESIA BRZESKIEGO

***Zarys treści*:** The article discusses main aspects of the influence of natural conditions on the formation of geochemical structure of landscapes. In particular, it considers the influence of climatic conditions (hydrothermic conditions, heat and moisture indicators, their ration, dynamics and rhythmics), ground and surface water runoff, vegetation cover. The geochemical differentiation of the territory of the Brest Polesie is determined by the structural diversity of its landscapes, and the analysis of conditions of the formation thereof makes it possible to give an environmental assessment of landscapes with the use of geochemical indices.

***Key words*:** natural conditions, landscape components, geochemical differentiation, geochemical index, environmental assessment
***Słowa kluczowe*:** warunki naturalne, elementy krajobrazu, zróżnicowanie geochemiczne, wskaźnik geochemiczne, oceny oddziaływania na środowisko

Introduction

The formation of landscapes of the Brest Polesie and their contemporary geochemical differentiation involves a large number of natural factors and processes with their further significant anthropogenic transformation. The integrated landscape

monitoring provides for the availability of objective data and keeping track of the environmental situation, the evolution and degradation of natural complexes. The intensity of migration of chemical elements depends on natural conditions of the region. The most important are climatic conditions (hydrothermic conditions, heat and moisture indicators, their ration, dynamics and rhythmics), ground and surface water runoff, vegetation cover. The objective to analyze the main classes of the Brest Polesie landscapes based on field, laboratory, cartographic and literary materials. The article presents the characteristics of one of the five classes of landscapes, in view of natural factors of its formation.

Results and discussion

The Brest Polesie climate is characterized by the following peculiarities: mean temperature in July is 18°C, in January is -4.9°C. In the Brest Polesie there are higher (by 1-2°C degrees) temperatures in summer and in winter than in Central Belarus and Poozerie. The temperature affects the process of physical disintegration of mineral matters. It is subject to fluctuations in the course of year which has an impact on the frequency of migration of chemical elements. At temperature of ≤0°C the migration of chemical elements takes place with solid atmospheric precipitations (Shklyar 1962).

The annual precipitation is 550-600 mm. The time of the stable snow cover formation is December 20-25. The height of snow cover is 15-20 cm. The snow generally dissolves on March 5-10. The duration of a vegetation period is 200 and more days. Sometimes evaporation exceeds the total precipitation but, on the whole, washing water conditions are prevailing. The relative humidity in this territory is 64-66% (Shklyar 1962). Within a melt period there is an active water and mechanical surface migration of chemical elements. Within a vegetation period according to temperature increase for each 10°C the rate of chemical reactions increases 2-3 times. The migration of chemical elements in the soil profile depends on the precipitation frequency and the total precipitation, as well as on the temperature. In the soil profile of the Brest Polesie the descending flow of moisture and chemical elements is dominating (Taranchuk 2001). Therefore, the atmospheric precipitations are an important criterion of the migration of chemical elements. Due to intermittent precipitation during a vegetation period there is an alternation of stagnant and descending dominating washing water conditions when up to 15 grams per square meter of salts are washed down the profile from upper soil layers within a vegetation period. Landscapes with peat and sand based soils through the down-flow migration lose more nutrients than they receive with precipitation and ground waters (Solntsev 1983).

The amount of ion ground water and surface runoff affects the hydrochemical water conditions. For the southern region an ion runoff is typical which corresponds to the shallow depth of relief fracturing and the low water migration of chemical elements (table 1 and 2).

Table 1

The total ionic composition of groundwater and surface water for the southern hydrogeological region

Tabela 1

Całkowity skład jonowy wód gruntowych i powierzchniowych na południu regionu hydrogeologicznego

Ion	Concentration ($mg \cdot dm^{-3}$)
Ca^{2+}	50.9
Mg^{2+}	5.9
$Na^{+}+K^{+}$	3.1
HCO_3^{-}	125.4
SO_4^{2-}	10.8
Cl^{-}	3.6
∑ ions	200

Source: Chertko 1990

Table 2

The ionic composition for river waters of Brest Polesie

Tabela 2

Skład jonowy wód rzecznych Polesia Brzeskiego

Ionic composition ($mg \cdot dm^{-3}$)	Average concentration ($mg \cdot dm^{-3}$)	Limits for ion ($mg \cdot dm^{-3}$)
O_2	8.12	7.25-8.5
S	60.00	55.7-66.7
Na	5.15	5.0-35.0
Ca	1.02	1.0-51.0
Mg	8.65	3.0-14.5
NH_4	0.83	0.7-1.4
Fe^{3+}	0.34	0.1-0.34
SO_4	29.55	28.0-105.0
NO_3	0.36	0.25-39.0
NO_2	0.014	0.011-0.058
HCO_3	171.2	67.9-175.0
PO_4	0.047	0.0-1.17
mineralization	299.3	35.0-300
SiO_2	8.54	7.0-13.0
Cu	8.24	8.0-22.5
Zn	12.4	-

Source: Chertko 1990

Alkaline and acid conditions of ground waters which regulate the migration of most chemical elements in oxygen and gley redox environments of the landscapes of Belarus form acid and faintly acid oxidizing waters with pH 4.8-6.0 in eluvial landscapes and faintly acid gley waters with pH 5.8-6.5 in superaqual landscapes. The specified geochemical water classes in combination with rock lithogeochemical features and the degree of agrogenic and man-induced impact on the cultivated land increase the washout of elements for the exception of Si, P, Mn.

In washing water conditions the landscape vegetation performs a function of accumulator of chemical elements (Kirvel 2005). The vegetation cover of natural landscapes is characterized by a great variety of species and associations thereof which depend on the relief pattern and its water cut. The Brest Polesie relates to the subarea of broad-leaved and pine forests, Bug-Polesie okrug. The structure of vegitation cover of this territory is primarily formed by the meadow boggy association, pine forests, broad-leaved and pine forests, boggy deciduous forests. The largest area is occupied by agricultural lands.

In the territory of the Brest Polesie the meadow boggy association primarily consists of noninundated meadows and low-land bogs. A big part in the formation of the plant stand of meadow bogs is played by the chemical composition of ground waters. In meadow areas where soils are wet with hard ground waters (soddy-gley, peaty gley) the vegetation cover is represented by more species, there are poly-dominant cereals: purple small reed, turfy hair grass, narrow reed grass, meadow fescue grass, crested dog's-tail grass, red fescue grass, dithering grass, sweet vernal grass, timothy. Legume poly-dominants: meadow pea, meadow clover, birds-foot trefoil. Miscellaneous herbs (with boggy herbs predominating): silverweed cinquefoil, cotton grass, marsh cinquefoil, bog bean, tall buttercup, evan's-root, etc. In peaty meadows there are much less dominants than in meadow bogs, the forage value of herbs is also lower. Dominants: spicate cotton grass, swamp horsetail, effusive and clustered rush, mosses. Annual meadow associations accelerate the circulation of chemical elements and facilitate the accumulation thereof in humus, peat. The carry-over of chemical elements out of the landscape is limited by a biogenic barrier (Vadkovskaya, Lukashev 1984). Meadow bogs regardless of the lower biomass in comparison with inundated meadows accumulate more chemical elements since they are formed in conditions of permanent excess water. As a result, there is peat formed in which chemical elements are preserved for a long time. The amount of biomass of meadow grass as well as of forest communities to a considerable extent depends on the degree of wetting, the availability of nutrients, species composition.

According to the mean content of chemical elements in the Brest Polesie vegetation the chemical elements form the following series in descending order: Mn > Ba > Ti > Sr > Zr > Pb > Ni > Cu > Zn > V > B > Co > Mo. If we compare the mean content of chemical elements in the Brest Polesie vegetation and vegetation of the whole Belarussian Polesie then in the area of interest Mn, Zr, Ni are accumulated considerably more than in the Belarussian Polesie, and Cu, Ba – almost twice as less (table 3).

Table 3

The accumulation of chemical elements in natural vegetation

Tabela 3

Akumulacja pierwiastków w naturalnej roślinności

Element	Average concentration in the Brest Polesie, $mg \cdot kg^{-1}$ (Chertko 1990)	The limits of fluctuations in Brest Polesie (Taranchuk 2001)	Average concentration in vegetation of Belarussian Polesie (Chertko 1990)
Mo	0.8	0.6-0.9	-
Mn	6811	628-24 000	1751
Ni	75.1	9.0-183	55.6
Cu	70.0	6.5-3 340	194
Ba	1300	58-3 750	23.9
Ti	653	159-1 375	911
Pb	82	9.5-195	82.5
Zr	506	133-1 600	393.6
Sr	578	7.0-2 275	627.8
B	12.4	3.0-25.0	-
V	25	20-30	-
Co	1.3	0.11-4.3	-
Zn	33.0	8.0-71.0	-

Source: Chertko 1990; Taranchuk 2001

Agrophytocenoses affect the migration of chemical elements in a different way in comparison with the natural vegetation. The most of biomass (90-96%) is disposed of with yield which leads to the removal of 205-419 kg per 0,01 km^2 of nitrogen and ash constituents; crop residues return 85-230 kg per 0,01 km^2 of nitrogen and ash constituents in soil. This creates a deficit of plant nutrition which is eliminated by the application of mineral fertilizers. As opposed to the natural vegetation agricultural plants are in soil during the part of a vegetation period. Therefore, in the beginning of spring and in autumn in the absence of vegetation there is the more active water and wind erosion. The mineralization of organic substance in cultivated lands is more intensive than under similar conditions of the natural systems (spruce forest and pine forest). It is explained by the difference in the chemical composition of initial organic compounds, frequent soil cultivation, lighting. Woody species contain more hardly soluble organic compounds in comparison with agrophytocenoses. Eventually, the cycle involves ten times more atoms of chemical elements than they are in a plant at a point in time (Sanko 1983).

All natural processes are based on the mass exchange and energy exchange between components of the environment. The vegetation cover is not only a geosystem

product but also the reflection of its organized nature, inertia and dynamics. Therefore, the changes thereof as the most mobile component may per se serve as an evidence of the man-induced transformation of territories.

The geochemical differentiation of the territory of the Brest Polesie is determined by the structural diversity of its landscapes at the level of kinds and makes it possible to give an environmental assessment of landscapes in respect of the concentration or removal of chemical elements. The analysis and assessment of the geochemical differentiation show the diversity of the chemical composition of geo-components of landscapes of the Brest Polesie.

In the analysis of landscape differentiation one should cover the maximum number of attributes which can be presented on a summary basis in the form of points. These are the data on the content of macroelements. For each element there will be a rating calculated which represents the ratio between the element content and the background or percentage abundance. For the assessment of the overall system situation the total geochemical indicator was calculated as the sum of ratings for each element. In this case the more the total point sum is, the more active the process of accumulation of chemical elements is. The rating which equals one unit is deemed the optimal one. For example, in soils of the secondary moraine landscape ten elements are analyzed, then the optimal total point equals ten. All points which exceed this sum are considered as environmetally unsafe. For example, geochemical indices of the secondary moraine landscape are as follows (Taranchuk 2001):

$$\text{for soils: } \frac{S(2,3);P(2,2);Ca(1,2)}{Si(0,7);Mg(0,4);K(0,3);Fe(0,2);Al(0,1);Mn(0,09);Na(0,01)}; \sum_{onm.=10} 7,5,$$

$$\text{for water: } \frac{K(9,4);Cl(5,1);Na(4,2);N(3,8);S(2,13);Ca(1,5)}{C(0,9);Mg(0,24);N(0,43);Fe(0,1);P(0,04)} \sum_{onm.=11} 27,8,$$

$$\text{for vegetation: } \frac{B(1,5);Cu(1,3);Co(1,3);Mo(1,1)}{N(0,8);P(0,5);Zn(0,5);K(0,4);Mg(0.2)} \sum_{onm.=9} 7,5.$$

I.e., according to geochemical indicators the secondary moraine landscape is characterized by accumulation of S, P, Ca in soil, K, Cl, Na in water, B, Cu, Co in vegetation. The total geochemical indicator points to the general trend toward the removal of chemical elements from soils and vegetation, and the accumulation thereof – in waters (Taranchuk 2001).

Conclusion

Therefore, the accumulation of data on the content of chemical elements in landscape components, taking into account conditions of the formation of the geochemi-

cal differentiation, will make it possible to give an environmental assessment of landscapes, to prepare recommendations on the control of surplus content of ameliorants and toxic compounds, to develop methods for maintaining the optimal ratio of chemical elements in soils, waters, vegetation, to develop methods for the environment pollution control.

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Summary

Formation of the geochemical structure of the Brest Polesie landscape depends on the climate conditions influence. The formation of the geochemical differentiation will give the ecological evaluation of the landscape thanks to the Ecological system sercvices will control l the environmental condition.