DOI: 10.2478/mgrsd-2004-0006

MISCELLANEA GEOGRAPHICA
WARSZAWA 2004 Vol. 11

Bogumił Wicik

CHEMISTRY OF RAW HUMUS VS. CHEMISTRY OF ATMOSPHERIC PRECIPITATION ON THE EXAMPLE OF PINE FORESTS OF THE POMERANIAN LAKELAND

Abstract: This research, conducted for the purposes of the protection of the National Park Bory Tucholskie, contains the results of the investigation of the chemical composition of humus (forest litter) and of atmospheric precipitation. The gathered material allowed determining the fate (accumulation or removal) of chemical elements contained in the pine forest humus as well as to compare the abundance of nutrients in humus and in atmospheric precipitation.

Key words: forest litter, humus, atmospheric precipitation.

INTRODUCTION

Humus, colloquially called forest litter, is the basic store of nutrients for forest communities, developed on rocks poor in easily accessible mineral components. Layers of humus are called biogeochemical barriers, and the intensity of the mineralisation and humification processes taking place there reflects the action of the heterotrophic soil organisms (Bogatyriev 1996). Atmospheric precipitation is another source of elements necessary for the development of such communities. Chemical components contained in both renewable sources, that is, in humus and in precipitation, decide about the current fertility of many forest habitats. In Young Pleistocene outwash landscapes, little changed by the humans, the abundance of nutrients in both humus and precipitation has been actually constant over millennia; it is a condition for the development of commonly encountered here pine forests. Changes of the chemistry of precipitation, as well as of the amount of vegetation precipitation and of the conditions of its distribution may change the trophism and the biological production of these habitats. Investigation of the chemistry of humus and precipitation becomes a necessity in the case of national and landscape parks: regions particularly valuable from the practical and scientific point of view.

MATERIALS AND METHODS

Field work was conducted in the National Park Bory Tucholskie (Tucholskie Forests), on the area of about 50 square km. The Young Pleistocene

outwash plain constitutes there a habitat of dry and fresh coniferous forest and pine constitutes 98% of the stand species composition. Loose sands are the parent rock of the dominating here podzolic soils (including brown podzolic soils). Samples of humus taken from the area of 100 square cm were dried in the temperature of 70°C (so-called dry mass); next, their abundance in mineral components after baking in 550°C was determined, and the general contents of carbon, nitrogen, silicon, iron, as well as of magnesium, calcium and others. The material for research was taken in dry and fresh forests, with pine stand composition of 60 – 90 years. Meteorological investigations were conducted in the points "forest" and "clearing" during the period November 2000 – October 2001. Samples of water from atmospheric precipitation were taken once a month.

RESULTS AND DISCUSSION

The thickness of humus, consisting mostly of litter (Ol) and fermentation (Ofh) subhorizons is equal in the Tucholskie Forests to around 7 cm and its mass, from 30 – 40 tons/hectare in young stand compositions to 60 – 80 tons/hectare in older ones. Humus is strongly acidic, and its abundance in mineral components in Ol subhorizons is around 3.3% and in Ofh horizons, 6.9%. Around 0.13 tons of ash substance is accumulated in the area of 1 hectare in the litter subhorizon, and around 1 ton in the fermentation subhorizon. The litter subhorizons contain on the average 33.3% of C, while the fermentation subhorizons, 31%. The contents of the nitrogen (N) are higher in the fermentation subhorizons (1.26%) than in the litter subhorison (1.12%). (Table 1). Small differences of the value C/N indicate weak intensity of the humification processes of the vegetation matter: in the Ol subhorizons C/N is equal to 28 – 32 and in the Ofh ones, 21 – 26. In the process of mineralisation of humus some of the elements are moved outside the organic subhorizons, while some remains in place. Silicon in accumulated particularly strongly: fermentation subhorizons contain up to 10 times as much of it (1.6% – 3.0%) than the litter ones (0.3% – 0.9%). Iron is accumulated just as strongly. Its content in the fermentation subhorizon is three times as large as in the litter subhorizon. A similar regularity was observed in the forests of the Baltic Coastland (Wajczis, 1979). The remaining elements are removed during the transformation of the dead vegetation residue from litter to fermentation humus [?], in the order: K > Mg > Ca > P. The depletion of potassium is marked particularly strongly: the fermentation subhorizon has usually one-third of this element compared with the litter subhorizon. The depletion of carbon is equal to around 10%, similarly to the depletion of phosphor. On the other hand, the contents of zinc and copper in both humus subhorizons don't change: the amounts of these elements are similar to those occurring in pine needles (Gworek, 2000). The area of 1 square meter of the humus of the pine forest under investigation contains on the average 677 g of carbon, 617 g of silicon, 49.5 g of nitrogen and the corresponding amounts of other elements (Table 2). In

the case of the destruction of the tree stand (fire, pest gradation, cuttings) the elements listed above, freed from the humus, may constitute a great threat, a.o. for the development of extremely oligotrophic hydrogenic habitats, including extremely valuable lobelia lakes, which are also protected in the National Park Bory Tucholskie.

Table 1.
Contents of selected chemical elements (% of sample dried in 70°C) in pine forest humus of the National Park Bory Tucholskie (n = 26)

Element	Genetic subhorizon	Average contents	Extremal values
C	Ol	33,40	30,49-35,67
	Ofh	30,70	30,07-31,93
N	Ol	1,12	0,95-1,33
	Ofh	1,26	1,11-1,41
P	Ol	0,070	0,060-0,092
	Ofh	0,064	0,046-0,075
Ca	Ol	0,19	0,13-0,25
	Ofh	0,11	0,07-0,22
Mg	Ol	0,033	0,023-0,040
	Ofh	0,016	0,012-0,021
K	Ol	0,203	0,12-0,26
	Ofh	0,066	0,04-0,11
Na	Ol	0,010	0,003-0,020
	Ofh	0,006	0,001-0,010
S	Ol	0,124	0,088-0,204
	Ofh	0,126	0,099-1,178

Table 2.
Contents of selected chemical elements (average contents) in pine forest humus (mg per square metre) and in "forest" atmosheric precipitation (mg per square metre per year)

Element	Humus mg per square metre, "A"	Atmospheric precipitation mg per square metre per year, "B"	A/B
P	2549	114	22,3
N	49500	2600	19,0
Ca	4860	865	5,7
K	3701	1257	2,9
Na	2105	736	2,8
S	3480	1470	2,4
Mg	794	693	1,1

In the sites "forest" and "clearing" 478 mm and 592 mm, resp., of precipitation was collected during a year. "Forest" precipitation was slightly more acidic that that from the clearing, independently of the season. Enrichment

of the precipitation by all chemical elements took place under the tree crowns. Compared with the water from the "clearing" stand, "forest" water contained almost five times as much of magnesium, three times as much of potassium and chlorine, twice as much of nitrogen and about 1.5 times as much of sulphur, sodium, calcium and phosphor. Such differences occurred mostly in the winter season. A similar regularity was marked also in the area of the Augustów Forest (Puszcza Augustowska) (Janek M. 1002). In the forests of the National Park Bory Tucholskie, atmospheric precipitation supplies during the year around 2.6 g of nitrogen, 0.8 g of calcium, 0.11 g of phosphor, etc., per each square metre (Table 2). Under the circumstances when the depletion of nutrients is very large, such amounts are significant and comparable with the mass of elements stored in humus horizons. In the case of phosphor and nitrogen humus occurring on the area of 1 square metre is twenty times as abundant than the atmospheric precipitation from the entire year in this area; in the case of calcium, six times as abundant; in the case of potassium and sulphur, only around three times as abundant (Table 2). Particular attention should be paid (apart from sodium) to magnesium, which undergoes a very intense washing out from the trees. The yearly supply of this element from the atmosphere (693 mg per square metre) is almost balanced by its contents (794 mg per square metre) in humus. There are even case (e.g., young tree stands) in which humus contains much less magnesium than the atmospheric precipitation reaching here during the year. In this situation, magnesium may be the main element restricting the vegetation growth. Its concentration in water from precipitation (1.45 mg per litre) is similar to that of the Ingestad culture medium (1.518 mg per litre), used in experiments with feeding pines (Józefkowicz-Kotlarz 2000).

CONCLUSIONS

In the humus of pine forests nutrients for the plants occur in amounts comparable with the yearly supply of these components through atmospheric precipitation.

Pine forest humus contains around 20 times as much phosphor and nitrogen, two to six times as much of sulphur, sodium, potassium and calcium, and about as much magnesium as annual atmospheric precipitation.

In the processes of mineralisation of pine forest humus a very strong concentration of biogenic forms, mostly of silicon and iron, takes place. Other elements, forming the main part of the residual ash, are removed in order: potassium, magnesium, calcium and phosphor.

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English translation: Małgorzata Mikulska