BALTIC COASTAL ZONE
Journal of Ecology and Protection of the Coastline

Vol. 15 pp. 97-107 2011

ISBN 1643-0115

Original research paper

Received: 11.01.2011
Accepted: 30.03.2011

THE EFFECT OF ABUNDANCE OF LITTERFALL ON RETENTION OF NITROGEN AND PHOSPHORUS IN ORGANIC HORIZONS OF FOREST SOILS IN THE SLOVINSKI NATIONAL PARK

Agnieszka Parzych, Jan Trojanowski

Department of Environmental Chemistry,
Institute of Biology and Environmental Protection,
Pomeranian University in Słupsk,
ul. Arciszewskiego 22b, 76-200 Słupsk, Poland,
e-mail: parzycha1@op.pl

Abstract

The paper presents results of research into organic horizons and litterfall in two different forest ecosystems: *Vaccinio uliginosi-Betuletum pubescentis* and *Empetro nigri-Pinetum* in 2003-2005. On the basis of the amount and abundance of litterfall and abundance of organic horizons in the nitrogen and phosphorus compounds retention time and biological circulation coefficient of these elements in researched forest ecosystems was calculated. The nitrogen and phosphorus in organic horizons of *Vaccinio uliginosi-Betuletum pubescentis* have the shortest retention time (44 and 57 years respectively). The retention time of nitrogen and phosphorus in *Empetro nigri-Pinetum* are similar and counted about 62 years. The coefficient values of biological circulation show the strong inhibition of circulation of these elements, what caused reservation of matter in organic horizons and acidity of soil.

Key words: forest, soil, litterfall, biological circulation coefficient

INTRODUCTION

In the nutrition of forest plants a very important role is played by the fertility of surface horizons of the soil profile, including the O horizon. Organic matter deposited on the forest floor, that is washed out by precipitation and subjected to continuous mineralization processes, gradually enriches organic soil subhorizons with biogens available to plants. The rate of litterfall decomposition depends on many factors and is one of the measures of efficiency of matter cycle in the ecosystem (Banaszuk 1996). A decisive role is played by temperature, moisture content and the presence of microorganisms, which to a considerable degree contribute to the release of simple inorganic compounds, available to plants, from the fallen organic matter (Jansson and Berg 1985, Berg et al., 1990, Dziadowiec 1990). In the litter-soil system the rates of nitrogen and phosphorus release are interdependent. Their total release time is approx. 120 years (Zimka 1989, Zimka et al. 1990, Stachurski and Zimka 2004). Studies conducted by Dziadowiec (1990) showed that from 41 to 73% phosphorus is released during the first years of litter mineralization. At the same time nitrogen is strongly immobilized, which means that plant nutrition is connected with a later stage of decomposition of more stable organic bonds. At the late stage of decomposition lignin predominates in the litter and its concentration determines the rate of the late stage of decomposition (McClaugherty and Berg 1987). The rate of release of biogenic elements from organic matter of the litter humus plays a decisive role in the process of plant nutrition. Efficiency of their utilization by plants is dependent both on environmental factors (precipitation and leaching deeper into soil profiles, reaction of soil, its sorption capacity) and physiology of individual plant species. The maritime climate with a considerable amount of precipitation and high humidity may have an advantageous effect on mineralization processes. Additionally, organic matter deposited on the forest floor is from time to time washed out by precipitation, which to a considerable degree contributes to leaching of soluble compounds and their supply to the soil.

The aim of this study was: (i) to estimate the effect of litterfall abundance on retention times of nitrogen and phosphorus in the organic horizons of podsolic soils, (ii) to determine retention times of nitrogen and phosphorus in organic horizons deposited under pine and pine-birch stands, and (iii) to compare the rate of biological cycle of nitrogen and phosphorus in the *Vaccinio uliginosi-Betuletum pubescentis* and *Empetro nigri-Pinetum* communities in the Slovinski National Park.

MATERIALS AND METHODS

Study site

Analyses were conducted on two 0.5 ha forested plots located 1.5 km from the Baltic Sea coastline in the Slovinski National Park (SNP – 17°15′E, 54°44′N) in the Smołdziński Las Protection District. The fact that the investigated forest ecosystems are located in close vicinity (600 m) guarantees a uniform effect of weather conditions on mineralization processes. Locations of the sample plots are given in Fig. 1. Sample plot I is covered by vegetation classified as *Vaccinio uliginosi-Betuletum pubescentis* community (*Vu-Bp*, pine-birch forest) growing on podsolic soils formed on fossil peat soils with the following structure of the soil profile: Ol-Ofh-AEes-Bhfe-C-Otni. Vegetation of plot II (*En-P*, pine coniferous forest) covered podsolic soils (Ol-Ofh-AEes-Bhfe-C) and belonged to the *Empetro nigri-Pinetum* community. Stands in the analyzed forest areas varied in terms of their species and age composition. Sample plot I was covered by a loose birch-pine stand of 18-19 m in height. Sixty-years old Scots pine (*Pinus sylvestris* L.) comprised 25% of the stand, while 47-years old downy birch (*Betula pubescens*) comprised 75%. Sample plot II

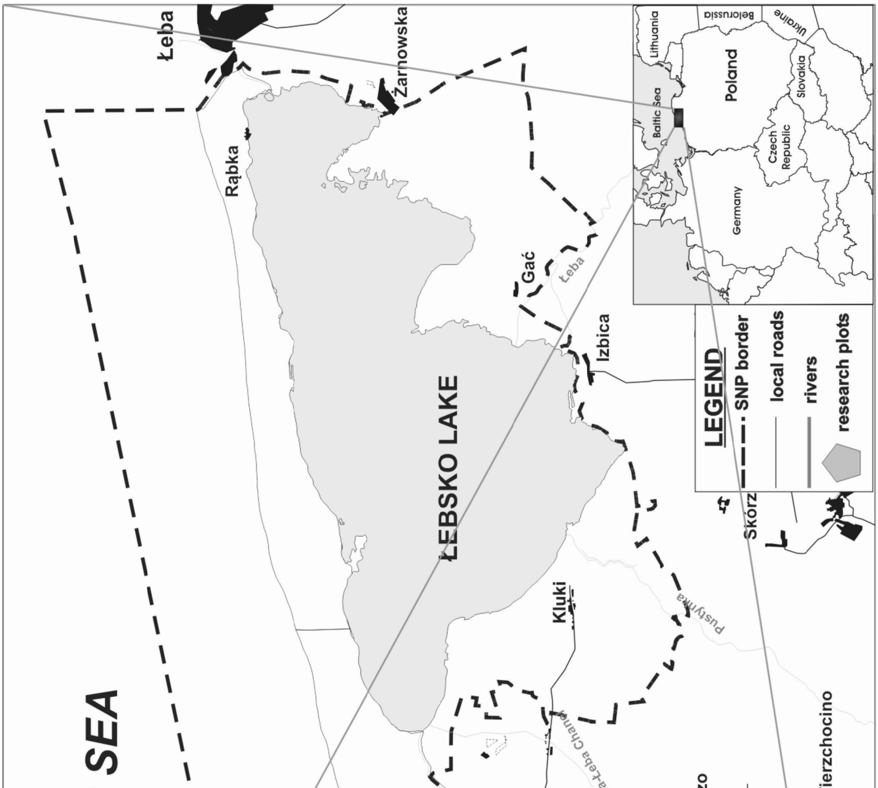

Fig. 1. Situation plan of the Slovinski National Park
I – research plot I (*Vu-Bp*), II – research plot II (*En-P*)

was covered by a homogeneous 140-years old pine stand (*Pinus sylvestris* L.) with low (7 m) deformed crowns and sloping stems (Plan Ochrony SPN 2003).

Sample collection and analysis

In each 0.5 ha forest sample plot litterfall was collected to 16 catchers placed under tree crowns, with a total interception area of 3.20 m^2. Placement of catchers at 80 cm above the ground made it possible to collect litterfall from the tree and shrub layer (Kowalkowski 1994, Dziadowiec and Kaczmarek 1997). Each time catchers were placed in 16 replications in four rows of 4, at a distance of 3 m. Litterfall was removed from catchers every 6-7 weeks in the years 2003, 2004 and 2005. A detailed characteristic of the stand and the method of litterfall collection in the investigated forest ecosystems were described by Parzych and Trojanowski (2009). Total weights of annual litterfall and their means for the years 2003-2005 were calculated on the basis of recorded data. In the analyzed forest plots soil pits were made and soil profiles were described. Soil taxonomy was conducted on the basis of Systematyka Gleb Polski PTG-leb (1989). Samples from organic horizons of the analyzed soil profiles were collected on the same dates as litterfall, both in the *Vaccinio uliginosi-Betuletum pubescentis* and *Empetro nigri-Pinetum* communities. Each time concentrations of total nitrogen and total phosphorus were determined in the litterfall and in the organic horizons with total nitrogen being determined according to Kjeldahl and total phosphorus using the molybdate method (after mineralization in a mixture of H_2SO_4 and H_2O_2), (Ostrowska et al. 1991). On the basis of bulk density, thickness of the organic horizon and the percentage contents of N, P and organic matter, the respective resources of N, P and organic matter were calculated according to Bednarek et al. (2005). Rate of release of nitrogen and phosphorus from soil profiles decay effort *Vaccinio uliginosi-Betuletum pubescentis* and *Empetro nigri-Pinetum* was calculated according to the formula:

$$Tr = 2A/F,$$

where:

Tr – retention time of a given element in the soil [years],
A – accumulation of the element connected with organic matter [kg/ha],
F – supply of the element with litterfall and precipitation [kg/ha·year].

The biological cycle index was calculated on the basis of the ratio of organic matter resources accumulated in the organic horizons of soil to the amount of the annual litterfall (Bednarek et al. 2005).

Table 1

Atmospheric conditions in the period between 2002 and 2005

	2003	2004	2005	Mean
Rainfall [mm]	552	848	579	660
Air temperature [^{o}C]	7.69	7.68	7.81	7.73
Air humidity [%]	83.5	84.5	83.6	83.90

Rainfall, air humidity and air temperature were recorded in the Gać meteorological station located inside the boundaries of SNP. Average values of major climatic conditions in both locations for the study period are shown in Table 1.

RESULTS AND DISCUSSION

The fluctuations of abundance and retention of organic horizons are affected by weather conditions. Sum of precipitation in the years of analysis was highly diverse. The biggest amount of rainfall was recorded in 2004 (848 mm), while the lowest in 2003 (552 mm), (Table 1). A much smaller diversification was found for mean annual temperature and humidity values, which in the successive experimental years on average amounted to 7.73°C and 83.90%.

Organic horizons in the analyzed podsolic soils differed in thickness (Table 2). In case of pine coniferous forest the ectohumus subhorizon was found to be thinner, while the thickness of the detritus horizon was bigger (5 cm) in comparison to the respective subhorizons of the pine-birch forest. In the *Empetro nigri-Pinetum* subhorizons were also characterized by a lower bulk density, a higher moisture content and acidity than the respective subhorizons in the *Vaccinio uliginosi-Betuletum pubescentis* community. The high moisture content of the Ofh subhorizons promoted mineralization processes in case of such high acidity. The *En-P* organic subhorizons contained also higher amounts of phosphorus and carbon than the respective *Vu-Bp* subhorizons, which may indicate slow rates of degradation processes of organic compounds, causing deposition of organic matter (Table 3). Higher concentrations of P and C in the subhorizons under pine coniferous forest were reflected in much

Table 2

Physicochemical properties of organic horizons in *Vaccinio uliginosi-Betuletum pubescentis* and *Empetro nigri-Pinetum*

Genetic level	Depth [cm]	Thickness of soil [cm]	Volumetric density [$g \cdot cm^{-3}$]	Humidity of soil [%]	pH H_2O	pH KCl
Vaccinio uliginosi-Betuletum pubescentis						
Ol	8-4	4	0.10	16.33	4.44	3.63
Ofh	4-0	4	0.22	23.06	4.62	3.83
Empetro nigri-Pinetum						
Ol	8-5	3	0.08	21.52	4.18	3.46
Ofh	5-0	5	0.17	32.31	4.19	3.37

Ol – fresh forest litter subhorizon, Ofh – detrytus subhorizon, reserves [$kg \cdot m^2$]= ($h \cdot D \cdot mo$):10, where: h – thickness of soil [cm], D – volumetric density [$g \cdot cm^{-3}$], mo – content of N, P and organic matter in organic horizons [%]

Table 3

Chemical properties of organic horizons *Vaccinio uliginosi-Betuletum pubescentis* and *Empetro nigri-Pinetum*

N [%]	P [%]	C [%]	Organic matter [%]	Reserves N [t/ha]	Reserves P [t/ha]	Reserves of humus [kg·m^{-2}]	C:N	C:P
Vaccinio uliginosi-Betuletum pubescentis								
1.069	0.113	27.6	88.79	0.43	0.045	3.55	25.8	244.2
1.011	0.109	26.6	79.83	0.89	0.096	7.02	26.3	244.0
				Σ=1.32	Σ=0.141	Σ=10.57		
Empetro nigri-Pinetum								
1.071	0.141	38.5	91.60	0.26	0.034	2.19	35.9	273.0
1.078	0.137	39.6	86.65	0.92	0.116	7.36	36.7	289.1
				Σ=1.18	Σ=0.150	Σ=9.55		

higher resources of phosphorus and higher values of C:N and C:P ratios in these horizons.

The weight of litterfall deposited in *Vu-Bp* and *En-P* varied in the period 2003-2005 (Table 4). Much higher amounts were recorded in the *Vaccinio uliginosi-Betuletum pubescentis* community, on average amounting to 4.050 t/ha·year. In the *Empetro nigri-Pinetum* pine coniferous forest litterfall was by 29% lower, amounting to a mean

Table 4

Litterfall in *Vaccinio uliginosi-Betuletum pubescentis* and *Empetro nigri-Pinetum* in 2003-2005

Litterfall	*Vu-Bp* [t/ha·year]			*En-P* [t/ha·year]		
	2003	2004	2005	2003	2004	2005
Total	4.346	4.159	3.645	3.014	2.920	2.714
Mean	4.050			2.883		

of 2.883 t/ha·year. The highest mean annual litterfall was observed in the both analyzed plots in 2003. The weight of litterfall in the pine-birch forest was at that time by 31% higher than in the pine coniferous forest. The deposited litterfall supplied considerable amounts of nitrogen and phosphorus compounds to the forest floor, in *Vu-Bp* amounting to a mean 42.51 kgN/ha·year and 1.09 kgP/ha·year, while in *En-P* to 21.02 kgN/ha·year and 0.96 kgP/ha·year (Table 5). We need to stress here a markedly higher inflow of nutrients to the soil in case of *Vaccinio uliginosi-Betuletum pubescentis* than in *Empetro nigri-Pinetum*, which is connected with the species

Table 5
The content of nitrogen and phosphorus in litterfall in 2003, 2004 and 2005

Parameter	*Vu-Bp* [kg/ha·year]				*En-P* [kg/ha·year]			
	2003	2004	2005	Mean	2003	2004	2005	Mean
T-N	45.92	43.84	37.78	42.51	21.14	22.38	19.54	21.02
T-P	1.04	1.15	1.08	1.09	0.90	0.88	1.09	0.96

composition of the stand, in which downy birch predominated, with a 25% admixture of pine producing litterfall richer in nitrogen compounds (Astel et al. 2009), as well as its age and the presence of fossil soil rich in biogens in the soil profile. In the pine-birch forest two times more nitrogen reaches the soil with litterfall, which obviously has an effect on trophic conditions in this forest site and the soil reaction (Table 2).

Using the results of investigations conducted by the authors as well as coefficients developed by Zimka (1989) the rates of release were calculated for nitrogen and phosphorus from the ectohumus in the soil profiles of *Vaccinio uliginosi-Betuletum pubescentis* and *Empetro nigri-Pinetum* (Table 6). Recorded results indicate considerable differences in the retention times of the above mentioned elements in the organic horizons. The shortest retention time was observed for nitrogen and phosphorus in the analyzed horizons of *Vaccinio uliginosi-Betuletum pubescentis,* at approx. 44 and 57 years. In *Empetro nigri-Pinetum* retention times of N and P were identical, amounting to 62 years. The difference in retention times of nitrogen and phosphorus was most probably caused by the mechanism and course of mineralization processes occurring in organic matter (Banaszuk 1997). The shorter retention times of N and P in *Vu-Bp* were a consequence of much more rapid mineralization processes. According to Stachurski and Zimka (2004), it is caused by the much higher abundance of nitrogen and phosphorus compounds in the litterfall (Table 6), thanks to which litterfall is more attractive for saprophages and is degraded by these

Table 6
The retention time of nitrogen and phosphorus in organic horizons
in *Vaccinio uliginosi-Betuletum pubescentis* and *Empetro nigri-Pinetum* in 2003-2005

	Vu-Bp		*En-P*	
	N	P	N	P
A [kg/ha]	1320	141	1180	150
F [kg/ha·year]	59.4	4.9	37.9	4.8
Tr [years]	44.4	56.9	62.2	62.2

organisms much more rapidly. The longer retention of nitrogen and phosphorus in the organic horizons of the *Empetro nigri-Pinetum* community may result directly from the slower rate of their biological cycle. According to Zimka (1989) and Zimka et al. (1990) the total release time of nitrogen and phosphorus for the entire soil profile is approx. 120 years. According to Trojanowski (1973), the actual retention times of certain organic fractions and related elements may amount to hundreds or even thousands of years. In conclusion, we would need to state that the efficient of release of nitrogen and phosphorus from the litter-soil system is dependent both on the quality and nutrient resources of the litterfall, as well as the amounts of elements introduced to the circulation with precipitation.

The biological cycle index was calculated on the basis of the ratio of organic matter resources accumulated in the organic horizons of soil to the amount of the annual litterfall. According to the literature, value of the index of the biological cycle varies widely. In ecosystems with an intensive biological cycle most commonly fraction values are assumed and in ecosystems with an inhibited biological cycle (in the state of stagnation) these values exceed 50 (Table 7), (Bednarek et al. 2005).

Table 7

Comparison of the flow of organic matter and reserves humus in organic horizons

Forest association	Reserves [kg·m^{-2}]		level O / litterfall
	level O	litterfall	
Vu-Bp	10.57	0.405	26
En-P	9.55	0.288	33

Recorded values of biological cycle indexes fell within the range of ratios from 21 to 50, which indicates strong inhibition of the biological cycle. It is much stronger in case of *Empetro nigri-Pinetum*. As a consequence in both analyzed forest ecosystems organic matter resources were accumulated in the organic horizons and soil was acidified (Table 2). The bigger thickness of the detritus subhorizon in *En-P* than in *Vu-Bp* is a result of the deposition of organic matter, caused by a slower mineralization of litterfall. A similar phenomenon was described by Wachowska-Serwatka (1966). In places where changes occur slowly a layer of litter accumulates, which results in the adverse situation when soil is cut off from the access of air, acids are formed and thus – podsolization processes are enhanced (Czarnowski 1978).

A much stronger inhibition of the biological cycle in *Empetro nigri-Pinetum* than in *Vaccinio uliginosi-Betuletum pubescentis* is indicated – apart from the considerably higher resources of phosphorus accumulated in the organic horizons of pine coniferous forest – by the broader range of values of the C:P ratio in the organic horizons (Table 2), as evidence of the slowing down of phosphorus mineralization (Fuller et al. 1956), and the value of the C:N ratio (>32), according to Enwezor (1976) indicating a slowing down of organic substance mineralization. Additionally, litterfall deficient in nitrogen and phosphorus compounds in comparison with the litterfall in the *Vaccinio uliginosi-Betuletum pubescentis* community is less attractive for saprophages and its mineralization is much slower (Stachurski and Zimka 1981). Recorded values of the above mentioned indexes indicate differences in the biological cycle of nitrogen and phosphorus in the analyzed forest ecosystems, despite their strong inhibition. A decisive effect on the rate of organic matter decomposition in the analyzed forest communities is exercised by the fertility of litterfall, and not – as it was previously assumed – the maritime climate with high humidity and considerable amounts of precipitation.

CONCLUSIONS

The weight of organic debris reaching the soil, its quality and chemical composition determine the intensity of processes occurring in soils, and the amount and quality of decomposed soil matter.

1. Litterfall in the analyzed forest ecosystems is characterized by the abundance of different nutrients. In *Vu-Bp* it supplied on average by 50% more nitrogen and by 18% more phosphorus than in *En-P*. The bigger supply of nutrients to the soil in case of *Vu-Bp* in comparison to *En-P* is connected with the species composition of the stand and fertility of the forest site.
2. Organic horizons of *Vaccinio uliginosi-Betuletum pubescentis* and *Empetro nigri-Pinetum* exhibit differences in terms of retention times of nitrogen and phosphorus, which depends on the fertility of litterfall.
3. Shorter retention times of N and P in the organic horizons of *Vu-Bp* than those of *En-P* result from the slightly faster rate of circulation of these elements, and most probably also the mechanism of mineralization processes.
4. Biological cycle indexes for nitrogen and phosphorus in *Vu-Bp* (26) and *En-P* (33) indicate a strong inhibition of the biological cycle, which has led to the accumulation of matter resources in the organic horizons and to soil acidification.
5. Strong acidification of organic horizons does not promote organic matter decomposition processes.
6. Litterfall poor in nutrients in the 140-year old pine coniferous forest decomposes very slowly, as indicated by retention times of N and P (62.2) in the organic subhorizons and by the high value of the biological cycle index (33).

REFERENCES

Astel A., Parzych A., Trojanowski J., 2009. Comparison of litterfall and nutrient return in a *Vaccinio uliginosi-Betuletum pubescentis* and an *Empetro nigri-Pinetum* forest stands in northern Poland. *For. Ecol. Manage*., 257, 2331-2341.

Banaszuk P., 1996. Dynamika opadu ścioły w zbiorowisku boru wilgotnego *Vaccinio myrtilli-Pinetum* i boru świeżego *Peucedano-Pinetum* w rezerwacie Szelągówka. (Dynamics of litterfall in humid forest *Vaccinio myrtilli-Pinetum* and fresh forest *Peucedano-Pinetum* in Szelągówka Reserve). *Zesz. Nauk. Polit. Białost*., *Inż. Środ*., 9, 109, 129-136, (in Polish).

Banaszuk P., 1997. Wpływ warunków siedliskowych na produkcję biomasy i obieg składników pokarmowych w wybranych zbiorowiskach borowych. (Effect of habitat conditions on biomass production and nutrient cycling in selected communities of coniferous forest). (mscr.), Polit. Białost., Białystok, (in Polish).

Bednarek R., Dziadowiec H., Pokojska U., Prusinkiewicz Z., 2005. Badania ekologiczno-gleboznawcze. (Ecological and soil research). PWN, Warszawa, (in Polish).

Berg B., Jannson P.E., McClaugherty C., 1990. Climate variability and litter decomposition, results from a transect study. In: Landscape-ecological impact of climatic change. (Eds) M. Boer, R. De Groot, IOS Press, Amsterdam, Washington, Tokyo, 250-273.

Czarnowski M.S., 1978. Zarys ekologii roślin lądowych. (Outline of ecology of land plants). PWN, Warszawa, (in Polish).

Dziadowiec H., 1990. Rozkład ściółek w wybranych ekosystemach leśnych. (Distribution of litterfall in selected forest ecosystems). UMK, Toruń.

Dziadowiec H., Kaczmarek J., 1997. Wpływ składu gatunkowego drzewostanu na opad roślinny i zasoby glebowej materii organicznej w Górznieńsko-Lidzbarskim Parku Krajobrazowym na Pojezierzu Chełmińsko-Dobrzyńskim. W: Zintegrowany monitoring środowiska przyrodniczego. Materiały z VIII Sympozjum ZMŚP. (Influence of the species composition of the tree stand on the litterfall and reserves of the soil organic matter in Górznieńsko-Lidzbarski Landscape Park on the Lake District Chełmińsko-Dobrzyńskie. In: Integrated monitoring of the natural environment. Materials of the 8th ZMŚP Symposium). Suwałki-Krzywe, 73-76, (in Polish).

Enwezor W.O., 1976. The mineralization of nitrogen and phosphorus in organic materials of varying C:N and C:P ratios. *Plant and Soil*, 44 (1), 237-240.

Fuller W.H., Nielsen D.R., Miller R.W., 1956. Some factors influencing the utilization of phosphorus from crop residues. Proceedings of the Soil Society of America, 20, 218-224.

Jansson P.E., Berg B., 1985. Temporal variation of litter decomposition in relation to simulated soil climate. Long-term decomposition in a Scots pine forest, *V. Can. J. Bot*., 63, 1008-1016.

Kowalkowski A., 1994. Metodyka badań ilościowo-jakościowych cech opadu organicznego na Stacjach Geoekologicznych Święty Krzyż i Góra Malik. W: Monitoring Środowiska Regionu Świętokrzyskiego. (Methodology of the research on quantitative-quality features of organic fallout on Geoecological Stations the Saint Cross and the Malik Mountain. In: Monitoring of the Świętokrzyskie Region environment.) (Ed.) A. Kowalkowski, KTN, Kielce, 2, 47-52, (in Polish).

McClaugherty C., Berg B., 1987. Cellulose, lignin and nitrogen concentrations as rate regulating factors in late stages of forest litter decomposition. *Pedobiologia*, 30, 101-112.

Ostrowska A., Gawliński S., Szczubiałka Z., 1991. Metody analizy i oceny właściwości gleb i roślin. (Research and evaluation of soil and plants methods). *Inst. Ochr. Środ*., Warszawa, (in Polish).

Parzych A., Trojanowski J., 2009. Struktura i dynamika opadu organicznego w wybranych drzewostanach Słowińskiego Parku Narodowego w latach 2003-2005. (The structure and dynamics of litterfall in forest stands in the Slovinski National Park in 2003-2005). *Leś. Pr. Bad*., 70 (1), 41-48, (in Polish).

Plan Ochrony Słowińskiego Parku Narodowego. Operat Ochrony Ekosystemów Leśnych na lata 2002-2021. 2003. T. 8: Opis ogólny. T. 9.1: Opis taksacyjny lasu – Obręb Lądowy Oddziały 1-63. (Slovinski National Park protection plan. Forest ecosystems protection procedures for the period between 2002 and 2021. Vol. 8: General description, Vol. 9.1: Taxonomical forest description – Land Compound, Units 1-63). Jeleniogórskie Biuro Planowania i Projektowania.

Stachurski A., Zimka J.R., 1981. The patterns of nutrient cycling in forest ecosystems. *Bull. Acad. Pol. Sci*., II, 29, 141-147.

Stachurski A., Zimka J.R., 2004. Obieg pierwiastków w ekosystemach lądowych. (Circulation of elements in land ecosystems). *Kosmos*, 54, 391-400, (in Polish).

Systematyka gleb Polski. (Systematic of soil in Poland), 1989. *Rocz. Glebozn.*, 40 (3/4), (in Polish).

Trojanowski J., 1973. Przemiany substancji organicznych w glebie. (Transformation of humus substances in soil). PWRiL, Warszawa, (in Polish).

Wachowska-Serwatka K., 1966. Sezonowe zmiany azotu i składników mineralnych w ściółce, w glebie i w roślinach lasu mieszanego Rezerwatu Lubsza. (Seasonal changes of nitrogen and mineral components in litterfall, soil and plants in mixed forest of Lubsza Reserve). *Acta Univ. Wrat.*, 48, *Pr. Bot.*, VII, 71-130, (in Polish).

Zimka J.R., 1989. Analysis of processes of element transfer in forest ecosystems. *Pol. Ecol. Stud.*, 15, 3-4, 135-212.

Zimka J.R., Stachurski A., Kwiecień M., 1990: Methods of studies on forest ecosystems: evaluation of nitrogen accumulation in leaf litter in association *Pino-Quercetum*. *Ekol. Pol.*, 38, 383-398.

WPŁYW ZASOBNOŚCI OPADU ORGANICZNEGO NA RETENCJĘ AZOTU I FOSFORU W POZIOMACH ORGANICZNYCH GLEB LEŚNYCH SŁOWIŃSKIEGO PARKU NARODOWEGO

Streszczenie

W pracy przedstawiono wyniki badań poziomów organicznych oraz opadu organicznego w dwóch różnych ekosystemach leśnych: *Vaccinio uliginosi-Betuletum pubescentis* i *Empetro nigri-Pinetum* w latach 2003-2005. Na podstawie ilości i zasobności opadu organicznego oraz zasobności poziomów organicznych w związki azotu i fosforu wyliczono czas retencji oraz współczynniki obiegu biologicznego tych pierwiastków w badanych ekosystemach leśnych. Najkrótszym czasem retencji charakteryzują się azot i fosfor w poziomach organicznych *Vaccinio uliginosi-Betuletum pubescentis* (44 i 57 lat). W *Empetro nigri-Pinetum* czas retencji N i P jest podobny i wynosi około 62 lat. Wartości współczynników obiegu biologicznego wskazują na silne hamowanie obiegu tych pierwiastków, w wyniku którego w obu ekosystemach leśnych doszło do zmagazynowania zasobów materii w poziomach organicznych i do zakwaszenia gleby.