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DYNAMICS OF NITROGEN DURING DECOMPOSITION PROCESSES OF ECTOHUMUS FROM DEGRADED FOREST ECOSYSTEMS IN THE SNIEZNIK MASSIF, EASTERN SUDETY MOUNTAINS

DYNAMIKA AZOTU W PROCESACH ROZKŁADU PRÓCHNIC NADKŁADOWYCH DEGRADOWANYCH EKOSYSTEMÓW LEŚNYCH W MASYWIE ŚNIEŻNIKA W SUDETACH WSCHODNICH

Abstract: Results of mineral forms of nitrogen ($N\text{-}NO_3$ and $N\text{-}NH_4$) changes in ectohumus layers and needles during decomposition processes are presented. The experiment was conducted in controlled conditions in a chamber with stable temperature and humidity. Plant samples and soil samples from ectohumus were taken in ecosystems in various stages (object without damages signs, in the process of degradation and degraded). In the fresh material, directly after sampling, content of mineral forms of nitrogen was analyzed. Controlling of the content changes were done after 30, 60 and 90 days of incubation. In the fresh material high differences of the content of $N\text{-}NO_3$ between degraded ecosystems were found. The lowest content were found in needles of degraded spruce forest and this situation was permanent during the incubation. In the Oh layer content of $N\text{-}NO_3$ was initially the lowest, but during incubation was increasing and after 30 days of decomposition was the highest. The highest content of ammonia nitrogen was found in needles from degraded ecosystems and despite of decreasing the amount during decomposition this was stable until 90^{th} day of incubation. In Oh layers content of $N\text{-}NH_4$ was decreasing with the time of incubation and the most clear was observed in ecosystems in degradation process and degraded as well.

Keywords: nitrogen forms, mountain soils, forest degradation

In the last decades an increase of nitrogen participation in terrestrial ecosystems is being observed in Europe. This can be affected by enhance of nitrogen oxides and ammonia emissions from industry and developing agriculture [1, 2]. Ecosystems enriched in excessive amount of nitrogen, defend themselves and the effect is leaching nitrogen compounds to the ground and underground waters what can favor disturbances in proper ecosystems' functioning [3–5].

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The Snieznik Massif forest ecosystems have been transformed for last decades under the influence of anthropogenic conditions. Forests in the range of Ladek Zdroj and Miedzylesie were classified to III degree of industrial damages [6]. The symptoms of the negative processes are mainly damages of needles development – yellowing and drying up.

The question is: whether in mountain spruce ecosystems we should be aware of uncontrolled nitrogen increase?

The aim of the work was to analyse changes of mineral forms of nitrogen ($N\text{-}NO_3$ and $N\text{-}NH_4$) in ectohumus layers (Olf i Oh) and spruce needles from the mountain forest ecosystems in various degrees of degradation during their decomposition process.

Material and methods

The experiment was carried out in closed chamber with controlled conditions: stable temperature 16 ^oC and humidity of 16 %. Samples – from needles and from ectohumus layers were taken in two replications (in tables results are given as a mean value) from the spruce forest ecosystems in the range of Snieznik Klodzki Massif, East Sudety Mountains. Samples were taken from differently degraded forest sites: object without negative changes – A, in the process of degradation – about 50 % of needles with symptoms of damages – B, and degraded – C. The objects were within approximately 200 m of each other and have the same elevation and are derived from the same parent rock. Soils in the analyzed ecosystems were podzols derived from gneiss with humus type mor. Type of forest sites was mountain coniferous forest, ass. *Calamagrostio villosae-Piceetum* [7].

In the fresh material, directly after sampling content of mineral forms of nitrogen was analyzed and after 30, 60 and 90 days of incubation. Analysis were done in the Chemical-Agricultural Station in Wroclaw using continuous flow colorimetry and analyzer SFA, type SAN++, Skalar Analitycal B.V. Holand. after the extraction in 1 % K_2SO_4.

Additionally soil samples were taken from mineral horizons, depth 0–44 cm, to characterize soil environment exposed to degradation processes.

Basic properties of the soils under degrading spruce forest (object B) are presented in the paper by Jamroz and Kocowicz [8]. In the present paper soil properties from spruce forest without degradation signs (A) and degraded (C) are reported. In the soil samples the following properties were determined: granulometric composition by areometric method Casagrande in modification of Proszynski, pH – potentiometrical in 1 M KCl, total content of organic carbon and total content of sulphur ussing CS-mat 5500 analyzer by Strohlein and total content of nitrogen using Kjeldahl method and Buchi analyzer.

Results and discussion

The analyzed soils from the region of Snieznik Massif represent podzols derived from gneiss with loamy sands and light loam (Table 1), with high content of skeleton 26 to 50 %. Ectohumus layers are divided to Olf – containing weakly decomposed organic matter, with rests of needles and parts of plants and Oh – containing well decomposed organic matter in the amount of 50–70 % less than in Olf horizon (Table 1), with black

color. Reaction of the soils in degraded ecosystem, according to Polish forest soils classification [9] is very strongly acid in the whole profile except horizon of parent rock – C (Table 1). In the ecosystem without degradation signs – A, horizon Bhfe and horizon C were characterized by strongly acid reaction. This is the effect of parent rock influence, which is naturally poor in alkaline compounds mainly in calcium as well as falling spruce needles which are strongly acidic. Content of nitrogen in soil profile is low, what is connected with spruce needles naturally poor in this element. This is reflected in wide C/N ratio (Table 1), over 20 in upper layers of soil profile, as well as in B horizon from the forest without negative changes.

Table 1

Some properties of podzols in the region of Snieznik Klodzki Range in forest ecosystems of various stages of degradation

Object/Horizon	Olf	Oh	Ees	Bhfe	C
	Content of fraction ∅ < 0.02 mm [%]				
Object A	n.d.	n.d.	22	16	18
Object B*	n.d.	n.d.	33	13	32
Object C	n.d.	n.d.	16	14	17
pH in 1 M KCl					
Object A	2.6	2.7	3.3	4.0	4.2
Object B*	2.4	2.7	3.3	3.5	4.2
Object C	3.1	2.7	2.7	3.2	3.6
$C_{org.}$ [g · kg^{-1}]					
Object A	453.0	231.2	9.7	64.6	62.7
Object B*	434.9	324.7	4.7	64.6	15.2
Object C	435.2	345.4	n.d.	44.6	25.8
N_t [g · kg^{-1}]					
Object A	16.4	11.3	n.d.	2.1	n.d.
Object B*	20.1	13.7	n.d.	6.1	0.8
Object C	22.1	19.3	n.d.	2.2	0.9
C/N					
Object A	28	21	n.d.	31	n.d.
Object B*	22	24	n.d.	11	19
Object C	20	18	n.d.	20	29

* reported in the paper Jamroz, Kocowicz [4]; n.d. – not determined.

Mineral forms of nitrogen in all investigated objects were characterized by predominance of ammonia (Table 2). Similar results received Brozek [10], in Beskid Zachodni and others in forest ecosystems [11,12]. Acid environment favor ammonification processes, what can be confirmed by study of Sapek and Kalinska [13]. On the base of results a dependence between degree of forest degradation and $N\text{-}NO_3$ and $N\text{-}NH_4$ content, especially in the fresh material (Table 1) is worth to note. During the incubation differences between forest sites were not so clear. In the fresh material high

differences of the content of $N\text{-}NO_3$ between degraded ecosystems were found. The lowest content were found in needles of degraded spruce forest – C and this situation was permanent during the incubation. In the Oh layer content of $N\text{-}NO_3$ in C object was initially the lowest, but during incubation was increasing and after 30 days of decomposition was the highest. Similar results can be found in researches by Maciaszek et al [12] during analysis of changes mineral forms of nitrogen in ectohumus layers in the controlled conditions. The highest content of ammonia form was found in needles from degraded ecosystems – C and despite of decreasing the amount during decomposition this was stable until 90^{th} day of incubation. In Oh layers content of $N\text{-}NH_4$ was decreasing with the time of incubation and the most clear was observed in ecosystems in degradation process and degraded as well (Table 2). Such distribution of mineral forms of nitrogen during mineralization reflects transformation processes of the organic matter in degraded forest ecosystems.

Table 2

Changes of mineral forms of nitrogen in ectohumus layers and spruce needles from the ecosystems in various stages of degradation

Object	Horizon	After sampling		30 days of incubaction		60 days of incubation		90 days of incubation	
		[mg · kg^{-1} d.m.]							
		$N\text{-}NO_3$	$N\text{-}NH_4$	$N\text{-}NO_3$	$N\text{-}NH_4$	$N\text{-}NO_3$	$N\text{-}NH_4$	$N\text{-}NO_3$	$N\text{-}NH_4$
A	needles	1.01	2.90	0.94	5.46	0.50	4.39	0.39	3.43
A	Olf	0.58	128.59	1.59	30.26	1.28	23.76	0.86	20.39
A	Oh	1.25	8.89	1.60	7.92	1.10	6.24	0.88	5.32
B	needles	1.52	10.29	0.86	4.55	0.60	3.95	0.51	3.19
B	Olf	1.38	149.56	1.29	34.37	0.81	24.21	0.63	18.90
B	Oh	1.41	19.55	0.71	4.87	0.57	3.87	0.37	3.14
C	needles	0.10	24.61	0.75	9.13	0.41	8.10	0.36	6.97
C	Olf	23.45	183.87	4.53	23.13	2.92	18.54	2.44	14.97
C	Oh	4.87	22.63	1.06	5.38	0.71	4.26	0.50	3.42

Lower content of mineral nitrogen together with natural low level of the element in coniferous trees, especially spruce, can favor to developing of damages as yellowing and premature falling needles [14].

In the forest ecosystems without negative effects the participation of mineral forms of nitrogen should reach 2–3 % of the total N [12]. Forest sites from the Snieznik Massif are characterized by rather small participation of $N\text{-}NH_4$ + $N\text{-}NO_3$ forms in total nitrogen – below 1 %.

Conclusions

In mountain coniferous forests in the region of Snieznik Range during decomposition of organic matter ammonia is mainly produced and acid reaction of the soil favor this

process. In spruce needles which are natural poor in nitrogen, its biological blockade can lead to chlorosis of needles. Degradation processes in the Snieznik Massif reflect changes in mineral forms of nitrogen. Higher content of $N\text{-}NO_3$ and $N\text{-}NH_4$ in more degraded forest ecosystems can point to lower biological activity in the ecosystems in degradation process.

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Abstrakt: W pracy przedstawiono wyniki analiz zmian zawartości mineralnych form azotu ($N\text{-}NO_3$ oraz $N\text{-}NH_4$) w poziomach próchnic nadkładowych (Olf i Oh) oraz w igłach świerków podczas procesów ich dekompozycji. Doświadczenie prowadzono w warunkach zamkniętych w komorze inkubacyjnej, przy stałej temperaturze oraz wilgotności. Próbki materiału roślinnego – igły oraz próbki z poziomów próchnicy nakładowej pobrano z ekosystemów świerkowych w różnym stadium degradacji (obiekt bez objawów degradacji, zamierający oraz obumarły). W materiale świeżym, bezpośrednio po pobraniu w terenie wykonano oznaczenia zawartości form $N\text{-}NO_3$ oraz $N\text{-}NH_4$. Kontrolę zawartości mineralnych form azotu przeprowadzono po upływie 30, 60 i 90 dni inkubacji. W materiale wyjściowym wystąpiły znaczne różnice w zawartości form azotu azotanowego. Najmniejszą jego ilość stwierdzono w igłach świerków obumarłych i taka zawartość utrzymywała się przez cały okres inkubacji. W poziomie epihumusowym (Oh) zawartość $N\text{-}NO_3$ była początkowo najmniejsza, spośród badanych obiektów, ale z upływem czasu inkubacji zwiększała się i od 30 dnia procesu dekompozycji utrzymywała się na najwyższym poziomie. Największą zawartość azotu amonowego odnotowano w igłach świerków obumarłych i mimo tendencji spadkowych we wszystkich obiektach, taki stan utrzymał się do 90 dnia inkubacji. W poziomach epihumusowych, niezależnie od stopnia degradacji siedliska, zawartość azotu amonowego zmniejszała się wraz z upływem czasu inkubacji, a najwyraźniej zmiany te zachodziły w siedliskach zamierających i obumarłych.

Słowa kluczowe: formy azotu, gleby górskie, degradacja drzewostanów