ECOLOGICAL CHEMISTRY AND ENGINEERING A

Vol. 18, No. 4 2011

Andrzej KOCOWICZ[1] and Elżbieta JAMROZ[1]

CARBON AND NITROGEN CONTENT OF MOUNTAIN MEADOW AND FOREST PODZOLS AND BROWN ACID SOILS

ZAWARTOŚĆ WĘGLA I AZOTU W BIELICOWYCH I BRUNATNYCH GLEBACH GÓRSKICH POD UŻYTKOWANIEM DARNIOWYM ORAZ LEŚNYM

Abstract: On Karkonosze Mts area investigation on some soil forming factors influence on total nitrogen content and C/N ratio of soil were conducted. The objects of researches were forest and meadow brown acid soils and podzols. Soil profiles were developed from granites and mica slates and localized in altitude range 650–1350 m a.s.l. The soils had texture of clay sands, very acid and acid reaction, high hydrolytic acidity and high content of carbon and nitrogen and high C/N ratio. Higher value of C/N ratio and carbon content of O and Bbr horizon was determined in the forest soils than in the meadow soils. The investigations showed influence of soil parent rock on carbon content of Bbr, Ees, Bhfe and C horizons. Soils developed from mica slates had higher carbon content than soils developed from granites. The influence of climatic condition were revealed in Bbr and parent rock horizons. Content of carbon and nitrogen which raised along with the altitude up to 1100 m a.s.l. Above 1160 m a.c.l. decrease of C/N ratio in O horizon has been observed.

Keywords: mountains soils, nitrogen, C/N ratio, vegetation, climatic condition, parent rock

Organic matter is one of the most important components of soil. Even though that usually is only small part of soil has influence on almost every soil proprieties and plants supply in nutrients. Research on organic matter distribution and transformation is possible by examination of the main components of organic matter – carbon and nitrogen. Equally relation between carbon and nitrogen content which is described as C/N ratio is very important. This indicator characterizes the organic matter transformation and describes indirectly many processes running in soils. Content of carbon, nitrogen and C/N ratio in soils depends on many factors but especially on soil forming factors. Convenient regions to conduct investigations on soil forming factor are

[1] Institute of Soil Sciences and Environmental Protection, Wrocław University of Environmental and Life Sciences, ul. Grunwaldzka 53, 50–357 Wrocław, Poland, phone: +48 71 320 56 40, fax: +48 71 320 56 31, email: andrzej.kocowicz@up.wroc.pl

mountains because in small area is possible to examine very different environmental condition. On the other side influence of man's activity on soil is relatively minor.

The considerable range of altitudes, the large variability of soil parental material and different vegetation in relatively small area enables to study climatic condition, parent rock and vegetation influence on soil properties.

Material and methods

Investigations were conducted on Karkonosze Mts (western Sudeten) area (Fig. 1). 32 profiles of mountain soil were selected. The soil profiles were situated in four perpendicular to contour line transects on northern slopes of mountains. Two transects was set on soils developed from granites and two on soils developed from mica slates. These rocks differ in texture, structure and resistance to weathering process as well as weathering products [1]. These attributes diversify mechanical and physical proprieties of rocks and residuum. Within the transects four altitude ranges (1–4) were set: 650–720, 820–900, 1000–1100 and 1160–1350 m a.s.l. (Table 1). The main differences between altitude ranges are climatic conditions. The most important were temperature and humidity (Table 2). These factors diversified water distribution of the soils, intensity of eluvial and weathering processes and organic matter transformations.

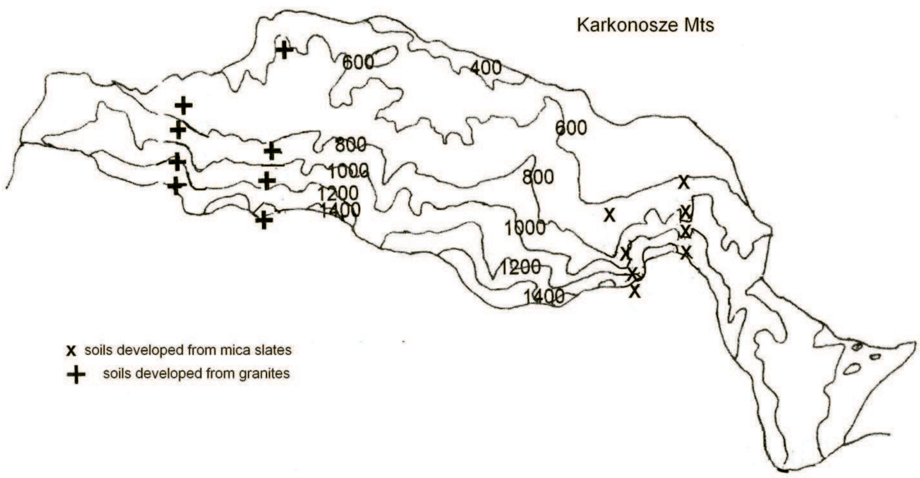

Fig. 1. Localization of investigated soils

The soils profiles were set parallel, in pairs under meadow and forest vegetation. On the meadow soils predominant species was *Calamagrostis villosa* and *Deschampsia flexuosa*, above 1000 m a.s.l. *Nardus stricta*. The spruce *Picea abies* on forest soils was the main species, while at zone of forest upper limit the was dwarf mountain pine *Pinus montana*.

In the range of height up to 900 m a.s.l. only brown acid soils were present, in the range from 1000 to 1100 m a.s.l. brown acid soil and podzols were found, and above 1160 m a.s.l. only podzols.

Table 1

Reaction, Hydrolitic acidity of soils Karkonosze Mts soils

Properties		O	A	Bbr	Ees	Bhfe	C
pH	H_2O	3.67	3.97	4.44	4.03	4.2	4.51
	KCl	3.32	3.53	3.97	3.49	3.74	4.14
Hh		12.85	9.18	6.17	7.88	8.33	4.38

Table 2

Fraction composition of soils of Karkonosze Mts

Fraction [mm]	Soil horizons			Soils developed from	
	A and Ees	Bbr Bhfe	C	granites	mica slates
1–0.01	47.4	49.8	48.6	50.9	44.6
0.1–0.02	37.5	35.1	33.6	31.3	40.7
< 0.02	15.1	15.1	17.8	17.8	14.7
< 0.002	1.9	2.2	1.8	1.9	1.9

The samples of the soils were taken from every genetic horizon. The following analyses in fraction below 1 mm were conducted: total organic carbon – C_{tot} with Tiurin method, total nitrogen – N_{tot} with Kjeldahl method, pH with potentiometer in H_2O and 1 M · dm^{-3} KCl solution, hydrolytic acidity (Hh) with Kappen method [2]. Average values of O, A and C horizons from all soil profiles for were calculated, for Bbr horizon from brown acid soil and for Ees and Bhfe horizons from podzols. Individual data for average values calculation were chose on the basis of the soil horizons morphology. Statistical analyses were executed at significance level 0.95 with *Statistica 9.0.*

Results and discussion

The texture of presented soils was clay sands with high content of silts and skeleton (Table 3). Minor differences were connected with depth of horizons and between soil developed from various rocks. The hydrolytic acidity was high, reaction very acid and acid (Table 4). The soils were developed from diluvial-weathered material.

Table 3

Climatic condition of Karkonosze Mts. area (Kwiatkowski, Hołdys 1985) [20]

Altitude [m a.s.l.]	Mean annual temperature [^oC]	Annual sum of percipitation [mm]	Days with temperature below 0 [^oC]
640	5.8	1158	83–118
872	4.0	1233	115–128
1077	3.7	1349	126–134
1331	1.9	1429	136–155

Table 4

Total carbon (C_{tot}) and nitrogen (N_{tot}) content and C/N ratio of meadow and forest soils of Karkonosze Mts

Soil horizon	C	N	C/N	C	N	C/N
	%					
	Meadow soils			Forest soils		
O	38.29	1.76	21.70	40.97	1.69	24.54
A	6.75	0.43	15.31	6.55	0.40	18.05
Bbr	3.21	0.21	14.74 a	4.51	0.25	18.91 a
Ees	2.64	0.17	14.08	2.53	0.22	14.27
Bhfe	4.80	0.31	15.39	3.99	0.22	17.96
C	1.70	0.13	12.91	1.95	0.13	14.77

Values differing signifficantly between vegetation were marked with the same letter.

Content of C_{tot} and N_{tot} of examined soil was high. Moreover this elements were present in every soil horizon including parent-rock horizon (Table 5–7). High content of organic matter is mountain soils attribute [3–6]. This characteristic is connected mainly with climatic condition of mountain areas – low temperatures and large precipitation what promotes organic matter accumulation. Content of C_{tot} and N_{tot} of investigated soils decreased in depth of profiles. Simultaneously process of organic matter eluviations from Ees horizon to Bhfe horizon took places, what resulted in reduction of C_{tot} and N_{tot} content in Ees horizons and increase in the Bhfe horizon.

The C/N ratio was high, what is typical for poor mountains sites. The high level of this indicator is connected with character of the organic matter of mountain environment, slow rate of organic matter mineralization as well as low pH of soil and high hydrolytic acidity [6–8]. Very significant was severe mountain climate condition which is not favorable for biological activity. C/N ratio were the highest in organic horizons and decreased in depth of the soils. Similar tendency observed Drozd [3], Drozd et al [4], Licznar and Mastalska-Cetera [5], Skiba [6], Drewnik [7]. C/N ratio was lower in albic horizons and higher in spodic horizons (Table 5–7) as effect of podzolization process.

The influence of vegetation on C_{tot} content and C/N ratio in soil was observed. Forest soils had higher content of C_{tot} than meadow soils in O, Bbr and C horizons but not statistically significant (Table 5). Higher content of C_{tot} in forest soils than in meadow soils has been reported by different researchers [5, 9–11]. Such regularity was not found in soils Ees and Bhfe horizons of podzols. Reason for this could be to overbalance of abiotic factor over biotic (vegetation influence) on the highest altitude range, where podzols dominate. Moreover in the highest zone the forest ecosystem withdraw and became more and more similar to meadow. Soils under meadow and forest had different values of C/N ratio. Higher value of this index were determined in the forest soils than in the meadow soils. The differences achieved significant level in Bbr horizon (Table 5). This indicates higher resistance of organic matter of the forest soils for mineralization. Similar results were reported by other researchers [5, 9, 12–14].

Table 5

Total carbon (C_{tot}) and nitrogen (N_{tot}) content and C/N ratio of soils developed from granites and mica slates of Karkonosze Mts

Soil horizon	C [%]		N [%]		C/N	
	Soils developoed from					
	granites	mica slates	granites	mica slates	granites	mica slates
O	43.43	37.73	1.89	1.6	22.82	23.95
A	7.38	6.97	0.45	0.38	16.32	17.86
Bbr	3.27	3.93	0.2	0.25	17.26	14.92
Ees	1.71 a	3.11 a	0.3	0.21	12.41	15.15
Bhfe	3.22	4.51	0.19	0.25	16.58	18.88
C	1.29 b	2.19 b	0.11	0.14	11.62	14.83

Values differing signifficantly between soil parential rock were marked with the same letter.

The investigations showed influence of the parent rock on C_{tot} content in soils. This relation was evident in the deeper soil depth and soil horizons of lower level of organic matter content. Origin of these horizons is mainly connected with abiogenic and only subsidiary with biogenic processes The higher amount of C_{tot} was discovered in Bbr, Ees, Bhfe and C horizons of soils developed from mica slates than from granites. These differences of Ees and C horizons were statistically significant (Table 6). Connections between parent rock and soil nitrogen transformation has been observed by Gonzalez--Prieto and Villar [15].

Table 6

Total carbon (C_{tot}) and nitrogen (N_{tot}) content and C/N ratio of soils from different altitudes of Karkonosze Mts

Soil horizon	Altitude range [m] above sea level m a.s.l. – (No of altitude range)											
	650–720 – (1)			820–900 – (2)			1000–1100 – (3)			1160–1350 – (4)		
	Ct	Nt	C/N	Ct	Nt	C/N	Ct	Nt	C/N	Ct	Nt	C/N
O	41.58	1.76	23.82	39.64	1.62	23.50	42.00	1.66	26.14 f	37.02	1.85	20.32 f
A	6.16	0.35	18.09	6.19	0.44	15.06	5.85	0.40	14.21	6.48	0.37	18.33
Bbr	3.07 a	0.19 c	15.57	2.98 b	0.17 d	17.30	5.03 a b	0.32 c d	16.11	n.d	n.d.	n.d.
C	1.19	0.08 e	13.37	1.74	0.12	14.21	2.38	0.17 e	14.18	1.38	0.12	16.67

Values differing signifficantly between soil parential rock were marked with the same letter.

Many authors [3, 10, 11, 14, 16–19] reported about influence of weather conditions on processes of organic matter in soil accumulation and transformation. They reported that on elevated localizations of low temperature and substantial precipitation organic matter content of soil is bigger than in areas localized lower where temperature is higher and precipitation lesser.

The content of C_{tot} and N_{tot} of presented soils in Bbr and C horizons showed tendency to growth along with the altitude up to 1100 m a.s.l. The increase were

Table 7

Total carbon (C_{tot}) and nitrogen (N_{tot}) content and C/N ratio of soils of Karkonosze Mts

Altitude range	Vegetation	Soils developed from granites								Soils developed from mica slates							
		Soil horizon	C %	N %	C/N	Soil horizon	C %	N %	C/N	Soil horizon	C %	N %	C/N	Soil horizon	C %	N %	C/N
650–720 m a.s.l.	meadow soil	Ol	56.33	2.50	22.53	Ol	47.10	1.90	24.79	Ad	5.54	0.34	16.29	Ad	10.91	0.69	15.74
		Ad	3.82	0.35	10.91	Ad	6.57	0.52	12.69	A	2.85	0.26	10.96	ABbr	6.06	0.48	12.64
		1Bbr	2.14	0.13	16.46	Bbr	3.42	0.18	18.60	Bbr1	0.86	0.13	6.59	C	4.99	0.31	16.10
		2Bbr	1.64	0.12	13.67	Bbrl2	3.00	0.17	17.65	Bbr2	0.70	0.12	5.83				
		C	1.19	0.07	17.04	C	1.40	0.08	17.50	C	0.18	0.04	4.55				
	forest soil	O	55.74	2.44	22.84	Ol	48.20	1.92	25.10	Ol	53.54	1.78	30.08	Ol	43.20	2.21	19.55
		A	6.21	0.21	29.57	Ofh	45.69	1.71	26.75	Ofh	32.84	1.24	26.48	Ofh	36.20	2.01	18.01
		ABbr	2.72	0.17	16.00	Ah	10.34	0.53	19.44	Oh	19.29	0.84	22.96	A	8.29	0.40	20.96
		Bbr	2.22	0.13	17.08	A	5.86	0.29	20.42	A	3.96	0.20	19.80	ABbr	7.28	0.39	18.90
		C	1.27	0.11	11.54	Bbr	2.68	0.12	22.59	Ees	1.94	0.12	16.14	BbrC1	4.17	0.20	20.83
						C	0.72	0.08	9.06	Bhfe	2.84	0.15	18.95	BbrC1	3.18	0.21	15.43
										C	2.43	0.13	18.69				
820–900 m a.s.l.	meadow soil	Ol	53.54	2.40	22.31	Ad	8.03	0.44	18.22	Ol	52.84	2.12	24.93	Ol	56.03	2.19	25.59
		AO	37.60	1.50	25.07	A	5.12	0.33	15.72	AO	21.66	1.05	20.63	AOd	13.21	0.80	16.55
		A	3.76	0.37	10.16	Bbr	3.90	0.24	16.07	Ees	3.26	0.16	20.39	Ad Bbr	5.27	0.30	17.58
		Bbr	1.89	0.17	11.11	C	2.67	0.18	14.83	Bhfe1	6.05	0.35	17.29	Bbr	3.20	0.17	18.53
		C	0.58	0.08	7.27					Bhfe2	4.20	0.28	15.00	BbrC	1.36	0.10	14.10
										C	1.16	0.10	11.60	C	1.02	0.07	14.57
	forest soil	Ol	54.64	1.79	30.53	Ol	55.80	2.04	27.35	Ol	55.81	1.92	29.07	Ol	55.57	2.08	26.72
		Of	50.64	1.71	29.61	Ofh	33.96	1.90	17.90	Ofh	51.84	1.65	31.42	Ofh	39.20	1.92	20.42
		Oh	45.40	1.66	27.35	AO	16.03	1.05	15.27	AO1	16.68	1.12	14.89	Oh	21.17	1.30	16.28
		A	6.21	0.73	8.51	ABbr	5.27	0.29	18.37	AO2	15.85	0.83	19.10	A	6.84	0.48	14.37
		ABbr	4.25	0.15	28.33	RBbrC	2.92	0.18	16.21	Ees	3.92	0.26	15.08	AEes	3.41	0.35	9.73
		C	1.15	0.09	12.76					Bhfe	4.85	0.29	16.72	Bhfe1	6.99	0.44	15.84
										C		1.19	0.08	Bhfe2	4.92	0.22	21.96
														C	3.24	0.15	21.60

Table 7 contd.

Altitude range	Vegetation	Soils developed from granites								Soils developed from mica slates							
		Soil horizon	C %	N %	C/N	Soil horizon	C %	N %	C/N	Soil horizon	C %	N %	C/N	Soil horizon	C %	N %	C/N
1000–1100 m a.s.l.	meadow soil	Ol	56.44	2.16	26.13	Ol	48.21	2.01	23.99	Ol	54.70	2.01	27.21	AOd	14.23	0.73	19.55
		AO	32.60	1.53	21.31	Ahd	10.53	0.53	19.87	AOd	17.66	0.70	25.23	ABbr	6.98	0.42	16.63
		ABbr	5.36	0.44	12.17	Bbr	4.06	0.30	13.53	ABbr	8.39	0.32	26.22	Bbr	4.10	0.23	17.57
		Bbr	3.54	0.18	19.66	C	1.06	0.13	8.15	BbrC	4.50	0.26	17.31	C	3.21	0.24	13.38
	forest soil	Ol	55.74	1.93	28.88	Ol	55.80	1.99	28.04	Ol	54.76	2.03	26.97	Ol	55.71	2.27	24.54
		Ofh	46.60	1.84	25.33	Ofh	37.51	1.95	19.21	Ofh	34.50	1.26	27.38	Of	49.48	2.13	23.23
		Oh	40.10	0.90	44.56	Oh	40.29	1.67	24.18	Oh	28.56	1.52	18.79	Oh	33.17	1.33	24.94
		A	6.37	0.45	14.16	AEes	3.75	0.26	14.23	Ees	3.92	0.23	17.04	Bbr	6.98	0.45	15.50
		ABbr	5.03	0.40	12.58	Bh	5.48	0.23	23.97	Bhfe	6.02	0.16	37.63	C	2.45	0.14	17.53
		BbrC	2.83	0.22	12.86	Bhfe1	3.07	0.20	15.31	C	1.06	0.06	17.67				
						Bhfe2	2.16	0.19	11.57								
						C	1.99	0.18	11.06								
1160–1350 m a.s.l.	meadow soil	Ol	56.15	2.69	20.87	Ol	53.59	2.31	23.20	Ol	55.16	2.25	24.52	Ol	56.20	2.19	25.66
		Ohd	14.80	1.68	8.81	AO	25.04	1.74	14.42	AOd	21.52	0.87	24.74	AO	34.25	1.55	22.14
		Ees	0.79	0.08	9.87	AEes	4.50	0.26	17.53	A	6.16	0.30	20.52	AhEes	10.85	0.59	18.35
		Bh	1.96	0.18	10.86	Ees	2.67	0.18	14.47	Ees	3.21	0.22	14.59	Bhfe	3.72	0.15	24.72
		Bfe	1.87	0.11	17.02	B	3.18	0.20	15.65	Bhfe	4.00	0.22	18.18	C	1.70	0.14	12.14
						C	1.16	0.10	11.60	C	1.77	0.16	11.06				
	forest soil	POt	34.60	1.42	24.37	Ol		1.79	53.46	Of	40.63	1.99	20.42	Ol	55.77	2.09	26.68
		OT	26.90	1.94	13.87	Ah	11.19	0.69	16.18	AO	25.04	1.49	16.81	AO	37.42	1.99	18.82
		Ees	0.99	0.13	7.62	AEes	4.10	0.21	19.11	Ees	2.09	0.16	13.06	AhEes	10.91	0.61	17.91
		Bhfe	2.35	0.16	14.69	Ees	2.40	0.14	17.68	Bh	6.28	0.32	19.63	Bhfe1	3.72	0.26	14.37
		C	0.51	0.06	8.47	Bhfe	4.13	0.21	19.37	Bhfe	2.52	0.21	12.00	Bhfe2	2.46	0.19	12.83
						Bhfe	2.11	0.14	14.56					C	1.83	0.11	16.60
						C	1.32	0.13	10.15								

significant of Nt content in C horizons between the height zone 1 and 3 also in Bbr horizon between the zones 1 and 3 as well as 2 and 3. Similarly content of C_{tot} in Bbr horizons differed significantly between altitude range 1 and 3 as well as 2 and 3 (Table 7).

In the altitude zone 1160–1350 m a.s.l. content of C_{tot} in O horizons was smaller than in lower altitudes (Table 7). The reason for this is more intensive elution of C_{tot} in higher altitude than in lower because of bigger precipitation (Table 2). Equally on this elevation C/N ratio was minor than in soils localized lower. This could be connected with relatively lower eluviations of N_{tot} than C_{tot}. Significant influence of altitude on C/N ratio in soils appeared in O horizons between altitudes 3 and 4.

Conclusions

1. Influence of vegetation appears in the C/N ratio C_{tot} content. Forest soils exhibit the higher value of C/N ratio and higher C_{tot} content than meadow soils.
2. Influence of parent material on C_{tot} level has been found. Content of C_{tot} in soils developed from mica slates was higher than in soils developed from granites. This tendency appeared in Bbr, Ees, Bhfe and C soil horizons.
3. Effect of climatic factor appeared in content of C_{tot}, N_{tot} and C/N ratio. Content of C_{tot} and N_{tot} were higher in Bbr and C horizon as well as C/N ratio of O horizons was minor in soils localized in higher altitudes.

References

[1] Kozłowski S.: Surowce skalne Polski. Wyd. Geolog., Warszawa 1986, pp. 539.
[2] Ostrowska A., Gawliński S. and Szczubiałka Z.: Metody analizy i oceny właściwości gleb i roślin. Katalog. Wyd. IOŚ, Warszawa 1991, pp. 334.
[3] Drozd J.: Problemy ekologiczne wysokogórskiej części Karkonoszy. Oficyna Wyd. Inst. Ekologii PAN, Dziekanów Leśny 1995, 113–121.
[4] Drozd J., Licznar S.E. and Licznar M.: Zesz. Probl. Post. Nauk. Roln. 1993, **411**, 149–158.
[5] Licznar S. and Mastalska-Cetera B.: Geoekolgiczne. Probl. Karkonoszy. Mat., vol. 1, Wyd. Acarus, Poznań 1998, 215–223.
[6] Skiba S.: Ocena wpływu imisji przemysłowych na gleby Karkonoszy. Problemy ekologiczne wysokogórskiej części Karkonoszy. Ofic. Wyd. Inst. Ekologii PAN, Dziekanów Leśny 1995, 97–121.
[7] Drewnik M.: Geoderma 2006, **132**, 116– 130.
[8] Fotyma M., Mercik S. and Faber A.: Chemiczne podstawy żyzności gleb. Wyd. PWRiL, Warszawa 1987, 320 pp.
[9] Brożek S.: Zesz. Probl. Post. Nauk Roln. 1999, **467**, 65–72.
[10] Miller A.J., Amundson R., Burke I.C. and Yonker C.: Biogeochemistry 2004, **67**, 57–72.
[11] Tian Y., Ouyang H., Song M., Niu H. and Hu Q.: Front. Agric. China 2008, **2**(4), 404–409.
[12] Ganuza A. and Almendros G.: Biol. Fertil. Soils 2003, **37**, 154–162.
[13] Kirschbaum M.U.F., Lan B.G. and Gifford R.M.: Forest Ecol. Manage. 2008, **255**, 2990–3000.
[14] Yimer F., Ledin S. and Abdelkadir A.: Geoderma 2006, **135**, 335–344.
[15] Gonzalez-Prieto S.J. and Villar M.C.: Soil Biol. Biochem. 2003, **35**, 1395–1404.
[16] Cui B., You Z. and Yao M.: China Front. Biol. China 2008, **3**(3), 351–359.
[17] Dai W. and Yao H.: Catena 2006, **65**, 87 – 94.
[18] Franzluebbers A.J.: Soil Tillage Res. 2002, **66**, 95–106.
[19] Lal R.: Forest Ecol. Manage. 2005, **220**, 242–258.

[20] Kwiatkowski J. and Hołdys T.: Klimat. Karkonosze polskie. Red. Jahn A., Zakład Narodowy im. Ossolińskich, Wrocław 1985, 87–116.

ZAWARTOŚĆ WĘGLA I AZOTU W BIELICOWYCH I BRUNATNYCH GLEBACH GÓRSKICH POD UŻYTKOWANIEM DARNIOWYM ORAZ LEŚNYM

Instytut Nauk o Glebie i Ochrony Środowiska
Uniwersytet Przyrodniczy we Wrocławiu

Abstrakt: Na terenie Karkonoszy prowadzono badania dotyczące określenia wpływu wybranych czynników glebotwórczych na zawartość azotu całkowitego i stosunku C/N w glebach. Obiektem badań były gleby łąkowe i leśne należących do typu gleb brunatnych kwaśnych i bielic. Zlokalizowane zostały one w przedziale wysokościowym 600–1350 m n.p.m. na granitach i łupkach łyszczykowych. Charakteryzowały się składem granulometrycznym piasków gliniastych, kwaśnym i bardzo kwaśnym odczynem, wysoką kwasowość hydrolityczną. Miały dużą zawartość azotu, węgla i wysoki stosunek C/N, które zmniejszały się w głąb profili gleb. Gleby leśne wykazywały większy stosunek C/N, a w poziomach O, Bbr i C zawierały więcej węgla niż gleby łąkowe. Współzależność pomiędzy rodzajem skały macierzystej gleb a zawartością węgla zaznaczyła się w poziomach Bbr, Ees, B, C – gleby wytworzone z łupków łyszczykowych zawierały go więcej niż gleby wytworzone z granitów. Wpływ warunków klimatycznych uwidocznił się w poziomach genetycznych Bbr i C. Profile gleb położonych wyżej zawierały więcej azotu i węgla niż gleby zlokalizowane niżej.

Słowa kluczowe: gleby górskie, azot, stosunek C/N, czynniki glebotwórcze