10.1515/umcsgeo-2015-0004

ANNALES
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN – POLONIA

VOL. LXIX, 2 SECTIO B 2014

Department of Soil Science and Protection, Maria Curie-Skłodowska University in Lublin
al. Kraśnicka 2cd, 20-718 Lublin, Corresponding author, e-mail: piotr.bartminski@umcs.pl

RYSZARD DĘBICKI, KATARZYNA BILAKOWSKA,
JACEK CHODOROWSKI, PIOTR BARTMIŃSKI

Impact of Tourism on Selected Properties of Soils of Bukowa Góra Educational Path (Roztoczański National Park, Eastern Poland)

Wpływ turystyki na wybrane właściwości gleb na ścieżce dydaktycznej Bukowa Góra
(Roztoczański Park Narodowy, Wschodnia Polska)

Keywords: Roztocze, tourist pressure, educational path, soil degradation, protected areas
Słowa kluczowe: Roztocze, presja turystyczna, ścieżki dydaktyczne, degradacja gleby, obszary chronione

1. INTRODUCTION

Areas of high natural value, especially national parks are very popular among domestic and foreign tourists. The development of tourism in these areas can therefore pose a threat to wildlife comparable to the impact of certain industries or intensive agriculture. Mass tourism causes changes in the landscape and contributes to the reduction of the forest area and displacement of the animals, the deterioration of forests and the production of garbage and waste (Sokołowski 1981). The intensity of tourist traffic also causes changes in the properties of the soil (Prędki 2000, 2002).

The aim of the study is to analyze the changes in the soil due to tourist traffic within the educational path to Bukowa Góra in the Roztoczański National Park (RPN).

2. AREA AND METHODS

Bukowa Góra forest reserve is located south of the city Zwierzyniec (Central Roztocze). It covers the top of a high hill (310 m a.s.l.) and its northern slope, which descends towards the Wieprz River valley. Due to the high attractiveness of natural landscape, a nature reserve on the area not exceeding 8 ha was established here in 1934. After the end of World War II, this area granted protection rights in 1957; 155.59 hectares are under strict protection and 82.83 hectares under partial protection, together about 198 hectares (Izdebki et al. 2000). The purpose of protection is to preserve the unique fir and fir-beech stands, consisting communities of upland fir forests and Carpathian beech forests as well as protection of rare representatives of flora and fauna. Besides its natural advantages, Bukowa Góra consists of excellent educational facility. Moving along a nature path on Bukowa Góra clear dependence between distribution of tree species and plant communities can be seen, and the diversity of the terrain, and the relationship of soil and water (Lipiec 1979; Izdebski et al. 1992, Izdebski et al. 2000).

Soil cover of the reserve is strictly dependent on the geological structure, relief and vegetation - particularly diverse forest communities. In the lower and middle parts of the path mainly podzol soils occur. In the upper part of the path, which includes the upper parts of the hill, the complex of proper leached brown soils, brown pararendzinas and brown rendzinas developed (Uziak et al. 1978, Uziak 1994, Chodorowski et al. 2000).

Six soil profiles were prepared in the reserve: three profiles in the middle of the path (marked with symbols 1A, 2A, 3A), and three within 8 meters of the path in the forest (benchmark profiles marked by the symbols 1B, 2B, 3B). Profiles 1A, 1B were located at the foot of the hill in the lower part of the path, the next two (2A, 2B) within the slope, and the last two (3A, 3B) within the plateau (Fig. 1). Soil samples were collected in all profiles from the depth of 0-5 cm, 20-25 cm and 40-45 cm. Exceptions are sections 3A and 3B, in which the soil material has been taken only from a depth of 0-5 and 20-25 cm because of the shallow occurrence of Cretaceous formations.

Following parameters were determined in the laboratory: current humidity, capillary water capacity, maximum water content, bulk density, particle size distribution aerometrically, pH in water and 1 M KCl - by potentiometry, organic carbon by Tiurin method, total nitrogen by Kjeldahl method, hydrolytic acidity - by Kappen method, exchangeable cations – by extraction in 0,5 M NH_4Cl (1 M in non-carbonate samples). The color of the soil in the dry state were determined by Standard Soil Color Charts (Oyama, Takehara 1967).

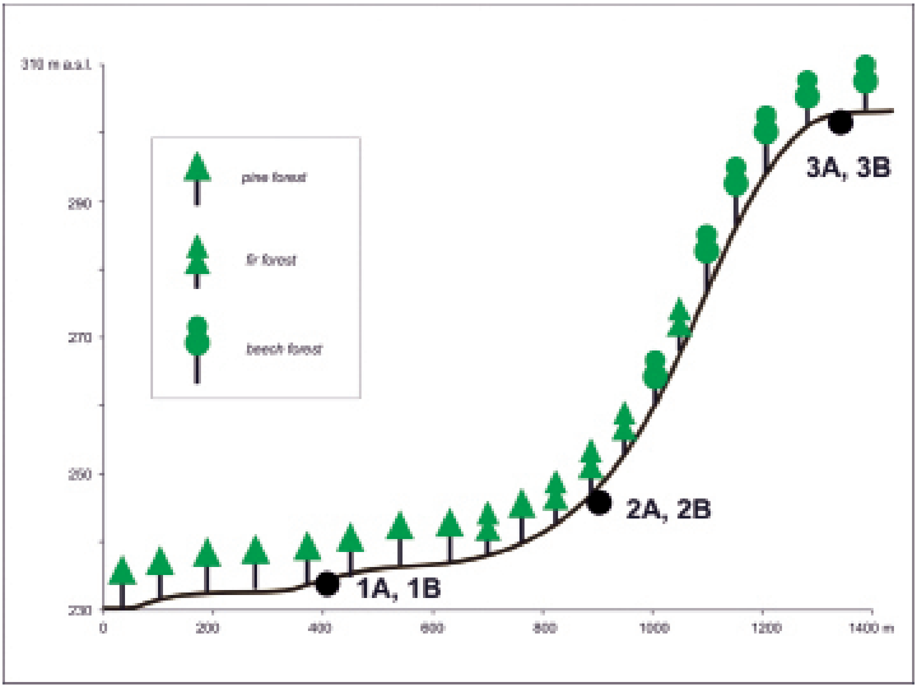

Figure 1. Location of research points within the track on Bukowa Góra (RPN)

3. RESULTS

The morphology of the investigated soils on the educational path is as follows:

Profile 1A. Typical podzol soil (PTG 2011)

delA	0-11 cm	Weakly loamy sand, deposited, brownish gray (10YR 6/1), flat sharp boundary
A	11- 15 cm	Loose sand, brownish gray (10YR 4/1), flat sharp boundary
Es	15-18 cm	Loose sand, brownish-gray (10YR 6/1), flat sharp boundary
Bs	18-23 cm	Loose sand, dull yellow orange (10YR 6/4), compact, distinct wavy boundary
BC	23-40 cm	Loose sand, dull yellow orange (10YR 6/4), distinct wavy boundary
C	>40 cm	Loose sand, bright yellowish brown (10YR 7/6), weakly moist

Profile 1B. Typical podzol soil (PTG 2011)

O	3-0 cm	Organic horizon, well decomposed leaves and pine needles
A	0-11 cm	Loose sand, brownish gray (10YR 4/1), distinct wavy boundary
Es	11-22 cm	Loose sand, grayish yellow brown (10YR 6/2), distinct wavy boundary
Bs	22-30 cm	Loose sand, dull yellow orange (10YR 6/4), distinct wavy boundary
BC	30-48 cm	Loose sand, bright yellowish brown (10YR 6/6), indistinct boundary
C	>48 cm	Loose sand, bright yellowish brown (10YR 7/6)

Profile 2A. Typical podzol soil (PTG 2011)

delA	0-3 cm	Loose sand, deposited, brownish gray (10YR 6/1), flat sharp boundary
A	3-9 cm	Loose sand, brownish gray (10YR 4/1), flat sharp boundary
Es	9-21 cm	Loose sand, grayish yellow brown (10YR 6/2), distinct wavy boundary
Bs	21-38 cm	Loose sand, brown (10YR 4/4), distinct wavy boundary
BC	38-80cm	Loose sand, dull yellow orange (10YR 6/4), distinct wavy boundary
C	>80 cm	Loose sand, bright yellowish brown (10YR 7/6)

Profile 2B. Typical podzol soil (PTG 2011)

O	2-0 cm	Organic horizon, weakly decomposed leaves and pine needles
A	0-5 cm	Weakly loamy sand, brownish gray (10YR 4/1), flat sharp boundary
AE	5-11 cm	Loose sand, dull yellowish brown (10YR 4/3), distinct wavy boundary
Es	11-31 cm	Loose sand, grayish yellow brown (10YR 6/2), sharp wavy boundary
Bs	31-45 cm	Loose sand, dull yellowish brown (10YR 5/4), distinct wavy boundary
BC	45-70 cm	Loose sand, dull yellow orange (10YR 6/4), distinct wavy boundary
C	>70 cm	Loose sand, bright yellowish brown (10YR 7/6)

Profile 3A. Pararendzina with browning process symptoms (PTG 2011)

A	0-5 cm	Sandy loam, yellowish gray (2,5Y 5/1), sharp irregular boundary
BC	5-27 cm	Sandy loam, yellowish gray (2,5Y 5/3), diffuse boundary
Cca	>27 cm	Light loam, dull yellowish brown (10YR 5/4), HCL^+

Profile 3B. Pararendzina with browning process symptoms (PTG 2011)

O	2-0 cm	Organic horizon, weakly decomposed beech leaves
A	0-6 cm	Sandy loam, dark grayish yellow (2,5Y 4/2), irregular sharp boundary
Bw	6-19 cm	Sandy loam, dark grayish yellow (2,5Y 5/2), diffuse boundary
BC	19-35 cm	Sandy loam, grayish yellow (2,5Y 6/2), indistinct boundary
Cca	>35 cm	Light loam, dull yellowish gray brown (10YR 5/4), HCL^+

As a result of tourism, in profiles located on the educational path (1A, 2A, 3A), there was no natural organic level O as compared to the control profiles (1B, 2B, 3B). Thickness of humus horizon A clearly increased in the profiles 1A and 2A as a result of surface accumulation of colluvial material.

Profiles 1A-2A, 1B-2B represent soils developed from loose sands and weakly loamy sands. Sand fraction dominates and the content of fine particles did not exceed several percent. Profiles 3A-3B represent soils showing texture of sandy loams and light loams. The sand fraction slightly dominates, with significant share of silt fraction and clay.

Current humidity at a depth of 0-5 cm in the soils on the educational path is generally less compared with control soils (Table 1). Similar results were also observed in the case of a capillary, and a maximum water capacity. Exceptions are profiles 1A and 1B. Differences in the capillary and maximum water capacity gradually disappear at depths of 20-25 cm and 40-45 cm. Research conducted by Kazanska (1972) and Róg et al. (1980) showed that the impact of physical compaction of soil surface on the water capacity of the soil is most visible at a depth of 0-5 cm.

The study also showed an increase in soil bulk density on the educational path.

Table 1. Basic physical properties of the soils studied

Profile No.	Depth (cm)	Current humidity %	Capillary water capacity %	Maximum water capacity %	Bulk density Mg·m-3
1A	0-5	19,34	23,39	33,57	1,16
	20-25	4,46	17,55	31,86	1,59
	40-45	2,70	17,75	32,64	1,58
1B	0-5	6,82	14,02	24,09	1,22
	20-25	7,96	14,54	27,61	1,49
	40-45	6,71	15,94	29,13	1,53
2A	0-5	7,01	20,03	22,43	1,61
	20-25	6,54	19,37	23,29	1,58
	40-45	6,37	18,36	24,23	1,51
2B	0-5	22,04	32,02	35,69	1,33
	20-25	4,96	17,72	22,86	1,57
	40-45	5,79	22,88	30,68	1,48
3A	0-5	28,54	31,57	37,33	1,31
	20-25	44,35	51,61	60,02	1,06
3B	0-5	36,04	40,89	49,29	0,84
	20-25	47,53	56,02	64,56	0,95

Reaction of anthropogenically compacted soils is higher than the control soils (Table 2). The distinct increase in the pH of profile 1A may be associated with the presence of the colluvial material moved from the higher parts of the hill, built from the Upper Cretaceous rocks containing carbonates.

Organic carbon content Corg. in the surface horizons (0-5 cm) of the soils studied on the path may be higher or lower compared to the surface horizons of benchmark soils (Table 2). A similar trend is observed in the case of nitrogen (Nt). In the podzol soils on the pah the C / N ratio is generally lower as compared to podzol soils outside the path. The values of C / N ratio in the paranendzinas on the path and beyond are similar.

Sorptive complex of soils subjected to tourism pressure is characterzsed by the increase in the value of the sum of bases absorbed (S, i.e. Ca^{2+}, Mg^{2+}, K^{+} and

Na^{+}). The impact of tourism on the soil can also be observ in changes in the value of hydrolytic acidity (Hh) and sorptive capacity (T), Table 2. Hydrolytic acidity is higher in the control soils than in soils on the path. This relationship is observed at all three sampling depths. It was also observed that, in general, compacted soils have lower sorptive capacity than control soils.

Table 2. Basic chemical and physicochemical properties of the soils studied

Profile No.	Depth Cm	pH		C org %	Nt %	C/N	Hh	S	T	V %
		H2O	1M KCl				cmol (+)/kg			
1A	0-5	7.45	7.02	4.36	0.44	10	1.20	3.62	4.82	75.10
	20-25	6.52	5.45	0.42	0.04	11	1.12	1.98	3.10	63.87
	40-45	6.47	4.84	0.17	0.02	9	1.12	0.64	1.76	36.36
1B	0-5	3.87	2.90	3.22	0.16	20	12.52	0.17	12.69	1.34
	20-25	4.08	3.50	0.72	0.04	18	3.90	0.11	4.01	2.74
	40-45	4.56	4.05	0.49	0.02	25	3.67	0.09	3.76	2.39
2A	0-5	6.08	6.05	0.76	0.06	13	0.90	2.04	2.94	69.39
	20-25	5.79	5.43	0.41	0.04	10	1.72	0.29	2.01	14.43
	40-45	5.68	5.04	0.20	0.03	7	1.65	0.15	1.80	8.33
2B	0-5	3.98	3.05	1.31	0.25	5	11.02	0.63	11.65	5.41
	20-25	4.36	3.68	0.21	0.01	21	1.65	0.13	1.78	7.30
	40-45	4.41	4.07	0.39	0.02	20	3.30	0.16	3.46	4.62
3A	0-5	5.17	4.19	1.41	0.21	7	4.10	4.09	8.19	49.94
	20-25	5.62	4.56	1.31	0.11	12	2.10	4.51	6.61	68.23
3B	0-5	3.89	3.23	1.24	0.21	6	12.82	3.51	16.33	21.49
	20-25	4.28	3.28	1.15	0.11	11	8.70	3.48	12.18	28.57

4. CONCLUSIONS

1. Tourist traffic causes adverse changes in the morphology of the soils within the educational path to Bukowa Góra. In the profiles located on the path lack of the organic horizon was noted when compared to the control profiles. In two profiles (1A and 2A) thickness of humus horizon A clearly increased as a result of surface accumulation of colluvial material.

2. As a result of soil compaction on the path, their current humidity, capillary water capacity and maximum water capacity generally decreases, while bulk density increases. This relationship is especially observed at a depth of 0-5 cm.

3. Soils located on the educational path have higher values of pH and lower values of hydrolytic acidity and sorptive capacity when compared to the control soils.

REFERENCES

Chodorowski J., Dębicki R., Klimowicz Z., Melke J., Moszyńska U., Gawrysiak L., 2000: *Mapa typów gleb Roztoczańskiego Parku Narodowego w skali 1:25000*. Opracowanie numeryczne Gawrysiak L. IUNG Puławy.

Izdebski K., Czarnecka B., Grądziel T., Lorens B., Popiołek Z., 1992: *Zbiorowiska roślinne RPN na tle warunków siedliskowych*. Wyd. UMCS, Lublin: 25–30.

Izdebski K., Grądziel T., Popiołek Z., 2000: *Ścieżka przyrodnicza na Bukowej Górze – przewodnik dydaktyczny*. Wyd. IV. RPN. Zwierzyniec.

Kazanska N. S., 1972: *Riekrieacyonnaja digriessija jestiestwiennych gruppirowok rastitielnosti*. Izd.A.N.SSSR. Ser. Geogr., 1.

Lipiec W., 1979: *Ścieżka przyrodnicza w Roztoczańskim Parku Narodowym*. Przyroda Polska, nr 10.

Prędki R., 2000: *Przemiany właściwości powietrzno-wodnych gleb w obrębie pieszych szlaków turystycznych Bieszczadzkiego Parku Narodowego*. Roczniki Bieszczadzkie 9, 225–236.

Prędki R., 2002: *Wpływ ruchu turystycznego na teksturę oraz właściwości wodne gleb Bieszczadzkiego Parku Narodowego* [w:] *Użytkowanie turystyczne parków narodowych. Ruch turystyczny-zagospodarowanie-konflikty-zagrożenia*. Pod redakcją J. Partyki. Instytut Ochrony Środowiska PAN Ojcowski Park Narodowy, 765–770.

PTG, 2011: *Systematyka gleb Polski*. Wydanie 5. Rocz. Glebozn. T. LXII, nr 3.

Oyama M., Takehara H., 1967: *Standard Soil Color Charts*.

Róg Z., Uggla H., Uggla Z., 1980: *Wpływ udeptywania na właściwości gleb leśnych*. Rocz. Glebozn., t. XXXI, 3/3, Warszawa.

Sokołowski A., 1981: *Turystyka w polskich parkach narodowych i jej wpływ na przyrodę parków*. Parki Narodowe i rezerwaty przyrody, t. 2, nr 1, 25–27.

Uziak S., Pomian J., Klimowicz Z., Melke J., 1978: *Pokrywa glebowa RPN*. Biuletyn LTN, sec. D, vol. 20, Lublin, 59–65.

Uziak S., 1994: *Gleby Roztoczańskiego Parku Narodowego i otuliny* [w:] *Roztoczański Park Narodowy*, praca zbiorowa pod red. T. Wilgata. Ostoja, Kraków.

STRESZCZENIE

Celem przeprowadzonych badań jest analiza zmian zachodzących w glebie w wyniku pieszego ruchu turystycznego w obrębie ścieżki dydaktycznej na Bukową Górę w Roztoczańskim Parku Narodowym (RPN). Rezerwat leśny Bukowa Góra położony jest na południe od miasta Zwierzyniec (Roztocze Środkowe, Polska E). Ze względu na dużą atrakcyjność przyrodniczą i krajobrazową już w 1934 roku utworzono tu rezerwat, którego powierzchnia nie przekraczała 8 ha. Celem ochrony jest zachowanie pięknych drzewostanów jodłowych i jodłowo-bukowych, wchodzących w skład zespołów wyżynnego boru jodłowego i buczyny karpackiej oraz zabezpieczenie rzadkich przedstawicieli fauny i flory. W wyniku udeptywania zmianom ulegają niektóre cechy morfologiczne po-

wierzchniowych poziomów genetycznych. Dotyczy to przede wszystkim poziomu organicznego O, którego brak w profilach na ścieżce, a także poziomu próchnicznego A, nadbudowanego deluwiami w profilach zlokalizowanych w dolnych partiach ścieżki. Ponadto w glebach poddanych presji turystycznej zmniejsza się na ogół wilgotność aktualna, kapilarna pojemność wodna i maksymalna pojemność wodna, natomiast wzrasta gęstość objętościowa w porównaniu z glebami kontrolnymi poza ścieżką. Zależność ta jest najbardziej widoczna na głębokości 0–5 cm. Dodatkowo gleby występujące na ścieżce cechują się wyższymi wartościami pH oraz niższymi wartościami kwasowości hydrolitycznej i pojemności sorpcyjnej.