POLISH POLAR RESEARCH	11	1—2	39—45	1990

Piotr BIEŃKOWSKI

Department of Ecological Bioenergetics
Institute of Ecology
Polish Academy of Sciences
Dziekanów Leśny
05—092 Łomianki, POLAND

The rate of cellulose decomposition in soils of Spitsbergen tundra

ABSTRACT: The annual rate of decomposition in five soil types of tundra situated in the Fugleberget drainage area (Hornsund Fjord, South Spitsbergen) was investigated by use of the method of standard cellulose samples. The rate of decomposition varied from 15% to over 65% a year and was closely connected with a contents of nitrogen in soil, amount of which varied from 0.33% to 3.44%. The results presently obtained are much higher than those obtained by the same method in other polar regions.

K e y w o r d s: Arctic, Spitsbergen, tundra, cellulose decomposition.

Introduction

The present paper aimed at the investigation of decomposition intensity proceeding in various habitats of Spitsbergen tundra. The cellulose as a standard substrate was chosen purposely in order to compare the intensity of decomposition processes in various soils and habitats of tundra.

The studies carried out formerly in polar regions (Rosswall 1974) indicate that the rate of decomposition process of the dead plant material is low. Thus, it seemed interesting to study the rate of the processes in a drainage area of Fugleberget, rich in nutrients and fertilized by the great colony of little auks (*Plautus alle*).

The year-round exposition of samples in the soil allows the global observation of mineralization processes and could be an indication of intensity of bioenergetic changes proceeding during a season. It could be especially significant in polar conditions where the decomposition process runs at lower level and where the soil thermic as well as the amount of water in the soil change considerably.

Material and methods

Investigations were carried out in south-western part of Spitsbergen at the Hornsund Fjord (77°00' N; 15°34' E) in Fugleberget drainage system. For the purpose of investigations five most characteristic habitats were chosen in drainage area studied (Tab. 1). The distribution of the stations in the area against the background of plant communities (Grodzińska and Godzik, unpubl. data) was shown in Fig. 1.

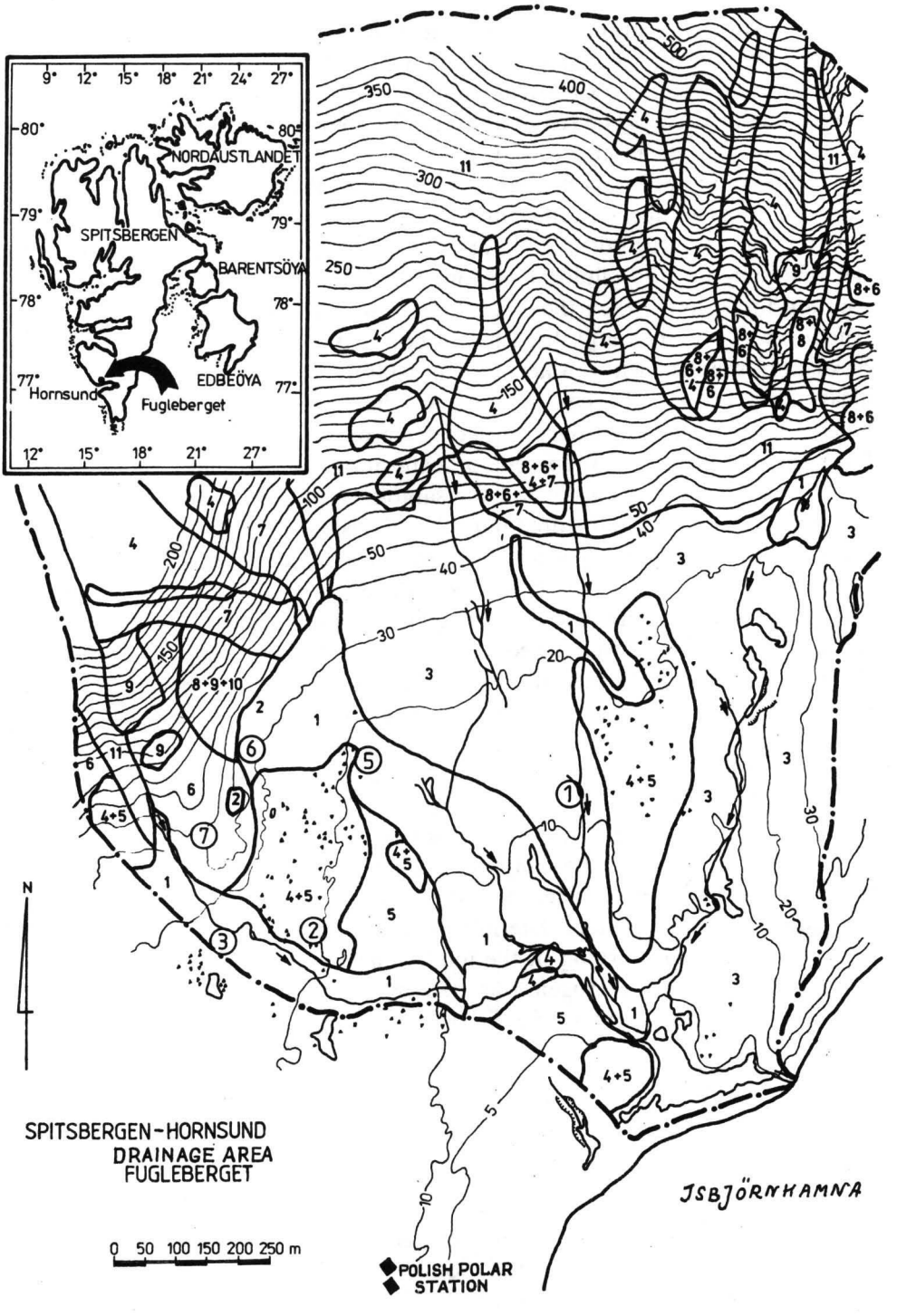
In places overgrown by the moss *Calliergon* sp. investigations were carried out in three stations (st. 4—6). They were selected taking into account their distances from the colony of little auks (*Plautus alle*). The first one (st. 4) was situated at the edge of drainage area not far from the mouth of the stream to the sea and was most distant from the colony of birds (Fig. 1). Station 5 was located at the foot of slope where the colony of little auks is situated and station 6 was located in the colony itself.

Table 1.

Decomposition rate of cellulose, organic matter contents and nitrogen contents in the Fugleberget drainage area (Hornsund, Spitsbergen)

Station	Habitat	Organic matter in soil (%)	Nitrogen in dry soil matter (%)	C/N	Decomposition of cellulose % ± SD	Number of samples n
1	Structural soil	5,0	0,20	18	20,73 ± 6,51	12
2	Rocky tundra	5,1	0,33	6	15,78 ± 7,91	14
3	*Salix* sp. moss *Calliergon* sp.	33,7	0,76	19	16,56 ± 9,49	23
4	a) at the stream mouth	52,4	1,17	19	21,75 ± 7,25	25
5	b) below the bird colony	84,4	1,80	18	27,22 ± 6,06	24
6	c) in the bird colony	86,9	1,81	19	31,58 ± 8,79	22
7	„Meadow" in the bird colony	89,9	3,44	11	66,47 ± 8,36	14

Fig. 1. Study stations in the Fugleberget drainage area against the background of flora communities; (according to Grodzińska and Godzik, unpubl. data); 1—7 — stations; 1 — *Calliergon stramineum — Sanonia uncinata*; 2 — *Tetraplodon mnioides — Aplodon wormskjoeldii*; 3 — Rocky tundra; 4 — *Cladonia mitis — Cetraria nivalis — Rhacomitrium lanuginosum*; 5 — *Sphaerophorus globosus*; 6 — *Chrysosplenium tetrandrum — Cochlearia officinalis — Cerestrium alpinum*; 7 — *Sanonia uncinata — Aulaconium turgidum — Saxifraga oppositifolia*, 8 — *Sanonia uncinata*, 9 — *Candelariella arctica*; 10 — *Xanthoria elegans*; 11 — saxicolous lichens.


9° 12° 15° 18° 21° 24° 27°
80°
79°
78°
77°
NORDAUSTLANDET
SPITSBERGEN
BARENTSÖYA
EDBEÖYA
Hornsund
Fugleberget
12° 15° 18° 21° 27°
N
SPITSBERGEN-HORNSUND
DRAINAGE AREA
FUGLEBERGET
0 50 100 150 200 250 m
POLISH POLAR
STATION
JSBJÖRNHAMNA

Under influence of nutrients originated from the bird colony were also the samples exposed in the clump of vascular flora (*Chrysoplenium tetrandrum — Cochlearia officinalis — Cerestrium alpinum*) called „meadow" and situated in the bird colony itself. The remaining stations were outside the immediate zone of nutrient flow from the colony.

The method applied consisted in putting into the soil the standard disks of pure cellulose (Jakubczyk 1969, author's unpubl. data). The disks of filter paper 9 cm in diameter (firm of Filtrak, nr 390) were used. In order to remove from the material the noncellulosal residues the disks were boiled in 2% KOH solution for 3 hours, then they were rinsed in distilled water until the neutral reaction was obtained and dried for 24 hours at a temperature of 105°C. The disks were weighed with an accuracy of 0,0001g and placed on both sides of glass plate of 10 × 10 cm in size. A whole has been protected against mechanical damages by a sack of plastic net of 1.5 × 1.5 mm in mesh. In this form the samples were prepared for exposition to the soil.

After taking out from the soil the samples were dried for 24 hours at the temperature of 105°C and stored until the analysis have been carried out. Then, the cellulose disks were separated from the glass plate and boiled in 2% KOH solution for removing from the disk's surface bacterial mucus or colonies of fungi and Actinomycetes the mass of which would reduce a loss of cellulose. After boiling the disks were dried again at the temperature of 105°C to obtain dry matter and then burned in a muffle furnace at the temperature 600°C in order to determine the amount of ash. The amount of ash in the filters not exposed in the soil was also determined. From the so obtained dry matter without ash percentage of cellulose loss was calculated.

The disks were buried vertically in soil in a layer of 0—10 cm in July, 1984 and taken out after one year of exposition in July 1985.

At the stations where the samples were exposed the samples of soil from the layer of 0—10 cm were taken and the contents of organic matter and the percentage of nitrogen were determined. The contents of organic matter was determined through burning in the muffle furnace at a temperature of 450°C while the amount of nitrogen was determined using a gas chromatograph CHN+O type of a firm Carlo Erba.

Results and discussion

The highest rate of cellulose decomposition was recorded in the „meadow" being the aggregation of *Chrysosplenium tetrandrum — Cochlearia officinalis — Cerastium alpinum* (Grodzińska and Godzik in press) and situated in the colony of birds. Within a year it exceeded 66%. The decomposition rate so high was probably connected with the high amount of nitrogen and other nutrients in

soil which flow off the bird colony located in the immediate vicinity. An exposure of slope where the samples were buried also influenced the results. Because of strong winds the snow cover was here much thinner and that is why the soil thaws in spring in this place about 6—8 weeks earlier than in the remaining stations situated below with the snow cover maintaining longer.

Over half as low the rate of decomposition was recorded in the stations overgrown with a moss *Calliergon* sp. situated in a colony and just under the slope of mountain settled by birds (Tab. 1). The differences in the rate of cellulose decomposition at the two stations are small but statistically significant. The analysis with the use of Student's t — test proved the significant difference at a level 0,05. The contents of nitrogen as well as the contents of organic matter in rotten moss where the samples were exposed are similar.

At the third station most distant from the colony of birds the amount of nitrogen in rotten moss was lower amounting to 1.17% and the contents of organic matter was also lower (Tab. 1). Also, the intensity of cellulose decomposition was lower in comparison to the previous stations. The decrease of intensity of cellulose decomposition as well as the drop of contents of nitrogen in rotten moss seem to be connected with a distance from the colony of birds and consequently with the amount of nutrients flowing off this colony.

The lowest rate of cellulose decomposition was recorded in the stations situated outside the zone of nutrients run-off from the colony of little auks (Tab. 1). The lack of influence of birds colony is also visible in an amount of nitrogen in the soils studied which dropped considerably below 1% in these three stations.

The analysis of results obtained at all studied stations of Fugleberget drainage area shows the great variability of intensity of decomposition processes. The present investigations revealed that the cellulose decomposition can vary within a year from about 65% in most fertile environment to 16% in most poor ones. Statistically highly significant relationship was recorded between the amount of nitrogen in the soil and the rate of cellulose decomposition (Fig. 2). The correlation coefficient for the relationship (r) is 0.932. Smaller yet also visible is a relationship between the contents of organic matter in a soil and the percentage of decomposed cellulose (Fig. 3).

The results obtained were compared with the results from tundra areas in different regions of the world (Rosswall 1974). It follows from this comparison that the rate of cellulose decomposition observed in the Spitsbergen tundra was higher than in different regions of similar climatic conditions. On the one hand it was probably caused by the different character of Spitsbergen tundra (Klekowski and Opaliński 1984) in comparison to the previously investigated environments. On the other hand the Fugleberget drainage area being under influence of the large colony of little auks (*Plautus alle*) is an especially rich environment which causes that the decomposition process is more intensive in comparison to various habitats in the tundra.

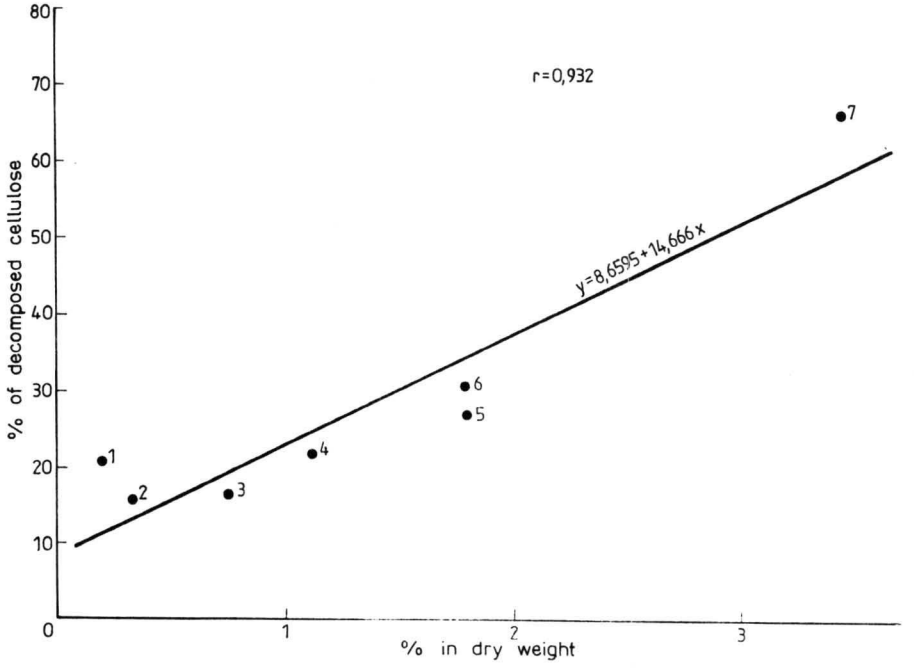


Fig. 2. Dependence of cellulose decomposition rate on the contents of nitrogen in soil.

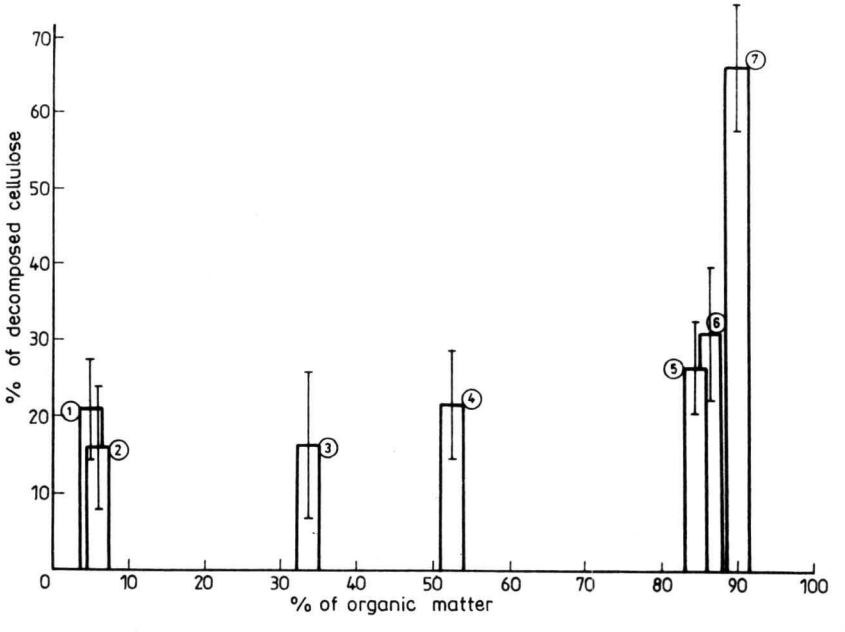


Fig. 3. Amount of cellulose decomposed within a year according to the contents of organic matter in soil.

Conclusions

1. The intensity of cellulose decomposition in the investigated soils of Fugleberget drainage area varied from about 15% to 65% according to the fertility of station.

2. There is a direct relationship between the cellulose decomposition and the contents of nitrogen in the soil.

3. The nutrients flowing off the colony of little auks (*Plautus alle*) have an effect on the intensity of decomposition processes.

4. The recorded decomposition rate of standard cellulose samples in the Fugleberget drainage area was higher than that recorded in other polar regions.

This work was supported by Polish Academy of Sciences within the C.P.B.B. 03.03. Project.

References

Jakubczyk H. 1969. Variations of microbiological activity in a meadow community. — Ekol. pol. A, 17: 855—878.

Klekowski R. Z. and Opaliński K. 1984. Matter and energy flow in Spitsbergen tundra. — Wiad. ekol., 30: 143—166.

Rosswall T., 1974. Cellulose decomposition studies in the tundra. — In: A. J. Holdings et al. (eds.), Soil organisms and decomposition in tundra. Tundra Biome Steering Committee, Stockholm; 325—340.

Received February 10, 1989
Revised and accepted July 15, 1989

Streszczenie

Tempo rozkładu było badane metodą wykładania do gleby standartowych krążków celulozy. Badania przeprowadzono w pięciu typach gleb, w siedmiu stanowiskach położonych w zlewni Fugleberget (fiord Hornsund, płd. Spitsbergen; rys. 1). Dwa z wybranych stanowisk były pod wpływem biogenów spływających z kolonii traczyków lodowych (*Plautus alle*). Stanowiska położone poza wpływem kolonii ptaków charakteryzowały się niską zawartością azotu w glebie i mniejszą zawartością materii organicznej (tab. 1). Tempo rozkładu celulozy w tych środowiskach wynosiło 15—20% na rok (tab. 1).

Najwyższe tempo rozkładu (powyżej 65%) zaobserwowano na „łące" porośniętej roślinnością naczyniową, położonej w bezpośrednim sąsiedztwie kolonii ptaków. Tempo rozkładu celulozy mierzone w płatach mchu *Calliergon* sp. wraz ze zwiększaniem się odległości od kolonii ptaków maleje (tab. 1).

Stwierdzono ścisłą zależność tempa rozkładu od zawartości azotu w podłożu, w którym eksponowane były próby (rys. 2). Tempo rozkładu związane jest również z zawartością materii organicznej w glebie (rys. 3).

Zaobserwowane tempo rozkładu celulozy w tundrze Spitsbergenu okazało się wyższe aniżeli w innych rejonach polarnych o podobnych warunkach klimatycznych.