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Joanna POCIASK-KARTECZKA

PHYSICO-CHEMICAL CHARACTERISTICS OF WATERS IN NORTH-WEST SØRKAPPLAND (SPITSBERGEN)

Hydrological Department, Institute of Geography, Jagiellonian University, 31–044 Kraków, Grodzka 64, Poland

ABSTRACT

The article presents the results of hydrographic investigations carried out in the North-West Sørkappland in the summer 1983.

In summer surface waters are warmer than subsurface waters. In the chemical composition waters both types bicarbonates prevail but their content is higher in the subsurface waters than in surface waters. In coastal areas surface, subsurface and rain waters contain higher a mounts of chlorides and sodium. The chemistry of subsurface waters flowing out of weathered limy waste is characterized by an increased content of calcium, magnesium and sulphates. The following factors affect the temperature and chemical composition of subsurface and surface waters: the geological structure, precipitation, the permafrost, the avifauna, the distance from the sea, the exposure of the terrain, conditions and duration of the water flow, the character of streams and the inclination of the land.

Key words: Spitsbergen, surface waters, subsurface waters, chemical composition.

1. INTRODUCTION

Investigations of South Spitsbergen water chemistry, which have been carried out till now, were concentrated on the chemistry of surface waters, of cool and warm karst sprig-water and of the waters from thermo-mineral springs.

The main objective of most works was to define the extent and dynamics of chemical denudation of nonglaciated areas of Spitsbergen (Krawczyk, Pulina 1982, Pulina 1977) and get to know the way of circulation of karst waters in polar areas (Leszkiewicz 1982, Pulina 1977).

The hydrochemical features of surface waters in the Hornsund region have been presented by Bieroński (1977). He has distinguished eight hydrochemicals types of water. The chemical composition of surface water is considerably affected by the sea, which is visible in a higher content of chlorides.

The chemical composition of water in the ponds situated near the Base of the Polish Academy of Sciences in Hornsund (Fig. 1) was investigated by Rakusa-Suszczewski (1968). Bicarbonates

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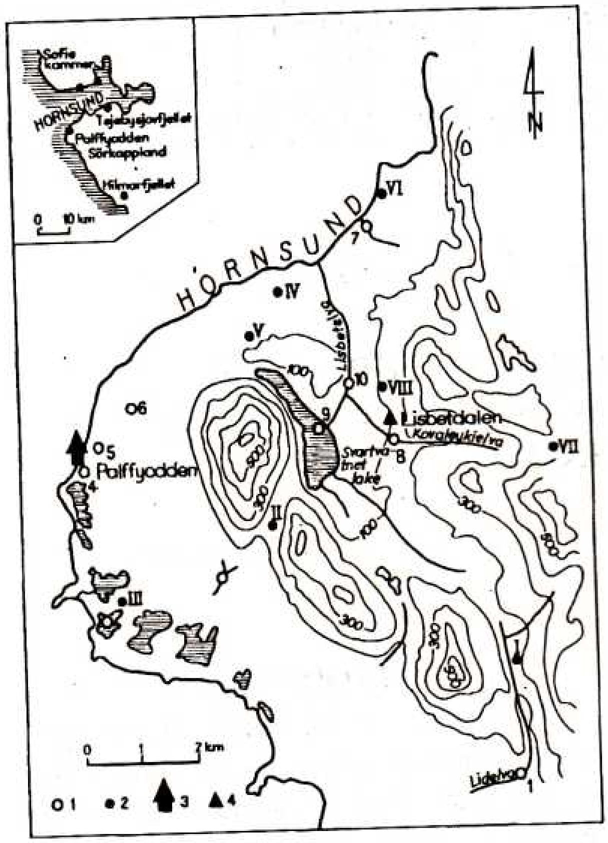

Fig. 1. Location of the study area. 1 – Positions of collecting surface water samples; 2 – Positions of collecting subsurface water samples;
3 – "Palffyodden" – base of the Expedition;
4 – "Lisbetdalen" – subbase of the Expedition.
Note: Numbers of positions refer to those in Tab. I, II

and calcium prevail in those waters. The biotic surroundings of the ponds affect the quantity and type of mineralization. Krawczyk and Pulina (1982) investigated the temporary changes of the quantity and type of mineralization of surface water near the base. According to those authors the seasonal increase of mineralization is due to the corrosion of carbonate rocks, to the cryochemical effect as well as to biochemical processes.

A separate problem is that of cool and relatively warm karst waters which occur in connection with carbonate rocks (the area of the Tsjebysjovfjellet and Sofiekammen massifs). Leszkiewicz (1982) has presented the hydrochemical characteristics of waters of the Tsjebysjovfjellet massif while Bieroński and Pulina (1975) as well as Pulina (1977) have characterized the waters of Sofiekammen massif. At the foot of the Tsjebysjovfjellet massif there occur cool karst springs (3°C) yielding Cl-Mg-HCO_3-type water. It has been found that there is an interdependence between the chlorides content in the spring water and its general mineralization; this has led to the hypothesis that karst water mixes with sea water. In the region of the Sofiekammen massif there is a spring yielding Cl-Na-Ca-type water of 12.4°C of temperature (August 1983). This temperature approximates that of the waters from thermomineral springs which occur in the karst region of Hilmarfjellet. The Cl-Ca-HCO_3-type water flowing out of those springs has a temperature of several to over ten °C. According to Pulina, the waters of those springs are the combination of slightly mineralized atmospheric and glacial waters and of thermomineral waters circulating in massif. The aim of the present paper is to show the connections between environmental conditions and the chemical composition and temperature of surface and subsurface waters within sea-side plains and mountainous valleys in the north-western part of Sørkappland (Hornsund, Spitsbergen – Fig. 1).

2. TERRAIN AND METHODS

Preliminary hydrological investigations of the north-west part of Sørkappland (Fig. 1) were carried out as a part of the expedition "Spitsbergen 83", organized by the Jagiellonian University. The area comprises mountains and sea-side plains which are not glaciated nowadays. The investigation concerned the hydrochemical characteristics of waters, based on chemical analysis of water samples collected once, each in a different point of the area, within a short time. K^+, Na^+, Ca^{2+} ions were determinated by means of a flame photometer; Mg^{2+}, HCO_3^-, SO_4^-, Cl-- ions – using the titration method. While Mg^{2+} – using the colorimetric method.

3. RESULTS

Characteristics of surface waters

Water from lakes and rivers was taken for hydrochemical investigations. In summer both lakes and river waters are fed mainly by waters from the thawing permafrost. It was stated that the temperature of stagnant waters (lakes and ponds) was higher than the temperature of flowing waters (Tab. I). The only exception is Svartvatnet lake (Tab. I, post 9), situated at the bottom of a wide valley depression. It is surrounded, to the west and south, by high massifs which render insolation impossible. The water temperature of the coastal ponds (Tab. I, posts 3, 4, 5, 6) approximates the temperature of the air.

The temperature of the flowing waters is differentiated. The temperature in the braded Lidelva stream (Tab. I, post 1) is 2.9 °C, while in a short, close stream it is 2.1°C (Fig. 2, post 7). In the Kovalevskielva stream (Tab. I, post 8) the water temperature reaches only 1.5°C. This is connected with occurrence, on rather large section of the river, of snow patches which make warming of water impossible. Thus the temperature of river waters depends on the length of river, on its character and on the conditions of the flow.

In the Lisbetelva river the water temperature is 3.2°C, although it flows out of a lake of 2.1° and collects cool waters from Kovalevskielva stream. The Lisbetelva waters get warmer owing to the fact that cool lake- and stream-water is mixed with warmer water flowing down the valley slopes. Before the melt-water from the slopes can reach the Lisbetelva it flows through a thick cover of moss overgrowing the valley bottom. There water flows very slowly. During that time it can be warmed up to 6°C.

The stream number 2 (Tab. I), flowing in its bed furrowed in mosses, has a rather high temperature (4°C). Only its bottom is gravelly. It is an intermitteing

Table I. Hydrochemical features of surface waters in summer 1983 (Sørkappland). Explanation of the signs: "•" – trace, "–" – absent

Number of sample	Data	Air temperature °C	Water temperature °C	Ca^{2+}	Mg^{2+}	Na^+	K^+	HCO_3^-	SO_4^{2-}	Cl^-
				mg dm^{-3}						
1	19 Aug.	3.8	2.9	8.0	2.7	0.9	0.8	73.2	48.0	5.7
2	21 Aug.	6.2	4.0	4.5	2.6	4.2	0.8	42.7	–	7.1
3	1 Aug.	5.8	5.6	–	–	0.8	0.1	48.8	–	6.4
4	21 Aug.	6.2	4.9	2.5	•	12.6	1.3	48.8	4.8	14.2
5	21 Aug.	6.2	5.2	1.5	2.3	9.3	1.3	42.7	2.4	12.8
6	21 Aug.	6.2	5.1	–	1.5	8.7	1.0	36.6	2.5	12.8
7	17 Aug.	3.4	2.1	–	–	4.6	0.4	61.0	–	19.9
8	17 Aug.	3.4	1.5	4.5	2.6	1.7	1.1	48.8	4.8	5.0
9	17 Aug.	3.4	2.1	–	–	1.4	0.2	42.7	–	7.8
10	17 Aug.	3.4	3.2	1.5	2.6	8.8	1.1	42.7	2.4	10.6

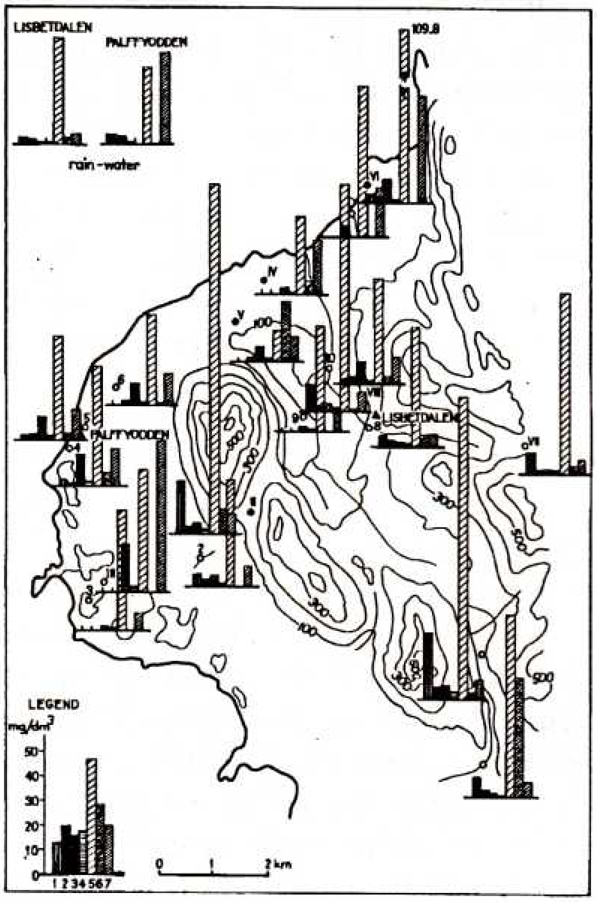

Fig. 2. Chemical composition of surface waters, subsurface waters and rain waters in summer 1983 (Sørkappland). 1 – Ca^{2+}, 2 – Mg^{2+}, 3 – Na^{+}, 4 – K^{+}, 5 – HCO_3^-, 6 – SO_4^{2-}, 7 Cl^-

stream, frequently disappearing in mosses. The high temperature of the water is due to its warming in mosses which absorb solar radiation.

In the chemical composition of surface waters in the investigated area bicarbonate ions (36–73 mg dm^{-3}) and chloride ions prevail (Tab. I). The Lidelva stream is an exception (Fig. 2, post 1) as, beside bicarbonates, there occurs a rather high content of sulphates. It might be due to situation of the Lidelva's basin within the Triassic formation, mainly formed as mudstones, shales and calciferous sandstone. The content of chlorides (12–20 mg dm^{-3}) is higher in the coastal zone than elsewhere, which confirms the thesis on the effect of the sea on the chemical composition of coastal surface waters (Bieroński 1977).

The surface waters of the whole area contain small or traces quantities of potassium, calcium and magnesium except the Lidelva where the calcium content is 8 mg dm^{-3}. The occurrence of calcium in the Lidelva is connected – the same as the sulphate content – with the Triassic formation, where calciferous sandstones occur.

The chemical composition of rain--water at the coast differs from that further inside the valley, primarily as to the chloride content (Tab. III). Inland it reaches 3.5 mg dm^{-3}, while it is ten times as high at the coast. This affects the chemistry of surface waters in the coastal zone, which can be proved by the above--mentioned higher content of chlorides.

Post number 2 (Fig. 2) is distinguished among all the surface waters for its trace content of phosphates. This should be attributed to the presence of bird colonies peopling the neighbouring mountain slopes.

Characteristics of subsurface waters

The outflows of subsurface waters in the investigated area occur mainly as bog-springs and leakages of subsurface water. They are fed mainly by melt-water from the frozen ground.

The temperature of subsurface water ranges from 0.2 to 2.2°C (Tab. II). The coldest water flows out of rock walls (Tab. II, post I). Water from waste cover is relatively warmer (1.3–2.2°C). The cold melt-water gets warmer flowing through warm waste cover. An outflow of 0.4°C (Tab. II, post VI) is an exception. It is situated under a small rock wall. The way of this melt-water through the waste-rock is prob-

Table II. Hydrochemical features of subsurface waters in summer 1983 (Sørkappland). Explanation of the signs: "•" – trace, "–" – lack

Number of sample	Data	Air temperature °C	Water temperature °C	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^-	SO_4^{2-}	Cl^-
				mg dm^{-3}						
1	19 Aug.	3.8	0.2	26.5	4.8	5.5	2.8	122.0	2.5	7.8
2	21 Aug.	6.2	1.3	20.5	2.1	4.5	1.3	140.3	9.6	7.8
3	1 Aug.	5.8	1.2	–	–	18.8	1.3	48.8	–	60.1
4	17 Aug.	3.4	1.2	–	–	2.0	0.2	30.5	4.8	21.2
5	17 Aug.	3.4	1.0	–	1.2	5.5	0.9	12.2	24.0	9.9
6	17 Aug.	3.4	0.4	3.5	2.4	9.7	0.6	109.8	–	42.5
7	18 Aug.	3.2	2.1	8.0	1.0	1.2	0.8	73.2	2.4	5.0
8	17 Aug.	3.4	2.2	10.5	1.0	2.5	0.9	91.5	•	7.1

Table III. Chemical composition of rain-water from Palffyodden and Lisbetdalen in summer 1983 (Sørkappland). Explanation of the sings: "P" – Palffyodden, "L" – Lisbetdalen, "•" – trace, "–" – lack

Data	Position	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^-	SO_4^{2-}	Cl^-
		mg dm^{-3}						
26 July	P	2.5	1.9	•	•	42.7	2.4	35.0
26 July	L	4.0	2.8	•	–	30.5	–	3.5

ably so short that it has no time to get warmed.

In the chemical composition of subsurface waters bicarbonates prevail visibly (70–140 mg dm^{-3}) except the discharges situated near the coast outflows Fig. 2, post III, IV, V). They all flow out of the waste-rock of carboniferous quartizitic sand-stones – very resistant and hardly soluble.

The form of outflows number III and V (Fig. 2) is worth notice. They are open rock fissures, reaching 2 m of depth, where the water from thawing ice-wedges and permafrost stagnates or flows slowly. Such a form of occurrence of subsurface water may be found in the studied area in zones of tectonic faults. The chemical composition of waters in those fissures shows most differences in their content of chlorides, which can be hardly justified. It is possible that the differences are due to different exposure of particular points to marine acrosols.

Outflows situated inland have a similar chemical composition (Fig. 2, post I, II, VII, VIII). They flow out of Triassic wasre-rock covers. It is reflected in their chemistry as a large content of calcium (8–26 mg dm^{-3}). Unlike the coastal outflows they contain very few chlorides.

4. DISCUSSION

In summer the surface waters of the studied area are warmer than the subsurface waters by 2–3°C averagely.

Bicarbonates prevail in the chemical composition of both surface and subsurface waters throughout the area. In coastal zones surface and subsurface waters display a higher content of chlorides and sodium. The chemistry of surface waters resembles that of subsurface waters which feed them. Surface and subsurface waters of the coastal zone resemble coastal rain water as regards their chemical composition. The chemistry of surface and subsurface inland waters approximates that of rain water occurring far from the coast.

The content of bicarbonates in subsurface waters is by 30–50 mg dm^{-3} higher than in surface waters. Two areas can be distinguished where both surface and subsurface waters differ as to their content of chlorides and natrium. They are: the coastal zone with a high content of chlorides and sodium, and the inland area where that content is low. There is a visible differences of chemistry between subsurface waters flowing from the Triassic waste-rock (a higher content of calcium, magnesium and sulphates) and subsurface waters flowing from the hardly soluble Carboniferous waste-rock. Consequently there are differences in the chemistry of surface waters fed by such subsurface waters.

The results of these investigations allow to state that, in summer, the temperature and the chemistry of surface and interflow waters in North-West Sørkappland are formed by the following environmental factors: the geological structure (mineral composition of rocks and their texture, precipitation, the permafrost, the avifauna, the distance from the sea, land exposure, the character of streams, the conditions and duration of the water flow.

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5. SUMMARY

Hydrologic investigations in the north-west Sørkappland were carried out in the summer of 1983 (Fig. 1). Surface and subsurface waters were characterized on the base of chemical analysis samples collected once, from different points of the area.

It has been stated that, in summer, surface waters are warmer than subsurface water by 2–3°C averagely (Tab. I, II, Fig. 2). Throughout the area bicarbonates prevail in the chemical composition of both surface and subsurface waters; the content of bicarbonate in subsurface waters is higher by 30–50 mg dm^{-3}. In coastal zones there is a higher content of chlorides and sodium in surface, subsurface and rain waters. The chemistry of surface waters resembles that of subsurface waters which feed them. There is a visible difference in the chemical composition of subsurface waters flowing out of the calciferous Triassic waste (a higher content of calcium, magnesium and sulphates) and of subsurface waters flowing from the waste of hardly soluble Carboniferous rocks. In summer the temperature and the chemical composition of surface and subsurface waters of North-West Sørkappland are formed by the following factors: the geological structure, precipitation, the permafrost, the avifauna, the distance from the sea, land exposure, the character of streams, the conditions and duration of the water flow.

6 STRESZCZENIE

Badania hydrograficzne w północno-zachodniej części Sørkapplandu przeprowadzono latem 1983 roku (Fig. 1). W oparciu o analizy chemiczne próbek wody pobranych jednorazowo z różnych punktów badanego obszaru dokonano charakterystyki wód powierzchniowych i śródpokrywowych.

Stwierdzono, iż wody powierzchniowe są w okresie lata cieplejsze o 2–3°C

wód śródpokrywowych (Tab. I, II, Fig. 2). W składzie chemicznym zarówno wód powierzchniowych jak i śródpokrywowych dominują na całym obszarze wodorowęglany, przy czym zawartość wodorowęglanów w wodach śródpokrywowych jest większa o 30–50 mg dm^{-3}. W okolicach nadbrzeżnych w wodach powierzchniowych, śródpokrywowych oraz w wodzie opadowej zaznacza się zwiększona obecność chlorków oraz sodu. Chemizm wód powierzchniowych jest zbliżony do chemizmu wód śródpokrywowych zasilających te wody. Wyraźna różnica chemizmu zaznacza się między wodami śródpokrywowymi wypływającymi ze zwietrzałych wapnistych utworów triasowych (podwyższona zawartość wapnia, magnezu i siarczanów) a wodami śródpokrywowymi wypływającymi ze zwietrzeliny słabo rozpuszczalnych utworów karbońskich.

Temperatura oraz skład chemiczny wód powierzchniowych i śródpokrywowych północno-zachodniego Sørkapplandu są w czasie lata kształtowane przez następujące czynniki: budowę geologiczną, opady, zmarzlinę, avifaunę, ekspozycję terenu, odległość od morza, charakter potoków, warunki i czas płynięcia wody.

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