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ON THE CONCENTRATIONS OF CERTAIN SUBSTANCES IN THE MELT WATER AND THE GROUNDWATER IN FINLAND

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ABSTRACT

In Finland the groundwater reservoirs will for the main part be replenished during the spring snow melt. Thus the composition of the groundwater does not only depend on geological factors but also to a large degree on the composition of the snow.

This study is a analysis on a budget basis of the changes in the content of the snow melt water and the groundwater in certain representative areas in the natural state. The material treated was from the period 1976 to 1980.

The study centered on the analyses for pH, conductivity, SO_4, PO_4-P, Tot. N, Cl, Na, Ca, K and the heavy metals, Mn, Cu, Pb, Zn and Hg.

The study brings forward the relative influence of fall-out and soil factors on the concentrations of groundwater. The mean time series of the groundwater quality values have also been related to the changes in groundwater recharge.

INTRODUCTION

The influence of the concentrations of certain substances in snow on the corresponding concentrations in the groundwater have been studied in five representative areas. The groundwater has been analysed before and after the snow melted in spring.

The snow samples were taken as profile samples before the snowmelt proper (ref. 1). The concentrations in the snow represent the snow-out of the whole winter. The duration of the winter in Finland is from three to seven months depending on the location. Thus an appreciable part of the precipitation falls as snow. The snow usually melts rather rapidly which leads to a sudden formation of groundwater. The groundwater reservoirs in Finland are in the main replenished after the spring snowmelt, as shown by the maximum of the groundwater stages. Groundwater stages often show a winter and a summer minimum. Therefore the groundwater was sampled before and after the snowmelt, to make it possible to evaluate the influence of the fallout and to trace the origin of the different substances to either snow or geological layers.

Groundwater as well as snow samples were collected at the same sites in the years 1976 to 1980. Here whole period mean values at the analyses are presented. The groundwater was sampled in natural springs (ref. 2).

RESULTS

Sulphate and acidity

It has, many times already, been shown that the steady increase of the acidity of the rain water has led to an increasing acidity in the environment and markedly so in the surface water. But in Finland it has not yet been possible to shown an influence on the groundwater, presumably because of a sufficiently large buffer capacity of the soil.

In Finland the groundwater has pH values between 5.9 and 7.3, which is about 2 pH units more than the pH of rain water and snow. But the rain water is of a sufficient acidity to dissolve certain substances in the soil, which leads to a change of their concentrations in the groundwater. Thus the influence of a growing acidity of the rain can best be seen as a change of conductivity of the groundwater.

The sulphate content of the snow varies locally with habitation density and industrial activities. In southern Finland the sulphate concentrations in the snow are exceptionally large, especially so when compared to the low values of northern Finland. The groundwater too shows high sulphate concentrations in the coastal areas. This is not due fall-out only; much of the soil in the coastal belt consists of old seabottom clays. So the high sulphate concentration values (73 and 58 mg/l) found in southwestern Finland relate to areas with sulphide clays (Fig. 1).

The concentrations of various substances in snow and groundwater

In the following are compared the concentrations of different ions in the snow and in the groundwater before (Gw_{min}) and after (Gw_{max}) the spring snowmelt (Table 1.). We find that the concentrations of Na, Ca, Mg and K almost without exceptions are larger in the groundwater than in the snow (Figs. 2 and 4). These elements thus primarily should derive from the soil. The heavy metals, on the other hand, are in most cases found with a larger concentration in the snow than in the groundwater. This leads one to suppose that the fallout is a more important source than the local geological layers (Fig. 5). Of course, the ore fields are exceptions (Fig. 3).

After the snow has melted the concentrations in the groundwater mostly become smaller, which in part, should be due to absorbtion, in part to dilution. The microbes on the soil particles tend to exert a greater purifying effect the longer the water remains in the soil stratum, and the slower the waters flows (ref. 3).

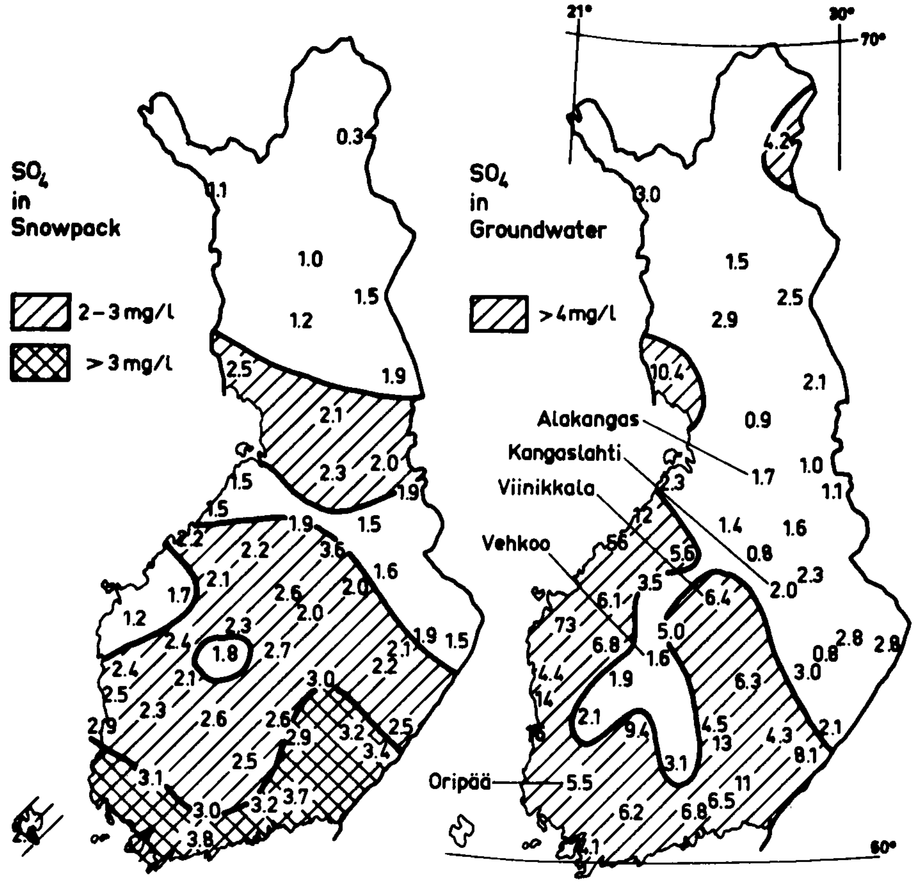

Fig. 1. The mean sulphate concentrations of snow (left) and groundwater (right) in Finland in 1976 to 1980.

Groundwater pollution may occur from inorganic fertilizers, sewage effluent and atmospheric sources. The influence of the quality of snow meltwater on groundwater is primarily determined by the time lag and distance of flow through the unsatured zone (ref. 3).

Table 1.

Concentrations in snow and groundwater (Gw) in 1976 to 1980 (Gw_{min} during minimum, Gw_{max} after snowmelt).

	pH	Cond.	SO_4	PO_4-P	Tot. N	Cl	Na	Ca	Mg	K	Mn	Cu	Pb	Zn	Hg
		mS/m	mg/l	µg/l	µg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µg/l	µg/l	µg/l	µg/l	µg/l
VEHKOO															
Snow	4,4	2,9	2,6	30	850	0,8	0,5	0,3	0,1	0,2	17	6	6	25	0,2
Gw_{min}	7,0	4,0	2,5	9	84	5,3	3,0	3,3	1,7	1,4	8	16	2	14	0,1
Gw_{max}	6,6	9,8	1,8	6	49	4,1	2,4	2,6	0,8	0,7	12	3	2	12	0,1
Gw_{min}-Snow	2,6	1,1	-0,1	-21	-766	4,5	2,5	3,0	1,6	1,2	-9	10	-4	-11	-0,1
Gw_{max}-Snow	2,2	0,9	-0,8	-24	-801	3,3	1,9	2,3	0,7	0,5	-5	-3	-3	-10	-0,1
Gw_{max}-Gw_{min}	-0,4	-0,2	-0,7	-3	-35	-1,2	-0,6	-0,7	-0,9	-0,7	4	-13	0	-2	0
KANGASLAHTI															
Snow	4,7	2,2	2,0	9	850	0,7	0,4	0,3	0,1	0,2	17	4	11	27	1,4
Gw_{min}	6,3	2,3	5,0	12	60	0,8	1,7	2,0	0,9	0,9	54	8	15	7	1,7
Gw_{max}	6,4	2,4	2,9	13	40	0,8	1,6	2,1	0,7	0,7	14	6	2	2	0,5
Gw_{min}-Snow	1,6	0,1	3,0	3	-790	0,1	1,3	1,7	0,8	0,7	37	4	4	-20	0,3
Gw_{max}-Snow	1,7	0,2	0,9	4	-810	0,1	1,2	1,8	0,6	0,5	-3	2	-9	-25	-0,9
Gw_{max}-Gw_{min}	0,1	0,1	-2,1	1	-20	0	-0,1	0,1	-0,2	-0,2	-40	-2	-13	-5	-1,2

Table 1. (cont.)

	pH	Cond.	SO_4	PO_4-P	Tot. N	Cl	Na	Ca	Mg	K	Mn	Cu	Pb	Zn	Hg
		mS/m	mg/l	µg/l	µg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µg/l	ug/l	µg/l	µg/l	µg/l
VIINIKKALA															
Snow	4,6	2,3	2,6	29	850	0,6	0,2	0,4	0,2	0,4	48	15	9	9	1,8
Gw_{min}	6,1	7,8	6,2	13	825	2,3	3,4	7,7	1,9	3,1	100	10	1	5	1,5
Gw_{max}	6,2	6,8	6,6	4	1330	2,6	2,5	5,4	1,7	2,8	52	4	1	6	0,4
Gw_{min}-Snow	1,7	5,5	3,6	-16	-25	1,7	3,2	7,3	1,7	2,7	4	-5	-9	-4	-0,3
Gw_{max}-Snow	1,6	4,5	4,0	-25	480	2,0	2,3	5,0	1,5	2,4	-44	-11	-8	-3	-1,4
Gw_{max}-Gw_{min}	0,1	-1,0	0,4	-9	505	0,3	-0,9	-2,3	-0,2	-0,3	-96	-6	1	1	-1,4
ORIPÄÄ															
Snow	4,7	2,8	3,1	23	1100	1,0	0,3	0,4	0,2	0,2	48	4	9	14	0,3
Gw_{min}	8,1	8,9	5,7	17	120	2,3	2,7	12	1,3	0,9	8	7	1	2	0,2
Gw_{max}	8,3	9,0	5,5	18	130	2,1	2,9	11	1,4	0,9	7	1	1	1	0,1
Gw_{min}-Snow	3,4	5,7	2,6	-6	-980	1,3	2,4	11,6	1,1	0,7	-40	-3	-8	-12	-0,1
Gw_{max}-Snow	9,6	6,2	2,4	-5	-870	1,1	2,6	10,6	1,2	0,7	-41	-3	-8	-13	-0,2
Gw_{max}-Gw_{min}	0,2	0,5	-0,2	1	10	-0,2	0,2	-1	0,1	0	-1	0	0	-1	-0,1
ALAKANGAS															
Snow	4,6	2,7	3,0	7	650	1,5	0,7	1,1	0,5	0,4	20	19	8	16	1,3
Gw_{min}	6,6	3,5	1,7	12	55	0,8	2,0	2,4	1,2	0,8	10	13	3	5	1,1
Gw_{max}	6,9	3,7	1,5	11	49	0,8	2,1	2,3	1,1	0,7	14	4	1	1	0,6
Gw_{min}-Snow	2,0	0,8	-1,3	5	-595	-0,7	1,3	1,3	0,7	0,4	-10	-6	-5	-11	-0,2
Gw_{max}-Snow	2,3	1,0	-1,5	4	-601	-0,7	1,4	1,2	0,6	0,3	-6	-15	-7	-15	-0,7
Gw_{max}-Gw_{min}	0,3	0,2	-0,2	-1	-6	0	0,1	-0,1	-0,1	-0,1	4	-9	-2	-4	-0,5

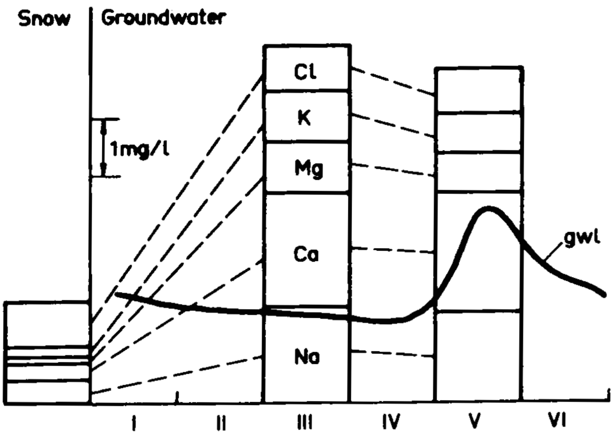

Fig. 2. The 1976 to 1980 mean concentrations of sodium, calcium, magnesium, potassium and chloride in snow and in groundwater for different hights of the groundwater level (gwl) in the Kangaslahti ore field.

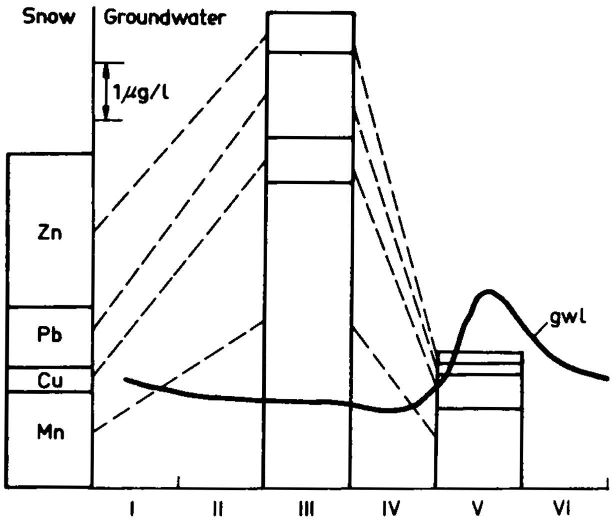

Fig. 3. The 1976 to 1980 mean concentrations of zinc, lead, copper and manganese in snow and in groundwater for different hights of the groundwater level (gwl) in the Kangaslahti ore field.

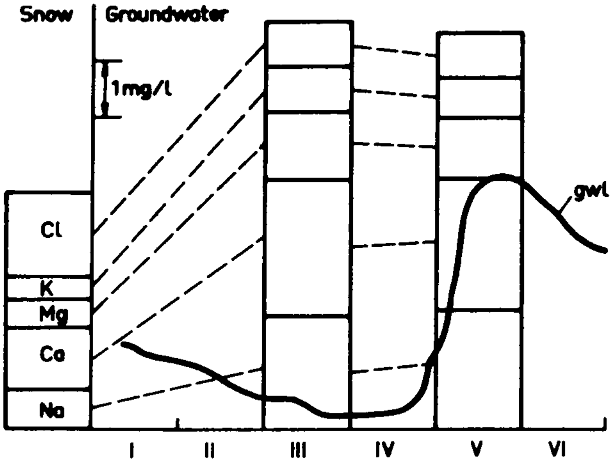

Fig. 4. The 1976 to 1980 mean concentrations of sodium, calcium, magnesium, potassium and chloride in snow and in groundwater for different hights of the groundwater level (gwl) in Alakangas.

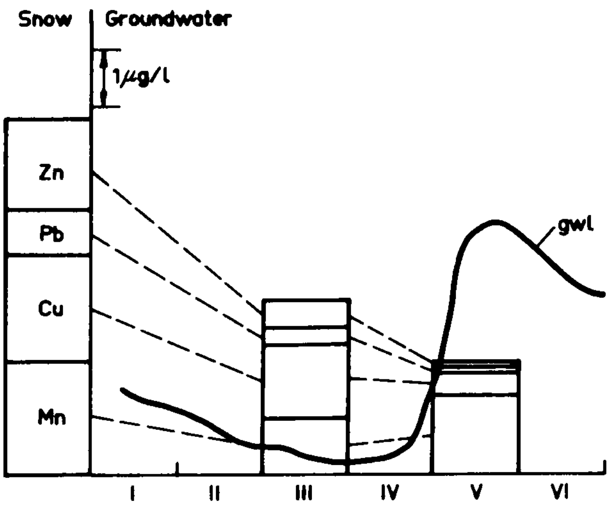

Fig. 5. The 1976 to 1980 mean concentrations of zinc, lead, copper and manganese in snow and in groundwater for different hights of the groundwater level (gwl) in Alakangas.

CONCLUSIONS

1. The concentrations of different substances in snow and in groundwater have been studied. This should make an evaluation of the source of these substances possible.
2. The sodium, calcium, magnesium and potassium in the groundwater should predominantly have been released by the soil.
3. The heavy metals manganese, copper, lead and zinc must be supposed to have been brought in as fall-out (snow-out) to a large degree.
4. The growing acidity of the precipitation has not yet lead to a direct increase of the acidity of the groundwater.

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