Quality of Groundwater, Proceedings of an International Symposium, Noordwijkerhout, 863
The Netherlands, 23–27 March 1981, W. van Duijvenbooden, P. Glasbergen and H. van Lelyveld (Eds.),
Studies in Environmental Science, Volume 17

HYDROLOGY AND WATER CHEMISTRY IN A SMALL WATERSHED

L.Bjerve, J.O.Englund and P. Jørgensen
Agricultural University of Norway, N-1432 Ås-NLH, Norway

ABSTRACT

The downhill movement of water toward streams within the studied watershed is largely by subsurface interflow and groundwater flow. Most of the streamflow occurs in spring when the accumulated snowpack melts. The watershed represents an ecocystem which has been manipulated by man, and the composition of river water is therefore dependent on both weathering of minerals and pollution from agriculture.

INTRODUCTION

This work is part of a project carried out by the Agricultural Research Council of Norway (NLVF) dealing with the pollution of groundwater and small rivers through agricultural activity.

The investigated watershed, Steinsengbekken (16 km^2) near lake Mjøsa in southern Norway, is underlain by faulted and jointed Precambrian gneisses and late Precambrian to Silurian shales, sandstones and limestones. The soils are mainly tills. Forests cover about 60 % of the area; the rest is cultivated or grazing land. The watershed has been studied during the years 1972–1978.

HYDROLOGY

On average 55 mm of water falls monthly (Table 1). 41 % becomes streamflow while the remaining 59 % is lost, mainly through evapotranspiration. However, a minor amount of water probably leaves the watershed as groundwater through rock fissures.

July–October is the wettest period of the year (monthly averages: 62–86 mm) and February to May the driest (monthly averages around 31 mm). However, during the winter (December–April) most of the precipitation falls as snow, accounting for about 30 % of the annual precipitation.

Most of the streamflow occurs during spring when the accumulated snowpack melts, with some 50 % of the annual discharge occuring in April and May (Table 2). The summer streamflow is low. A minor peak occurs in September-November, but winter streamflow diminishes as precipitation accumulates as snow.

Table 1. Average monthly hydrologic budget for the Steinsengbekken watershed. Observation period 1973-1978.

	mm	per cent
Input (precipitation)	55	100
Output (streamflow)	23	41
Output (evap., transp. and gr.water)	32	59

The infiltration capacity of the soils and rocks is mostly high enough to allow immediate infiltration of most precipitation given the observed rain intensities. The downhill movement of water toward streams is therefore largely by subsurface interflow and groundwater flow. Data from drilled wells show that groundwater occurs throughout the area (refs. 2-3).

WATER CHEMISTRY

An increase in the concentration of all constituents is observed in groundwater compared with the values found for precipitation (Table 2) (refs. 1-2).

TABLE 2. AVERAGE CHEMICAL COMPOSITION OF SOME WATERS FROM THE STEINSENGBEKKEN WATERSHED. OBSERVATION PERIOD 1972 - 1978

TYPE OF WATER		PH	µS/CM 20°C	MG/L CA	MG	NA	K	SIO_2	NH_4-N	NO_3-N	TOT P	CL	SO_4	NUMBER OF ANAL.	AVERAGE WATER YIELD MM
PRECIPITATION		4.6	31	0.48	0.07	0.18	0.25	<0.20	0.75	0.55		0.32	3.7		
RIVER AT OUTLET	SEASONAL PERIOD:														
	1.JAN.-31.MARCH	7.4	186	29.2	4.8	4.11	4.27		0.36	4.04	0.16	13.60	10.5	23	26.4
	1.APRIL-31.MAY	7.3	122	18.7	3.9	3.05	2.78		0.17	4.29	0.14	7.55	6.1	31	139.2
	1.JUNE-31.AUG.	7.6	178	25.5	4.1	4.04	4.59		0.11	2.66	0.14	10.40	6.8	75	19.7
	1.SEPT.-14.OCT.	7.6	199	30.4	5.5	4.01	5.19		0.50	2.31	0.18	12.17	8.3	40	22.0
	15.OCT.-31.DEC.	7.5	181	31.3	4.9	4.08	3.77		0.16	4.07	0.16	13.00	8.7	37	68.3
															Σ275.6
GROUNDWATER IN QUATERNARY DEPOSITS	UNPOLLUTED	6.6	130	20.1	2.6	3.6	0.55	6.8	0.05	1.3	0.014	2.9	15.0	25	
	POLLUTED	6.6	255	29.6	7.2	6.4	3.34	8.7	0.11	6.2	0.046	15.0	24.8	48	
GROUNDWATER IN BEDROCKS, 5-100 M BELOW SURFACE	LIMESTONE	7.6	528	65.3	13.8	28.8	3.00	10.0	0.04	3.6	0.003	11.4	38.1	11	
	SANDSTONE SANDY LIMESTONE GREY SHALE	7.2	467	63.1	15.7	17.4	4.71	10.6	0.08	1.6	0.010	31.6	21.4	32	
	DARK SHALE LIMESTONE	7.1	794	152.1	34.1	25.0	9.32	18.0	0.51	0.07	0.070	44.6	106.1	12	

The investigated watershed represents an ecosystem which has been manipulated by man. The chemistry of the river Steinsengbekken is therefore mainly dependent on the composition of: 1) precipitation/ wind blown particles/aerosols, 2) interflow/groundwater, and 3) pollution from manure/road salt/soap (Fig. 1).

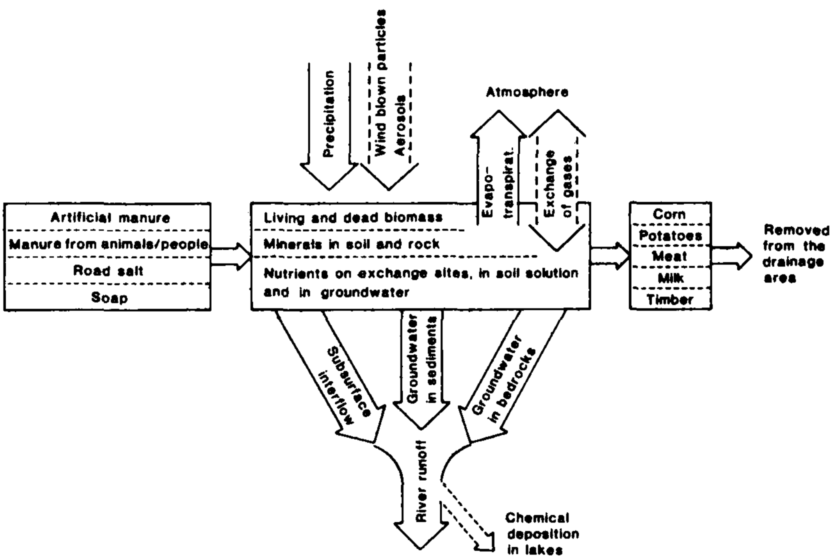

Fig. 1. Model showing major pathways for water and nutrients within the watershed.

The composition of groundwater is mainly dependent on the weathering of minerals, in soils and on joint fissures (refs. 1-2). The interflow is also greatly influenced by weathering reactions, but pollution from agriculture is important during summer and autumn. The influence of atmospheric deposition on the river composition is small.

Fig. 2 illustrates an annual cycle for hydrology as well as hydrochemistry. While the water flow in summertime rarely exceeds 500 l/ sec, even after heavy rain, it reaches 2000-2500 l/sec during the spring thaw.

During this melting period the concentration of the four major cations drops to around 1 meqv. per liter. As the water flow decreases during summer, autumn and winter, the concentration increases to

2.7 meqv. per liter. This increase reflects the increasing contact time between minerals and water with decreasing flow. The average snow sample contains about 0.1 meqv. per liter, while the brook has concentrations about 10 times higher. Since evapotranspiration is only slight during the melting period, the increased concentration must be due to the outwashing of ions from exchange sites and/or the soil solution, as well as due to fairly rapid interaction between meltwater and minerals.

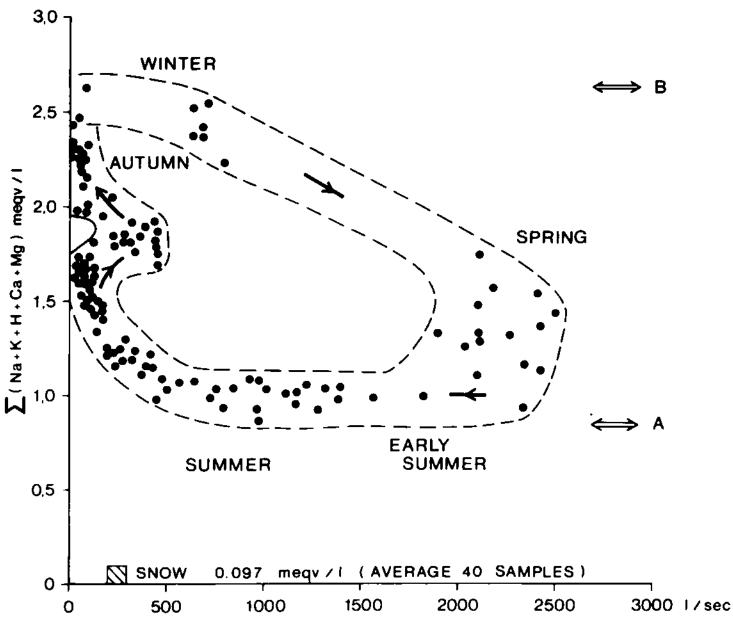

Fig. 2. Relationship between concentrations of major cations and stream discharge at the outlet of the watershed.

REFERENCES

1 J.O. Englund, P. Jørgensen, E. Roaldset and P. Aagaard, Composition of water and sediments in Lake Mjøsa, South Norway, in relation to weathering processes. Pros. Int. Symp., Amsterdam, Sep. 6-10(1976) Dr. W. Junk, B.V. Publ., the Hague. 1977, pp.125-132.

2 J.O. Englund and J.A. Myhrstad, Groundwater chemistry of some selected areas in Southeastern Norway. Nord. Hydrol. 11-2(1980)33-54.

3 S. Skjeseth, Geologi og vannboring. Kambro-silurbergartenes hydrogeologi i Mjøs-traktene. Nor. Geol. Unders.195(1956)15-36.