VESIENTUTKIMUSLAITOKSEN JULKAISUJA
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57

Erkki Alasaarela & Pertti Heinonen: Alkalinity and chemical oxygen demand in some Finnish rivers during the periods 1911—1931 and 1962—1972
Tiivistelmä: Eräiden Suomen jokien alkaliniteetti- ja COD_{Mn}-arvoja vuosilta 1911—1931 ja 1962—1979 3

Kirsti Haapala, Tuija Ruoho-Airola, Lennart Granat & Olli Järvinen: Comparability of results from deposition samples
Tiivistelmä: Laskeumanäytteiden tulosten vertailtavuus 14

Lea Kauppi: Contiribution of agricultural loading to the deterioration of surface waters in Finland
Tiivistelmä: Maatalous vesistöjen tilan muuttajana Suomessa 24

Lea Kauppi: Nitrate in runoff and river waters in Finland in the 1960's and 1970's
Tiivistelmä: Valuma- ja jokivesien nitraattipitoisuudet Suomessa 1960- ja 1970-luvulla 31

Lea Kauppi & Maarit Niemi: The role of runoff water phosphorus in eutrophication
Tiivistelmä: Valumavesien fosforin merkitys vesistöjen rehevöitymisessä 41

Reino Laaksonen & Väinö Malin: Changes in water quality in Finnish lakes 1965—1982
Tiivistelmä: Järvien veden laadun muutoksista v. 1965—1982 52

Reino Laaksonen & Väinö Malin: Changes in ionic distributions in Finnish lake water during the period 1968—1983
Tiivistelmä: Ionikoostumuksen muutoksista järvissä v. 1968—1983 59

Jarmo J. Meriläinen: Macrophyte vegetation at the River Kyrönjoki estuary in 1982
Tiivistelmä: Kyrönjoen suiston suurkasvillisuus vuonne 1982 61

Jorma Niemi & Juhani Eloranta: Application of the FINNECO model to Lake Pyhäjärvi
Tiivistelmä: FINNECO-mallin soveltaminen Tampereen Pyhäjärveen 77

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CHANGES IN IONIC DISTRIBUTIONS IN FINNISH LAKE WATER DURING THE PERIOD 1968—1983

Reino Laaksonen & Väinö Malin

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Considerable changes most likely indicating the effects of acid rain were observed during the period 1968—1983 in the ionic composition of the waters of larger Finnish lakes.

Index words: Water quality, lakes, acid rain, ionic composition.

INTRODUCTION

The National Board of Waters has been responsible for extensive monitoring of inland waters in Finland. The results are stored in registers and occasionally scrutinized for possible trends. The electrical conductivity has in particular been shown to have increased over the past two decades in many watercourses monitored, with the exception of northern Lapland (Laaksonen and Malin 1982). Changes are therefore also to be expected in ionic distributions.

In order to shed some light on this question a comparison is made in the following of the concentrations of calcium, magnesium, sodium, potassium, hydrocarbonate, sulphate (=3 × tot.S) and chloride measured in the month of March in the network of deepwater lake observation sites of the Water Administration during the periods 1968—1970 and 1981—1983. In this investigation the data from only 104 out of a total of 160 deepwater stations were available, due to the missing observations.

RESULTS AND DISCUSSION

On the basis of the observation results presented in Table 1 the following conclusions can be drawn with regard to the mean ionic composition in the observation sites:

The concentration of cations was 4.0 % greater than that of anions during the period 1968—1970, but by 1981—1983 this discrepancy had increased to 11.5 %. The concentration of cations increased between the two observation periods by 9.5 %, while that of anions increased only by 2.1 %. — The mean electrical conductivity of the water at the stations increased during the same period by 11.3 % (from 5.5 to 6.1 mS m^{-1}). — The change was very similar in waters known to be polluted and in more undisturbed waters.

Calcium was the dominant cation during both of the periods of observation. The concentration of sodium was greater than the magnesium concentration only in waters known to be polluted. The mean growth of magnesium concentrations between the two periods of observation was greater than that

Table 1. Mean ionic concentrations ($\bar{x}$ meq l^{-1}) and standard deviations (SD) at 104 lake deep observation sites during the periods 1968—1970 and 1981—1983.

	1968—1970			1981—1983			
Variable	$\bar{x}$	SD	%	$\bar{x}$	SD	%	Change %
Ca	0.218	0.140	44.0	0.237	0.132	43.6	+8.7
Mg	0.126	0.082	25.4	0.142	0.102	26.2	+12.7
Na	0.122	0.109	24.6	0.132	0.155	24.3	+8.2
K	0.030	0.017	6.0	0.032	0.017	5.9	+6.7
Tot.	0.496		100.0	0.543		100.0	+9.5
HCO_3	0.172	0.141	36.1	0.167	0.131	34.3	−2.9
SO_4	0.203	0.170	42.5	0.212	0.168	43.5	+4.4
Cl	0.102	0.074	21.4	0.108	0.085	22.2	+5.9
Tot.	0.477		100.0	0.487		100.0	+2.1

of the other ions and probably indicates mainly runoff due to natural leaching. By contrast with the results of Table 1, the concentration of iron decreased slightly between the two observation periods (from 0.018 to 0.017 meq l^{-1}).

The most important anion was sulphate during both periods of observation. Its mean concentration, along with that of chloride, increased as expected, while that of hydrocarbonate correspondingly decreased. During the period 1968—1970 sulfate was the most important anion in 52 % of the observation stations, whereas in 1981—1983 the corresponding number of stations had increased up to 65 %. In the case of hydrocarbonate the corresponding percentages indicating change were 48 and 35 %. This change can also be indicated by stating that the proportion of HCO_3 of the total concentration of anions decreased in three stations out of four. Chloride was not the dominating anion at any of the observation sites.

Data (not shown here) concerning increased concentrations of total nitrogen (Laaksonen and Malin 1982) would not appear to allow nitrate significant influence as an equilibrator of the increased cation-anion discrepancy. Adherence of the "excess cations" on the surface of colloids (humus), abundant in Finnish waters, in the same way as iron would appear to provide the best explanation. During the period of observation water colour increased at the sites by an average of 8.2 % (from 49 to 53 Pt mg l^{-1}), but no significant change in the mean pH of the water was observed in the data (6.45 and 6.49).

LOPPUTIIVISTELMÄ

Vesihallinnon järvisyvänneverkolta maaliskuussa mitattuja kalsiumin, magnesiumin, natriumin, kaliumin, hydrokarbonaatin, sulfaatin ja kloridin pitoisuuksia v. 1968—1970 verrattiin vastaaviin keskiarvoihin v. 1981—1983. Havaintojen puuttumisen vuoksi oli tarkastelussa mukana 104 syvännepaikkaa kaikkiaan 160:stä.

Ionikoostumuksen jakautumasta eri vuosijaksoina voidaan todeta mm. seuraavaa:

Kationien osuus ekvivalenttiyksiköiden määrästä oli v. 1968—1970 4,0 % suurempi, mutta v. 1981—1983 vastaava epätasapaino oli 11,5 %. Muutos oli saman suuntainen niin likaantuneiksi tiedetyillä kuin vähän muuttuneillakin havaintopaikoilla. Humuskolloidit osallistunevat "ylimääräkationien" pidättämiseen.

Kalsium oli kummallakin vuosijaksolla pitoisuudeltaan suurin kationi, joskin magnesiumin kasvu oli muita suurempi. Natriumin pitoisuudet olivat magnesiumia suurempia vain likaantuneiksi tiedetyillä vesialueilla.

Tärkein anioni oli sulfaatti v. 1968—1970 52, v. 1981—1983 65 %:lla havaintopaikoista. Hydrokarbonaatti-ionin osuus oli pienentynyt kolmella asemalla neljästä.

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