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LEACHING OF ORGANIC CARBON AND NITROGEN FROM PEATLAND-DOMINATED CATCHMENTS

Kortelainen, P. & Saukkonen, S. 1992: Leaching of organic carbon and nitrogen from peatland-dominated catchments. — Suo 43:221–225. Helsinki. ISSN 0039-5471

The area of 13 study catchments is 2.5–56.3 km^2 and 37–87% of the catchments is covered by peatlands. Ditching intensities varied from 0 to 100%. Median total organic carbon (TOC) in runoff waters from the catchments was 10–30 mg l^{-1} and median total nitrogen (N_{tot}) 380–1 000 µg l^{-1}. The annual leaching of TOC and N_{tot} was calculated for five catchments for which daily runoff data was available. The range for mean annual leaching of TOC and N_{tot} from the catchments was 4 700 to 7 300 kg $km^{-2}a^{-1}$ and 190–250 kg $km^{-2}a^{-1}$, respectively. The variation between different years was high and annual leaching was closely related to annual runoff. The regional variation in the leaching of TOC and N_{tot} was small compared to the annual variation.

Keywords: Hydrology, leaching, organic carbon, peatlands, runoff

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INTRODUCTION

The net primary production, vegetation type and the depth of the peat profile, together with topography and hydrological processes, all contribute to the leaching of organic carbon and nitrogen from peatlands. Land use affects natural leaching processes, and ditching is one of the most large-scale human impacts to have taken place in Finnish catchments this century (The Committee Report 1987). The leaching of organic carbon and nitrogen has been found to increase during and immediately after ditching. However, ditching is usually performed to lower the groundwater level, which can decrease leaching in the long-term (e.g. Heikurainen et al. 1978, Moore 1987, The Committee Report 1987, Ahtiainen 1988).

A changing climate can be expected to have an impact on all hydrological processes contributing to the leaching: precipitation, evaporation, seasonal and annual runoff, peatland water table. Seasonal hydrological changes in long-term leaching can be more important than changes in mean annual values. Changes in temperature and moisture conditions are likely to have an impact on primary production and decomposition processes as well.

This paper summarizes total organic carbon (TOC) and total nitrogen (N_{tot}) concentrations in runoff waters from 13 catchment areas. Much of the catchments is covered by peatlands having different ditching intensities. The annual leaching of TOC and N_{tot} is calculated for five catchments for which daily runoff data and frequent water quality data over the last decades are available. In the SUOSILMU project, this data base will be used to estimate the impacts of a changing climate on leaching from peatlands.

MATERIAL AND METHODS

Study catchments

The selection criteria for the study catchments (n = 13) (Fig. 1, Table 1) were: a high peatland percentage, a low percentage (<5%) of agricultural fields, and the availability of long-term water quality data. The area of the catchments ranges from 2.5 to 56.3 km^2, the peatland percentage from 37 to 87, and the proportion of ditched peatlands from 0 to 100% of the total peatland area (Table 1). Most areas have been ditched, mostly in the 1970s. The advantage of small catchment areas is that they are natural hydrological units and the leaching measured at the outlets represents the actual load discharged to surface waters.

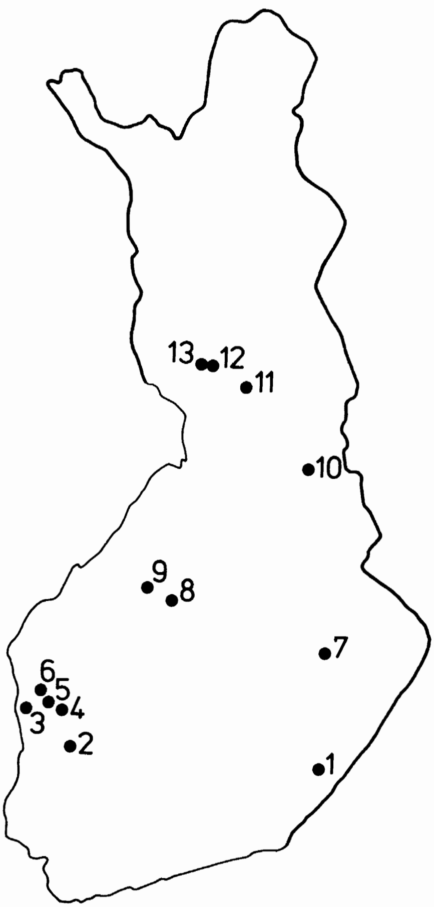

Fig. 1. Location of the study catchments.

Methods

In all catchments, runoff and water quality have been monitored since the beginning of the 1970s (some, since the 1960s). Daily runoff data were used for the leaching calculations for five catchments (leaching calculations for the remaining catchments will be based on runoff data from similar catchments nearby).

The sampling frequency for water quality in the catchments having daily runoff data was approximately 12 per year, but the sampling strategy was changed in 1981 to concentrating the sampling to periods of high runoff (spring and autumn). The analysis program for water quality includes 25 chemical parameters, e.g., total organic carbon, colour, chemical oxygen demand, total nitrogen, nitrate, ammonium, conductivity, pH, alkalinity, turbidity, suspended solids, total phosphorus and iron. The analyses were carried out using the methods of the National Board of Waters and the Environment (National Board of Waters 1981).

The annual leaching of TOC and N_{tot} for the five catchments having daily runoff data were calculated using four different methods (Rekolainen et al. 1991). In method (1), the concentrations are multiplied with the runoff of the period after sampling. In method (2), the period around the sampling time was used. In method (3), the leaching was estimated as the product of the annual runoff times the arithmetic mean of the sampled concentration values. In method (4), the sampled

Table 1. The surface area of catchments, percentage of peatlands in the catchment and the percentage of peatlands that are ditched.

Catchment	Surface area (km^2)	Peatlands (%)	Proportion of ditched peatlands (%)
1 Huhtisuonoja	5.0	47	85
2 Katajaluoma	11.5	37	100
3 Heinästönluoma	16.1	59	57
4 Sydänmaanoja	3.8	52	20
5 Kruunuoja	10.5	87	0
6 Töllinoja	3.4	38	100
7 Kesselinpuro	20.7	37	94
8 Vertailualue	2.5	65	61
9 Pahkaoja	20.9	41	49
10 Joutenpuro	3.5	46	100
11 Kirsioja	22.9	59	54
12 Kotioja	18.1	54	49
13 Ylijoki	56.3	59	50

concentration values were weighted with the flow at the sampling times and multiplied by the annual runoff. The four calculation methods gave rather similar results (Fig. 2). The TOC and N_{tot} leaching values presented in this paper are calculated by averaging the results given by the methods (1)–(4).

RESULTS AND DISCUSSION

There was a large seasonal variation in runoff in all five catchments. The annual runoff during the observation period in the five catchments ranged from 120 to 610 mm a^{-1}. Also the TOC concentrations in all catchments showed seasonal

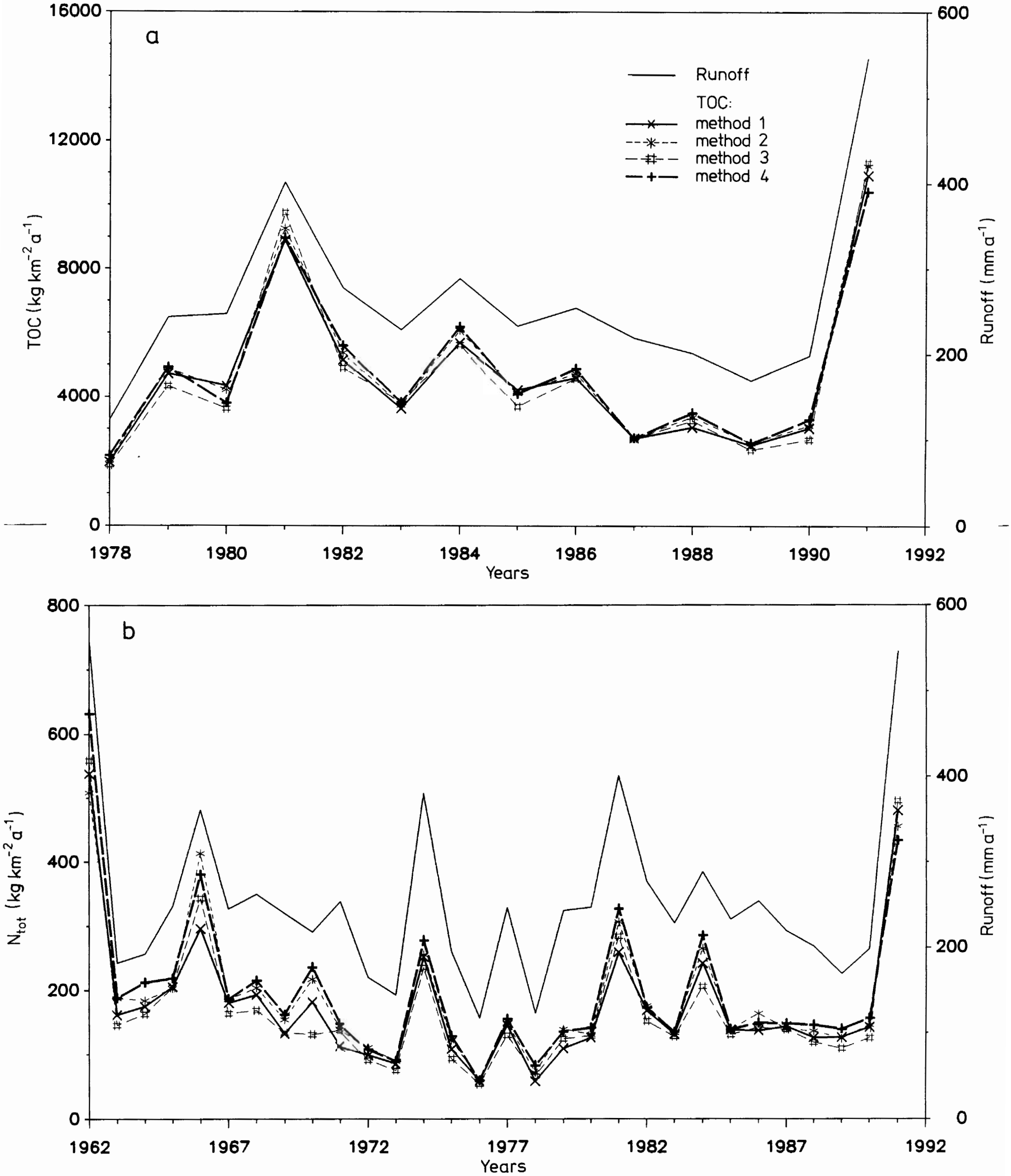

Fig. 2. The annual runoff and the annual leaching of TOC (a) and N_{tot} (b) from the Huhtisuonoja catchment.

variation. The median TOC in the 13 catchments ranged from 10 mg l^{-1} to 30 mg l^{-1}. The TOC concentrations were slightly lower in the northernmost catchments (Table 2).

Table 2. The minimum and maximum total organic carbon (TOC) concentration, median TOC and median total nitrogen (N_{tot}) during the observation period (see Tables 3–4) in the catchments.

Catchment	TOC (mg l^{-1}) Min	Max	Med	n	N_{tot} (µg l^{-1}) Med	n
1	8.0	41	18	101	590	308
2	3.5	30	18	8	1 000	180
3	3.8	68	30	141	900	146
4	12	57	26	88	900	96
5	13	53	23	77	500	101
6	2.0	33	10	123	400	127
7	4.9	60	27	85	680	331
8	9.0	96	27	99	740	108
9	1.6	35	18	70	600	274
10	2.1	59	23	60	470	98
11	5.0	32	15	57	380	61
12	5.8	25	15	70	520	146
13	1.0	20	13	72	560	165

During the observation period, the annual leaching of TOC from the catchments ranged from 1 900 to 18 000 kg $km^{-2}a^{-1}$ (Table 3). The leaching was strongly dependent on hydrological conditions; annual leaching was closely related to annual runoff (Fig. 2a). Higher leaching values during rainy years are often a result of both high runoff and high concentrations. In a review, Mulholland et al. (1990) concluded that organic carbon concentrations are typically positively correlated with discharge. In rainy years, surface runoff is high due to a high groundwater table and often results in high TOC concentrations in runoff waters (Sallantaus 1986).

The mean annual runoff in the five catchment areas increased to the north (Tables 3–4). This trend compensated for the lowest TOC concentrations recorded for the two northernmost catchments such that there was little variation in the mean annual leaching between the five catchments. The range for mean annual leaching of TOC in different catchments was lower (4 700–7 300 kg $km^{-2}a^{-1}$) than the range for annual leaching in any of the five catchment areas (Table 3).

Table 3. Annual leaching of total organic carbon (TOC) and annual runoff during the observation period in five catchments. The mean annual leaching of TOC was calculated by averaging over all years the results of methods (1)–(4). The range presents the minimum and maximum annual leaching given by any of the four methods.

Catchment	TOC (kg $km^{-2}a^{-1}$) $\bar{x}$	Range	Runoff (mm a^{-1}) $\bar{x}$	Range	Years
1	4 700	1 900–11 000	260	120–550	1978–1991
7	7 300	4 100–18 000	280	140–440	1978–1989
9	6 700	2 900–15 000	330	170–530	1978–1986
12	5 400	3 800– 8 100	380	230–510	1979–1989
13	5 000	2 300– 8 200	400	220–610	1979–1986

Table 4. Annual leaching of total nitrogen (N_{tot}) and annual runoff during the observation period in five catchments. The mean annual leaching of N_{tot} was calculated by averaging over all years the results of methods (1)–(4). The range presents the minimum and maximum annual leaching given by any of the four methods.

Catchment	N_{tot} (kg $km^{-2}a^{-1}$) $\bar{x}$	Range	Runoff (mm a^{-1}) $\bar{x}$	Range	Years
1	190	54–630	250	120–560	1962–1991
7	210	95–590	260	140–460	1962–1989
9	200	78–500	310	150–560	1962–1989
12	200	75–320	390	230–510	1976–1989
13	250	110–410	410	220–610	1976–1986

Nitrogen cycling in terrestrial catchments is closely related to organic carbon cycling. The median N_{tot} in the 13 catchments ranged from 380 to 1 000 µg l^{-1}. The average proportion of inorganic nitrogen ((NO_3 + NH_4)/N_{tot}) was 28% ranging from 14% in Kruunuoja to 43% in Katajaluoma. In the five catchments included in the leaching calculations, median N_{tot} concentation values were very similar (520–680 µg l^{-1}) (Table 2). No remarkable differences in the mean annual leaching of N_{tot} in these areas was found either: the mean annual leaching of N_{tot} ranged from 190 to 250 kg $km^{-2}a^{-1}$ (Table 4). The leaching values are comparable to those reported by Ahtiainen (1988) for forested catchment areas with variable peatland proportions. As with TOC, nitrogen leaching was closely related to hydrological conditions. Variation between different years was high and annual leaching was closely related to annual runoff (Fig. 2b).

The climate change is expected to cause changes in temperature and precipitation. The leaching of both TOC and N_{tot} were found to be strongly dependent on runoff, which is closely related to precipitation. The available data base (13 catchments with different ditching intensities) will enable the study of the impacts of different hydrological conditions (e.g., rainy and less rainy years, and early spring melting) on leaching. The regional results will be used to estimate the effects of the predicted changes in climate on leaching from ditched peatlands.

ACKNOWLEDGEMENTS

Maximilian Posch is acknowledged for valuable assistance in the leaching calculations and comments on the manuscript.

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