

SOURCE OF DRAINAGE WATER ACIDITY IN PEAT HARVESTING

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SUMMARY

Water and soil samples were collected from different peat production areas in mostly Western and Northern Finland in order to determine the difference between organic and mineral acidity in drainage water. Mineral acidity typically originates from the oxidation of sulphidic mineral subsoil.

KEYWORDS: Acidity, acid sulphate soil, drainage water, peat production

INTRODUCTION

Most of Finnish natural waters are humic and acidic (Kortelainen, 1993, Lahermo *et al.*, 1996). This is mainly due to the high peatland coverage of Finland, estimated in 2010 to be 9,3 million ha (Leinonen, 2010).

Another potential source of acidity is sulphide-rich mineral soils. Two common types of sulphide rich regions in Finland are the coastal land uplift area, including the Littorina Sea area, and black shale areas (both coastal and inland areas). Littorina Sea area refers to the area, which was in the past covered by Littorina Sea, an earlier stage of Baltic Sea, with higher salt concentrations and higher water level reaching up to 100 m above current sea level (Erviö, 1975). Black shale areas refer to areas that are above black shales in the bed rock or within their immediate glacial dispersal area. In peat production water quality problems have been detected especially in areas where there may be impact of both land uplift and black shales.

In earlier studies (Picken, 2007) of peat production areas, approximately one fifth of the mineral subsoil samples in sulphide risk regions contain relatively high concentrations of water soluble sulphur, which mainly represents the oxidized fraction. Sampling mineral subsoil is relatively easy towards the end of peat production. Doing the study beforehand is more challenging: sulphide sediments are covered by thick peat layers and they also may be covered with thin layers of other mineral soils.

The aim of this study was to find an easy to use and reliable analysis method to differentiate the two source of acidity in water. The acid load to a water course resulting from oxidation of sulphidic soil can cause severe damage e.g. fish kills.

MATERIALS AND METHODS

Soil and water samples were collected from 45 Vapo Oy's peat production sites in 2010 and 2011. The study sites were chosen on the basis of their location in the Littorina area or near a black shale formation and also on the results of peat productions' regulatory water monitoring data.

The water samples were mostly collected at the measuring damn or in some case field ditches. The soil samples were collected from either ditch or sedimentation basin banks where the mineral soil was easily accessible. The sampling was done with a plastic spade to avoid possible metal contamination.

All the soil samples were analysed at Enas Oy laboratory and the water samples at University of Jyväskylä Institute of Environmental Research and Nab Labs Ltd.'s Oulu laboratory. The water samples were analysed for pH, electro conductivity (EC), alkalinity, acidity, SO_4^{2-} , Al and Fe using standard analysis methods. Chemical oxygen demand (COD_{Mn}) was obtained from peat production's water monitoring data if available from the same time period. The soil samples were analysed for pH, EC, water soluble SO_4^{2-} , Fe, and Al, and total Al, Fe, and S as well as ash %, moisture, and bulk density.

Samples which had pH below the end point of the alkalinity titration were treated as alkalinity = 0.

RESULTS

Water Samples

The drainage water quality varied considerably between the sampling sites (Table 1). pH values ranged from 2,8 to 7,7, the majority of samples being acidic. Samples with the lowest pH values had also highest sulphate concentrations and ECs. 14 water samples had good (0,11-0,2 mmol l^{-1}) or excellent ($>0,2 \text{ mmol l}^{-1}$) alkalinity levels according to Heikkinen and Alasaarela (1988), whilst most of the samples were moderate (0,2-1,0 mmol l^{-1}) or high ($>1,0 \text{ mmol l}^{-1}$) acidity (N=35 and N=7, respectively). The sulphate concentrations varied from under detection limit ($<0,3 \text{ mg l}^{-1}$) to 1800 mg l^{-1} in the Rauansuo field ditch sample. Significant Pearson correlations were found e.g. between EC and sulphate (0,974 / P 0,000) and pH and EC (-0,444 / 0,003). A number of chemical compounds are plotted as function of SO_4^{2-} concentration in (Fig. 1) excluding the Rauansuo sample. No significant correlation was found between COD_{Mn} and pH or acidity (Fig. 2).

Table 1. Sampling site water qualities.

	pH	EC [mS m^{-1}]	Alkalinity [mmol l^{-1}]	Acidity [mmol l^{-1}]	COD_{Mn} [$\text{mg O}_2 \text{ l}^{-1}$]	SO_4^{2-} [mg l^{-1}]	Fe [mg l^{-1}]	Al [mg l^{-1}]
N	45	45	45	45	23	35	45	45
Min	2,8	2,5	0	0,16	1,5	0,3	0,11	0,046
Max.	7,7	245	3	15	140	1800	45	70
Mean	5,0	24	0,18	1,1	74	116	5,8	2,6
Med.	4,9	8,08	0,009	0,44	78	15,2	2,6	0,49

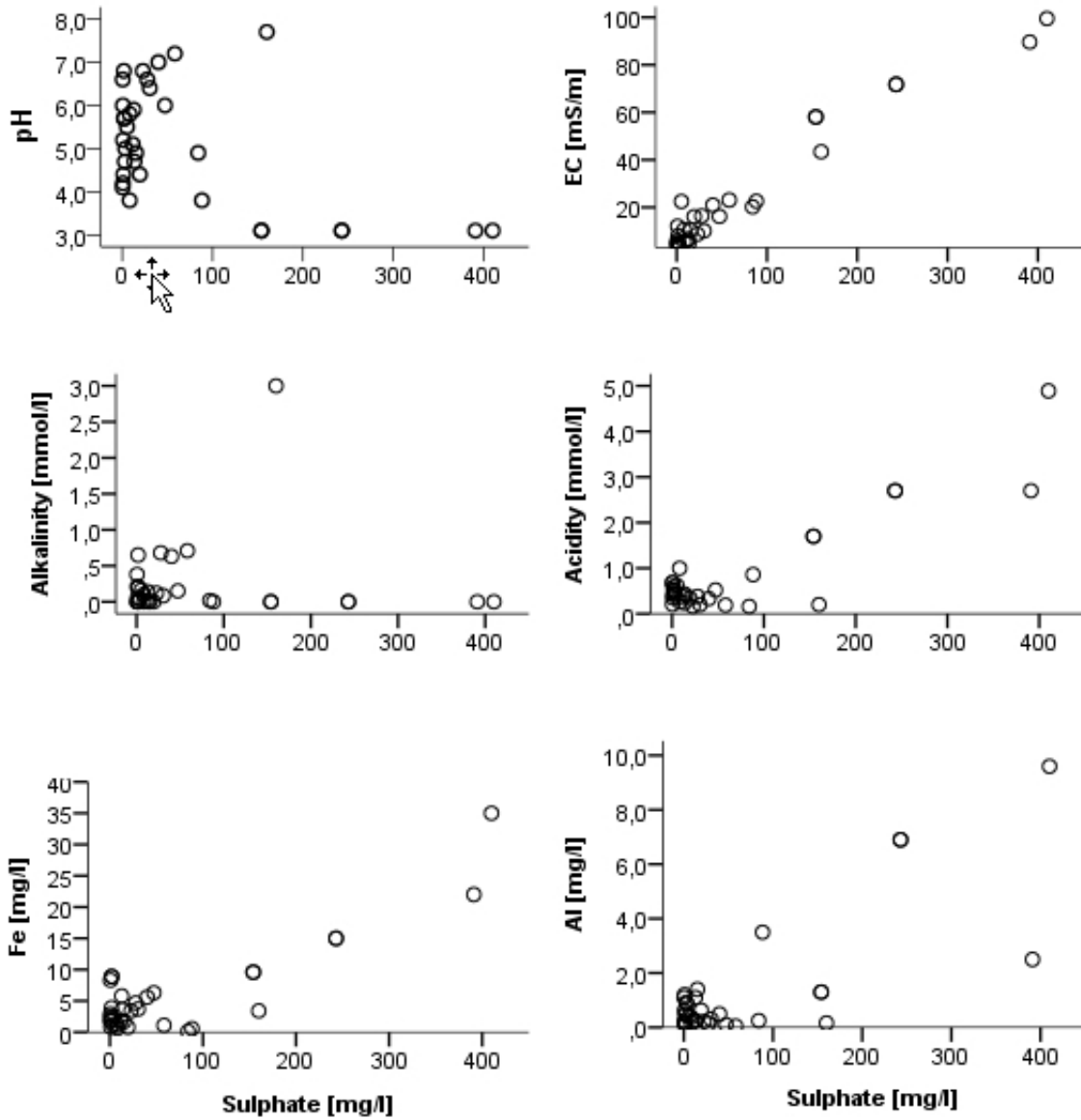


Figure 1. pH, EC, alkalinity, acidity, Al, and Fe in water samples vs. sample sulphate.

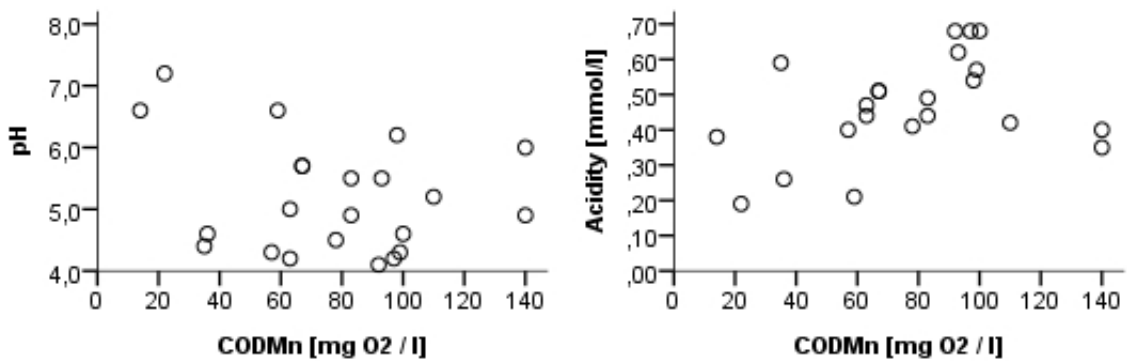


Figure 2 pH and acidity as function of COD_{Mn}

Soil samples

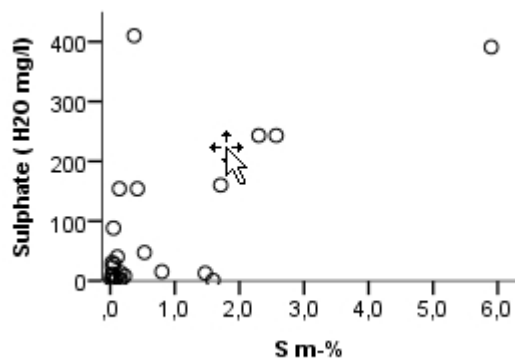
The mineral soil samples had mostly high ash content suggesting low content of organic matter (Table 2) in which sulphur can be enriched. The total sulphur levels varied from under detection limit to 5,9 m-% in Hakasuo sample. pH values correlate negatively with EC and soluble SO_4^{2-} values (-0,546 / P 0,000). EC correlates positively with soluble SO_4^{2-} (0,944 / 0,000) and total Fe (0,387 / 0,009) values. Total S % has significant correlation with $\text{EC}_{\text{H}_2\text{O}}$ (0,612 / 0,001), $\text{SO}_4^{2-}(\text{H}_2\text{O})$ (0,661 / 0,000) (Fig. 3), and total Fe (0,719 / 0,000).

Table 2 Mineral soil quality

	Moisture m-%	Bulk density [g l ⁻¹]	Ash m- %	Al _(tot) [mg (kg) ⁻¹]	Fe _(tot) [mg (kg) ⁻¹]	S _{tot} m- %	S _{tot} [mg l ⁻¹]
N	45	45	45	44	45	29	29
Min	7,9	730	68,4	3700	4900	0,02	198
Max.	72,5	2174	99,6	51600	109300	5,9	26255
Mean	32,0	1486	95,8	28966	33751	0,69	3525
Med.	25,2	1470	98,1	35150	25900	0,16	1406

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Actual acid sulphate soil according to suggested classification for Finnish acid sulphate soils (Toivonen and Österholm, 2011) was found at three production sites, the sulphur content criteria (>0,2 m-%) was met at ten sites. Of these sites four had severely acidic drainage water containing sulphates and high EC.

Figure 3. SO_4^{2-} concentration in water samples as a function of total sulphur content of soil samples.

CONCLUSIONS

Low drainage water pH can be caused by both organic substances and sulphuric acid formed as a result of oxidation of sulphidic mineral sub soil. The most efficient method in differentiating these two seems to be EC. The higher the EC value is in peat production drainage water in addition to low a pH value, the more likely it is to have also a high sulphate concentration. This study suggests appropriate limit values to be $\text{pH} < 4,5$ and $\text{EC} > 10 \text{ mS m}^{-1}$. It is also concluded that metal in even low pH values are mostly bound to organic matter since the EC value is typically low in the absence of SO_4^{2-} . When even low concentrations of SO_4^{2-} are present, the EC value rises rapidly.

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