Fractionation of Water and Soil Water Samples in the Lake Skjervatjern and its Catchment Area

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Acidification may influence the physico-chemical form of several compounds. In the HUMEX lake areas, the relative distribution of elements among low and high molecular weight compounds may therefore change. This may have a influence on the behaviour chemical and biological of elements. In order to study the size distribution pattern of several minor and major compounds and their mobility, water samples from the HUMEX-lake and from soil water the catchment area, have been ultrafiltered by the use of hollow fibres. This fractionation technique is non destructive, no chemicals are added and the disturbance of the sample is reduced to a minimum, as the pressure used during the separation, is rather low (usually 10 psi). Furthermore, the separation of the sample is fast and can be performed in situ (Salbu et al. 1985).

The mobilization of different Al-fractions are known to be sensitive to levels of dissolved organic carbon (DOC) and to pH (Vogt et al. this Newsletter). It is important to assess which size fraction of the DOC that organic Al (AlO) is associated with. Therefore different aluminium fractions have been studied in more detail using the ultrafiltration technique in combination with the Al fractionation technique after Barnes (1975) and Driscoll (1984).

EXPERIMENTAL

Ultrafiltration

The lake and the soil water was ultrafiltered by using an Amicon CH₂ concentrator equipped with hollow fibre cartridges (nominal molecular weight cut off 3 kDa and 10 kDa). By means of a peristaltic pump the water was pumped directly into the molecular weight discriminator. The cartridges were conditioned with an aliquot of the sample prior to collecting the sample. Samples were collected from the acidified and the reference side both within the lake and at the outlet of the lake. Soil water was sampled from lysimeters situated at soil profiles classified as Podzol (Plot D and H) and Dystric Histosol (Plot B and F) from both the acidified and from the reference area. As a certain filtration volume was needed, the soil waters were collected from the lysimeters during several days. The ultrafiltration was performed in the concentration mode; i.e. the water sample not passing the membrane was recirculated to the original sample, while the filtrate was continuously removed.

Aluminium speciation:

Aluminium speciation was conducted according to a method given by Barnes (1975) and Driscoll (1984).

Organic carbon:

The absorbance of the sample was measured at 254 nm by a Shimadzu (UV-120-0Z) spectrophotometer.

Elements:

Ca, Mg, Na and K were measured by ICP, Fe, Mn and Zn by graphite furnace and SO₄²⁻ and Cl⁻ by ion chromatography.

RESULTS AND DISCUSSIONS

The lake Skjervatjern:

According to the UV-absorption data measured at 254 nm, a significant amount of the humic substances are in a high molecular weight form. Approximately 85 percent was > 3 kDa (Fig. 1). Simultaneously with a reduction in the UV- absorption, there is a slight increase in pH. This is probably due to the removal of organic acids.
There is a deficit of anions compared to cations in the analysed lake water samples (Fig. 2).

By removing the high molecular weight compounds, the ratio between cations and anions is closer to 1 compared to the unfiltered samples. At an average, the difference between cations and anions are 24 and 6 μeq/l in the unfiltered and the ultrafiltered samples (< 3 kDa) respectively. Analysis on cations in the fraction < 3kDa from the outlet of the acidified part is yet not available (Fig. 2), and are therefore not included in the average values given above.

Furthermore, part of the sulphate, calcium, magnesium, sodium and potassium are also removed during the ultrafiltration, which may indicate that they are associated with high molecular humic substances. However, all the chloride was present in a low molecular weight form, as could be expected due to small ionic radius.

The ionic composition in the samples from the lake and the inlet from the acidified and the reference part are quite similar. However, there are some variations in the SO$_4^{2-}$ concentration between the different samples (varies from 21-37 μeq/l in the unfiltered samples), and pH is app. 0.1 lower in the acidified compared to the reference part of the lake.

Figure 3. Organic monomeric Al (Al$_o$) and inorganic monomeric Al (Al$_i$) in the different size fractions.
The major fraction of Fe was in a high molecular weight form, as 85% was > 3 kDa. With regard to Mn the high molecular weight fraction was considerably less as app. 35% was > 3 kDa. Practically all organic monomeric Al (AlO) was as expected removed during the ultrafiltration; i.e. was > 3 kDa (Fig. 3). The very low inorganic monomeric Al (AlI) concentration decreased further in the fraction < 3 kDa. This may indicate that AlO is somewhat overestimated in the total samples, although artefacts due to charge balance constraints may as well be the cause for this decrease.

Figure 4. Fe as a function of UV-absorption measured at 254 nm.

Figure 5. Mn as a function of UV-absorption measured at 254 nm.

Figure 6. Organic monomeric Al (AlO) as a function of UV-absorption measured at 254 nm.

Fe in the ultrafiltered samples was linearly correlated to the UV absorption data, while Fe in the unfiltered samples showed a more scattered pattern (Fig. 4). This supports the assumption that colloids/particulate materials in unfiltered water samples influence the chemistry of the Fe results. Mn was also positively correlated with the UV-absorption data, but the linear regression curve does not go through zero (Fig. 5). This is in agreement with the result that a major fraction of Mn was low molecular; i.e. not associated with high molecular weight humic substances. AlO in all fractions was linearly correlated to the UV-absorption data (Fig. 6). This may indicate that the DOC concentration is controlling the AlO in solution. A similar conclusion was reached by Vogt et al. (this newsletter) studying soil waters with high DOC concentration.

Soil water from lysimeters in the catchment:
The content of humic substances in soil waters decreases with depth in the Podzol profiles (plot D and H), while it seems to increase slightly in the Dystric Histosol profiles (plot B and F). It seems as if the relative distribution between high and low molecular humic substances increases with depth in the soil profiles (Fig. 7).
A significant amount of sulphate (app. 60% in the Dystric Histosol and 35% in the Podzol) seems to be associated with high molecular weight compounds in the soil water of the upper horizons, while in the deeper layers almost all the sulphate seems to be at a low molecular form.

In the upper horizons of the podzol profiles, app. 40-50% of calcium seems to be high molecular. With regard to magnesium, 50% is apparently high molecular in the upper horizons of the Dystric Histosol and the Podzol profiles, while 20% and 5-10% is high molecular in the deeper horizons of the Dystric Histosol and the Podzol profiles respectively.

As for the lake water all the chloride was present in a low molecular form and almost all the AlO was in a high molecular form.

These preliminary results indicate that the relative amounts of low molecular compounds increases with soil depth, which is consistent with the hypothesis that they are more mobile than the high molecular weight compounds.

REFERENCES

