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# Characterization of dissolved organic carbon (DOC) in a dystrophic lake and an adjacent fen

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**Abstract.** Dissolved organic carbon (DOC), humic substances (HS), polysaccharides (PS) and low molecular weight acids (LMWA) were characterized in water from the dystrophic Lake Große Fuchskuhle over a period of seven months. In addition, porewater from an adjacent fen was investigated in order to obtain information about the DOC in the catchment area. Size-exclusion-chromatography combined with UV- and organic carbon (IR)-detection was used to quantify DOC and its fractions. The lake had previously been divided into four separate sections by large sheets of plastic, and the DOC composition differed markedly between the four compartments. Spatial variations in HS and PS concentrations were greater than seasonal variations. The high amounts of HS (up to 58%) in the western sections of the lake, indicated influence by subsurface water from the fen, whereas the eastern sections were dominated by PS (up to 35%) of algal origin. These differences could be explained by hydrological conditions, indicating that completely different catchment areas influenced the water chemistry in the separate compartments. By characterizing the HS by their average molecular weight and their aromaticity, three different groups of HS could be distinguished depending on their origin and fate. Microbial degradation of DOC and its fractions differed between two of the compartments during incubation studies over a period of six weeks.

## Introduction

The total mass of dissolved organic carbon (DOC) in aquatic ecosystems generally exceeds that of particulate organic carbon (POC) by one order of magnitude and also greatly exceeds that of living organisms (Thomas 1997; Steinberg et al. 2000). Recalcitrant humic substances, consisting of humic and fulvic acids, contribute 60 to 90% of the DOC in natural waters (Klavins 1997). Only about 20% are biological available labile organic compounds

such as carbohydrates, carboxylic acids and amino acids (Thurman 1985; Amon & Benner 1996). Humic substances (HS) directly influence biological and chemical processes in surface waters. They show absorption in the visible and UV ranges, act as electron acceptors and complexing agents to nutrients, metals and organic substances such as pollutants and degrade into labile low molecular weight compounds (Jones 1992; De Haan 1992, Lovely et al. 1996, Bertilsson & Tranvik 2000). HS may also serve bacteria as a source of direct or indirect nutrients (Jones 1992; Steinberg & Bach 1996).

The variability of DOC concentration and composition in surface waters is due to its sources, transport and reactivity. According to its origin, aquatic organic matter can be separated into two major groups. Allochthonous organic carbon is derived from the terrestrial and semiaquatic environment. It depends quantitatively and qualitatively on the landscape characteristics as well as anthropogenically influenced allochthonous organic compounds that are derived from agricultural, domestic and industrial activities. The transport of allochthonous organic matter largely depends on hydrological factors (Moore & Jackson 1989). Exudation and excretion of organisms of all trophic levels and decomposition products of dead organisms contribute to the autochthonous portion of DOC (Tranvik 1993).

Aquatic organic matter is regionally and seasonally variable and its concentration is influenced by the balance between its formation processes, fluxes, transformation and removal processes. Peatlands are sinks for nutrients and carbon of plant origin (peat). On the other hand, they have been shown to be one of the quantitatively most important carbon sources for surface waters especially of HS (Hemond 1990; Mullholland et al. 1990; Sachse et al. 2000). Several studies have indicated that DOM export from the catchment into surface waters is particularly high for regions with a substantial proportion of peatlands (Urban et al. 1989; Sallantaus 1992; Kortelainen 1999). DOC concentration often exceed 10 mg/L in those lakes that receive extensive water input from wetlands (Klavins 1997). Most of the studies described above only deal with the total DOC and therefore little is known about peatlands influencing the amount of different fractions of DOC in surface waters (Sachse et al. 2000).

In order to better understand how DOC quality is influenced by geological and biological factors, the small dystrophic Lake Große Fuchskuhle was studied, near the city of Berlin. It was divided into four compartments in 1991 for previous experimental studies (Kasprzak et al. 1988, 1993). Investigations of the different compartments indicated a completely different development in biological and chemical parameters in the western and eastern sections, especially differences in the compositions of DOC compounds in August and September 1996 (Bittl 1999). Due to hydrological factors, the western and the

eastern sections are expected to have completely different catchment areas reflected in their divergent chemical and biological parameters (Bittl 1999).

The aim of this study was to analyze differences in DOC and its compounds, especially the HS fraction, in the four compartments and in the porewater of the adjacent fen in order to adress the following questions. (1) Is the quantitative and qualitative DOC composition in the sections dependent on the catchment area? (2) Are any spatial differences in DOC greater than vary seasonally? (3) Do the DOC components in the different sections show differences in their degradation by heterotrophic bacteria? Hydrological factors concerning the subsurface waterflow in the catchment were expected to be of paramount importance in answering these questions.

## Material and methods

### *Study site*

The dystrophic Lake Große Fuchskuhle is situated in the north-eastern part of Germany about 100 km north of the city of Berlin (53°10′ N, 13°02′ E, 59 m above sea level). It is located within a basin in a pine forest. The lake is a glacial spillway in an outwash plain formed during the post-glacial period. It has no contact to the main aquifer because of layers of clays and silts on the ground. Due to reduced percolation of water through these layers, a second groundwater storey has developed situated above the main aquifer (Ginzel 1999). The lake has no surface inlet or outlet and is fed only by rainwater and shallow groundwater. In 1986, the lake was divided into two and in 1990 into four sections for biomanipulation experiments, using large plastic sheets (Kasprzak et al. 1988; Babenzien & Babenzien 1990, Figure 1). The lake was characterized by acidic pH values and low conductivities (Table 1). After the subdivision all four sections (southeast = SE, southwest = SW, northeast = NE, northwest = NW) but especially the NE and the SW compartments showed a divergent development in their physico-chemical characteristics (Table 1). Since 1994 the lake has been stratified nearly throughout the year, due to the wind-protected position, with a metalimnion at a depth between two and three meters. Near the sediment the water body is anoxic.

As a result of lake genesis an oligotrophic, acidic fen adjacent to the lake developed during the last thousand years (Figure 2). The fen is characterized by a Ledo-Pinetum vegetation (Succow & Jeschke 1990). Waterlogged conditions up to the surface peat layer were found only at the south-western edge. At the northern and the eastern part of the fen the groundwater table is decreasing, leading to a change in vegetation.

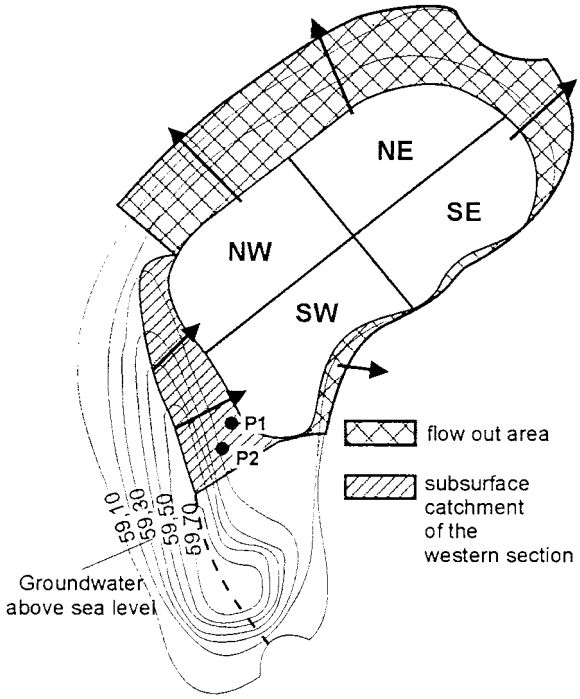


*Figure 1.* Divided experimental Lake Große Fuchskuhle. P1 and P2 indicate locations of the dialysis samplers.

*Table 1.* Characteristics of the Lake Große Fuchskuhle before and after division (Bittl 1999)

| | lake before division | SW compartment after division (1994–1996) | NE compartment after division (1994–1996) |
|---|---|---|---|
| volume ($m^3$) | 53 000 | 9 700 | 11 300 |
| surface ($m^2$) | 15 000 | 4 430 | 3 360 |
| max. depth (m) | 5.5 | 4.5 | 5.5 |
| pH | 4.2–4.6 | 4.4 | 5.8 |
| conductivity ($\mu$S/cm) | 60 | 50 | 35 |
| DOC (mg/L) | — | 8.7–18.6 | 4.7–12.3 |

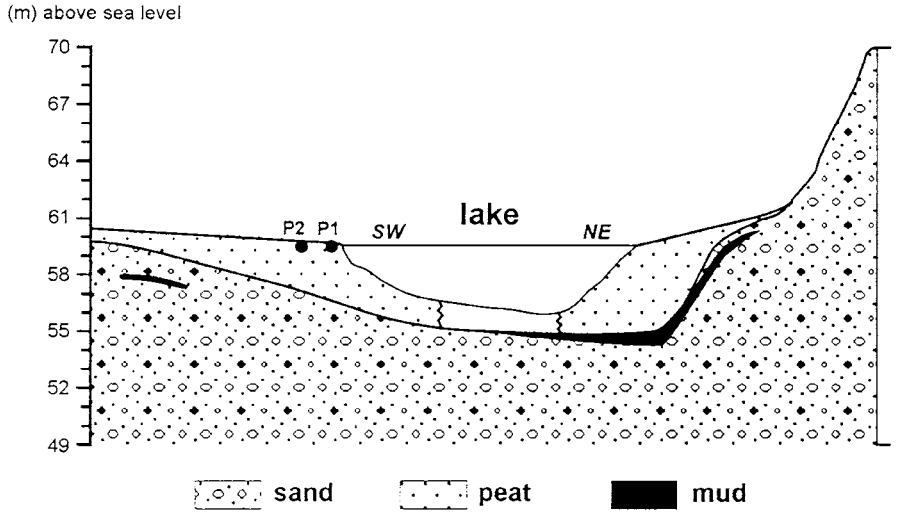


*Figure 2.* Geological profile of the catchment around the lake. P1 and P2 indicate locations of the dialysis samplers.

Several groundwater wells and soil cores were investigated for a hydrological and geological characterization of the catchment, that will be described in detail later (Figure 1 and Figure 2).

*Sampling*

The four compartments of the lake (NW, NE, SE and SW) were investigated monthly from February to August 1998. Surface water samples were taken at a depth of 0.5 m in all compartments and additionally at 4.0 m in the SW and NE compartments. Deep water samples from the lake were anoxic. An equilibrium diffusions technique was used for porewater investigations of the oligotrophic, acidic fen according to the method of Hesslein (1976) and Carignan (1984), which allowed an anoxic in situ sampling of porewater up to a depth of about 60 cm. The dialysis porewater samplers consist of a long board of Plexiglas with a series of sampling chambers. These chambers were filled with deaerated, deionized water and were covered by a polysulfone membrane (HT-Tuffryn, 0.2 $\mu$m pore size). The samplers were inserted into the fen and allowed to equilibrate for one to two weeks with the anoxic porewater (Brandl & Hanselmann 1991). Samples of porewater of the fen were analyzed in May 1998 at two different sites, one porewater sampler at a distance of half a meter from the SW section (P1) with waterlogged conditions up to the surface, the other (P2) two meters from the edge of the same compartment (Figures 1 and 2).

*Chemical analysis*

Automated size-exclusion-chromatography with UV- and organic carbon detection (IR) (Huber & Frimmel 1991, 1996) was used for DOC analysis of the water samples. Total DOC was obtained by injection of 0.45 $\mu$m (surface and deep water) and 0.2 $\mu$m (porewater), respectively, filtered samples bypassing the chromatographic column. The chromatographied portion of DOC (DOC′) and its different compounds were analyzed by passing the samples through size-exclusion-chromatography (SEC). The column was packed with Toyopearl HW-50S resin and had a volume of 250 × 20 mm. Phosphate buffer (0.029 mol/L, pH 6.5) was used as eluent at a flow rate of 1 ml/min. The difference between total DOC and DOC′ was due to sorption of a small portion of the total DOC on the resin. Three different groups of DOC (polysaccharides = PS, humic substances = HS and low molecular weight acids = LMWA) could be fractionated by the column, characterized by UV-detection (254 nm) and quantified by IR-detection after UV oxidation in a cylindrical UV thin-film reactor (Gränzel, Germany; wavelength: 185 nm). The fraction of PS are high molecular weight carbohydrates, that are mainly biodegradable. They show no absorption in the UV range. HS include recalcitrant humic and fulvic polyelectrolytic acids, that are UV active due to aromatic groups. LMWA are defined as low molecular weight carboxylic acids such as several metabolites in biological and chemical processes, also accounting to the labile portion of the carbon pool. DOC in the low molecular weight range after a retention time of 45 minutes was described as 'other'. The DOC-chromatograms of some samples showed a single or double peak within this range (low weight substances = LWS), which was probably caused by mono – or disaccharides or amino acids. Fractions were identified by using standards (humic and fulvic acid standards from the IHSS) and simple compounds of different origin and by characterizing the biological availability of each fraction (Huber et al. 1994; Huber & Frimmel 1996; Bittl 1999). The ratio between the spectral absorption coefficient (SAC in $m^{-1}$, at 254 nm) and the organic carbon (DOC in mg/L) was calculated as an indicator of the proportion of aromatic structure in the HS (SAC/DOC in L $mg^{-1}$ $m^{-1}$). For molecular weight calibration saccharides (raffinose, maltose, glucose, glycerin and methanol from Merck) and polydextranes ($M_p$ = 830, 4400, 9900, 21400, and 43500 g/mol from Polymer Standards Service) were used. The calibration curve was obtained by plotting the retention times of the standards against the logarithm of their molecular weights using the program 'Geltreat' (I. Perminova, personal communication). Molecular weights of HS (M) in the water samples were calculated by comparing their retention times with the calibration curve.

*Microbial studies*

To investigate differences in degradation of the DOC fractions by heterotrophic bacteria, 150 ml of 0.45 $\mu$m filtered water from the sections SW and NE (0.5 m depth) were incubated with an addition of 1.5 ml of 0.8 $\mu$m filtered water (for removal of grazers). The samples were incubated at 18 °C in the dark under oxic conditions and were stirred once a day. DOC and its compounds were analyzed before incubation and 36 hours, 60 hours, 8 days and 6 weeks after incubation.

## Results

The results of the hydrological investigations and studies of the geological profile are illustrated in Figures 1 and 2 (S. Gross, personal communication). As demonstrated by the water surface contours in Figure 1, a groundwater divide had developed in the peat adjacent to the SW and NW sections. Because of that water divide the SW and NW compartments were in hydraulic contact with the peat and received an input of subsurface water from the fen (Figure 1). Outside of this water divide lake water of all compartments was flowing from the lake into the surrounding catchment. Differences in the geological profile around the lake are given in Figure 2.

Mean concentrations of DOC and the organic components HS, PS, LMWA and 'other' in the porewater and lake water samples are displayed in Table 2. The porewater of the fen in the dialysis samplers P1 and P2 had higher DOC concentrations with higher amounts of HS (up to 72%, Table 2) than the lake water. Porewater from sampler P2, at a greater distance from the lake, was higher in DOC concentration than porewater from sampler P1 near the lake. Peak concentrations of DOC, HS and PS in the porewater of both samplers were found at a depth of about 10 cm and in the deeper peat layers below 50 cm (Figure 3).

Differences in DOC and its composition between the four compartments are demonstrated in the size-exclusion-chromatograms (Figure 4). These DOC-fingerprints were obtained in February 1998 at a depth of 0.5 m. Samples from east sections (NE and SE) showed the highest peak of the chromatograms in the high molecular weight range (PS) with an average molecular weight of about 6700 g/mol, near the exclusion limit. Samples from the west sections (SW and NW) showed a major DOC-peak at a higher retention time at an average molecular weight of about 3900 g/mol, in the HS range. Quantification of DOC and the different fractions (HS, PS, LMWA and 'other') over the study period from February to August emphasized these differences between the east and west sections of the lake (Table 2). At the

*Table 2.* pH, conductivity, average concentrations of DOC and percentages of DOC′, HS, PS, LMWA and 'other' from total DOC (*R. Koschel, personal communication)

| | pH | conductivity | DOC [mg/L] | DOC′ | HS | PS | LMWA | 'other' |
|---|---|---|---|---|---|---|---|---|
| SW 0.5 | 4.97* | 41* | 11.8 ± 1.7 | 88% | 58% | 16% | 0 | 14% |
| SW 4.0 | 5.35* | 45* | 14.1 ± 3.0 | 89% | 58% | 11% | 5% | 14% |
| NW 0.5 | — | — | 12.0 ± 1.6 | 84% | 45% | 26% | 0 | 13% |
| NE 0.5 | 6.33* | 35* | 12.8 ± 2.0 | 79% | 33% | 35% | 1% | 11% |
| NE 4.0 | 5.82* | 42* | 11.3 ± 1.4 | 87% | 40% | 32% | 2% | 14% |
| SE 0.5 | — | — | 13.0 ± 2.9 | 75% | 35% | 28% | 0 | 11% |
| P1 | 3.60 | — | 24.1 ± 7.8 | 86% | 66% | 7% | 0 | 13% |
| P2 | 3.70 | — | 56.6 ± 32.4 | 87% | 72% | 3% | 4% | 9% |

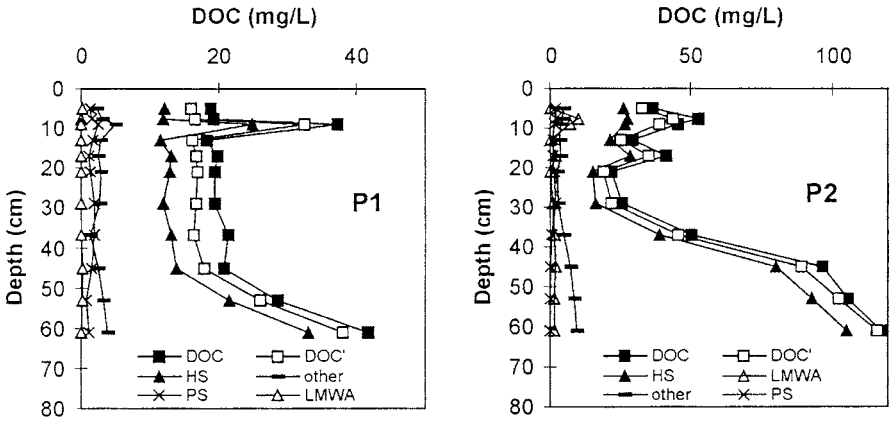


*Figure 3.* Porewater profiles from the oligotrophic acidic fen (P1 and P2).

surface of the four compartments average total DOC concentrations were similar and ranged from about 11 to 13 mg/L (Table 2). However, the proportions of the separate fractions were different in the SW and NW sections with HS as the major component, compared to the NE and SE sections which had high amounts of PS throughout the year (Table 2). DOC concentration was higher at a depth of 4.0 m in the SW section because of higher concentrations of HS and LMWA, whereas in the NE section DOC was higher at the surface. In both compartments concentrations of PS were highest at a depth of 0.5 m.

The HS of the different sampling sites were characterized using their molecular weight and their aromaticities (SAC/DOC ratios, Figure 5). HS in porewater from sampler P1 and from the deeper peat layer of sampler P2

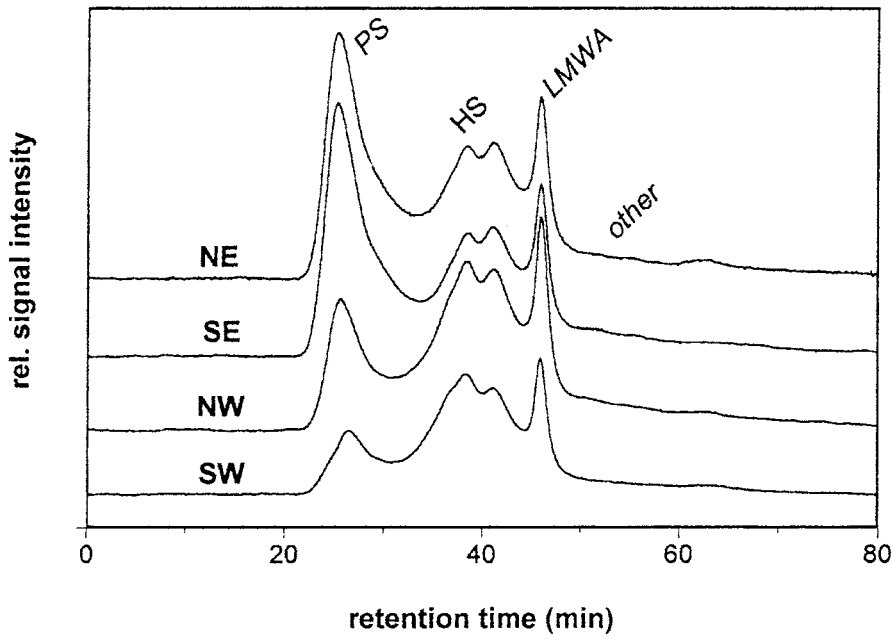


*Figure 4.* Organic carbon chromatograms of the four compartments.

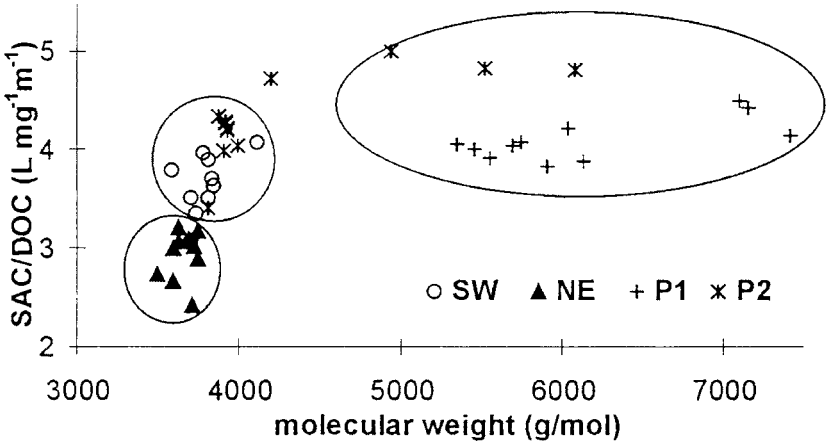


*Figure 5.* Characterization of HS by molecular weight and SAC/DOC ratios (aromaticity).

(> 30 cm) had higher molecular weights compared to the HS in surface water of the four sections. The HS in porewater from sampler P1 between 45 and 60 cm were highest in molecular weight (> 7000 g/mol). HS in the NE section were lower in aromaticity (< 3.5 L $mg^{-1}$ $m^{-1}$), compared to HS in surface water and porewater from the SW compartment (> 3.5 L $mg^{-1}$ $m^{-1}$).

*Table 3.* Microbial degradation of DOC and its compounds

| | Date | DOC′ [mg/L] | HS [mg/L] | PS [mg/L] | 'other' [mg/L] | LWS [mg/L] |
|---|---|---|---|---|---|---|
| SW | 0 h | 11.5 | 7.4 | 2.2 | 1.8 | 0 |
| | 36 h | 11.3 | 7.1 | 1.8 | 2.4 | 0.5 |
| | 60 h | 11.4 | 7.0 | 1.9 | 2.4 | 0.6 |
| | 8 d | 11.9 | 7.4 | 1.8 | 2.6 | 0.7 |
| | 6 w | 10.4 | 7.2 | 1.3 | 1.9 | 0 |
| NE | 0 h | 9.8 | 4.4 | 4.1 | 1.3 | 0 |
| | 36 h | 9.9 | 4.2 | 3.7 | 2.1 | 0.6 |
| | 60 h | 9.9 | 4.2 | 3.6 | 2.1 | 0.5 |
| | 8 d | 9.6 | 4.4 | 3.6 | 1.7 | 0.3 |
| | 6 w | 8.0 | 4.3 | 2.2 | 1.5 | 0 |

Seasonal variations in DOC′ concentration of the surface water of the SW section were mainly caused by increasing concentrations of HS in spring and summer (Figure 6). LMWA were found in very low concentration. In the same section variation of DOC′ was stronger in deep water because of high concentrations of HS and, especially, of LMWA from June to August. Variation was low in the groups PS and 'other' in deep water as well as in surface water. In the NE section the concentrations of HS were nearly constant at both depths. PS were mainly responsible for changes in DOC′ concentration, especially in July and August. LMWA occurred only in February and August at a depth of 4 m. In the SE and NW section both PS and HS, showed seasonal dynamics.

Due to these differences in DOC composition and seasonal variations in the compartments one may expect differences in the microbial degradation of the fractions by heterotrophic bacteria. The chromatograms in Figures 7 and 8 illustrate changes in concentrations of DOC′ and its size fractions during an incubation experiment over a period of six weeks. Chromatograms of both the SW and the NE section indicate an increase in DOC in the low molecular weight range with a new double peak occurring at a retention time of about 60 minutes and a simultaneous decrease in the high molecular weight range after an incubation time of 36 h. After six weeks the LWS fraction had completely disappeared (Table 3, Figures 7 and 8). In both samples HS were characterized by an increase in molecular weights during the whole experiment (Figure 9), whereas the SAC/DOC ratios varied only over a small range.

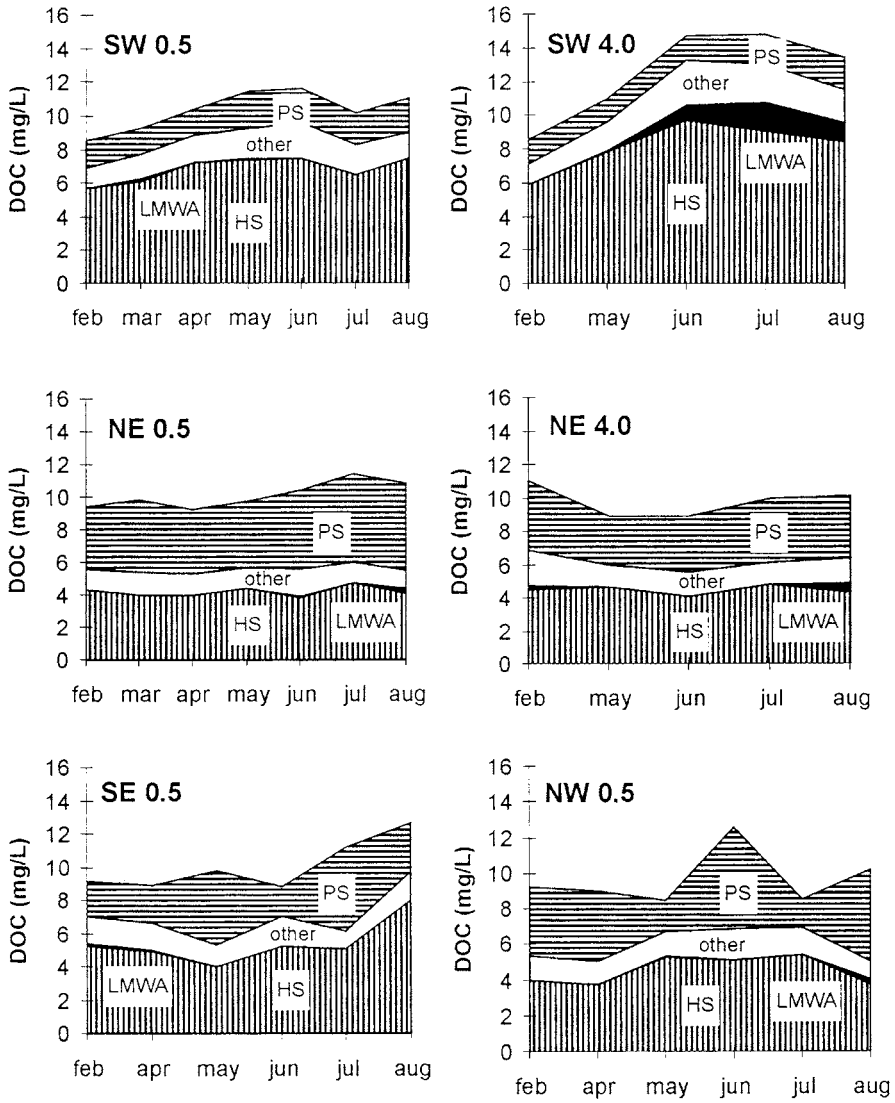


*Figure 6.* DOC dynamics in the four compartments.

## Discussion

The deep profiles of the porewaters demonstrate the influence of the fen on water chemistry as acidic pH values and high DOC and HS concentrations (up to 100 mg/L) within the whole depth profile were found (Table 2, Figure 3). The observed spatial differences in DOC in the depth profile and between the two dialysis samplers are typical of the spatial heterogeneity of peat-

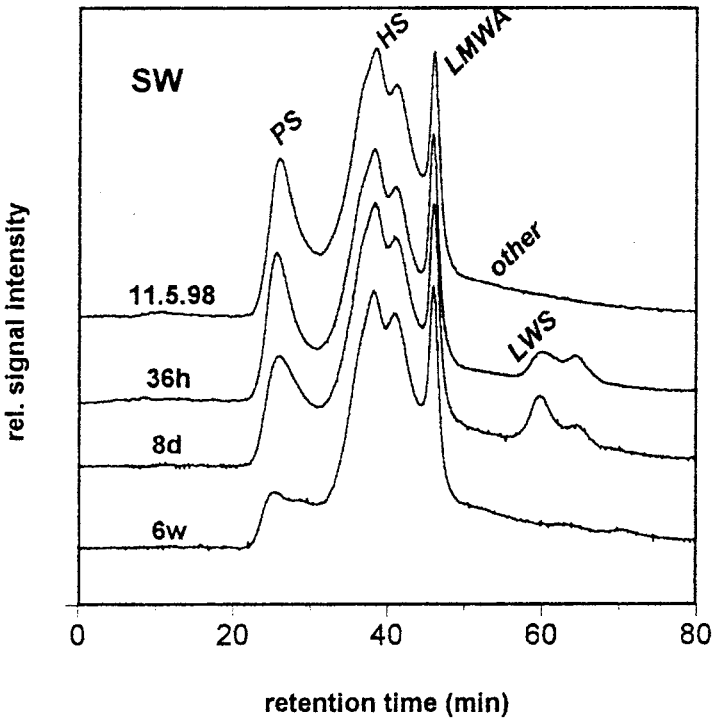


*Figure 7.* DOC chromatograms after different incubation times of 36 hours, 8 days and 6 weeks in the SW section.

lands (Steinmann & Shotyk 1997; Sachse et al. 2000). Hunt et al. (1997) attributed differences in DOC concentration with depth to a combination of factors, such as evapotranspiration, the vigorous microbial community, and the proximity of the reduced saturated zone to the oxidized unsaturated zone. Peak DOC concentrations at a depth of about 10 cm were assumed from high amounts of decomposed plant material and a higher microbial activity.

Although the compartments had similar depths, surfaces and volumes (Table 1) they differed substantially in their DOC characteristics. In the DOC-fingerprints a similarity in DOC composition between the NE and the SE sections was obvious, whereas between the SW and the NW sections differences in the high molecular weight range were found (Figure 4). These differences in DOC composition between the compartments can be explained by hydrological conditions and transformations of organic compounds in the catchment (Figure 1) as well as by DOC degradation and formation in the water column.

The high amounts of HS in the west sections were mainly caused by the hydraulic contact with the fen. The higher degree of aromaticity shows that

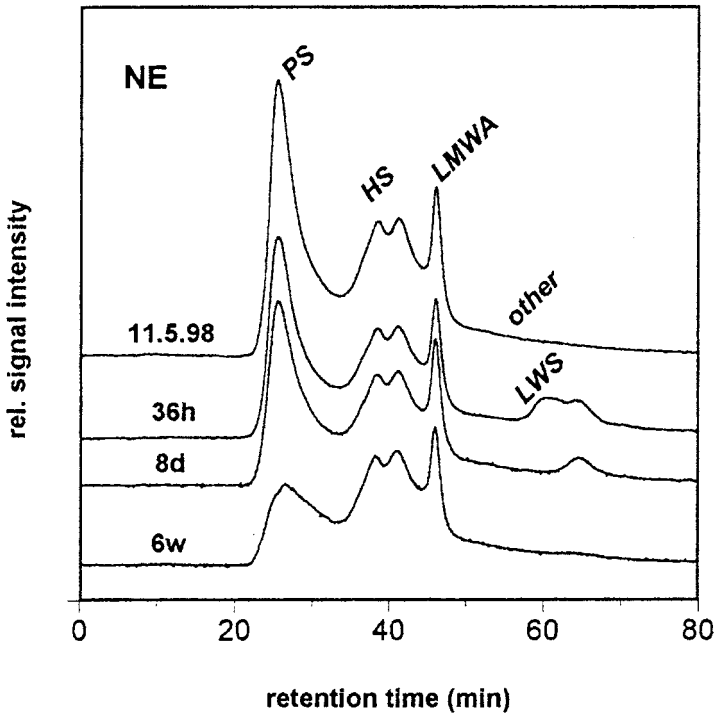


*Figure 8.* DOC chromatograms after different incubation times of 36 hours, 8 days and 6 weeks in the NE section.

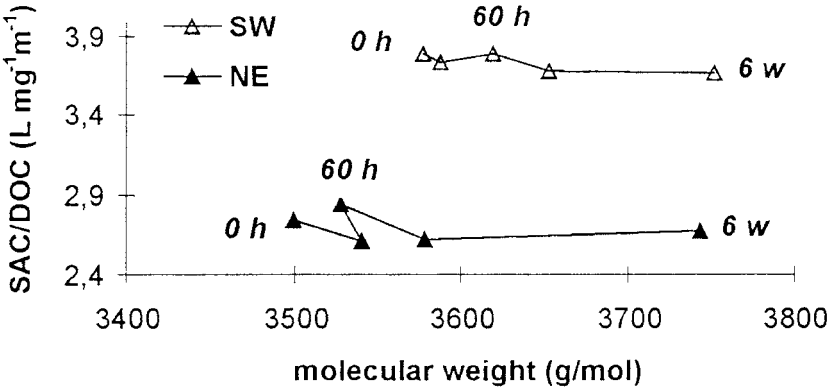


*Figure 9.* Development of HS during incubation.

this fraction was a mixture of aquatic and peat humic substances (Thurman 1985) that were flushed out of the fen (Clair et al. 1996). Higher DOC and HS concentrations at a depth of 4 m may be caused by an incomplete degradation of organic material under anoxic conditions (Cole et al. 1984; d'Angelo & Reddy 1994; Mitsch & Gosselink 1993). Another reason could be a higher DOC concentration of the incoming porewater of the fen, as the depth profile of the fen showed a strong increase in DOC with increasing depth (Figure 3). The east sections receive no water input from the fen. Their DOC originated from rainwater, small water inputs from the west sections and autochthonous sources, resulting in high concentrations of more labile DOC as PS and aquatic HS with lower aromaticities that were probably mainly of autochthonous origin. DOC concentrations were higher at the surface (0.5 m) because of higher concentrations of PS due to higher primary production. Concentrations of HS, LMWA and 'other' were low in variation at both depths. The differences in DOC composition are in agreement with the studies from Bittl (1999) who measured higher primary production, bacterial abundances and nearly doubled bacterial cell production and bacterial biomass production in the NE section in relation to the SW section. Moran and Hodson (1990) also found a clear dependence of bacterial production on quality of DOM, especially on non humic material.

Regarding the molecular weight and the SAC/DOC ratios of the HS in the different water samples, three main groups can be distinguished (Figure 5). HS in the deeper porewater of P2 (> 30 cm) were associated with HS in sampler P1 and form one group at molecular weights above 5000 g/mol and aromaticities above 3.5 L/(mg*m) that originated from the peat. Near the lake, the water saturation prevents a degradation of peat. HS in surface waters of the SW section and in porewater from P2 up to a depth of 30 cm form a second group at lower molecular weights of about 3500 to 4000 g/mol and aromaticities above 3.5 L/(mg*m). If oxic conditions were assumed in the upper part of the fen at a greater distance from the lake, HS were biochemically and microbiologically more decomposed at the surface than in the deeper peat layers with water saturation throughout the year. The NE surface waters form a third group at the same molecular weights but lower aromaticities (below 3.5 L/(mg*m)). HS in the surface waters of the SW and NE sections are assumed to be a mixture of allochthonous HS from the fen, especially in the SW compartment, and biologically and chemically produced autochthonous HS. Kracht and Gleixner (2000) studied humification processes in a *Spagnum* bog and suggested microbial in situ formation of HS, indicated by isotope ratios of pyrolysates from peat and from an adjacent bog lake. The lower aromaticities in the NE section are distinctive features of algal-derived fulvic acids (McKnight et al. 1994). Another reason for the lower molecular

weight of the HS in the surface water compared to the porewater may be an adsorption of high molecular weight HS to sediment particles (Schulten & Leineweber 2000).

Seasonal DOC variations in the sections were apparently caused by two different effects. One was due to an allochthonous component depending on the subsurface flow from the catchment into the lake (Cronan 1990; Kortelainen 1999). This effect was responsible for variation in the HS fraction and was the dominating factor in the SW section especially from April to June. PS and 'other' were more or less constant whereas HS varied for about 10% at a depth of 0.5 m and 16% at 4.0 m. The second was due to an autochthonous component influenced by all organisms in the lake leading to high concentrations of labile DOC compounds as PS and to an autochthonous HS production. It can be assumed that the second factor was mainly responsible for DOC variation in the NE compartment. This hypothesis is supported by the studies by Bittl (1999) of microbial parameters in the four sections from 1994 to 1996. In the NW and SE sections allochthonous and autochthonous factors seem equally to influence the DOC composition and its seasonal variation, although the hydrological investigations demonstrated differences in the interactions with their catchments. PS concentration of about 4 mg/L in the SW section and 2 mg/L in the NE section seem to be a relatively constant proportion of DOC over the study period. Inputs were probably balanced by outputs and only a small fraction of the PS may be variable.

A reason for the accumulation of the LMWA from June to August may be an anaerobic metabolism of organic material due to the anoxic conditions in the lake. LMWA may also originate from the peat or the sediment porewater. Sachse et al. (2000) found an accumulation of LMWA in natural fens and attributed it to a lack of inorganic electron acceptors. In the porewater of the fen, concentrations of nitrate and sulfate were very low (nitrate: 0–0.3 mg/L; sulfate: 0.9–3.6 mg/L; H. Lengsfeld, personal communication). In porewater from the sampler P2, LMWA concentrations up to about 9 mg/L were found.

One may expect that these differences in DOC composition between the SW and NE compartments were reflected in different degradation of the carbon compounds by heterotrophic bacteria. At the end of the incubation experiment, after 6 weeks, DOC′ decreased by 18% in the NE and by 9% in the SW sample. The decrease in PS concentrations were strongest (40% in the SW and 45% in the NE water), whereas HS showed only small variation in concentrations (3% in SW and NE) and a slight increase in molecular weight. In contrast, concentrations of the fraction 'other' increased by 7 and 13%, respectively. This LWS fraction probably consists of small saccharides and amino acids. 0.5 mg/L of LWS were produced in the SW sample and 0.6 mg/L in the NE sample, while concentration of PS decreased by 0.4 mg/L in

the SW and the NE section samples after 36 h. Hence, LWS may be degradation products of the PS or they may be released by hydrolysis from the HS. Photolytic reactions could be excluded because the samples were stored in the dark. After six weeks 1.3 mg/L of the PS in the SW and 2.2 mg/L in the NE section remained, so that carbohydrate material must be rather resistant to degradation.

In conclusion, the DOC in the western sections was mainly characterized by an allochthonous input of HS caused by water input from the adjacent fen, whereas DOC in the eastern compartments was characterized by an autochthonous DOC production resulting in high concentrations and high dynamics of the PS fraction. Differences in DOC characteristics could be explained by hydrological conditions and were in good agreement with microbiological data of previous studies.

## Acknowledgements

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