activity (β-GL) was determined by adding β-glucosido-saligenin as substrate to the moist soil and incubating for 3h at 37°C. Saligenin released from the substrate was determined colourimetrically after colouring with 2,6-dibromchinon-4-chlorimide at 578 nm. The results are given in µg saligenin g^{-1} soil dry mass. Arylsulfatase activity (ARYL) was measured according to Tabatabai & Bremner (1970). After the addition of a p-nitrophenylsulfate solution, soil samples were incubated at 37 °C for 1 h. The p-nitrophenol released was colourimetrically quantified at 420 nm. The results are given as µg phenol g^{-1} soil dry mass.

Results and discussion

Typical soils of the subpolar tundra region (moist to wet mineral soils and peat soils) were investigated which had an easily detectable and visible high degree of crude oil contamination and compared to soils with no detectable contamination (Table 1). The degree of pollution was extremely high by European bioremediation standards (e. g. Germany: 0.5 - 1 mg g^{-1} soil dry mass (e. g. LAGA, 1997). This was already found with the visibly and organoleptically 'uncontaminated' soils (Table 1: soil 2: 0.9 - 1.8, soil 3: 2.8 - 4.3, soil 6: 2.9 mg g^{-1} soil dry mass). In some horizons the oil-derived carbon content was higher than the biogenic and soil-derived carbon (C_{bioorg}), so the ratio between them was <1. This means ecologically that the natural carbon source in the soil is smaller than that from the pollution. This suggest a significant impact on carbon-consuming soil microbiota. In the mineral soils this ratio decreased with increasing oil contamination (Table 1). This was not detectable for the peat soils. The extremely high C_{bioorg}/N_t ratios in the organic layers (O horizons) and peat layers (Oi, Oe horizons) suggest that the oil extraction method used (German H18-method) is not appropriate for quantitative extractions of the mineral oil carbohydrates; this has been a general methodological problem for years (Hüttmann, 1999). However, from the viewpoint of the current paper this is of minor importance because the not-extractable oil components are strongly fixed to the soil matrix and therefore little or probably not bioavailable.

The CFE biomass carbon level (CFE-C_{mic}) was similar to those known from temperate soils in North Germany (Table 2). The CFE-C_{mic} procedure showed no lower levels of microbial biomass for the cold tundra soils, despite the suggestion that the microbial activity would be much lower due to the cold conditions (Schmidt, 1999). The reaction of CFE-C_{mic} with oil was not exactly clear. This means statistically CFE-C_{mic} was not significantly correlated positively or negatively with the oil content. Probably for the microbes it makes no difference where the carbon sources are coming from - if it is natural or pollution-derived carbon. This is in line with the observations of Schmidt (1999), who showed the positive impact of the native soil carbon level (C_{bioorg}) on CFE-C_{mic} in the mineral arctic soils, while Jörgensen et al. (1995) discovered the same pattern for an oil-derived carbon source. Nevertheless, the relative CFE-C_{mic}/C_{bioorg} ratio (percentage of CFE-C_{mic} from C_{bioorg}) and the oil carbon content (Oil-C) showed significant correlations (Huyke, 2001). The CFE-C_{mic}/C_{bioorg} ratio was higher in the upper soil horizons and increased with increasing oil content. Obviously crude oil promotes the microbial biomass, which was also detectable by comparing the data of the peat soils.

On the other hand it might be possible that with the extraction of CFE-C_{mic} oil compounds are also extracted (Jörgensen et al., 1995). Statistically this would cause a "pseudo" correlation between CFE-C_{mic} and Oil-C and of course an overestimation of the microbial biomass values. In addition CFE-C_{mic} did not reflect the commonly known low microbial activity of arctic soils (Schmidt, 1999) in comparison to soils of the temperate climate (Beyer, 1998).

In contrast to the CFE-C_{mic} the SIR-C_{mic} was very low in comparison to data from temperate soils (Table 2). This was surprising with such high C_{bioorg}. Nevertheless a strong correlation between SIR-C_{mic} and C_{bioorg} was detected (r = 0.85).With the commonly used SIR method for the cold and subarctic soils, the microorganisms are probably not able to use the applied glucose as substrate within the methodological time limit of 6 hours, because the microbes are not adapted to the high temperatures in the laboratory. If so, the commonly used procedure for the SIR method would be inappropriate for the investigated cold soils. The application of another substrate to glucose should be preferred, as Hüttmann (1999) has proposed for diesel-contaminated soils, and the incubation should be modified with a longer time period. However, in comparison to soils of temperate climates SIR-C_{mic} showed a significantly lower level of the microbial biomass. This was not found with the CFE-C_{mic} data. For this reason SIR-C_{mic} reflects reality in a better way than CFE-C_{mic} does. However, for the CFE-C_{mic} one has to keep in mind the possible extraction errors, which would induce the already discussed overestimation of the microbial biomass. In every case the results suggest that quantitative data are not available from either of the microbial biomass