

Microbial activity measurements for a soil quality assessment of highly crude oil contaminated soils in the Russian tundra at the Arctic Circle

Lothar Beyer¹, Wiebke Huyke¹, Stephan Hüttmann², Inna Archegova³ and Tatiana V. Titarenko⁴

¹ Institute of Polar Ecology, University of Kiel, Wischhofstraße 1-3, Building 12, D-24148 Kiel, Germany, Email: lbeyer@ipoe.uni-kiel.de, *current postal address*: Soil Science Germany, International Soil Consultancy, Hinter dem Klosterhof 8, D-25524 Itzehoe, Germany

² Groth & Co. (GmbH & Co.), Environmental Technology and Consult Section, Feldmannstraße 1, D-25524 Itzehoe, Germany,

³ Institute of Biology, Komi Scientific Center, Ural Branch of the Russian Academy of Sciences, 167610 Russia, Komi Republic, Syktyvkar, Kommunisticheskaya St. 28

⁴ KomiArcticOil JSC, Vozeyskaya St. 21-A, Usinsk, 169706, Komi Republic, Russia

ABSTRACT. Crude oil-polluted and non-polluted soils of the subpolar tundra region were investigated with commonly used enzymatic activity tests and microbial biomass determinations (microbial basal respiration, substrate-induced biomass-C and chloroform-fumigation biomass-C, arginine ammonification, dehydrogenase, β -glucosidase and arylsulfatase activities). The purpose was to obtain information about the suitability of the tested methods to characterize the microbial soil conditions affected by oil pollution and/or cold environmental soil conditions. Recommendations for the application of the methods for investigation of selected soil microbial activity in cold climates are given. Detailed information on soil minerals, organics, texture etc., the degree of oil pollution, the age of the contamination and suitability of the microbial activity methods themselves are required for an interpretation. We urgently recommend (I) to test the method for its suitability before any data collection in series and (II) the general application of ecophysiological ratios between two parameters instead of single parameters.

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Introduction

The Upper Vozey oil field in the subpolar region of the Komi Republic close to the Arctic Circle has one of the most prominent oil resources in Russia west of the Ural mountains. Defective pipeline systems and obsolete oil extraction techniques during the Soviet era have produced extensive oil pollution: up to 30% crude oil in the soil and oil lakes on the soil surface everywhere. It is proposed that the contamination be removed, the soils remediated and the sites be recultivated. In order to control the efficiency of these treatments selected environmental indicators must be applied to characterize soil quality (Ad-hoc-Arbeitsgruppe, 1995; Pankhurst et al., 1998). In the first period commonly used enzymatic activity tests and microbial biomass determinations (Alef, 1991; Schinner et al., 1996) were tested for their effectiveness in characterizing the microbial conditions in soils affected by oil pollution as well as under cold environmental conditions.

Methods

The soil survey and soil description was carried out according to the US Soil Taxonomy (Soil Survey Staff, 1998). Most non-biological methods are described in detail in Schlichting et al. (1995). Dry mass was determined gravimetrically after burning the oven-dried (105°C) soil sample at 600°C for 24 h. Total organic carbon (TOC) was calculated by measuring the evolved CO₂ after dry combustion. Crude oil was measured after extraction with 1,1,2-trichlorotrifluoroethane using an IR spectroscope (Hüttmann, 1999). Crude oil carbon (Oil-C) was estimated as follows: Crude oil $\times$ 0.86 [(CH₂)_n]. The biogenic organic carbon (C_{bioorg}) was defined as TOC - Oil-C. Total nitrogen (N_t) was measured by Kjeldahl extraction in a flow injection analyzer (Jones, 1991). The pH value was measured in 0.02 N CaCl₂.

The CFE-microbial biomass-C (CFE-C_{mic}) was determined by the chloroform-fumigation-extraction (CFE) procedure according to Vance et al. (1987). After soil fumigation with chloroform for 24h, carbon was extracted from the soil with 0.5 M K₂SO₄ and determined after dry combustion (see TOC determination). The extracted carbon was converted into biomass carbon with the k_{EC} factor 0.37. The SIR-microbial biomass-C (SIR-C_{mic}) was indirectly determined by substrate induced