Assessing Microbial Quality of Polluted Marine and Soil Sediments with Advanced in Situ Monitoring Tools

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Introduction: The assessment of sediment quality usually focuses on pollution and the microbial performance for contaminant degradation. However, in polluted sediments the proof and quantification of microbial purification is a challenging task, particularly within the frame of remediation technologies. Here, we present four *in situ* tools to characterize the microbial quality of marine and soil sediments with a special focus on the attenuation of polyaromatic and aliphatic carbohydrates (PAH, AH): Isotope-labeled *in situ* microcosms (BACTRAPS, MYCOTRAPS), diagnostic ratios of pollutants, phospholipid patterns (PLFA), and metabolite analysis. These methods are applied to develop and control innovative remediation technologies for a coastal sediment (EU-LIFE project SEDREMED) and for several soil types (EU-LIFE project MySoil).

Fig. 1: Variations of *in situ* microcosm cages containing carrier materials for ^{13}C-labeled pollutants.

Methods: BACTRAPS and MYCOTRAPS are *in situ* microcosms newly developed for the trapping of pollutant-degrading bacteria in a marine sediment from Bagnoli (Italy) and of pollutant-degrading fungi in various contaminated soil types, respectively. According to different environments, specific cages (teflon, stainless steel) were designed (Fig. 1) containing carrier materials (active coal, sediment) loaded with a ^{13}C- or ^{2}H-labeled pollutant (phenanthrene, naphthalene, acenaphthene, hexadecane). The TRAPS were exposed in pilot mesocosms or in real sediments for several weeks. Retrieved *in situ* microcosms were analyzed for specific biomolecules (PLFA, amino acids) in order to record the colonizing microbial community. In addition, ^{13}C- and ^{2}H-isotope values of biomolecules were determined showing up semi-quantitative evidence for natural or enhanced attenuation of target pollutants.
Further monitoring tools provided a differentiated characterization and thereby a multi-line of evidence of degradation processes. For instance, GC-MS fingerprinting for specific diagnostic ratios of contaminants delivered the stage of chemical and biological weathering, while determination of certain metabolites indicated actual pathways of PAH degradation. The amount of bacteria as well as the amount of fungi could be estimated by analysis of amino acid and PLFA patterns, respectively.

Results: The applied monitoring tools provided a clear picture of variable microbial degradation activity in marine as well as in soil sediments. Due to different features (target compounds, validity, sensitivity, precision, duration, expenditure, workload) the combination of these methods delivered an effective proof and understanding of microbial processes, which are highly relevant for sediment management.

Discussion: In a nutshell, a suitable toolbox of methods is available to assess the microbial activity in polluted sediments. It can be adapted according to sediment conditions (marine, soil, aquifer) and contamination patterns. Investigations like that will deliver key information on the necessity and also the success of remediation strategies (e.g. dredging vs. monitored natural attenuation vs. *in situ* treatment). Therefore, they are highly recommended for the assessment of sediment quality.