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Volatile Fatty Acids in Arctic Sediments

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In temperate environments, microbial activity decreases substantially during the cold season. However, in permanently cold sediments of Svalbard remineralization rates are comparable to those found in warmer environments [Arnosti et al., 1998]. Heterotrophic microbial processes in water samples from Newfoundland were reported to require elevated substrate concentrations with decreasing temperature. It was suggested that a lower substrate affinity of bacteria at low temperatures is responsible for the diminished bacterial activity [Pomeroy et al., 1991]. Therefore, considering comparable sulphate reduction rates at permanently cold and temperate sites, diminished substrate affinity would have to be accompanied by higher substrate concentrations. Volatile fatty acids (VFA) are important substrates for sulfate-reducing bacteria. Up to 90% of the sulfate reduction in temperate marine sediments is fueled by VFA, with acetate being the most important [Parkes et al., 1989]. At the moment, values for substrate affinities of psychrophilic bacteria to VFA and threshold concentrations are not known, however, threshold concentrations found for mesophilic sulfate reducers in culture experiments are <15µM for acetate [Oude Elferink et al., 1998].

Homogenized sediment from the anoxic layer (2-9 cm) from Kongs Fjord in Svalbard was incubated in bags at three different temperatures (-1, 15 and 25 C) and porewater VFA concentrations were determined. Concentrations of most acids increased after the first mixing and reached a maximum after 30 to 130 hours. Acetate concentrations were highest in all samples and the maximum concentration increased with increasing incubation temperature. After about 180 hours the concentrations reached almost constant values. These equilibrium concentrations were similar at all three temperatures (Acetate 3-8µM). Additionally, porewater concentrations of VFA in sediment cores from several fjords in Svalbard were measured. The VFA profiles were compared with profiles of suphfate reduction rate measurements. Acetate concentrations were highest among measured VFA with values below 15µM in most samples. However, in some distinct peaks acetate, lactate, and propionate showed considerably higher concentrations. Highest concentrations were 640, 88, and 73µM for acetate, propionate, and lactate, respectively. Profiles from three cores from Magdalenen Fjord were highly variable in shape and concentration. Whereas, in two profiles the concentrations of acetate were below 15µM, the highest acetate concentration of 640µM was measured in the third.

Equilibrium concentrations of VFA in homogenized sediments of Svalbard were in the same range as in temperate environments and concentrations did not vary with incubation temperature. VFA show a very heterogeneous horizontal distribution in Svalbard sediments. The comparison of the sulphate reduction rate profiles and the VFA profiles showed no dependency of these two parameters. Acetate concentrations in these arctic sediments are similar to the threshold concentrations found for mesophilic bacteria in culture experiments. Hence, our data show no evidence for a diminished substrate affinity of sulphate-reducing bacteria in these permanently cold sediments.

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