Co-existence of methanogenesis and sulfate reduction with common substrates in sulfate-rich estuarine sediments

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The competition between sulfate reducing bacteria and methanogens over common substrates has been proposed as a critical control for methane production. In this study, we examined the co-existence of methanogenesis and sulfate reduction with shared substrates over a large range of sulfate concentrations and rates of sulfate reduction in estuarine systems, where these processes are the key terminal sink for organic carbon. Incubation experiments were carried out with sediment samples from the sulfate-methane transition zone of the Yarqon (Israel) estuary with different substrates and inhibitors along a sulfate concentrations gradient from 1 to 10 mM. The results show that methanogenesis and sulfate reduction can co-exist while the microbes share substrates over the tested range of sulfate concentrations and at sulfate reduction rates up to 680 µmol L^{-1} day^{-1}. Rates of methanogenesis were two orders of magnitude lower than rates of sulfate reduction in incubations with acetate and lactate, suggesting a higher affinity of sulfate reducing bacteria for the available substrates. The co-existence of both processes was also confirmed by the isotopic signatures of $\delta^{34}S$ in the residual sulfate and that of $\delta^{13}C$ of methane and dissolved inorganic carbon. Copy numbers of *dsrA* and *mcrA* genes supported the dominance of sulfate reduction over methanogenesis, while showing also the ability of methanogens to grow under high sulfate concentration and in the presence of active sulfate reduction.