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How Infauna Metabolism and Burrow Water Irrigation Affect Early Diagenesis in Burrowed Aquatic Sediments: A Simulation Study Using Dynamic Bio-Irrigation Model

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Benthic infauna strongly affect the chemical mass transfer regime in coastal and estuarine sediments through (1) active participation in organic carbon re-mineralisation processes, and (2) transport of dissolved oxygen to deeper parts of the sediments. Our study quantitatively demonstrates the importance of burrow flushing frequencies, infaunal metabolism, and deep introduction of dissolved oxygen in determining the spatial and temporal distribution of diagenetically important solute species, SO_4^{2-} and NH_4^+, through the simultaneous execution of numerical simulations and laboratory mesocosm experiments. The numerical model calculates the spatial distribution of a given solute species using vertical diffusion perpendicular to the water-sediment interface, radial diffusion perpendicular to the burrow walls, and production/consumption reaction rates (Aller, 1980). The model parameters newly taken into account include the depth-dependent distribution of burrows and burrow flushing frequencies. The model also considers the periodic, time-dependent fluctuation of NH_4^+ concentration in burrow water due to infaunal excretion, as well as the spatially heterogeneous aerobic re-oxidation of reduced sulphur species in the vicinity of burrow walls. The laboratory mesocosm experiments, which utilised a fine-grained siliciclastic sediment substrate and the mud-dwelling acorn worm *Schizocardium sp.*, provided all geochemical and physical parameters necessary to properly constrain the model. The well-constrained model allowed us to conduct simulations with no adjustable parameters. The results quantitatively show that the spatial distribution of NH_4^+ is strongly influenced by the macrofauna metabolism and cannot be determined by the traditional approach of transport and microbial reactions alone. This result implies that macrofauna metabolism is quantitatively significant in the mass balance of not only the metabolite reactions but also the organic carbon re-mineralisation. The simulation results also indicate that the spatial distribution of SO_4^{2-} is strongly influenced by the deep introduction of O_2 and subsequent aerobic re-oxidation of reduced sulphur species in the vicinity of burrows.

Aller RC, *Geochim. Cosmochim. Acta*, **44**, 1955-1965, (1980).