**ABSTRACT**

The ocean, and by extension the ocean floor, covers 71% of our planet. Microorganisms make up 90% of the ocean's total biomass. These microorganisms drive the major biogeochemical cycles that allow life to exist both in and out of the ocean. Sediments are generally considered sinks of N\(_2\)O, a greenhouse gas. However, recent investigations provide evidence that under changing environmental conditions, N\(_2\)O production significantly increases and the ocean floor becomes a source of N\(_2\)O. At the USC Wrigley Institute on Catalina Island we use special aquaria and flow boxes to perform detailed studies using a suite of microsensors (O\(_2\), N\(_2\)O). We are able to simulate in-situ conditions (light, water current, tidal flushing, decreased O\(_2\)), nutrient loading and perform investigations on the dynamics of the benthic nitrogen cycle with a focus on N\(_2\)O production and fluxes. We specifically examined the effect of bioturbation (the burrowing activity of benthic invertebrates, including the 'ghost shrimp', N. californiensis), the role of subsurface phototrophic organisms in the production of N\(_2\)O and the subsequent release of N\(_2\)O to the atmosphere. We observed N\(_2\)O production in the walls of active ghost shrimp burrows, which can be explained by deeper oxygen penetration into the sediment. Ghost shrimp allow zones of aerobic respiration and denitrification in otherwise anoxic areas. Results also show N\(_2\)O production in sediment surface photosynthetic mats. In addition, subsurface N\(_2\)O production increased with higher N\(_2\)O concentrations. Thus, dynamic interstitial sediment may play a larger role in N\(_2\)O production than previously thought.

**INTRODUCTION**

N\(_2\)O, a greenhouse gas with a warming potential 310 times that of CO\(_2\) [1], has been increasing in the atmosphere by 0.6 ppb/year [2]. It is not clear whether sediments are a sink or source of N\(_2\)O. Within the nitrogen cycle, the two main pathways of N\(_2\)O production are believed to be nitrification and denitrification (Fig. 1).

**RESULTS**

N\(_2\)O Production in a Newly Formed Ghost Shrimp Burrow Wall

Analysis of a new (42 days old) burrow revealed enhanced N\(_2\)O production over time inoxic burrow walls, suggesting the burrow walls increase zones of nitrification (Fig. 5).

N\(_2\)O Production in Well Established Subsurface Burrow Walls

N\(_2\)O production between 0.4 and 1.7 μM was consistently observed in oxic macrofauna burrow walls, suggesting enhanced nitrification as the primary source of N\(_2\)O production (Figs. 6 A, B, C). These burrow walls were first established approximately 3 months prior to profiling. Similar N\(_2\)O production was also measured in meiobenthic burrow walls (Figs. 6 D).

**CONCLUSIONS**

Bioturbation/nitrification on different scales—from macrofauna to meiofauna—createsoxic zones in otherwise anoxic sediment layer, enhancing oxidation processes and aerobic respiration. Our data shows that increased nitrification in burrow walls leads to N\(_2\)O production and the diffusive flux of N\(_2\)O into the burrow and consequently into the overlying water and atmosphere.

Using Fick's First Law (J = D * c \text{d}x/v, where D is the diffusion coefficient of N\(_2\)O, is 2.1×10\(^{-5}\) cm\(^2\)/s [9]), we calculated a simple diffusive flux from the burrow walls to the atmosphere based on the N\(_2\)O concentration profiles measured as shown in Figs. 6 C, D. The diffusive flux was found to be 5.43×10\(^{-3}\) mol m\(^{-2}\) m\(^{-1}\) day\(^{-1}\).

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