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Methane sources and sinks in karst systems: The Nerja cave and its vadose environment (Spain)

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Abstract

Karst caves are considered a natural sink of atmospheric methane (CH_4). Studies generally focus on measuring CH_4 within the cave environment, and little information is available about the factors influencing CH_4 abundance, such as the surrounding vadose and saturated zones of the aquifer, inputs of carbon dioxide (CO_2) – a potential precursor of CH_4 – and methanotrophic bacteria, which is likely the main cause of CH_4 consumption. In this paper we report the first study of CH_4 budget in Nerja, one of the main karst caves in Spain, based on seasonal monitoring of CH_4 and CO_2 concentration and stable C isotopic ratio in the cave system, integrated with analogue data from the underlying and overlying saturated/vadose zone, and methanotrophic bacteria activity (rDNA and Polymerase Chain Reaction analyses) in cave sediments and water. The results show that the cave environment consumes, via methanotrophic activity and through γ- and α–Proteobacteria, CH_4 coming from both the atmosphere and the vadose/saturated zones of the aquifer, where it is produced microbially. However, vadose zone methanogenesis may seasonally exceed the methanotrophy capacity of the cave, resulting in a net CH_4 increase in it. This competition process may be an important factor limiting the sink potential of karst caves.

Keywords: Cave; Methane; Greenhouse gas; Methanotrophy; Methanogenesis; Karst

1. INTRODUCTION

Subterranean air in karst cavities is typically characterized by sub-atmospheric concentrations of methane ($CH_4 < 1.9$ ppmv) due to methanotrophic consumption by bacteria and given their connection with the atmosphere, karst systems have been considered a sink of atmospheric methane (e.g., Mattey et al., 2013; Webster et al. 2018 and references therein). However, the lack of a sufficiently

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