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The emission of volatile halocarbons by seaweeds and their response towards environmental changes

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Abstract

Volatile halocarbons can deplete the protective stratospheric ozone layer contributing to global climate change and may even affect local climate through aerosol production. These compounds are produced through anthropogenic and biogenic processes. Biogenic halocarbons may be produced as defence compounds, anti-oxidants or by-products of metabolic processes. These compounds include very short-lived halocarbons (VSLH), e.g. bromoform ($CHBr_3$), dibromomethane (CH_2Br_2), methyl iodide (CH_3I), diiodomethane (CH_2I_2). Efforts to quantify the biogenic sources of these compounds, especially those of marine origin, e.g. seaweeds, phytoplankton and seagrass meadows, are often complicated by inherent biological variability as well as spatial and temporal changes in emissions. The contribution of the coastal region and the oceans to the stratospheric load of halocarbons has been widely debated. This highlights the need to understand the factors affecting the release of these compounds from marine sources for which data for modelling purposes are generally lacking. Seaweeds are important sources of biogenic halocarbons subjected to changing environmental conditions. Huge uncertainties in the prediction of current and future global halocarbon pool exist due to the lack of spatial and temporal data input from coastal and oceanic sources. Therefore, investigating the effect of changing environmental conditions on the emission of VSLH by the seaweeds could help towards better estimations of halocarbon emissions. This is especially important in light of global changes in both climate and the environment, the expansion of seaweed cultivation industry and the interactions between halocarbon emission and their environment. In this paper, we review current knowledge of seaweed halocarbon emissions, how environmental factors affect these emissions and identify gaps in understanding. Our aim is to direct much needed research to improve understanding of the contribution of marine biogenic sources of halocarbons and their impact on the environment.

Keywords Halocarbons · Bromoform · Air-Sea gas exchange · Climate change · Environmental change · Seaweed

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Introduction

Research on biogenic very short-lived brominated compounds (e.g. $CHBr_3$, CH_2Br_2) resurfaced in recent years (Ziska et al. 2013; Liang et al. 2014; Hossaini et al. 2016) due to knowledge of the increasingly significant contribution of very short-lived halocarbons (VSLH) to the tropospheric and stratospheric bromine load, which can potentially alter ozone abundance and radiative impact (Stemmler et al. 2015; WMO 2018). Global ocean fluxes of $CHBr_3$ and CH_2Br_2 range between 120–820 and 57–100 Gg Br $year^{-1}$, while CH_3I ranges between 157 and 550 Gg I $year^{-1}$ (WMO 2018). The phytoplankton and cyanobacteria emit majority of the CH_3I from the ocean (Yokouchi et al 2008; Saiz-Lopez et al. 2011; WMO 2018). Short atmospheric lifetime of some of these compounds means that they can only reach the lower stratosphere through rapid convective uplifting, particularly from the

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