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Halocarbon emissions by selected tropical seaweeds exposed to different temperatures

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ABSTRACT

Four tropical seaweeds, *Gracilaria manilaensis* Yamamoto & Trono, *Ulva reticulata* Forsskål, *Kappaphycus alvarezii* (Doty) L.M.Liao and *Turbinaria conoides* (J.Agardh) Kützing, collected from various habitats throughout Malaysia, were subjected to temperatures of 40, 35, 30, 25 and 20 °C in the laboratory. An exposure range of 21–38 °C is reported for Malaysian waters. The effect of the temperature exposures on the halocarbon emissions of the seaweeds were determined 4 and 28 h after treatment. The emission rates for a suite of six halocarbons commonly emitted by seaweeds, bromoform ($CHBr_3$), dibromomethane (CH_2Br_2), diiodomethane (CH_2I_2), iodomethane (CH_3I), dibromochloromethane ($CHBr_2Cl$) and dichlorobromomethane ($CHBrCl_2$), were measured using a cryogenic purge-and-trap sample preparation system coupled to a gas chromatography–mass spectrometry. The emission rate of $CHBr_3$ was the highest of the six halocarbons for all the seaweeds under all the temperatures tested, followed by CH_2Br_2, and CH_2I_2. The emission rates were affected by temperature change and exposure duration, but overall responses were unique to each seaweed species. Larger decreases in the emissions of $CHBr_3$, CH_2Br_2, CH_2I_2 and $CHBr_2Cl$ were found for *K. alvarezii* and *T. conoides* after 4 h at 40 °C. In both cases there was a >90% ($p < 0.05$) reduction in the F_v/F_m value suggesting that photosynthetic actitivity was severely compromised. After a 28 h exposure period, strong negative correlations ($r = -0.69$ to -0.95; $p < 0.01$) were observed between temperature and the emission of $CHBr_3$, CH_2Br_2 and CH_2I_2 for *U. reticulata, K. alvarezii* and *T. conoides.* This suggests a potential decrease in the halocarbon emissions from these tropical seaweeds, especially where the temperature increase is a prolonged event. Strong correlations were also seen between seaweed chlorophyll and carotenoid pigment contents and the emission rates for $CHBr_3$, CH_2Br_2 and CH_2I_2 ($r = 0.48$ to 0.96 and -0.49 to -0.96; $p < 0.05$). These results suggest that the regulation of halocarbon production versus reactive oxygen species production in seaweeds is an area worthy of further exploration.

1. Introduction

Seaweeds are an important source of revenue in the tropics and especially within the Coral Triangle. The latest UN FAO statistics show an increase in seaweed cultivation with a three-fold increase in global production from 10.6 million tonnes in 2000 to 32.4 million tonnes in 2018 (FAO, 2020). Whilst economically important, seaweeds are also responsible for the emission of trace gases, including short-lived volatile halocarbons (Keng et al., 2013; Leedham et al., 2013; Mithoo-Singh et al., 2017; WMO, 2018), which are often implicated in affecting the tropospheric oxidizing capacity, contributing to stratospheric ozone loss and cloud nuclei formation, affecting radiative forcing and local climate (Read et al., 2008; Carpenter et al., 2013; Hossaini et al., 2016; Willis et al., 2016). Reactive bromine constituted around 5 (3–7) ppt, or 25%, of the total stratosphere bromine recorded in 2016, with a large contribution from oceanic sources such as seaweeds, especially from emissions in the tropics (Ziska et al., 2013; WMO 2018). Iodine occurs in the shortest-lived gases and is thought to mostly influence tropospheric

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