Halocarbon emissions by selected tropical seaweeds: species-specific and compound-specific responses under changing pH

Paramjeet Kaur Mithoo-Singh[1,2,*], Fiona S.-L. Keng[1,3,*], Siew-Moi Phang[1,2,*], Emma C. Leedham Elvidge[4], William T. Sturges[4], Gill Malin[4] and Noorsaadah Abd Rahman[5]

[1] Institute of Ocean and Earth Sciences (IOES), University of Malaya, Kuala Lumpur, Malaysia
[2] Institute of Biological Sciences, Faculty of Science, University of Malaya, Kuala Lumpur, Malaysia
[3] Institute of Graduate Studies (IGS), University of Malaya, Kuala Lumpur, Malaysia
[4] Centre for Ocean and Atmospheric Sciences, School of Environmental Sciences, University of East Anglia, Norwich Research Park, Norwich, United Kingdom
[5] Department of Chemistry, University of Malaya, Kuala Lumpur, Malaysia
[*] These authors contributed equally to this work.

ABSTRACT

Five tropical seaweeds, *Kappaphycus alvarezii* (Doty) Doty ex P.C. Silva, *Padina australis* Hauck, *Sargassum binderi* Sonder ex J. Agardh (syn. *S. aquifolium* (Turner) C. Agardh), *Sargassum siliquosum* J. Agardh and *Turbinaria conoides* (J. Agardh) Kützing, were incubated in seawater of pH 8.0, 7.8 (ambient), 7.6, 7.4 and 7.2, to study the effects of changing seawater pH on halocarbon emissions. Eight halocarbon species known to be emitted by seaweeds were investigated: bromoform ($CHBr_3$), dibromomethane (CH_2Br_2), iodomethane (CH_3I), diiodomethane (CH_2I_2), bromoiodomethane (CH_2BrI), bromochloromethane (CH_2BrCl), bromodichloromethane ($CHBrCl_2$), and dibromochloromethane ($CHBr_2Cl$). These very short-lived halocarbon gases are believed to contribute to stratospheric halogen concentrations if released in the tropics. It was observed that the seaweeds emit all eight halocarbons assayed, with the exception of *K. alvarezii* and *S. binderi* for CH_2I_2 and CH_3I respectively, which were not measurable at the achievable limit of detection. The effect of pH on halocarbon emission by the seaweeds was shown to be species-specific and compound specific. The highest percentage changes in emissions for the halocarbons of interest were observed at the lower pH levels of 7.2 and 7.4 especially in *Padina australis* and *Sargassum* spp., showing that lower seawater pH causes elevated emissions of some halocarbon compounds. In general the seaweed least affected by pH change in terms of types of halocarbon emission, was *P. australis*. The commercially farmed seaweed *K. alvarezii* was very sensitive to pH change as shown by the high increases in most of the compounds in all pH levels relative to ambient. In terms of percentage decrease in maximum quantum yield of photosynthesis (F_v/F_m) prior to and after incubation, there were no significant correlations with the various pH levels tested for all seaweeds. The correlation between percentage decrease in the maximum quantum yield of photosynthesis (F_v/F_m) and halocarbon emission rates, was significant only for CH_2BrCl emission by *P. australis* ($r = 0.47$; $p \leq 0.04$), implying that photosynthesis may not be closely linked to halocarbon emissions by the seaweeds studied. Bromine was the largest contributor to the total mass of halogen emitted for all the seaweeds

Submitted 23 August 2016
Accepted 17 December 2016
Published 25 January 2017

Corresponding author
Siew-Moi Phang, phang@um.edu.my

Academic editor
Ronaldo Francini-Filho

Additional Information and Declarations can be found on page 16

DOI **10.7717/peerj.2918**