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The impact of eutrophication towards selected bacterial process rates in tropical coastal waters

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ABSTRACT

The dissolved organic nutrient conditions and bacterial process rates at two tropical coastal sites in Peninsular Malaysia (Port Klang and Port Dickson) were initially studied in 2004–2005 period and later revisited in 2010–2011. We observed that dissolved organic nitrogen (DON) increased about two- and ten-fold at Port Klang and Port Dickson, respectively and resulted in a significant change in DOC:DON ratio ($t \geq 2.077$, $p < 0.05$). Among the bacterial processes measured, bacterial respiration (BR) was lower in the 2010–2011 period at both stations ($t \geq 3.390$, $p < 0.01$). BR also correlated to the DOC:DON ratio ($R^2 \geq 0.259$, $p < 0.01$). The increase in substrate quality enabled the bacteria to respire less in the dissolved organic matter degradation. As a result, the average bacterial growth efficiency increased slightly in the 2010–2011 period.

1. Introduction

Primary production and decomposition of dissolved organic matter by heterotrophic bacteria are the two most important biological processes that sustain the marine food web (Azam et al., 1983; Armengol et al., 2019). Bacterial growth is associated with the microbial loop where bacterial utilisation of dissolved organic matter forms a shunt back to the food web (Azam et al., 1983; Wang, 2018). Relative to primary producers, bacteria have a larger surface area to volume ratio, and thus are generally more efficient at scavenging available nutrient to sustain their growth (Caston et al., 2009; Harris and Theriot, 2018). This could be a reason to the development of net-heterotrophy across different habitats around the world (Hutchins and Fu, 2017) along with other factors (e.g. warming and eutrophication) that could have also contributed (Lee et al., 2009).

Bacterial production (BP) and bacterial respiration (BR) are two of the main pathways involved in the bacterial growth process (del Giorgio and Cole, 1998). BP refers to the production of new biomass whereas BR is linked to the maintenance of the intra-cellular metabolism of bacteria. Although both BP and BR are linked to the heterotrophic process, they respond differently to different environmental variables, and thus could have contributed differently to total bacterial metabolism (Ram et al., 2003; Pollard and Ducklow, 2011). The common drivers for both BP and BR are temperature, freshwater input, substrate concentration, substrate quality as reflected by dissolved organic carbon: dissolved organic nitrogen (DOC:DON) ratio, grazing by protozoa and viral lysis (del Giorgio and Cole, 1998; Ram et al., 2003; Apple and del Giorgio, 2007; Lee et al., 2009; Pollard and Ducklow, 2011). Although it is difficult to ascertain which factor is more important, Lee et al. (2009) have found that BP increases with net primary productivity, whereas BR increases with temperature and DOC:DON ratio.

Excessive nutrient input or increasing eutrophication is a common issue for many coastal habitats, and one of the ways to evaluate it is through extensive monitoring for an extended period of time (e.g. more than 5 years). Long-term trends in nutrient concentration could reveal associations with bacterial processes that are otherwise not observable from a shorter sampling period (Sutton et al., 2017; Watanabe and Wakita, 2018). For example, BP decreased over a span of 24 years at Sargasso Sea due to a change in the flow of organic carbon through the food web and the partitioning of dissolved and particulate phases (Lomas et al., 2013) or the constant BP over 10 years at the Bermuda Atlantic Ocean (Steinberg et al., 2001). In contrast, BR measurements remained relatively scarce due to the complexity of the experimental technique (del Giorgio and Cole, 1998; del Giorgio and Duarte, 2002). As a result, most of the available publications on BR are from modelling or extrapolated from short-term sampling periods (del Giorgio and

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