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Coastal micro-phytoplankton community changes during the toxigenic *Alexandrium minutum* blooms in a semi-enclosed tropical coastal lagoon (Malaysia, South China Sea)

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ABSTRACT

Estuarine lagoons often experience eutrophication due to anthropogenic activities in proximity and poor water exchange. Deterioration of water quality in the lagoon has driven the shifts in micro-phytoplankton communities that often form coastal harmful algal blooms (HABs). This study investigated changes in the micro-phytoplankton community in a tropical semi-enclosed lagoon, Geting Lagoon, for two consecutive years during the study periods of 2014/2015 (September 2014–March 2015) and 2015/2016 (August 2015–March 2016). A total of 38 phytoplankton taxa were identified throughout the sampling periods, with 17 taxa of harmful algae identified microscopically. The diatoms *Skeletonema costatum* and *Chaetoceros* were predominant in the lagoon. The lagoon was significantly enriched in macronutrients, and high overall nitrogen and phosphorous concentrations likely supported substantial phytoplankton blooms in the lagoon throughout the studied periods. It was observed that with similar temperatures and nutrient availability between the 2014/2015 and 2015/2016 periods, the density of *A. minutum* in 2014/2015 did not reach as high as in those of the 2015/2016 period, in which higher precipitations, streamflow, and decreased in salinity stratification index had prevented the development of *A. minutum* bloom. The findings of this study revealed that the coastal micro-phytoplankton community was dependent on the interplay of environmental variables and unique strategic adaptations of the functional types in the assemblages. This study provides valuable insights into the phytoplankton community dynamics in a tropical eutrophic lagoon.

1. Introduction

Phytoplankton, the primary producers in aquatic systems, are important components that sustain various aquatic life at higher trophic levels. They contribute to the various biogeochemical cycles and global carbon fixation in the oceans (Falkowski and Raven, 2007). Excessive growth of some phytoplankton to a nuisance level in coastal waters, however, may cause tremendous socioeconomic impacts that threaten human health and marine life of the coastal zones. Some phytoplankton taxa form massive blooms or commonly known as harmful algal blooms (HABs) that discolor the waters, reduce light penetration, and cause the formation of hypoxic/anoxic zones. Others release biotoxins that accumulate and transform in the marine food webs, which are often associated with various types of poisoning syndromes in human or marine organisms, while some produce biotoxins that directly or indirectly kill marine animals (Berdalet et al., 2017).

Alteration of nutrient stoichiometry in marine ecosystems is one of the significant processes that shift the phytoplankton composition and community structure (Buyukates and Roelke, 2005; Spatharis et al., 2007). Deterioration of water quality in the coastal ecosystems due to the intrusion of excessive nutrients from anthropogenic activities is known to cause a shift from a highly diverse phytoplankton community to a less diverse algal bloom community (e.g., Chu et al., 2014; Mohd-Din et al., 2020, 2022). Most HAB species, particularly the dinophytes, exhibit a nutrient-retrieval strategy (Smayda and Reynolds, 2001), and are able to utilize alternative nutritional sources by mixotrophy (Stoecker, 1999; Glibert, 2016). Apart from nutrients, distinct weather patterns and seasonality also affect the phytoplankton community assemblages in the water. In tropical regions, coastal phytoplankton blooms are often regulated by tropical monsoonal changes, with distinctive precipitation patterns and wind-driven coastal upwelling events (Palani et al., 2012; Kok et al., 2017; Taufikurahman and Hidayat, 2017).

The Geting Lagoon is a shallow semi-enclosed tropical lagoon located in the estuarine delta of northeastern Peninsular Malaysia (Fig. 1). The water is brackish, receiving freshwater

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