Marine Pollution Bulletin 128 (2018) 415–427

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Distributions of particulate and dissolved phosphorus in aquatic habitats of Peninsular Malaysia

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ARTICLE INFO

Keywords:
Particulate phosphorus
Dissolved inorganic phosphorus
Dissolved organic phosphorus
Alkaline phosphatase activity
Tropical waters

ABSTRACT

Particulate phosphorus was the dominant phosphorus species and accounted for 72 ± 5% of total phosphorus in coastal habitats, 63 ± 4% in estuaries, 58 ± 6% in lakes and 80 ± 7% in aquaculture farms whereas dissolved inorganic phosphorus (DIP) and dissolved organic phosphorus (DOP) were minor components. Correlation analyses (DIP vs Chl *a*; $R^2 = 0.407$, df = 31, $p < 0.001$) suggested phosphorus limiting conditions in lakes, which was corroborated with the highest alkaline phosphatase activity (APA) that fluctuated from 0.38 to 41.14 nmol L^{-1} min^{-1}. In contrast, APA was elevated in coastal habitats and estuaries only when DIP concentration decreased below 0.9 µM. Moreover size-fractionation experiment showed that the highest APA was detected in the 0.2–2 µm pico-size fraction. Our results suggested that the main APA in coastal habitats and estuaries was from phototrophic pico-eukaryotes and heterotrophic bacteria, and regulated largely by DIP availability.

1. Introduction

In the last 50 years, rapid population growth, extensive development and significant changes in land use are taking their toll on different aquatic habitats leading to increase eutrophication (Bennett et al., 2001; Rabalais et al., 2009). As a result, excessive nitrogen and phosphorus loading have increased remarkably throughout the years (Seitzinger et al., 2005; Chislock et al., 2013; Lee et al., 2013; Song et al., 2015). As nitrogen loading generally exceeds the input of phosphorus, it is more common to observe phosphorus depletion in estuaries and coastal waters around the world (Howarth and Marino, 2006; Elser et al., 2007).

Phosphorus is an important element for all living organism and plays an important role in many of the fundamental processes i.e. storage and transfer of genetic materials, cell metabolism and energy storage of cells (Karl, 2000; Paytan and McLaughlin, 2007). Generally, the phosphorus pool in aquatic habitats can be divided into three main compounds; dissolved inorganic phosphorus (DIP), dissolved organic phosphorus (DOP) and particulate bound phosphorus (Part-P) (Froelich et al., 1982; Karl and Björkman, 2001). Part-P is a complex intermediate compound where phosphorus derivatives are bound to the biogenic and non-biogenic particulate matter. In habitats with serious phosphorus limitation, biogenic Part-P (i.e., living and dead cells or plankton biomass) can be remineralized into DOP and can sustain the phosphorus cycle. In contrast, non-biogenic Part-P is generally bound on clay or rock fragments, and is less significant for biological processes (Paytan and McLaughlin, 2007; Meng et al., 2014).

Relative to Part-P, DIP is more commonly measured because it represents the bioavailable component of the phosphorus pool. Specifically, orthophosphate (HPO_4^{2-}) can be assimilated directly by a wide range of organisms without any additional expenditure of energy, and thus play a vital role in regulating different biological processes (Cotner and Wetzel, 1992). In contrast, DOP which is not directly available for biological activities, has received a great deal of attention as an alternative source of phosphorus in habitats with serious phosphorus limitation (Nausch and Nausch, 2006; Paytan and McLaughlin, 2007). With the use of phosphatase enzymes, HPO_4^{2-} from DOP can be hydrolytically cleaved and transformed into bioavailable phosphorus. A variety of phosphatase enzymes are capable of breaking down DOP compound for example C-P lyase, phosphodiesterase, pyrophosphatase

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https://doi.org/10.1016/j.marpolbul.2018.01.037
Received 2 June 2017; Received in revised form 10 January 2018; Accepted 17 January 2018