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Pressure on oxygen levels of Jakarta Bay

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ABSTRACT

Jakarta Bay is subject to inputs of large amounts of dissolved inorganic nutrients and organic matter deriving from the Jakarta Metropolitan Area and its hinterland. As a consequence, inorganic and organic nutrient concentrations in the nearshore area are considerably increased. The hydrographic pattern inside the bay fosters phytoplankton bloom formation due to pronounced vertical density gradients. High Biomass Blooms (HBB) of phytoplankton are observed recurrently, representing an additional source for oxygen consuming degradable organic matter. An oxygen deficiency area of 20 km^2 can be identified in the eastern part of Jakarta Bay where oxygen levels decrease to 60% saturation, equaling a noxiously low concentration of 4.0 $mg \cdot dm^{-3}$ O_2. The absolute minimum detected was 51% O_2 or 3.2 $mg \cdot dm^{-3}$ O_2. The observed oxygen concentrations fail Indonesian quality standards for seawater.

1. Introduction

The capitol of Indonesia, Jakarta, is a megacity located at the southern coast of Jakarta Bay neighboring the Java Sea. In the entire Jakarta Metropolitan Area (JMA) the population accounted for nearly 30 million inhabitants of which 9.6 million lived in Jakarta City in 2010 (Badan Pusat Statistik, 2015). Urban wastewater of the JMA remains largely untreated and is *i.a.* discharged through a number of rivers and canals into the adjacent bay, thereby loading the coastal waters with nutrients and degradable oxygen consuming organic matter. The World Bank (2008) calculated an annual domestic input to inland water bodies of 15,644 tons of nitrogen, 3998 tons of phosphorus and a biological oxygen demand (BOD) of 86,910 tons of oxygen for Jakarta. The shallow Jakarta Bay exhibits water depths of less than 25 m (Damar, 2003) and is subject to diverse anthropogenic use, as *e.g.* aquaculture and fisheries, shipping, tourism and land reclamation. The massive input of nutrients and organic matter to the bay drives the eutrophication process which becomes apparent from an increase in nutrient levels and an increasing frequency of microalgae blooms (Arifin, 2004). Algal blooms were accompanied by events of fish kills in 2004, 2005, and 2007. These were suspected to be due to oxygen deficiency rather than algal ichthyotoxins (Wouthuyzen et al., 2007). The present paper focuses on the potential factors which might be responsible for recurrent oxygen deficiencies in the bay.

2. Material and methods

2.1. Field measurements and laboratory analysis

Sampling was carried out from 2nd to 4th of October 2012 and covered the whole Jakarta Bay and parts of the adjacent Java Sea (Fig. 1). The sampling grid consisted of 44 coastal sampling stations. Water samples were taken from the sea surface with a Niskin bottle from aboard a 10 m motorboat. Vertical hydrographic profiles were conducted by means of a CTD multiprobe equipped with a Clark cell for oxygen determination and a backscat fluorometer for phytoplankton chlorophyll-*a* measurements.

Unfiltered subsamples for the analysis of total nitrogen (TN) and phosphorus (TP) were stored deep frozen in 200 ml PE bottles. Subsamples for the determination of ammonium (NH_4^+), nitrite (NO_2^-), nitrate (NO_3^-), phosphate (PO_4^{3-}), and silicate (SiO_4^{4-}) were filtered through Rotilabo® CME syringe filters of 0.45 μm pore size, fixed with mercury chloride ($HgCl_2$) and stored dark and cool in 250 ml PE bottles until further analysis in the laboratory according to Grasshoff et al. (1999). Dissolved organic and particulate organic nitrogen (DON + PON) and dissolved organic phosphorus plus particulate phosphorus (DOP + PP) were calculated as the difference between total nutrient concentration and the dissolved inorganic fraction (TN − DIN; TP − PO_4^{3-}).

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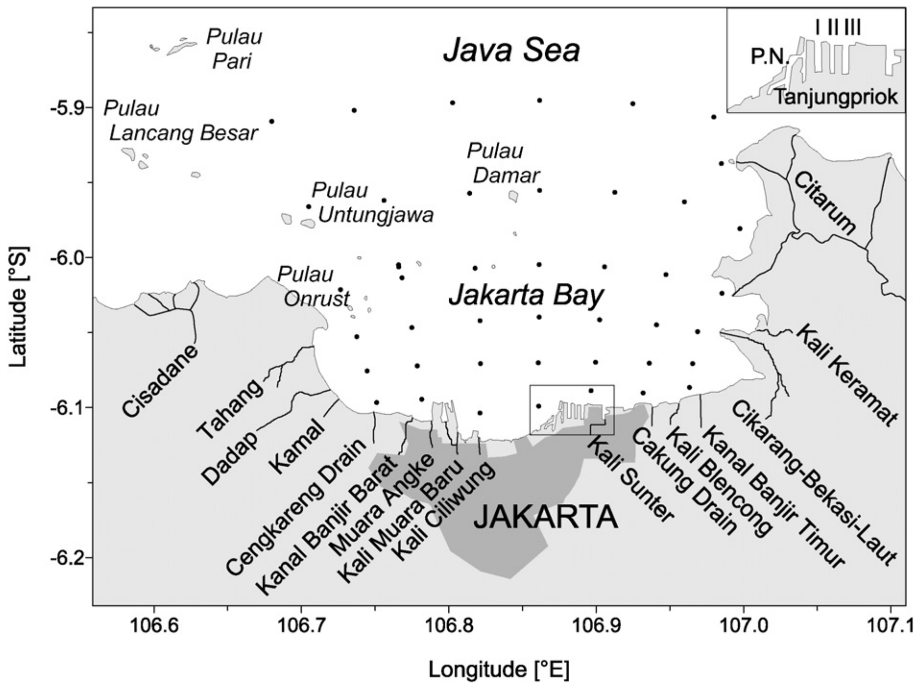

Fig. 1. Jakarta Bay sampling grid (black dots) in October 2012 (Jakarta City indicated by dark grey area, rivers and canals by black lines; rectangle indicates insert of Tanjungpriok with port basins I–III and P.N. = Pelabuhan Nusantara).

2.2. Calculation of the vertical density gradient

The vertical density gradient of the water column was calculated from CTD sigma measurements by means of Eq. (1).

$$\Delta\sigma_t = (\sigma_{tx} - \sigma_{ty}) \cdot \frac{1}{\Delta z} \qquad (1)$$

where:

σ_t = sigma (density − 1000) corrected for compression heating (t) [$kg \cdot m^{-3}$]
$\Delta\sigma_t$ = vertical sigma$_t$ change in the water column [$kg \cdot m^{-3} \cdot m^{-1}$]
σ_{tx} = sigma$_t$ at depth x [$kg \cdot m^{-3}$]
σ_{ty} = sigma$_t$ at depth y [$kg \cdot m^{-3}$]
Δz = depth difference between depth x and depth y [m].

3. Results

3.1. Hydrography

The temperature distribution of Jakarta Bay is characterized by tropical water temperatures of 30.0 °C to 32.5 °C at the sea surface with a

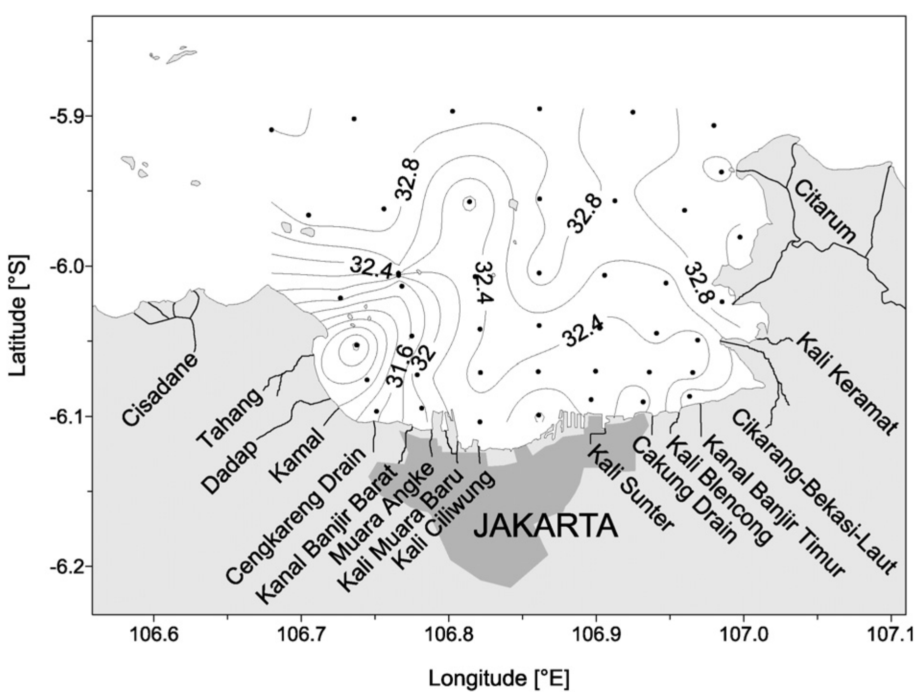

Fig. 2. Surface salinity [−].