DISSOLVED AND PARTICULATE CARBON IN JAKARTA BAY, INDONESIA

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ABSTRACT

In order to investigate spatial and temporal variability of dissolved organic carbon (DOC) and particulate organic carbon (POC), several samples were collected from five estuaries, inner part and outer part of Jakarta Bay. The samples were collected on 15 and 16 February 2007, a week after heavy flood in Jakarta Area, and on 16 May 2007. DOC concentration in February and May in Jakarta Bay ranged between 100-950 µg-C /l and between 0-850 µg-C /l respectively. POC concentrations ranged between 50-650 µg-C /l and 50-900 µg-C /l in February and May 2007, respectively. Even though the concentrations between both periods were similar, the load of organic carbon from the land to Jakarta Bay showed a large contrast due to the different amount of freshwater input. The Total organic carbon fluxes from the rivers to the bay in February and May 2007 were 107.6 t d^{-1} C-(ton per day Carbon) and 42.7 t d^{-1} C, respectively.

Keywords: Dissolved Organic Carbon, Particulate Organic Carbon, Seasonal variations, Carbon flux, Jakarta Bay

INTRODUCTION

It is believed by many researchers that the present global warming threatening the earth is due to the anthropogenic activities that produce increasing carbon emission. At present many data of water quality such as nutrient, plankton and heavy metals are available for the rivers and the coastal waters. On the other hand, the carbon flux data, especially of the fluvial system of Indonesian region is still very limited. Jakarta Metropolitan Area with the population of 8,489,910 people (Anonymous, 2008) and 15 million more people in the surrounding suburban of Jakarta is a strategic hub for regional socio economic development. The urbanization in the greater Jakarta, called Jabodetabek, creates a significant anthropogenic impact to the environmental system. On the other hand, the limited infrastructures, such as sewerage system and lack of industrial waste management, cause the rivers in this region are overloaded beyond their carrying capacity. The major objective of the present study is to investigate the pattern and variability of organic carbon content in the rivers and in Jakarta Bay as carbon reservoir systems in terms of temporal as well as spatial distribution. The specific objective of this study is to understand the process and magnitude of the carbon flux from the river system to the Jakarta Bay system. The main interaction of the environmental factors versus biogeochemical factors which arises from human perturbation will be indicated.

Jakarta Bay is a semi enclosed bay located on the northern coast of Jakarta Metropolitan City, extending from 5°55'30" to 6°7'00"S and 106°42'30" to 106°59'30" E. The bay is bordered by two capes, those are the Tanjung Karawang in the east and the Tanjung Pasir in the west. Jakarta Bay has an area of approximately 496 km^2 with a coast length of around 85 km and a mean depth of 8,4 m. Due to its shallow bathymetry, water mixed thoroughly in the whole water column (Damar, 2003). Topographical pattern follows the shape

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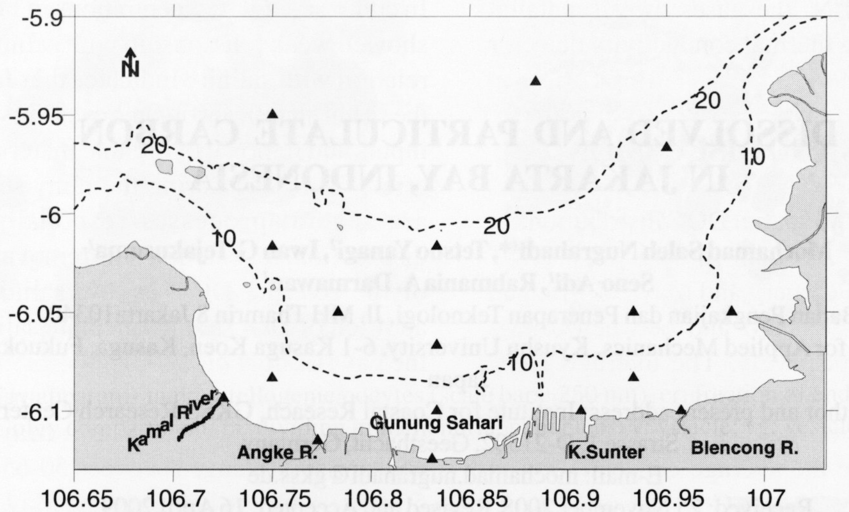


Figure 1. Map of study area, dashed line of bathymetry indicates depth in meter. Black triangles denote sampling stations.

of the bay, shallow and flat in the middle of the bay, and steep near both capes (Fig. 1).

There are 13 rivers that flows into the Jakarta Bay. Among these rivers there is the main river called Ciliwung River that diverge into the Angke River and Gunung Sahari River. It has a significant impact on the coastal water of Jakarta Bay. However, samples were collected from the mouth of five rivers mouth namely the Kamal River (M1), Angke River (M2), Gunung Sahari (M3), Kali Sunter (M4) and Blencong (M5). In terms of, water pollution and sediment flux, especially during the last heavy flood, these rivers discharge over 500 m^3s^{-1} bringing the debris of approximately 11,000 m^3 consisting of trash and domestic junks. In a semi-enclosed coastal water system like Jakarta Bay, natural rivers water input would be accumulated in the bay.

MATERIAL AND METHODS

In order to investigate spatial and temporal variability of the DOC and POC in Jakarta Bay, water samples were collected from five estuaries, and 10 stations in the inner part and two stations in the outer part of the bay. The samples were taken about one meter below the surface (Fig. 1).

In 2007 two surveys were carried out, one during the wet, northwest monsoon, and the other during intermediate the transition season, respectively in February and May. The samples were preserved with $HgCl_2$ saturated concentration solution. For determination of particulate organic carbon (POC) samples were filtered through pre-weighed, pre-combusted glass fiber filters (Whatmann GF/F) and dried at 40^{o}C. Each sample was stored in the brown glass bottle with Teflon cap and brought back to the laboratory immediately for quantitative filtration and analyzes. The river discharges were estimated from the cross section area and mean water velocity, of the profile and also was measured with a flow-meter.

Dissolved organic carbon

DOC was determined with a Dohrmann DC-190 Total Organic Carbon Analyzer using high temperature catalytic oxidation. The samples were combusted at 680^o C within a quartz column, packed with platinum that was covered with Al_2O_3-balls. The evolving CO_2 was purified, dried and detected by a non dispersive infrared detection system. For detail analysis method see Skoog (1997).

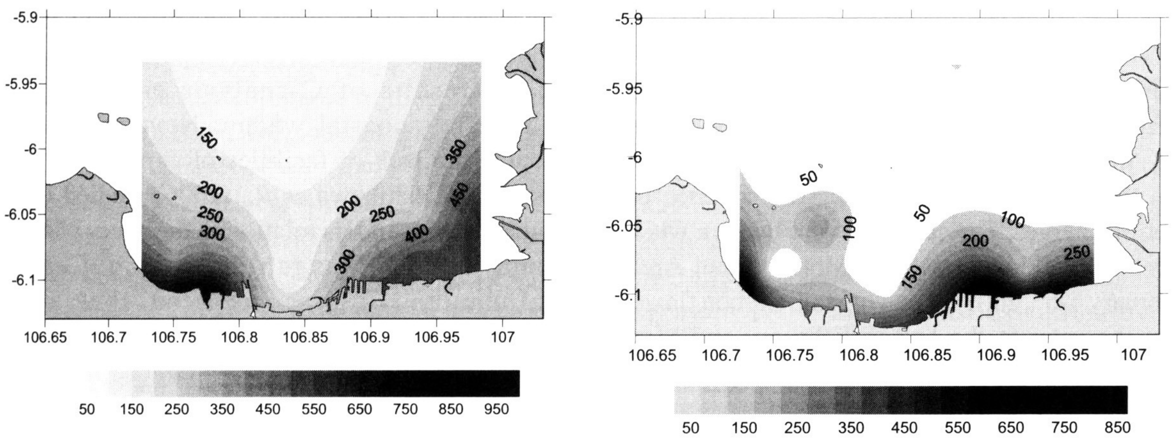
Particulate organic carbon

After removal of inorganic carbon by acidification with 1 N HCl, filters were dried at 40^o C and subsequently analyzed for total carbon and nitrogen in a Carlo Elba NA 2100 elemental analyzer. Within the analyzer the samples were oxidized at 1100^o C and the oxidation product were transported by a carrier gas (He) through a reduction tube where NO_x was reduced to N_2. After removing water and halogens from the evolving CO_2 and N_2 the gases were separated and quantified by a thermal conductivity detector (Verardo *et al.*, 1990).

RESULTS AND DISCUSSION

The temporal and spatial DOC distributions in Jakarta Bay are shown in Fig. 2. DOC concentrations in February and May 2007 ranged between 100 µM–950 µM and between 0 µM-850 µg-C l^{-1}, respectively. The average DOC concentrations in estuaries stations in February and May 2007 were 566 µg-C l^{-1} and 605 µg-C l^{-1} respectively, while the average concentration in the inner bay were 264 µg-C l^{-1} and 66 µg-C l^{-1} respectively. Figure 3 shows a relationship between decreasing DOC and increasing salinity in the estuaries and in the bay. The range of salinity in February and May were 0-30 and 0-32, respectively. A good linear relationship between salinity and DOC found in May 2007 (Fig. 3 b) indicated conservative mixing during those periods. In contrast, DOC concentrations in February 2007 showed weak relationship with salinity. Such low relation with salinity indicates that Jakarta Bay is the site of significant organic cycle, in which internal inputs and removal of organic material exceed the effect of mixing during the rainy season. There are several processes responsible for such distribution, for example, the removal of a fraction of the riverine DOC at low salinities and the addition of DOC at intermediate salinities within the bay (Goni *et al*, 2003).

Figure 4 shows the temporal and spatial POC distributions in February and May 2007. POC concentrations ranged between 50-650 µg-C l^{-1} and 50-900 µg-C l^{-1} in February and May, respectively. For comparison to other studies, POC concentrations Jakarta Bay was below the Brantas River that was between 6.3 to 1425 µg-C l^{-1} (Aldrian *et al.*, 2008, Aldrian et al 2006), but higher than that in Bengawan Solo River which was between 175 to 511 µg-C l^{-1} and Serayu River which was 393 µg-C l^{-1} (Li *et al.*,1995). High



(a) (b)

Figure 2. DOC concentrations (µg-C/l) in the surface layer in February 2007 (a) and May 2007 (b)

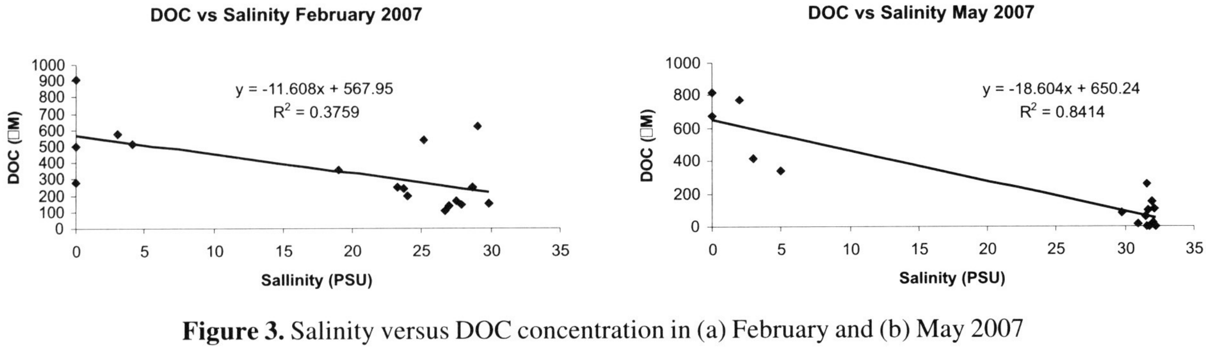
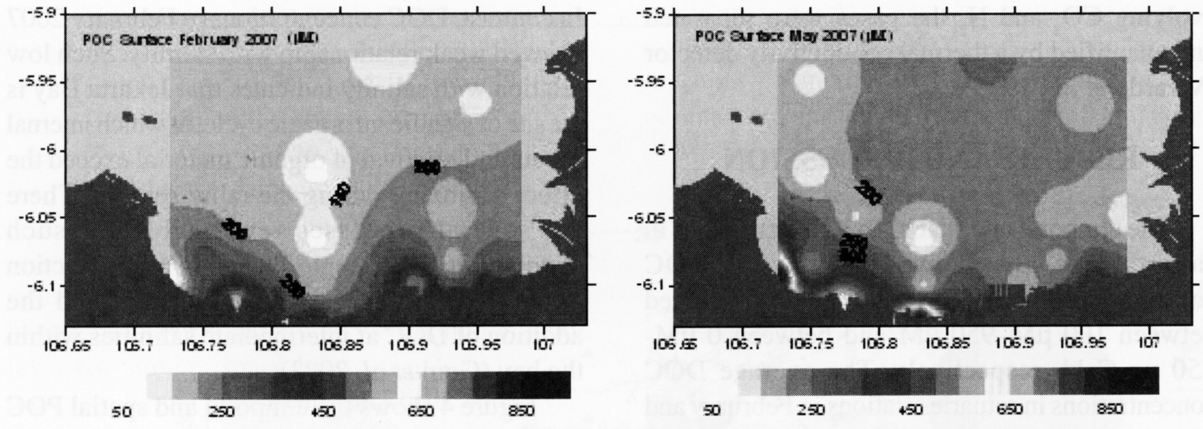


Figure 3. Salinity versus DOC concentration in (a) February and (b) May 2007



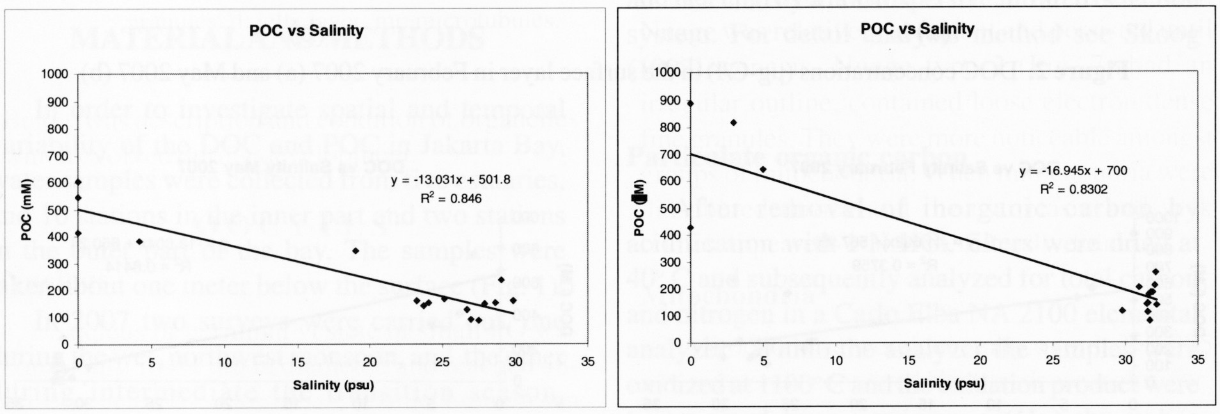
(a) (b)

Figure 4. POC concentrations in the surface layer in (a) February 2007 and (b) May 2007

concentration of POC existed along the coastline or estuaries, and then it decreased toward the sea. High POC values varied widely in February than in May due to high load from the rivers. In both measurement periods, POC concentrations generally exhibit linear decreased with salinity indicating the conservative mixing over the measured salinity range (Fig. 5).

TOC yields from Jakarta's rivers are shown in Fig. 6. Even though the average TOC concentration in February was lower than that in May, the TOC load in February was much higher than that in May due to the large difference of river discharge. The samples were taken a week after heavy flood in Jakarta Metropolitan Area (February 4-6th, 2007). Total organic Carbon fluxes from the river to the bay in February and May 2007 were 107.6 t d^{-1} and 42.7 t d^{-1} C, respectively.

Despites of its potential importance, however, seasonal observation of carbon (dissolved and particulate) dynamics in the freshwater and coastal ecosystem of Indonesia were not conducted often enough. It is probably because of limitations in carbon analysis facilities, and carbon as regarded of low importance as chemical parameter for water quality assessment. Therefore, there is not so much data available for comparison purposes of the results of C-analysis especially in Indonesia's coastal waters. Nevertheless, to resolve the lack of facilities of carbon analyzer instrument, Ishikawa *et al*., (2006) studied DOC concentration and its relation to the water color in Kahayan and Rungan Rivers in Central Kalimantan. It was reported that DOC concentration in these rivers ranged between 416-4166 μg-Cl^{-1}. The mean DOC concentrations in Siak River, Dumai River, and Brantas River are



(a) (b)

Figure 5. Salinity versus POC concentrations in (a) February and (b) May 2007

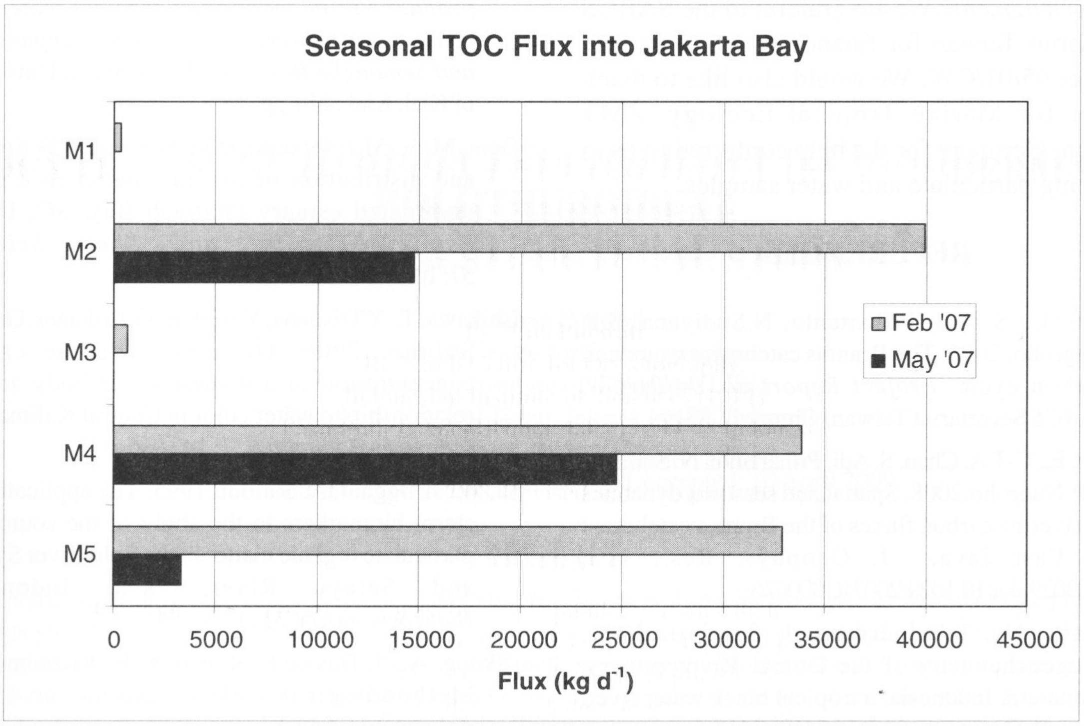


Figure 6. Seasonal Total Organic Carbon (TOC) in kg d^{-1} flux from land to the Jakarta Bay

1240 µg-C l^{-1} (Baum *et al.*, 2007), 4908 µg-C l^{-1} (Alkhatib *et al.*, 2007), and 1000 µg-C l^{-1} (Aldrian *et al.*, 2008). When compared to those numbers, it is obvious that the DOC concentration in Jakarta Bay and its estuaries is very low (Table 1). Siak River and Dumai Rivers are black-water rivers that drain the vast lowland peat soils of eastern Sumatera and they are characterized by low pH and high amount of DOC. Additionally, on a global scale, riverine DOC input into the ocean tends to increase with catchment (Ludwig *et al.*, 1996 in Alkhatib *et al.*, 2007). Due to low concentration and low river discharge, the total organic carbon discharge into the Jakarta river basin was very low on national scale and global scale as well.

CONCLUSION AND SUGGESTION

This study clearly shows the seasonal variability in anthropogenic organic carbon flux in Jakarta Bay. Despite of densely populated in its catchment area and heavily polluted, Jakarta Bay received less carbon from land compared to the other areas in Indonesia. The linear relationship between DOC and salinities indicates the conservative mixing, and it can be concluded that the source of carbon in Jakarta Bay is from land. However, a non linear relationship found in February indicated that the decrease of DOC can not be explained solely with conservative mixing, therefore the correlation among DOC and the other data such as chlorophyll-a, dissolved oxygen and nutrient should be investigated furthermore.

Table 1. DOC concentrations in Indonesia.

Location	DOC	DOC flux	Reference
	µg-C l^{-1}	kg d^{-1}	
Dumai River, Sumatera	4908	827,397	Alkhatib *et al.*, (2007)
Siak River, Sumatera	1240	746,666	Baum *et al* (2007)
Brantas, East Java	1000	3.53 - 1878	Aldrian *et al* (2006)
Kahayan and Rungan, East Kalimantan	416-4166	*Not available*	Ishikawa *et al* (2006)
Jakarta Bay	0-950	42.7 – 407.6	This study

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