WATER POLLUTION LEVELS IN THE SUWUNG ESTUARY-BALI BASED ON BIOLOGICAL OXYGEN DEMAND

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ABSTRACT

Biological Oxygen Demand (BOD) is generally used for determining the water pollution level in water bodies. Estuary is a semi-enclosed water, that can be influenced by pollution from land areas or rivers. This research was aimed to determine the spatial distribution of water pollution levels based on BOD_5 analysis. This research was conducted in January and February 2016 in Suwung estuary, Bali. Samples were taken in 20 points (19 points were located in Suwung Estuary and one point was located outside the Suwung estuary as a control point) and the BOD_5 samples were analyzed in the laboratory. The method for BOD_5 analysis was using amperometric method in National Field Manual for the Collection of Data Water-Quality, Chapter A7. The BOD_5Samples were taken at all tide cycles, during ebb to high tide and high tide to ebb. The range of BOD_5 values were: 0.84 mg/L – 9.47 mg/L during ebb to high tide and 0.96 mg/L – 8.75 mg/L during high tide to ebb. The result of BOD_5 analysis showed that the water pollution level in the Suwung estuary was slightly contaminated in both tide conditions. The spatial distribution of BOD_5 value tended to be higher around the cage aquaculture area, near the river, landfill area and around Benoa harbour.

Keywords: BOD_5, spatial distribution, Suwung estuary, water pollution level

INTRODUCTION

Suwung estuary is a transitional area located in the sub-district of South Denpasar, Bali. This estuary is a habitat for mangrove vegetation with about 734.5 Ha (Sari, 2002). In addition, there are several activities also take place in Suwung estuary namely cage aquaculture area in the Northeastern part of Suwung Estuary, landfill area (Suwung Landfill area), and Benoa harbour in the Southern part of Suwung estuary. These activities possibly contribute pollution materials originated from feeding remains and fish metabolism products in cage aquaculture area, leachet leak from landfill area, or oil spills from harbour activities, and this will likely affect the water quality of Suwung estuary. The pollution pressure can affect the quality of the water, especially the dissolved oxygen (DO) in the water. According to Hendrawan and Asai (2014), the flushing rate of the tides around Suwung Estuary is low, with only 30% of particle transport directly to the sea. This condition potentially decreasing the water quality around Suwung Estuary.

The concentration of oxygen levels is one of the indicators of the estuary's health in supporting the life of aquatic organisms (NOAA, 2007; Ohrel and Register, 2006). All living organisms need oxygen to breathe and metabolize. In addition, oxygen plays an important role in the process of oxidation and reduction of organic and inorganic compounds to become simpler non-toxic substances (NOAA, 2007; Salmin, 2005). The oxidation process of organic materials by the organism is related to biological oxygen demand (BOD).

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BOD is defined as the amount of oxygen required by the organisms to break down the organic matter in aerobic conditions through biological and chemical processes (Ohrel & Register, 2006; Henze & Yves, 2008). BOD is also one of indicators for determining the water pollution level in water bodies, and as the early warning of water quality degradation (Sheldon and Alber, 2011). As the water is dynamic, distribution of pollutants in the water of estuaries is much affected by the existence of the tides. The flow movement of tides will affect the pattern of distribution and the organic materials from the river. Therefore, the aim of this research is to know the level of contamination based on BOD analysis and spatial distribution in Suwung estuary.

MATERIALS AND METHODS

BOD_5 samples were collected in Suwung Estuary area in January and February 2016. The number of sample points were 20 points, which 19 points in Suwung Estuary area and 1 point was out of the estuary as the control point (Figure 1). The control point was determined by an area with no activities and river inputs, and one with fast flushing rate. Samples were taken from the surface water in both ebb to high tide and high tide to ebb conditions during the day. While taking the BOD_5 samples, it was ensured that there were no bubbles in each sample-bottle, thus water sampling was taken under the water's surface. All samples were kept in a box with the temperature 4°C to minimize bacterial activities.

BOD_5 analysis using amperometric method refers to the standard method in the National Field Manual for the Collection of Data Water-Quality, Chapter A7, by Delzer & McKenzie (2003) in . Analysis processes were done in Faculty of Marine Sciences and Fisheries Laboratory, Udayana University. Nutrient solution ($CaCL_2$, $FeCl_3$, $MgSO_4$ and phosphate buffer) and dilution water were prepared before it was mixed with BOD_5 samples. These solutions had to be prepared three to five days before starting the test. The mixing of these solutions of the BOD_5 sample is necessary if the range of BOD_5 is larger than 7 mg/L. The anticipated range of BOD_5 in this research was 6 – 21 mg/L, therefore the nutrient solution was needed with 100ml of BOD_5 samples and 200ml of nutrient solution. The DO meter was calibrated before measuring the initial DO (D1) and final DO (D2). After all of the BOD_5 samples were treated with nutrient solution and measured using DO meter, then it stored in an incubator with constant temperature 20±1°C for five days. During the incubation, all samples was kept in dark bottles to avoid sun reactions with the photosynthetic microorganisms that possibly add oxygen concentration to the sample. The general equation of BOD_5 from initial DO (D1) and final DO (D2) is:

$$BOD_5\ (mg/L) = \frac{D1-D2}{P} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (1)$$

where
D_1 = initial DO of the sample,
D_2 = final DO of the sample after 5 days, and
P = decimal volumetric fraction of sample used.

The BOD_5 results were then compared to the categorization of water pollution level by Wirosarjono (1974) *in* Salmin (2005) (Table 1).

Table 1 Water pollution level based on BOD value.

Range of BOD value (mg/L)	Pollution Level
0-10	Low
10-20	Moderate
25	High

Spatial distribution of the BOD_5 values in the coastal water of Suwung estuary are displayed in three conditions, namely the conditions of ebb to high tide, high tide to ebb and the average of both the tides. The method used in mapping the spatial distribution was Inverse Distance Weighted (IDW). This method was processed in QGIS software (version 2.4.0). The area of Suwung estuary is divided into two parts called the Southern part of the estuary (point 1 until 11) and the Northeastern part of the estuary (point 12 until 19). In the water that is part of the Gulf of Benoa there are two Gulf mouths, namely the mouth of the gulf I (in the Northeastern part of estuary) and the mouth of the gulf II (in the Southern part of estuary). The distribution of the BOD_5 values is indicated by the difference in the thickness of the color, where thicker colors equates to higher values of BOD_5. The color level is determined based on range value of BOD_5 obtained. Based on the BOD_5 value, the categories in this research were made from the lowest extensions to the highest: very low (0 - 1

Point	Longitude	Latitude
1	115.213873	-8.744991
2	115.217039	-8.744525
3	115.214631	-8.741668
4	115.218075	-8.74088
5	115.215427	-8.737275
6	115.21883	-8.73645
7	115.215759	-8.732862
8	115.220196	-8.73292
9	115.215747	-8.728299
10	115.219176	-8.728571
11	115.222675	-8.727605
12	115.228181	-8.724523
13	115.227038	-8.722199
14	115.23042	-8.721906
15	115.233072	-8.72066
16	115.23685	-8.719873
17	115.239646	-8.71835
18	115.242096	-8.717234
19	115.241303	-8.720366
20	115.247311	-8.741177

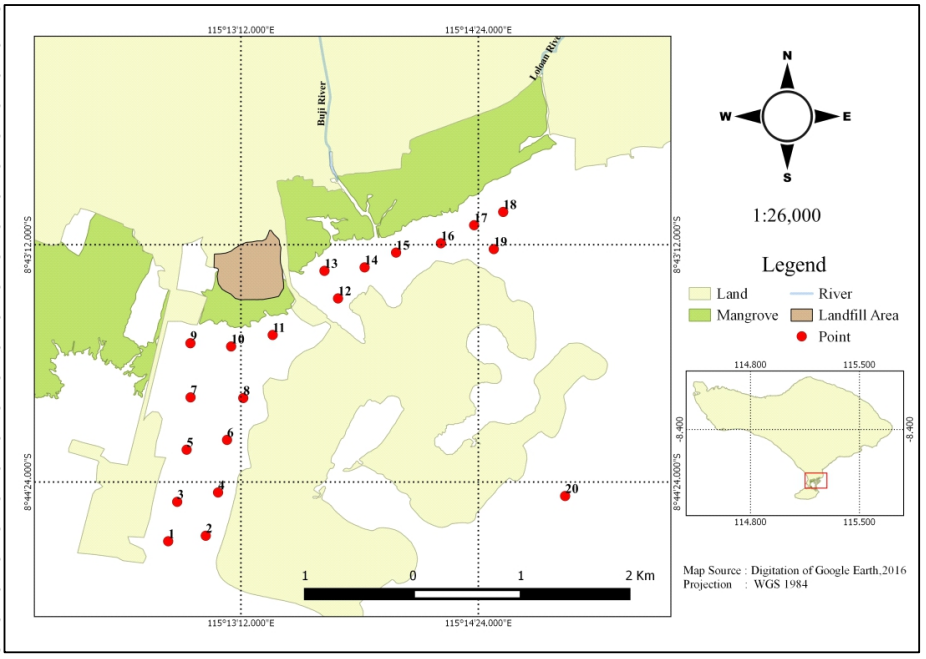


Figure 1 Distribution of twenty sample points in Suwung estuary (19 points were inner of estuary and a point was outer estuary)

mg/L), low (>1 - 4 mg/L), moderate (>4 - 6 mg/L), high (>6 - 8 mg/L) and very high (>8 - 10 mg/L).

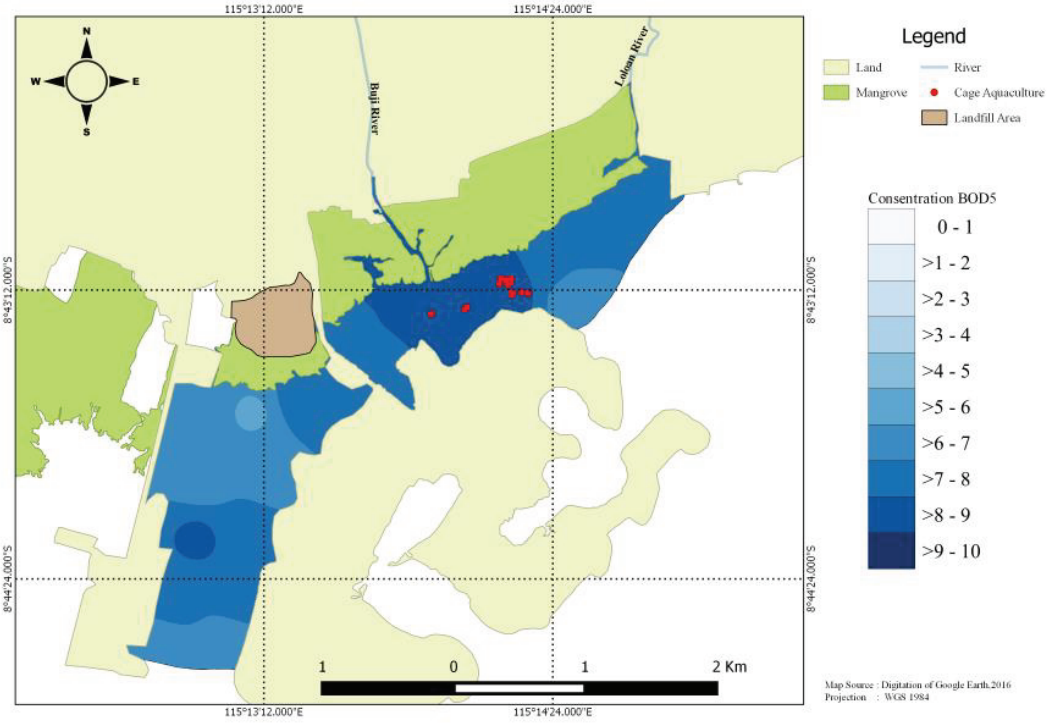
RESULTS AND DISCUSSION

The weather conditions when sampling in January 2016 was sunny on all tide conditions. In February 2016, it was rainy and cloudy in almost all of the tide conditions. The BOD_5 value during these two months in Suwung estuary showed that the estuary still classified as slightly polluted. The influence of contaminant input to the Suwung estuary tended to be in a low concentration.

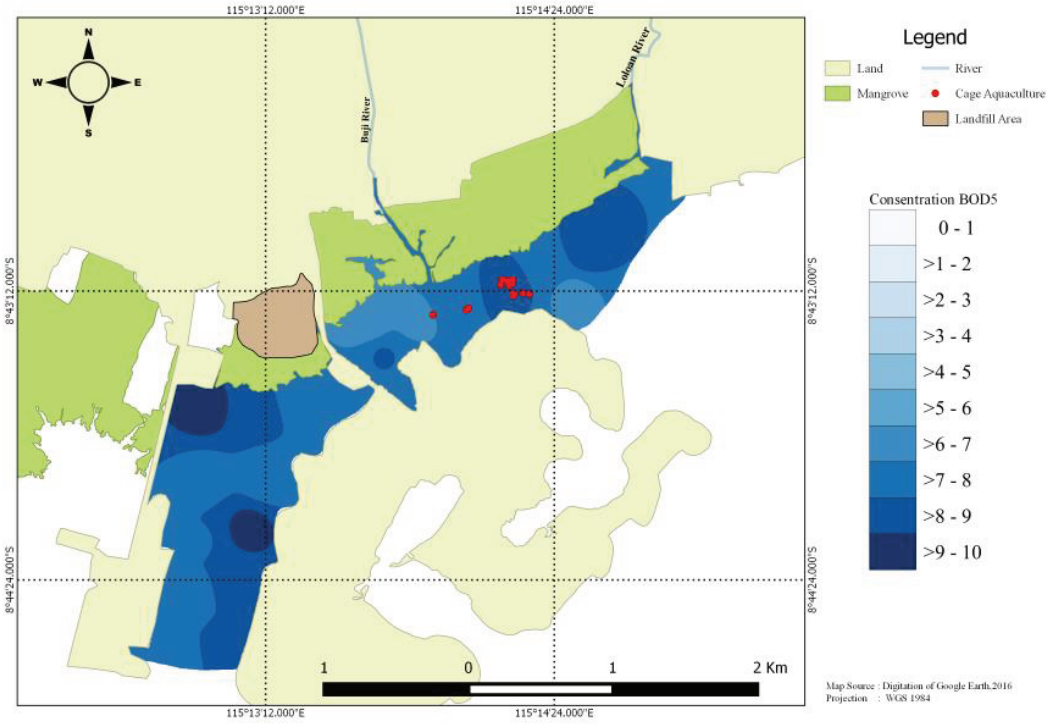
The distribution of the BOD_5 during January to February looks relatively high on the cage aquaculture area, river mouth area, Suwung landfill area and Benoa harbour. This condition was not settled in one area, but changes with the succession of the tides. The range of BOD_5 in these two months were 3.13 to 9.47 during ebb to high tide and 2.73 to 8,86 mg/L during high tide to ebb. Based on tide conditions, BOD_5 value in control point showed a high concentration during condition ebb to high tide in both months. However, that concentration was still lower than BOD_5in the inner Suwung estuary. This condition is allegedly caused by the input of organic material from the land and river around the estuary. Most of the organic materials are donated by the rivers input, and their concentration will be high in ebb condition.

In average, the spatial distribution of BOD_5 values in January 2016 in Suwung estuary tended to be high. These results were different with the average of BOD_5 values in February 2016 which the distribution of BOD_5 values were moderate in the Northeastern and Southern part of the estuary. This moderate value were also seen around the mouth of the river, cage aquaculture, Suwung landfill areas and Benoa harbour. According to Lihawa (2014), the movement of sea water causes the dilution that may be reducing the distribution and concentration of pollutants which are followed far away to the sea movement.

BOD_5 value can be used to determine the level of contamination in a body of water (Cahyaningsih and Harsoyo, 2010; Salmin, 2005). High concentration of BOD_5 can cause the anaerob condition, and it will be affecting the life of fish and other organisms (Mocuba, 2010). The category of water pollution level refers to Wirosarjono, 1974 *in* Salmin, 2005, namely slight or low pollution levels (0 - 1 mg/L), medium pollution levels (>10 - 20 mg/L) and high pollution levels (>20 - 25 mg/L). The pollution level in Suwung estuary differed between the tide conditions in each month (January and February 2016) during the research. Based on BOD_5 values

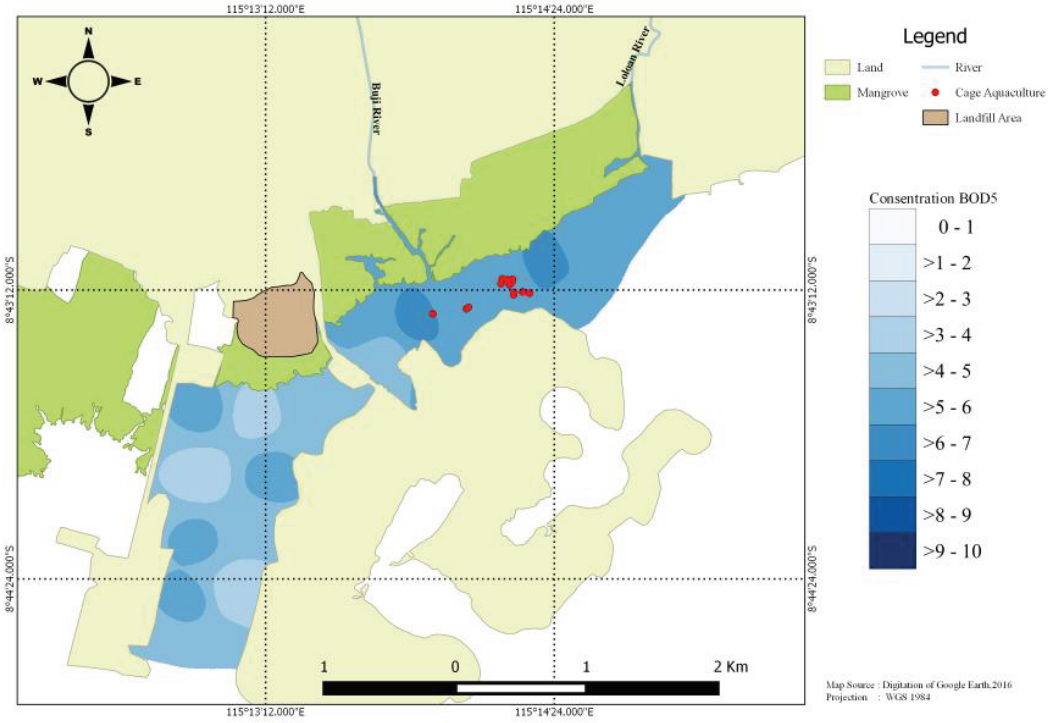


(a)

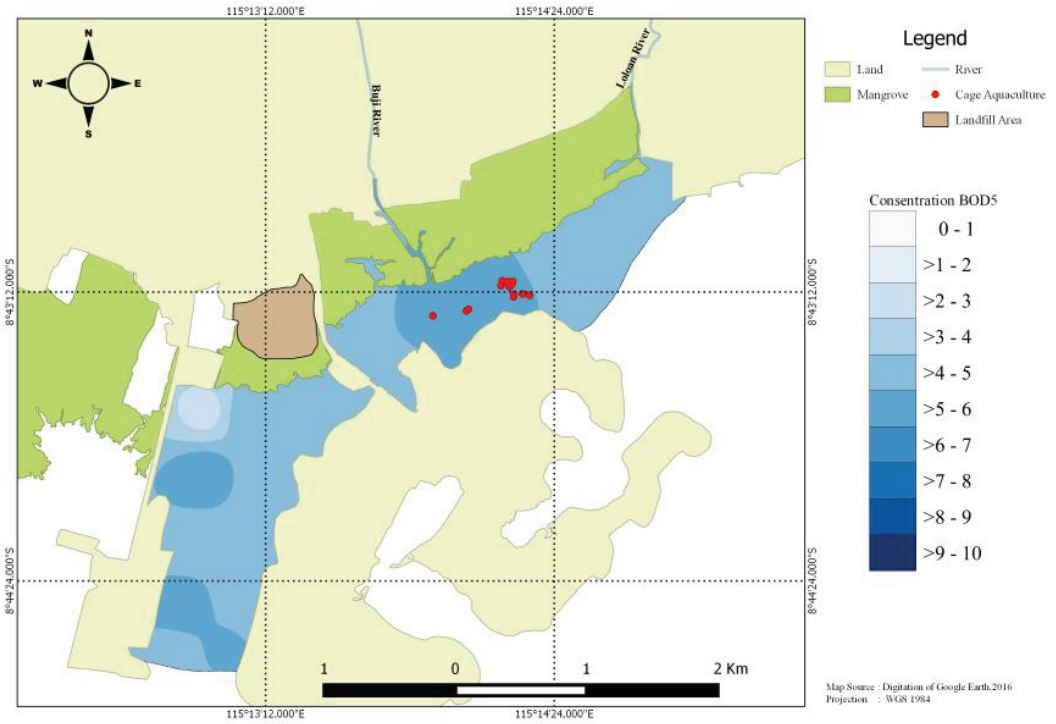


(b)

Figure 4 Spatial distribution in January 2016 (a) ebb to high tide and (b) high tide to ebb conditions

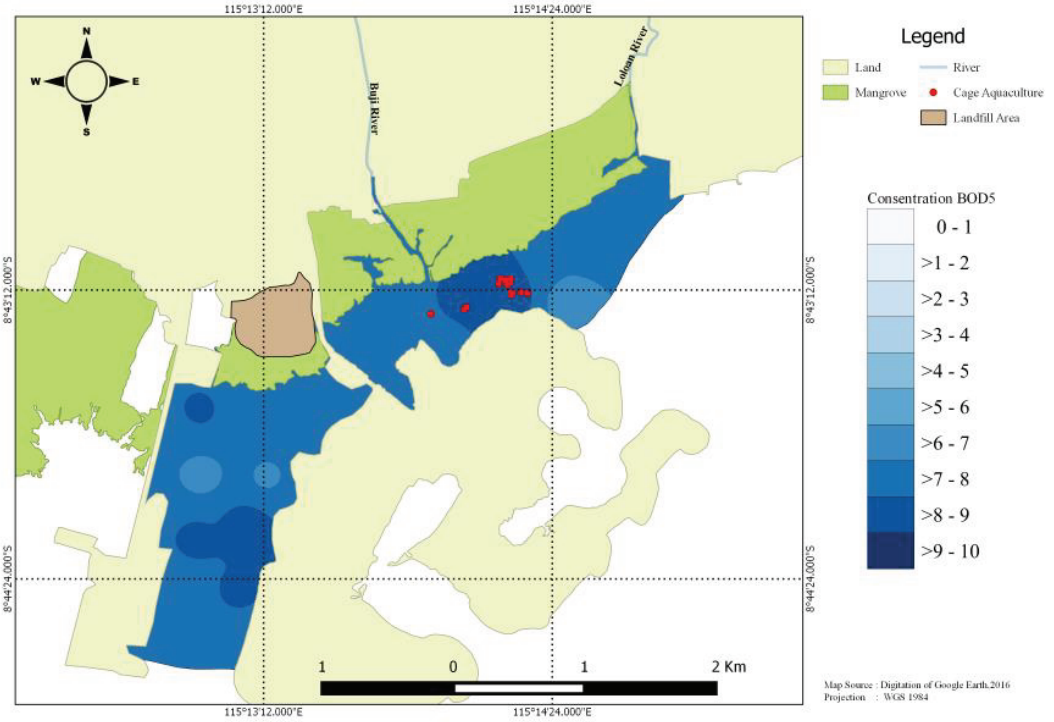


(a)

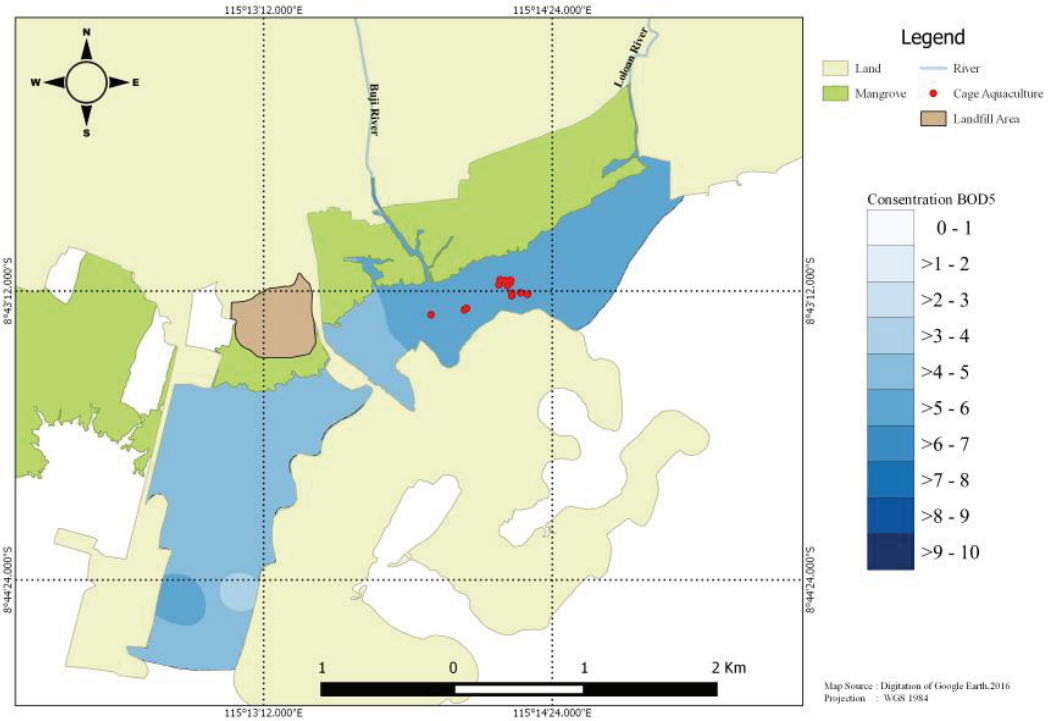


(b)

Figure 5 Spatial distribution in February 2016 (a) ebb to high tide and (b) high tide to ebb conditions



(a)



(b)

Figure 6. Average of spatial distribution in (a) January 2016 and (b) February 2016

in these two months showed that the waters in Suwung estuary was slightly polluted. January 2016 had the most number of points with BOD_5 values more than 5 mg/L in both of the tide conditions, compared to February 2016. These high values were because of hot weather in January 2016, which was increasing organic materials concentration in estuary (Islam *et al.*, 2015). In addition, the trend of high BOD_5 values in each month was more dominant during ebb to high tide condition.

Tides and rain were suspected to dilute the pollutant in the waters of Suwung estuary, during this research. This can be seen during high tide to ebb, as BOD_5 values tended to decline. It might be caused by the existence of two mouth of Benua gulf (mouth of Gulf I and Gulf II). The estuary ability to cope with the pollution depends on its waterways when the tides go in and out and its open channel to the sea. Rain seems to be capable of diluting the pollutant materials in the area of the estuary. The influence of the tides and rain is very important in the process of dilution, dispersion and self-purification on estuary areas. BOD_5 values will be lower in the rainy season than the dry season (Maitera *et al.,* 2010).

However, though the pollution level based on BOD_5 values in January and February 2016 was still classified as slightly contaminated, it potentially increases to a medium or high pollution level. This possibility is related to the existence of the activities around Suwung estuary (cage aquaculture, landfill area, harbour and the river mouth that bring contaminants from the mainland).

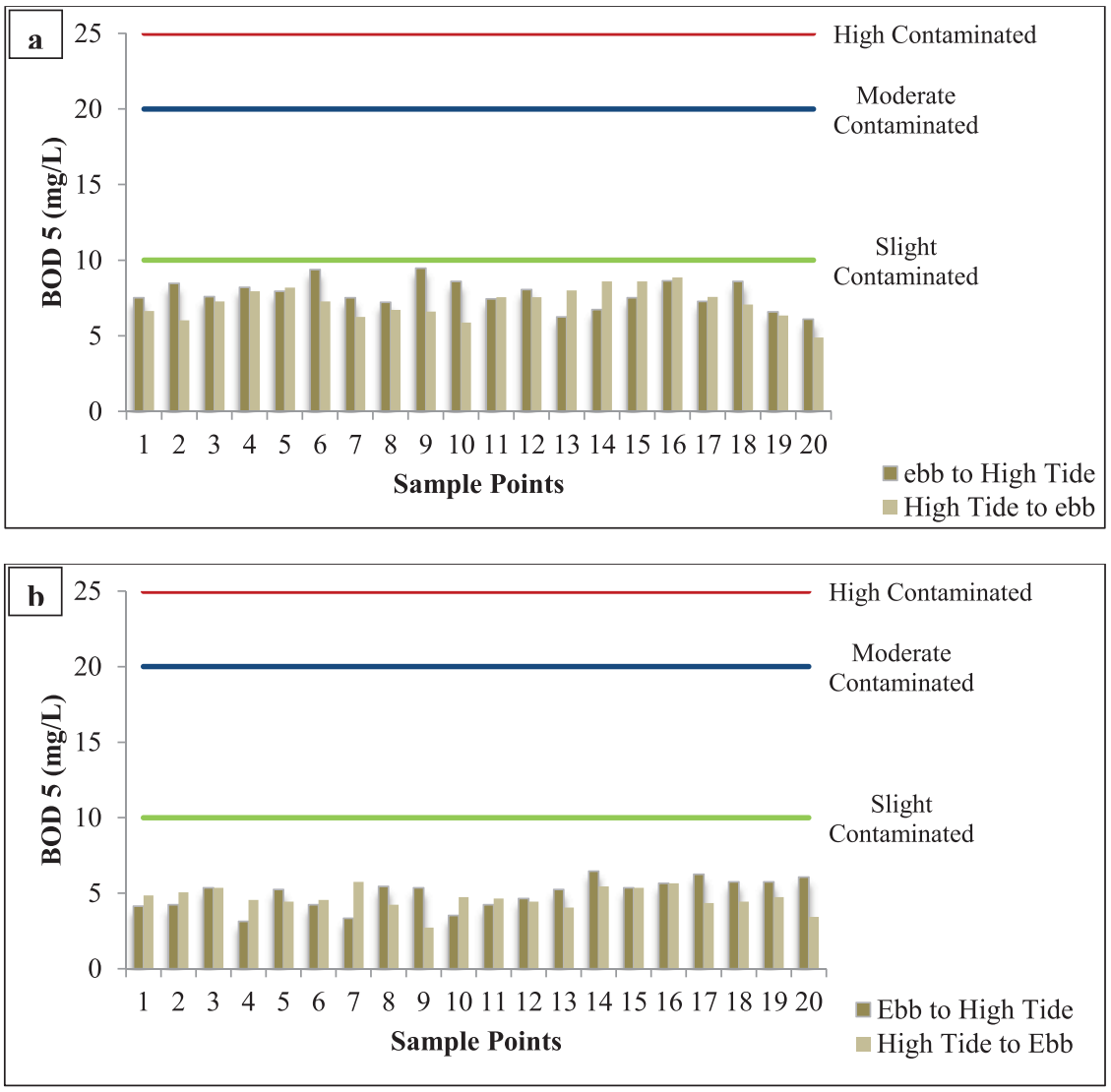


Figure 7 Water pollution level in Suwung estuary in (a) January 2016 and (b) February 2016

CONCLUSIONS

Based on BOD_5 analysis, pollution level in Suwung Estuary during January to February 2016 was classified as slightly contaminated. The BOD_5 was relatively high around the cage aquaculture area, mouth river, landfill area and Benoa harbour in both the tides condition. Rain visibly as the factors that affected the lowest BOD_5 values in February 2016, where the average of BOD_5 value was declined in all tides condition.

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