The Assessment of Biological and Pollution Index of Estuaries Around Port of Tanjung Emas Semarang

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Abstract. Estuary is a place of accumulation of the population’s activities produced by domestic, industry or agriculture. This research was conducted to three of estuaries of the rivers around the waters of Port of Tanjung Emas Semarang (PTES). They were estuaries of Baru river, Banjir Kanal Timur (BKT) and Siangker in west monsoon from October to December 2015. The purpose of this research was to analyze pollution index, the abundance of microorganisms either phytoplankton or zooplankton, the content of heavy metal in sediment and sea water, biological index that included diversity (H), uniformity (e), dominance (D), Saprobik Index (SI), and the Total of Saprobik Index (TSI) in the waters either HTL (High Tide Level) or LTL (Low Tide Level). The concentration of heavy metal in both sea water and sediments were analyzed by using Atomic Absorption Spectrophotometer (AAS). The result obtained from 12 parameters which were tested showed that the three waters can be categorized at heavily polluted condition at each value from 12.52 to 24.98. The concentration of heavy metal at sea water during HTW and LTW ranging from Cd is around 0.033 and 0.048 mg/kg, Cu 0.047 and 0.07 mg/kg, Pb 0.48 and 0.71 mg/kg, and Zn 0.043 and 0.057 mg/kg. The saprobity value index based on the existence of phytoplankton or zooplankton was ranging of Oligosaprobik at low pollution or has not been polluted yet.

Keywords: Port of Tanjung Emas Semarang (PTES), pollution index, heavy metal, biological index, west monsoon.

1. Introduction
Coastal areas and river estuaries are susceptible area of pollution from upstream. Pollution in the river estuary area is caused by frequent activity by both domestic and shipping industries in the region [1].

Kali Baru river estuaries located in the Port of Tanjung Emas Semarang (PTES), beside the domestic pollution from upstream, port activities such as shipyards, power plants, ship activities in the region have affected the estuary. Banjir Kanal Timur estuary is an area that is also close to PTES waters and a fishing area where the water quality is influenced by fishing activities and discharges from domestic households in the area. Siangker Estuary is a river estuary located in the west side of PTES close to the airport that will affected to the river estuary.
The purpose of this research is to analyze the value of Kali Baru river estuary pollution, BKT (Banjir Kanal Timur) and Siangker in terms of diversity (H'), uniformity (e), dominance (D), Saprobi Index (SI) and Total Saprobi Index (TSI) in both phytoplankton and zooplankton at HTL (High Tide Level) and LTL (Low Tide Level). Analysing the heavy metal concentrations Cu, Cd, Pb and Zn in both seawater and sediment. The last calculation of the pollution index on the territorial waters

2. Material and Methods
The research was conducted at the coastal estuaries around the Port of Tanjung Emas Port Semarang (PTES) in 3 areas with 3 research station, 1st station (estuary Kali Baru), 2nd station (estuary Banjir Kanal Timur) and 3rd station (estuary Siangker). Research conducted from October to December 2015.

Phytoplankton identification includes phytoplankton endemic in port waters, environmental parameters other than depth, current velocity, direction of current at each station also physical parameters (brightness, BOD₅, DO, temperature), chemical parameters (pH, salinity), while phytoplankton was analyzed using individual abundance (N), index of species diversity (H'), fairness index (E), dominance index (D), Saprobi Index (SI) and Total Saprobi Index (TSI) [2,3,7].

Abundance of individuals (N) = \( N = \frac{1}{A} \times \frac{B}{C} \times \frac{D}{E} \times F \) (1)

Where
- N = abundance (individual/liter),
- A = volume of filtered water (liter),
- B = volume of water in sample (125 ml),
- C = volume of preparation at identification (1 ml),
- D = breadth of glass cover (mm²),
- E = field view area (mm²),
- F = average number of observed individuals

The diversity index and equitability index by Shannon-Wier (1949),

\[ H' = - \sum (p_i \ln p_i) \] (2)

Where
- H' = index of species diversity,
- \( p_i = \) species abundance at rank -1,
- N = total abundance

The evenness index (e)

\[ E = \frac{H'}{H'_\text{max}} \] (3)

Where
- e = (Index of evenness or stability),
- \( H'_{\text{max}} = \log 2 S = 3.3219 \log 10S \),
- S = the number of taxa in a community.

To know the dominance of certain types in the waters can be used Simpson dominance index,

\[ D = \sum_{i=1}^{S} \left| \frac{n_i}{N} \right|^2 \] (4)

where
- D = Simpson dominance index,
$N_i =$ individual type of rank -i,
$N =$ total number of individuals,
$S =$ number of genera.

Index of dominance between 0-1; $D = 0$, means that no species dominate other species or community structures in a stable state;
$D = 1$, there is a species that dominates other species or unstable community structures, because of the ecological pressures.

Saprobik Index (SI) Persoone & de Pauw is used to determine the level of contamination of organic matter in water [2][7].

\[
SI = \frac{C + 3D + B - 3}{A + B + C + D} 
\]

(5)

where,
$SI =$ saprobic coefficient (-3 to 3),
$A =$ Ciliata organism group
$C =$ Chloroccales and Diatomae organism group
$D =$ Peridinae, Chrysophyceae and Conjugaeceae organism group
$A, B, C$ and $D =$ the amount of different organism of each group

Index Saprobic Trophic is

\[
TSI = \frac{1(nC + 3(nD) + (nB) - 3(nA))}{1(nA) + 3(nB) + 1(nC) + 1(nD)} \times \frac{\frac{nA + nB + nC + nD + nE}{nA + nB + nC + nD}}{2} 
\]

(6)

where
$N =$ number of individual organisms in each group of saprobity,
$NA =$ the number of individual composers of the polysaprobik group,
$NB =$ the number of individual composers of the α-Mesosaprobic group,
$NC =$ the number of individual composers of the β-Mesosaprobic group,
$ND =$ the number of individual composers of the Oligosaprobik group,
$NE =$ the number of individual composers other than A, B, C and D

Index Pollution method is use to determine the level of relative pollution toward the parameter of water quality needed with formula (Nemerow and Sumitomo, 1970)

\[
IP_j = \sqrt{\frac{(C_i / L_{ij})_M}{2} + \frac{(C_i / L_{ij})_R}{2}} 
\]

(7)

In which:
$IP_j =$ index of pollution for j
$C_i =$ parameter of concentration of water quality i
$L_{ij} =$ parameter of quality which submitted in quality j water
$M =$ maximum
$R =$ average

There are 4 IP (Index Pollution) class with score $0 \leq IP \leq 1.0$ fullfilled quality standard, $1.0 \leq IP \leq 5.0$ slightly polluted, $5.0 \leq IP \leq 10$ moderately polluted and $IP \geq 10$ status of the water heavily polluted. The observed parameter consist of 12 parameters, there are turbidity, pH, sulfida, phenol, DO, BOD$_5$, PO$_4$ (phosphat), nitrat , metal Cd, Cu, Pb and Zn.

3. Results and Discussion
The mean average concentration of heavy metal under sea water at three estuaries when LTL is bigger than when its HTL, but for Cu concentration when LTL smaller than when its HTL. Heavy metal concentration, both when its LTL or HTL each are Cd around 0.033 and 0.048 mg/kg, Cu around 0.046 and 0.070, Pb around 0.48 and 0.71 mg/kg and Zn around 0.043 and 0.057 mg/kg (Figure 1).
Figure 1. Heavy metal concentration in sea water at three estuaries around PTES

Zn concentration at three estuaries each Zn around 23.253 and 53.957 mg/kg, Pb around 7.583 and 18.0 mg/kg, Cu around 6.947 and 22.03 mg/kg meanwhile Cd around 0.247 and 0.351 mg/kg. Concentration Zn is on highest rank then followed by Cu, Pb and last, Cd. All of metal element concentration are on highest rank at Kali Baru estuary (Figure 2).

Figure 2. Heavy metal concentration in sediment at three estuaries around PTES

H’ index (diversity) at three estuaries when its HTL around 0.65 and 1.65 meanwhile when LTL around 0.975 and 1.88 which shows when its LTL, the estuary of Kali Baru is heavily polluted, BKT moderate and Siangker heavily polluted. When the condition HTL and each is heavily polluted, moderate and moderate. The uniformity index (e) at LTL ranges from 0.37 and 0.66 while in HTL 0.425 and 0.71. The higher the uniformity index value indicates that all species are more abundant while the lower shows the smaller [5]. The dominance index (D) at LTL ranges from 0.32 and 0.7 whereas when the tide ranges from 0.21 and 0.565. Based on the index, the three river estuaries showed a heavily polluted condition when LTL, while when HTL of Kali Baru river, BKT and Siangker each showed heavily, moderate and heavily polluted (Figure 3).
Saprobity Index (SI) value is when it’s HTL or LTL close to similar of the three estuary. Meanwhile TSI value at three estuary get several difference in which when it’s HTL the value will be bigger compared when it’s LTL (Table 1.). At three estuaries, the value of saprobity counted as oligosaprobic waters, in which slightly polluted or haven’t polluted [3].

Table 1. SI and TSI phytoplankton at three estuary at October 2015 around PTES

| Stations/Tides | Baru | BKT | Siangker |
|---------------|------|-----|----------|
| SI LTL        | 1.925| 1.33| 1.8      |
| SI HTL        | 1.925| 1.28| 1.8      |
| TSI LTL       | 3.255| 4.08| 3.22     |
| TSI HTL       | 3.545| 6.12| 3.98     |

There are four classes of phytoplankton found in October 2015 named Bacillariophyceae, Dinophyceae, Chrysophyceae and Cyanophyceae where the abundance at HTL is greater than at LTL. The abundance of Skeletonema when HTL or LTL dominate between the other genus (Table 2)

Table 2. The abundance of phytoplankton in HTL or LTL on three estuaries on October 2015

| No. | Genus          | Estuaries | LTL | HTL |
|-----|----------------|-----------|-----|-----|
|     |                | Baru | BKT | Siangker | Baru | BKT | Siangker |
| A.  | Bacillariophyceae |      |     |          |      |     |          |
| 1   | Skeletonema sp.  | 13822| 122 | 20255     | 32197| 34  | 13248     |
| 2   | Syndra sp.       | 127.5| 8   | 255       | 2357 | 20  | 637       |
| 3   | Rhizosolenia sp. | 95.5 | 8   | 637       | 732.5| 4   | 1083      |
| 4   | Asteroinella sp. | 605  | -   | -         | 1306 | 1   | -         |
| 5   | Chaetoceros sp.  | 286.5| 4   | 573       | 1242 | 1   | 955       |
6  *Thalassionema sp.*  159  14  -  10350  6
7  *Thalassiothrix sp.*  478  30  2357  1337.5  52  1720
8  *Navicula sp.*  32  -  -  32  -  -
9  *Cyclotella sp.*  63.5  3  -  700.5  1  -
10  *Stephanopyxis sp.*  63.5  -  -  63.5  -  -
11  *Guanardia sp.*  -  27  -  0  18  191
12  *Coscinoduscus sp.*  -  -  382  318.5  3  955
13  *Pleurosygma sp.*  -  -  -  3  -  -
14  *Bacteriasrum sp.*  32  -  -  -  -  -
15  *Pleurozygma sp.*  -  6  127  -  -  -
16  *Hemiaulus sp.*  -  -  -  -  -  -
17  *Eucampia sp.*  -  4  -  -  -  -
18  *Biddulphia sp.*  -  4  -  -  2  -
19  *Nitzschia sp.*  6.5  -  -  -  -  -
20  *Asterionella gracialis*  -  -  -  -  -  -
21  *Amphora sp.*  -  -  -  -  -  -
22  *Thallasiostra sp.*  -  -  -  -  -  -
23  *Gyrosigma sp.*  -  -  -  -  -  -
B.  *Dinophyceae*
24  *Ceratium sp.*  -  -  382  -  -  446
25  *Protoperidinium sp.*  -  -  -  -  -  -
26  *Noctiluca sp.*  -  -  -  1  382  -
27  *Ornithocercus sp.*  -  -  -  -  -  -
C.  *Chrysophyceae*
28  *Peridinium sp.*  -  -  -  -  -  191
29  *Pyrocystis sp.*  -  -  -  -  -  -
30  *Dictyoacha sp.*  -  -  -  -  -  -
D.  *Cyanophyceae*
31  *Anabaenopsis sp.*  95.5  1  -  63.5  2  -
Total  15866.5  231  24968  50700  148  19808

The zooplankton biodiversity index in October at HTL ranged from 1.92 and 2.26 while at LTL ranged from 1.13 and 2.22 indicating that Kali Baru estuary and BKT were slightly polluted while the Siangker estuary was slightly polluted. The uniformity index (e) shows that the species condition is abundant except for the LTL condition at the Kali Baru estuary. The dominant index on the three river estuaries indicates the absence of a species dominance in these waters (Figure 4).
Figure 4. The index values of $H'$, $e$ and $D$ zooplankton in October 2015 in three estuaries around PTES

The *Acartian* genus dominates on three estuaries compared to *Microstella sp.* and *Trocophora sp.* Where the abundance of zooplankton is more at the Kali Baru estuary than in other waters. Crustacean class is more dominant than other classes, where in that class found 21 species of genus while in class *Ciliata* only found 13 genus while class *Cirripida* least found (Table 3).

Table 3. The abundance of zooplankton at HTL and LTL on three estuaries in October 2015 around PTES waters

| No. | Genus              | HTL       | LTL       |
|-----|--------------------|-----------|-----------|
|     |                    | Baru  | BKT  | Siangker | Baru  | BKT  | Siangker |
| 1   | *Nauplius*         | 2.12  | -    | -       | -     | -    | -       |
| 2   | *Corycaeus*        | 0.64  | -    | -       | -     | -    | -       |
| 3   | *Acartia*          | 3.48  | 7.64 | 13      | 28.5  | 6    | 6       |
| 4   | *Calanus*          | 0.64  | 2.55 | 25      | 12.5  | 2    | 19      |
| 5   | *Oithona*          | 0.85  | 6.37 | 38      | 19    | 5    | 51      |
| 6   | *Euterpina sp.*    | -     | -    | 6       | 16    | -    | -       |
| 7   | *Eurytemora sp.*   | -     | 5.1  | 25      | 22.5  | 4    | 19      |
| 8   | *Undinopsis sp.*   | -     | -    | -       | -     | -    | -       |
| 9   | *Oncaea sp.*       | -     | 1.27 | -       | -     | -    | -       |
| 10  | *Eucalanus sp.*    | -     | -    | -       | -     | -    | -       |
| 11  | *Microsetella sp.* | -     | -    | -       | -     | 1    | -       |
| 12  | *Parvocalanus sp.* | -     | -    | 13      | -     | -    | -       |
| 13  | *Evadne sp.*       | -     | -    | -       | -     | -    | -       |
| 14  | *Euphausia sp.*    | -     | -    | -       | -     | -    | -       |
| 15  | *Tigriopus*        | -     | 1.27 | -       | -     | 4    | -       |
| 16  | *Paracyclopinia sp.*| - | -    | -       | -     | -    | -       |
17 Canthocalanus sp. - - - - - -
18 Acrocalanus sp. - - - - - -
19 Podon sp. - - - - - -
20 Sergia sp. - 1.27 - - 1 -
21 Sapphirina sp. - - - - - -

**Ciliata**

22 Eutintinnus 6.115 - - - - -
23 Salpingella 1.27 - - - - -
24 Codonellopsis 5.48 - - - 1 -
25 Epicycloclysis 3.32 - - - - -
26 Achantostomella 5.32 1.27 - - 8 -
27 Lepro tininnus sp. - 2.55 6 3 2 19
28 Sclocalethrix sp. - - - - - -
29 Tintinnopsis sp. 11 17.84 25 32 30 -
30 Parafavella sp. - - - - 3 6
31 Favella sp. - 5.1 - - 7 -
32 Xystonellopsis sp. 6.5 - - - - -
33 Rhabdonella - - - - - -
34 Dictyoscysta sp. - - - - - -
35 Trocophora sp. - - - - 1 -

**Scyphomedusae**

36 Trichocerca sp. - - - -
37 Branchionus sp. - 5.1 - - 13

**Tentaculata**

38 Notholca sp. - - - -
39 Salpinengacantha 5.48 - - - - -
40 Rhodonella sp. 5 - - - - -
41 Trocophora sp. - - - - - -
42 Balanus - - - 3 3 6
43 N Eurytermora - - - - - -
44 N Euphasia - - - - - -
45 N Oithona - - - - - -
46 N Acartia - - - - - -

**Branchiolaria sp.**

47 Branchiolaria sp. 8 - - - - -

**Cirripeda**

48 Balanus - - - - - -

**Total** 65.215 57.33 151 136.5 91 126

Diversity value in Kali Baru estuary at HTL or LTL show that biota community is not stable or heavily polluted while at another water area is slightly polluted to moderate. These things seen at the value of homogeneity at Kali Baru estuary which is equally relative of homogeneity while for another estuary territory low species homogeneity is occurred. Ecological pressure is occured at Kali Baru...
estuary rather than other water in BKT and Siangker because domination value that close to one. This thing is because of the pressure form domestic waste and shipyard around the estuary (Figure 5).

Saprobity water condition is in oligosaprobik condition or slightly polluted or haven’t polluted at all except at HTL at BKT is in condition β-mesosaprobik which is polluted condition at low to medium level (Table 4).

In November there is amount of class that fewer than in the earlier month at west season, there are only three classes which are Bacillariophyceae, Dinophyceae, Chrysophyceae dan Cyanophyceae. Skeletonema genus is still dominating followed by Synedra sp. and the last is Thalassiothrix sp. and Pyrocystis sp. (Table 5).
Table 6. Zooplankton abundance when HTL and LTL in all three estuaries in November 2015

| No. | Genus                  | HTL     | Station         | LTL     |
|-----|------------------------|---------|-----------------|---------|
|     |                        | Baru    | BKT             | Siangker| Baru    | BKT     | Siangker|
| A.  | Crustacea              |         |                 |         |         |         |         |
| 1.  | Acartia                | 25.4775 | 15.92           | 35.03   | 19.11   | 15.92   | 9.55    |
| 2.  | Calanus                | 3.1845  | 6.37            | 22.29   | 7.96    | 9.55    | 19.11   |
| 3.  | Oithona                | 19.1085 | 41.4            | 73.23   | 25.48   | 12.74   | 22.29   |
| 4.  | Euterpina sp.          | 0       | 3.18            | 0       | 1.59    | 3.18    | 0       |
| 5.  | Eurytemora sp.         | 19.1085 | 9.55            | 22.29   | 12.735  | 12.74   | 9.55    |
| 6.  | Eucalanus sp.          | 0       | 0               | 3.18    | 0       | 9.55    | 9.55    |
| 7.  | Macrostella sp.        | 0       | 0               | 3.18    | 0       | 3.18    | 0       |
| 8.  | Parvocalanus sp.       | 6.3695  | 15.92           | 38.22   | 3.185   | 3.18    | 12.74   |

Figure 6. Index value $H'$, $e$ and $D$ zooplankton in November 2015 in three estuaries around PTES
|    | Species               | H' (HTL) | e (HTL) | D (HTL) | H' (LTL) | e (LTL) | D (LTL) |
|----|-----------------------|----------|---------|---------|----------|---------|---------|
| 9  | Tigriopus             | 0        | 3.18    | 3.185   | 0        | 0       | 0       |
| 10 | Undinopsis sp.       | 0        | 0       | 1.59    | 0        | 0       | 0       |
| 11 | Ctenocalamus sp.      | 0        | 0       | 0       | 6.37     | 6.37    |         |
| 12 | Metridia sp.         | 0        | 0       | 1.59    | 0        | 0       | 0       |
| 13 | Brachionus sp.        | 0        | 3.18    | 6.37    | 0        | 0       | 0       |
| 14 | Cytemnestra sp        | 0        | 0       | 0       | 3.185    | 0       | 0       |
| 15 | Globigerina sp        | 0        | 0       | 0       | 0       | 3.18    |         |
|    | **B. Ciliata**        |          |         |         |          |         |         |
| 16 | Codonellopsis        | 0        | 0       | 0       | 3.185    | 0       | 0       |
| 17 | Achanstostomella      | 0        | 0       | 0       | 3.185    | 0       | 0       |
| 18 | Leprotintinnus sp.    | 6.3695   | 3.18    | 15.92   | 31.845   | 0       | 0       |
| 19 | Tintinnopsis sp.      | 12.7395  | 0       | 0       | 14.33    | 0       | 0       |
| 20 | Parafavella sp.       | 0        | 3.18    | 9.55    | 0        | 6.37    | 22.29   |
| 21 | Favella sp.           | 0        | 6.37    | 6.37    | 6.365    | 0       | 0       |
|    | **C. Tentaculata**    |          |         |         |          |         |         |
| 22 | Notholca sp.          | 0        | 0       | 0       | 0        | 22.29   | 0       |
|    | **D. Rotatoria**      |          |         |         |          |         |         |
| 23 | Balanus               | 0        | 0       | 0       | 6.37     | 3.18    | 9.55    |
|    | **E. Mollusca**       |          |         |         |          |         |         |
| 24 | Trocophora sp.        | 0        | 0       | 0       | 3.185    | 0       | 0       |
|    | **F. Cirripeda**      |          |         |         |          |         |         |
| 25 | Balanus               | 3.1845   | 0       | 6.37    | 0        | 0       | 0       |
|    | **Total**             | 95.542   | 111.43  | 242     | 148.075  | 108.25  | 124.18  |

Figure 7. Index value H’, e and D phytoplankton in December 2015 in three estuaries around PTES
### Table 7. SI and TSI phytoplankton in three estuary in December 2015 around PTES

| Station/Tide | Baru | BKT | Siangker |
|--------------|------|-----|----------|
| SI HTL       | 1    | 0   | 1        |
| SI LTL       | 1    | 1.67| 1        |
| TSI HTL      | 2.745| 0   | 1.13     |
| TSI LTL      | 2.62 | 2.7 | 2.32     |

### Table 8. Phytoplankton abundance when HTL and LTL in all three estuaries in December 2015

| No. | Genus | HTL Station | LTL Station |
|-----|-------|-------------|-------------|
|     |       | Baru | BKT | Siangker | Baru | BKT | Siangker |
| A.  | Bacillariophyceae | 1 | 16410.83 | 2886.4 | 5391.72 | 3949.04 | 9235.67 |
| 1   | Skeletonema sp.   | 2 | 63.695 | 828.03 | 63.695 | 764.33 | 1592.36 |
| 2   | Rhizosolenia sp.  | 3 | 3.185 | 4012.74 | - | - | - |
| 3   | Asteroinella sp.  | 4 | 713.38 | 382.17 | 264.33 | - | - |
| 4   | Chaetoceros sp.   | 5 | - | 573.25 | - | - | - |
| 5   | Thalassionema sp. | 6 | 35.03 | - | 127.39 | - | - |
| 6   | Thalassiothrix sp.| 7 | 334.395 | 318.47 | 1436.305 | - | 1783.44 |
| 7   | Cyclotella sp.    | 8 | - | - | - | 254.78 | - |
| 8   | Stephanopyxis sp. | 9 | - | - | 1146.5 | 130.575 | - |
| 9   | Guinardia sp.     | 10 | 73.25 | 127.39 | 130.575 | - | - |
| 10  | Coscinodiscus sp.| 11 | 82.805 | 764.33 | 63.695 | 318.47 | - |
| 11  | Pleurosygma sp.   | 12 | - | 191.08 | - | - | - |
| 12  | Hemialus sp.      | 13 | 168.79 | 1910.83 | 512.74 | - | 445.86 |
| 13  | Biddulphia sp.    | 14 | 191.08 | - | - | - |
| 14  | Helosira sp.      | B.  Dinofyceae | 15 | 254.775 | 700.64 | 226.115 | 1401.27 | 2292.99 |
| C.  | Chrysophyceae     | 16 | 63.695 | 191.08 | 63.695 | - | - |
| D.  | Chyanophyceae     | 17 | 63.695 | 127.39 | - | - | - |
| 17  | Anabaenopsis sp.  | 18 | 191.08 | 1719.75 | 194.27 | - | - |
| 18  | Oscillatoria sp.  | Total | 18458.605 | 16071.13 | 8605.105 | 6687.89 | 15350.32 |
Figure 8. Index value $H'$, $e$ and $D$ for zooplankton in December 2015 in the three estuaries around of PTES.

Table 9. Zooplankton abundance HTL or LTL on the three river estuary in December 2015

| No. | Genus                | HTL         | LTL         | HTL         | LTL         |
|-----|----------------------|-------------|-------------|-------------|-------------|
|     |                      | Baru        | BKT         | Siangker    | Baru        | BKT         | Siangker    |
| A.  | Crustacea            |             |             |             |             |
| 1   | Acartia              | 11.4655     | 0           | 42.04       | 8.9175      | 10.191      | 3.82        |
| 2   | Calanus              | 5.096       | 0           | 11.46       | 0.637       | 1.274       | 1.27        |
| 3   | Oithona              | 14.0125     | 0           | 91.72       | 14.014      | 6.369       | 1.27        |
| 4   | Euterpinia sp.       | 3.185       | 0           | 0           | 6.37        | 0           | 1.27        |
| 5   | Eurytemora sp.       | 4.459       | 0           | 3.82        | 3.1845      | 2.548       | 0           |
| 6   | Oncaea sp.           | 0           | 0           | 6.37        | 0           | 0           | 0           |
| 7   | Parvocalanus sp.     | 5.0955      | 0           | 0           | 4.459       | 0           | 0           |
| 8   | Tigriopus            | 1.274       | 0           | 0           | 3.185       | 1.274       | 0           |
| 9   | Acrocalanus sp.      | 3.185       | 0           | 0           | 0           | 0           | 0           |
| 10  | Sergia sp.           | 0.637       | 0           | 0           | 0           | 0           | 0           |
| 11  | Lucicutia sp.        | 1.274       | 0           | 2.55        | 3.185       | 0           | 0           |
| 12  | Eutintinus           | 0           | 0           | 2.55        | 0           | 0           | 0           |
| 13  | Canthocalanus sp     | 0           | 0           | 0           | 0.637       | 0           | 0           |
| B.  | Ciliata              |             |             |             |             |
| 14  | Leprotintinnus sp.   | 10.192      | 0           | 15.29       | 21.021      | 2.548       | 8.92        |
| 15  | Tintinnopsis sp.     | 14.0135     | 0           | 57.32       | 16.2405     | 2.548       | 7.64        |
| 16  | Parafavella sp.      | 0           | 0           | 0           | 0           | 1.274       | 0           |
| 17  | Favella sp.          | 0           | 0           | 1.27        | 4.775       | 0           | 1.27        |
| C.  | Mollusca             |             |             |             |             |
Table 10. Physical-chemical waters parameters

| Parameter   | Unit | Baru HTL | BKT HTL | Siangker HTL | Quality [6] |
|-------------|------|----------|---------|--------------|-------------|
| Temperatur  | °C   | 27.82    | 30.18   | 18.43        | 30.3        |
| Depth       | meter| 6.257    | 6.33    | 1.26         | 1.62        |
| Brightness  | meter| 1.08     | 1.27    | 0.71         | 0.63        |
| TDS         | mg/l | 303.7    | 508.5   | 426          | 447.67      |
| Salinity    | %    | 33.35    | 33.2    | 22.3         | 27.67       |
| pH          |      | 7.887    | 7.812   | 5.327        | 7.94        |
| DO          | mg/l | 5.573    | 4.157   | 3.33         | 5.75        |
| Nitrate     | mg/l | 0.19     | 0.14    | 0.0365       | 0.53        |
| Phosphat    | mg/l | 0.955    | 0.455   | 0.84         | 0.483       |
| Turbidity   | NTU  | 33.125   | 36.87   | 27.25        | 16.59       |
| Sulfide     | mg/l | 0.065    | 0.088   | 0.075        | 0.063       |
| Phenols     | mg/l | 0.018    | 0.022   | 0.033        | 0.034       |
| BODs        | mg/l | 3.265    | 1.617   | 2.175        | 1.557       |

The pollution contamination index on the three river estuaries shows highly polluted conditions. The BKT and Siangker estuaries are higher at HTL while at LTL at the estuary of the BKT river having the highest value (Table 11).

Table 11. IP values on the three estuaries around PTES waters from October to December 2015

| No. | Parameters | HTL C_{max} | LTL C_{max} | HTL C_{max} | LTL C_{max} | L_{ij} | IP HTL | IP LTL |
|-----|------------|--------------|--------------|--------------|--------------|--------|--------|--------|
| 1   | Turbidity  | 62.5         | 32.1         | 19.5         | 113          | 98.5   | 5      |        |
| 2   | pH         | 7.96         | 8.07         | 7.95         | 7.93         | 7.88   | 8      |        |
| 3   | Sulfide    | 0.07         | 0.08         | 0.08         | 0.23         | 0.11   | 0.08   | 0.01   |
| 4   | Phenol     | 0.027        | 0.04         | 0.037        | 0.03         | 0.032  | 0.04   | 0.002  |
| 5   | DO         | 5.7          | 5.2          | 5.4          | 5.2          | 8.94   | 5.9    | 5      |
| 6   | Cd         | 0.05         | 0.049        | 0.045        | 0.049        | 0.058  | 0.052  | 0.01   |
| 7   | Cu         | 0.072        | 0.067        | 0.061        | 0.06         | 0.066  | 0.077  | 0.05   |

Table 11. IP values on the three estuaries around PTES waters from October to December 2015.
4. Conclusion
Pollution index from all three estuaries shows the most heavily polluted condition which are in BKT and Siangker the value is higher when the HTL, and when the LTL BKT estuary has the highest value. The result obtained from 12 parameters which were tested showed that the three waters can be categorized in heavily polluted condition at each value from 12.52 to 24.98, the concentration of heavy metal at sea water during HTL and LTL ranged from Cd is around 0.033 and 0.048 mg/kg, Pb 0.48 and 0.71 mg/kg, and Zn 0.043 and 0.057 mg/kg. the saprobity value index based on the existence of phytoplankton or zooplankton was ranged of Oligosaprobl as a slightly polluted or haven’t been polluted.

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