Determination of water quality condition from water samples around location of ship to ship transfer of coal in Balikpapan, East Kalimantan, Indonesia

I Suyatna¹, R I Riadi², I J Feriyanto², Ghitarina¹, B I Gunawan¹, R R Sasono³, A Rafii¹

¹ Faculty of Fisheries and Marine Science, Mulawarman University, Samarinda, East Kalimantan, Indonesia
² Office of Marine Affairs and Fisheries, East Kalimantan, Indonesia
³ Office of Governor of East Kalimantan, Indonesia

Email: isuyatna@ymail.com

Abstract. A collection of water samples from area of Ship To Ship (STS) transfer of coal in Balikpapan was carried out in June - November 2018 to provide data for a study related to issues on fish catch decline in the area that was claimed by mini trawlers. The study aimed to determine and assess water quality parameters which play an important role on the current issues. All samples were taken in six sampling sites between the shore and the STS, and the nearest sampling site was 0.18 km and the farthest was 5.5 km from the STS. Each sample consisted of 27 analysed parameters including eight heavy metals. Results of laboratory analysis showed that the concentration of water transparency, DO (dissolved oxygen), turbidity, TSS (total suspended solid), temperature, NH₃, PO₄-P and NO₃-N in the sampling sites far from the STS were found higher than those ones near the STS. In contrary, the concentration of pH, salinity, BOD₅ and Phenol were noticed to be high near the STS. Others such as odour (smell), debris, oil layer and H₂S were observed nil, while CN, oil and fat and MBAS (methylene blue active substances) showed the same concentration at all sampling sites. Hence, all of the concentration was in the range of allowable limit according to KepMen LH No.51 Year 2004 except for PO₄-P and NO₃-N. From eight heavy metals, Hg, As, Cd, Cu, Zn and Ni were discovered to comply with the regulation while two metals Cr (IV) and Pb reached the limit. The study concluded that the water quality around the STS transfer was generally in favourable condition. However, harmful algal blooms could be occurred since the study area was detected to have high concentration of nutrients.

1. Introduction

Known as the maritime transportation, industrial and commercial city, Balikpapan is the second most populous city of East Kalimantan after Samarinda. As maritime transportation, Balikpapan has been completed with floating terminal for ship to ship (STS) transfer of coal, shipyards, and seaports for passengers and cargo as well (such as crude palm oil (CPO) and coal). A STS is a place at sea where coal is transferred to another ship. These human activities affect marine pollution [1], and in many instances vessels intentionally discharge illegal both wastewater and wastes which have a negative impact on the marine environment, demersal fishes and benthic habitats due to accumulated cargo deposits and the food chains for marine organisms. Heavy metal level in fish samples obtained from a
STS in Muara Badak East Kalimantan was higher than the recommended permissible limit [2]. The rapid development of industries and human population and urbanization in the city contribute to an accumulation increase of heavy metal in coastal waters [3].

Therefore, a large amount of wastewater disposal from communities should be also considered as another major pollution on the seawater and could enhance negative influences of water quality conditions. Nutrient pollution is perhaps less widely recognized as a threat to coastal marine ecosystems than other pollution [4]. Meanwhile, nutrient pollution stimulates excessive growths of algae that cause algal blooms which is physically able to decrease oxygen concentration, increase pH of waters, and affect productivity of fish [5]. Industries, communities, oil spill and fuel leak from boats are source of certain heavy metals such as Pb (lead) and Cd [6]. In general, concentration of heavy metals (in mg/kg) for most coals according to [7] is Cr (0.5-60), Co (0.5-30), Cu (5-50), Pb (0.5-80), Mn (5-80), Mn (5-300), Ni (0.2-50), Zn (0.2-300), Hg (0.5-1), Ag (0.5-2) and As (0.5-80), while coal ash and coal waste contain toxic heavy metals such as Cr, Co, Cu, Pb, Mn, Ni, Zn, Hg, Ag, and As. Chronic coal exposure can cause lethal effect on corals, reduction in seagrass and fish growth rates [8], water acidity in river downstream [9,10].

Coal is one of the oldest and most widespread anthropogenic contaminants in marine and estuarine environments and has been traded by sea at least since Roman times [11]. This study was carried out to evaluate water quality related to the present issues of fish catch decrease of mini trawlers and to observe coastal environment around location of STS transfer in Balikpapan reported by fishers. While the aim of the study was to identify the condition of the water quality for marine biota and potential land effect to the study area.

2. Materials and Methods

2.1. Study area

Study area was located around the location of Ship To Ship (STS) transfer of coal in Balikpapan. The distance from the coast to the area is within 10.63 km or 5.70 nautical miles. According to the depth gauge that was installed inside the floating terminal, the water depth showed -30.0 m.

2.2. Water samples

Water samples were taken on November 23 to 24, 2018 and January 2019 from six sampling sites at the surface water. Sites were determined by GPS Garmin 60CSx. Two sampling sites were located 203 m and 1173 m near the STS, and four others were in between 1921 m to 5884 m from the STS. Samples were moved into glass bottles of 2000 ml, six bottles were preserved with HNO₃ but the other six with no preservation for physic-chemical analysis. All bottles of sample were put into a cool box and brought to laboratory for further treatments. The parameters analysed were water temperature, transparency, odour, turbidity, oil layer, salinity, total suspended solid (TSS), pH, DO, BOD₅, NO₃, NH₃, H₂S, PO₄, CN, Phenol, MBAS, oil and fat and heavy metals (Hg, Cr, As, Cd, Cu, Pb, Zn, Ni). Temperature and pH was measured by Ohaus type starter 300 pH meter, while salinity and DO was measured in site using Atago hand refractometer and Schott Duran winkler bottle respectively.

2.3. Laboratory used

Preparation of all water samples and parameters analysis were organized and conducted under Water Quality Laboratory (KAN√ISO/IEC 17025), Faculty of Fisheries and Marine Science, Mulawarman University, Samarinda East Kalimantan. We also used other laboratories such as Sucofindo, Baristand (Research and Industrial Standardization Center), Ministry of Industry Republic of Indonesia and Mutu Agung Lestari in Samarinda for cross reference needs. Determination of heavy metals was based on Atomic Absorption Spectrophotometer on the basis of the standard of the [12,13,14].

2.4. Data analysis

The data of water quality parameters resulted from laboratory analysis were compared to the standard concentration limit of government regulation [15] to assess the water quality condition for marine
biota at the location around STS transfer. Other national and international water quality guidelines as well as literatures (articles and scientific reports) were also considered.

3. Results and Discussion
Figure 1 shows the location of STS transfer, floating terminal and stockpile inside the terminal. The six sampling sites were located around the location of the STS (see the box). The laboratory analysis of physic-chemical parameters from six sampling sites shows that the concentration of water transparency, DO (dissolved oxygen), turbidity, TSS (total suspended solid), temperature, NH$_3$, PO$_4$-P and NO$_3$-N in the sites far from the STS were found higher than near ones.

Figure 1. Map showing the sampling site distribution (left) and location (area) of STS transfer and the floating terminal (right)

Odour (smell), debris, oil layer and H$_2$S were observed nil, while CN, oil and fat and MBAS (methylene blue active substances) exhibited the same concentration at all sampling sites. Hence, all of the concentration was below the government regulation [15], except PO$_4$-P and NO$_3$-N. From the eight heavy metals, Cr (IV) and Pb reached the limit while the remaining Hg, As, Cd, Cu, Zn and Ni were discovered below the standard limit. Up to this point, the present issues of fish catch decrease of mini trawlers reported by fishers around the location seem being difficult to relate with the effect from STS transfer of coal. Table 1 shows the concentrations of all parameters analysed.

However, PO$_4$-P and NO$_3$-N and ammonia (NH$_3$), were extremely exceeding the allowable limit according to the same guideline. In order to make sure of those concentrations, we repeated taking water samples in January 2019 in the same sampling sites for obtaining more information of phosphate and nitrate as well as ammonia. The results presented in the Table 2,3 and 4 below. Each laboratory (Sucofindo, Baristand and Mutu Agung Lestari) that analysed these parameters, the results varied, from below to extremely above the standard limit.

Table 1. Results of the water samples analysis from six sampling sites around the location of STS transfer in Balikpapan

| Parameter          | Sampling site | Reference of standard limit |
|--------------------|---------------|-----------------------------|
|                    | 1  2  3  4  5  6 |                             |
|                    | 20mW 20mE 25mW 25mE 30mW 30mE |                     |
| Transparenr.(m)    | 7.3  7.5  9.2  9.4  15.2  14.9 | Natural                 |
| Odour              | Nat  Nat  Nat  Nat  Nat  Nat | Natural                 |
| Turbidit.(NTU)     | 3  3  0  2  0  0 | <5$^1$                  |
Table 2. Results of the Sucifindo laboratory analysis of the water samples from six sampling sites around location of STS transfer of coal in Balikpapan, January, 2019

| Parameter          | 20mW | 20mE | 25mW | 25mE | 30mW | 30mE |
|--------------------|------|------|------|------|------|------|
| TSS (mg/l)         | 12   | 12   | 6    | 8    | 5    | 5    |
| *Waste*            | Nil  | Nil  | Nil  | Nil  | Nil  | Nil  |
| Temperature °C     | 31   | 31   | 30   | 30   | 28   | 28   |
| Oil lay. (mg/l)    | Nil  | Nil  | Nil  | Nil  | Nil  | Nil  |
| pH                 | 7.43 | 7.43 | 8.05 | 8.15 | 8.09 | 8.06 |
| Salinity (%)       | 30   | 30   | 30   | 30   | 35   | 35   |
| DO (mg/l)          | 5.84 | 5.84 | 5.68 | 5.68 | 5.20 | 5.52 |
| BOD₅ (mg/l)        | 2.68 | 2.68 | 3.08 | 3    | 3.36 | 2.52 |
| NH₃ (mg/l)         | 0.33 | 0.33 | 0.15 | 0.27 | 0.13 | 0.17 |
| PO₄-P (mg/l)       | 0.04 | 0.04 | 0.09 | 0.05 | 0.01 | 0.04 |
| NO₂-N (mg/l)       | 0.64 | 0.64 | 0.19 | 0.73 | 0.35 | 0.29 |
| CN (mg/l)          | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| H₂S (mg/l)         | Nil  | Nil  | Nil  | Nil  | Nil  | Nil  |
| Phenol (mg/l)      | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| MBAS (mg/l)        | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| Oil & fat (mg/l)   | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Hg (mg/l)          | <0.0003 | <0.0003 | <0.0003 | <0.0003 | <0.0003 | <0.0003 |
| Cr (VI) (mg/l)     | <0.007 | <0.007 | <0.007 | <0.007 | <0.007 | <0.007 |
| As (mg/l)          | <0.003 | <0.003 | <0.001 | <0.003 | <0.001 | <0.001 |
| Cd (mg/l)          | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Cu (mg/l)          | <0.007 | <0.007 | <0.007 | <0.007 | 0.010 | <0.007 |
| Pb (mg/l)          | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Zn (mg/l)          | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 |
| Ni (mg/l)          | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |

1KepMenLH (the Decree of State Minister for the Environment)no: 51 year 2004 [15]
2Nazir et al (2015) and Malaysian Marine Water Quality Criteria Standard in Sabri et al, 2014 [16, 17]
3WHO (2003) [18]
4Governor of EastKalimantan no.339 year 1988 i.e for TSS=20mg/l (coral reef), 80mg/l (mangrove) [19]
5Australian Government (2008). Notes: 30 mW= water depth and in West. [20]
Table 3. Results of the Baristand laboratory analysis of the water samples from six sampling sites around location of STS transfer of coal in Balikpapan, January, 2019

| Parameter      | 20 m W | 20 m E | 25 m W | 25 m E | 30 m W | 30 m E | KepMen LH |
|----------------|--------|--------|--------|--------|--------|--------|-----------|
| NH₃ (mg/l)     | 0.082  | 0.039  | 0.081  | 0.072  | 0.107  | 0.108  | 0.30¹     |
| PO₄-P (mg/l)   | 0.004  | 0.002  | 0.006  | 0.006  | 0.009  | 0.003  | 0.015¹    |
| NO₃-N (mg/l)   | <0.008 | <0.008 | 0.037  | 0.030  | 0.016  | 0.108  | 0.008¹    |

¹KepMen LH no. 51 Year 2004 [15]

Table 4. Results of the Mutu Agung Lestari laboratory analysis of the water samples from six sampling sites around location of STS transfer of coal in Balikpapan, January, 2019

| Parameter      | 20 m W | 20 m E | 25 m W | 25 m E | 30 m W | 30 m E | KepMen LH |
|----------------|--------|--------|--------|--------|--------|--------|-----------|
| NH₃ (mg/l)     | 0.170  | 0.110  | 0.060  | 0.070  | 0.160  | 0.070  | 0.30¹     |
| PO₄-P (mg/l)   | 0.670  | 0.110  | 0.110  | 0.100  | 0.120  | 0.080  | 0.015¹    |
| NO₃-N (mg/l)   | 2.120  | 1.860  | 1.410  | 1.360  | 2.050  | 1.790  | 0.008¹    |

¹KepMen LH no. 51 Year 2004 [15]

Several reports on high concentration in coastal water of the mentioned three parameters reported by [21, 22, and 23], the last reporter specify to mention ammonia from 0.8 to 11.6 mg/L, nitrate from 0.009 to 0.54 mg/L and phosphate from 0.016 to 1.19 mg/L. The concentration of eight heavy metals from six sites around location of STS transfer, five of them such as Hg, As, Cu, Zn and Ni were observed to have below the standard limit based on government regulation [15], while the other three Cr (IV), Cd and Pb showed to reach the level of standard limit. The Ennore estuary in India which receives effluents discharges from heavily industrialized and highly populated settlements, from eight metals (Cu, Cd, Cr, Ni, Zn, Pb, As and Hg), Cu was higher 0.0473 mg/L, while Hg was the lower 0.0018 mg/L [24]. In coastal water sediment, Cu, Pb and Zn concentration are most influenced by wastewater discharge and organic matter, whereas Cd and Cr are known affected by biological sources of mariculture [25]. High concentration of Cd and Pb were related with heavy activities of aquaculture and fisheries [26]. Water samples collected from three locations including around the STS in Mahakam Delta, of the 10 heavy metals analysed only four were detected, Cu 0.004 mg/L, Zn 0.02 mg/l, Mn 0.01 mg/l, and Fe 0.02 to 0.73 mg/l.

On the other hand, all fishing activities including mini trawler not only have a direct impact on target species and by catch but also on marine ecosystem such as population structure, habitats, biodiversity and productivity [27]. Anthropogenic activities in city of Balikpapan might be the major sources of phosphate, nitrate and ammonia pollution in aquatic ecosystems in Balikpapan.

4. Conclusion
Water quality around the STS transfer in Balikpapan was generally observed in favourable condition, and included as an eutrophic water (water transparency: <10m). However, the concentration of three from eight heavy metals reached the standard limit. In addition, phosphate and nitrate were determined extremely high and therefore regular water quality monitoring is urgently needed. High concentration of ammonia, nitrate and phosphate exceeding the permissible limit was supposed to have a relation to the rapid development of industries and human population and urbanization in Balikpapan (anthropogenic activities).
Acknowledgments

Authors express gratitude to Faculty of Fisheries and Marine Science, Mulawarman University for supporting the facility and Prof Achmad Syafei Sidik for his suggestion and correction. We also thank Muhammad Raafi, Zainal Haris, Muhammad Mutaqin, Husen for their help during survey and laboratory analysis.

References

[1] Rusdianasari, Arita S, Ibrahim E, Ngudiantoro 2013 Evaluation of environmental effect of coal stockpile in Muara Telang, Banyuasin, IOP Publishing. Indonesia. Journal of Physics: Conference Series 423 (2013) 012053 doi:10.1088/1742-6596/423/1/012053

[2] Suyatna I, Sulistyawati, Adnan A, Syahirr, Ghitairina G, Abdunnur A, Syahrul S 2017 AACL Bioflux, 10 (5): 1319-1329. http://www.bioflux.com.ro/aacl

[3] Armid A, Shinjo R, Ruslan R and Fahmiati 2017 Distributions and pollution assessment of heavy metals Pb, Cd and Cr in the water system of Kendari Bay, Indonesia. IOP Conf. Ser.: Mater. Sci. Eng. 172 012002: 1-8

[4] Nixon SW and Fulweiler RW 2009 Nutrient pollution, eutrophication, and the degradation of coastal marine ecosystems. Global loss of coastal habitats. Rates, causes and consequences. Fundacion BBVA, www.fbbva.es. 25-60. ISBN: 978-84-96515-84-0

[5] Sabater S and Elosegi A 2013 River Conservation Challenges and Opportunities. Chapter 4 Offprint Nutrient Pollution: A Problem with Solutions (R. Jan Stevenson Peter C. Ssselman), First published: July 2013 ISBN: 978-84-92937-47-9

[6] Permanawati Y, Zuraida R, danIbrahim A 2013 Jurnal Geologi Kelautan. 11 (1): 9-16. (Indonesian).

[7] Xu M, Yan R, Zheng C, Qiao Y, Han J and Sheng C 2004 Fuel Proces. Tech. 85(2–3): 215–237. https://doi.org/10.1016/S0378-3820(03)00174-7

[8] Berry KLE, Hoogenboom M, Flores F, Negri AP 2016 Simulated coal spill causes mortality and growth inhibition in tropical marine organisms. Sci. Rep. 6, 25894; doi: 10.1038/srep25894

[9] Marginirung D, Noviardi R 2010 Journal of Geology and mine research 20 (1): 11-20. [Indonesian].

[10] Supriyono, Iskarni P, Barlian E 2015 Journal of Geography 4 (2): 185-197. [Indonesian]

[11] Michael J, Ahrens, Donald J, Morrisey 2002 Oceano. and Mar Bio. An Annual Review (43): 69-122

[12] Indonesian National Standard (SNI) No. 7387 2009 Maximum limits for heavy metal impurities in food. Jakarta,29 pp. (in Indonesian)

[13] Indonesian National Standard (SNI) No. 7388 2009b Maximum limits for heavy metal impurities in food. Jakarta. 41 pp (in Indonesian)

[14] American Public Health Association (APHA) 2005 Standard methods for the examination of water and wastewater analysis. American Water Works Association/Water Environment Federation, Washington D.C., 289 pp

[15] Keputusan Menteri Lingkungan Hidup 2004 Baku Mutu Air Laut intuk Biota Laut. The Decree of State Minister for the Environment: Marine Biota

[16] Nazir R, Khan M, Masab M, Rehman HU, Rauf NU, Shahab S, Ameer N, Sajed M, Ullah M, Rafeeq M, Shaheen Z 2015 J. Pharm. Sci. & Res. 7(3), 2015, 89-97

[17] Sabri S, Said MIM, Azman S 2014 The Malaysian Journal of Analytical Sciences 18 (1): 37-42

[18] World Health Organization (WHO) 2003 Guidelines for drinking water quality. Volume 1, Recommendations. WHO Geneva, 130 pp

[19] Governor of East Kalimantan 1988 Standard limit for environment of province of East Kalimantan

[20] Australian Government 2018 Asean Marine Water Quality.Management guidelines and monitoring manual.New Millennium Pty Ltd, Australia. 195 p

[21] Silalahi HN, Manaf M, Alianto 2017 Sumberdaya Akuatik Indopasifik 1(1): 33-42
[22] Adesuyi AA, Nnodu VC, Njoku KL, Anuoluwapo, Jolaoso 2015 *Jou. of Geology, Agric. and Env. Scie.* 3(5): 14-19
[23] Hamuna B, Tanjung RHR, Suwito, Maury SHK 2018 *EnviroScienteae* 14(1): 8-15. ISSN 2302-3708 (online)
[24] Kumar CS, Jaikumar M, Robin RS, Karthikeyan P, Kumar CS 2013 *The Journal of Toxicology and Health* Photon (103): 192-201
[25] Weiping S, Jianjun Y, Xiaoqun X, Weiyan Z, Ruijuan L, Jianming P 2014 *Acta Oceanol.* 33 (4): 101–107. DOI: 10.1007/s13131-014-0456-z
[26] Yona D, Febriana R, Handayani M 2017 The comparison of heavy metals (Pb and Cd) in the water and sediment during spring and neap tide tidal periods in Popoh Bay, Indonesia.Asean-Fen International Fisheries Symposium. *IOP Conf. Series: Earth and Envi. Scie.* (137) 012037.doi :10.1088/1755-1315/137/1/012037
[27] Bas C 2005 *Sci. Mar.* 69 (1): 139-156