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Study on The Effect of Reclamation to Seawater Quality in Makasar City with Numerical Modeling

Mardi Wibowo
Center of Port Infrastructure and Coastal Dynamic Technology-BPPT, Indonesia
Corresponding Author: Mardi Wibowo

Abstract: *To fulfill the demand for land in the surrounding of Losari Beach in Makasar city due to increasing population growth and economic activities, now the local government is and will be doing the reclamation in the area that will be referred to as Center Point of Indonesia (CPI). Coastal reclamation has potential to affect the quality of marine waters. Therefore, it is necessary to water quality computational modeling to forecast changes in water quality due to reclamation to consequently planned measures to minimize the negative impact. Computational modeling of water quality is done by the software MIKE-21 Flow Model FM from DHI. This module is the latest a numerical simulation tool for modeling 2D and 3D ecology an ecosystem. Based on modeling results, the value of Biological Oxygen Demand, Dissolved Oxygen and salinity less change as a result of reclamation activities. In general the reclamation will decrease the quality of seawater indicated by the average BOD value increased between 2.11 - 101.36%, the average value of DO fell between 0.47 - 17.29%. After the reclamation value of BOD, DO and salinity of sea water around the reclamation area still meet the quality standards of sea water for tourism (BOD <10 mg/l, DO:> 5 mg/l; salinity appropriate environmental conditions ± 5%), except the sea waters that located in west of the reclamation area where the salinity: 19.4558% o and DO: 4.6204.*

Keywords : *reclamation, water quality, BOD, DO, numerical modeling*

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I. Introduction

Indonesia is a maritime country where most of the people live on the coast and have livelihoods as fishermen and traders. As an archipelago country, it is estimated that 60% of the Indonesian population live and live in coastal areas (Supriharyono, 2002). Around 9,261 villages of 64,439 villages in Indonesia can be categorized as villages or coastal settlements (Supriharyono, 2002). Increasing the number of people living in coastal areas has an impact on the coastal natural resources such as coastal degradation, waste disposal to the sea, coastal erosion (abrasion), coastal accretion (coastal addition) and so on. This happens in all major cities in Indonesia including in Makassar. The increasing population and economic activities, need broader land in coastal areas. One of the most common ways of expanding new land in coastal areas is by reclamation, as it is being and will be conducted at Losari Beach in Makassar City..

Reclamation is a process of creating new land in a waters area/coastal or swampy areas. This generally motivated by the increasing of human populations, especially in coastal areas. Population growth in all its activities cannot be released to the land requirements.

Coastal reclamation is the activity of hoarding or inserting certain materials in the coastal area with the intention to obtain dry land (Nurmandi, 1999). Meanwhile, according to UU No. 27 Year 2017 reclamation is an activity undertaken by people in order to increase the benefits of land resources in terms of environmental and socioeconomic circumstances by way of landfilling, draining or drainage (UU No. 27, 2007). This is motivated by the increasing levels of human population, especially in coastal areas, which causes the land for development to become narrower. Population growth with all its activities can not be separated with the problem of land needs. Based on the identification results of the Ministry of Marine Affairs and Fisheries, now there are 17 locations that have been and are being reclaimed and 20 locations will do reclamation (KKP, 2016).

Now Makassar City has reclaimed the area of Losari Beach along 950 m with an area that will be leveled and compacted to reach 106,821 m² which is entirely reserved for the public interest, especially for recreation (Jaya, et al, 2012). This reclamation area is planned to a depth of 10-12 m to the south and west of Losari Beach (Anonymous, 2015). This reclamation area is planned to be the Center Point of Indonesia (CPI) area which became one of the magnificent planning in South Sulawesi.

Coastal reclamation , beside has positive impacts also has many negative impacts such as damage to coastal ecosystems, increased flood potential, invasive species spread, social conflicts, shipping lanes disturbances, livelihoods, potential water quality pollution, etc. (KKP, 2016). In general, the impacts of

reclamation on the environment can be grouped into impacts on biogeophysics-chemicals (hydrooceanography, hydrology, bathymetry,
topography, geomorphology, water quality, etc.), socio-economic-culture (demography, public access, relocation) and public health Sudijanto, 2014).

The reclamation of Losari Beach in Makassar waters which is currently being undertaken is also potentially great for reducing water quality (especially BOD, DO and salinity) in the waters surrounding the reclaimed area that juts into the sea.

Based on the results of previous research, in general the phenomenon of pollution continues to tend to increase in Makassar City which resulted in the quality of waters in Loasari Beach decreased and not utilized according to its allocation (Jaya, et al, 2012). Dissolved oxygen levels in the coastal waters of Losari ranged from 5.88 to 6.66 mg/L and support marine life (Anonymous, 2015). BOD concentration in the waters of Losari has a range of 1.35-1.94 mg/l is the normal range and still below the required quality standards of the Minister of Environment Decree No. 51 Year 2004 and Government Regulation No. 82 Year 2001 (Anonymous, 2015). The concentration of COD in Losari waters indicates that the amount passes the quality standard specified for recreational facilities (Class II) (> 25 mg /L) where the highest value is 77 mg/l and the lowest is 38 mg/L (Anonymous, 2015). The results of the water quality analysis show that the flow of waste from Jenneberang and Tallo Rivers and several main canals that leads to the coast of Makassar is quite high. Average monthly waste load (ton/month) is BOD5 25596,42; COD 146178,40; NO3 227,82; PO 41565,28 (Hamzah, 2012). The pollution index value depicting water pollution level shows that Jenneberang River, Jenneberang River Estuary, Port, Tallo River are lightly contaminated, while Tanjung Bunga station, losari beach, Potere, Tallo river estuary, Panampu canal, Benteng, H Bau, Jongaya including tainted moderate (Hamzah, 2012). The waste parameter that has not exceeded the assimilation capacity as it has a concentration value that has not exceeded the permitted water quality standard is BOD5 but for COD, NO3 and PO4 parameters have exceeded the quality standard and some stations have exceeded their assimilation capacity (Hamzah, 2012).

To know the approximate magnitude of water quality change and its distribution it is necessary to simulate the numerical modeling of water quality in the territorial waters. The purpose of this study is to know the change of concentration and distribution pattern of water quality parameters before and after reclamation in Losari Beach Makasar Based on the simulation result of this model can be planned anticipative actions that need to be done so that negative impact to environment especially to marine waters can be minimized.

The reclamation impact assessment with modeling is largely undertaken as it is helpful in estimating environmental impacts (water quality) that will occur after the reclamation lands are realized, such as the environmental impact assessment of reclamation in Benoa Bay (Amelia et al, 2016), water harvesting reclamation model of Jebel Ali harbor , Dubai-UAE (Maraqa, et al, 2007), reclamation impact modeling at Aiwan Cove, Zhejiang Province, China (Huang, et al, 2016), environmental modeling to select reclamation techniques that have the least environmental impact for airport development on a loose reclamation island beaches in Jinzhou Bay, Bohai Sea Sea, China (Yan, et al, 2013). Especially for Losari Beach the impact of reclamation development has been done on socio-economic aspects (Hasani, 2015) and environmental, social and economic aspects (Jaya, et al, 2012).

II. Materias and Methods

2.1. Governing Equation

Numerical modeling of adversion-dispersion was conducted to find out the distribution of water quality parameters to be reviewed, based on local hydrodynamic conditions. Modeling is done by using MIKE 21 - Flow Model FM, with MIKE 21/3 WQ Simple Template. Based on this template the main parameters are DO (Dissolved Oxygen), BOD (Biological Oxygen Demand) and salinity (DHI, 2012a). This template was chosen because DO and BOD is the main parameters of water quality that is essential to know the assimilation capacity of seawater (Thomas, et al, 1987). Another reason is the limitations of secondary data obtained for other parameters. The complete secondary water quality data at all river mouths, marine waters and at all specified times are BOD and DO. DO describes the amount of oxygen dissolved in water, the value of DO is greatly influenced by the large amount of incoming waste, especially organic materials that cause depletion (lack) of oxygen in the process of degradation of organic materials (Babu, et al, 2006). Oxygen enters the water through the process of photosynthesis of aquatic biota and transfers through air and water interfaces and is consumed by the process of reproduction of plants, animals and bacteria (Radwan, et al, 2003). DO with a value of <5 mg / l will cause pressure on the aquatic biota and if below 2 mg/l in 1-4 days will kill all existing biota (Gower, 1980). While BOD is the amount of oxygen required by the process of degradation of organic material (Radwan, 2003; Babu 2006) means the value of BOD indicates the amount of waste of organic material that exists in a natural aquatic environment. The higher the BOD value and the lower the DO value of a waters means the higher the level of pollution from the organic waste in the water (Amelia, 2016).

Governing equation for water quality modeling based on the advection dispersion process. Dynamism of a substance to be modeled in the advection process can be expressed by the equation of its transport, which for non-conservative form can be written as follows (DHI, 2012a; Carreras et al, 1990, Zhu at al, 2009):

$$\frac{\partial c}{\partial t} + u\frac{\partial c}{\partial x} + v\frac{\partial c}{\partial y} + w\frac{\partial c}{\partial z} = D_x\frac{\partial^2 c}{\partial x^2} + D_y\frac{\partial^2 c}{dy^2} + Dz\frac{\partial^2 c}{dz^2} + |S_c + P_c \qquad (1)$$

which :

c	:	Concentration of Variables
u, v, w	:	Current Velocity Components
Dx, Dy, Dz	:	Dispersion Coefficient
Sc	:	*Sources* and *sinks*
Pc	:	Water Quality Processes

This modeling method has also been used to determine the smallest environmental impact reclamation method choices, such as those done in the selection of reclamation techniques in airport construction on offshore reclamation islands in Jinzhou Bay, Bohai Sea Sea, China (Yan, et al., 2013). Modeling with this software was once done to model the impact of reclamation at Aiwan Cove China with a good result that is the difference between the measurement and modeling results of about 8% (Huang et al, 2016).

2.2. Location of Study

Location of the study is the sea waters around Losari Beach Makasar City with the northern boundary around the border with Kab. Maros, the southern boundary around Limbung area with a distance of about 25 km. Overall the study area is 30 x 35 km (see figure 1).

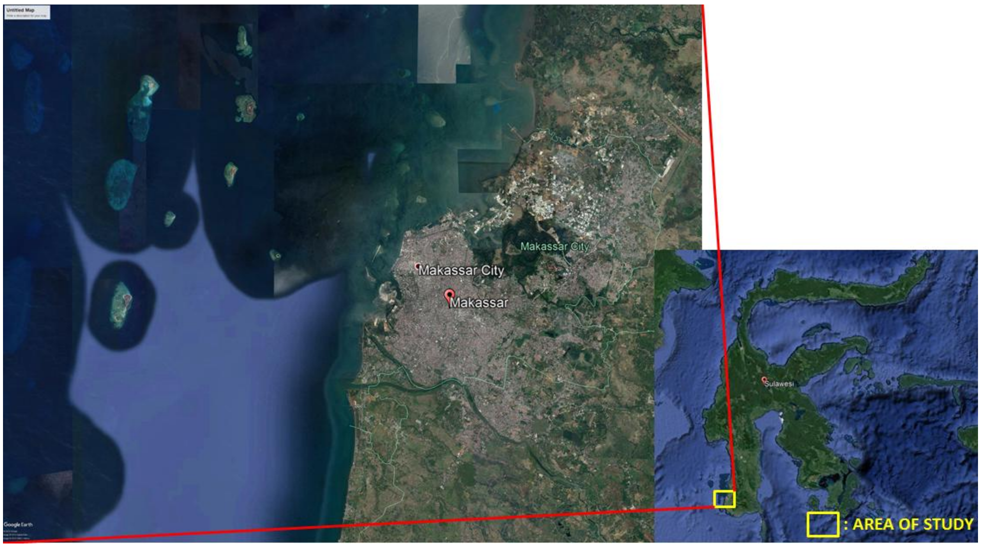

Figure 1. Location of Area Study

2.3. Steps of Study

To do the simulation and modeling using MIKE 21 Flow Model FM, the following steps are done:

a. Preparation of modeling scenarios
b. Data collection
c. Pre processing data
d. Selection of MIKE 21/3 WQ Simple Template
e. Setup and model running
f. Validation and calibration of model results
g. Analysis of modeling results

2.4. Equipments and Data

To do the water quality modeling used some equipments both hardware and software, such as:

a. Computers, with minimal specifications: pentium processor, AMD with 2GHz speed, 512 MB memory, 20 Gb hard drive, 1024x768 SVGA monitor, 32 MB graphics card and 24 bit true color.
b. MIKE-21 FM module hydrodynamic software

c. Global Mapper software for processing raw data to be used as input on MIKE 21.

Most of the data used in this study are secondary data, the data that used in this study are follows :
a. Hydrodynamic data at *boundary*, such as salinity, temperature and tidal level, etc.
b. Source : river debit
c. Water quality data at boundary, concentration of BOD and DO that will simulated
d. Water Quality constanta
e. Water Quality Load : temperature, concentration at source (BOD, DO and TSS)

2.5. Modeling Scenarios
Some of the parameters and assumptions used in this model are:
a. By default of from MIKE21/3 WQ Simple
b. By default of MIKE21/3 WQ Simple Including Temp/Salinity with 4 parameters: BOD, DO, Temperature and Salinity
c. Method of solving model equations by Euler integration method.
d. Horizontal dispersion is scaled using eddy viscosity formulation
e. The source of pollutant comes from the discharge in the river mouth (assuming there is water quality data at the mouth of the river).
f. River discharge and pollutant concentrations during the simulation time were constant.
g. There is no new pollutant source after reclamation.
h. Reclamation materials not to be a pollutant source.
i. Initial and boundary conditions are based on existing seawater quality data.
j. For the west season can not be done because of limited water quality data on 3 (three) pollutant sources that exist.

Based on these scenarios then built 3 bathymetry domains of modeling as shown in Figures 2. Modeling boundary conditions is tidal data that generated by TMD (Tides Model Driver) software. The tides in the boundary conditions is the data for 15 days starting August 15, 2015 at 00.00 PM until August 31, 2015 at 23:00 pm.

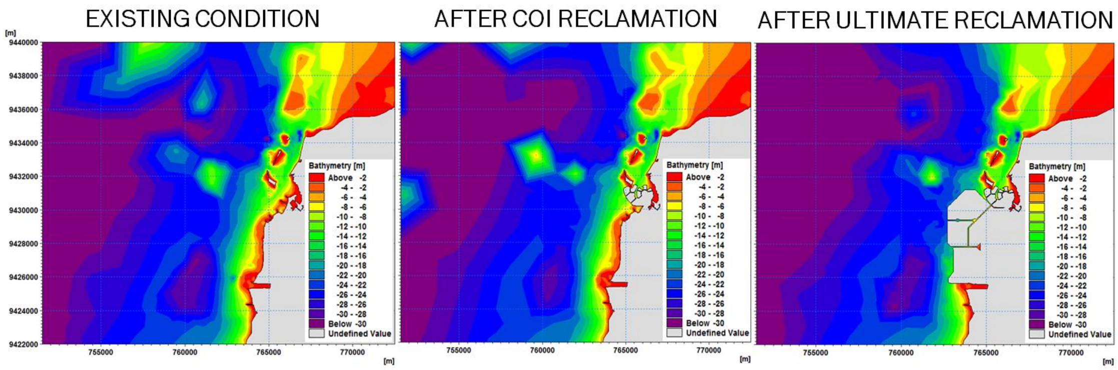

Figure 2. Bathymetry domains for water quality modeling

III. Result and Discussion

3.1. Validation Model

Validation modeling results is done by comparing the current patterns and speed of data survey conducted at the time with current patterns and speed that resulted from tide modeling. From the current data towards the maximum tide, current patterns can be described as follows (see figure 3).

Based on the model results, the trend current movement while toward maximum tide is to the north with current velocity 0,24 – 0,28 m/s. It is relatively equal to the current pattern of survey results with average current velocity/speed at the same time about 0,2 – 0,4 m/s. So the model can be used to determine the pattern current/ hydrodynamics in accordance with the planned scenario.

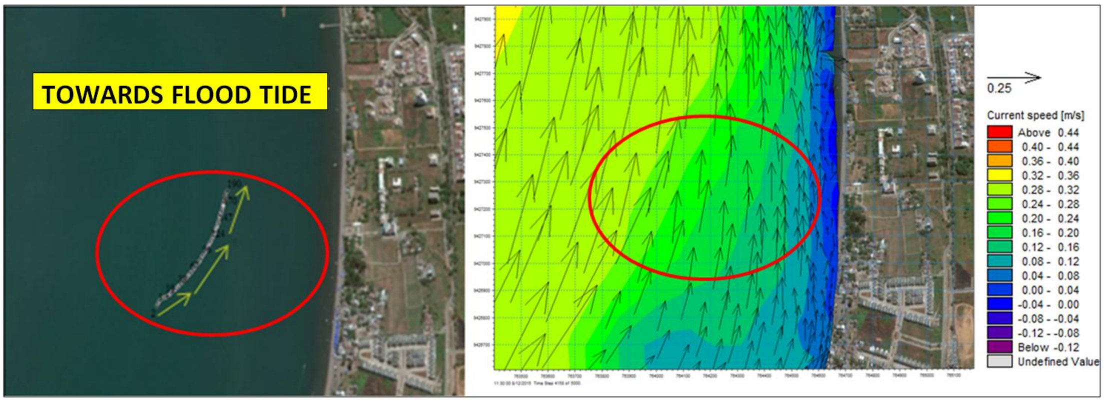

Figure 3. Validation model with comparing velocity and direction of current between measurement and modeling result (when toward maximum tide)

3.2. Result of Water Quality Modeling

Comparison of modeling results under existing conditions, after area CPI reclamation and after the overall reclamation (ultimate) at the east season (August 2015) is presented in Figure 4 below.

Based on figure 4 it is seen that there is no significant change in the spread or concentration of BOD, DO or salinity. This is mainly due to pollutant sources (river discharge in the Pintu Air and Jongaya Canal) has small discharge and low concentrations. The great discharge is only found at the mouth of the Jeneberang River, but the river estuary is not completely covered by reclamation (only slightly closed on the north side), so the overall distribution pattern and BOD, DO and salinity concentrations have not changed significantly.

Around the mouth of Jeneberang River, after the overall reclamation (ultimate condition) during the simulation time, the distibution of BOD, DO and salinity to the north is slightly restrained so that it is relatively concentrated around pollutant source but the environmenta was not a problem because the value of BOD <10 mg/l and DO value> 5 mg/l and it's still meet the seawater quality standard for tourism (Kementerian Lingkungan Hidup, 2004).

For the waters at east of the CPI reclamation area (Jongaya Canal estuary), from 5th day onwards the BOD, DO and salinity traps occured, because the origin of the canal is open and face to face with the free sea, after reclamation becomes slightly obstructed so that as if by trapped in these waters.

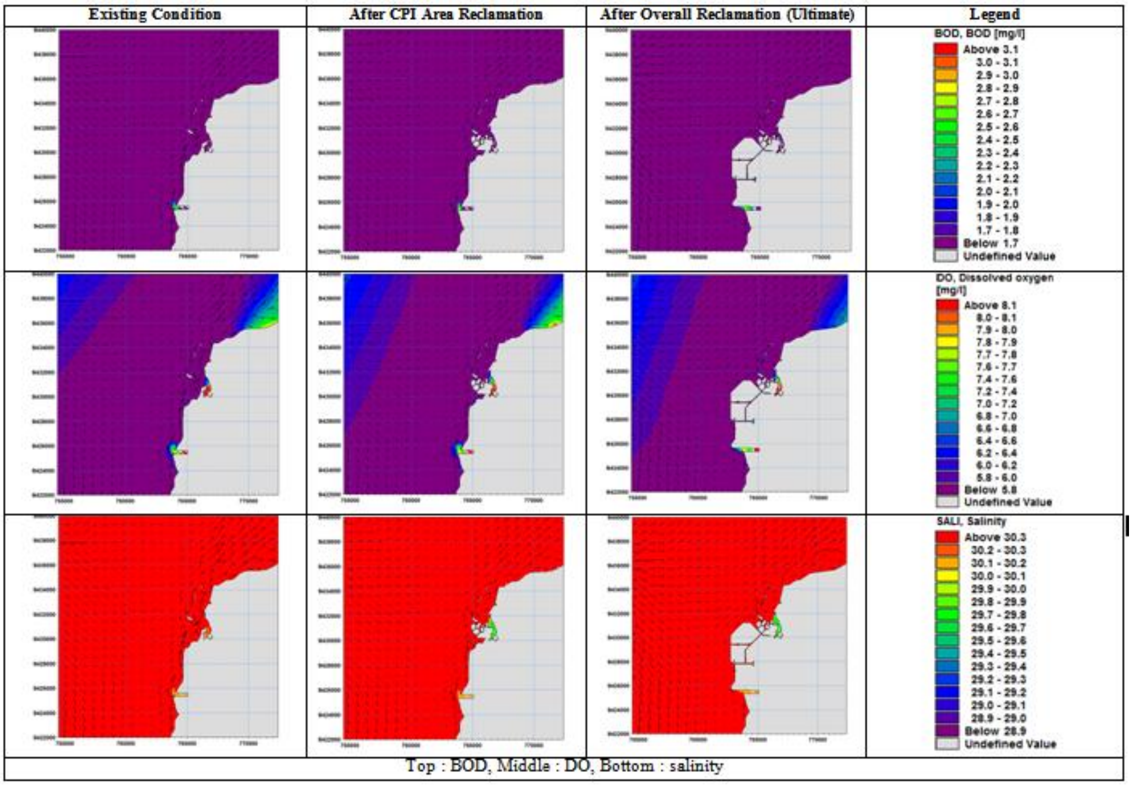

Figure 4. Snapshot of modeling result after 15 days simulation

The data extraction needs to be done on specific locations to compare the BOD, DO, and salinity concentration in this study. Coordinates of extraction location for observation are as follows (see figure 5):

a. Extraction location 1 : UTM 50S 763231 mS 9425486 mE
b. Extraction location 2 : UTM 50S 762748 mS 9427861 mE
c. Extraction location 3 : UTM 50S 762453 mS 9429479 mE
d. Extraction location 4 : UTM 50S 764725 mS 9431079 mE
e. Extraction location 5 : UTM 50S 766798 mS 9430749 mE

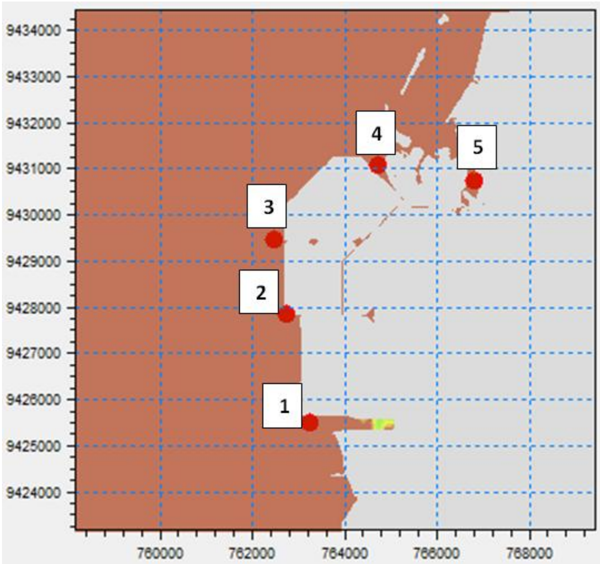

Figure 5. Extraction location for observation

3.2.1. Location 1 (Mouth of Jeneberang River)

Based on the results of extraction, at the mouth of Jeneberang river (location 1), it's known that the value of BOD and DO not change significantly between the existing condition and after reclamation CPI, but it's change significantly after the overall reclamation (ultimate) (see figure 6). The average value of BOD after 15 days simulation is the existing condition 0.6840 mg/l, after CPI reclamation 0.7035 mg/l (increase 2,85%) and after overall reclamation 1.3773 mg/l (increase 101,36%). The average value of the DO after 15 days simulation is the existing condition 5,9587 mg/l, after CPI reclamation 5.9404 mg/l (decrease 0,31%) and after overall reclamation 6.5374 mg/l (increase 9,71%). While the average value of salinity after 15 days simulation is the existing condition 30.4386 %o, after CPI reclamation 30.5102 %o (increase 0,24%) and after overall reclamation 30.3441%o (decrease 0,31%). This is caused CPI reclamation area is located quite far from this location so it's not affect the concentration of BOD and DO, whereas for the overall reclamation is little affect because the location is just north of the mouth of Jeneberang river. But overall value of BOD, DO and salinity conditions after the reclamation is still quite good and meet seawater quality standard for tourism activities (BOD: 10 mg/l, DO:> 5 mg/l and salinity: natural with a deviation of 5 % of seasonal average) (Kementerian Lingkungan Hidup, 2004).

3.2.2. Location 2 (West of Southern Reclamation Land)

Based on the results of extraction, the the west from southern reclamation land (location 2), it's known that the average value of BOD, DO and salinity didn't change significantly between the existing condition and after CPI reclamation, only a slight increase in the salinity value that caused obstruction freshwater supply from Jeneberang river (see figure 7). The average value of BOD after 15 days simulation is the existing condition 0.2929 mg/l, after CPI reclamation 0.3329 mg/l (increase 13,66%) and after overall reclamation 0.3321 mg/l (increase 13,38%). The average value of the DO after 15 days simulation is the existing condition 5.5887 mg/l, after CPI reclamation 5.5901 mg/l (increase 0,03%) and after overall reclamation 5.5814 mg/l (decrease 0,01%). While the average value of salinity after 15 days simulation is the existing condition 30.6635 %o, after CPI reclamation 30.7271%o (increase 0,21%) and after overall reclamation 30.7260 %o (increase 0,2%). The increase in the value of salinity is likely due to obstruction of the supply of fresh water from Jeneberang river. But overall value of BOD, DO and salinity after the reclamation is still quite good and meets the seawater quality standard for tourism and ports.

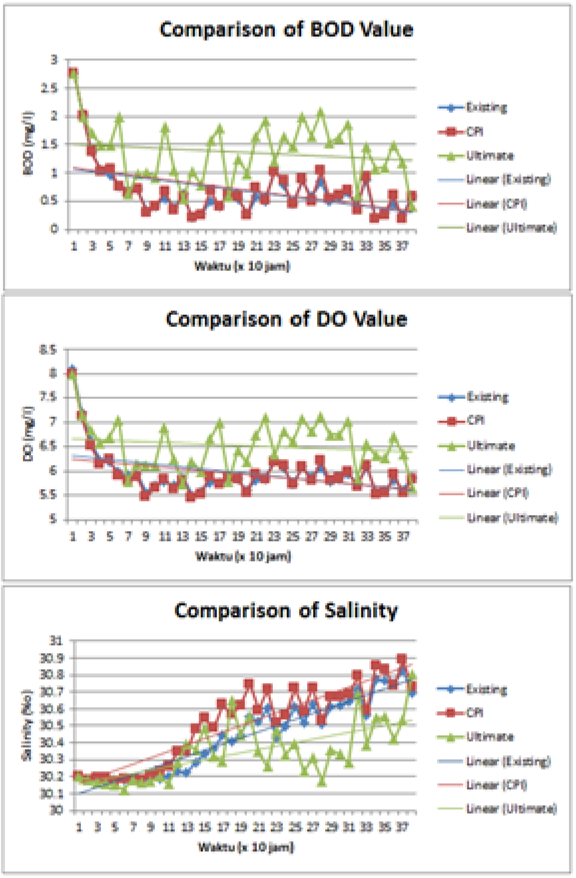

Figure 6. Comparison BOD, DO and salinity value between existing condition, after CPI reclamation and after overall reclamation at mouth of Jeneberang river (location 1)

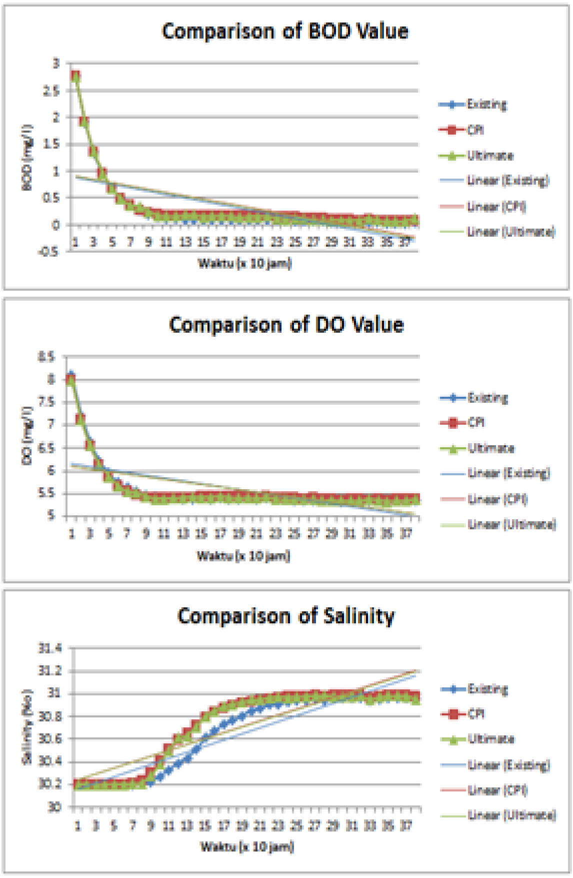

Figure 7. Comparison BOD, DO and salinity value between existing condition, after CPI reclamation and after overall reclamation at west of southern reclamation land (location 2)

3.2.3. Location 3 (West of Northern Reclamation Land)

Based on the results of extraction, at the west of the northern reclamation land (location 3), the condition is similar to the second location, because this location has relatively the same position to the sources of pollution (see figure 8).

The average value of BOD after 15 days simulation is the existing condition 0.3098 mg/l, after CPI reclamation 0.3645 mg/l (increase 17,66%) and after overall reclamation 0.3395 mg/l (increase 9,59%). The average value of the DO after 15 days simulation is the existing condition 5.5987 mg/l, after CPI reclamation 5,6193 mg/l (increase 0,37%) and after overall reclamation 5.5925 mg/l (decrease 0,11%). While the average value of salinity after 15 days simulation is the existing condition 30.7080 %o, after CPI reclamation 30.7625 %o (increase 0,18%) and after overall reclamation 30.7469 %o (increase 0,13%).

3.2.4. Location 4 (West of CPI Reclamation Land)

Based on the results of extraction, the seawaters at west of CPI reclamation land (location 4), it's known that the average value of BOD, DO and salinity did not change significantly between the existing condition and after reclamation. It's due to this location is still quite open to the sea.

The average value of BOD after 15 days simulation is the existing condition 0.2787 mg/l, after CPI reclamation 0.2867 mg/l (increase 2,87%) and after overall reclamation 0.2728 mg/l (decrease 2,11%). The average value of the DO after 15 days simulation is the existing condition 5.5915 mg/l, after CPI reclamation 5,5651 mg/l (decrease 0,47%) and after overall reclamation 5.5276 mg/l (decrease 1,14%). While the average value of salinity after 15 days simulation is the existing condition 30.6297 %o, after CPI reclamation 30.6294 %o (decrease 0,001%) and after overall reclamation 30.6382 %o (increase 0,03%)(see figure 9). A slight decrease in salinity due to their value a little resistance flow of fresh water from the Jongaya canal to sea, so it's cause a slight decrease in the salinity value at this location.

3.2.5 Location 5 (East of CPI Reclamation Land)

Based on the results of extraction, the seawaters at east of CPI reclamation (location 5), it's known that the average value of BOD, DO and salinity did not change significantly between the existing condition and after CPI reclamation. But in general the value at this location is more fluctuating compared to other locations, especially after the reclamation (see figure 9).

The average value of BOD after 15 days simulation is the existing condition 0.7430 mg/l, after CPI reclamation 1.0054 mg/l (increase 35,32) and after overall reclamation 0.9743 mg/l (increase 31%). The average value of the DO after 15 days simulation is the existing condition 5.5676 mg/l, after CPI reclamation 5.2811 mg/l(decrease 5,15%) and after overall reclamation 4.6047 mg/l (decrease 17,29%). While the average value of salinity after 15 days simulation is the existing condition 24.6222 %o, after CPI reclamation 22.3019 %o (decrease 9,42%) and after overall reclamation 19.4558%o (decrease 20,98%). Generally at this location with reclamation, BOD values will tend to be higher because the BOD of Jongaya canal spread slightly covered by reclaimed so that contact with the open sea slightly obstructed. For DO and salinity values with reclamation tend to be lower due to eddy current of seawater can add dissolved oxygen and salinity to this location. But overall value of BOD, DO and salinity conditions after the reclamation is still quite good and meets the seawater quality standard for tourism and ports.

For the west season can not be done due to lack of data on the water quality of three existing sources of pollution.

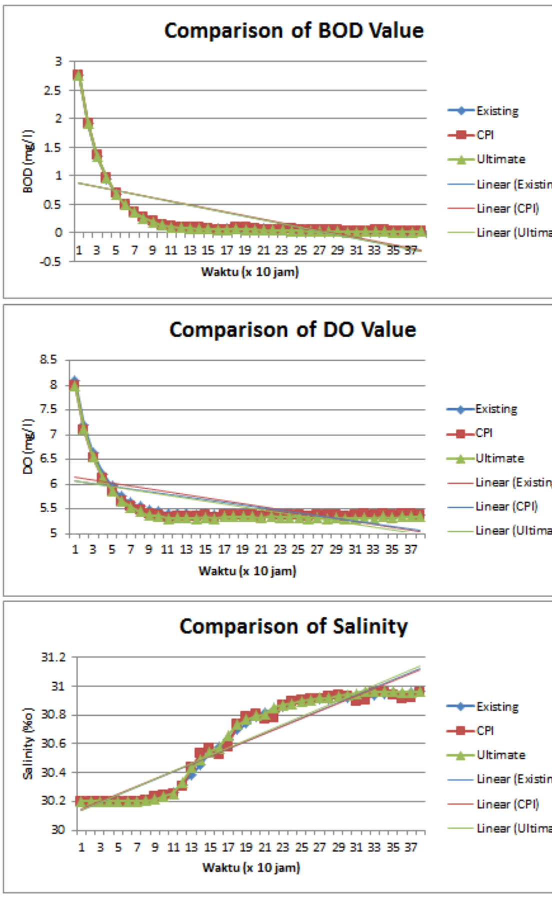

Figure 8. Comparison BOD, DO and salinity value between existing condition, after CPI reclamation and after overall reclamation at west of CPI reclamation land (location 4)

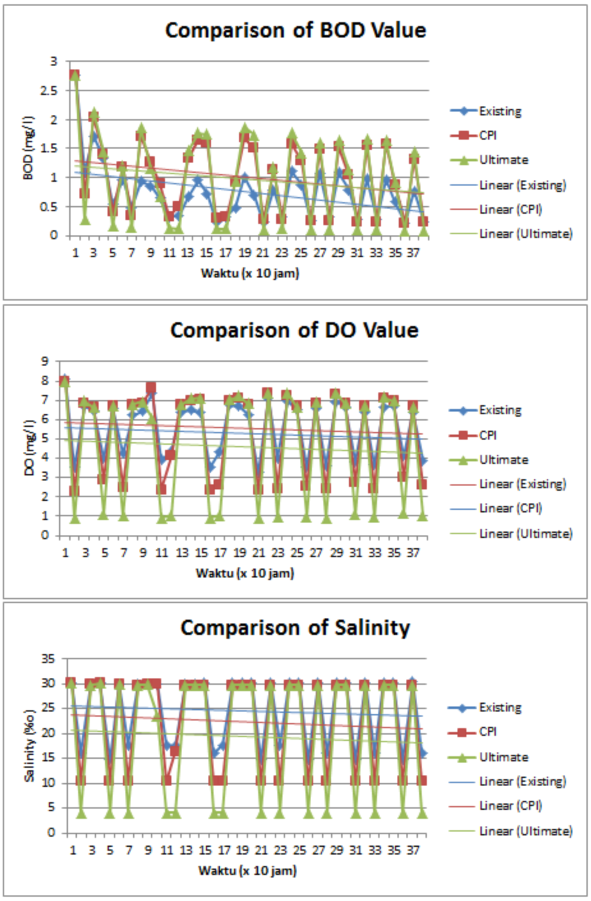

Figure 9. Comparison BOD, DO and salinity value between existing condition, after CPI reclamation and after overall reclamation at east of CPI reclamation land (location 5)

Based on the modeling results in the east season (August), generally the reclamation will decrease the quality of seawater that indicated by the average BOD value increased between 2.11 - 101.36%, the lowest increase occurred at location 4 (west of CPI reclamation) and the highest increase occurred at location 1 (around mouth of S. Jeneberang). The average value of DO decreased between 0.47 to 17.29% compared to the simulation of the existing condition, the lowest decrease occurred at location 4 (west of the CPI reclamation) and the highest decrease occurred at location 5 (east of CPI reclamation/ south Losari Beach). The decrease in the average salinity value due to reclamation varies greatly depending on its position from the open sea, where in a relatively closed location against the open sea the salinity value is relatively decreased and vice versa in the relatively open location of the loose. These results are generally relative similar to the results of research on the impact of reclamation in Losari Beach conducted by Jaya, et al (2012). The results stated that the chemical meters of Losari waters before and after the recalamsi also experienced a change towards the negative category after Losari Beach reclamation. There are several chemical parameters that have passed the standard of sea water that is Ammonia, Phosphate, and Nitrate (Jaya, 2012). The result of research using MIKE 21 Flow Model FM from DHI to know the impact of reclamation of Port of Jebel Ali-Dubai to water quality shows that BOD value increase reaches 201% compared to existing condition at present (Maraqa, et al, 2007).

Other research results at Benoa Bay-Bali, using Finite Volume Coastal Ocean Modeling (FVCOM) indicate that reclamation will decrease water quality where the water quality in Tukad Badung watershed. Six location in Tukad Badung Watershed classified as polluted due to exceeding the water quality requirement of class I water with temperature parameters $29^{o}C$, pH (6,00-9,58), BOD (14,00-22,89 mg/l), COD (30,41-122,20 mg/l) (Amelia, 2016).

Other research results related to the impact of reclamation on aquatic quality also indicate that reclamation will degrade the quality of the surrounding waters (Huang, et al, 2016; Radwan, 2003 and Babu, 2006).

IV. Conclusion

Based on the modeling results in the east season (August) in general the reclamation will decrease the quality of seawater which is indicated by the average BOD value increased between 2.11 - 101.36%, the average value of DO fell between 0.47 - 17, 29% compared to simulation results of existing conditions, whereas salinity value varies greatly depending on its position on the open sea (assuming the source of pollution remains the same as the existing condition and the reclamation material is not a source of pollution).

After the reclamation of the average BOD, DO and salinity value of sea water at the extract site (around the reclamation area) generally still fulfill the seawater quality standards for tourism activities (BOD <10 mg/l; DO:> 5 mg/l; salinity according to environmental conditions $\pm$ 5%). Except around location 3 where salinity reach 19.4558 %o and DO: 4,6204 mg/l).

The detailed and time series of debit river data and quality of water from all river that flows to seawater in surrounding the reclamation area are needed for further detail study

Acknowledgements

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