# Mapping of Pollution Load Capacity of Tidal Manggar Watershed, Balikpapan City

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# Mapping of Pollution Load Capacity of Tidal Manggar Watershed, Balikpapan City

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**Abstract.** The Tidal River Manggar system is mostly (± 75%) still in the form of forest and about 25% is land that has been exploited / developing land. Manggar River is influenced by the tides of sea water making the characteristics of brackish water with thick mangrove trees. The purpose of this research is to know the characteristics of tidal water quality and calculate the pollution load value of Manggar River by using GIS mapping. Water sampling was divided 10 segments of the river and then analyzed the laboratory. Calculation of river basflow was using Thornwhite approach. The influence of sea water and mangrove estuaries has become more dominant in the formation of river water quality characteristics, especially in the dry season. The sea water entering the river brings minerals from both the sea and the mainland into a trap that causes the Manggar River to become rich in nutrients and river biota. Regulations in Indonesia have not specifically regulated brackish water quality. High BOD and COD values can not be categorized as polluted by law standard, because the source of pollutants is a natural material, where this condition is a balance of mangrove ecosystem. The pollutant source of the Manggar River originates from the Sub-Basin which contributes to pollution loads whose value depends on the discharge of each sub-catchment.

**Keywords**: *Brackish River, Water Quality, Pollution Load, GIS Mapping.*

## 1. Introduction

The Manggar River has an important role in the protection of mangrove estuary and animals around it. Most of the rivers on the island of Kalimantan have sloping characteristics and are influenced by tides. River pollutants come from runoff water of various types of land use and the results of human activities as non point source (NPS) pollutants. Disposal of NPS pollutants has a significant impact on river water quality in a watershed [1]. There needs to be water quality monitoring to estimate the sources of river pollutants. Sufficient data will assist in the effort to control pollutants and improve water quality, and ensure water quality standards are met [2]. Related to water quality reduction can be reduced by reducing the burden of pollutants entering water bodies of magnitude determined by power the water body's environmental capacity to pollutants [3].

Research on the carrying capacity of water resources plays an important role in combining the ecology of sustainable development and the configuration of water resources, given the carrying capacity is the conclusion of the theory of sustainable development, that is, sustainable water resources management strategies [4]. As a regulatory basis, mass loading control pollutant discharge permits are elucidated in the Waste Water Quality Standard law (2014). In the stream standard are regulated in Management Of Water Quality And Water Pollution Control law (2001). The regulation is comprehensive in rivers in Indonesia. However, the river category is not explained in detail regarding the characteristics of local natural conditions. Whereas the quality of seawater is regulated in Raw Quality Of Sea law (2004). pollution based on regulations is the delay in water quality based on the

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stipulated water standard. So the large sting of brackish river will be predicated as polluted because water quality regulation follows the standard river regulations.

There have been many previous studies related to the calculation of non-point source pollutants carried out in various countries such as China, America and Europe. Most of the research uses modeling and mathematical methods where most are freshwater rivers. Calculation of NPS in fresh water emphasizes land use as the main cause of pollutants [5]. Most of the discussions focus on the main sources of pollution in the form of residential and agricultural areas [5–7]. Whereas in tidal rivers the water quality is also influenced by pollutants entering from seawater. The tidal river also has hydrodynamics for which the meeting of fresh and sea water makes the current pattern change according to the season[8].

Tidal areas have different characteristics of freshwater quality. Rivers in Indonesia have specific condition due to climatic, geological and socio-economic factors than developed countries. The quality conditions of tidal rivers in locations that have dense mangrove estuaries are interesting things to examine. The purpose of this research is to know the characteristics of tidal water quality and calculate the pollution load value of Manggar River. The results of this study can be used as a reference in determining the quality status of water quality in rivers affected by sea water. The Pollution Load Models, combined with regular monitoring programs for water quality and hydrologic, provides better understanding of the river system hence, are important evaluation tools for decision making [9].

## 2. Methods

The research location in Lamaru Subdistrict, Manggar Subdistrict and Karangjoang Subdistrict are included in Manggar River Flow Area of Balikpapan City. Water sampling was using water sampler, sample bottle, label, stationery, calculator, and computer. Sample location was conducted on 23-24 August 2014 at nine points on the Manggar River form 18.4 km, 17.5 km; 16.8 km; 15.6 km; 14.3 km; 12.5 km; 11.2 km; 9.4 km; 3.7 km which is calculated from manggar dam breaker.

The research used quantitative method. Stages in the study include first recognizing the hydrological conditions of the Manggar River, both analyzing pollution characteristics through calculations. pollution load, the three river capacity analysis either from natural sources or human activities. Calculation of reliable flow using mathematical model of Thornwhite runoff rain through rain and climate data conversion. Estimation flow uses manning equation. Then the evaporation calculation uses Penman method. Climatology data used in this study was taken from Balikpapan Airport station in 2009 - 2013 consisting of temperature, humidity, wind speed, duration of solar radiation.

Dissolved oxygen (DO), Temperature (T), salinity, and pH were measured in situ. Samples were analyzed in the laboratory, in order to determine the concentrations of BOD and COD using standard methods [10]. Domestic charges are calculated by looking at the number of residents based on BPS data. The level of water demand for District of Karangjoang is 100 liters / person / day because most of the population is still classified as rural. the transmission coefficient of 25% due to its remote location with the river so it is possible that the water will be more evaporated and soaked in the soil. Waste load conversion factor Liquid waste with septic tank is BOD 12,6 Kg /person / year, COD 24,2 Kg / person / year with Almost all residents living in reservoir dam have septictank.

Gross domestic pollution load = population jml x water requirement x coefficient of waste water x koef. transmission

## 3. Results and Discussion

Manggar river system is a river functioned as one of the main drainage system in Balikpapan. The area of Manggar Drainage System has an area of 9.993 ha of watershed. Manggar area drainage system is mostly (± 75%) still in the form of forest and about 25% is land that has been exploited / developing land. Drainage in this area is still natural but in the future, of course, there will also be the development of the area into a cultivation area that will result in increased water discharge that will enter the drainage

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channel. Base on the calculation of Flow Duration Curve found that Manggar River has a freshwater inflow discharge of 1.25 $m^3$ / s from the water catchment area of 50 $km^2$ at 50% confidence level. When viewed from the width of the river which averages over 30 m downstream at a depth of more than 3 meters, the abundance of existing water is more affected by seawater supply (see Figure 1).

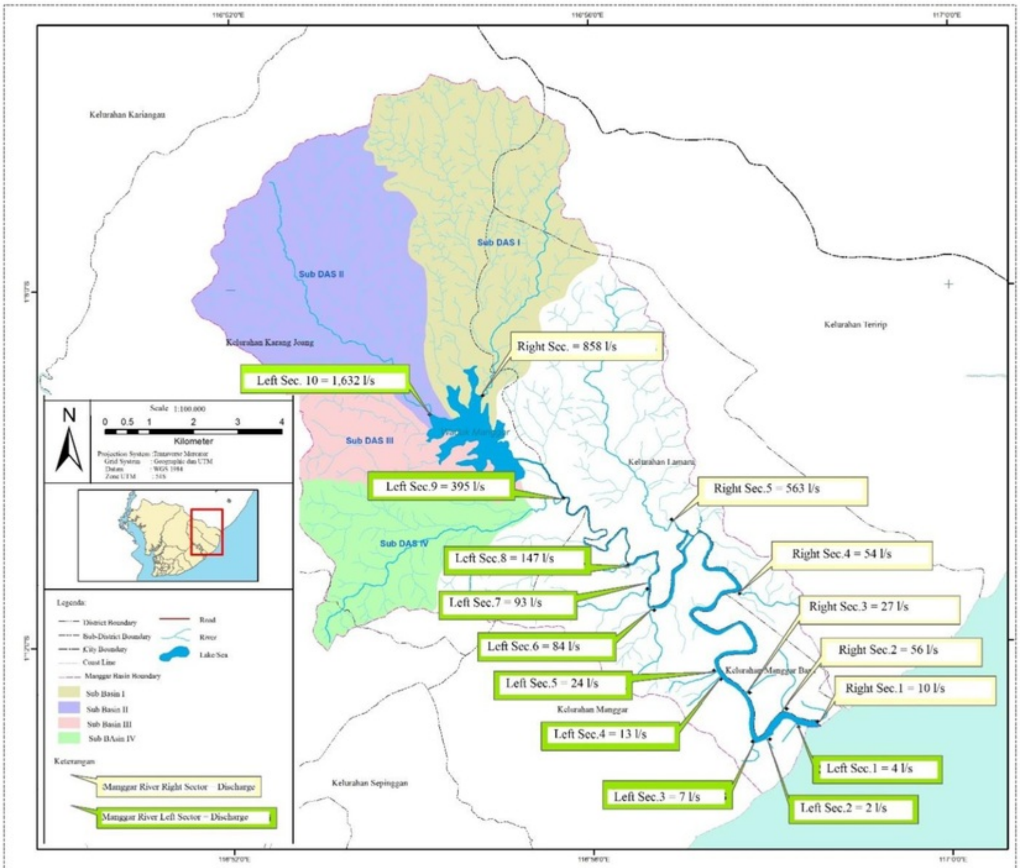


**Figure 1.** Projected Map of Any Mainstream Flow on Manggar Watershed

The peak fresh water flow occurs in February and July of the rainy season and the dry season occurs in August, September and October. The availability of critical flow in August reached 2.3 $m^3$/s. However, when viewed on the topography of the river then the available discharge reaches more than 30 $m^3$/s. The analysis of river water quality in this study starts from the wastewater to the beach. The differences in these characteristics are influenced by different natural conditions. Upstream areas are fresh water surrounded by secondary and primary forests, while downstream areas are affected by tidal sea water, salt and mangrove forests. Freshwater discharge The Manggar River is smaller than sea air supply which is affected by the season. At the time of sampling, an analysis of tides was carried out around the river mouth. The use of dehydros data produces heights that produce high values and have a relatively high altitude pattern that makes sense. Important data on river water collection is Highest Water Spring (HWS) 175.25 cm, Mean High Water Level (MHWL) 80.68 cm, Mean Sea Level (MSL)

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0.21 cm, Mean Low Water Level (MLWL) -80.22 cm, Lowest Water Spring LWS) -164.72 cm (see Figure 2 and Figure 3).

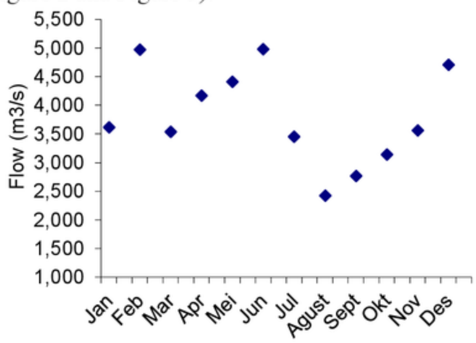


**Figure 2.** Mainstay Flow of Manggar River using Thornwhaitte Method

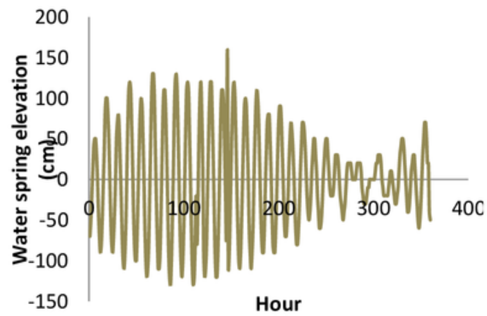


**Figure 3.** Balikpapan Sea Water Level Elevation (10 - 25 August 2014) Average at 0 cm Dehidros elevation data.

There is always a periodic change in river water level downstream, due to the influence of the tides. Water that comes from the sea, will enter the river at high tide or so-called flood tide, and will flow back into the sea at low tide, or ebb tide. Part of this tidal river will have a water discharge that varies according to the prevailing season, and is highly dependent on the water flow that exists on the upper reaches of the river. Flow affects the dilution process due to increased discharge and water flow and disseminates organic matter throughout the body of water. So the quality of water when the tide will tend to be better than the quality of water when it recedes.

The condition of river Manggar under the Dam has a characteristic that is included in the estuary system. Estuary are semi-enclosed waters that are related freely with the sea, so seawater with high salinity can be mixed with fresh water from upstream. This combination of sea and freshwater influences will result in a distinctive community, with varying environmental conditions, such as: where rivers meet with tidal currents, the opposite causes a strong influence on sedimentation, water mixing and traits other physics, as well as bringing great influence on its biota. Sea tide is a phenomenon of periodic sea level rise and fall movement caused by a combination of gravitational forces and the attraction of astronomical objects, especially by the sun, earth and not.

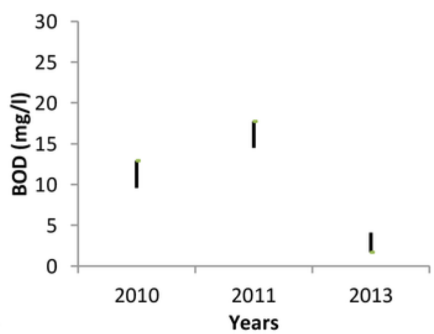


**Figure 4.** BOD government monitoring water quality 2010-2013

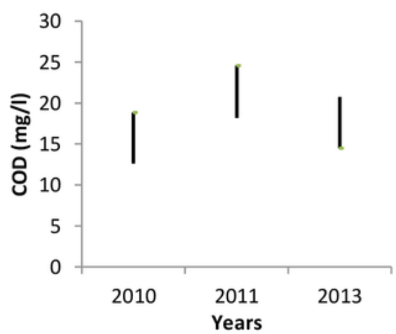


**Figure 5.** COD government monitoring water quality 2010-2013

The BOD's value is very high in 2010 and 2011 have exceeded the standard of 4th grade river by 12 mg / l BOD by goverment regulation. The higher the BOD value the lower the dissolved oxygen value in water and indicates the biological and chemical degradation of pollutants found in river water.[11][11]. While the whole COD entered in grade 2 under 25 mg / l. The BOD / COD ratio is very high with an average exceeding 0.6 so it can be categorized as contamination of estuary activity in the mangrove area and due to the sea tides. Source of waste not only from domestic waste but also from home industry [12] (see Figure 4 and Figure 5).

In addition, if the BOD value of sea water in accordance with the Ministry regulation no. 51 of 2004 on the standard of marine life has a value of less than 20. If the condition of the Manggar river is more influenced by sea tides then the conservation of BOD in the larger sea will be the dominant factor. COD value in regulation is not set because the main source of pollutants in the sea is BOD. The highest value of DO in the upstream reaches 9.27 in 2011 and 2013 tends to be in the range of 5.4 - 7.3. Dissolve Oxygen in upstream is relatively higher than the middle and downstream. In the wet season, water quality form Manggar Dam tends to have low DO and high Fe [13]. It same with other china research, the variation in concentration of DO shows that the water quality in the tidal river significantly, deteriorates as it flowed from upstream. The discharge of petroleum and non-point source pollution aggravates river pollution[8]. pH show values still within the quality standard range between 6 to 9. So almost aquatic organisms fit in this condition. The pH stabilization process becomes better because the river water has been mixed with seawater that has normal pH. This is because the amount of water from the sea is more dominant in the downstream of the river Manggar. The amount of discharge that enters about 5 m3 / s is still small compared to sea water intrusion (see Table 1).

**Table 1.** Salinity of Manggar River

| Distance from downstream (km) | Salinity (mg/l) | Concentration |
|---|---|---|
| 0.55 | 20.8 | 100% |
| 1.24 | 16.4 | 79% |
| 2.51 | 15.1 | 73% |
| 3.84 | 15.4 | 74% |
| 5.78 | 18 | 87% |
| 7.07 | 21.2 | 102% |
| 8.90 | 13 | 63% |
| 14.50 | 6.7 | 32% |

Manggar River is a brackish water mixing from seawater from makassar strait and Manggar River. The influence of salt level is influenced by the tidal distance upstream. In the upstream of the river at 14.5 kilometers is still obtained a high enough salinity level indicates that the mixing of sea water far into the upper river. At the tide there will be waves coming from the sea carrying salt, while at low tide the fresh water will become more. The sample point 1 to 8 is the salinity value that is in the position close to the sea. So it is known the farther from the sea the value of salinity becomes smaller. Point 1 with a distance of 1 km from the open sea has a value of 20.8 and the smaller the salinity value.

Tidal areas have different characteristics of freshwater. Where the water entering the river brings minerals from both the ocean and the trapped plains. This resulted in the Manggar River becoming rich in nutrients and river biota. High BOD and COD values can not be categorized as polluted, because the source of pollutants is a natural material, where this condition is a balance of mangrove ecosystem. The best way to know the level of pollution is to measure the productivity of Manggar River endemic animals such as mangrove crabs, black bush fish, spell laws that are still easily found by fish finders. So if the conditions of this ecosystem quality change these animals will not be able to meet because it can not be cultivated by humans and sensitive to environmental changes.

In general, estuaries have an important ecological role, among others, as sources of nutrients and organic matter transported through tidal circulation, habitat providers for a number of estuary-dependent animal species as shelter and feeding ground and as place for reproduction and / or nursery ground, especially for a number of fish and shrimp species. Estuary waters are commonly used by humans for settlements, fishing grounds and fish resource cultivation, transportation routes, ports and industrial estates. Manggar River is a water body, with a variety of marine life living in it, which is brackish because it is much influenced by the sea. In government regulations number 82 of 2001 only listed fresh water quality standards, not brackish water or sea brackish water has a high natural nutritional content so that the value of BOD is measured large enough. The concentrations of BOD at the river mouth had a significant impact on water quality for the tidal sections of due to mixing of waters [14]. The presence of tides also affects the quality of brackish water so that it changes in semi diurnal daily. Upstream, the water quality has distinctive characteristics and has not been contaminated with human activity waste and no significant runoff from the reservoir.

Based on the Decree of the Minister of Environment No 51 of 2004 Article 7, the stipulation of seawater quality standards for marine water areas outside the Port and Marine Waters refers to the Standard of Sea Water Quality for BOD Marine Biota of 20 mg / l and dissolved oxygen of 5 mg / l. At the river flow according to the calculation, the maximum allowable contamination load for each scenario is as follows (Table 2):

**Table 2.** Calculation Polutant Load of BOD Manggar River

| Distance from Upstream (km) | Flow ($m^3$/sec) | BOD Concentration (mg/l) | Pollution Load (kg/day) | Pollution Capacity (kg/day) |
|---|---|---|---|---|
| 3,7 | 9,30 | 11,5 | 9.240 | 6.829 |
| 9,4 | 9,72 | 9 | 7.558 | 9.237 |
| 11,2 | 11,88 | 12,3 | 12.625 | 7.903 |
| 12,5 | 11,08 | 11,6 | 11.112 | 8.047 |
| 14,3 | 14,59 | 11,2 | 14.120 | 11.094 |
| 15,6 | 16,48 | 11 | 15.664 | 12.816 |
| 16,8 | 20,42 | 10,5 | 18.528 | 16.764 |
| 17,5 | 36,30 | 9,6 | 30.108 | 32.617 |

Mixing the two kinds of water produces a special environmental physics that is not the same as the nature of river water and sea water properties. changes that occur due to tides require the community to make physiological adjustments to the surrounding environment. The level of salt in the estuary depends on the seawater, the flow of fresh water and other currents, and the topography of the estuary. In the upper part of the river there is a Manggar Dam that is surrounded by protected forest. In the middle of the river there are many fish farmers while in the downstream area of residence, as well as the market. The upstream part of Manggar Reservoir has a red podsolic soil type containing high Fe that can be washed when it rains. Arrangement of the area around the river based on Spatial Plan and Area of Balikpapan City will be utilized as a center of trade and service of city scale, tourism, sport development center, and protected area in upstream and solid settlement, downstream market.

Watershed has a Sub-Basin that provides pollution load input from streams flowing into the main river. Due to the small discharge, pollution load input from the sub watershed does not significantly affect the water quality of the main river of Manggar River. Settlement activity along the river flow will have an impact of increasing the flow of domestic waste into the river considering the function of the river as the main drainnage Domestic waste water comes from waste water from human activities from residential sources, offices and commercial areas that can be fecal waste, waste water, washing and kitchen containing organic matter. In very large quantities, domestic waste can affect the quality of river water capacity [11]

Marine quality protection is based on seawater quality standards, standard of marine damage and status of marine quality. Based on Government Regulation No. 19/1999 on Pollution Control and / or Sea Damage Article 5 states the status of marine quality shall be determined based on the inventory and / or research on seawater quality data. Conditions of marine damage affecting the quality of the sea.

After attachment II of Candidate of environment No. 01 of 2010, the determination of capacity is carried out after the stipulation that the river or estuary has the status of the most polluted quality. The Manggar

In general, the management of the Manggar River must be carried out through an ecosystem approach implemented under the principle of "one river, one plan, one management" with respect to a decentralized system of government according to a broad, real and responsible autonomous spirit, or in one river one must apply a management system that can ensure the integration of policies, planning strategies and operational activities from upstream to downstream.

## 4. Conclusion

Manggar River that influeced by Tidal areas have different characteristics of freshwater river. Where the sea water entering the river brings minerals from both the ocean and the trapped plains. Availability of critical discharge inlet in August reached 2.8 $m^3$ / s. The peak of the dry season occurs in August, September and October. Freshwater discharge The Manggar River is smaller than sea air supply which is affected by the season. At the tide there will be waves coming from the sea carrying salt, while at low tide the fresh water will become more. Sea water entering the river brings the mineral from both the sea and the mainland trapped. The main source of pollutants came from natural material, where this condition is a balance of mangrove ecosystem. The upstream part of Manggar Reservoir has a red podsolic soil type containing high Fe that can be washed when it rains. This resulted in the Manggar River becoming rich in nutrients and river biota. High BOD and COD values can not be categorized as polluted like in government regulation. The best way to know the level of pollution is to measure the productivity of Manggar River endemic animals such as mangrove crabs, black bush fish, spell laws that are still easily found by fish finders.

However, due to the limited data, there was uncertainty in predictions of pollution load calculations. The relationship between mangrove ecosystems and river water quality needs to be studied more deeply in future. Pollution load calculation by involving more data and a long time will produce better predictions.

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