ANALYSIS OF TOTAL ORGANIC MATTER, TOTAL NITROGEN, AND TOTAL PHOSPHORUS IN THE ESTUARY WATERS OF MAROS AS A SOURCE OF BRACKISH WATER FOR FISH PONDS AQUACULTURE

ABSTRACT

Indonesia is a tropical area with high rainfall, the area on land is connected by around 472 large and small rivers that flow into the sea. The estuary area is the meeting area of rivers or fresh water streams with the ocean. Transportation of organic matter, minerals and sediments from upstream to the estuary and from the sea containing minerals, hence estuarine waters are more fertile than other areas. In addition, estuary areas are important habitats for several types of marine and freshwater organisms to fulfill their life cycles, which are used as spawning, foraging, and nursery grounds.

This study aimed to determine the total organic contents, total Nitrogen, and Phosphorus in the estuary waters of Maros as a source of brackish water for fish pond aquaculture in Maros Regency. The research was conducted in the estuary waters of Maros for three months from September to November 2020. Sampling was conducted four times with an interval of once every 15 days. Sampling was carried out at five stations based on water movements to the estuary, station A was located at the seawater, station B was located in the pond wastewater locations, station C was water sources from residential waste, station D was located in the river, and station E was the estuarine water. The results showed that the dominant water quality parameters affecting estuarine water quality were salinity, total organic matter, nitrogen content, either in the form of ammonia, nitrate, or nitrite, and phosphorus content, especially phosphate. Water entering the estuary has an impact on high concentrations of total organic matter, increased concentrations of Total N, and phosphorus. The results of water quality analysis in estuaries showed that salinity, organic matter, ammonia, nitrite and nitrate, and phosphate exceed the standard threshold for water quality standards for fish pond aquaculture. Thus, the waters of the Maros estuary are not suitable for aquaculture, especially for the 5 observed stations (A, B, C, D and E).

Key words: Total Organic matter, Total N, Phosphor, Estuary, brackish water

1. INTRODUCTION

Indonesia is a tropical country, and the climate is fairly even throughout the year. Which is divided into 131 watersheds with more than 5,700 rivers, and contains many dams, weirs, and canals [1]. Estuary ecosystems in river mouths are a place where fresh water and seawater are mixed and contain a lot of organic matter, minerals, and sediments that come from upstream to the estuary, while seawater flows contain lots of minerals so that estuarine waters are more fertile. Compared to other areas. In addition, estuary areas are important habitats for several types of marine and freshwater organisms to fulfill their life cycles, which are used as spawning grounds, foraging areas, and nurseries.

Many estuaries are left exposed to environmental impacts due to excess nutrients from the anthropogenic activities installed in their watersheds. These include changes in community structure and food webs, harmful algae, seaweed, and epiphyte overgrowth, low oxygen levels, and reduced biodiversity [2]. Most impacts result from a complex series of events that vary in space and time, but they can be caused by major stresses: the accumulation of excess nitrogen and phosphorus in fluvial water as it heads out to sea [3].

Many estuaries in Indonesia are located near intensive shrimp farming and other agricultural and livestock activities and are therefore at risk of receiving nutrients from anthropogenic sources. Shrimp pond aquaculture threatens the water environment due to nitrogen and phosphorus eutrophication, which has already caused great concern in many regions [4; 5]. Nitrogen and phosphorus are also important in shrimp pond aquaculture, and improper management can result in environmental eutrophication [6]. Lacerda [7] stated that the disposal of untreated waste; in the form of solid waste and wastewater, urban runoff, livestock, and the use of fertilizers and other chemicals in agriculture exacerbate the pollution of organic waste into rivers. Besides anthropogenic sources, natural processes that contribute to the nutrient load are atmospheric deposition and soil runoff.

Maros is one of the districts in South Sulawesi Province, which has a coastline of 14 km and is fed by two rivers, making this area a potential area for fishery business. The coastal area of South Sulawesi Province has a large potential for the development of shrimp and fishponds aquaculture. For example, in 2008, Maros Regency reached 20,197.93 tons of fish production, 68.3% of capture fisheries, 26.4% of fishponds aquaculture, and the remaining 5.3% of other fisheries production. Therefore, fishponds aquaculture had a significant role in determining the fisheries production in Maros [8]. Based on the description above, it is necessary to study the content of organic matter, total N, and phosphorus in water entering estuaries, including seawater, pond wastewater, river water, and the feasibility of estuarine water as a source of raw water for pond cultivation. The study aimed to determine the state of organic matter, total Nitrogen, and Phosphorus in the estuarine waters of Maros, and to analyze the feasibility of the estuary waters of Maros as a source of brackish water for fish pond aquaculture.

2. MATERIAL AND METHODS

2.1. Study Period and Location

This research was conducted from September to November 2020. The location of this study is in the Maros estuary area of Maros Regency, South Sulawesi, Indonesia.

Measurement of Total Organic Matter (TOM), Total Nitrogen, and Total Phosphorus was conducted in the Water/Soil Laboratory, Pangkep State Polytechnic of Agriculture. The determination of total organic matter was based on the method recommended by Namour [9], while the measurement of Total Nitrogen in water samples was carried out according to the method of Gentle [10]. The measurement of Total Phosphorus was based on the method of Ma [11]. Parameters in the form of salinity, pH, and temperature are measured in situ.

2.2. Experimental Setup

This research was carried out in three steps; Step (I) survey of the research location, step II, Data collection, and step III, Data analysis.

Step I: A survey of the research location was conducted to get an overview of the condition of the research location and the problems that occurred at the location during the research. The means of transportation used in the sampling was using a 24 pk motorboat.

Step II: The types of data obtained were measurements of Total Organic Matter (TOM), Total Nitrogen, and Total Phosphorus, which were analyzed in the laboratory, in which the parameters measured included pH, salinity, and temperature which were measured in situ. While data on the general condition of the watershed were obtained from the Central Bureau of Statistics.

Step III: Sample analysis was carried out to determine the quality of estuarine waters and the feasibility of the estuary waters of Maros for fish pond aquaculture.

2.3. Determination of Observation Stations

The determination of stations based on the flow of water movements in the estuary includes the front at the mouth of the estuary in contact with the sea, the anchorage channel, the river, the canal of the settlement that goes into the estuary, and the estuary areas.

In the estuary of Maros, there are six branches of the river with five estuary mouths. Determination of sampling points in the estuary is determined by three branches of the river. The location of this point starts from the edge of the river in the middle and edge. The determination of the retrieval point between the edge and the middle was carried out by forming an angle of 45^0, which was 500 m apart, between points from one another. The number of sampling points was set at 10 for each branch of the river. In total 30 sampling points were within the estuary. Hence, of the five mouths of the Maros River, three were substations each with five points. Overall, there were 15 sampling points.

The pond wastewater sampling substation is determined on the existing block and corresponds to the station in the estuary, in which, there were 6 sampling spots. For domestic wastewater, one station is established consisting of three collection points. In this Maros estuary, two rivers enter so there are two substations, in the determination of the sampling point, a horizontal line was made in the direction of the width of the river of 5 points. The observation stations are as follows:

A. = seawater entering the estuary through the tides
B. = pond flower water that enters the estuary
C. = domestic wastewater
D. = river water from the watershed area
E. = water in the estuary

Figure 1. The observation area around the Maros river with the fifth observation stations

2.4. Sampling

Sampling was carried out at the highest tide, this was intended to get a clear picture of the water quality in the estuary, at the same time refilling water was also carried out in the ponds. Sampling was performed in the afternoon around 16.00, 4 times with a time interval of 15 days. Field equipment used includes *a* Kemmerer water sampler, hand refractometer, temperature thermometer, and sample bottles.

Sampling was conducted at predetermined stations, both from estuaries and from water entering the estuary. In taking water samples, the Kemmerer water sampler was used to take samples at the bottom, middle, and surface of the water (if the depth is more than one meter). However, in depths of water less than a meter. the water samples were only taken at the bottom. Samples obtained from all over the estuary were composted for analysis. The collected samples were put in a box and given ice and then taken to the laboratory.

2.5. Measurement of Parameters

Parameters of water quality observed were the measurement of total organic matter, Total Nitrogen, and Phosphorus inputs which were analyzed in the soil and water laboratory of Pangkep State Polytechnic of Agriculture. Other supporting data measured include temperature, dissolved oxygen, ammonia, pH, and salinity, which is part of this phase III research and is used to evaluate the feasibility of brackish water sources in the Maros estuary to support aquaculture activities for people living around the area, thus policies can be recommended to the local government.

2.6. Data Analysis

The data obtained were analyzed descriptively and presented in tables and graphs. Meanwhile, to determine differences in water quality between observation stations, one-way variance analysis [12 was used. If the water quality values show a significant difference, proceed with using the Tukey HSD Test [13]. Statistical data processing was assisted by the SPSS Version 10 program [14]. To assess the feasibility of the estuary of Maros as a source of brackish water for fish pond aquaculture.

3. RESULTS AND DISCUSSION

The results of the analysis of the quality of water entering the estuary are shown in Table 1. The results obtained showed that there were several prominent parameters such as Total Organic matter (TOM), Total Nitrogen (Total N), and Total Phosphorus, showing the difference between the five observation stations, where all waters observed show criteria as hypereutrophic water [15].

Table 1. Results of measuring the average Water Quality Parameters at Each Station Observations A, B, C, D, and E.

No.	Parameters (mg/l)	Station A Seawater	Station B Pond Wastewater	Station C Domestic wastewater	Station D River Water	Estuary E Station	National Standard Criteria [15]
1	TOM	32.36±0.03^{a}	12.36±0.04^{a}	61.2±0.06^{b}	79.78±0.04^{b}	71.43±0.04^{b}	Hypereutrophic
2	Total N	22.1±0.05^{a}	35.1±0.04^{c}	32.5±0.05^{bc}	16.2±0.06^{a}	25.2±0.04^{ab}	Hypereutrophic
3	Total Phosphorus	2.24±0.03^{c}	0.92±0.05^{a}	1.57±0.03^{b}	2.39±0.05^{c}	2.36±0.06^{c}	Hypereutrophic

Data are expressed as mean± standard error. Values in the same column with the same superscript are not significantly different ($P > 0.05$).

3.1. Total Organic Matter (TOM)

Measurement of the range of total organic matter (TOM) concentrations at each station showed different results. The highest TOM concentration was found in river water (79.78 mg/l), followed by estuary water (71.43 mg/l). However, no significant difference between those two stations. However, the lowest concentration was found in pond wastewater (12.36 mg/l). The results indicated that the average concentration of TOM between different observation stations is very significant. The concentration of TOM in pond wastewater was significantly different from that of in other areas including domestic wastewater, estuaries, and rivers, but the concentration of TOM between pond wastewater and seawater was not significantly different. Likewise, it was found that the TOM of river water was not significantly different from domestic and estuary wastewater.

The total organic matter in seawater and pond wastewater was found to be lower than the others. Although the lowest concentration of TOM was found in pond wastewater, there was no statistically significant difference between seawater and pond wastewater. This result indicated that fish farming in ponds near the estuary of the Maros area is not the main source of TOM. Pond fish cultivation in the Maros estuary area has switched to traditional ponds which do not use artificial feed as a source of TOM.

Of the four TOM sources, river water was the largest contributor to organic matter entering the estuary. The high concentration of organic matter in river water was closely related to the activities of the people who live around the watershed, in which 38.91% of the population work in agriculture that runs intensively, 39,376 Ruminantia farmers with livestock that are grazed illegally, besides that there is a poultry farm, intensive aquaculture activities, rice milling, and small industry. The Maros River passes through the domestic, trade, and population centers that are high in the watershed area with a density of up to 190 people/km^2, all of these of course have the potential to be a source of organic matter carried by the waters.

In addition, an increase in TOM in estuary waters can be caused by silting of estuaries which causes no water circulation. This has an impact on increasing the accumulation of organic matter in the estuary, which in turn affects other water quality parameters, through the anaerobic and aerobic decomposition of microorganisms [16].

3.2. Total Nitrogen

Measurement of the total nitrogen value at each observation station shows a different value. The total nitrogen obtained from pond wastewater is around 35.1 mg/l and the lowest value is found in river water (16.2 mg/l). The results indicated a very significant difference in total nitrogen content between observation stations. The total nitrogen in river water was different from the total nitrogen in domestic wastewater and pond wastewater, but not significantly different from seawater and estuary water. Total nitrogen in pond wastewater was different from total nitrogen in the estuary, and river water, but not different from domestic wastewater.

Pond wastewater and domestic wastewater have the highest total nitrogen concentrations. This was because pond wastewater and domestic waste experience a slow nitrification process due to low dissolved oxygen levels, while river water has a low total nitrogen concentration when compared to other stations, this indicates that the nitrification process in the area is going quite well due to the availability adequate oxygen [17].

3.3. Total Phosphorus

The average concentration of phosphorus in each observation shows that the highest value was found in river water, while the lowest value was found in pond water. The concentration of phosphate in river water comes from particles of soil, rock, plant, and livestock waste, in the watershed, which was carried through the river water. In addition, the source of phosphorus also comes from the decomposition process of organic matter containing orthophosphates [18].

Higher levels of phosphorus in seawater indicate that the coastal waters of Maros receive inputs of phosphorus from land, through rivers, and from the ocean. Wardoyo [19] states that the phosphate content in natural waters is generally not more than 0.1 mg/l, except in these waters receiving household waste and agricultural waste. In addition, phosphate input can also come from weathering of rocks and the decomposition of organic matter.

Tukey HSD advanced test results show that the phosphate concentration in pond wastewater was significantly different from those in domestic wastewater, seawater, river water, and estuarine water. The phosphate concentration in domestic wastewater differs markedly from those in seawater, estuarial, and river water. However, the phosphate concentrations of seawater and estuary and river water do not differ markedly.

Thus, it can be said that the largest sources of phosphates in the estuary waters of Maros were river water and seawater. Phosphate is very important and becomes a limiting factor for water and can be used as a determinant of aquatic productivity, but if the concentration of phosphate contained in large quantities exceeds the needs of plants, it will cause eutrophication which has an impact on reducing oxygen levels in waters and can kill organisms. Based on national regulations stipulated by the ministry of environment and forestry [15] that the values of TOM, Total phosphorus, and Total nitrogen were found in sampling conducted at the five observation stations, it was found that the Maros estuary waters were classified as hypertrophic waters.

3.4. Evaluation and feasibility of the estuary water of Maros as a source of brackish Water for fish pond aquaculture

The feasibility of the estuary water of Maros as a source of brackish water for fish pond aquaculture can be known by comparing the results of the analysis of water quality parameters with water quality standards for pond cultivation

It appears that several water quality parameters of estuarine water do not meet water quality standards for fish pond aquaculture. The water quality parameters include TOM, NH_3, salinity, and phosphate. Based on the data presented in Table 2, the estuary water of Maros was no longer suitable as a brackish water source for fish pond aquaculture, particularly intensive aquaculture. The ineligibility of water quality affects fish pond production in surrounding areas.

3.4.1. Total Organic Matter (TOM)

The results of the TOM analysis in the estuary showed concentrations that exceeded the threshold for pond cultivation during observations if it was related to the quality standards for pond cultivation water the limit set by the Indonesia Ministry of Environment and Forestry Regulation (MEFR), KEPMEN. 28/KLH/2004 [20], which is < 50 mg/l.

The content of TOM in these waters comes from agricultural waste, domestic waste, livestock waste, industrial waste, urban waste, and waste from pond cultivation businesses. TOM in the waters indirectly affects aquatic organisms but affects other water quality parameters. TOM will decompose both aerobic and anaerobic, resulting in compounds CH_4, H_2S, Ammonia, NO_2, NO_3, and CO_2 and affecting changes in pH [21]. Therefore, table 2 indicated that the values of TOM, NO_3, NO_2, NH_3, and phosphate are inappropriate for aquaculture purposes [20].

Table 2. Comparison of the water quality of the estuary water of Maros and water quality standards for fish pond aquaculture.

No.	Quality Parameters	Ranged Values	Standards For Aquaculture	National Standard	Classification
1	Water temperature (^oC)	32,2 – 33,1	26 - 33 ^oC	[20]	Suitable
2	Dissolved Oxygen (mg/l)	7,73 – 8,45	> 4	[20]	Suitable
3	Ph	7,12 – 7,54	6,5 – 8,5	[20]	Suitable
4	Salinity (ppt)	26 – 38	10 – 30	[20]	Not Suitable
5	TOM (mg/l)	59,15 – 82,65	< 50	[20]	Not Suitable
6	NO_3 (mg/l)	59,17 – 76,85	< 75	[20]	Not Suitable
7	NO_2 (mg/l)	1,35 – 2,65	< 2,5	[20]	Not Suitable
8	NH_3 (mg/l)	0,21 – 0,29	< 0.1	[20]	Not Suitable
9	Phosphate (mg/l)	1,86 – 2,35	< 0.5	[20]	Not Suitable

3.4.2. NH_3, NO_2, and NO_3

This total concentration of NH_3 in estuarial waters is the result of the decomposition of organic matter and the remains of the metabolism of aquatic organisms. According to [22], the main sources of NH_3 in waters are the destruction of organic matter, domestic waste, industrial waste, and livestock waste.

High concentrations of NH_3 directly inhibit growth and can kill aquatic organisms and indirectly affect the reduction of dissolved O_2 in waters due to the use of microbes in the nitrification process. The concentration of NH_3 in estuarine waters during observations ranged from 0.21 – 0.29 mg/l, this range

was above the recommended limit for pond aquaculture quality standards set at <0.1 mg/l [21]. Nkuba et al. [23] found the same thing, that the concentration of NH_3 in the ponds was <1 mg/l, suitable for the growth and survival of shrimp and fish was 0.1 mg/l.
Nitrite is formed from ammonia and can accumulate in water due to an imbalance in the activity of nitrifying bacteria. Table 2 showed that nitrite levels were found to be in a slightly higher range than the level recommended by the national regulation [20]. High levels of nitrites in the water are a potential factor that can trigger stress in aquatic organisms. Nitrite is formed as an intermediate product during either the nitrification of ammonia bacteria or the denitrification of nitrate bacteria. Nitrite is also produced in denitrification, where nitrate is biologically reduced to gaseous di-nitrogen (N_2) or nitrous oxide (N_2O) [24].

This study shows that nitrate levels are above the standards for intensive cultivation (59,17 – 76,85 mg/l). Nitrate toxicity is more of a problem for shrimp producers who raise shrimp, especially when the water has a low salinity approaching freshwater conditions. However, in this study, a lower range of salinity was found, so fish or shrimp does not have to use significant energy to regulate their osmotic pressure levels to compensate for the reduced saline environment [25].

3.4.3. Dissolved Oxygen, Salinity, and pH

One of the most important metrics is dissolved oxygen. The growth of aquatic organisms is retarded if the dissolved oxygen level is too low. In this study, dissolved oxygen levels ranged from 7.73 to 8.45 mg/l, still within the recommended limits for aquaculture commodities. Meanwhile, High salinity reduces the amount of dissolved oxygen in the water. In this study, the salinity ranged from 26 to 38 ppt. As a result. The ideal concentration should be between 10 and 30 ppt [20]. Furthermore, extreme pH levels are detrimental to shrimp, resulting in a brittle shell, particularly for shrimps, and low survival rates. As shown in Table 2, the pH of estuarine water is between 7.12 and 7.54. This level is suitable for the survival and growth of cultivated commodities [20].

Salinity measurements are carried out repeatedly between October and November (The beginning of the rainy season). In the first observation, the measurement results are 38 ppt, the second measurement is 32 ppt (October), the third measurement is 32 ppt, and the fourth measurement is 26 ppt (November). The results of these measurements indicate that the salinity in October was high and early November is not suitable for fish and shrimp life, so it can be said that fish and shrimp farming is feasible from November to April during the rainy season. The optimum salinity range for fish and shrimp growth is 12 – 28 ppt. Salinity > 33 Growth starts late, if the salinity reaches above 48 ppt it causes growth to stop and die if it is greater than that. At a salinity that is greater than the optimum requirement, aquatic organisms will expend greater energy to maintain their life. Supriharyono [26] said that salinity affects the balance of osmoregulation in the bodies of aquatic organisms related to the process of energy expenditure which will in turn affect growth. Aquatic organisms are forced to expend greater energy to adapt to these circumstances.

3.4.4. Phosphate

The results of the analysis of phosphate in the estuary ranged from 1.86 to 2.46. This result exceeds the water quality standards for pond cultivation, namely 0.5 mg/l. (Ministry of Environment and Forestry Regulation (MEFR), KEPMEN No. 28/KLH/2004 [19]. This phosphate is very important in waters because it is an essential nutrient for the growth of phytoplankton and aquatic plants, so it is one of the determining factors for aquatic productivity. However, if the phosphate content in the waters is present in large quantities that exceed the needs for phytoplankton and aquatic plants, this is one of the factors for eutrophication, which results in higher oxygen levels during the day and even reaches oversaturated conditions and at night, there is a shortage of oxygen (anoxic) due to the use of oxygen for respiration and overhaul of organic matter by aquatic micro-organisms

4. CONCLUSION

Community activities in the Maros watershed area have an impact on increasing the concentration of TOM in the river water, which affects the quality of estuary water as a source for pond cultivation. River water and seawater are the biggest sources of phosphate for estuary waters. The water quality of the estuary water of Maros exceeds the water quality threshold for fish pond aquaculture; TOM (59.15 – 82.65 mg/l), NH_3 (0.21-0.29 mg/l), salinity (26-38 ppt), and phosphates (1.86 -2.36 mg/l). Thus the Maros estuary water is not suitable for pond cultivation, especially for intensive pond cultivation. This can interfere with the existence of pond cultivation. Therefore, in the management of pond cultivation, it is better to carry out water management before it is used. There is a need for sewage treatment before being discharged into the waters, and the use of fertilizer should be adjusted to the needs and adjusted to a predetermined dose. Future research should be carried out over a longer period, hence the information obtained will be more complete and representative

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