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Fluctuation of NO_3-N and PO_4 Elements in The Traditional Pond Area at Tides

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***Abstract*— *Traditional pond technology depends on nature in management, such as filling and disposal of pond water utilizing the time of low and high tides. The food for traditional pond technology comes from nature. The availability of nutrients such as N and P greatly determines the productivity of pond. The study was aimed to determine the fluctuations of N and P elements in traditional pond areas at tides. This research was conducted with purposive sampling method and laboratory analysis for several water parameters. The results showed that pH ranged from 7 to 8 both at low tide and high tide. The average value of nitrate (NO_3) from five locations was extended from 0.106 to 1.495 mg/l. The value of silica (Si) ranged from 5,287 to 10,876 mg/l in low tide. Orthophosphate at low tide ranged from 0.027 to 0.090 mg/l, the highest value was in the coast station and the lowest was in the sea station. Whereas the value of nitrate (NO_3) and orthophosphate in high tide ranged from 0.830 to 1.495 mg/l and 0.039 to 0.090 mg/l. Nutrients were abundant enough to support the growth and development of primary producers. So, the waters in this region include fertile waters.*

Keywords*— *high tide, low tide, nitrate, phosphate, traditional pond.

I. INTRODUCTION

Indonesia is the country with high potential of marine and fisheries resources. One of the potential is aquaculture sector with shrimp commodity in the coastal area. The area of shrimp farms in Indonesia is currently 344,759 ha or 39.78% from the total of potential land which is spread throughout Indonesia (Arifin et al. 2012). Currently, the various technologies of shrimp cultivation have developed rapidly from the simplest to the most modern technology.

One of the technology in pond cultivation is traditional pond that is widely used by Indonesian people. The traditional pond technology is largely dependent on nature, such as filling and disposal of pond water utilizing the time of low and high tides. Water quality plays a major role as a medium of cultivation. The cultivation requires sea water as a medium that is highly dependent on the quality of optimal water supply. Changes of water quality are closely related to potential waters in the availability of N and P elements.

The nitrate and phosphate content of coastal waters is used as a benchmark for aquatic fertility. When the content was optimal, the phytoplankton is more abundant (Mustofa 2015). Risamasu and Prayitno (2011) also state that nitrogen (N) and phosphorus (P) play an important role in the growth and metabolism of phytoplankton including plants autotrophs. Nutrient enrichment in the aquatic environment has a positive impact, but it can also have a negative impact in certain level. The positive impact was an increase in phytoplankton production and total fish production (Jones-Lee and Lee 2005; Gypens et al. 2009). While the negative impact is a decrease in oxygen content in the waters, decreasing biodiversity, and sometimes increasing the potential appearance and development of dangerous phytoplankton species commonly known as Harmful Alga Blooms or HABs. Therefore, environmental preservation around traditional pond areas needs to be considered. According to Abraham and Sasmal (1995), traditional pond productivity depends on the quality of coastal resources around it.

Coastal areas with river estuaries have their own characteristics. The hydrodynamic process such as currents and tides causes the distribution pattern and concentration of organic matter to vary in different location. The result study from Lihan et al. (2008) find that strong currents expand the distribution of nutrients, which can move elsewhere.

Traditional farms are generally still adjacent with mangrove forests. The mangrove forests are thought to provide or contribute to fertilizing the surrounding waters. Mangrove ecosystems serve as a place to nurture larvae, breeding sites and food sources for various aquatic species, especially shrimp and milkfish (Sikong 1978). Mangrove litter as a source of organic matter is very important in the supply of nutrients through decomposition process by active organisms. Litter decomposition is a very important process in nutrient dynamics in ecosystem (Regina and Tarazona 2001). The study was aimed to determine the fluctuations of N and P elements in traditional fishpond area in Soppeng Riaja Subdistrict, Barru District, South Sulawesi.

II. MATERIALS AND METHODS

Location and Time of Research

The study was conducted in the mangrove forest area of Soppeng Riaja Subdistrict, Barru District, South Sulawesi. This area was partly used for the cultivation of shrimp ponds with traditional technology. Sampling was carried out in May 2017 until February 2018. This research was conducted with post facto survey methods and laboratory analysis for several water parameters. Sampling, preservation, transportation, and water quality analysis were carried out based on Standard Methods for The Examination of Water and Wastewater (APHA 2012). Determination of sampling locations was established with purposive sampling method and the station as follows:

1. Freshwater area (river), this is intended to measure nutrient content from land.
2. Sea area, this is intended to measure the nutrient content in the sea
3. The coastal area is intended to measure nutrient content in the coast
4. The mangrove area is intended to measure the nutrient content in the mangrove ecosystem
5. The pond area is intended to measure the nutrient content in the pond area.

Data analysis

The fluctuations of each variable nitrate and phosphate at different locations were using correlation and regression. The analysis employed SPSS version 22.

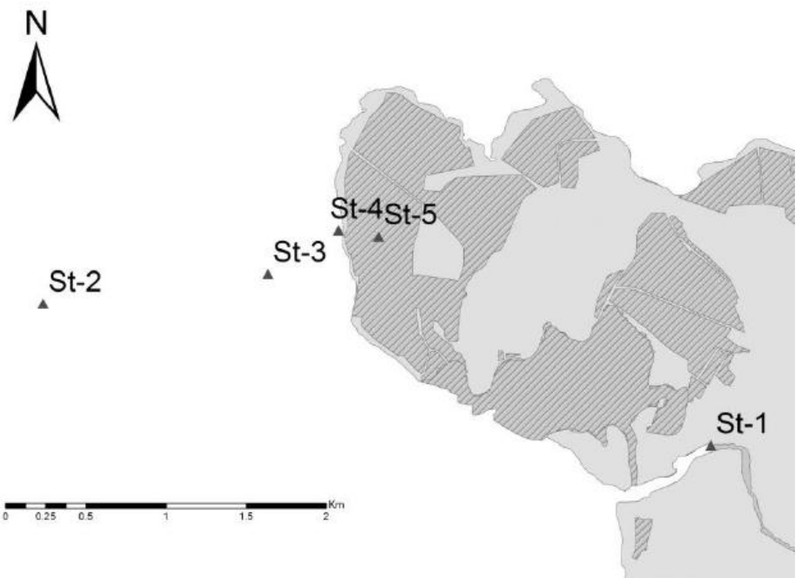

Fig.1: Location of water sampling station in Soppeng Riaja Sub district, Barru District, South Sulawesi, the sampling location st 1 (4°15'19.08'S, 119°36'58.32'E), st 2 (4°14'50.28'S, 119°34'43.32'E), st 3 (4°14'44.52'S, 119°35'28.68'E), st 4 (4°14'35.52'S, 119°35'43.08'E), and the st 5 (4°14'36.96'S, 119°35'51'E).

The sampling used purposive sampling method that could represent the overall state of the research area. Water sampling at each station was carried out in three replications and carried out during high and low tides with a one-month interval. Taking water samples used Nansen bottles, then water samples were stored in the cool box, and analyzed in the laboratory of the Brackish Aquaculture Research Institute (BPPAP) in Maros, South Sulawesi. Dissolved oxygen levels were measured by DO meter, the degree of acidity (pH) was measured by a pH meter and salinity was measured by refractometer.

Table.1: The parameters of water quality

No	Parameters	Unit	Tools	Methods	Description
Physics					
1.	Temperature	°C	Thermometer	Expansion	*In-situ*
2.	Brightness	meter	*Secchi disk*	Visual	*In-situ*
3.	Rainfall	mm/day	Secondary data	-	
4.	Tides		Tides bar	Visual	*In-situ*

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Chemistry					
5	pH	-	pH meter	Electrode	*In-situ*
6	Salinity	‰	Refractometer	Light refraction	*In-situ*
7	Nitrate (NO_3^-)	µmol/L	Spectrophotometer	Ultraviolet light	*Ex-situ*
8	Silicate (SiO_2)	mg/L	Spectrophotometer	Ultraviolet light	*Ex-situ*
9	DO	mg/L	DO meter	Electrode	*In-situ*
10	Orthophosphate	mg/L	Spectrophotometer	Ultraviolet light	*Ex-situ*

III. RESULTS AND DISCUSSION

The results of measurements and laboratory analysis of the physical and chemical parameters were presented in Tables 2 and 3. Based on the results, water temperature at low tide ranged from 27-29°C with the highest value in the sea station and the lowest value in the mangrove station. The temperature at high tide ranged from 27-30°C with the highest value in the sea station and the lowest value in the mangrove station. Temperature influenced the biological and chemical processes of aquatic organisms. In the tropical area, temperature range was very reasonable and the difference between the lowest and highest temperatures was not far. It did not have much effect on the metabolic process in waters. When light penetration entering into the waters decreased, it would reduce phytoplankton activity to photosynthesis (Abida 2010).

The results of salinity measurements at low tide ranged from 27-32 ppt, whereas in rivers the salinity value at low tide was 0 ppt. In high tide, salinity ranged from 30-33 ppt and salinity in the river rose to 11 ppt. This condition indicated that the flow or strength of entering fresh water is greater than the entering tide. According Wisha et al. (2015), currents made the main transport of waters that weak currents created weaker transport. The main parameter in studying seawater mass was salinity, salinity was greatly affected by high salinity at high tide and the amount of freshwater concentration in the waters.

The pH ranged from 7–8 at low tide and high tide. The degree of acidity (pH) of water indicated the presence of hydrogen ions in water. This was caused hydrogen ions acidic. Most aquatic biota was sensitive to changes in pH and like around 7–8.5 (Effendi 2003). Referring to this opinion, the pH of the water could still support the life of aquatic biota and could live well.

Table.2: Average range of several water quality parameters in the mangrove forest in Soppeng Riaja Subdistrict, Barru District, South Sulawesi, during low tide

Station	Parameter						
	Temperature	pH	Salinity	Nitrate	Si	DO	Orthophosphate
Sea	29.98	8.110	32.906	0.524	6.439	6.986	0.027
Coastal	29.26	7.933	30.450	0.818	10.876	7.072	0.086
Mangrove	27.96	7.941	29.863	0.402	7.977	6.633	0.062
River	29.71	8.067	0.000	0.106	9.627	7.228	0.049
Pond	29.66	7.493	27.896	0.231	7.038	6.867	0.044

Table.3: Average range of several water quality parameters in the mangrove forest in Soppeng Riaja Subdistrict, Barru District, South Sulawesi, during high tide

Station	Parameter						
	Temperature	pH	Salinity	Nitrate	Si	DO	Orthophosphate
Sea	30.51	8.113	33.039	0.830	5.287	6.956	0.049
Coastal	28.67	8.033	32.339	0.980	6.512	7.078	0.039
Mangrove	27.88	7.859	31.359	1.495	7.433	6.411	0.090
River	29.93	8.106	11.272	0.970	6.676	7.089	0.039
Pond	29.41	7.356	30.281	1.063	6.850	6.633	0.047

The results of temperature around the mangrove ecosystem at low tide showed that the water temperature ranged from 27.96–29.98°C, while the temperature at high tide ranged from 27.88–30.51°C. The temperature conditions were still within the water quality standard of Government Regulations Number 82 in 2001. High and low water temperature was influenced by the temperature in surrounding air, the exposure intensity of sunlight entering water body, and the surrounding vegetation. The intensity of sunlight was influenced by cloud cover, season, and time of day. The more intensity of sunlight would make the water temperature higher. Likewise, more close vegetation around it would make the surrounding air

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temperature lower so that the water temperature also got lower.

An increase in temperature would cause a rise in the metabolism and respiration speed of aquatic organisms resulting in improved oxygen consumption. The increase in temperature also caused an increase in the composition of organic matter by microbes. This condition was impacted to increase the BOD levels in water. The optimum temperature for phytoplankton growth in waters ranged from 20–30°C (Effendi 2003). This showed that the water temperature conditions around the mangrove area did not interfere to phytoplankton growth. Water temperature could affect to dissolved oxides (DO) in these waters (Aprianti et al. 2015). Dissolved oxygen (DO) at low and high tide in five stations ranged from 6.4 to 7 mg/l. DO levels that safe for marine biota based on Decree of the State Minister of the Environment Number 51 of 2004 were > 5 mg/l, DO concentrations in this study were safe for marine biota.

Test Result of Chemical Parameters

Nitrate (NO_3)

Nitrate was the main form of nitrogen in the waters and the main nutrient for plant growth and algae. Nitrate nitrogen was very easy to dissolve and stable in water (Effendi 2003). Results of nitrate in the mangrove area during low tide and tide were showed in Figure 2.

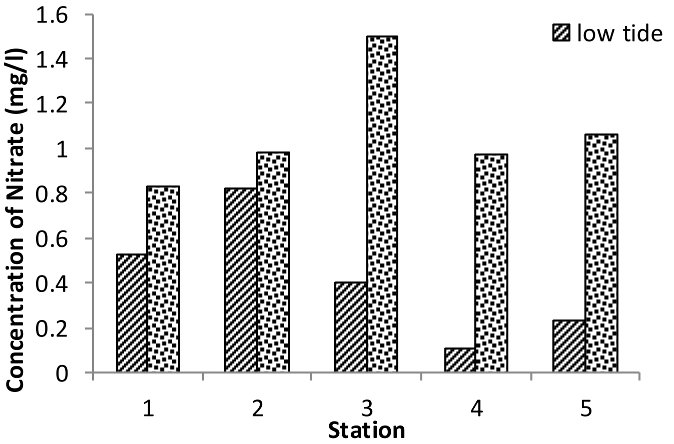

Fig.2: Nitrate levels at low and high tide in five stations

The average value of nitrate (NO_3) at low tide from five locations ranged from 0.106-0.818 mg/l with the highest value in the coastal station. While, the value at high tide ranged from 0.970-1.495 mg/l with the highest value at the pond station followed by mangrove station. The coastal stations at low and high tide have high nitrate levels, while mangrove stations were high concentration at high tide. Mustofa (2015) suggested that nitrate (NO_3) was highest in locations near mangroves. The waters that have mangrove vegetation supported the fertility of the waters with abundant elements from the mangrove litter. The distribution of nitrate concentrations was influenced by the season which affected to the tides (Ahmad et al., 2012). Nitrate concentration in general was still high in coastal areas and mangrove areas compared to marine waters (Patty et al. 2015). Suprapto et al. (2014) stated that river flows contributed to the process of nutrient availability in the waters.

Based on the quality standards (Decree of the State Minister of the Environment Number 51 of 2004), the nitrate levels in waters were 0.008 mg/l. Nitrate concentrations in this study were exceed quality standards. From these data indicated that the traditional pond waters of Soppeng Riaja Subdistrict, Barru District, South Sulawesi, were under pressure in the form of nitrate enrichment and potentially caused algal bloom. The fertility level of waters was strongly influenced by the nutrient content. The amount of NO_3 content would affect to marine population that required nutrients as the main ingredient in their life process. Isnaeni et al. (2015) suggested that the nitrate content was getting lower towards the sea. Based on Table 4, nitrate correlation analysis at low tide and pairs with a correlation coefficient of 0, 754, with a Sig (0.019) <α, it can be concluded that nitrates at low and high tide have a significant. Regression analysis with Sig (0.051), linear model at low and high tide variables with significant.

Silica (Si)

Silica (Si) was one of the essential elements for living things. Some algae, especially diatoms (Bacillariophyta), required silica to form a frustule (cell wall) (Effendi 2003).

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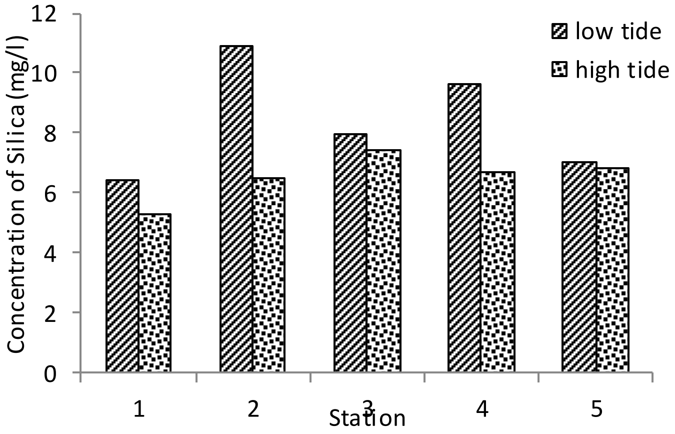

Fig.3: Silica levels at low and high tide in five stations

The measurement results of silica (Si) at low tide from the five locations ranged from 6.439-10.876 mg/l. The highest value was at the coastal station and the lowest at the sea station. The silica value at high tide ranged from 5.287-7.433 mg/l with the highest value at the mangrove station. Marling (2016) stated that the highest silica (Si) was found in coastal areas and river estuaries. Silica (Si) was an element other than nitrogen and phosphorus which was also important for primary productivity (Papush & Danielsson, 2006). Silica was also a nutrient that acted as a regulator for phytoplankton competition, where diatoms always dominated phytoplankton populations in high silica concentrations (Egge and Aksnes, 1992).

Phosphate (PO_4)

Phosphate in waters was not found in free form as an element, but in the form of dissolved inorganic compounds (orthophosphate and polyphosphate). Inorganic phosphorus compounds found in the mangrove ecosystem area were shown in Figure 4. The average orthophosphate concentration at low tide in five stations ranged from 0.027 to 0.086 mg/l with the highest in the coastal station and the lowest in the sea station. The average orthophosphate at high tide ranged from 0.039-0.090 mg/l with the largest in the mangrove station and the lowest in the coast and river station. At low tide, the current movement tended towards the sea and carries phosphate from river to ocean waters. Maslukah et al (2014) stated that the current movement played a role in nutrient spread. Costa et al (2008) indicated that higher phosphate concentrations near land, were affected by water waste. According to Endiger et al (1998), phosphate in coastal waters was very possible originating from land. Crossland (1983) suggested that seasonal variations didn't hardly affect to phosphate concentrations in waters, but phosphate concentration was more influenced by phosphate use activities such as fertilization and detergents.

Based on the Decree of the State Minister of the Environment Number 51 of 2004 in attachment III, the threshold of phosphate content was 0.015 mg/l. According to Mustofa (2015), the highest concentration of phosphate (PO_4) was in locations near mangroves. The waters that have mangrove vegetation support the abundant fertility of the elements, because the mangrove litter is falling. Marlian (2016) stated that the phosphate (PO_4) element was highest in coastal areas. According to Ulqodry et al. (2010), phosphate compounds naturally originated from the waters themselves through decomposition processes of weathering or plants, residual dead organisms, and waste from livestock or leftover feed with bacteria decomposes into nutrients.

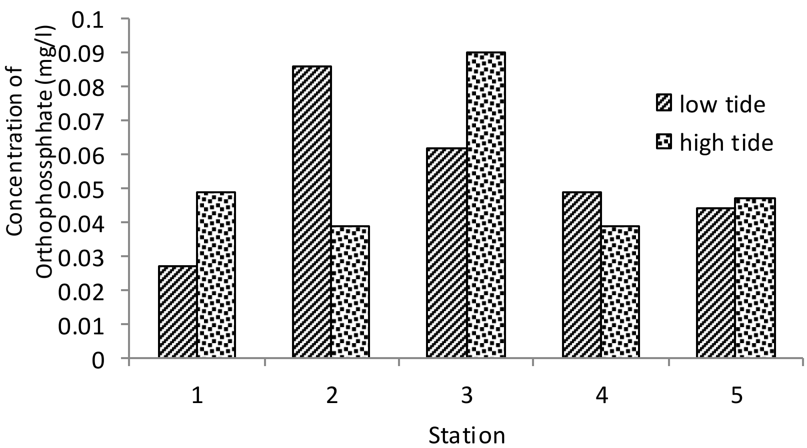

Fig.4: Orthophosphate levels at low tide and high tide

Based on the concentration of nitrate, phosphate, and silica, the water quality in the traditional pond area of Soppeng Riaja Subdistrict, Barru District, South Sulawesi in general was still relatively good. In addition, high nitrate concentrations illustrated the availability of nitrogen sources for phytoplankton growth. The main inorganic nutrients needed by phytoplankton to grow and multiply in the form of nitrate. The factors that distinguish the productivity of the coastal ecosystem from the open sea were; 1). Coastal waters received a large number of critical elements, namely N and P in the form of NO_3 and PO_4 through runoff from land where the content was more than the water, 2). Shallow, so phytoplankton production could continue, 3). There was rarely a permanent thermocline, so no nutrients were trapped in the bottom of water, 4). There were litter debris originating from land (Nybakken 1998). Phosphate distribution was not different at high and low tide (Budiasih et al. 2015). Phosphorus correlation analysis at low tide and tide shows a small correlation coefficient of 0.410. Sig (0.273)> α. it can be concluded that phosphorus at low and high tide is not significant. Regression analysis with the Sig value (0.161), a linear model between the tide and low tide with insignificant phosphorus values.

IV. CONCLUSION

Nutrient fluctuations in the traditional pond area of Soppeng Riaja Subdistrict, Barru District, South Sulawesi were generally still good. Nutrients were abundant enough to support the growth and development of primary producers. So, the waters in this region include fertile waters. The highest nitrate at low tides was 0.818 mg/l in the coastal station and the lowest was 0.231 mg/l in the pond station. While, the highest and the lowest nitrate at high tides were 1.495 mg/l in the mangrove station and 0.830 mg/l in the sea station. The highest and the lowest phosphorus at low tides were 0.086 mg/l in the coastal station and 0.027 mg/l in the sea station. While, the highest and the lowest phosphorus at high tide were 0.090 mg/l in the mangrove station and 0.039 mg/l in the coastal and river stations.

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