Distribution of Nitrate, Phosphate and N/P Ratio in Maninjau Lake, West Sumatra, Indonesia

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Abstract. This research aim to study of spatial distribution of Nitrate and Phosphate concentration, and also N/P ratio in waters of Maninjau Lake (0°19’ S; 100°12’E), West Sumatera Province, Indonesia, collected from 11 sampling points of water samples which were performed during 3 (three periods) May, June and July 2017. Other major sources of environmental nitrogen and phosphate are fertilizers and wastewater discharged from farms and livestock facilities, and sewage from residential areas which leak into lakes. The Nitrate and phosphate concentrations in Maninjau Lake waters, the results of the analysis found that Nitrate values ranged from 0.02 - 0.40 mg/L (quality standard 10 mg/L), while phosphate ranged from 0.12 - 0.54 mg/L (quality standard 0.2 mg / L). Nitrogen (N) and phosphorus (P) generally limit the main productivity in lakes. The N/P Ratio calculation results are known that 0.29 -0.58, the value shows that there has been an excessive addition of phosphate elements into the waters, so that it appears that the N element is a limiting element that affects the biological conditions of ecosystems such as phytoplankton biomass, species composition which is likely to occur dominance of certain types. This situation is quite reasonable, considering that around the study site is a residential area that discharges household wastewater that uses detergents into the waters. Anthropogenic nitrogen and phosphorus supply to natural ecosystems has increased them in many lakes.

1. Introduction
Water pollution is a global issue and world community is facing worst results of polluted water. Major sources of water pollution are discharge of domestic and agriculture wastes, population growth, excessive use of pesticides and fertilizers and urbanization [1]. Water pollution may pose serious threat to the environment as well as lives. Pollutant effects may vary depending on their types and source. [2] and it occurs when harmful substances—often chemicals or microorganisms—contaminate a stream, river, lake, ocean, aquifer, or other body of water, degrading water quality and rendering it toxic to humans or the environment [3]. Water is uniquely vulnerable to pollution. Known as a “universal solvent,” water is able to dissolve more substances than any other liquid on earth. Toxic substances from farms, towns, and factories readily dissolve into and mix with it, causing water pollution [4].

Lake as water ecosystems are an important resource for aquatic wildlife and human needs [5], [6] the water quality is governed by complex anthropogenic activities and natural processes [7] The ecosystem services include the provision of water for various purposes, including power generation, transportation, fisheries, tourism, and recreational enjoyment [8]. The alterations of water quality has wide-ranging ecological and societal implications that In general, lake ecosystems face threats that arise from a variety
of stresses, related to excessive nutrient (nitrogen: N and phosphorus: P) from nutrient runoff [9] modified hydrology, and climate change [10].

Important elements in waters that affect the availability of aquatic nutrients are nitrogen and phosphate because they play an important role in the formation of phytoplankton composition and biomass which will determine the primary productivity of waters. The anthropogenic nitrogen is accumulating in environmental reservoirs and altering many ecological processes whereas phosphorus is considered the limiting nutrient for phytoplankton production in freshwater systems [11]. Furthermore, the N: P ratio affects the food web in the water, so the values are different for plants, bacteria, zooplankton and fish.

Maninjau Lake (0°19’ S; 100°12’E) is a natural lake located in West Sumatra Province (Sumatra Island). The functions of Maninjau Lake are as a catchment area, water recreation area, and fish breeding area. Inlet channel comes from Batang Antokan River while its outlet channel flows into 3 small rivers namely Batang Tumayo, Batang Amparan, and Batang Kurambik. Around Maninjau Lake there are recreation areas, housing, laundry, hotels, and restaurants [12], [13]. The functions of the lake are very diverse, so the input of nitrogen and phosphorus elements in the waters is high, of course, it greatly affects the level of water fertility. The aim of the research to 1) Analysed the Concentration of Nitrate and Phosphate, 2) Determine the N/P Ratio (Redfield) in Maninjau Lake waters.

2. Research Method
This research was conducted in aquatic ecosystem of Maninjau Lake (0°19’ S; 100°12’E) located at Tanjung Raya Sub-District, Agam District, West Sumatera Province, Indonesia (Sumatra Island) (Figure 1). The waters samples were collected monthly from May to July 2017 by using water sampler by boat to get to the sampling location, which was determined based on Indonesian National Standard (SNI) 6989.57: 2008 about surface water sampling method [14] at 11 sampling point scattered along the waters were representing main inlet, main outlet and the activities both of waters surrounding as show in Table 1.

Parameters analyzed were Nitrate (N), Phosphate (P), were examined in the laboratory. The sample was put into a glass bottle with a volume of 1 L and tightly closed and placed in the cool box. The Nitrate concentration was measured by spectrophotometric, and the phosphate concentration was determined by calorimetric technique with molybden blue staining at a wavelength of 693 nm. Measurement of N-total, determined by spectrophotometry using the indophenol blue color generator method, measurement of P-total, was carried out using the Bray I Method [15].

Figure 1. Sampling Location in Maninjau Lake
Maninjau Lake water characteristics were compared to the quality standards by Government Regulation No. 82 of 2001 concerning Management of Water Quality and Water Pollution Control Class 2 for water recreation facilities, fisheries, irrigation, and stockbreeding.

3. Result and Discussion

3.1 Nitrate Concentration in Maninjau Lake Waters

The results of laboratory analysis in Table 2 showed that nitrate concentrations > 2.0 mg/l were found at several sampling points (3, 4 and 8) in period 1 due to the accumulation of waste from residential, pond fishery and agricultural activities in these locations. Moreover, at this location there is a Lake Maninjau Hydropower activity which results in the bottom of the estuary waters there are pipes for hydropower and canteen activities that dispose of waste water, causing pollutants to be stagnant and accumulation in the bottom lake.

In some waters, nitrates are described as micronutrient compounds controlling primary productivity in the euphotic layer. Nitrate concentrations that exceed 5.0 mg/l represent the occurrence of anthropogenic contamination originating from human activities and animal feces. Nitrate concentrations in excess of 0.2 mg/l can cause in eutrophication of waters which stimulates rapid growth of algae and aquatic plants (blooming) [16], [17]. The results of laboratory analysis obtained the following nitrate concentration data in Maninjau Lake.

Table 2. Nitrate Concentration in Maninjau Lake Waters

| Period | Unit | Quality Standard | Sampling Point | Average |
|--------|------|------------------|----------------|---------|
| 1      | mg/l | 10               | 1  0.09  0.09  0.36  0.30  0.11  0.07  0.20  0.32  0.15  0.24  0.16 | 0.19 |
| 2      | mg/l | 10               | 0.17  0.04  0.31  0.13  0.15  0.11  0.02  0.40  0.08  0.08  0.02 | 0.14 |
| 3      | mg/l | 10               | 0.11  0.13  0.19  0.10  0.08  0.07  0.05  0.30  0.04  0.10  0.08 | 0.11 |

Range Concentration: 0.02 - 0.40 mg/L comply to WQS

Meanwhile, at the other sampling points, there is the lowest nitrate concentration value, which is <0.2 mg/l, this occurs due to at that point the nitrogen in the form of nitrate has reduction process to form nitrite and ammonia (denitrification).
Figure 2. Nitrate Concentration in Maninjau Lake Waters

3.2 Phosphate Concentration in Maninjau Lake Waters
Phosphate is a very important nutrient compound. Source of phosphate compounds in waters usually from natural sources such as soil erosion, waste from animals and weathering plants. The concentration of phosphate increases due to discharge of domestic waste (detergent, etc.), home industry and agriculture/plantation (fertilizer) which contains a lot of phosphate [18], [19].

Table 3. Phosphate Concentration in Maninjau Lake Waters

| Period | Unit | Quality Standard | Sampling Point | Average |
|--------|------|------------------|----------------|---------|
|        |      |                  | 1 2 3 4 5 6 7 8 9 10 11 |         |
| 1      | mg/l | 0.2              | 0.50 0.44 0.15 0.19 0.41 0.53 0.28 0.19 0.39 0.25 0.31 | 0.33   |
| 2      | mg/l | 0.2              | 0.28 **0.50** 0.16 0.35 0.32 0.48 **0.52** 0.12 0.41 0.47 **0.54** | 0.38   |
| 3      | mg/l | 0.2              | 0.34 0.40 0.29 0.37 0.44 0.51 0.48 0.17 0.45 0.30 0.46 | 0.38   |

Range Concentration: 0.12-0.54 mg/L comply to WQS

The results of the analysis of phosphate concentrations in the waters of Maninjau Lake show in Table 3, shows that the value of the phosphate concentration exceeds the standard Quality. Excess phosphate in the waters causes the blooming of algae (eutrophication) with the side effect of decreasing oxygen concentration in water bodies, causing the death of aquatic biota [16] [17] [20].

Figure 3. Phosphate Concentration in Maninjau Lake Waters
4. **N/P Ratio in Maninjau Lake Waters**

The elements Nitrogen (N) and Phosphorus (P) are two important elements in the metabolic process of cells and their presence always serves as a benchmark for whether these elements are limiting factors or not. The ratio of the uptake rate of elements by microorganisms (Phytoplankton) is described by the N/P Ratio. Using this ratio can explain that the availability of elemental nitrogen in the form of nitrate (NO3) must be 16 times more than elemental phosphorus (PO4), this ratio is called the "Redfield Ratio". If the value of N/P Ratio is below 16, then the N element becomes the limiting element, whereas if the N/P ratio is higher than 16, then the P element is the limiting element from the existence of phytoplankton. This has an impact on the biological conditions of the ecosystem such as phytoplankton biomass, the composition of the species where certain species are likely to dominate and also on the dynamics of the food web [21], [22].

| Period | N/P Ratio | Sampling Point | Average |
|--------|-----------|----------------|---------|
|        |           | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  |       |
| 1      | <16 = P   | Low | 0.18 | 0.20 | 2.40 | 1.58 | 0.27 | 0.13 | 0.71 | 1.68 | 0.38 | 0.96 | 0.52 | 0.58 |
| 2      | <16 = P   | Low | 0.61 | 0.08 | 1.94 | 0.37 | 0.47 | 0.23 | 0.04 | 3.33 | 0.20 | 0.17 | 0.04 | 0.37 |
| 3      | <16 = P   | Low | 0.32 | 0.33 | 0.66 | 0.27 | 0.18 | 0.14 | 0.10 | 1.76 | 0.09 | 0.33 | 0.17 | 0.29 |

**Figure 4. N/P Ratio in Maninjau Lake**

Overall show that N/P Ratio in Lake Maninjau Waters lowes than 16, means the P element is the limiting element from the existence of phytoplankton. This condition should be a concern, because if management is not implemented, it will be to nutrient enrichment, eutrophication can occur [23], [24].

5. **Conclusions**

1. Activities that are a source of ammonia and nitrite pollutants in the waters of Lake Maninjau include activities around the sampling location (which can be in the form of organic waste and ammonia compounds), human settlements (in the form of detergent organic waste), fish cages (produce leftover feed) in lake waters.
2. The results showed that the phosphate compounds had the largest concentration in the waters of Lake Maninjau when compared to nitrogen compounds.
3. The N/P ratio is very less than 16. This condition shows that there has been an excessive addition of phosphate elements in these waters.
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