Nutrient, Macroalgae, and Echinodermata distribution in Northern Ambon coast during 2017 until 2018

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Abstract:
Northern Ambon Coast has a unique characteristic in term of biodiversity, including Macroalgae and Echinodermata. This research aims to determine the distribution of nutrients in the territorial waters of North Ambon in 2017 and 2018 and their effects on the distribution of Macroalgae and Echinodermata. Seawater samples were obtained in 26 sampling points in 2017 and 18 sampling points in 2018. Chemical parameters from seawater samples were determined by using a UV-Vis spectrophotometer and pH meter. The results of the analysis show that the average concentrations of NO$_3$, PO$_4$, and SiO$_2$ in the study area in 2017 were 0.090 mg/L; 0.042 mg/L; and 0.330 mg/L with an average DO and pH content of 5.83 mg/L and 8.19. The average concentrations of NO$_3$, PO$_4$, and SiO$_2$ in the sampling area in 2018 were 0.028 mg/L; 0.021 mg/L; and 0.129 mg/L with an average DO content and pH of 7.54 mg/L and 7.64 mg/L. The results show that nutrients concentration on the Northern Ambon coast exceeds the maximum threshold that has been determined by 2004 Decree of the State Minister of the Environment No.51, but still sustains the life of the biota. Decrease concentration of the nutrients leads to the variability of macroalgae and Echinodermata observed in the study area in 2018 when compared to 2017. The Macroalgae classes that can be found in this area are Rhodophyceae, Phaeophyceae, and Chlorophyceae. Furthermore, the Echinodermata classes found in this area are Holothuroidea, Ophiuroidea, Asteroidea and Echinoidea.

1. Introduction
Eastern Indonesia has a rich and unique biodiversity compared to the rest of Indonesia [1]. The region location, which located on the east of the Wallace line and Sahul continental shelf are contributed to its rich natural resources. In ocean alone, Tapilatu [2] in her study stated that Eastern Indonesia Water has great potential when it comes to its marine biodiversity. Two groups of biota that often found in the ocean are Echinodermata and Macroalgae, which are well known for their bio-prospective application as a drug and food. Unfortunately, the prospects of these marine biotas are yet to be explored, most likely due to its relative isolation compared to the Western of Indonesia.

One initial study to determine the potential of marine biota in one area is by measuring the seawater nutrients content and distribution, corresponding to its trophic status. Northern Ambon area, which has a direct exposure to the Banda Sea and continuously habited by human population most likely will have its nutrient content affected by oceanography phenomenon, anthropogenic activities, and input from the river [3,4]. Northern Ambon coastal area is consists of several settlements which showed in Figure 1. Northern Ambon coast also contains some rivers which have sources on the mountain range located in the middle of Leihtu Peninsula. The most notable river from this region are Wailela, Wailoi and Wae Ela. Seawater...
nutrients such as nitrate and phosphate are often measured as a seawater quality indicator and trophic status whereas silicate is measured to indicate the diatomic microalgae [5][6].
This present study aims to determine and visualize the distribution nitrate, phosphate and silicate in Northern Ambon coastal area and families group of Echinodermata and Macroalgae observed at this area of study. The comparison of nutrients change from 2017 to 2018 on this particular area are also observed to predict the factors of nutrient dynamics. The outcome of this study can give a brief image of Northern Ambon seawater quality and its marine biodiversity potential.

2. Materials and Method

Figure 1. Sampling points from 2017 and 2018 (a). The overlap sampling points from 2017 (Sta. 7 and Sta. 11) and 2018 (Sta. 17 and Sta. 18) located at Seith area marked by red box (b)

This study was conducted during East Monsoon of 2017 and 2018 (June-August). Specifically, the study in 2017 is conducted twice in July and August and once in June 2018. In 2017, the seawater samples obtained in 26 sampling points are located in Northern Ambon coast and in 2018, 18 sampling points located in Northwestern Ambon. Both sampling points have intersected points in Seith area where the nutrients distribution were compared as shown in Figure 1.

2.1. Spectrophotometry Methods for analyzing nutrients concentration

The seawater nutrients consist of Nitrate, Phosphate and Silicate were determined at this research by using the standard spectrophotometry methods from Strickland and Parsons (1972) using UV-VIS Shimadzu 1700, while DO and acidity was determined in-situ with Hanna Instruments 98196 Multiparameter Meter. Furthermore, seawater samples were acquired with rosette bottles at three different depths (sea surface, 25 m, and 50 m) and then stored with light-proof bottles inside an icebox before further treatment [7].

Nitrate was determined by using Cadmium reduction tube method. After 100 mL of seawater samples passed over the reduction tube, they were treated by using sulfanilamide and N-(1-
Naphthyl)ethylenediamine solution prepared before. The final solution then determined its nitrate concentration with UV-Vis Spectrophotometer at 543 nm [8].

Meanwhile, Phosphate underwent a method called Ascorbic Acid method. The reactant was produced by mixing ammonium molybdate, sulfuric acid, ascorbic acid, kalium antimonyl tartrate with ratio 2:5:2:1 by volume. The final solution then determined its phosphate concentration with UV-Vis Spectrophotometer at 885 nm [8].

Concurrently, Silicate was determined by treating the seawater sample with molybdate reagent and reducing agent (a mixture of metol-sulphite, oxalic acid and sulphuric acid 50%). Then the silicate concentration determined from analyte by using UV-Vis Spectrophotometer at 810 nm [8].

The standard solution was prepared with a similar method used aforementioned and using nitrate standard, phosphate standard, and silicate standard instead (0.01 ppm, 0.1 ppm 0.5 ppm, 1 ppm). The absorption result then used to make a standard curve for sample determination.

2.2. Data visualization and Interpolation method

After all of the content from each seawater sample was determined, then the data of nutrients were interpolated into 100x44 grid map for 2017 and 90x100 grid map for 2018. The distribution of Echinodermata and Macroalgae were obtained by a study from Rajab and Arfah for further comparison with the nutrients distribution [9,10]. Echinodermata and Macroalgae data obtained with observation along the coastal area at both low tide and high tide, then sorted based on the morphology features (descriptive).

3. Result and Discussion

3.1. Concentration of Nutrients of Seawater from Northern Ambon Area

The average concentration of seawater nutrient are shown in Table 1 and 2.

Table 1. The average of nutrient concentration from seawater samples obtained in 2017

| Depth (m) | [NO3] average (mg/L) | [PO4] average (mg/L) | [SiO2] average (mg/L) | DO average (mg/L) | pH average |
|-----------|----------------------|----------------------|-----------------------|-------------------|-----------|
| 0         | 0.062                | 0.041                | 0.326                 | 6.18              | 8.20      |
| 25        | 0.080                | 0.034                | 0.258                 | 6.02              | 8.20      |
| 50        | 0.127                | 0.052                | 0.405                 | 5.29              | 8.17      |
| Average   | 0.090                | 0.042                | 0.330                 | 5.83              | 8.19      |

Table 2. The average of nutrient concentration from seawater samples obtained in 2018

| Depth (m) | [NO3] average (mg/L) | [PO4] average (mg/L) | [SiO2] average (mg/L) | DO average (mg/L) | pH average |
|-----------|----------------------|----------------------|-----------------------|-------------------|-----------|
| 0         | 0.022                | 0.018                | 0.224                 | 7.87              | 7.68      |
| 25        | 0.027                | 0.024                | 0.077                 | 7.51              | 7.63      |
| 50        | 0.034                | 0.022                | 0.084                 | 7.23              | 7.61      |
| Average   | 0.028                | 0.021                | 0.129                 | 7.54              | 7.64      |

Based on the nutrients concentration analysis from Table 1 and 2, we can see the similarity that all of the concentration of the nutrients from both years tends to have higher concentration at the deeper depth. The average concentration of NO3 is increasing because some of the nutrient like phosphate (in the form of orthophosphate) and nitrate are both being the nutrition uptake by marine microbiological organism living in a surface [11]. The high concentration of nutrients at the bottom of the sea may be caused by the weathering of the sediment catalyzed by the abiotic decomposition processes carried by the microorganism [12]. As for silicate, although the trend shows a similar pattern as nitrate and phosphate, the concentration for dissolved silicate is much higher than the other nutrients. The higher of silicate concentration indicates that the Northern Ambon seawater has an enormous amount of diatomic microalgae such as Bacillariophyceae as silicate is needed for their cell wall formation [13].
DO concentration and pH are quite similar in every depth because the sampling depth still in the mixed layer where the changes of DO and pH is not drastic. Seawater will retain its buffer properties through various deep because seawater contains various salts which can neutralize the acid/basic input. DO concentration shows us that the oxygen concentration is being distributed evenly, which is favourable for the marine organism to live. However, there is a slight decrease in concentration for deeper depth because the deeper sea column means less contact with the atmosphere, thus lowering the chance of oxygen diffusion case [14]. Moreover, deeper sea level has less photosynthetic organisms which can avoid oxygen production in return.

Comparison by time, the values of nutrients concentration, DO, and pH are lower for 2018 compared to 2017. This is because, in 2017, the sampling activities were conducted at more frequent raining on rainy seasons compared to 2018. The rain can increase the chance of nitrogen and phosphate-rich elements from fertilizer and waste from the human-populated area are being carried away, thus increasing the concentration of dissolved nitrate and phosphate [15].

3.2. Spatial Distribution of Nutrients in 2017 and 2018

![Spatial distribution of nutrients in 2017](image)

*Figure 2. Spatial distribution of nutrients in 2017*
Figure 3. Spatial distribution of DO and pH in 2017

Figure 4. Spatial distribution of nutrients in 2018
Spatial distribution of nutrients, DO and pH which generated from the interpolation of sampling data, also in agreement with the expectation stated previously in section 3.1. In addition, a new trend can be observed from the maps, such as the closer it is to the coast, the more concentrated the nutrients are. This is because there is more likely a chance the concentration of the nutrients is being affected by anthropological activities (Figure 2., Figure 3., Figure 4., and Figure 5.). Moreover, there are some points which have a higher concentration of nutrients such as at station 22, 24 and 25 for surface nitrate concentration in 2017 (0.3798 mg/L; 0.2869 mg/L; and 0.4230 mg/L respectively) which are shown with a brighter colour scale than its surrounding. Higher concentration at some points might indicate that the anthropological activities are higher in that surrounding area, some estuaries that swept away artificial fertilizer and human waste to the coastal area, and upwelling phenomenon also might playing similar role. Other than anthropological activities, the higher concentration on the coastal area can be attributed to submarine groundwater discharge (SGD) [16].

Based on the 2004 Decree of the State Minister of the Environment, No. 51 about Sea Water Quality Standards for Marine Biota, the concentration of nitrate and phosphate in the northern Ambon exceeded above the maximum threshold that has been determined (0.008 mg/L for nitrate and 0.015 mg/L for phosphate). However, the conditions are still maintain the tolerable parameters of DO and pH (above 5 mg/L for DO and between 7.0-8.5 for pH). The region of Northern Ambon coast is considered very fertile and has a big potential of algae blooming to happen because of excessive concentration of nitrate and phosphate. A reference from Lakewatch [17] shows us that the Northern Ambon coastal seawater trophic status would be fall between oligotrophic and mesotrophic based on the concentration of nitrate and phosphate. Further research is needed to gather sufficient data in order to classify the tropic status.

**Table 3.** Trophical status classification from nitrate and phosphate content [17]

| Indicators | Oligothropic (mg/L) | Mesothropic (mg/L) | Eutrophic (mg/L) | Hypereuthropic (mg/L) |
|------------|---------------------|-------------------|-----------------|---------------------|
| Nitrate    | < 0.4               | 0.4 – 0.6         | 0.6 – 1.5       | > 1.5               |
| Phosphate  | < 0.015             | 0.015 – 0.025     | 0.025 – 0.1     | > 0.1               |
3.3. Overlaps Sampling Points Time/Location Differences

The sampling points from 2017 and 2018 has two particular laps. First at Station 7 (2017) and Station 18 (2018), the second one at Station 11 (2017) and Station 17 (2018). For the nutrient concentration on the surface, there is a noticeable difference in phosphate concentration between 2017 and 2018, where the concentration of phosphate and silicate are lower in 2018 than in the 2017 counterpart as shown in figure 6 and figure 7. This might be caused by nutrients being less concentrated because it is swiped away by the frequent rain. Other causes might be that the biological intake for phosphate in 2018 is higher than in 2017.

![Figure 6](image-url)

*Figure 6.* The graphic bar of changes in concentration between 2017 and 2018 at each overlap points in the surface
A big difference for each chemical parameter can be observed at the depth of 25 m below the sea level (Figure 7). There is a probability that there might be an upwelling phenomenon happened there on sampling period in 2017 (which August is the peak of upwelling phenomenon), although more data is needed to justify. Upwelling phenomenon usually indicated by higher concentration of nutrients than the year average concentration because the mass of seawater rich in nutrients are being moved to the surface layer.

**Figure 7.** The graphic bar of changes in concentration between 2017 and 2018 at each overlap points in the 25 m depth
3.4. Echinodermata and Macroalgae Phylums Found in the Area of Study

In addition to observing the distribution of nutrient, this study also tracks the distribution of Echinodermata and Macroalgae scattered around Northern Ambon coastal area as shown in Figure 8. The species found at this study are shown in Table 4 and 5 below.

![Figure 8. The map of local settlements, estuaries, macroalgae and echinodermata samples found in Northern Ambon coastal area](image)

| No. | Macroalgae          | Station (2017) | Manula | Morela | Wakal | Seith |
|-----|---------------------|---------------|--------|--------|-------|-------|
|     | **RHODOPHYCEAE**    |               |        |        |       |       |
| 1   | Acanthophora specifera | +            | +      | +      | +     |       |
| 2   | Gracilaria crassa   | +            | +      | -      | -     |       |
| 3   | G. lichenoides      | +            | -      | -      | +     |       |
| 4   | G. salicornia       | -            | +      | -      | -     |       |
| 5   | Galaxaura subfruticosa | +          | +      | +      | -     |       |
| 6   | Jania arberescus    | +            | +      | -      |       |       |
| 7   | Liagora             | +            | -      | -      |       |       |
| 8   | Hypnea              | +            | -      | -      |       |       |
|     | **PHAEOPHYCEAE**    |               |        |        |       |       |
| 1   | Sargassum duplicatum | +            | +      | +      | -     |       |
| 2   | Turbinaria ornata   | +            | +      | -      |       |       |
| 3   | Padina crassa       | +            | +      | +      | +     |       |
| 4   | Ticyopteris acrostichoides | +      | _    | -      |       |       |
|     | **CHLOROPHYCEAE**   |               |        |        |       |       |
| 1   | C. serralata        | +            | +      | +      | -     |       |
| 2   | Halimeda opuntia    | +            | +      | -      | -     |       |
| 3   | H. makroloba        | -            | -      | -      | -     |       |
| 4   | Volonia aegagrophylla | +          | -      | -      |       |       |
| 5   | Codium acroricatum  | +            | -      | +      |       |       |
| 6   | Neumeris annulata   | -            | +      | -      | +     |       |
|     | **Total Genus**     |               | 15     | 11     | 6     | 5     |
Table 5. The frequency of echinodermata classes found in the Northern Ambon area

| No. | Station (2017) | Class               | Family                        | Species               |
|-----|---------------|---------------------|-------------------------------|-----------------------|
| 1   | Morella       | Holothurioida       | Holothurida                   | *H. leucospilota*     |
|     |               | (Sea Cucumber)      |                               | *H. scabra*           |
|     |               |                     |                               | *H. atra*             |
| 2   | Mamala        | -                   | -                             | -                     |
| 3   | Wakal         | Holothurioida       | Holothurida                   | *H. atra*             |
|     |               | (Sea Cucumber)      |                               |                       |
| 4   | Seith         | -                   | -                             | -                     |

In terms of frequencies, Rhodophyceae is more prevalent than the other macroalgae like Phaeophyceae and Chlorophyceae. The composition of Macroalgae is also higher in Mamala and Morela than the other observation points. The differences can be caused by macroalgae reproduction time and substrate in which some macroalgae are thriving in the dead coral substrate [18]. Macroalgae from phylum
Rhodophyceae like Acanthophora, Codium, Gelidiella, Galaxaura, Jania, Amphiroa, dan Gracilaria are more likely to be found in the dead coral substrate, thus increasing their chances to be found at various condition. Mamala has the highest composition of macroalgae because the nutrient condition in Mamala and Morela area are considerably higher than the other area of study.

In 2018, Echinodermata has more variation in the number of species found rather than 2017. Holothuroidea is more likely to be found than other class like Asteroidea and Ophiuroidea in 2018, and only Holothurioidea can be found in 2017. Moreover, Echinodermata was nowhere to be found at Mamala and Seith area. This can be attributed to the effect of fish bomb usage in 2017 at both area can still be observed even though it’s already passed a year. The effect of the fish bomb can also be observed in 2017 as only Holothurioidea can be observed in the nearby area. For the same reason though, it can be seen that Macroalgae are more prevalent in these areas because they can live in the dead coral substrate caused by fish bomb. The increasing number of Macroalgae and Echinodermata found in 2018 is thought to be connected with the decreasing concentration of nutrients showed in section 3.3.

4. Conclusion
The result of the study shows that the seawater of Northern Ambon area has a very fertile based on its nutrient content. The high content of nutrients on the Northern Ambon area, which are mostly higher than 2004 Decree of the State Minister of the Environment, No. 51 about Sea Water Quality Standards for Marine Biota limit, thought to originate from the domestic and agricultural waste. The nutrients horizontal distribution shows that the concentration of nutrients, DO and pH is higher closer to the coastal area. Also, for the vertical distribution, there is a trend to have a higher concentration of chemical parameters on the deeper layer.

There is a trend in decreasing concentration of the nutrients between 2017 and 2018 which are predicted to be caused by the upwelling phenomenon happens in 2017 and an increase in nutrients uptake in 2018. Based on the nitrate and phosphate concentration, Northern Ambon area are considered between oligotrophic and mesotrophic status. The number of Macroalgae and Echinodermata phylum found in the area of study are fewer in 2017 because the effect of fish bomb causing the decreases in both Macroalgae and Echinodermata population hence proved the assumption of higher nutrient concentration in 2017.

5. References
[1] Resosudarmo B P and Jotzo F 2009 Working with Nature against Poverty: Development, Resources and the Environment in Eastern Indonesia (ISEAS–Yusof Ishak Institute.)
[2] Tapilatu Y H 2015 Status of Drug Discovery Research Based on Marine Organisms from Eastern Indonesia Procedia Chem. 14 484–92
[3] Carter C M, Ross A H, Schiel D R, Howard-Williams C and Hayden B 2005 In situ microcosm experiments on the influence of nitrate and light on phytoplankton community composition J. Exp. Mar. Bio. Ecol. 326 1–13
[4] Weinstein Y, Yechieli Y, Shalem Y, Burnett W C, Swarzenski P W and Herut B 2011 What is the role of fresh groundwater and recirculated seawater in conveying nutrients to the coastal ocean? Environ. Sci. Technol. 45 5195–200
[5] Egge J K and Aksnes D L 1992 Silicate as regulating nutrient in phytoplankton competition Mar. Ecol. Prog. Ser. 83 281–9
[6] Tsunogai S and Watanabe Y 1983 Role of dissolved silicate in the occurrence of a phytoplankton bloom J. Oceanogr. Soc. Japan 39 231–9
[7] Dore J E, Houlihan T, Hebel D V., Tien G, Tupas L and Karl D M 1996 Freezing as a method of sample preservation for the analysis of dissolved inorganic nutrients in seawater Mar. Chem. 53 173–85
[8] Strickland J D H and Parsons T R 1972 A Practical Handbook of Seawater Analysis
[9] Pusat Penelitian Laut Dalam 2017 Strategi Pengelolaan dan Pemanfaatan Sumberdaya Hayati Laut Secara Berkelanjutan di Kawasan Laut Ambon (Tahun Pertama) (Ambon)
[10] Pusat Penelitian Laut Dalam 2018 Strategi Pengelolaan dan Pemanfaatan Sumberdaya Hayati Laut Secara Berkelanjutan di Kawasan Laut Ambon (Tahun Kedua) (Ambon)

[11] Paytan A and McLaughlin K 2007 The Oceanic Phosphorus Cycle Chem. 107 (2) 563–76

[12] Yilmaz A 2000 Ocean Colour Remote Sensing Course Topic 14 : Nutrients Middle East Tech. Univ. Inst. Mar. Sci.

[13] Effendi H 2003 Telaah Kualitas Air bagi Pengelolaan Sumberdaya dan Lingkungan Perairan (Jakarta: Kanisius)

[14] Pearson P N 1999 Middle Eocene seawater pH and atmospheric carbon dioxide concentrations Science (80-. ). 284 1824–6

[15] Hutagalung H P and Rozak A 1977 Metode Analisis air laut, sedimen dan biota (Jakarta: Pusat Penelitian dan Pengembangan Oseanologi LIP.)

[16] Uchiyama Y, Nadaoka K, Ro P and Adachi K 2000 Submarine groundwater discharge into the sea and associated nutrient transport in a Sandy Beach Submarine groundwater discharge into the sea and associated nutrient transport in a sandy beach Water Resour. Res. 36 1467–79

[17] Lakewatch (Institute of food and agricultural science U of F 2017 Trophic State: A Waterbody’s Ability To Support Plants, Fish, and Wildlife (University of Florida)

[18] Kadi A 2005 Rumput Laut di Beberapa Perairan Pantai Indonesia J. Oseanologi di Indones. 4 25–36