

Original Research

Correlation between macroalgae diversity and water quality in Southwest Maluku waters

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ABSTRACT

Macroalgae play an important role in the ecosystem of the coastal area, serving as a shelter ground, nursery ground, and feeding ground. Macroalgae communities are directly influenced by water quality. This study aim was to determine the correlation between the macroalgae diversity and water quality in southwest Maluku waters. This research was conducted in September 2019 at seven research stations. Macroalgae samples were collected by transect method, while seawater quality was measured using Van Dorn Water Sampler. The macroalgae diversity, species composition, and dominance were determined. Water quality parameters analyzed were temperature, salinity, pH, phosphate, nitrate, and ammonia. Correlations between macroalgae diversity and water quality were determined using principal component analysis. This study recorded 45 species of macroalgae consisting of 15 species of red algae (Rhodophyta), 6 species of brown algae (Phaeophyta), and 24 species of green algae (Chlorophyta). Diversity Index varied ranged from low to moderate categories (0.969 - 2.345). Water quality in general is still quite good for macroalgae life. Macroalgae diversity and water quality correlate and influence each other.

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1. Introduction

Southwest Maluku Regency consists of 48 small and large islands including 7 outer islands. Substrate composition of the research site consists of dead coral, sand, and corals. The presence of a macroalgae community has an important role for other marine biota as a shelter and as a fishing ground. Macroalgae communities can also serve as a habitat for other marine organisms, both large and small, such as amphipods, crabs, and others marine biota. Currently, the utilization of macroalgae has been widely developed as raw materials for food, beverage, medicines, pharmaceutical, cosmetics, and as additives in the industrial process of plastic, steel, film, textile, and paper (Bedoux *et al.*, 2014). Besides, it can also be widely exploited in the field of biotechnology and microbiology (Resita *et al.*, 2010).

Macroalgae are generally found in a suitable place for attachment. For example, a coastal area consisting of rocks (rocky shore) is a suitable place for their lives, so we often find many macroalgae that live in this area. The

distribution of macroalgae in waters is caused by the compatibility of their habitat. Seaweed habitat is generally on the level of coral reefs. They stick to the hard material substrate in the form of sand, coral, dead coral fragments, or shells. Its depth starts from the lowest tidal line to about 40 meters. This algae habitat is generally on coral reefs, the distribution of macroalgae species also follows the distribution of coral reefs. Whereas for the life of coral reefs, high clarity is needed that is free from sedimentation and high salinity, which is 30 ‰ or more. Indonesian waters are getting to the east the higher the brightness and salinity, therefore the structure and condition of coral reefs are getting better and causing higher diversity of seaweed.

Water quality affects the abundance of macroalgae. Macroalgae growth is directly affected by nutrients. The light intensity and nutrients such as phosphate and nitrate are needed in the formation of proteins in photosynthesis. The study of the nutrition of certain cultivation organisms aims to get good products in quality and quantity. Supporting factors for macroalgae growth are very complex and interrelated between physical-chemical factors, such as temperature, salinity, pH, and concentrated things like nitrogen and phosphorus

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(Nasution *et al.*, 2013). Supply of organic material which can continuously increase nutrients in coastal waters and ultimately cause increased water fertility and can even cause eutrophication which can disturb the balance of the ecosystem. A phosphate is a form of phosphorus that can be utilized by plants and is an essential element for higher plants and algae, so this element is a limiting factor for plants and aquatic algae and greatly affects aquatic productivity. This research determine the correlation between the macroalgae diversity and water quality in southwest Maluku waters, to support for macroalgae development activities in the area.

2. Materials and Methods

This research was conducted in September 2019. The research location was conducted on one location in Leti Island (Liuketi) and six location in Moa Island (Siota, Kaiwatu, Tiakur, Kliss, Nyama and Patty) Southwest Maluku Regency. Map of the location was shown in Figure 1.

Macroalgae samples were collected by the quadratic transect method that is made perpendicular to the coastline towards the slope with an interval of 100 meters with 10 transects at each location (Figure 2). Every 10-meter interval from the shoreline was sampled macroalgae biomass on an iron frame measuring 50×50 cm, besides that a free collection was also carried out to obtain the types of living macroalgae growing on each substrate. Samples were collected in a plastic bag. Samples were selected and separated according to species and genus, and weighed wet weight. Then do the identification and preserved in 70% alcohol solution. The identified samples were stored in the Biology Laboratory of the Center for Deep Sea Research – LIPI. The identification of macroalgae is based on Marine algae – Varieties (Bedoux *et al.*, 2014). Diversity index was measured according to Shannon Index. Macroalgae dominance using Simpson Index (Krebs, 2001).

Water quality parameters observed were temperature, salinity, pH, phosphate, nitrate, ammonia, and silicate. Seawater samples were taken using a Nansen tube on the

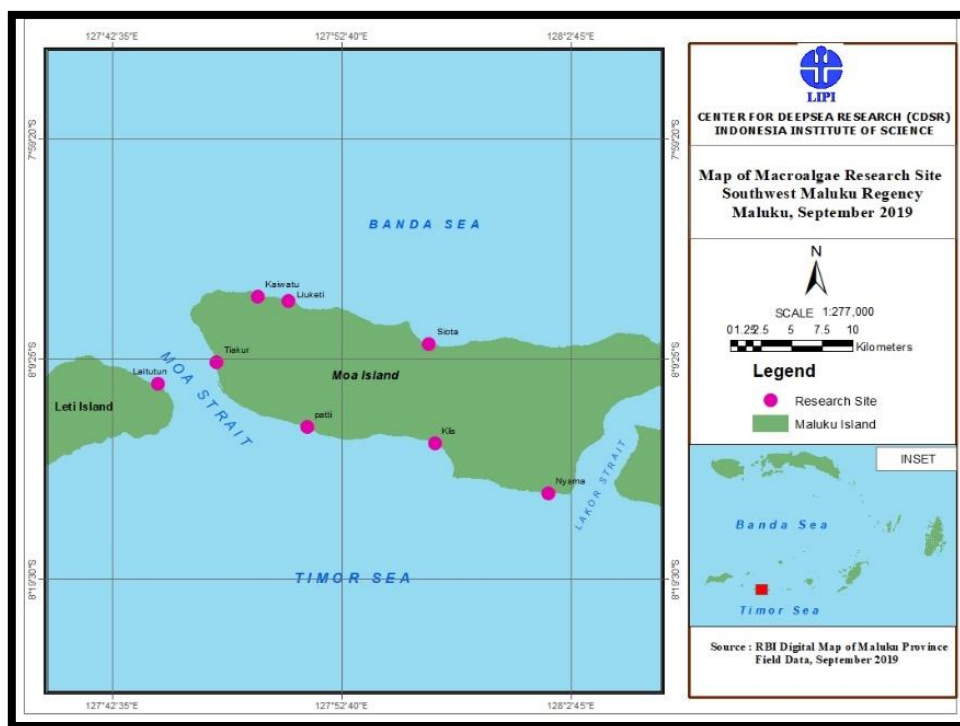


Figure 1. Map of research site in Southwest Maluku Regency, September 2019



Figure 2. Field sampling using transect quadrant in Southwest Maluku Regency, 2019

surface layer. Measurements of temperature, salinity, and pH are carried out in situ. Seawater temperature was measured using a GMK-910T thermometer, salinity was observed using the Atago Hand refractometer, and pH using a HANNA series HI9024 pH meter. Analysis of phosphate, nitrate, nitrite and ammonia according to seawater analysis (Strickland *et al.*, 1972) based on spectrophotometric methods using UV-VIS spectrophotometer Shimadzu 1700. To find out the correlation between macroalgae diversity and water quality in the waters of Southwest Maluku used Principal Component Analysis (PCA).

3. Results

Macroalgae obtained from the study site in the waters 45 species consisting of 15 species of red algae (Rhodophyta), 6 species of Brown algae (Phaeophyta) and 24 species of Green algae (Chlorophyta). The most species of macroalgae were found in Leti, as many as 28 species, while the lowest species of macroalgae were found in Nyama (7 species). Green algae (Chlorophyta) has the highest number of species (Figure 3).

The diversity index (H') obtained is shown in Table 1. The H' is 2.101 in Laitutun, 2.345 in Liuketi, 1.525 in Siota, 0.969 in Tiakur, 1.859 in Klis, 1.885 in Nyama, and 1.425 in Patti (Figure 4). Siota have highest macroalgae dominance (16.13%) even though this below in Kaiwatu

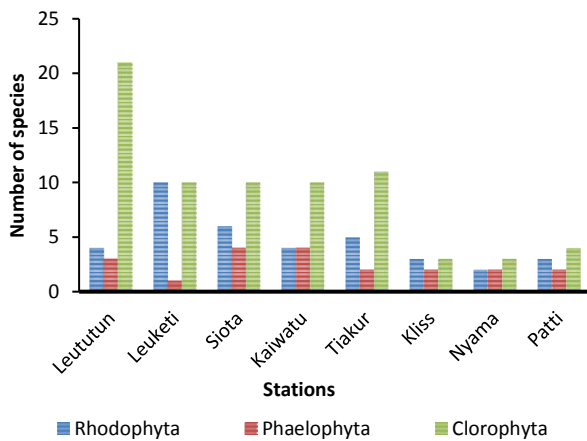


Figure 3. The number of species of macroalgae in Southwest Maluku Regency, 2019

(31.53%) and Tiakur (16.24%). The lowest dominance of the macroalgae is in Kliss (0.84%), Nyama (3.55%), Patti (5.17%), and Leitutun (10.54%) (Figure 5). Macroalgae density are shown in Figure 6. *Hypnea* has the highest density at the Tiakur village (1338 gr/m²). Tiakur village had highest macroalgae at this study. Leitutun village (2963.4 gr/m²) had very high density. In Leitutun village, 26 of the 27 species macroalgae were found.

The water quality in Southwest Maluku Regency was presented in the following Figure 7. Temperature, salinity, and pH in Southwest Maluku waters not varied. Water temperature had ranges from 25.92 °C to 26.64 °C. Salinity had ranges 33.56 to 33.87. pH had ranges from 6.82 to 8.12. These conditions are still good for macroalgae life.

Phosphate, nitrates, and ammonia in the Southwest Maluku waters was presented in Figure 8. The highest phosphate concentration was found in Liuketi (0.2326 mg/l), while the lowest phosphate concentration was found in the Siota, Kaiwatu, and Patti (0.0465 mg/l). The highest nitrate concentration was found in Liuketi (0.0451 mg/l) while nitrate concentration in Siota was undetectable. Ammonia has a high concentration in Tiakur (0.5140 mg/l) and the lowest ammonia concentration was found in Siota (0.0699 mg/l). According to the Decree of the Minister of Environment No. 51 (2004), has exceeded the standard quality for phosphate, nitrate, and ammonia were allowed.

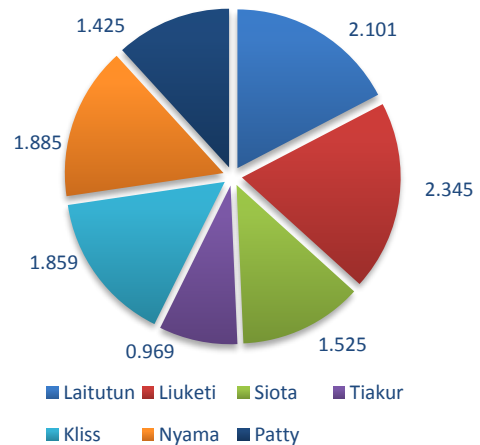


Figure 4. Diversity Index of macroalgae in Southwest Maluku Regency, 2019

Table 1. Macroalgae diversity and water quality parameters in Southwest Maluku waters, September 2019

Station	H'	pH	PO ₄	NO ₃	NH ₄	Temp	Salinity
Laitutun	2.101	7.16	0.0791	0.0114	0.2016	26.04	33.85
Liuketi	2.345	8.06	0.2326	0.0451	0.1935	25.96	33.81
Siota	1.585	8.12	0.0465	undetectable	0.0699	26.51	33.56
Kaiwatu	1.525	8.06	0.0465	0.0023	0.1457	26.64	33.76
Tiakur	0.969	6.82	0.0605	0.0171	0.5140	26.08	33.87
Klis	1.859	7.54	0.0605	0.0277	0.1818	26.06	33.78
Nyama	1.882	7.74	0.0558	0.0368	0.1189	25.92	33.82
patti	1.425	7.81	0.0465	0.0046	0.1480	26.39	33.75
min	0.969	6.820	0.047	0.000	0.070	25.924	33.56
max	2.345	8.120	0.233	0.045	0.514	26.638	33.87
average	1.712	7.664	0.078	0.018	0.197	26.200	33.77

The relationship between diversity and water quality parameters was analyzed using Principal Component Analysis. Table 2 shows the correlation between macroalgae diversity and water quality. Phosphate and nitrate have positive results that are quite consistent with variations. pH has a weak positive conversion but is definitely correlated with macroalgae (Niamaimandi *et al.*,

2017). While temperature and ammonia have a strong negative correlation to macroalgae diversity. In the current study, salinity factors correlated very weakly with macroalgae. The correlation between diverse and quality parameters of West Maluku was presented in Figure 9.

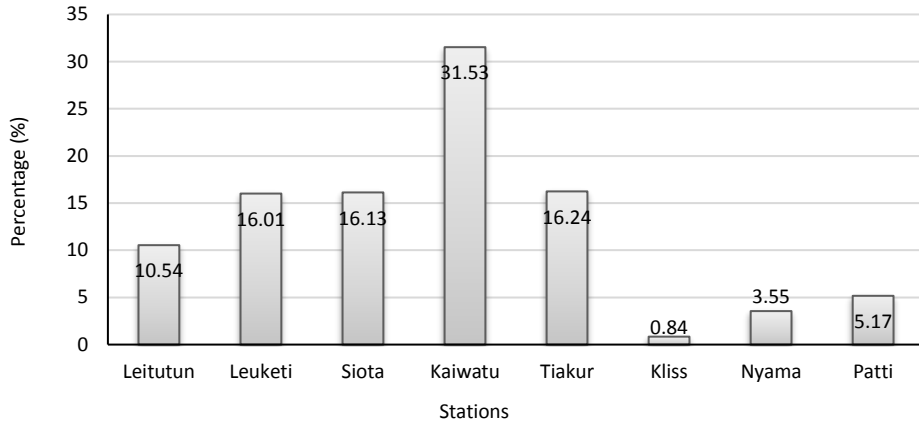


Figure 5. Macroalgae dominance, Southwest Maluku Regency, 2019

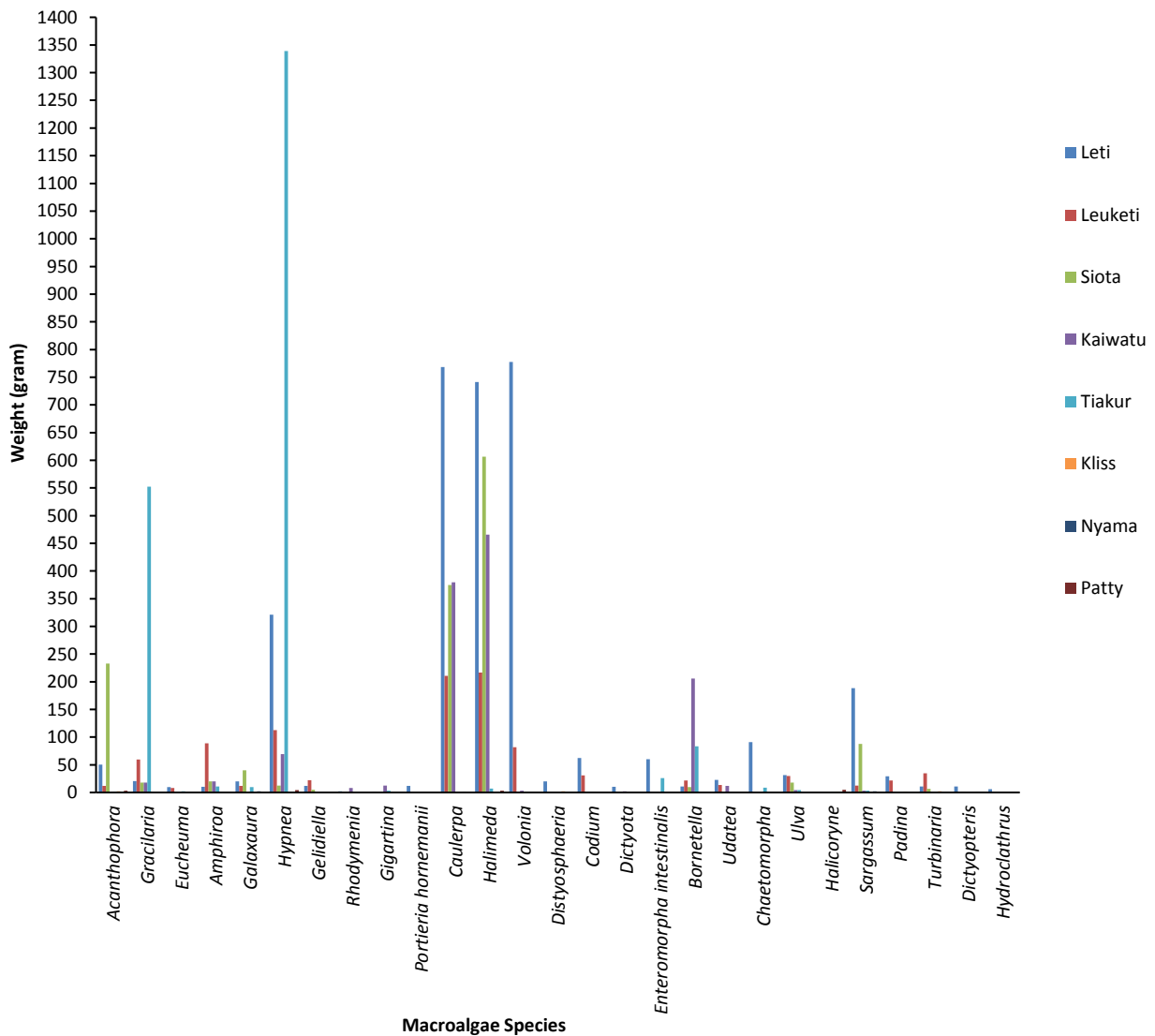


Figure 6. The density of macroalgae in Southwest Maluku Regency, September 2019

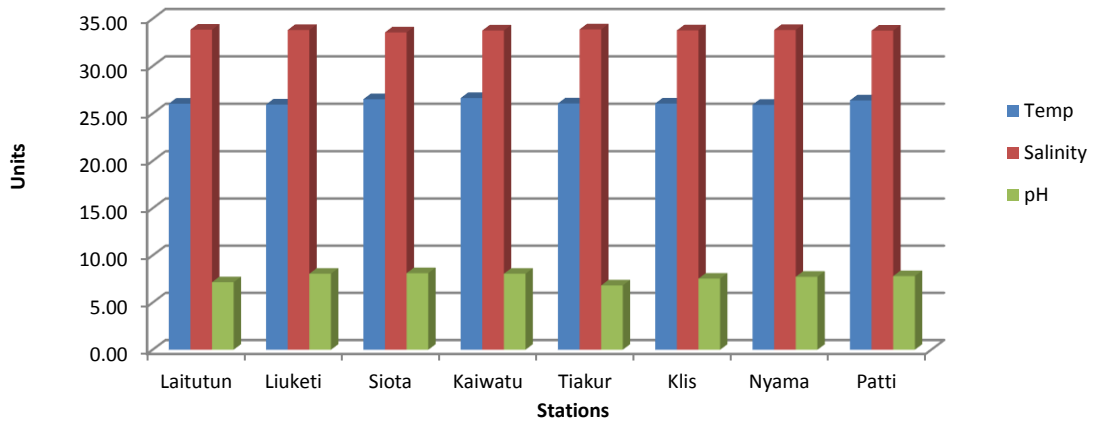


Figure 7. Macroalgae dominance, Southwest Maluku Regency, 2019

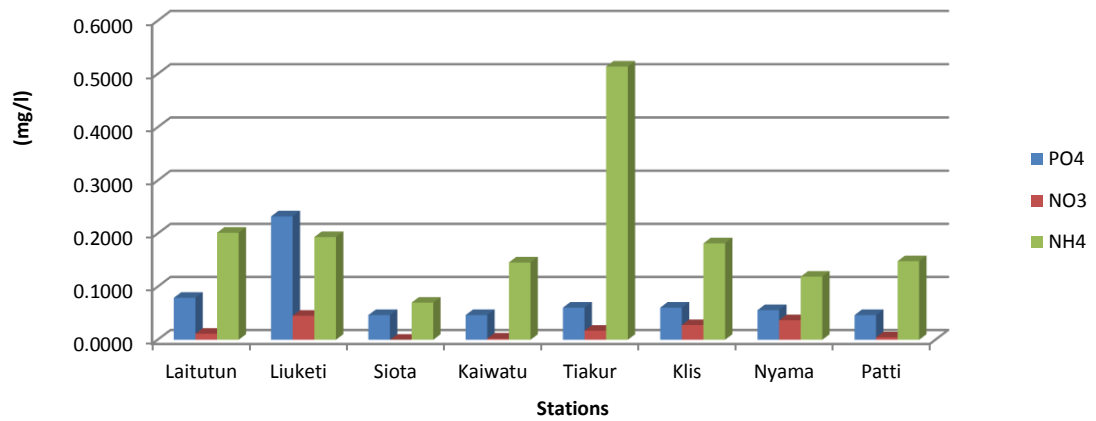


Figure 8. The density of macroalgae in Southwest Maluku Regency, September 201

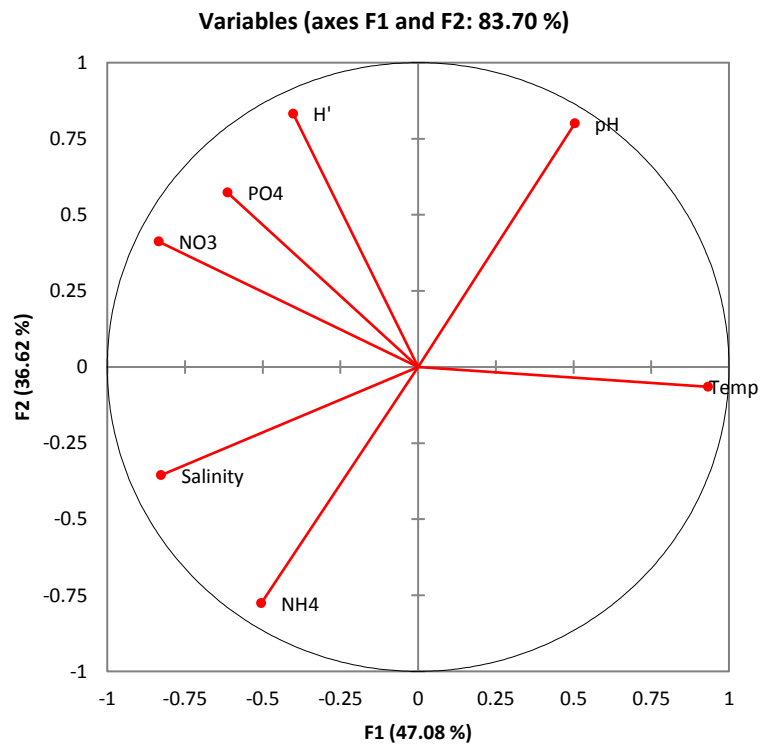


Figure 9. Correlation between macroalgae diversity and water quality in Southwest Maluku, September 2019

Table 2. Table Correlation matrix (Pearson (n))

Variables	H'	pH	PO ₄	NO ₃	NH ₄	Temp	Salinity
H'	1	0.358	0.652	0.574	-0.521	-0.447	0.084
pH	0.358	1	0.215	-0.024	-0.815	0.480	-0.670
PO ₄	0.652	0.215	1	0.686	0.051	-0.470	0.262
NO ₃	0.574	-0.024	0.686	1	0.108	-0.841	0.501
NH ₄	-0.521	-0.815	0.051	0.108	1	-0.338	0.630
Temp	-0.447	0.480	-0.470	-0.841	-0.338	1	-0.675
Salinity	0.084	-0.670	0.262	0.501	0.630	-0.675	1

Values in bold are different from 0 with a significance, level alpha=0.05

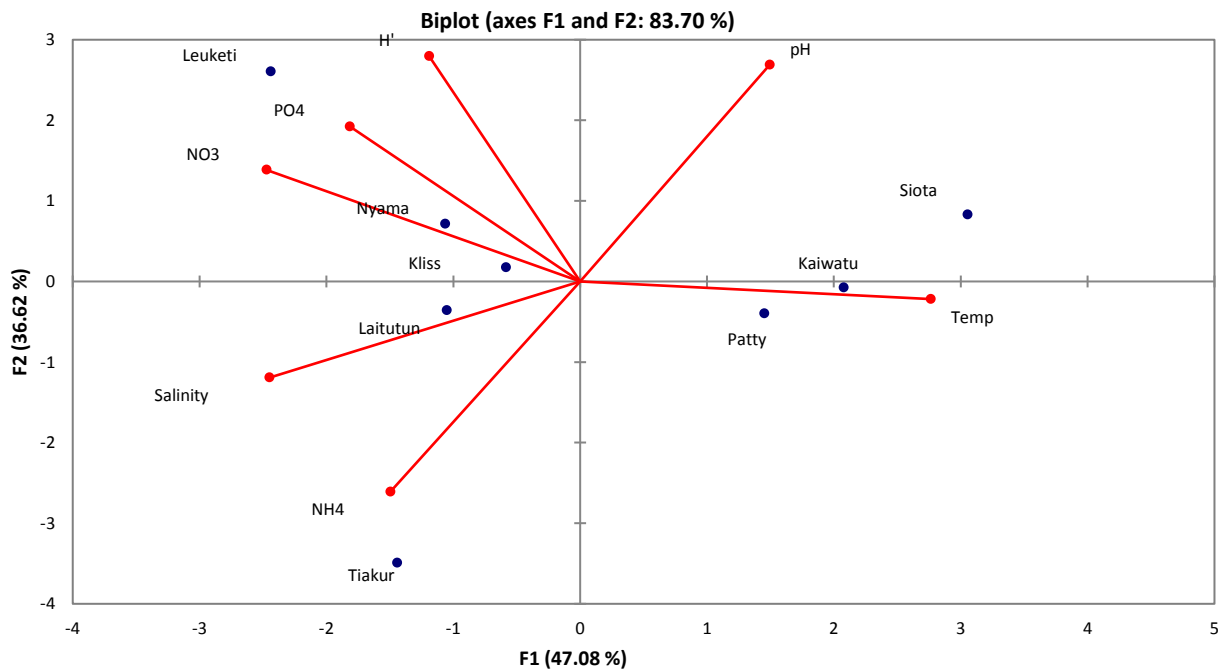


Figure 10. Grouping parameters and research sites in Southwest Maluku, September 2019

Figure 10 shows the characteristics of a research station based on its constituent parameters. Leuketi, Nyama, and Kliss were characterized by high diversity, phosphate, and nitrate. Siota was characterized by a high pH. Tiakur and Laitutun were characterized by salinity and ammonia. Kaiwatu and Patti are characterized by high temperatures.

4. Discussions

Based on total phosphorus content, waters are classified into three, namely: waters with low fertility levels, which have total phosphate content from 0 to 0.02 mg/l; waters with moderate fertility, which have total phosphate levels of 0.021 to 0.05 mg/l; and waters with high fertility, which have a total phosphate content of 0.051 to 0.1 mg/l (Effendi, (2003) and Joshimura *in* Arfah and Simon, 2016). This phosphate content range still within safe limits to life Marine biota. KMLH (2004) stipulates standard phosphate for marine biota was 0.015 mg/l. If phosphate content to the fertility category in above, then these waters belong to in the category of quite fertile and still good for macroalgae growth. NO₃ (nitrate) and NH₄ (ammonium) in water can be used for plant and algal growth (D' Costa *et al.*, 2006). Southwest Maluku Regency had lower nitrate concentrations than Poole

Harbour, England (Franklin *et al.*, 2020). Nitrate needs for macroalgae varied. Nitrate content ranging from 0.9 to 3.5 m/l is the optimal concentration for macroalgae growth (Arizuna *et al.*, 2014).

Temperature can affect the growth of macroalgae, namely the activity of photosynthesis. High temperatures are causing disruption of photosynthesis activity (Hill *et al.*, 2009). Temperature was around 26.2°C (25.9°C to 26.6°C). The temperature was still supporting macroalgae growth. According to Dawes (1991), that the normal temperature range for macroalgae growth was 25-35°C, High temperatures above 30°C, will stop photosynthetic and pigments were damaged (Hill *et al.*, 2009). Salinity at the study site was 33.56 to 33.87. This value is still suitable for macroalgae. According to Kadi and Atmadja (1988) *in* Ira *et al.* (2018), benthic algae grow in waters with salinity 13-37. Salinity can affect the physiology and rate of macroalgae photosynthesis (Xiong & Zhu, 2002). The average of pH value at the study was 7.66 (6.82-8.12). This is still suitable for macroalgae growth. According to Ira *et al.* (2018), pH for growth macroalgae was 7-8.5. This is also supported by the statement (Papalia & Arfah, 2013), acidic or alkaline will endanger the survival of the organism because it will cause metabolic and respiratory disorders. pH can affect the growth of macroalgae.

Phosphate, nitrate, pH, and salinity had positive effect on the diversity of macroalgae in Southwest Maluku waters. Increasing the concentration of phosphate, nitrate, pH, and salinity increase the diversity of macroalgae (Fried *et al.*, (2003); Lee *et al.*, (2010); Rybak, (2018)). In contrast, temperature and ammonia will degrade the diversity of macroalgae in Southwest Maluku waters (Werner *et al.*, (2016)). The maximum ammonium concentration allowable in seawater is 0.05 mg/l (Sabri *et al.*, 2017), According to Sabri *et al.*, (2017), ammonium is the chemical form of the mineral nitrogen preferentially assimilated by the algae even in the presence of nitrate. Also, deleterious level of algal decomposition in waters produces ammonium and could contribute to the increase of its concentration

5. Conclusion

Southwest Maluku waters had low to medium categories of macroalgae diversity (0.969 - 2.345). Generally, water quality in Southwest Maluku waters is good for macroalgae life. The diversity of macroalgae species had a positive correlation and a negative correlation with water quality parameters. Increasing the concentration of phosphate, nitrate, pH, and salinity increases the diversity of macroalgae. In contrast, increasing temperature, salinity, and ammonia decreased macroalgae diversity.

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Conflict of interest

The authors declare no conflict of interest.

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