Seaweed Culture for Nutrient Abatement in Spermonde Waters

Andriani Nasir[1], **Muhammad Ikbal illijas**[1], **Mirta Teichberg**[2], **Muhammad Lukman**[3]

[1] Department of Aquacuture, Pangkep State Polytechnic of Agriculture, Pangkep, South Sulawesi, Indonesia
[2] Leibniz Center for Tropical Marine Ecology, Bremen, Germany
[3] Department of Marine Science, Faculty of Marine Science and Fisheries, Hasanuddin University, Makassar, South Sulawesi, Indonesia

Corresponding Author:
Andriani Nasir[1]
Jalan Poros Makassar-Parepare Km 83 Mandalle, Pangkep, South Sulawesi, 90655, Indonesia
Email address: andriani_nasir@yahoo.co.id; andriani@mail.polipangkep.ac.id

Abstract

The coastal waters of the Strait of Makassar are classified as a productive coastal area, in which there are mangrove ecosystems, seagrass beds and Spermonde coral reefs that play a crucial role in sustaining the economic life of coastal communities and food security. Our previous results have calculated the outflow of nutrient land to sea with nitrate concentrations ranging from 0.01-0.44 mg/L and phosphate 0.04-0.35 mg/L. This condition has caused coastal waters of permonde to be eutrophicated with the occurrence of mass death of several species of fish and the emergence of dangerous microalgae species. This study aims to calculate the current nutrient value in the area of seaweed cultivation as a biological absorber. Based on the interim results, the decrease or absorption of nutrients by seaweed ranges from 0.08-1.55 mg/L-nitrate and 0.01-0.71 mg/L-phosphate.

Introduction

The coastal zone, especially estuaries, is the focus for population settlements and new estimates indicate that about 40% of the global population lives within 100 km of the coastline [1], causing these waters to receive loads of anthropogenic material inputs from sources such as farming activities and agriculture [2] [3] [2] [4] subsequently entered the waters through streams and runoffs from the mainland. This source is a source of nutrients in coastal waters [5]; [6]; [7]; [8]; [9]. It is estimated that about 450 megatons/year of organic pollutants are derived from fertilizers, pesticides, synthetic organic materials, chemical production and the occurrence of oil spills dumped into the coast and sea around the world. The above-mentioned exhausts have an impact on the coastal and marine environment. High nutrients damage coral reef ecosystems and biodiversity [10] [11]. Coastal and coastal possible emergence of dangerous microalgae (plankton) species [13] [14] [15]. The emergence of dangerous algal species greatly threatens public health. In addition, eutrophication in the waters may lead to red tides (or Harmful Alga Bloom, HAB) [9] [14]. The occurrence of algae bloom causes anoxia (oxygen depletion) to harm

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marine aquaculture and can lead to mass mortality of fish ([13] [15]. In addition, anoxia can occur due to high extraction of organic matter from the land [16] [17] [18]. The high organic matter itself triggers the acidification of seawater [19], which results in a decrease in coral calcification rates [20] [21]. Increased supply of these nutrients in the long term will result in more severe coastal ecosystem conditions. Therefore, this study aimed to analyze the nutrient composition along the coast of Spermonde waters in different seasons by looking at changes in the ratio of NH_3^-/NOx^-, DIN/DIP, DSi/DIN.

Materials & Methods

A. Study Area

Research sites in coastal waters of the Makassar Strait, which directly support the health of coral reef ecosystems and fisheries located in the Spermonde islands, one of Coral Reef's mega-biodiversity coral reefs. Coral reefs in the Spermonde region have been under pressure not only from the high exploitation of reef fish but also from high levels of nutrients (bottom-up pressures) derived from agricultural and urban activities.

The study was conducted in three seasons, namely during the transition-dry, dry, and rainy season. Sampling was conducted in coastal waters of Pangkep (04º52 S, 119º30 E - 04º49 S, 119º29 E).

B. Sampling and Sample Preparation

Parameters measured in all samples were salinity, pH, temperature, dissolved oxygen (DO), ammonia, nitrate, nitrite, dissolved inorganic nitrogen (DIN), dissolved inorganic phosphorus (DIP), dissolved organic silicates (DSi), NH_3/NOx, DIN/DIP, and DSi/DIN. Sampling of water for nutrients using Nelum bottle volume of 5 liters at a depth of 1-2 meters below the surface of the river mouth and 5 meters below sea level, for the purpose of measuring N, P, Si nutrient. Sampling of nutrient samples was carried out by filtering the sample water with a GF/F (0.7 µm) filter and using a vacum pump (pressure of 200 mm Hg). The nutrient filter results were bound to a mercury chloride solution (400 µl/100 ml sample) and frozen in the freezer and brought to the laboratory for further analysis. Filtering is done an hour after sampling.

C. Analysis

Sample Analysis

Measurement of oceanography parameters was done in situ which included salinity measurement using WTW Multi340i, pH with Orion 3 Star brand pH meter, temperature and dissolved oxygen with STD brand YSI 550A. Method and analysis of nitrate concentration (cadmium reduction), nitrite (sulfanilamide), ammonia (amonimum molarc), phosphate (stanous chloride), and silicate (molybdosilicate) with UV A1800-Shimadzu Spectrophotometer calibrated using autoanalyzer in chemical chemistry laboratory ZMT Bremen Germany, with sample preparation and measurement based on the method of [22].

Data analysis

To determine the spatial-temporal association of nutrient parameter composition (N, P and Si), NO_3^-/NOx^-, DIN/DIP and DSi/DIN ratios, a univariate analysis was used.

Results

A. Nitrogen Composition

Ammonia (NH_3^-) is the dominant form of inorganic nitrogen and the concentration is always higher in river water, ammonia is measured because it can provide an indication of water quality and has an important role as an intermediary in the organic matter cycle. However, in the determination of the ratio, nitrite and nitrate are combined to give the oxidized total nitrogen value, assuming that nitrite represents only a small component of total nitrate plus nitrite in oxic conditions.

In Figure 1 the ratio of NH_3^-/NOx^- (NOx^-=NO_3^-+NO_2^-) in each season observation of coastal stations of Pangkep except in the rainy season the ammonia supply is large compared to nitrate. The high supply of nitrate to the coast of Pangkep during the dry and dry seasons indicating a supply of aquaculture and agricultural activities that use Urea and N, P, K fertilizer. The concentration of ammonia in each observation season at each station is very high, so after normalization of NOx^-, the NH_3^-/NOx^- high ratio is due to the NOx^- minimum concentration.

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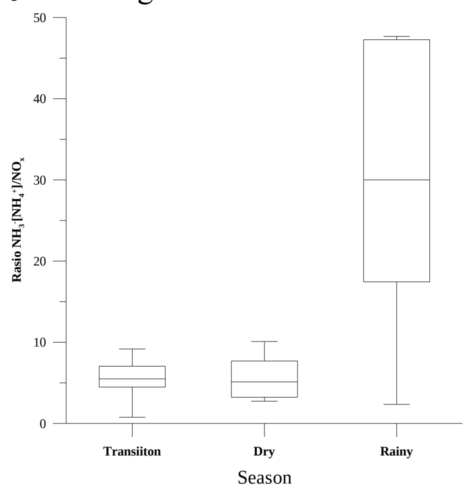

Figure 1. The composition of nitrogen in the transition season, dry and rainy in the Spermonde Coast

When compared to nitrogen concentrations in areas with no seaweed cultivation area, the seaweed cultivation area (Figure 2) shows a very low NH_3^-/NOx ratio in the dry season and the increase in the rainy season. The increase in value of this ratio is in line with the average increase in the value of nitrogen concentration, where during the dry season the average minimum ammonia concentration is 0.08-0.18 ± 0.05 mg/L and the rainy season 0.28-0.81 ± 0.18 mg/L. However, after the average ammonia concentration is normalized by the average of NOx concentrations, ie during the transition period the average NOx^- maximum concentration; 0.27 mg/L than in the rainy season of 0.11 mg/L, the composition of the nitrogen ratio will change ie during the dry-season-drying ratio of NH_3^-/NOx- minimum and in the rainy season the ratio of NH_3^-/NOx- maximum.

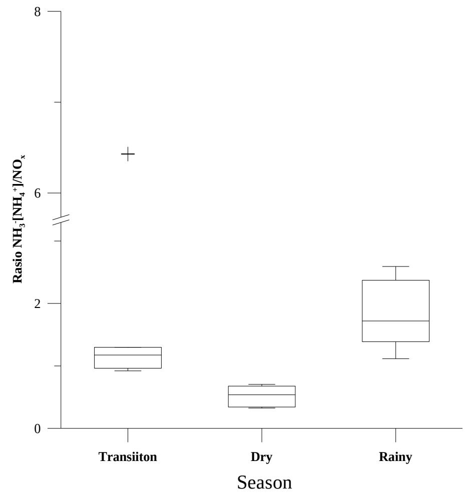

Figure 2. The composition of nitrogen in the transition season, dry and rainy in the area of seaweed cultivation

B. N, P Ratios

The relative concentrations of N and P have been used to estimate nutrient constraints for the growth of macroalgae and microalgae in waters. This approach is simple and easy to use as long as there are N and P concentration data. However, the interpretation of results should be done by connecting the DIN/DIP ratio. This approach is primarily used for coastal waters, where nutrients are physically likely to limit the growth of macroalgae and microalgae. DIN/DIP ratio in Spermonde coastal during transition 7.92; dry season 3.72; rainy season 3.08. The value of DIN/DIP ratios per observation location is significant against the season of observation. While based on the interaction characteristics of DIN/DIP ratios to the location of significant observations.

Discussion

Freshwater flow along the watershed has brought a variety of materials from the mainland causing the magnitude of nutrients in the estuary to fluctuate. Changes in nutrient concentration will affect the balance of N, P, Si [23] [24] ratios, for example the difference in NH_3-/NOx- ratios in the Spermonde coastal waters with different sources due to the impact of coastal activity different. Coastal Spermonde is dominated by aquakultur and agriculture activities that use Urea fertilizer ($(NH_2)_2CO$); N, P, K which have globally increased a hundredfold in the last four decades [25]. Input stream from this activity to the coast [5] [6] [9] adds nitrogen and phosphorus concentrations [26] [3] [27] in the waters. It is also reinforced that seasonal factors [28] [29] also influence the concentration of nutrients in waters, where nutrients previously accumulated in soils and aquifers.

In observation of the rainy season the ratio of NH_3^-/NOx^- is much greater than that of the dry-and-dry seasons, where this factor accelerates the runoff to the coast. This nutrient enrichment is also a stressor in primary production [30] [31] in coastal ecosystems. The high concentrations of

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NH_3^- in waters are strongly influenced by the source point [32], as occurs on the Spermonde coast in each observation season containing NH_3^- maximum concentration. This is contrary to the statement of [28], that nitrate is an inorganic form of nitrogen that is always far more dominant in river water.

In the coastal waters of the Spermonde, the range of NH_3^- and silicate concentrations is the most dominant sequence found. These two forms of nutrients are indispensable directly by macroalgae and microalgae for growth, especially the Diatoms. Diatoms are recognized as the most opportunistic species in taking advantage of nutrient availability [33] [24]. Phosphorus concentrations are also large.

The high human activity in the basin significantly alters the natural cycle of N/P [34] [35], ie causing excess nitrogen [36] [37] and imbalance in the N/P ratio [23] [24]. This difference in nutrient composition as a runoff implication of the domains along the stream.

While in the cultivation area of grass, the minimum DIN concentration and maximum phosphor concentration in the rainy season that causes low DIN/DIP ratio but inversely proportional to the increase in the ratio of DSi/DIN, except in the rainy season the DSi/DIN ratio is low. This suggests that seaweed as a biological filter has been exploiting the excess nutrients on the Spermonde coast. The ratio of DIN/DIP ratio of marine waters in the transition is greater, then the ratio decreases with the changing seasons, where the transition is significant with dry season and rainy season at *p value* 0.00 but dry season not significant with rainy season at p value 0.49. Based on homogenous test the average ratio of DIN/DIP during the maximum and significant transition to dry season and rainy season at *p value* 1.00 and dry season and rainy season is not significant at *p value* 0.44. Conversely, the average value of the DSi/DIN ratio during the dry season is maximum and significant against the transition and rainy season seasons with *p value* 1.00 and the mean value of the transition drought DSi/DIN ratio is not significant with rainy season at *p value* 0.98.

Maximum silicate concentrations were found on the coast at all seasons of observation, also causing an imbalance in the DSi/DIN ratio. Thus, nitrogen as a limiting nutrient for the growth of phytoplankton [38]. However, an increase in SiO_4^{4-} concentration was not significant in all seasons of observation (*p value* 0.23) with an increase in DSi/DIN ratio. The anthropogenic mobilization of these nutrients will lead to consistent emissions of the environment [39] [40] and increased nutrient loads to water bodies will further affect human and aquatic health ecosystems [41] [42]. The effects of nutrient change on ecological status, where any change in the ratio of N, P, Si may cause changes in the phytoplankton community composition [18] [14] and species abundance at the bottom of the chain [29] and the resilience of ecosystems against anthropogenic strees. An increase in the N/P ratio can fuel eutrophication in coastal ecosystems within nitrogen limitations. Therefore, to avoid the continuous increase of nutrients and the disturbance of natural ratios between the two elements, it is necessary to integrate nitrogen and phosphorus strategies.

The interaction of the runoff type with the runoff location in the seaweed and seasonal cultivation areas provides a different nutrient composition that characterizes the activity around the location of the observation. The seasonal factor also influenced the average nutrient concentration, mean concentrations of NH_3^- $[NH_4^{4+}]$-N and NO_3^--N were significant in each observation season. Where, there has been a decrease in nitrate concentration ranging from 0.01-0.44 mg/L-nitrate and 0.04-0.35 mg/L-phosphate. Average NO_2^--N concentrations in the transition period are not significant with rainy season and significant in the dry season. While the average concentration of SiO_4^{4+}-Si in the dry season is not significant with the drought-drift and significant with the rainy season. The average PO_4^+-P concentration during the transition is significant with the rainy and dry seasons.

Conclusions

The existence of this difference in runoff to the coast has shown a different in nutrient concentration and affects the imbalance of NH3- / NOx-, DIN / DIP, DSi / DIN ratios. This ratio difference also as differentiation of composition in coastal and between coastal and cultivation area of seaweed. In addition, seasonal factors contributed to the increase of magnitude nutrients on the coast, especially in the rainy season whic accelerate runoff from land and flushing nutrients accumulated in the sediments.

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