Nutrient Content of Seagrasss *Enhalus acoroides* Leaves in Barranglompo and Bonebatang Islands: Implication to Increased Antrhropogenic Pressure

Khairul Amri[1*], Dede Setiadi[2], Ibnul Qayim[2] dan D. Djokosetiyanto[3]

[11]Department of Marine Science, Faculty of Marine Science and Fisheries, UNHAS Makassar Jl. Perintis Kemerdekaan KM. 10 Tamalanrea 90245. Telp: 0411-587000, Fax: 0411-586025, HP: 081342526342, E-mail: tsaustrina@gmail.com
[2]Department of Biology, Faculty of Mathematics and Natural Sciences, IPB, Bogor
[3]Department of Aquaculture, Faculty of Fisheries and Marine Science, IPB, Bogor

Abstrak

Seiring dengan peningkatan jumlah penduduk di daerah pesisir, tekanan terhadap ekosistem pantai semakin meningkat pula. Untuk mengetahui dampak dari aktifitas anthropogenik terhadap status hara (karbon, nitrogen dan fosfor) pada lamun telah dilaksanakan penelitian pada dua pulau di Kepulauan Spermonde yakni Pulau Barranglompo dan Bonebatang. Kedua pulau ini mendapat tekanan anthropogenik berbeda. Sampel diambil dari daun lamun Enhalus acoroides pada tiga stasiun dengan jarak berbeda dari garis pantai pada masing-masing pulau. Hasil pengukuran hara menunjukkan bahwa konsentrasi nitrogen di Pulau Barranglompo jauh lebih tinggi dibandingkan Pulau Bonebatang. Nilai rasio C:N yang lebih rendah dan nilai rasio N:P yang lebih tinggi di Pulau Barranglompo memperkuat hal ini. Perbedaan ini mengindikasikan pengaruh dari pengayaan hara akibat aktifitas anthropogenik yang semakin meningkat. Hal ini didukung oleh nilai Total Padatan tersuspensi yang jauh lebih tinggi di Pulau Barranglompo dibandingkan Pulau Bonebatang. Aktifitas anthropogenik yang paling potensial mempengaruhi komposisi hara di Pulau Barranglompo adalah pembuangan sampah rumah tangga dan aliran limbah cair dari rumah penduduk di sekitar pantai.

***Kata kunci**: lamun, hara, rasio C:N:P, aktifitas anthropogenik, Barranglompo, Bonebatang*

Abstract

As human population increase in coastal areas, significant pressure to the coastal ecosystem increase as well. In order to reveal possible impacts of anthropogenic activities to the nutrient status of seagrasses, a study has been done in two small islands within Spermonde Archipelago i.e. Barranglompo and Bonebatang Islands. Currently, these two islands are facing different anthropogenic pressure. Samples of seagrass Enhalus acoroides were collected from three stations based on their different distances from the shoreline. Results of the nutrient measurements showed that nitrogen concentrations in Barranglompo Island were significantly higher than those in Bonebatang Island. This was supported by lower C:N ratios and higher N:P ratios in Barranglompo Island. This difference indicated influence of nutrient enrichment due to increased anthropogenic activities. Significantly higher Total Suspended Solid (TSS) values were also a strong evidence of this process. Potential anthropogenic activities affecting nutrient composition in Barranglompo Island are domestic sewage disposal and drainage of liquid household sewage.

***Key words**: seagrass, nutrient, C:N:P ratio, anthropogenic activities, Barranglompo, Bonebatang*

Introduction

Tropical marine environments are characterized by low nutrient levels (Hemminga & Duarte, 2000). However, significant nutrient enrichment occurs widely due to increased anthropogenic activities (Lapointe *et al*., 2004). For example, human activities including point source of urban, residential and industrial pollution, and non-point source of agricultural pollution discharge rich-nutrient materials to the coastal environments (Havens *et al*., 2001). Global human fixation of nitrogen has increased up to three-fold since 1960 and global riverine nitrogen discharges have almost doubled over the past two centuries (Newton *et al*., 2003; Heck *et al*., 2006). Similarly, inputs of phosphorus from agricultural sources and detergents

*) Corresponding author

Diterima/Received: 07-09-2011
Disetujui/Accepted: 09-10-2011

have also increased since the 1950s, with dramatic increased in the last two decades (Newton *et al*., 2003).

Nutrient content of seagrass leaves is the results of the balance between nutrient availability and nutrient requirement (Terrados & Medina-Pons, 2011). Nutrient requirements for seagrasses are lower than other aquatic organisms such as macroalgae and phytoplankton. It is estimated that seagrasses requires about 4 times less nitrogen and phosphorous per weight than phytoplankton cells. Access to both water column and sediment nutrients is an important adaptation that has permitted seagrass to persist and to out-compete algae (Hemminga & Duarte, 2000; Kaldy, 2009). Internal resorption of N and P from senescing leaves can fulfill part of the seagrass nutrient requirements (Kaldy, 2009). In addition, seagrasses have ability to recycle nutrients efficiently (de Boer, 2007). This gives the seagrasses an advantage to grow in nutrient-poor environments compared with other primary producers (Hemminga & Duarte, 2000; Kaldy, 2009).

Elemememtal stoichiometry and the spatial pattern in elemental content of primary producers have been shown to be good integrators and indicators of ecological processes (Fourqurean & Zieman, 2002). Moreover, stoichiometric analysis has been proven useful in studying species interaction and trophic relationship among different components in aquatic environment (Elser & Hassett, 1994). Seagrasses can take up nutrients from both the water column and sediment, therefore, seagrass leaf nutrient contents reflects the nutrient availability in the environment (Lee *et al*., 2004; Evrard *et al*., 2005).

This study was aimed to investigate carbon, nitrogen and phosphorus contents retained within tropical eelgrass *Enhalus acoroides* leaves in Barranglompo and Bonebatang Islands of Spermonde Archipelago, South Sulawesi. Barranglompo and Bonebatang are two small islands facing different anthropogenic pressure. Barranglompo is inhabited by more than five thousand people, while Bonebatang is an uninhibited island.

Materials and Methods

This research was conducted from October 2010 to April 2011 in two islands within Spermonde Archipelago of South Sulawesi i.e. Barranglompo (5° 02' 55"S, 119° 19' 45"E) and Bonebatang (5° 00' 50"S, 119° 19' 36"E). Samples of seagrass *Enhalus acoroides* leaves were collected from three stations in each island. Station 1 was located in coastal area close to the shoreline where the seagrass first found, station 2 was located approximately 100m from the shoreline, and station 3 was in 200m from the shoreline where the outer seagrass bed found. In each station, three 0.01 m^2 quadrats of seagrass were haphazardly collected. Samples were selected from healthy complete leaves. The samples were stored in an icy cool box to be transported to the laboratory. As supporting data, several water quality parameters were also measured. Temperature, salinity and current velocity were measured *in situ,* while water samples for Total Suspended Solid (TSS) were brought to the laboratory for further analysis.

In the laboratory, the leaves were gently scraped with a scalpel and rinsed in tap water to remove algal and faunal epiphytes. The leaves were dried to a constant weight for 24-48 hours at 60°C and homogenized by grounding to a fine powder using a mortar and pestle. Total organic carbon was determined by Wakley & Black method (Schumacher, 2002), nitrogen was determined by Kjeldahl method (Amin & Flowers, 2004), while phosphorus was analyzed using extract HCl 25% method (Johengen, 1996).

Elemental content was determined on a dry weight basis, whereas, elemental ratios were calculated on a mole:mole basis.

Results and Discussion

Nutrient concentrations

Average (± SE) nutrient concentrations of seagrass *E. acoroides* (as % dry weight) in Barranglompo Island were 34.77 ± 2.41 carbon (C), 2.42 ± 0.22 nitrogen (N), and 0.15 ± 0.02 phosphorus (P), while in Bonebatang Island were 34.62 ± 4.04 carbon, 1.75 ± 0.47 nitrogen, and 0.14 ± 0.03 phosphorus. Carbon content in both islands was quite similar, however, in Bonebatang Island, the nutrient showed slightly higher variability (Figure 1). Nitrogen is the only nutrient that significantly different between the two islands (Tukey, $p = 0.0056$).

Duarte (1990) compiled literature data from various seagrass species worldwide and found that average seagrass C, N, and P concentrations (as % dry weight) were 33.6, 1.92 and 0.23, respectively. C and N in Barranglompo Island and C in Bonebatang were higher compared to these global values. High C in both islands is affected by type of sediments covering coastal beds in these areas. According to Erftemeijer (1994), intertidal reef flat areas in these islands were covered by approximately 30cm-thick coarse carbonate sand and coral rubble (93 to 100% $CaCO_3$). Carbonate-rich sediments are common in tropical coastal areas and originated from the erosion of coral reefs and the fragmentation and accumulation of skeletal elements of marine organisms such as molluscs, echinoderms, foraminifera, and calcified algae (Hemminga & Duarte, 2000).

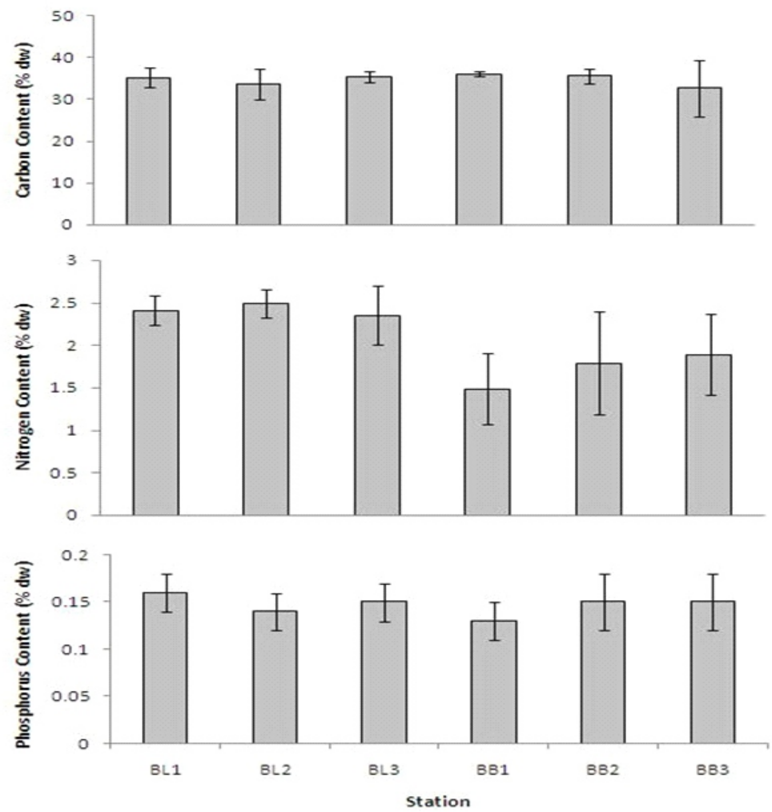

Figure 1. Mean (± SE) of carbon, nitrogen and phosphorus contents (as % dry weight) retained within seagrass E. acoroides leaves in Barranglompo (BL) and Bonebatang (BB) Islands

When seagrass growth rate is potentially high enough to outstrip the nutrient supply rate, nutrient limitation will occur (Fourqurean & Zieman, 2002). Nutrient limitation may occur at nitrogen contents below 1.8% of dry weight and at phosphorus contents below 0.2% of dry weight (Duarte, 1990). Based on this standard, finding of nutrient contents retained within *E. acoroides* leaves (Figure 1) has shown light N limitation at Bonebatang Island, and P limitation at both islands. Low P concentration at both islands is caused by the characteristics of carbonate sediments as substratum at both islands, which have high capacity for binding P and thereby induce P limitation to this plant (Hemminga & Duarte, 2000).

C:N:P ratios

Table 1 summarised mean values of elemental ratios at each station in both islands. Values of C:N and N:P showed significant variability among stations ($p < 0.05$). C:N ratios in Barranglompo Island was lower than those in Bonebatang Island, in contrast, N:P ratios in Barranglompo Island was significantly higher than those in Bonebatang Island.

Previous studies indicated high variability of C:N:P ratios. Atkinson & Smith (1983) calculated that median C:N:P atomic ratio for benthic plants i.e. macroalgae and seagrass was approximately 550:30:1. This ratio is regarded as "seagrass Redfield ratio" (Johnson *et al*., 2006) or Atkinson ratio (Baird & Middleton, 2004), and far above popular Redfield ratio of phytoplankton i.e. 106:16:1. Seagrass and other benthic marine plants have large quantities of structural carbon resulting in higher ratios compared to the average phytoplankton (Baird & Middleton, 2004; Johnson *et al*., 2006).

For seagrasses, N:P ratios above 30 are considered to be evidence of P limitation and ratios less than 25-30 are considered to show N limitation (Duarte, 1990; Johnson *et al*., 2006). Mean N:P ratios at each station at Barranglompo Island ranged between 33-40 indicating P limitation, whereas in Bonebatang was 26-28 showing mild N limitation. Significantly higher N contents in Barranglompo Island compared to Bonebatang Island, therefore, could be used as an early warning indication of anthropogenic nutrient enrichment such as from liquid and solid sewage (Lapointe *et al*., 2004). The nutrient concentrations of seagrass tissues therefore provide a tool for examining nutrient availability over much longer time scales (Fourqurean *et al*., 1992). In addition,

Table 1. Mean C:N:P ratio of seagrass *Enhalus acoroides* leaves from Barranglompo and Bonebatang Islands

Location	C:N	C:P	N:P	C:N:P
Barranglompo				
Bl1	17.2	568	33	568:33:1
BL2	15.9	636	40	636:40:1
BL3	17.5	595	34	595:34:1
Bonebatang				
BB1	28.6	744	26	744:26:1
BB2	23.0	599	26	599:26:1
BB3	20.5	574	28	574:28:1

seagrass could be used as an excellent indicator of nutrient availability in marine ecosystem because they are fixed to the substratum, they often grow in nutrient-limited clear-water area, and the nutrient contents of their leaves reflects relative availability (Atkinson & Smith, 1983; Duarte, 1990)

Water quality

Table 2 listed mean values of measured water quality parameters at each station in Barranglompo and Bonebatang Islands. Temperature, salinity and current velocity in both islands showed almost similar ranges. Temperature in Barranglompo Island ranged between 27-32 °C, whereas, in Bonebatang Island was between 28-32 °C. Slightly warmer temperature at stations closer to the coastline is affected by depth differences among stations. Salinity in both islands ranged between 29-32 °/₀₀. In contrast to the temperature, salinity was slightly higher at stations farther from the shoreline. Possible cause of this difference is drainage of freshwater discharges from households. Tropical seagrass species have evolved under intermittent or chronic exposure to hypersalinity, therefore they have higher salinity tolerance (Koch *et al*., 2007). Most of seagrass species can tolerate a wide range of salinity, from full-strength seawater to either brackish or hypersaline waters (Hemminga and Duarte, 2000). However, decrease in salinity in nearshore area influence the distribution and growth of single species as well as modify competitive interaction leading to species replacements (Lirman & Cropper, 2003).

Current velocity ranged between 0,009 – 0,130 m/s at Barranglompo and 0,012 – 0,126 m/s at Bonebatang. Different currents velocities give different effects to the seagrass photosynthesis (carbon uptake), nitrate assimilation and ammonium assimilation (Morris *et al*., 2008).

Values of Total Suspended solid (TSS) are significantly different in both islands ($p < 0,0005$). TSS values are much higher in Barranglompo than in Bonebatang. Distinct difference in TSS clearly demonstrated significant influence of anthropogenic activities occurred in both islands.

Potential anthropogenic activities

There were seven anthropogenic activities observed at Barranglompo Island (Table 3), whereas, in Bonebatang Island, it was identified two human activities (Table 4). These activities are potentially affecting physical, chemical and biological processes occurred in the coastal ecosystems. Among all of the anthropogenic activities occurred at Barranglompo Island, domestic solid sewage disposal and drainage of liquid sewage are two activities primarily contribute to

Table 2. Mean values (± SE) of several water quality parameters in seagrass habitat of Barranglompo and Bonebatang Islands

Parameter	Barranglompo			Bonebatang		
	1	2	3	1	2	3
Temperature (°C)	30.3 ± 1.6	30.4 ± 1.4	30.1 ± 1.7	30.4 ± 1.0	30.3 ± 1.2	30.2 ± 1.3
Salinity (°/oo)	30.4 ± 1.1	30.6 ± 1.1	30.7 ± 0.9	30.6 ± 1.0	30.8 ± 1.0	30.8 ± 1.0
Current Velocity (m/s)	0.038± 0.030	0.040± 0.031	0.044± 0.041	0.040± 0.031	0.041 ±0.025	0.046± 0.034
TSS (mg/l)	16.7 ± 1.7	13.2 ± 0.6	15.7 ± 0.5	10.1 ± 0.6	9.5 ± 1.4	8.7 ± 2.0

Table 3. Anthropogenic activities observed at Barranglompo Island

No.	Activity	Intensity	Possible Impacts to the Seagrass
1.	Boat transportation	High	Physical damage caused by anchors and propellers; spilled oil reduces light availability
2.	Domestic sewage disposal	High	Solid wastes reduce light intensity received by seagrass
3.	Drainage of domestic liquid sewage	Moderate	Increased nutrients; turbidity reduces light for plant photosynthesis
4.	Utilization of coastal areas as public bathing, washing and toilet facilities	Moderate	Increased organic and pollutant matters affect seagrass growth
5.	Boat/ship repairs	Low	paints, boat caulking and other chemical used would increase pollution in seagrass environment
6.	Stony coral excavation	Moderate	Change in water hydrodynamic (i.e. current and wave)
7.	Fish trap	Moderate	Placement of this gear will physically damage seagrass

Table 4. Anthropogenic activities observed at Bonebatang Island

No.	Activity	Intensity	Impacts to the seagrass
1.	Fishermen boats	Low	Physical damage caused by anchors and propellers
2.	Sand excavation	Moderate	Increased turbidity will reduce light availability for plant photosynthesis

the change of nutrient composition in the coastal area. Various solid household rubbish will be decomposed by microorganisms and eventually will increase turbidity as shown by significantly higher TSS values at Barranglompo compared to Bonebatang.

Conclusion

Significantly higher N concentration at Barranglompo Island compared to Bonebatang indicated influence of increased anthropogenic activities occurred at this island. The potential activities affecting these differences as observed during the study are solid waste disposal and drainage of household liquid waste. This was supported by high total suspended solid (TSS) values particularly in sites where these activities occurred.

Acknowledgements

This work was financially supported by Postgraduate Scholarship (BPPS) of Directorate General of Higher Education and Data Analysis Grant provided by Hasanuddin University. I would like to thank to Abdul Muttalib for assistance during the fieldwork of this study.

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