IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 10, Issue 6 Ver. III (Jun. 2016), PP 33-41
www.iosrjournals.org

Diversity of Seagrasses Relation with Environmental Characteristics in the Labakkang Coastal Waters, Pangkep, South Sulawesi, Indonesia

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Abstract: *One component of the coastal ecosystem is seagrass ecosystems which play an important role in the life at sea. Seagrass ecosystems grow between mangrove and coral reef ecosystems. Seagrass coastal waters Labakkang existence provides many benefits but still lack the information about the data of seagrass. This study aims to determine the species composition, density, diversity and distribution of seagrass relation to environmental characteristics. The study was conducted from July to September 2013. Observations of seagrass in the field include the identification of the types of seagrass, density, diversity and distribution as well as environmental parameters. Seagrass density observed using transects squares, seagrass distribution relation to environmental parameters were analyzed using multivariate analysis approach the Principal Component Analysis (PCA). The results showed that seagrass communities in the Labakkang coastal waters including mixed communities consisting of 1- 6 species of seagrass. Seagrass species found there are 6 types i.e. Enhalus acoroides, Thalassia hemprichii, Halophila minor, Halophila ovalis, Cymodocea rotundata and Haludule pinifolia. Seagrass distribution patterns are categorized in groups (id > 1). While the content of nitrate, C-organic, turbidity, TSS, current speed, temperature, depth and substrate are the main factors limiting the distribution of seagrasses in coastal Labakkang.*
Keywords: *Seagrass distribution, PCA, mixed communities, environment parameter, species composition*

I. Introduction

Seagrass is one of the shallow marine ecosystems have a vital part of life at sea, and is one of the most productive ecosystems. The existence of seagrass in the coastal area ecologically provide substantial contributions particularly important role as a contributor to nutrient for fertility coastal waters and marine environment. Seagrass in the coastal areas have high biological productivity, has the function as primary producers, recycling nutrients, stabilizers bottom waters, sediment traps and barriers to erosion (Tomascik *et al*., 1997; Nobi *et al.*, 2011).

Seagrass beds as important as other ecosystems in the shallow waters are coral reefs and mangrove ecosystems. Seagrass is a primary producer in the sea which is quite large compared to other ecosystems (Azkab, 2006). Seagrass are the classic ecosystems and highly productive habitat because it is a habitat for many types of biota such as macroalgae, sponges, coral, various types of shells, and various types of invertebrates that are sessil (Duffy, 2006).

Labakkang coastal area is in one of the District in Pangkep (Pangkajene and Islands) which has the water area larger than the land area. The total area of its land is 829.29 km^2 and sea space is 11,464.44 km^2, so the land versus sea is 1: 13.

The main coastal ecosystems in Pangkep are coral reefs, mangroves and seagrass beds. Along with the high human activity (anthropogenic) in these waters such as the construction industry, ports, housing and fishing are not environmentally friendly such as the use of bombs and anesthesia may cause changes in the quality of the water environment such as changes in physical and chemical properties that can affect the existence of water seagrass ecosystems. Reduction or loss of seagrass ecological ecosystems functions impact on the biodiversity (marine biota) and decrease in fishery productivity. Anyona *et al*. (2014), anthropogenic activities adversely affect to the changes of physical of chemistry waters parameters as well as to the existence of macroinvertebrate organisms and others aquatic biota.

Seagrasses worldwide deployment identified as many as 60 species of seagrasses, 20 species were found in the waters of Southeast Asia and there are 12 species of 7 genera in Indonesia. As many as 12 species of seagrass in Indonesia, and 8 species are found in the Thousand Islands (De Hartog, 1970).

Seagrass located on the coast Labakkang used by communities to catch fish, especially during the west monsoon (winds), the types of mollusks (especially shellfish), crab, and so on. The existence of seagrass beds is very important as a habitat for many types of biota so it is very important to know the condition of seagrass were in coastal waters Labakkang such as species composition, density, diversity and distribution of seagrass relation to environmental characteristics. The results of this study are expected as information in an effort utilization and management of marine resources especially seagrass in coastal areas of Pangkep.

II. Materials And Methods

The research was conducted in July until September 2013 in the coastal of Region Labakkang in District of Pangkep include Borimasunggu Village, Village Pundata Baji and Bontomanai Village, which are located along the coast (Figure 1). The method of this research is survey method, and also using sampling, dialogue, and documentation methods for data collecting. Primary data was collected with simple random sampling. The data were analyzed with quantitative.

Analysis of water quality and sediment/substrate as well as the identification of seagrass species conducted at the Laboratory of Chemical Oceanography and the Laboratory of Marine Biology, the University of Hasanuddin, Makassar. Determining the site at each location is based on coastal geomorphology, seagrass distribution (which is considered to represent the condition of seagrass) and land use. The number of sitess observed there are three sites and each sites comprises three sub-sites (Table 1).

Sampling method of seagrass using a combination of transect lines and rectangular with how stretched perpendicular line of the coast towards the sea as far as 100 m (depending on conditions on the ground) were placed randomly systematically on seagrass with the distance of each transect squared is 20 m (McKenzie and Yoshida, 2009). Identify the type of seagrass using (McKenzie and Yoshida, 2009; De Hartog, 1970; Phillips and Menez, 1988).

Measurement of environmental parameters include: salinity, nitrate, phosphate, water temperature, substrates/sediment, depth, turbidity and flow velocity of surface waters. Methods of measurement of environmental parameters is done in situ (on the ground) is dissolved oxygen (DO), temperature and salinity using a DO meter of type YSI 650MDS, the depth with a stick-scale and speed of the flow by using current meter. While the content of nitrates, phosphates, turbidity and sediments in water were analyzed at the Laboratory of Chemical Oceanography, the University of Hasanuddin, Makassar.

The density of species is the number of individual of seagrass (stand) per unit area. Seagrass density is calculated by the following formula (Brower *et al*., 1990):

$$Ki = \frac{\sum_{i=1}^{p} nij}{A}$$

Where:

K_i = absolute density of species the-i
n_{ij} = the total number of individuals of species the-i in unit area the-j
A = total area of sampling (m^2)

Species diversity can be said as the heterogeneity of species and is a hallmark of community structure. The formula used to calculate diversity is Shannon-Wiener formula (Odum, 1993), namely:

$$H' = -\sum_{i=1}^{S} pi \log_2 pi$$

Uniformity can be said to be a balance that individual composition of each species present in a community. Uniformity index (regularity) is calculated by the following formula (Odum, 1993) is:

$$E = \frac{H'}{H\max}$$

To determine whether there is dominance of a particular species used Simpson Dominance Index (Brower and Zar, 1990), namely:

$$D = \sum_{i=1}^{S} (pi)^2 = \sum_{i=1}^{S} (ni/N)^2$$

To determine the distribution pattern of an organism to the habitat types used method of distribution patterns Morisita (Brower and Zar, 1990). The formula for calculating the Morisita Spread Index is as follows:

$$Id = \frac{n \sum_{i=1}^{p} (xi^2 - N)}{N(N-1)}$$

Where:
Id = Morisita Index
n = the sum of squares of sampling
N = number of individuals in n squared

x_i = number of individuals species thei on each squared

To see the distribution of seagrass and grouping research sites based on the aquatic environment used approach to multivariate statistical analysis such as Principal Component Analysis (PCA) referring to the research result of Sartimbul *et al*. (2010) about the effects of climate variability in Chl-a and CpUE to yield of *Sardinella lemuru* in Bali.

III. Results And Discussion

Environmental parameters waters and sediment

Based on Table 2 that in general the range of physical-chemical parameters of waters within the limits of tolerance for seagrass growth life except turbidity and TSS obtained already in excess of that required in Decree of the Minister of Environment of the Republic of Indonesia (DMERI) No. 51/2004 for Marine Biota is <5 NTU and 20 mg/L, but the growth of seagrass still good enough for the intensity of the light arriving at the base large enough for fairly shallow waters with depths ranging from 34-42 cm. The range of flow velocities during the study was 0.0431-0.0532 m/s, it means the speed of this flow including weak. Flow velocity is directly affects the growth, recruitment, morphometric leaf, rhizome and roots of seagrass (Peralta *et al*., 2006).

The nutrient levels of nitrate are 0.116-0.176 mg/L) and phosphate is 0.026-0.060 mg/L) (nitrate and phosphate), based on the quality standards DMERI 51/2004 has exceeded the threshold for microbial life but can still be tolerated by seagrass. Baron *et al.* (2006) nitrate levels exceeding 0.2 mg/L can result in eutrophication (enrichment) waters, which in turn stimulate the growth of algae and aquatic plants quickly (blooming). While orthophosphate needed by marine organisms, including sea grass, the surface waters of dissolved phosphates will be utilized by plants in photosynthesis process so that the levels in the ocean are minimal (Evrald *et al.*, 2005).

Sediment quality measurement results (Table 3) showed that the levels of C-organic and N-total is low enough because if C-organic levels of <2 % and N- total < 0.2 % mean levels in sediments are low (Eviati and Sulaiman, 2009). While the composition of the sediment texture at all observation sitess in the category of muddy sand. In general, the criteria are found in the coastal sand in Labakkang is in the category of fine sand (0.125-0.25 mm) that get a lot of influence from the mainland. The composition of the sediment texture still supports the growth of seagrass in the coastal waters of Labakkang.

Type Composition and Density of Segrass

Based on the results of the identification of seagrass species were found during the study there are 6 types consist of two families namely (a) Hydrocharitaceae there are four species (*Enhalus acoroides*, *Thalassia hemprichii*, *Halophila minor*, *Halophila ovalis*), and (b) Potamogetonaceae there are two species (*Cymodocea rotundata, Haludule pinifolia*) (Table 4, Figure 2). While the measurement results of density can be seen in Table 5.

Table 5 shows, seagrass species that dominate in the coastal of Labakkang is *Enhalus acoroides*, *Thalassia hemprichii* and *Cymodocea rotundata* since almost every observation sitess found this type. It is suspected because of the condition of the substrate that supports the growth of this type are also conditions the area is heavily influenced by the flow of river entrance which can affect the condition of the substrate in this waters. Research results of Feryatun *et al*. (2012) in the waters of the Thousand Islands also found three dominant species of the seven species of seagrasses namely *Thalassia hemprichii*, *Cymodocea rotundata* and *Enhalus acoroides*.

According to Yakub *et al*. (2013), there are about 12 species of seagrass found in Singapore is dominated by *Enhalus acoroides* and *Halophila ovalis* type being the least is the type *Halodule pinifolia, Halophila decipiens* and *Halophila minor*. The spread of seagrass found ranging from sand to muddy substrate. Research conducted by Nobi (2011) in the waters of the Indian discovered seven species of seagrasses that *Halophila decipiens*, *Thalassia hemprichii*, *Cymodocea rotundata*, *C. serrulata*, *Halodule pinifolia*, *Halodule uninervis* and *Syringodium isoetifolium*, dominated by the type *C. serrulata*, while Vibol *et al*. (2010), the diversity of species of seagrass found off the coast of Cambodia around 12 types dominated by *Halodule uninervis*.

The most of dense seagrass found in the type *Enhalus acoroides*, then *Thalassia hemprichii* and *Cymodocea rotundata*. Tomascik *et al*. (1997) states, *Enhalus acoroides*, *Cymodocea rotundata*, *Thalassia hemprichii* and *Halodule uninervis* are seagrass species most common and widespread in Indonesia. The types of seagrass are commonly grown form mixed communities in a variety of different habitat types. Further explained, the kind of *Enhalus acoroides* is the most common ranging from fine sediments to the mud. However, this kind does not grow on a medium to sediment because its roots long and strong so as to absorb food properly and stand firm. Patty and Rifai (2013), the density of seagrass species are influenced by environmental factors such as brightness, depth and substrate type.

Patang (2009) conducted a study in the coastal of Pangkep at sites B (Pundata Baji) finds three seagrass species (*E. acoroides*, *C. serrulata*, *T. hemprichi*) with substrate rather sandy mud , while the results obtained at the same location there are 5 types (*E. acoroides*, *C. rotundata*, *T. hemprichii*, *Halophila ovalis*, *Halophila minor*) with argillaceous sand substrate. Seagrasses communities in coastal Labakkang classified as mixed community consisting of 1-5 species of seagrasses (Tomascik *et al*., 1997) even though the region is dominated by *E. acoroides*. According to Nienhuis *et al*. (1989), seagrass vegetation types in tropical waters are generally composed of four or seven species such as *Cymodocea rotundata, C. serrulata*, *Halodule uninervis, Halophila ovalis*, *Syringodium isoetifolium*, *Thalassia hemprichii* and *E. acoroides*. Usually these seagrass dominated by *E. acoroides* and *T. hemprichii.*

Seagrass density and percentages of overall relative density in Table 5 shows that the highest density at Sites C and then followed by sites B and Sites A (the lowest). The low density of seagrass at Sites A suspected because this region is the region bordering districts of boat traffic activity is high enough so that it can affect the growth of seagrass habitat and seagrass. While on sites B (residential area), the condition of the waters environment heavily influenced by the variety of fishermen household activities.

Ecological Index

Values of species diversity index (H'), species evenness/uniformity index (E) and dominance index (C) are used to estimate the condition and existence of seagrass resources in coastal waters ecosystems. By using the values of the index, seagrass ecosystems can be classified into three categories i.e. high, moderate (medium) and low.

Value of species diversity index (H') ranged 1.0691-1.4734 (Table 6). In general, the diversity index of seagrass in Labakkang coastal waters classified as category "medium", meaning that the stability of seagrass conditions in the Labakkang coastal waters already occurring ecological pressure. This is due to a variety of activities around the coastal of Labakkang derived from land and in the waters itself can affect the condition of seagrass ecosystems. Activities referred them come from settlements, port of cement factory and ferry harbor (to the islands), aquaculture area (ponds of milkfish) and agricultural (paddy lands) wastes go into coastal waters through rivers. Akaahan *et al.* (2014) explains, the value of diversity index of benthic animals obtained ranged from 1.81 to 2.91, which means the condition in moderate (moderate) (1-3), the value of diversity index is greater than three (>3) shows that the structure of the habitat in stable condition and balanced, and if less than one (<1) indicates the condition of the habitat in a state of polluted and damage to the habitat structure. While according to Lyimo *et al*. (2008), species diversity index (H ') in the Gulf of Chwaka Tanzania gained around 1.29 by the number of seagrasses is seven species. Arbi (2011) explains, the level of the index value of biodiversity can be caused by various factors such as the number of species or individuals, there are some types that are found in large quantities, the condition of homogeneity of the substrate, the condition of three important ecosystems in the coastal areas (seagrass, coral reefs, mangrove forests) as the habitat of aquatic fauna.

Value of species evenness/uniformity index (E) ranges from 0.5471 to 0.6745 belong to the category of "moderate" means the species of seagrass found in each of observation sitess is relatively uniform (variation types were found to be very low). Odum (1993) states, the index value ranges uniformity is if $E < 0.4$ (low), $0.4 < E < 0.6$ (moderate) and $E > 0.6$ (high). Kharisma *et al.* (2012), the value of uniformity/evenness index describe the ecological balance in a community, where the higher of the uniformity value of the environment quality is getting better and suitable for microbial life even though there are some species that are greater than other types.

Dominance index value (C) ranges from 0.2182 to 0.3664, meaning no seagrass species dominates. The dominance value close to one ($C > 0.5$) indicates that there are organisms that dominate and if close to 0 ($C < 0.5$) means that no organism is dominating even though there is a type that has the highest density compared with other types namely *E. acoroides* (Akhrianti *et al*., 2012).

Seagrass Distribution Patterns

The seagrasses distribution pattern of in Labakkang coastal waters is calculated by using Morisita Index and Chi Square Test. Based on Table 7, it can be seen that the value of the Morisita Index ranged from 1.043 to 4.684 (id > 1). It means that the distribution pattern of all types of seagrass during research is clustered. Morisita disperse index criteria (Kreb, 1972) is Id < 1 (uniformly disperse patterns), Id = 1 (random disperse patterns) and, Id > 1 (clumped disperse patterns).

According to Azkab (2006), for the waters of tropical is like Indonesia, seagrass grow dominant with colonies consisting of several types (mixed species) in a certain region. In contrast to the area of temperate or cold regions that mostly dominated by single species seagrass.

The spread of seagrass indeed vary greatly depending on the topography of the beach and tidal patterns. The distribution pattern of seagrasses in Labakkang coastal waters at each sites approached random groupings, it is suspected because of environmental parameters and sediment type is not too much different (Table 2, Table 3), although the levels of nutrients (nitrates, phosphates) have passed the threshold for aquatic biota. High content of nutrients thought to be caused by the presence of brackishwater aquaculture areas along the coastal in Labakkang.

Seagrass Spatial Distribution Relation with Habitat Characteristics

The results of principal component analysis (PCA) showed that the information that describes the distribution of seagrass and environmental characteristics centered on two main axes F1 and F2 with the contribution of each axis by 33.79% to 26.92% axes F1 and F2 to the axis, so the variance seagrass habitat characteristics at each sites in the coastal waters of Labakkang can be explained by two main axes in the amount of 60.71%. Axis 1 is characterized by the parameters of TSS, turbidity, dust, nitrates and C-organic (positive correlation), while the temperature, depth, clay and the velocity (negative correlation) against density *T. hemprichii*, *C. rotundata*, *H. ovalis* and *H. minor.* While axis 2 is characterized by the parameter DO, pH, phosphate, N-total, clay (positive correlation) and salinity as well as the total organic material (negative correlation) against density *E. enhallus* (Table 8).

Table 8 and Figure 3 show that TSS parameter is inversely proportional to the flow velocity and vice versa in turbidity. Akhrianti *et al*. (2014) said, TSS has an inverse relationship with the current speed , this indicates that the current low speed can cause high TSS value. Instead, have a positive correlation with turbidity means that the higher the turbidity TSS also higher. TSS and turbidity value has a positive correlation with the density of seagrass that even though both parameters were high but the growth of seagrass still good enough for the intensity of the light arriving at the base large enough for fairly shallow waters. One of the parameters that determine the distribution of sedimentary environments is the speed of the flow, variable flow axis F1 negatively correlated to the sand substrate and positively correlated with dust means that the smaller the current speed, the smaller presence of sand and conversely the greater presence of dust. According to Marcia (2012), the first major component of clay is negatively correlated and seagrass biomass (leaves and rhizomes) are positively correlated, meaning that the lower clay content in the substrate, the higher biomass of seagrass. Temperature and depth parameters are negatively correlated, this is due to the three observation sitess there are stream flow causes the temperature remained low despite the shallow waters. Environmental parameters that most influence of the spread and growth of seagrass are brightness, temperature, salinias, substrate, pH and flow velocity (De Hartog, 1970; Dahuri, 2003; Herkul and Kotta, 2009). While Tomascik *et al.* (1997) spread of the organism is closely related to the characteristics of the environment such as temperature, salinity, pH, DO, brightness, BOT water, ammonium, nitrate, nitrite and orthophospat.

Diagram representation of the distribution sites relation to environmental parameters (Figure 4) on the axis of F1 and F2 showed two groups: group 1 (A1, A2, A3, B3 and C3) were characterized TSS, turbidity, dust, nintrat and C-organic, while group 2 (B1, B2, C1 and C2) which is characterized by dissolved oxygen, pH, phosphate, N-total, and clay. Characteristics of group 1 that sites A (bordering the harbor of cement industry) and sites B (residential) with high levels of TSS and turbidity is higher than the other sitess, this is due to the activity transfortasi high enough, settlements, there are streams and input from the mainland. Wijaya and Pratiwi (2011) explains, coastal waters that near the river and the landscape will affect the physical condition of the water chemistry because of the river carrying the flow of fresh water and sediments. While the second group is the sites B and C with high levels of DO and phosphate levels were quite high compared to other sitess, it is thought to be caused because of residential areas, farms and seagrass density is quite high (one source of oxygen through photosynthesis activity).

Distribution of seagrass species based observation sitess show that the type of *T. hemprichi*, *C. rotundata*, *Halophila ovalis*, *Halophila minor* and *Haludule pinifolio* spread at sites B and C while the type *Halophila ovalis*, *Halophila minor* and *Haludule pinifolio* not match at sites A. *E. acoroides* species found in all sitess and the kind that dominate the coastal waters of Labakkang.

IV. Conclusion

Based on the research results can be summarized as follows: (1) Three seagrass species i.e. *E. acoroides*, *T. hemprichii* and *C. rotundata* dominate the seagrass beds in Labakkang, (2) Diversity of seagrass species can be used as an indicator to estimate the status of the waters environmental condition, and (3) The content of Nitrate and C-organic (in the water), turbidity, TSS, temperature, current speed, depth and substrate are the main limiting factors of seagrass distribution.

Therefore, it is recommended to conduct a study of economic valuation of seagrass resources and biota associated with seagrass to kow the level of economic losses due to reduced of seagrass populations. And it takes a policy from Government of Pangkep in an effort to support the implementation of management strategies of seagrass resource in Labakkang coastal areas.

Acknowledgement

Thanks to the Rector of Indonesian Muslim University (IUM) and Dean of the Faculty of Fisheries and Marine Science of IUM has provided moral and material support in this study. We greatly appreciate their assistance to Mrs. Asmidar, Mr. Yaya and students who have helped me during the process of data collectiion on the research location.

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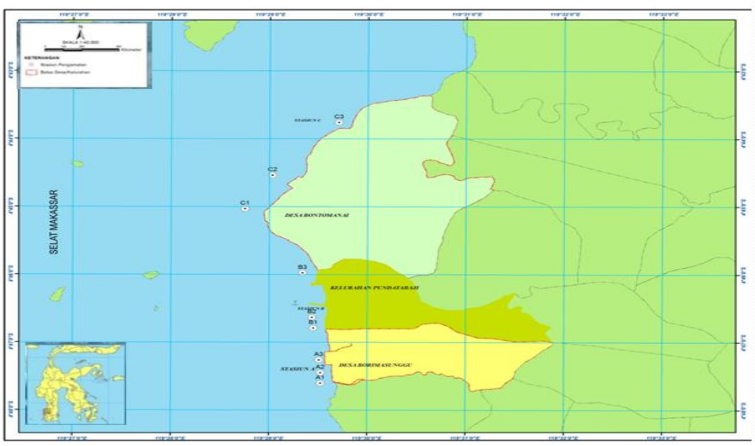

Figure 1. Map of sampling sites

Figure 2. Types of seagrasses in coastal waters of Labakkang

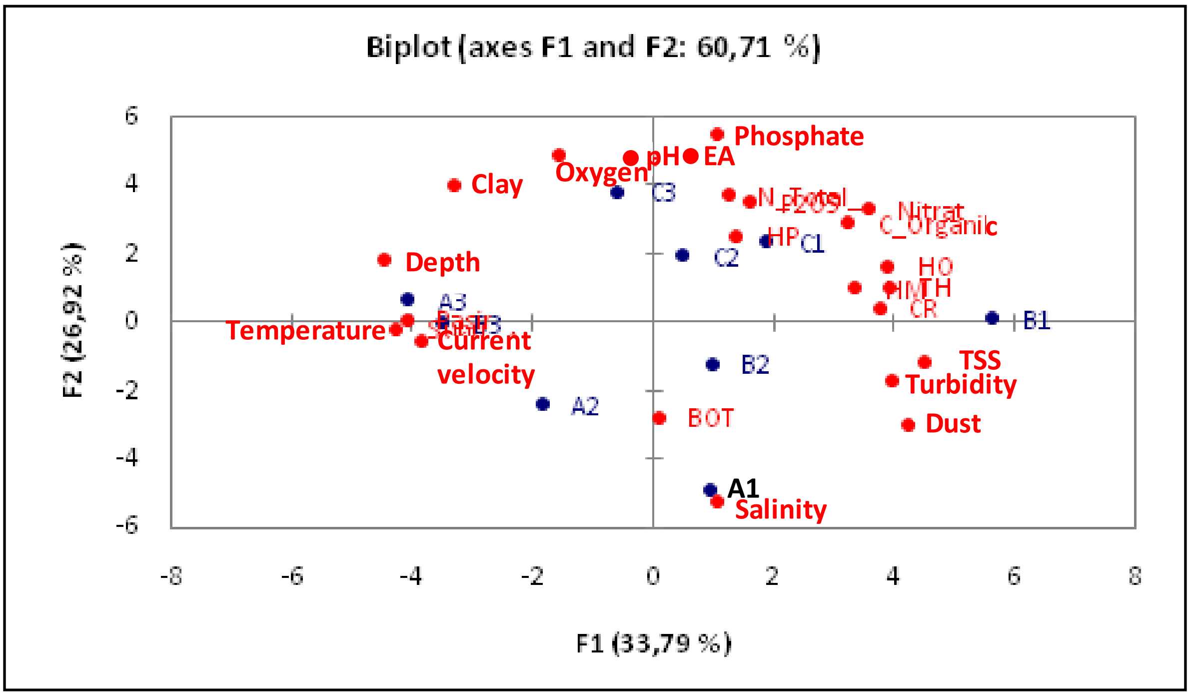

Figure 3. Diagram PCA biplot parameters of water physical chemistry, EA (*E. acoroides*), TH (*T. hemprichii*), CR (*C. rodundata*), HO (*H. ovalis*), HM (*H. minor*) and HP (*H. pinifolia*)

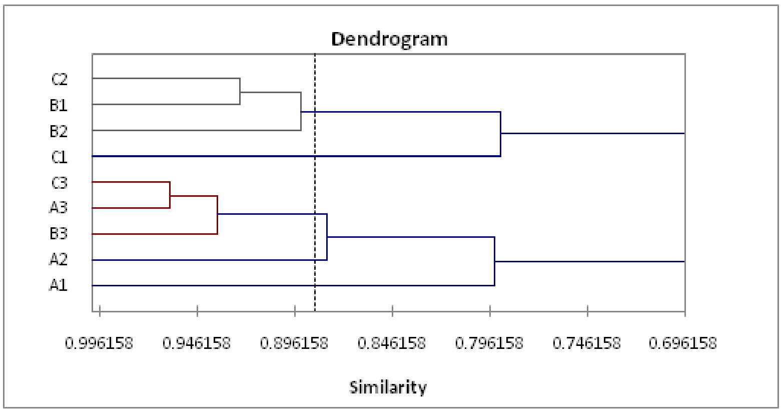

Figure 4. Dendogram classification of hierarchical the observation sites based on characteristics of observations

Table 1. Characteristics of sampling sites

Sites	Sub Sites	Coordinates	Characteristics
Village of Borimasunggu (Sites A)	A1	119°49'20.26" EL; 04°79'33.75" SL	Seagrass habitats bordering with the harbor of Tonasa cement, small rivers, mangroves forests and brackish water aquaculture
	A2	119°49'20.19" EL; 04°79'07.99" SL	
	A3	119 °49'01.77" EL; 04°78'76.38" SL	
Village of Pundata Baji (Sites B)	B1	119°49'10.17" EL; 04°77'64.66" SL	Seagrass habitats bordering with the settlements, river, ferry harbor to the islands, mangroves forests and brackish water aquaculture
	B2	119°48'89.68" EL; 04°77'01.79" SL	
	B3	119°48'86.37" EL; 04°76'61.35" SL	
Village of Bontomanai (Sites C)	C1	119°47'91.55" EL; 04°75'05.19" SL	Seagrass habitats bordering with mangrove forests, brackish water aquaculture and small rivers
	C2	119°48'37.66" EL; 04°74'22.85" SL	
	C3	119°49'50.12" EL; 04°72'92.89" SL	

Table 2. The average value of environmental parameters water in the coastal of Labakkang

Parameters	Sites A	Sites B	Srasiun C	Quality Standards
Temperature (°C)	31.49±0.25	31.12±0.72	31.33±0.24	Decree of the Minister of the Environment No. 51/2004 (28-30)
Salinity (ppt)	34.21±0.52	33.87±0.23	33.49±0.33	Decree of the Minister of the Environment No. 51/2004 (33-34)
Current Velocity (m/sec.)	0.053±0.06	0.043±0.04	0.050±0.01	Dahuri (2003) (0.5 m/sec.)
Turbidity (NTU)	20.89±3.76	29.53±9.58	18.82±10.45	Decree of the Minister of the Environment No. 51/2004 (<5)
TSS (mg/L)	35.33±7.01	53.33±22.50	22.67±32.33	Decree of the Minister of the Environment No. 51/2004 (20)
Depth (cm)	42.00±14.80	34.33±14.01	39.33±17.04	-
Nitrate (mg/L)	0.12±0.02	0.14±0.020	0.18±0.015	Decree of the Minister of the Environment No. 51/2004 (0.015)
Phosphate (mg/L)	0.03±0.021	0.03±0.015	0.06±0.010	Decree of the Minister of the Environment No. 51/2004 (0.008)

Table 3. The average value of measurement results of sediment quality

Sites	C-Organik (%)	N-Total (%)	P_2O_5 (ppm)	Sand (%)	Dust (%)	Clay (%)	Type of Substrate
A	0.89±0.12	0.07±0.01	16.90±5.41	81.33±2.31	12.67±6.11	6.00±4.00	Muddy sand
B	1.33±0.95	0.07±0.03	15.28±12.31	78.67±1.16	15.33±5.03	6.00±4.00	Muddy sand
C	1.42±0.47	0.10±0.04	24.96±11.07	79.33±1.16	11.33±1.16	9.33±1.16	Muddy sand

Table 4. The type and distribution of seagrasses in coastal of Labakkang

No.	Type of Seagrasses	Sites A	Sites B	Sites C
1	*Enhalus acoroides* (EA)	√	√	√
2	*Thalassia hemprichii* (TH)	√	√	√
3	*Cymodocea rotundata* (CR)	√	√	√
4	*Halophila ovalis* (HO)	-	√	√
5	*Halohila minor* (HM)	-	√	√
6	*Halodule pinifolia* (HD)	-	-	√

Note : (√) = found (-) = not found

Table 5. Density Type (DI) (stand/m^2) and Relative Density (RDI) (%)

Type of Seagrasses	A	B	C

	Di	RDi	Di	RDi	Di	RDi
Enhalus acoroides	76.89	47.96	87.22	36.39	109.22	33.61
Thalassia hemprichii	45.33	28.27	42.89	17.90	69.33	21.33
Cymodocea rotundata	38.11	23.77	39.89	16.64	61.56	18.94
Halophila ovalis	0	0	38.00	15.86	37.22	11.45
Halohila minor	0	0	31.67	13.21	22.67	6.98
Halodule pinifolia	0	0	0	0	25.00	7.69
Amount	160.33	100	239.67	100	325.00	100

Table 6. Ecology Index on seagrass

Sites	Ecology Index			∑ Species	∑ Shoot
	H'	E	C		
A	1.0691	0.6745	0.3664	3	160
B	1.2703	0.5471	0.2348	5	239
C	1.4734	0.5700	0.2182	6	325
Averages	1.2709	0.5972	0.27314	4.667	241.333

Table 7. Morisita Index and Chi Square Test on the distribution of seagrass

Jenis	Morisita Index (Id)	X^2 Stat	X-Table (0,05)	Type of Distribution
Enhalus acoroides	1.043	854.438	15.51	Group
Thalassia hemprichii	1.076	507.563	15.51	Group
Cymodocea rotundata	1.094	456.903	15.51	Group
Halophila ovalis	2.259	507.455	15.51	Group
Halohila minor	2.382	385.890	15.51	Group
Halodule pinifolia	4.684	346.640	15.51	Group

Table 8. Principal Component Analysis (PCA): the seagrass distribution density relation to variables of waters environmental

Parameters	F1	F2	F3	F4	Parameters	F1	F2	F3	F4
EA	0.114	**0.805**	0.166	0.056	Current vel.	**-0.710**	-0.093	0.503	0.379
TH	**0.731**	0.164	0.331	0.401	Turbidity	**0.735**	-0.288	0.180	-0.415
CR	**0.700**	0.061	0.500	0.314	Phosphate	0.196	**0.903**	-0.208	0.224
HO	**0.724**	0.268	0.404	-0.012	Nitrate	**0.669**	0.544	0.350	0.216
HM	**0.625**	0.159	-0.060	0.188	TSS	**0.840**	-0.201	0.039	-0.331
HP	0.258	**0.413**	0.777	0.186	Liat	**-0.610**	**0.655**	0.429	0.038
Temperature	**-0.789**	-0.041	0.529	-0.012	Dust	**0.788**	-0.501	-0.195	-0.159
Salinity	0.197	**-0.877**	-0.120	0.254	San	**-0.759**	0.004	-0.311	0.304
pH	-0.078	**0.819**	0.041	-0.275	C-Organic	**0.604**	0.475	-0.593	0.056
DO	-0.290	**0.803**	0.153	-0.425	N-Total	0.239	**0.609**	-0.648	0.217
Depth	**-0.827**	0.292	-0.375	0.025					