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Diversity and Characteristics of Macrozoobenthos in the Water of Tompe River (A Study from Indonesia)

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Abstract : Based on the research conducted in the water of the Tompe river, and by dividing the study area into four stations each determined by considering the environmental setting and community activities along the river, this study is aimed at determining the level of diversity and characteristics of macrozoobenthos in Tompe river, where the level of diversity of macrozoobenthos is very important to maintain the stability of aquatic environment of the river. A descriptive method with station determination using a purposive sampling technique along the river stream is applied in this research; the said technique involved is 1x1 meter square plot sampling technique. The result of this research shows that there are nine species of macrozoobenthos: *Polycentropus* sp*,* *Ephemerella* sp*,* *Macromia magnifica, Gammarus fossarum, Perla marginata* larva*, Agriocnemis pygmaea* larva*, Bellamya javanica* larva*, Faunus ater,* and *Ocypode.*
Keywords: Tompe river, diversity level and characteristics, macrozoobenthos.

Introduction

Benthic animal is a group of animals that occupy the bottom of waters. Based on body sizes, benthic animals are classified into several groups of macrofauna; macrofauna is often referred to as macrozoobenthos. Based on the circumstances at the bottom of waters, macrozoobenthos creeping at the bottom of surface water is called epifauna such as crustaceans and insect, while macrozoobenthos living on soft substrates in the mud is called infauna such as Bivalvia and Polychaeta. Macrozoobenthos diversity is a trait that affects the level of diversity of other organisms. Macrozoobenthos is organisms that dwell at the bottom of waters and habitats settled. Changes in water quality and habitat substrate greatly affect the composition of changes in water quality as well as the abundance and diversity.

River is one of the common water spread throughout Indonesia. Because of its benefits as water source, domestic use, agriculture, fishery, and even as a means of transportation, river has a very important meaning in people's lives especially in rural areas. Its utilization greatly affects the physical condition and chemical compositions of the water; this is one of the most important factors to maintain the level of diversity of macrozoobenthos to stabilize the aquatic environment. Macrozoobenthos diversity is a trait that affects the level of diversity of other organisms.

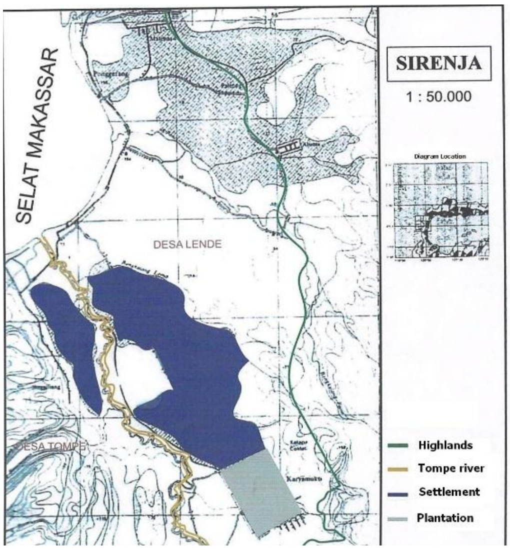


Figure 1. Map of Tompe River in Sirenja District, Donggala

Sulawesi is the largest island in eastern Indonesia which has a richer aquatic fauna compared with other areas, one of which is the dominant aquatic fauna of benthic animals. In Sulawesi Tengah Province, there are several rivers including Tompe river located in Sirenja Donggala district. Approximately 5 km long and 8 m wide, Tompe river is characterized by its fast flow and sufficient light intensity. The tropical rain forests in the upper part reach the river. This circumstance supports the diversity of aquatic organism species, which is very important to support the economic potential and ecological communities. Based on the above, research on macrozoobenthos diversity and characteristics needs to be conducted on Tompe river. The purpose of this study is to explore the diversity of macrozoobenthos in Tompe river in Donggala district, Central Sulawesi Province.

Materials and Method

Population and Sample

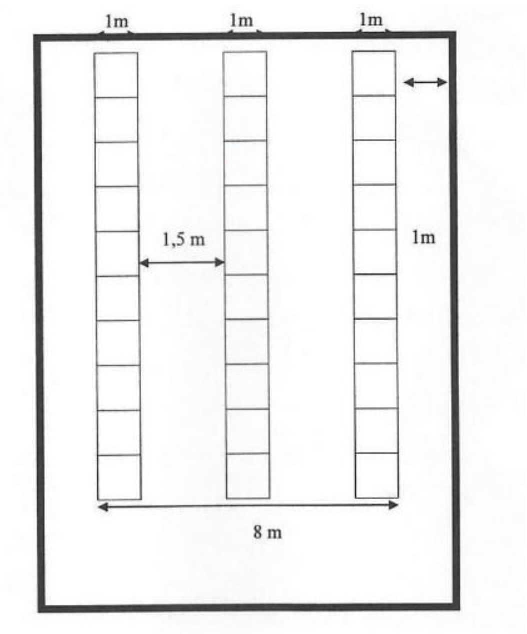
The population in this study is all kinds macrozoobentos in the waters of Tompe river, while the sample is all selected macrozoobentos contained in each plot of research. Samples were collected from March to May, 2011.

Physical-Chemical Conditions of Tompe River Waters

Physical and chemical conditions of the waters of Tompe river as measured from the study include temperature, salinity, current strength, dissolved oxygen, and the content of the substrate.

Research Design

The determination of the station is done by using a purposive sampling technique with consideration of the hue of its environment and community activities along the river. Based on that consideration, there are four stations in this research. Station I is the part of the waters of the river around the natural forest. Station II is the part of the waters of the river around a cocoa plantation area. Station III is river waters surrounding settlements. Finally, station IV is part of the river mouth. At each station are placed 3 pieces of line transects, namely, the left and right edges with 1 transect each, and the middle of the river with 1 transect. The length of Transect is 150 m and spacing between transects is 1.5 m. The plot placed on each transect is sized 1x1 m; the spacing of each plot is 5 m.



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distance betwen plot	: 5 m
distance of each transect	: 1,5 m
distance from the riverbank	: 1m

The Collecting of Macrozoobenthos

A surber sampler is used in sampling, held with a handle and lowered into the water. And the upper end of the net should be facing the current. A horizontal frame is pressed down on the riverbed until there is no space between the edge and the riverbed surface. If the base is a rocky base, close the separator in the bottom frame part, with hoards of the outside frame to the base material. Nets must constantly face the direction of the flow. Stirred raw material is covered by a horizontal framework, and at the time of stirring, fine sand should not be too much stirred into the net. When the base material to a depth of 2 cm is stirred, lift it straight. The opening is carefully kept while facing the fixed net to the current flow. Removed organisms are collected in nets by reversing the inside net out to a small gutter filled with water[1].

All types of macrozoobenthos found on each sampling in a plot are placed in a small gutter adjusted to a predetermined station, then put them into a roller bottle which has been given alcohol or formalin as a preservative. Stirred raw material is covered by the frame horizontally. The trapped material will be brought into the net by a stream of water. The obtained samples are directly identified on genus up to species level on the basis of Baumgartner and Rothhaupt[2], Bazova and Bazov[3], Beauger et al.[4], Bednarek and Hart[5], Macan[6], MacCafferty et al.[7].

Data Analysis

In order to measure the diversity of macrozoobentos, two diversity indices are used: the Shannon-Weiner index and the dominance index by Brower et al.[8] and Chao and Shen[9]. The Shannon-Weiner index formula used is as follows:

Diversity Index : (H') = $-\Sigma P_i \text{ Log } P_i$

$$P_i = \frac{S \text{ (the number of individuals in species)}}{N \text{ (the number of total individuals in a sample)}}$$

Note:

H' = diversity index
S = the number of individuals in a species
P_i = proportion of every sample of the total sample[10,11,12]

Based on the calculation of diversity index, the classification of species diversity of Wilhem[13,14,15] is characterized as follows:

a. If diversity index (H') < 1 = low species diversity, low distribution of individual species, and low ecosystem stability;
b. If 1 < diversity index (H') < 3 = medium species diversity, and medium ecosystem stability;
c. If diversity index (H') > 3 = high species diversity, high distribution of individual species, and high ecosystem stability.

While to determine the dominance index (Brouwer et.al., 1998; Chao & Shen, 2003), the formula used is as follows:

$$I = \frac{\sum(ni-1)}{N(N-1)}$$

Note:

I = dominance index
ni= the number of individual types
N= total number of all-type individuals in a community[8,9]

Results

Study Area

Tompe river, which is made the object of this study, is located in Tompe village, Sirenja sub-district, Donggala district ± 40 km from the city of Palu, Sulawesi Tengah Provincial Capital. The topography of the place is in the lowlands with two seasons: the rainy season and dry season. The average temperature is 30^0C with 180 mm of rainfall per year.

Physical-Chemical Conditions of Tompe River Waters

The research was conducted in Tompe river by dividing the study area into 4 stations. The determination of the station was done by using a purposive sampling technique with consideration of the hue of its environment and community activities along the river. The description of each parameter of station can be seen in Table 1.

Table 1. The Physical-Chemical Conditions of Tompe River Waters, Donggala District, Central Sulawesi Province

Parameter							
No.	**STATION**	**Temperature (°C)**	**Salinity (ppm)**	**dissolve Oxygen (mg/I)**	**pH**	**Substrate**	**Wave strength**
1	Station I	29 - 30	0.2 - 0.3	4.2 - 8.7	7.0 - 7.8	Rocky	3
2	Station II	29 - 30	0.1 - 0.3	2.3 - 3.3	7.0 - 7.8	Muddy sand	9
3	Station III	29 - 31	0.3 - 0.4	2.3 - 3.3	7.5 - 7.62	Sandy	4
4	Station IV	30 - 32	0.4 - 0.5	2.3 - 2.4	6.9 - 7.0	Sandy Silt	7

In the table, the measurement of abiotic factors of river waters to obtain their physical-chemical conditions is different from that of the observation station. Station I has a temperature range of 29 to 30^{0}C. Salinity ranges from 0.2 to 0.3 ppm. Dissolved oxygen ranges from 4.2 to 8.7 mg / L. pH ranges from 7.0 to 7.80. Rocky substrate has a strong flow of 3 seconds/1 m. Then station II has a temperature range of 29 to 30^{0}C. Salinity ranges from 0.1 to 0.3 ppm. Dissolved oxygen ranges from 2.3 to 3.3 mg/L. pH ranges from 7.0 to 7.80. Muddy sand substrate has a strong flow of 9 seconds/1 m. Station III has a temperature of 29 to 31^{0}C. Salinity ranges from 0.3 to 0.4 ppm. Dissolved oxygen ranges from 2.3 to 3.3 mg/L. pH ranges from 7.50 to 7.62. Sandy substrate yields strong currents measuring 4 seconds/1 m. And the last is station IV, which has a temperature range of 30 to 32^{0}C. Salinity ranges from 0.4 to 0.5 ppm. Dissolved oxygen ranges from 2.3 to 2.4 mg/ L. pH ranges from 6.9 to 7.0. Sandy silt substrate shows a strong flow of 7 seconds / 1 m.

Types of Macrozoobenthos in the Donggala River Waters

The identification results of the study find 9 (nine) species of macrozoobenthos in Tompe River as shown in Table 2.

Table 2. Types of Macrozoobenthos in the Tompe River Waters, Donggala District, Sulawesi Tengah Province

Ordo	*Family*	*Genus*	*Species*
Trichoptera	*Polycentropodidae*	*Polycentropus*	*Polycentropus* sp
Ephemeroptera	*Ephemerellidae*	*Ephemerella*	*Ephemerella* sp
Odonata	*Macromiidae*	*Macromia*	*Macromia magnifica*
Amphipoda	*Gammaridae*	*Gammarus*	*Gammarus fossarum*
Plecoptera	*Perlidae*	*Perla*	*Perla marginata* ninfa
Odonata	*Coenagrionidae*	*Agriocnemis*	*Agriocnemis pygmaea* ninfa
Caenogastropoda	*Viviparidae*	*Bellamya*	*Bellamya javanica* ninfa
Sorbeoconcha	*Pachychilidae*	*Faunus*	*Faunus ater*
Decapoda	*Ocypodidae*	*Ocypode*	*Ocypode stimpsoni*

The first is *Polycentropus* sp. They are identified with long and slender larvae such as worms. From the observed length of 2 to 30 mm, they have a pair of prolegs on the prothorax and the other pair at the end of the abdomen. They are yellowish-white, mostly tendipedidae larvae found in a shallow place in a slow wing river; only a few species live in the rapid river. The second is Ephemerella sp. Nymphs. They live in the water, with two or three caudal filaments jointed. They have a tracheal gills on the abdominal segment. Almost all, from a few months to three years in water, undergo metamorphosis up to 21 times. When the adult (imago) lives on land, it is found that, from the results of observation, the body length is 5 to 25 mm and it lives a few hours or days. It is known to fly a day, not eating. It dies soon after spawning, creeping at the bottom of waters. The third is *Macromia magnifica.* The rear base wing is bigger than the front wing. When resting, wings are leaned to lateral. *Ninfa* has gills inside rectum; the coming in and out of water in rectum for respiratory purposes also assists it to move. The result of observation shows that the body size is 15 to 45 mm and is able to catch half of its body mass. It can use labium that can be secreted and function as clamper. It is able to creep on water, roam over substrate, and have a life cylce of 1 year –even more. The fourth is *Gammarus fossarum*. Most of them live in the sea and some live in freshwater, creeping on water or under stones. Some species live on land and become parasites for fish, other crustaceans, and wood drillers. Its body generally has a flat dorsal, short abdomen. In part or whole the body of abdomen is fused. The short first antenna and the second antenna are *uniramous*. The compound antenna of the first sessile appendages thorax as appendages thorax of others can be used to creep. Based on the observation result, the body length is 5 to 15 mm and is of a dull gray color. The fifth is *Perla marginata ninfa.* It is named the stone fly or the fruity fly. The characteristics of adult body length is that they have a long antenna. At the end of the abdomen are two cerci, with a dull color. A few weeks old, they are not good fliers. They are found in the forms of rock or sand and are usually spotted near a river or lake. *Ninfa* is there among plants, algae, or under rocks in flowing waters. They are only found in waters with high oxygen content. They are never found in polluted waters, to be used as biological indicators. Based on the observation, the *Ninfa* body is 6 to 50 mm long. There are two strands at the end of the abdomen and they have tracheal gills-shaped filament at the ventral thorax and the base of legs.

The Sixth is *Agriocnemis pygmaea* ninfa. The abdomen is long and slender, with a rod-shaped base wing. The adults are yellowish green and black; the males have more beautiful and striking colors than the females. The end of the abdominal males is blue-green, while the females are greenish. Its shut wings are on the body. *Ninfa* lives in the water. The adults are often found along streams, ponds, swamps, and even in plants. *Ninfa* could climb up the stems of flooded plants to find their prey, usually flying insects. The seventh is *Bellamya javanica.* It has thick and strong branches, thick operculum, shiny and hard nature. The eye ring is shaped like the shell. The inside is yellow and smooth. The outside is a ring shaped like the shell protrusion evident until the end of the blunt shell. These types are categorized as shell herbivores. Based on the observation done, it can be shown that a shell length is 2.3 cm and its width is 1.2 cm. The Eight is *Faunus ater.* It has a long-shaped shell, spine (bumps) on the flat surface of the shell. It doesn't have teeth on its columella, without an apparent ribsture. The overculum is not calcareous, including herbivores. It has a long spine and a turnover umbilicus and dextral shell, and the shell is colored shiny black. *Faunus ater* has a relatively large, dark-brown to black shell, reaching up to 90 mm in length but usually averaging about 50–60 mm[16]. Based on the observation conducted, it is indicated that the type of shell has a length of 8 cm and width of 1 cm. The Ninth is *Ocypode stimpsoni.* The structure of the book consists of plates (sheets) that are called complex dorsal tergum. The transversal ventral plate is called the sternum. The hanging sided plate is called the pleura. The plate between the pleurae and the foot is called epineura. It has claws that serve as weapons or tools used to attack small animals. It has a gills compound. It has two convex sections located next to branchiostegite which is contiguous, and it protects the gills underneath. It can live in fresh and sea water. It can make a hole on the beach, and serve as a predator for the animals that exist in the deep-bottom waters of both rivers and marine. Based on the observation, it has a length of 1 to 2 cm and width of 1 cm.

The average number of Macrozoobentos biota in Tompe River is shown in Table 3.

Table 3. The Average Number of Macrozoobenthos Biota in the Tompe River Waters, Donggala District, Sulawesi Tengah Province

Species Name	ST I	ST II	ST III	ST IV	∑
Polycentropus sp	56	33	5.33	0	94.33
Ephemerella sp	52	33.3	4.66	0	89.6
Macromia magnifica	43	27.3	6.33	1	77.63
Gammarusfossarum	28	25.3	7.66	1	61.96
Perla marginata ninfa	38	81.6	7	0	126.6
Agriocnemis pygmaea ninfa	24	25	18.33	0	67.33
Bellamya javanica ninfa	18	33.3	18.33	0	69.63
Faunus ater	16	27.6	51.33	90.6	185.53
Ocypode stimpsoni	13	19.6	69.66	91.33	193.59
*Polycentropus*sp	56	33	5.33	0	94.33
Ephemerella sp	52	33.3	4.66	0	89.6
Macromia magnifica	43	27.3	6.33	1	77.63
Gamarus fossarum	28	25.3	7.66	1	61.96
Perla marginata ninfa	38	81.6	7	0	126.6
Agriocnemispygmaea ninfa	24	25	18.33	0	67.33
Bellamya javanica ninfa	18	33.3	18.33	0	69.63
Faunus ater	16	27.6	51.33	90.6	185.53
Ocypode stimpsoni	13	19.6	69.66	91.33	193.59
Total Number	**288**	**306**	**170.3**	**183.93**	**896.93**

Diversity Index and Dominance Index

From the calculation of the diversity index and dominance index of the equation of Shannon-Wiener and Simpson, the data found are as shown in Table 4.

Table 4. The Number of Diversity Index and Macrozoobenthos Dominance Index in the Donggala River Waters in each Station

Station	Diversity Index Shannon-Wiener (H')	Dominance Index Simpson (I)
STATION I	2.44	0.521
STATION II	4.636	0.52
STATION III	1.886	0.62
STATION IV	0.963	1.46

The highest species diversity index is found in Station II (4.636), followed by Station I (2.44), and Station III (1.886); a low diversity index is found in station IV (0,963).

Discussion

The calculation of the number of individuals of each species in each station is different. Station II is the station most widely acquired, amounting to 306 individuals. This is followed by station I with the acquisition of 288 individuals. Station IV gains 183.93 for the number of individuals. Station III obtains the lowest, i.e. 170.3 for the number of individuals. High and low numbers of individuals of all species are due to the condition of each station. Thus, the roles of river water environmental conditions on the lives of animals including macrozoobenthos are very influential. Damage to the river environment, especially the marine environment, would be fatal for the life of the animals in this macrozoobenthos in the waters of the river.

The calculation of the diversity index based on Shannon-Wiener diversity index reveals that the index obtained from each station is different. The highest species diversity index is found in Station II with 4.636, followed by Station I with 2.44, Station III with 1.886, and Station IV with a low diversity index, i.e. 0.963. Differences in species diversity index at various observation stations are caused by environmental conditions and/or very influential factors, namely, the biotic and abiotic factors. Both factors have a high priority for the environment and the damage level of adaptation of animals to their environment.

Abiotic environmental factors that affect the existence of the animals, especially in the waters of the river macrozoobenthos are a physical - chemical factor of aquatic environments—including penetration of light that affects the water temperature, the base substrate, the content of chemical elements such as dissolved oxygen, strong currents. On top of all these conditions is the pH value or the degree of acidity or alkalinity of water. Furthermore, the tolerance of water organisms towards pH is varied. This depends on water temperature, dissolved oxygen, and substrate content of river waters. The biotic environmental factors that influence the presence of animals of macrozoobenthos in the waters of the river cannot be separated from the ability of the species to compete in self-defense—in this case fighting over food availability and dominating the territorial area. It can be said that if a type of macrozoobenthos can be controlled or dominated in a community, the level of diversity in the community is low. On the contrary, if the level of diversity in the community is high, the dominance of existing species is low. Thus, the level of species diversity may also be influenced by the degree of dominance of species present at the station.

Based on the measurement, the abiotic factors of river waters maintain that physical-chemical conditions are different in each measurement of the observation station. These conditions correspond to the station where macrozoobenthos is located; it is due to the aquatic ecosystem of the river that is an integral component of the set of abiotic (physical-chemical) and biotic (living organisms) environment which are related to each other and interact with each other to form a functional structure. A change from one of the components would certainly affect the whole system of life in it, while the changes of physical-chemical factors and the type of biological organisms have a high tolerance of water which would increase and spread widely[1]. The tolerant organisms could grow up and could be developing in a range of conditions—even in poor quality environmental conditions. In contrast, biota species intolerant of water would only spread in certain waters.

It is necessary to conduct further research towards diversity and characteristics of macrozoobenthos especially in the river waters, such as ecological studies of biodiversity in a longer term period. In the research, the observations at a range of scales are helpful in indicating in what ways patterns, and hence processes, vary with the change of scale, and therefore also at what particular scale the process of interest could best be studied[17]. Moreover, biodiversity baseline data for near natural reference rivers and river segments are badly needed to develop viable conservation and management strategies[18]. Benthic macrofaunal communities are monitored for various purposes, the most frequent of which is status and trend assessment[19]. Other objectives may include site-specific impact assessment, identification of causes for regional degradation, quantification of process rates for ecosystem model parameterization, or quantification of prey availability to higher tropic levels.

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