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Macrozoobenthos as bioindicator of ecological status in Tanjung Pasir Coastal, Tangerang District, Banten Province, Indonesia

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Abstract. *Sahidin A, Zahidah, Herawati H, Wardiatno Y, Setyobudiandi I, Partasasmita R. 2018. Macrozoobenthos as bioindicator of ecological status in Tanjung Pasir Coastal, Tangerang District, Banten Province, Indonesia. Biodiversitas 19: 1123-1129.* The existence of macrozoobenthos organism allow for bioindicator of ecological status and detected water pollution in coastal environment with observing the response, diversity, and abundance. The one of biological method for water quality analysis is AZTI Marine Biotic Index (AMBI). This research aims to determine water quality status in Tanjung Pasir water coastal Tangerang, Banten. The research was conducted in April - August 2014 in Tanjung Pasir Coastal, Tanggerang, Banten with purposive sampling method and be forwarded with water pollution analysis with AZTI Marine Biotic Index (AMBI) model. The research showed 4.552 individual of macrozoobenthos found divided into 52 species with the average of diversity amount 634 ind./m^2 with dominated by bivalve species Nuculana bicuspidate 22.89%, it is a bivalve an extreme species that can live in waters with very low oxygen concentrations and hight pollution. The result of AMBI (4.01 to 5.02) indicates water pollution in Tanjung Pasir Coastal classified in medium-heavy pollution and concentred in coastal zone. Polychaeta is a key bioindicator in the determination of water pollution and ecological status in Tanjung Pasir coastal.

Keywords: Bioindicator, ecological status, macrozoobenthos, pollution

INTRODUCTION

Macrozoobenthos is an organism that lives on the surface or in water sediment. Macrozoobenthos is the one of the most important organism in coastal and sea ecosystem (Dean 2008; Junardi and Wardoyo 2008; Shokat et al. 2010; Tabatabaie and Amiri 2010; Sharma et al. 2018), because it has a direct function in the nutrient cycle, pollutant metabolism and secondary productivity in water sediment (Kroncke and Reiss 2010; Tabatabaie and Amiri 2010, 2011). Macrozoobenthos also become one of the most important parts of water ecosystem food chain as food for demersal fish and some sea mammals (Sahidin and Yusli 2016). The existence of macrozoobenthos is widespread, each area has their community, depend on waters characteristic. Spatial distribution difference of macrozoobenthos is affected by depth, temperature, salinity, and substrate type (Shou et al. 2009; Gholizadeh et al. 2012).

Macrozoobenthos movement is very limited, and relative settle on a particular substrate, make macrozoobenthos more sensitive to environmental pressure as like water quality declamation and sediment (Manoharan et al. 2011; van Loon et al. 2015; Wardiatno et al. 2017). Physical, chemical and biological changes are the indicator of coastal water quality declamation (Sharma et al. 2018). The changed of a physical compound and chemical compound also generate sediment quality declamation. Seawater biota which impacted by water and sediment quality declamation directly in coastal is macrozoobenthos. Declamation of species composition in coastal waters particularly infauna is a response from pollutant mater in sediment from anthropogenic activity. According to Gholizadeh et al. (2012), the spatial changed of macrozoobenthos community is dependent on the shape of sediment particle, organic matter, and dept. So that, macrozoobenthos always used to be a bioindicator for monitoring coastal water pollution (Dean 2008; Shokat et al. 2010; Subida et al. 2012; Sundaravaman et al. 2012; Wibowo et al. 2017; Sharma et al. 2018).

Approachment to determine water condition would be conducted with two methods, using biota response to environmental pressure, describe the water quality and environment condition and known as bioindicator (Prato et al. 2009; Ritter et al. 2009; Sundaravaman et al. 2012). Determining waters condition with a biological method is better than use physical-chemical methods because physic-chemical methods only describe waters condition in short-term (Junshum et al. 2008). The biological method could describe waters condition in long-term because this method will analyze biota response in pressure water (Carretero and Dauvin 2010; George et al. 2010).

There are many researchers who study about estuarine or sea with macrozoobenthos as bioindicator with (richness, diversity, similarity, and domination) index (Junshum et al. 2018; Gandomy et al. 2011; Reizopoulou et al. 2014). One of the biological methods for water quality analysis is *AZTI Marine Biotic Index* (AMBI) which introduced by Bojan et al. (2012). AMBI is index calculation to determine waters status, pressure and pollution status based on biota response particularly for tolerance benthos, intolerance, and the diversity (Borja and Tunberg 2011), and also fully equipped by software to make calculation easier (Borja et al. 2012). AMBI method always used for some researcher in the world such as researcher from Atlantic Ocean and Mediterania (Carretero dan Dauvin 2010), eastern Florida coastal (Borja and Tunberg 2011), Brazil coastal (Valenca dan Santos 2012), Baltik ocean (Zettler et al. 2009), Atlantic ocean in North America (Riera and Carretero 2014), Caspia sea (Gandomy et al. 2011), Hindia ocean in North West (Bigot et al. 2008; Martin et al. 2011) and Asia (Sahidin et al. 2014).

Tanjung Pasir coastal belongs to the Tangerang coastal area of northern Banten province with various community activities around it (industry, fishery, housing and tourism) that have negative effects such as coastal erosion, pollution, and organic waste. So that, Tanjung Pasir coastal belongs to the one of the coasts of Indonesia with high level of vulnerability. Overflow that goes to Tanjung Pasir coastal not only organic material rich in nutrients also contains toxic materials (toxins) are harmful to aquatic biota. Based on the topography of the western coast of Tanjung Pasir bordering the eastern coast of Jakarta. Riyadi et al. (2012) declare that Jakarta coastal has a high level of pollution, so that on the West Tanjung Pasir coastal will get pollutant contamination from Jakarta coastal. In addition, the Tanjung Pasir coastal into the mouth of several major rivers like Cisadane river and Dadap river. The rivers flow will bring nutrient and pollutant into the coastal (Riyadi et al. 2012). There are many of research about ecology status and pollution in Jakarta bay since 1970-1990 which focus on seawater quality with physicochemical parameter, and be continued in 1990-2000, developing to biota and sediment, and in 2000- now focus on biomass and heavy metal (Wibowo et al. 2017).

However, in the coastal areas of Tanjung Pasir, areas adjacent to Jakarta still lack research directed to ecological status and pollution. Therefore, the determination of ecological status and contamination that is compared between instantaneous pollution (physical-chemical waters) and long-term pollution (biota response) becomes the basis for coastal resource management in Tanjung Pasir coastal.

MATERIALS AND METHODS

The research was conducted in Tanjung Pasir Coastal Waters, Tangerang District, Banten Province, Indonesia. Sample was taken from 22 stations (Table 1) and each location divided into three zonations (shore, middle, and sea) (Figure 1). Each station was taken three times of replication for macrozoobenthos and one replication for sediment analysis using Van Veen grab with wide aperture tool 0.04 m^2. Sample filtered with modification filter for macrozoobenthos with mesh size 0.5 mm to separate between benthos and mud (substrate). Result of filtered put into sample bottle which stuck by label. Sample preserved with formalin 5% and put into the cool box and identified in laboratory.

In the laboratory, macrobenthos samples were observed using binocular microscopes for small size and magnifying glass (lup) for larger ones (Lizarralde and Pittaluga 2010). Identifying macrobenthos morphologically to the species level was conducted by using standard macrobenthos identification books (Fauchald 1977; Dharma 2005) and nomenclature writing following World Register of Marine Species (WoRMS: http://www.marinespecies.org/index.php). Organic carbon and sediment particle size (sand, mud, and clay) were analyzed using the "wet sieving" method (Reizopoulou et al. 2014). Water temperature measurements using standard thermometer and brightness are measured with a Secchi disk. Salinity was measured by using a refractometer, and the pH was measured by pH meters. Measurement of depth of waters with the aid of scaled ropes and suspended solids was measured by filtration method. Dissolved oxygen (DO) is estimated by modification of the winkler method. The water nutrients are first put into a polyethylene bottle and collected in the icebox to be brought to the laboratory. The water sample was filtered using a Millipore strainer to analyze the nitrates, nitrites, soluble phosphates with the aid of the spectrophotometer. While water used to measure biological oxygen demand (BOD5) was inputted into dark glass bottles and analyzed by a modification of the Winkler method (Lizarralde and Pittaluga 2010; Reizopoulou et al. 2014).

Ecological and pollution status analysis based on macrozoobenthos using AZTI Marine Biotic Index (AMBI) (Borja et al. 2012; Carretero dan Dauvin 2010). AMBI analysis was started with the calculation of diversity for each species in each station. The species were divided by five Ecological Group (EG) there as (i) EGI: Macrozoobenthos species with very sensitive to organic matter composition. (ii) EGII: Macrozoobenthos species with not affected by organic matter composition with low concentration. (iii) EGIII: Macrozoobenthos species with tolerant from more organic matter composition. (iv) EGIV: Opportunistic macrozoobenthos species grade II. (v) EGV: Opportunistic macrozoobenthos species grade I.

$$AMBI = \frac{(0 \times \%EG_1) + (1.5 \times \%EG_2) + (3 \times \%EG_3) + (4.5 \times \%EG_4) + (6 \times \%EG_5)}{100}$$

Based on the divided group, AMBI formula calculated and classified based on AMBI (*biotic coefficient*) in Table 2.

Table 1. Station in different zonation

Zonation	Station
Coastal zone (cz)	T1, T2, T3, T10, T11, T12, T16, T17, T18
Middle zone (mz)	T4, T5, T6, T13, T14, T15, T19, T20
Sea zone (sz)	T7, T8, T9, T21, T22

Note: T= Tanjung Pasir Coastal station

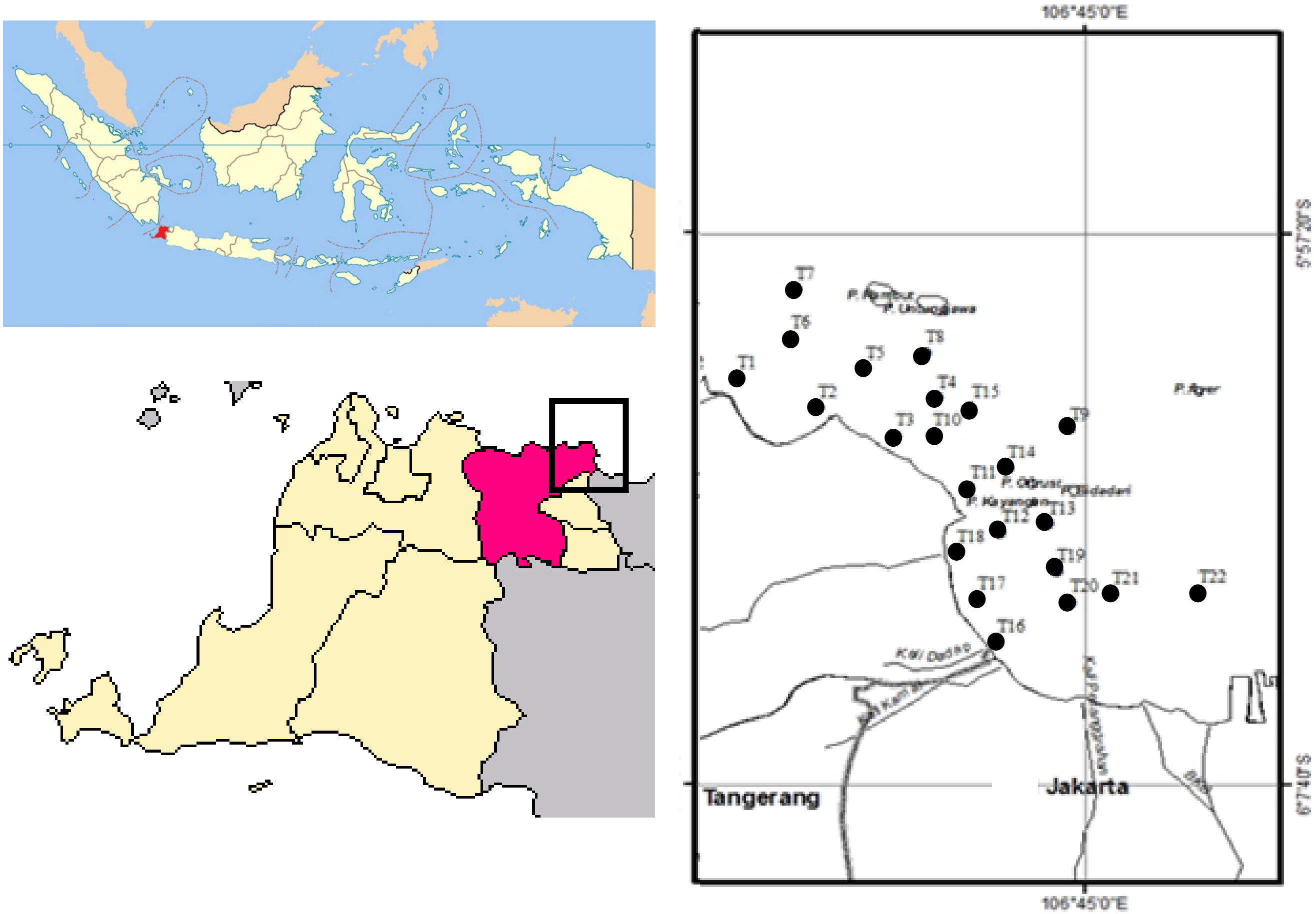

Figure 1. GIS location of sampling sites in Tanjung Pasir Coastal Waters, Tangerang District, Banten Province, Indonesia

Table 2. Ecological group classification of macrozoobenthos on analysis value of AMBI and BI (Biotic Index) based on Borja et al. (2012) and Carretero dan Dauvin (2010)

AMBI	Biotic index	Domination EG	Pollution status	Health of benthos community	Ecology status
0.0 < BC≤ 0.2	0	Egi	Not polluted	Normal	Very good
0.2 < BC≤ 1.2	1	Egi	Not polluted	Increase	Very good
1.2 < BC≤ 3.3	2	Egiii	Easy polluted	Not balance	Good
3.3 < BC≤ 4.3	3	Egiii	Medium polluted	Transition to polluted	Medium
4.3 < BC≤ 5.0	4	Egiv-V	Medium polluted	Polluted	Bad
5.0 < BC≤ 5.5	5	Egiv-V	Heavy polluted	Transition to heavy polluted	Bad
5.5 < BC≤ 6.0	6	Egv	Heavy polluted	Heavy polluted	Very bad
Azoic	7	Azoic	Very heavy polluted	Azoic	Very bad

Note: BC: biotic coefficient, EG: ecological group

RESULTS AND DISCUSSION

Water and sediment quality parameters

The result of water quality in every sample zonation are presented in Table 3. Water quality as temperature parameters, pH, biochemical oxygen demand (BOD) and salinity found between zonation with values was not significantly different. As for parameter dissolved oxygen (DO) and turbidity seen significant difference between coastal zonation with two other zonation's. Dissolved oxygen in coastal zonation was found with a very low value of 0.5 mg/L, while the turbidity in coastal zonation was found with the highest value of 7.2 mg/L. Seen from sediment size composition, sand presentation decreased toward sea (sand presentation at cz = 44.28%, mz = 27.23% and sz = 17.97%), vice versa increasing muddy (mud presentation at cz = 55.6%, mz = 72% and sz = 82.20%).

Table 3. Physical quality and chemical coastal waters of Tanjung Pasir Coastal Waters, Tangerang District, Banten Province, Indonesia

Parameters	Unit	Coastal zone		Middle zone		Sea zone	
		x	r	x	r	x	r
Water quality							
Temperature	^{0}C	31.0	30.4-31.8	30.8	30.3-31.4	30.9	30.1-31.5
pH		8.2	7.1-8.7	8.4	7.1-8.4	8.3	7.9-8.5
Dissolved Oxygen	mg/L	7.1	0.5-10.1	8.3	7.6-9.1	9.0	6.8-10.6
Biochemical Oxygen Demand	mg/L	3.6	0.7-6.9	2.8	1.0-6.4	2.2	1.5-3.0
Salinity	**‰**	27.4	12.2-30.3	29.2	24.7-30.3	29.5	28.5-30.3
Turbidity	**NTU**	7.2	0.5-21.6	2.2	0.4-11.4	1,6	0.5-2.9
Sediment quality							
Sand	%	44.28	37.6-53.7	27.23	18.1-54,5	17.97	7.9-28.1
Mud	%	55.58	46.3-63.6	72.72	58.1-90,1	82.20	72.3-92.1
C-Organic	%	1.78	1,31-2,50	1.65	1.52-2.50	1.65	1.54-1.76

Note: x: average, r: range

Composition and abundance of macrozoobenthos

The composition and abundance of macrozoobenthos are one of the characteristics of the community structure. Based on the results of research, macrozoobenthos found as many as 52 species were divided into 14 classes. The highest species composition was found in 17 Polychaeta classes followed by Bivalvia class of 10 species, 4 species of gastropods, 6 species of crustaceans, and other classes. The total number of macrozoobenthos total specimens were 4552 specimens dominated by bivalve class followed by Polychaeta. The highest number of specimens found in the bivalve class reached 71% of the total number of macrozoobenthos found, followed by the Polychaeta class and clitellate class (Figure 2). The bivalve class was dominated by *Nuculana bicuspidata* 22.89% of the total number of bivalve individuals found. *Nuculana bicuspidata* were found in T12, T16 and T17 stations. The stations adjacent to the mouth of the river (Figure 3) were T2, T12, T16, T18 stations found high density of macrozoobenthos and high deviation values, which means that macrozoobenthos at the station was very dynamic or volatile in a short span of time.

Discussion

Total species of macrozoobenthos were found in 52 species divided into 14 classes. The Polychaeta class (17 species) was found with the largest number of species Polychaeta deposit feeder (20 species), followed by Bivalvia classes and other classes (Table 4). Shou et al. (2009) state that Polychaeta dominates the community of infauna benthos and the amount in nature reaches 80% of the total macrozoobenthos community. The research location is dominated by mud substrate. The muddy bottom of the waters is the preferred habitat for polychaete to grow and reproduce (Sundaravarman et al. 2012), since the organic matter as the main food polychaete deposit feeder is easily settled and binds to the mud substrate (Golizhadeh et al. 2012; Junardi and Wardoyo 2008). But in this study, the highest total density was not occupied by the Polychaeta class but Bivalvia namely *Codakia puncata*, *Tellina palatum* and *Tellina timorensis*. These three biotas are small-sized bivalves and reproduce with external fertilization with very high egg fecundity and are concentrated in one place.

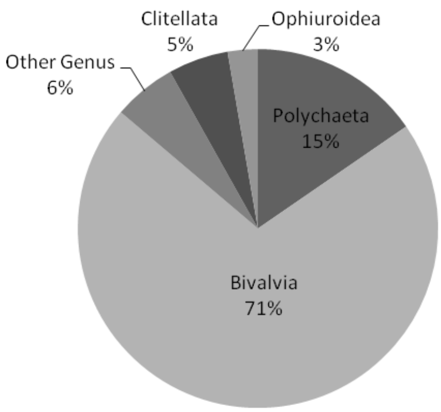

Figure 2. Macrobenthos composition in Tanjung Pasir Coastal Waters, Tangerang District, Banten Province, Indonesia

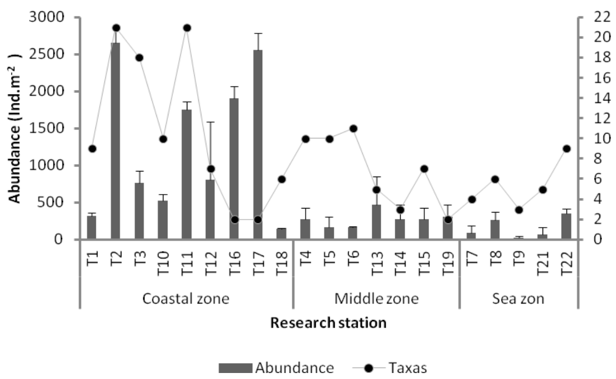

Figure 3. Abundance and taxa of macrozoobenthos in Tanjung Pasir Coastal Waters, Tangerang District, Banten Province, Indonesia

Table 4. Composition ecological group of macrozoobenthos in Tanjung Pasir Coastal Waters, Tangerang District, Banten Province, Indonesia

Taxa	Tangerang coastal			Ecol. group*
	cz	mz	sz	
Polychaeta				
Aphrodate aculeata	+	-	-	I
Arenicola marina	+	-	-	III
Capitella capitata	+	-	-	V
Exogone naidina	-	+	-	II
Glycera capitata	+	+	+	II
Melinna cristata	+	-	-	III
Nephtys caeca	+	-	-	II
Nereis fucata	+	+	+	III
Ophryotrocha puerilis	+	+	+	IV
Orbinia sp.	+	-	-	I
Petta pusilla	-	+	-	I
Platynereis dumerilii	+	-	-	III
Polyphysia crassa	+	-	-	III
Rhodine loveni	+	-	-	II
Scalibregma inflatum	+	-	-	III
Sternaspis scutata	+	-	-	III
Syllis gracilis	+	-	-	II
Bivalvia				
Brachidontes granulatus	+	-	-	II
Cardium sp.	-	+	-	III
Codakia punctata	+	+	+	I
Ensis ensis	+	-	-	I
Perna viridis	-	+	-	-
Pharella javanica	+	-	-	I
Tellina palatum	+	+	+	I
Tellina sp.	-	-	+	I
Tellina timorensis	+	+	+	I
Nuculana bicuspidata	+	+	+	II
Gastropoda				
Nassarius liversen	+	-	-	II
Nassarius stolatus	+	-	-	II
Tetraphora princeps	+	-	-	-
Turicula javana	+	-	-	-
Crustacea				
Apseudes coriolis	-	+	-	III
Cancer pagurus	+	+	+	III
Leucosia sp.	-	+	-	-
Pasiphaea sp.	+	-	-	II
Pontophilus aracilis	+	-	-	I
Xantho pilipes	+	+	+	I
Anopla				
Cerebratulus fuscus	+	-	-	III
Micrura purpurea	-	-	+	I
Psammamphiporus elongatus	+	-	-	II
Tubulanus annulatus	+	+	-	II
Enopla				
Oerstedia dorsalis	+	+	-	III
Tetrastemma melanocephalum	+	+	-	III
Echinoidea				
Brissopsis pasifica	-	-	+	I
Clitellata				
Clitellio arenarius	+	+	+	V
Pontobdella muricata	+	+	-	-
Sipunculidea				
Phascolion strombus	+	-	-	I
Asteroidea				
Astropecten indicus	+	-	-	I
Ophiuroidea				
Amphiura chiajei	+	+	+	II
Echiuroidea				
Echiura sp.	-	-	+	II
Anthozoa				
Metridium senile	+	-	-	I
Brachiopoda				
Linguila unguis	+	-	+	I

Note: **+** : present, **-** : not present, cz:coastal zone, mz: middle zone, sz: sea zone. * Borja et al. (2000, 2012).

Bray Curtis similarity analysis results from 22 stations formed four different groups. T2, T12, T17 and T19 stations each station form one group, the other stations form one other group (Figure 4). T2 station found *Melinna cristata* with the highest density, followed by *Ophryotrocha puerilis*, *Syllis gracilis* and *Travesia forbesii* also dominated the station. T17 stations found *Tellina timorensis* and *Nuculana bicuspidata* with the highest density compared to other stations, while *Perna viridis* and *Tellina palatum* were found to be concentrated at T19 stations. This grouping difference is possibly due to differences in pollution levels and substrate texture differences that will decrease or increase the number of types and densities of macrozoobenthos. The type of intolerant and facultative group will disappear as the Polychaeta class is not resistant to the low DO, and the dominant tolerant group appears to be the type of *Nuculana bicuspidata* bivalvia class that is tolerant to the low DO (Sahidin et al. 2014).

Coastal waters analysis can be seen vertically (perpendicular from the coast towards the sea) and horizontal (along with the coast). Tanjung Pasir, which borders the Bay of Jakarta, is heavily influenced by the pollution inputs of the Cisadane River and the overflowing of the bay of Jakarta carrying a current range of AMBI values (4.01-5.02) with moderate to severe pollution levels and moderately-categorized ecological status (Table 5). Riyadi et al. (2012) state that Coastal Jakarta has a high level of pollution, so that on the eastern coast of Tanjung Pasir will get pollutant contamination from Jakarta Coastal. Overflow that goes to the Coastal Tangerang not only organic material rich in nutrients also contains toxic materials (toxins) that are harmful to aquatic biota.

The coastal waters status of Tanjung Pasir was vertically seen towards the sea the smaller the AMBI value. This means that the lower the sea level the disturbance is smaller and the water status based on the benthic biota the better. It is possible that there are organic materials and macrozoobenthic food sources. Spatial distribution of benthic organisms is influenced by aquatic organic matter (Golizhadeh et al. 2012; Martin et al. 2011; George et al. 2010). In addition, the dominance of the sand substrate will decrease the content of organic matter in the sediments, thereby decreasing the presence of macrozoobenthic biota in both abundance and type and will ultimately affect ecological status (Zetler et al. 2009). Organic materials are sedimented into the substrate, the farther away from coastal zonation the less organic matter is sedimented (Ansari et al. 2014), so the macrozoobenthos food is reduced and has an effect on decreasing the number of types and densities of macrozoobenthos. This decrease of macrozoobenthos is possible because the decreasing of marine status at sea zonation based on AMBI value.

Nuculana bicuspidate Determination of water quality status based on AMBI result (4.01 - 5.02), increasingly the water quality with avoiding of shore with heavy pollution in the coastal zone (cz), medium in middle zone (cz), and middle in sea zone (sz). Bivalve species (*Nuculana bicuspidate*) was dominated by 22.89% from all bivalve in result. *Nuculana bicuspidate* is an extreme species that can live in waters with very low oxygen concentrations and high pollution.

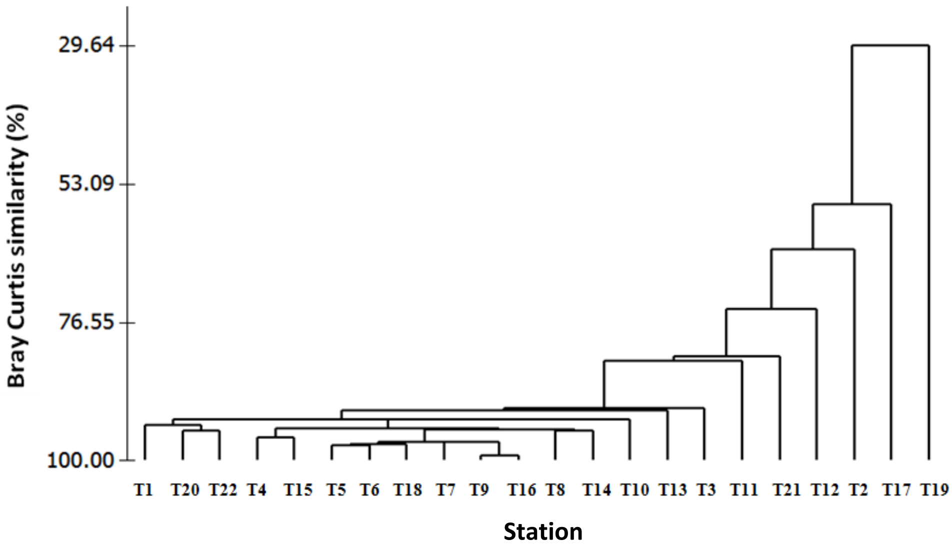

Figure 4. Similarity analysis of macrobenthos in Tanjung Pasir Coastal Waters, Tangerang District, Banten Province, Indonesia

Table 5. Presentation ecological group, AMBI value and pollution status in Tanjungg Pasir Coastal Waters, Tangerang District, Banten Province, Indonesia

Zone	Group ecology (GE) (%)					Pollution status		Ecological status	
	I	II	III	IV	V	AMBI	Status	BI	Level of disturbance
cz	2.6	4.7	8.2	24.7	59.8	5.02	Heavy polluted	5	Disturbed
mz	8.7	5	41	16.3	29	4.15	Medium polluted	4	Medium disturbed
sz	12.7	6.4	33.6	31.8	15.6	4.01	Medium polluted	4	Medium disturbed

Note: cz:coastal zone, mz:middle zone, sz:sea zone, BI: Biotic index

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