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Procedia Environmental Sciences 33 (2016) 470 – 477
Procedia Environmental Sciences

The 2nd International Symposium on LAPAN-IPB Satellite for Food Security and Environmental Monitoring 2015, LISAT-FSEM 2015

Horizontal distribution of zooplankton in Tangerang Coastal Waters, Indonesia

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Abstract

Zooplankton plays an important role in aquatic ecosystems. It has both horizontal and vertical distribution. This research was conducted in Tangerang coastal waters with the purpose to determine horizontal distribution of zooplankton and its correlation to water quality. The results showed that there were 12 groups of zooplankton found in Tangerang coastal waters dominated by Crustacean. Based on Morisita Index, zooplankton in Tangerang coastal waters has been grouped as patchy pattern distribution. Horizontal distribution of zooplankton was divided into two clusters of site location and more influenced by pH and ammonia.

Peer-review under responsibility of the organizing committee of LISAT-FSEM2015

Keywords: horizontal distribution; Morisita index; Tangerang coastal waters; water quality; zooplankton groups.

1. Introduction

Zooplankton is heterotrophic organism that plays important role in aquatic environment. In aquatic food webs, zooplankton, as primary consumers, transfers energy from primary producers (phytoplankton and bacteria) to higher trophic levels (aquatic insects and fish) [1,3]. Zooplankton abundance is related to environmental factors such as physicochemical and temporal fluctuations [4,5], thus zooplankton could be used as bioindicators of the aquatic ecosystem state.

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Peer-review under responsibility of the organizing committee of LISAT-FSEM2015
doi:10.1016/j.proenv.2016.03.099

Tangerang coastal waters is a tropical aquatic ecosystem receiving many organic matters input from surrounding river [6]. The organic matter sources from anthropogenic activities, such as agriculture, aquaculture, industry, and domestic activities in surrounds coastal waters area. This might disturb aquatic environment, particularly living organism such as zooplankton. Zooplankton abundance and distribution is influenced by physicochemical parameters (current, wind, waves, and water quality) and season [4,7]. The zooplankton community structure fluctuates as a result of anthropogenic activities in such waters [8].

Many researches on zooplankton diversity and distribution had been conducted in various type of waters to determine the relation of zooplankton to environmental factors [4,9,12]. Nevertheless, there is lack of information on zooplankton distribution in tropical waters, especially in Tangerang coastal waters. Tangerang coastal waters has high abundance planktivorous fishes, thus it is important to understand about zooplankton composition and distribution in order to maintain sustainability of aquatic resources regarding its role in aquatic ecosystem. The aim of this research was to explore horizontal distribution of zooplankton in Tangerang coastal waters based on taxa composition, abundance, and water quality.

2. Materials and Methods

2.1. Study area

The research was conducted using a vessel in Tangerang coastal waters, Banten Province, Indonesia. Sampling site was divided into five sites with 51 sub sites, those were Kronjo (K; K01-K09), Mauk (M; M01-M06), Rawa Saban (R; RS01-RS15), Tanjung Pasir (T; T01-T15), and Dadap (D; D01-D08) (Figure 1). Those sampling sites were determined by considering the input from river that disembogues in each site. Kronjo represented Sipanjang and Cipasilian River; Mauk represented Cimandiri, Cileleus, and Cimauk River; Rawa Saban represented Cirarab and Cisadane River; Tanjung Pasir represented Cisadane River; and Dadap represented Dadap and Kamal River. Samples of zooplankton and water were collected three times in April, August, and November 2013.

2.2. Sample collections

Zooplankton samples were collected using plankton net (mesh size 25 μm) and preserved by 1% Lugol solution [13]. Furthermore, zooplankton were identified morphologically [14] and the taxa number was counted with SRC (Sedgewick Rafter Counting Cell) using census method [15] under a stereomicroscope.

Water samples were collected using Van Dorn water sampler for ammonia (NH3-N) analysis [13]. Temperature and salinity (SCT meter), pH (pH meter), DO (DO meter), and depth (scaling rope) were measured in situ.

2.3. Data analysis

- Diversity index (H'), evenness index (E), and dominance index (C)
  Zooplankton abundance (N) was calculated using abundance formula [13]. Zooplankton diversity was analysed using Shannon-Wiener diversity index (H') [15]. Zooplankton evenness and dominance were analysed using Evenness index (E) and Simpson dominance index (C) [15]
- Zooplankton distribution pattern
  Zooplankton distribution pattern was determined using Morisita index [16]. The validity of index was tested by Chi-square test [17]. The $\chi 2$ value obtained from test ($\chi 2$ test) was compared to $\chi 2$ from Chi square table ($\chi 2$ table). The higher value of $\chi 2$ test shows that there is randomly significantly different, vice versa.
- Horizontal distribution
  Clustering was conducted to identify similarity of zooplankton abundance and water quality in Tangerang coastal waters. Based on ANOVA two-factor without replication, there was not any intertemporal differences on chemical and physical parameters value (p=0.75), and also zooplankton abundance (p=0.36). In consequence, further cluster analysis was only conducted spatially.

Site cluster analysis was performed based on biological (zooplankton abundance) using Bray-Curtis index [18, 19] and physical chemical (temperature, salinity, pH, DO, and depth) parameters using Canberra index [19]. Furthermore, those similarity index values were used to construct dendrogram using Minitab 15 software.

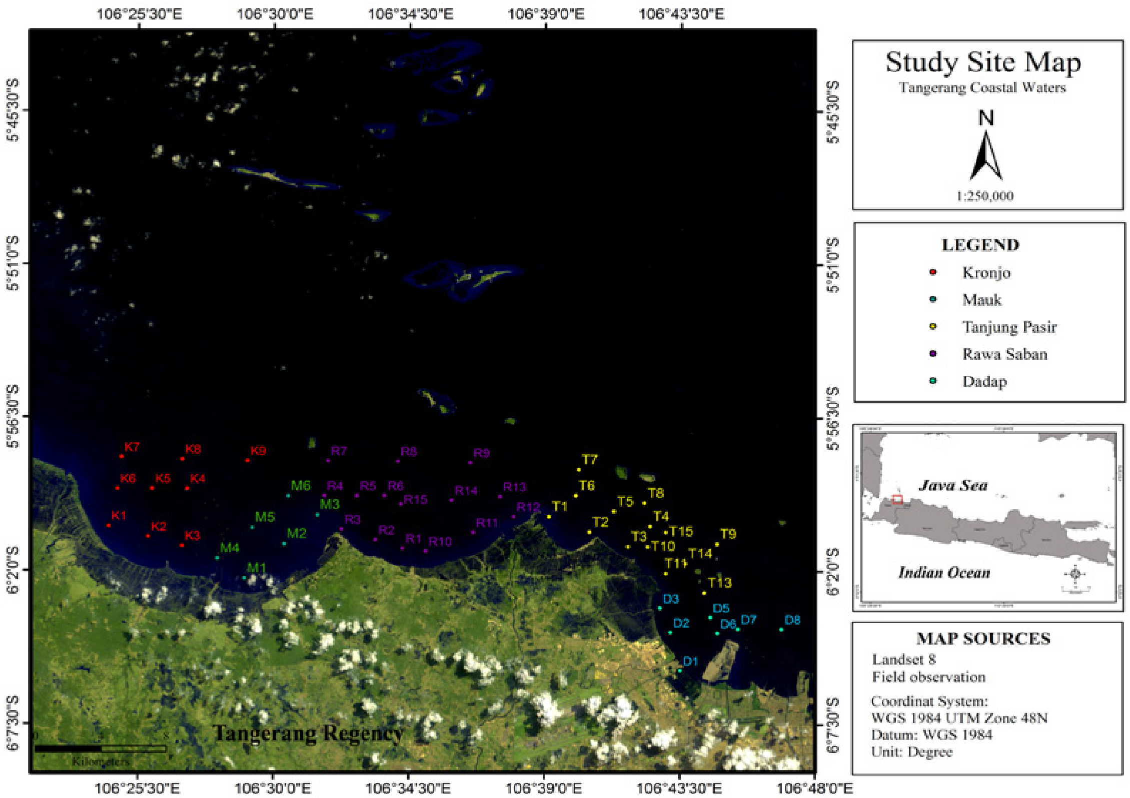

Fig. 1. Sampling location at Tangerang coastal waters, Banten Province.

3. Results and Discussion

3.1. Water quality

Physical and chemical water quality parameter is abiotic factor in ecosystem that have important role in aquatic organism. Results of water quality parameter analysis from three times observation in Tangerang coastal waters were expected representing same season, therefore it was featured in average (Table 1). Table 1 shows condition for optimum zooplankton growth and can be tolerated by zooplankton [20, 21]. Ammonia tended to increase from eastern site (Kronjo) to western site (Dadap). It was presumed relating to land use condition around Tangerang coastal waters that the more western the higher number of settlement society. This condition might influence water quality characteristic in Tangerang coastal water through anthropogenic activities input. Coastal waters is subject to various kinds of human pressure, such as domestic sewage, industrial waste, aquaculture [8], and agricultural activity and being source of high material input.

3.2. Zooplankton composition and abundance

Zooplankton community in Tangerang coastal waters consisted of various zooplankton populations. A total of 12 groups of zooplankton were identified during research period (Fig. 2a and 2b), those were Protozoa (2 genera), Rotifera (3 genera), Crustacea (5 genera and nauplius stage), Ctenophora (1 genus), Chaetognata (1 genus), Urochordata (3 genera), *Nematoda larvae*, *Coelenterata larvae*, *Echinodermata larvae*, *Gastropoda larvae*, *Polychaeta larvae*, and *Pelecypoda larvae*. Crustacea had the highest genus diversity (27%) and abundance (2,894,149 ind m^{-3}).

Tabel 1. Water quality at each site in Tangerang coastal waters.

Parameter	Site				
	K	M	R	T	D
Temperature (°C)	30.4 ± 0.23	30.23± 0.40	30.0 ± 0.65	30.7 ± 0.90	32.1 ± 0.46
Depth (m)	7.80 ± 3.41	4.44 ± 1.37	6.71 ± 4.81	7.00 ± 3.41	5.57 ± 3.34
Salinity (psu)	29.3 ± 0.29	28.2 ± 3.89	29.7 ± 0.49	28.9 ± 2.57	28.2 ± 2.45
pH	8.47 ± 0.05	8.45 ± 0.04	8.54 ± 0.06	8.51 ± 0.20	8.65 ± 0.16
DO (mg L^{-1})	7.01 ± 0.36	6.70 ± 0.34	6.60 ± 0.52	7.10 ± 0.95	6.80 ± 1.68
Ammonia (mg L^{-1})	0.13 ± 0.02	0.14 ± 0.02	0.13 ± 0.06	0.29 ± 0.18	0.35 ± 0.24

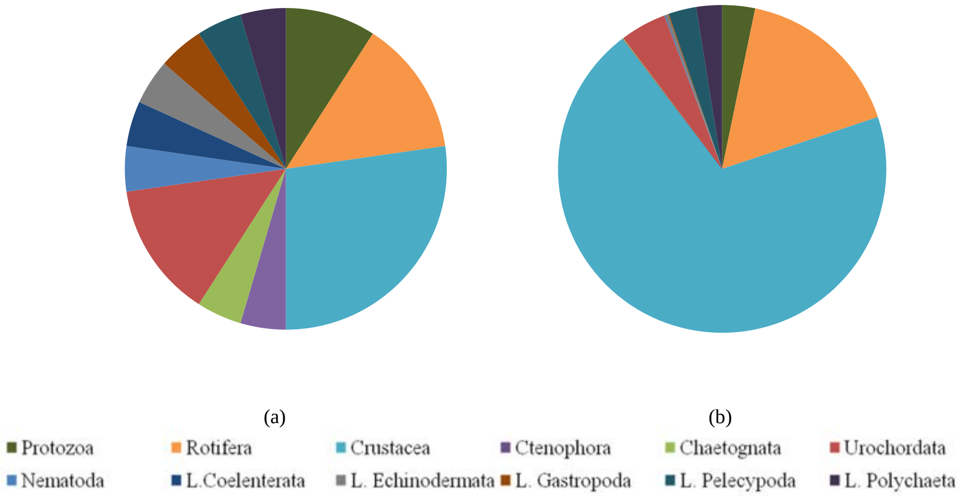

Fig. 2. Composition of zooplankton groups in Tangerang coastal waters based on (a) number of taxa; (b) abundance.

Zooplankton composition in Tangerang coastal waters was dominated by Crustacea, with nauplius stage as zooplankton that had the highest abundance (Fig. 3). The other Crustaceans were *Acartia* sp., *Calanus* sp., *Evadne* sp., *Microsetella* sp., and *Oithona* sp. that were classified to Copepoda. Copepoda is the dominant zooplankton found in the sea [22]. Zooplankton in Tangerang coastal waters also consisted of several meroplankton larvae, those were Coelenterata, Echinodermata, Gastropoda, Nematoda, Pelecypoda, and Polychaeta larvae. Coastal water is influenced by input from surrounds river mouth. This condition make coastal waters ecosystem rich with organic matter and nutrient, provides habitat for nursery, feeding, and also spawning ground for some species of fish and shrimp [23]. Therefore, coastal waters is suit for the living of *Meroplankton larvae*.

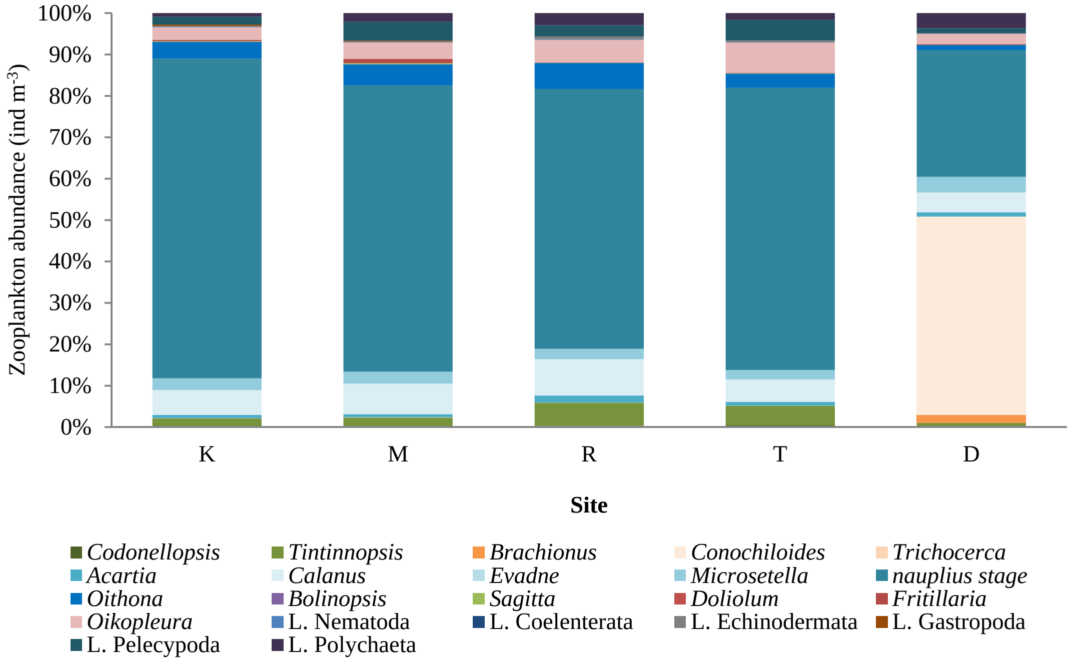

Fig. 3. Composition of zooplankton abundance at each site in Tangerang coastal waters.

The taxa composition of zooplankton were almost similar among sampling sites (Fig. 3). Kronjo (K), Mauk (M), Rawa Saban (R), and Tanjung Pasir (T) sites were dominated by nauplius stage, *Calanus* sp., *Tintinnopsis* sp., and *Oikopleura* sp. Dadap (D) was the only site that had different zooplankton taxa composition. The dominant taxa consisted mainly of *Conochiloides* sp., nauplius stage, *Calanus* sp., and *Oikopleura* sp. Different dominant zooplankton taxa composition between Dadap and other sites was presumed relating to river mouth runoff input. In addition, there were high abundance of *Brachionus* sp. and *Conochiloides* sp. (Rotifera) only found in Dadap site. This is probably closely related to material input from surrounds coastal waters. Dadap site is located near more crowded settlement area than other sites. Therefore, it contributed in increasing organic matter and nutrient concentration in this site (Table 1). Furthermore, nutrient correlated positively with phytoplankton abundance. This made Dadap has higher phytoplankton abundance than other sites [24]. It clearly explained the existence of Rotifers in Dadap site since Rotifers utilizes the organic matter and phytoplankton as source of food.

The average abundance of zooplankton during research period was 458,883 to 1,357,775 ind m^{-3} and the average number of taxa was 18 to 21 (Fig. 4). The highest abundance was found in Dadap site and the lowest in Mauk site. Dadap site is more influenced by domestic activities and had higher ammonia concentration, while Mauk site was more influenced by agricultural activities and had the lowest ammonia concentration. As described previously, this condition probably generated high abundance of phytoplankton in Dadap site and low abundance of phytoplankton in Mauk site [24] that closely related to zooplankton abundance in those sites.

The difference of zooplankton existence among sites could be also influenced by current [7]. In June, current pattern in Tangerang coastal waters originated from South and August originated from East [25]. However, in this research, the current condition did not generate significant influence to the existence of zooplankton in Tangerang coastal waters.

3.3. Diversity index (H'), evenness index (E), and dominance index (C) of zooplankton

Diversity, evenness, and dominance index value of zooplankton could be used to evaluate aquatic ecosystem stability [15]. As a whole, diversity index in Tangerang coastal waters ranged from 0.69 to 1.50, evenness index ranged from 0.27 to 0.65, and dominance index ranged from 0.36 to 0.73 (Table 2). Diversity index showed that zooplankton diversity in Tangerang coastal waters was relatively low. Evenness index showed that zooplankton distribution was not evenly distributed. This condition was supported by dominance index value which showed that there was domination of zooplankton genus. Dominant species in a community shows strength of species than other species [26]. Those result showed that the stability of zooplankton community in Tangerang coastal waters was low [15].

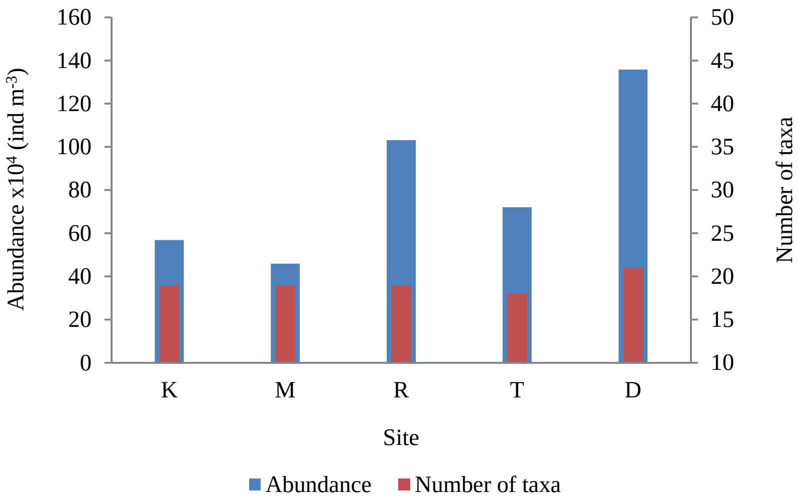

Fig. 4. Zooplankton abundance and number of taxa average at each site in Tangerang coastal waters.

Table 2. Diversity index (H'), similarity index (E), and dominance index (C) of zooplankton in Tangerang coastal waters.

Site	H'	E	C
K	0.74-1.42	0.30-0.51	0.42-0.72
M	1.04-1.45	0.42-0.56	0.39-0.57
R	1.03-1.50	0.39-0.65	0.36-0.59
T	0.83-1.41	0.33-0.64	0.37-0.67
D	0.69-1.43	0.27-0.54	0.36-0.73

3.4. Zooplankton distribution pattern

Zooplankton distribution pattern is influenced by water characteristic and zooplankton adaptation ability. Result of zooplankton Morisita index validated by Chi-kuadrat test showed that zooplankton in Tangerang coastal waters had grouped distribution pattern ($I\delta > 1$; $\chi 2$ count > $\chi 2$ table). The grouping (patchiness) of plankton is commonly found in neritic zone, in particular estuary influenced area, than oceanic zone [27]. The uneven distribution of plankton in waters is caused by the plankton which has distribution patterns "patchy" (clump together) and also has the low ability to move, so that its distribution will depend on the movement of water masses [28]. Physical factors that affect uneven phytoplankton distribution are flows or current, nutrient, temperature, light, brightness, wind, pH, turbidity, and diurnal migration of plankton itself [27].

3.5. Horizontal distribution of zooplankton

Based on zooplankton abundance, zooplankton community was distributed into two clusters of sites, those were cluster 1 (Kronjo, Mauk, Rawa Saban, and Tanjung Pasir) and cluster 2 (Dadap) (Fig. 5a). This distribution was supported by water quality condition which had the same grouping distribution with the zooplankton (Fig. 5b). The similarity of site cluster distribution indicates conformity between biological index and physicochemical characteristic in characterizing quality of aquatic ecosystem.

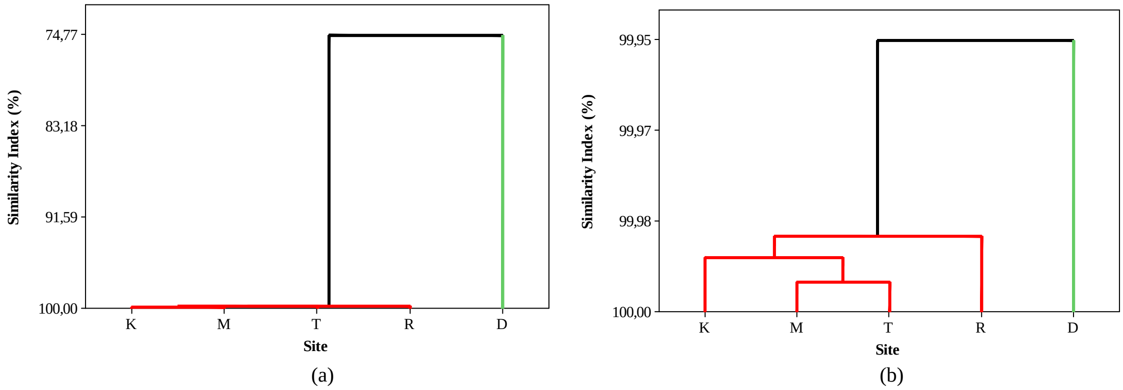

Fig. 5. Dendrogram of site grouping based on (a) zooplankton abundance and (b) water quality.

Zooplankton has certain preferences to environmental (physicochemical) characteristic determined on the highest correlation value of all environmental parameters. Based on analysis, pH and ammonia had the highest correlation value; those were 0.95 and 0.62, respectively. It indicated that pH and ammonia more influenced in forming zooplankton distribution in Tangerang coastal waters. Other research shows that number of zooplanktons in the sea is closely related with temperature, salinity and nutrient salt [7].

4. Conclusion

Zooplankton in Tangerang coastal waters consisted of 12 groups of Protozoa, Rotifera, Crustacea, Ctenophora, Chaetognata, Urochordata, *Nematoda larvae*, *Coelenterata larvae*, *Echinodermata larvae*, *Gastropoda larvae*, *Polychaeta larvae*, and *Pelecypoda larvae*. Zooplankton distribution in Tangerang coastal water was grouped. Horizontal distribution of zooplankton was divided into two clusters of site location. This distribution was influenced by water quality characteristic, in particular pH and ammonia.

Acknowledgements

This research was supported and granted by PT. Kapuk Naga Indah cooperated with LPPM IPB and Department of Aquatic Resources Management of IPB.

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