

# ZOOPLANKTON FROM CAN GIUOC RIVER IN SOUTHERN VIETNAM

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## Abstract

In this study, the variables of zooplankton and water quality were investigated in the Can Giuoc River, Southern Vietnam. Zooplankton was monitored in April and September 2015 at 5 sampling sites in the river. Some basic water quality parameters were also tested, including pH, total suspended solid (TSS), dissolved oxygen (DO), biological oxygen demand (BOD<sub>5</sub>), inorganic nitrogen (NH<sub>4</sub><sup>+</sup>), dissolved phosphorus (PO<sub>4</sub><sup>3-</sup>), and coliform. The zooplankton biodiversity indices were applied for the water quality assessment.

The results showed that pH ranged from 6.7 to 7.6 during the monitoring. The TSSs were between 34–117 mg/L. The DO and BOD<sub>5</sub> were from 0.6 to 3.8 mg/L and from 6.3 to 13.2 mg/L, respectively. The NH<sub>4</sub><sup>+</sup> and PO<sub>4</sub><sup>3-</sup> concentrations ranged from 0.44 to 3.23 and from 0.08 to 1.85 mg/L, respectively. The coliform number was between 9.3x10<sup>3</sup>–9.3x10<sup>4</sup> MPN/100 mL. The zooplankton analyses showed that there were 31 species of coelenterates, rotatoria, oligochaetes, cladocerans, copepods, ostracods, mysidacea, and 8 larval types. Thereof, the species of copepods were dominant in the species number. The zooplankton density ranged from 9 500 to 23 600 individuals/m<sup>3</sup> with the main dominant species of *Moina dubia* (Cladocera), *Thermocyclops hyalinus*, *Acartia clausi*, *Oithona similis* (Copepoda), and nauplius copepods. The biodiversity index values during the monitoring were from 1.47 to 1.79 characteristic of mesotrophic conditions of the aquatic environment. Besides, the species richness positively correlated with pH, TSS, DO, BOD<sub>5</sub>, NH<sub>4</sub><sup>+</sup>, PO<sub>4</sub><sup>3-</sup>, and coliform, while the zooplankton densities got a positive correlation with DO, BOD<sub>5</sub>, NH<sub>4</sub><sup>+</sup>, PO<sub>4</sub><sup>3-</sup>, and coliform. The results confirmed the advantage of using zooplankton and its indices for water quality assessment.

**Key words:** Can Giuoc River, zooplankton, biological indices, water quality assessment.

## 1 INTRODUCTION

Zooplankton consists of tiny animals, such as rotifers, copepods, and krill, and of microorganisms once classified as animals, such as dinoflagellates and other protozoans [1]. Like phytoplankton, Zooplankton are usually weak swimmers and typically just drift along with the currents [1]. Zooplankton are the key components of aquatic ecosystems and the animal constituent of the plankton, some of them are herbivores, feeding on phytoplankton, while others are carnivorous, feeding on other members of the zooplankton. Some members of the zooplankton community, particularly copepods (small crustacea) are important for higher trophic levels as food for fish larvae. Zooplanktons are critical links in riverine food webs between phytoplankton and fish [2]. Zooplankton is one of the most common organisms on the earth, which are mostly present and well develop in aquatic habitats including lakes, ponds, reservoirs, rivers, streams, and oceans [3]. Many environmental factors interact to regulate the spatial and seasonal growth and succession of zooplankton [1]. The environmental variables of DO and nutrients are important for the presence and distribution of zooplankton; for example the DO below 1.0 mg/L would limit the development of zooplankton. Nutrients including NH<sub>4</sub><sup>+</sup> and PO<sub>4</sub><sup>3-</sup> are important for the growth of zooplankton. Moreover, pH and TSS are essential for the distribution of zooplankton [1, 4]. Zooplankton could be used as bio-indicators for water quality and ecosystem health [5]. In addition, the indices based on zooplankton such as biodiversity, similarity, among others, are useful for water quality and ecological health evaluation. In Vietnam, a variety of investigations have been conducted focusing on morphological biodiversity of zooplankton [6]. However, publications on interactions between zooplankton and environmental parameters based on the zooplankton from rivers in Vietnam are limited. Nguyen et al. (2007) found the variation of zooplankton abundance between dry and rainy seasons [6]. In this study, we investigated the variation of zooplankton as well as the water quality based on zooplankton in the Can Giuoc River in Southern Vietnam.

## 2 MATERIALS AND METHODS

### 2.1 Study Area and Sample Collection

The Can Giuoc River is a small river and its length is of around 38 km. It is located within the Long An Province and apart of Ho Chi Minh City, Southern Vietnam. The Can Giuoc River plays a key role in the navigation through the Long An Province and the western area of Ho Chi Minh City. Recently, the Can Giuoc River has been received many different effluents from industrial, agricultural, and domestic activities by human beings. In the Can Giuoc River, qualitative and quantitative samples of zooplankton at 5 sites were collected and fixed with a formaldehyde solution in April and September 2015 (Figure 1; Table 1) [5].

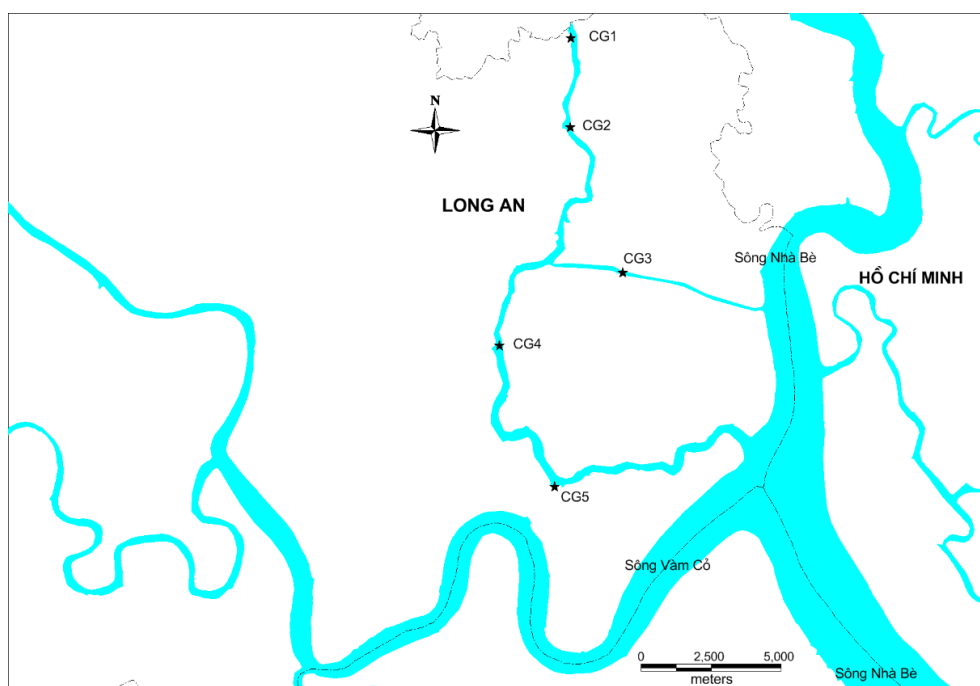


Fig. 1 Can Giuoc River with 5 sampling sites (CG1-CG5).

Tab. 1 Coordinates and locations of the sampling sites.

Sampling Sites	Local Names	Longitude (N)	Latitude (S)
CG1	Confluence of Cay Kho Canal and Can Giuoc River	10°38'25.54"N	106°40'23.22"E
CG2	Can Giuoc River in Can Giuoc Market Area	10°36'42.31"N	106°40'21.69"E
CG3	Confluence of Mong Ga Canal and Rach Cat River	10°33'54.05"N	106°41'24.30"E
CG4	Can Giuoc River in Thu Bo Bridge Area	10°32'29.79"N	106°38'58.42"E
CG5	Confluence of Nuoc Man Canal and Rach Cat River	10°29'46.12"N	106°40'03.32"E

The samples for the water quality analysis in the field were collected according to the Operational Guide (3rd Ed.), UN Environment Programme (1992) [7]. The samples were taken in April and September of 2015. The samples at each site were taken in the middle of the river with a depth layer of surface water from 30 to 40 cm. The water samples were collected in 2 litre plastic bottles and kept at 2°C temperature [7]. The samples were taken at least 1 m from potential contaminants such as debris and aquatic plants, and at least 2 m from vertical banks. The samples are usually collected in the middle flow of rivers. At sites where the water current is too fast to sample exactly in the mid-stream, the samples could be taken in near the right or left banks, but not too close to the banks [5]. Before sampling at each site, the equipment is washed to remove any organisms and other matter left from the previous site. 10 L of river water at a depth of 0–0.5 m is collected in a bucket. The 10 L of river water are filtered slowly through the plankton net (with a mesh size of 20 µm) to avoid any overflow from the net. The water is splashed on the outside of the net to wash down any zooplankton adhering to the inner parts

of the net [5]. When the water volume remaining in the net is only about 150 mL, the water (which contains the zooplankton sample) is transferred to a 250 mL plastic jar. The sample is immediately fixed in the field by adding ~ 75mL of 10% formaldehyde to achieve the final concentration of 4–5% formaldehyde. The sample jars are labelled with the site name, the site code, the sampling position, and the sampling date. The information was also noted in the field notebook, as is any information about the site that could be influencing for the presence or abundance of different types of zooplankton [5].

## 2.2 Physical, Chemical and Zooplankton Analysis

The aquatic environmental parameters (pH, TSS, DO, BOD<sub>5</sub>, NH<sub>4</sub><sup>+</sup>, PO<sub>4</sub><sup>3-</sup>, and coliform) were analysed according to standard methods (APHA-AWWA-WEF, 1998) [8]. All individuals collected were identified and counted under a compound microscope (with magnifications of 40–1200x) or a dissecting microscope (16–56x). The results were recorded on data sheets and specimens are kept at the Ton Duc Thang University, Ho Chi Minh City, Vietnam [5].

## 2.3 Data Analysis

For all sites sampled in April and September 2015, the following metrics were calculated: (i) taxonomic richness (i.e. number of taxa); (ii) abundance (i.e. numbers of individuals per site); (iii) the Shannon-Wiener Diversity Index [9]. The Pearson test (SPSS, version 16.0) was used for calculating the correlations between the zooplankton species number, abundance, and biodiversity index and environmental parameters in the Can Giuoc River. The three metrics were tested for their potential as indicators of human impact by regressing the values for two seasons of 2015 (10 sampling events for 5 sites) against the water quality variables (pH, TSS, DO, BOD<sub>5</sub>, NH<sub>4</sub><sup>+</sup>, PO<sub>4</sub><sup>3-</sup>, and coliform). For each metric examined against these variables, p values and r<sup>2</sup> values were calculated from the regression analyses.

## 3 RESULTS

The TSSs highly fluctuated from 34 to 117 mg/L. In rainy season, the TSS concentrations in the Can Giuoc River were much higher than those in dry season. The DO and BOD<sub>5</sub> values were from 0.6 to 3.4 mg/L and from 6.3 to 13.2 mg/L, respectively. The NH<sub>4</sub><sup>+</sup> and PO<sub>4</sub><sup>3-</sup> concentrations in the Can Giuoc River fluctuated from 0.44 to 3.23 mg/L and from 0.08 to 1.85 mg/L, respectively. And, the coliform values were from 9.3x10<sup>3</sup> to 9.3x10<sup>4</sup> MPN/100 mL in the Can Giuoc River (Table 2).

**Tab. 2 Physical, chemical, and microbial parameters of the Can Giuoc River and its tributaries during 2015. The data were presented as minima to maxima values.**

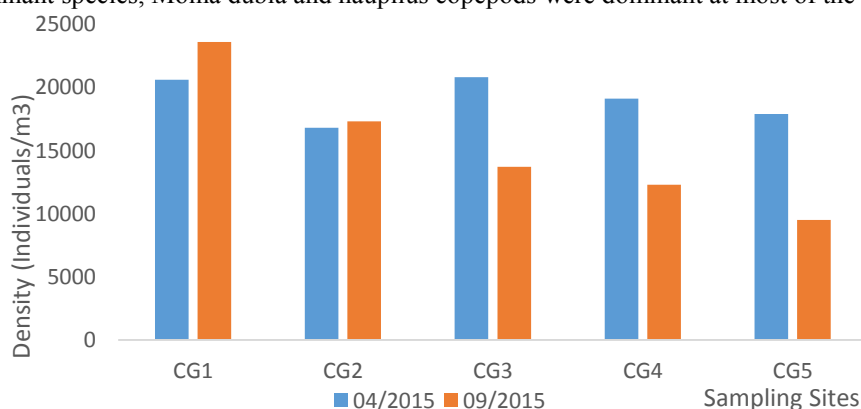
Sampling	pH	TSS	DO	BOD <sub>5</sub>	NH <sub>4</sub> <sup>+</sup>	PO <sub>4</sub> <sup>3-</sup>	Coliform
Sites		mg/L	mg/L	mg/L	mg/L	mg/L	MPN/100mL
CG1	6.7-7.2	41-117	0.6-2.5	7.4-12.8	0.91-3.23	0.19-1.84	4.3x10 <sup>4</sup> - 9.3x10 <sup>4</sup>
CG2	6.8-7.3	34-104	0.9-2.6	7.1-13.2	0.83-3.23	0.14-1.85	4.3x10 <sup>4</sup> - 9.3x10 <sup>4</sup>
CG3	7.0-7.4	56-94	1.1-3.4	7.0-11.3	0.64-2.97	0.12-1.23	2.3x10 <sup>4</sup> - 4.3x10 <sup>4</sup>
CG4	7.2-7.5	49-93	1.2-3.8	6.5-11.7	0.44-3.00	0.11-1.29	1.5x10 <sup>4</sup> - 2.3x10 <sup>4</sup>
CG5	7.2-7.6	52-88	1.4-3.7	6.3-11.6	0.50-2.52	0.08-1.23	9.3x10 <sup>3</sup> - 2.3x10 <sup>4</sup>

During the two monitoring times, there were 39 species of zooplankton belonging to 8 groups of zooplankton in the studied area. Among the zooplankton groups, copepods were dominant in the species number with 15 species in total, gaining around 38.5% of total (Table 3). In each monitoring, the species number of zooplankton ranged from 19 (in April) to 33 (in September).

**Tab. 3. Structure of zooplankton communities from Can Giuoc River during 2015. Numbers in the table indicated the species number of each zooplankton group.**

Zooplankton groups	04/2015	09/2015	Total	%
Coelenterata	1	1	1	2.6
Rotatoria	1	7	7	17.9
Oligochaeta	0	1	1	2.6
Cladocera	0	5	5	12.8
Copepoda	9	11	15	38.5
Ostracoda	0	1	1	2.6
Mysidacea	1	0	1	2.6
Larva	7	7	8	20.5
Total species number	19	33	39	100

Most of zooplankton species and genera recorded in the river originated from the estuary or coastal region such as *Obelia* sp., *Brachionus plicatilis*, *Paracalanus parvus*, *Pseudodiaptomus incisus*, *Acartia clausi*, *Oithona similis*, *Halicyclops* sp., *Microsetella norvegica*, larva of shrimp and crabs. However, some of them are characteristic of fresh water and low brackish water like most species of Rotatoria, Cladocerans, Ostracods, and Chironomid larva. Therefore, the aquatic environment in the studied area was co-affected by sea water via the tide and freshwater from inland. The Zooplankton density ranged from 9 500 to 23 600 individuals/m<sup>3</sup>, the lowest value at the sampling site 5 (Confluence of Nuoc Man Canal and Rach Cat River) and the highest at the site 1 (Confluence of Cay Kho Canal and Can Giuoc River, Figure 2). *Moina dubia*, *Acartia clausi*, *Thermocyclops hyalinus*, *Oithona similis*, nauplius copepod were the dominant species in the monitored area. Among the dominant species, *Moina dubia* and nauplius copepods were dominant at most of the sampling sites.



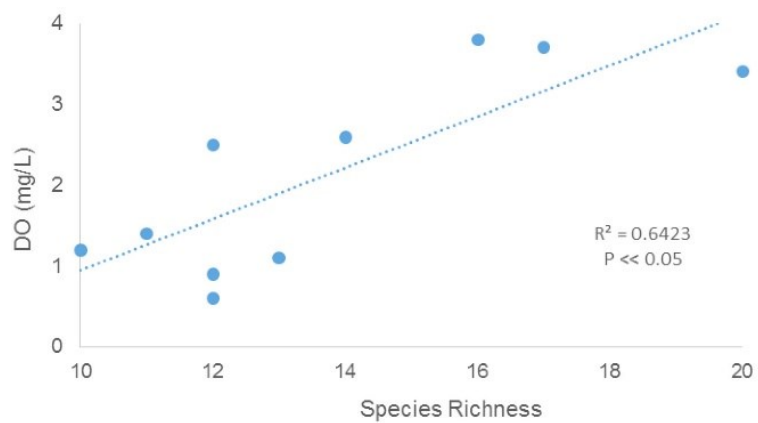
**Fig. 2 Zooplankton density from Can Giuoc during 2015.**

The values of zooplankton biodiversity index during the monitoring in 2015 ranged from 1.47 to 1.79 (Table 4). In the Can Giuoc River, the values of biodiversity index at the site CG5 were higher than those at the site CG1. The values of biodiversity index in the rainy season were higher than those in the dry season (Table 4).

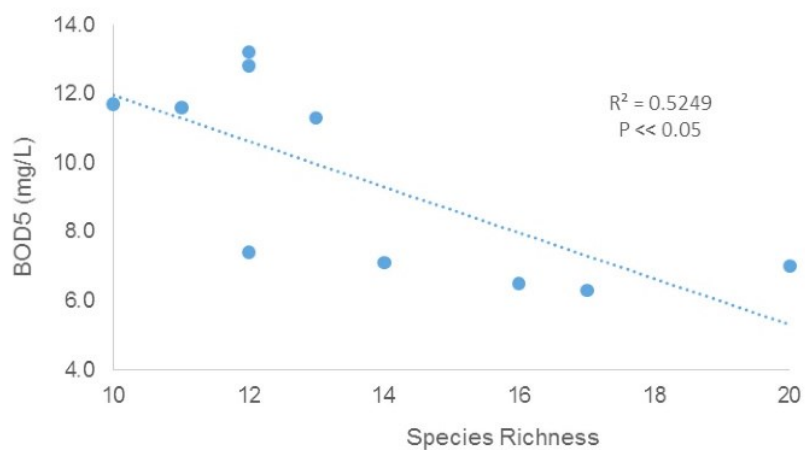
**Table 4. Biodiversity index values ( $H'$ ) of zooplankton from Can Giuoc River during 2015.**

$H'$	CG1	CG2	CG3	CG4	CG5
04/2015	1.47	1.52	1.53	1.56	1.60
09/2015	1.49	1.63	1.78	1.62	1.79

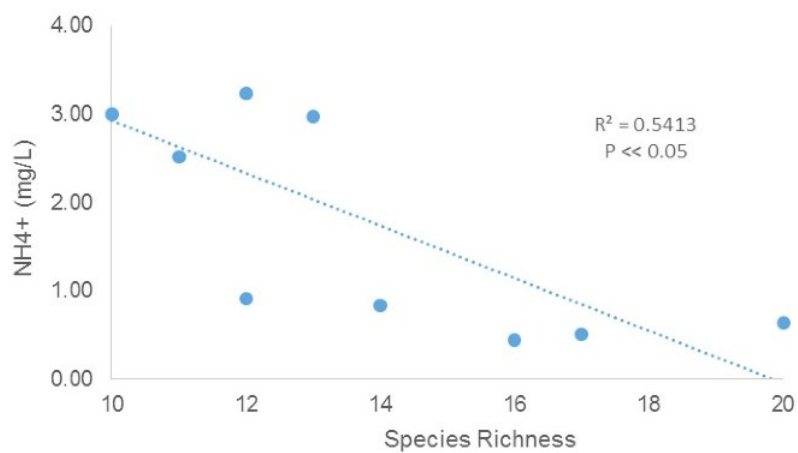
The statistical data treatment showed that the species number of zooplankton strongly correlated with all environmental variables of DO, BOD<sub>5</sub>, NH<sub>4</sub><sup>+</sup> and PO<sub>4</sub><sup>3-</sup> in water ( $r = 0.4654-0.6423$ ) (Figure 3), while the density of zooplankton highly correlated only with DO ( $r = 0.4868$ ) (Figure 4); and negatively correlated with pH and TSS concentrations in water ( $r = 0.0083-0.0365$ ). Besides, the biodiversity of zooplankton strongly correlated with most environmental variables of DO, BOD<sub>5</sub>, NH<sub>4</sub><sup>+</sup> and PO<sub>4</sub><sup>3-</sup> and coliform in water ( $r = 0.1804-0.5847$ ). However, the biodiversity negatively correlated with pH ( $r = 0.0088$ ).



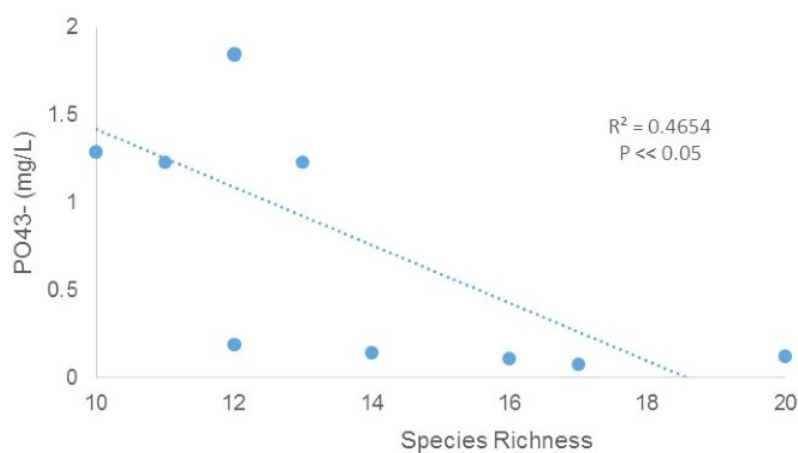
(a)



(b)

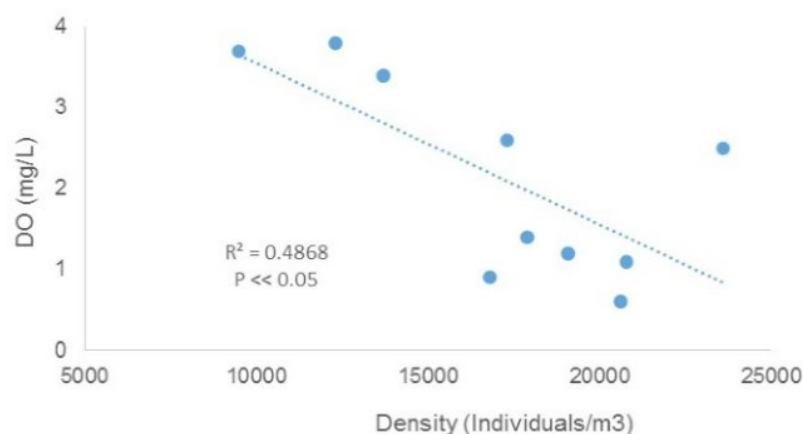


(c)



(d)

**Fig. 3 Species richness of Zooplankton strongly correlated with environmental variables of DO (a), BOD<sub>5</sub> (b), NH<sub>4</sub><sup>+</sup> (c), and PO<sub>4</sub><sup>3-</sup> (d).**



**Fig. 4 Density of Zooplankton strongly correlated with environmental variable of DO.**

#### 4 DISCUSSION

As a running water body, the Can Giuoc River had the pH of neutral water (Table 2) and the pH was similar to that in the Can Gio area [10]. In the rainy season, the TSS concentrations were high than those in the dry season because of strong flows. The NH<sub>4</sub><sup>+</sup> and PO<sub>4</sub><sup>3-</sup> concentrations in the Can Giuoc River were higher than those inorganic nitrogen and dissolved phosphorus concentrations from the rivers in the Can Gio Area, fluctuated from 0.8 to 3.0 mg/L and from 0.11 to 0.89 mg/L [10], and not as high as that in inside canals of Ho Chi Minh City, ranging from 3.2 to 4.0 mg/L and from 1.20 to 1.34 mg/L [10]. Therefore, the Can Giuoc River should be characterized by polytrophic conditions in the dry season and mesotrophic levels in the rainy season, in term of NH<sub>4</sub><sup>+</sup> and PO<sub>4</sub><sup>3-</sup> during the monitoring in 2015. Pham et al. (2012) recorded 94 species of zooplankton during 6 year monitoring in the Can Gio Area where copepods contributed to the highest species number for the zooplankton community [11]. Throughout 5 years of sampling in the Tien Giang coastal area, 58 zooplankton species were reported, from which copepods were also dominant in the species number [12]. For the whole year of monitoring in this area, the copepods contributed to the highest number of species. This should be related to the water characteristics for the Can Giuoc River, strongly influenced by sea water from the East Sea. Most of species were estuary and coastal species, and well developed in rich nutrient conditions. In general, the species number and densities during the monitoring were affected by water quality in the Can Giuoc River. Some environmental conditions such as TSS, DO, and coliform were not favourable for zooplankton development as mentioned above; their species number and densities were not high in the river. They could be related to the wastewater from Ho Chi Minh City, which needs further investigation, especially the monitoring on the water quality, to confirm. The bio-diversity index values were characteristic of mesotrophic conditions in rainy season and polytrophic conditions in dry season of the aquatic environment. Generally, the values of biodiversity index were rather low in the dry season (April) and higher in the rainy season of the year (September, Table 4). Moreover, the values seemed to be higher at the sites in near the river mouth. Those should be related to the water current from the sea which helped for self-purification.

## 5 CONCLUSION

During the two monitoring times in 2015 in the Can Giuoc River, the nutrients including  $\text{NH}_4^+$ , and  $\text{PO}_4^{3-}$  concentrations were characteristic of mesotrophic conditions in the rainy season and polytrophic condition in the dry season. Besides, the pH values were favourable for the development of zooplankton. There were 39 zooplankton species belonging to 8 groups of coelenterates, rotatoria, oligochaetes, cladocerans, copepods, ostracods, mysidacea, and larval types in the studied areas, thereof the copepods were dominant in the species number. Generally, the zooplankton abundance during the monitoring was rather high but its species composition was rather low. The values of zooplankton biodiversity index reflected the mesotrophic condition.

The species number of zooplankton strongly correlated with all environmental variables of DO,  $\text{BOD}_5$ ,  $\text{NH}_4^+$ , and  $\text{PO}_4^{3-}$  in water. While the density of zooplankton highly correlated only with DO, it negatively correlated with pH and TSS concentrations in water. Further, the biodiversity of zooplankton strongly correlated with most environmental variables of DO,  $\text{BOD}_5$ ,  $\text{NH}_4^+$ , and  $\text{PO}_4^{3-}$  and coliform in water. However, the biodiversity negatively correlated with pH.

The results of this study contributed to the interesting information on zooplankton composition and abundance, their correlations with environmental parameters and environmental characteristics, which was quite limited in Southern Vietnam. Moreover, the results confirmed the advantage of using zooplankton and their indices as useful tools for water quality assessment.

### ACKNOWLEDGMENT

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