Evaluation of Surface Water Quality Using Biodiversity Indices in Phu My Species – Habitat Conservation Area, Kien Giang Province, Vietnam

Huynh Thi Hong Nhien[1], Nguyen Thanh Giao[1*]

[1] College of Environment and Natural Resources, Can Tho University, Can Tho City 900000, Vietnam
* Corresponding author's e-mail: ntgiao@ctu.edu.vn

ABSTRACT

Phu My species-habitat conservation area (PMCA) is a seasonal wetland area; thus, water quality plays an essential role in the development of organisms. Therefore, the study was carried out to assess surface water quality based on phytoplankton, zooplankton and benthic composition at PMCA, which has been little studied. The phytoplankton, zooplankton and benthic samples were collected at six locations (N1-N6) of the habitats and canals in November 2021. Shannon-Wiener biodiversity index (H'), Pielou index (J) and average score per taxon (ASPT) were used to assess pollution levels of surface water. A total of 71 species of phytoplankton belonging to five phyla (i.e., Chlorophyta, Euglenophyta, Bacillariophyta, Dinophyta and Chrysophyta), 57 species of zooplankton belonging to three phyla (i.e., Protozoa, Rotifera, Arthropoda) and two benthic species belong to two groups (i.e., Oligochaeta and Insecta) were detected. The phyla of Euglenophyta, Rotifera, and Insecta were the dominant groups in species composition and the phyla of Chlorophyta, Protozoa, and Insecta were dominated in terms of individual density. Species of *Trachelomonas volvocina, Phacus torta, Euglena oxyuris, Arcella vulgaris, Brachionus bidentata, Lecane hastata, Lecane bulla, Lecance pyriformis* and *Polyarhtra vulgariis* appeared at most of the studied sites, indicating the organic and nutrient pollution of the water bodies. The Shannon-Wiener biodiversity index (H') and Pielou index (J) showed the water quality from moderate to severe pollution. The results of water quality classification according to ASPT and H' of benthic animals had similar characteristics, indicating that the surface water is very dirty (heavy pollution). The current findings could be used to manage water quality in the future to conserve biodiversity. Furthermore, it helps to improve and expand methods for monitoring surface water quality in the conservation area, in addition to evaluating based on physical and chemical parameters.

Keywords: water quality, biodiversity indices, Phu My, species habitat .

INTRODUCTION

Phu My species-habitat conservation area (PMCA) is located in Phu My commune, Giang Thanh district, Kien Giang province. The area plays an essential role in preserving the habitats and environment of many different species of flora and fauna, especially *Grus antigone sharpii* and *Lepironia articulate*. Water quality in the PMCA plays a significant role in maintaining and developing the diversity of plant and animal species. Therefore, water quality monitoring is performed annually through physical and chemical parameters since it is a seasonal wetland area. In addition, water quality directly affects the diversity and development of aquatic species, of which plankton species are recognized as the most sensitive. Furthermore, previous studies have shown that the dominant plankton species and their seasonality vary widely in different water bodies (Thakur et al., 2013). Thus, biodiversity indices of plankton species could reflect the water quality in the water bodies (Gao et al., 2018).

Plankton is composed of phytoplankton and zooplankton. Plankton plays a vital role in aquatic

ecosystems and its population changes and community structure affect the function of the ecosystem directly, such as the production and transmission of nutrients (Luu, 2017; Gao et al., 2018). The structure of species composition and density of plankton are strongly influenced by environmental conditions such as temperature, dissolved oxygen and nutrient composition, especially orthophosphate (Jiang et al., 2014; Sihombing et al., 2017). Plankton is considered a biological indicator to assess the level of water pollution (Ren et al., 2011; An et al., 2012; Thakur et al., 2013; Ha et al., 2016) because of its short development cycle, rapid reproduction, abundant taxonomic, wide distribution and sensitivity to environmental conditions changes (Jakhar, 2013; Xiong et al., 2019). For an unpolluted ecosystem, phytoplankton would have high diversity, many species distribution and low density of each species, whereas affected ecosystems would have high densities of a few species, leading to low diversity (Yen et al., 2021). In addition, some studies have also used zoobenthic as an indicator of water quality in certain study areas (Bhadrecha et al., 2016); these species are usually easy to observe with the naked eye and are relatively easy to collect samples (Sharma et al., 2006). For example, arthropod species often live on the surface of sediments in unpolluted environments, while the dominant *Limnodrilus hoffmeisteri* and *Tubifex species* show low organic and oxygen pollution in the water bodies (Peng et al., 2020).

Nevertheless, studies at PMCA mainly evaluated water quality based on physical and chemical parameters. Relatively few studies assessed water quality based on the presence of plankton and zoobenthic species. Therefore, this study was conducted to evaluate surface water quality through the composition and density of phytoplankton, zooplankton and zoobenthos species at PMCA.

MATERIALS AND METHODS

Phytoplankton, zooplankton and zoobenthos samples were collected at six sites, which were signed from N1 to N6 (Figure 1).

Sampling phytoplankton and zooplankton

Qualitative samples were collected by using nets, turning the nets in round eight at least 20 times in surface water. The collected sample is stored in a plastic bottle, recorded with information (sample type, date and location of sample collection) and then fixed with 2–4% formaldehyde. Regarding quantitative samples, filtering 100 L of water through a 25 μm mesh. Samples were concentrated and placed in 110 mL vials and fixed with 2–4% formaldehyde. Qualitative analysis was performed using 10X-40X objective microscopy and phytoplankton imaging to determine morphological, structural and taxonomic features, according to Tien and Hanh (1997) and Tuyen (2003).

Sampling zoobenthos

Qualitative and quantitative samples were collected using a Petersen gauge (20×20 cm). At each location, benthic animals were collected five times and then sieved with a bottom sieve with a mesh of 0.5×0.5 mm to remove mud and debris. The samples obtained after sieving were stored in plastic bags and fixed in 10% formalin (100 mL of 37% formaldehyde was diluted with 900 mL of water to obtain 1 L formalin 10%) (Dung et al., 2011; Lien et al., 2014). The samples were washed in the laboratory, completely removed organic matter, retained benthic and fixed with 4% formol (Quyen et al., 2011). For qualitative analysis, zoobenthic species were observed by microscopy to determine morphological, structural and taxonomic characteristics (Quynh et al., 2001). For quantitative analysis, zoobenthic species are listed and then the number of individuals of each benthic species is counted to calculate the density (individuals/m^2) of each species on each survey site.

Data analysis

Quantitative sample analyses were performed by counting individual phytoplankton according to the method of Boyd and Tucker (1992). Densities of phytoplankton were calculated using Equation 1:

$$Y = \frac{X \times 1000 \times Vcd}{N \times A \times Vtt} \quad (1)$$

where: Y – the density of individuals (individual/L), X – the number of phytoplankton in the counted cells, V_{cd} – the volume of sample concentrate (mL), N – the number of incoming cells, A – possible cell volume (1 mm^2) and V_{tt} is actual collection volume (mL).

Densities of zooplankton were calculated using Equation 2 (2):

$$D = X/V \qquad (2)$$

where: D – the density or number of zooplankton individuals (individuals/m^2), X – the number of organisms counted in the $V(L)$ sample, V – the sample volume after concentration (mL).

Densities of zoobenthos were calculated using Equation 3 (3):

$$N = X/S \qquad (3)$$

where: N – the density of benthic (individuals/m^2), X – the number of each group of benthos in the sample, S – the collected area with $S = n \times d$ (n – the number of buckets and d) is the bucket area).

The diversity of organisms was determined by the Shannon-Wiener diversity index using Equation 4, which was applied in the previous studies of Shannon and Weaver (1949) and Ren *et al.* (2011).

$$H' = -\sum_{i=1}^{S}(Ni/N) * ln(Ni/N) \qquad (4)$$

where: N_i – the number of individuals of species i, N – the total number of individuals of all species in the samples. According to Shannon and Weaver (1949), water quality is divided into three pollution levels based on H' values: H'>3 indicates good water quality or unpolluted water; 1≤H'≤3 indicates moderate water pollution; H'<1 indicates the water is heavily polluted.

Plankton uniformity was checked by the Pielou index (J) according to Equation 5 (Eq. 5) (Pielou, 1975; Ren *et al.,* 2011):

$$J = H'/lnS \qquad (5)$$

where: S is the number of plankton species.

The pollution rating scale is based on the J value, which ranges from 0 to 0.4; 0.4–0.6; 0.6–0.8; >0.8 corresponds to heavy, moderate α, moderate β and light or no pollution (Pielou, 1975; Van & My, 2020). The BMWP Vietnam – ASPT biological monitoring index based on the taxonomy at the family level of the benthic taxonomy system is calculated by Equation 6 (Eq. 6) (Thuan et al., 2010):

$$ASPT = \frac{\sum_{i=1}^{n} BMWP}{N} \qquad (6)$$

where: N – the total number of benthic families present in a sample; $\sum$ BMWP is the total score of benthic families according to the score table of BMWP Vietnam. Water quality based on the ASPT index includes 6 levels: 0 (extremely dirty), 1–2.9 (very dirty), 3–4.9 (relatively dirty, level β), 5–5.9 (medium dirty, level α), 6–7.9 (reasonably clean) and 8–10 (very clean) (Thuan et al., 2010).
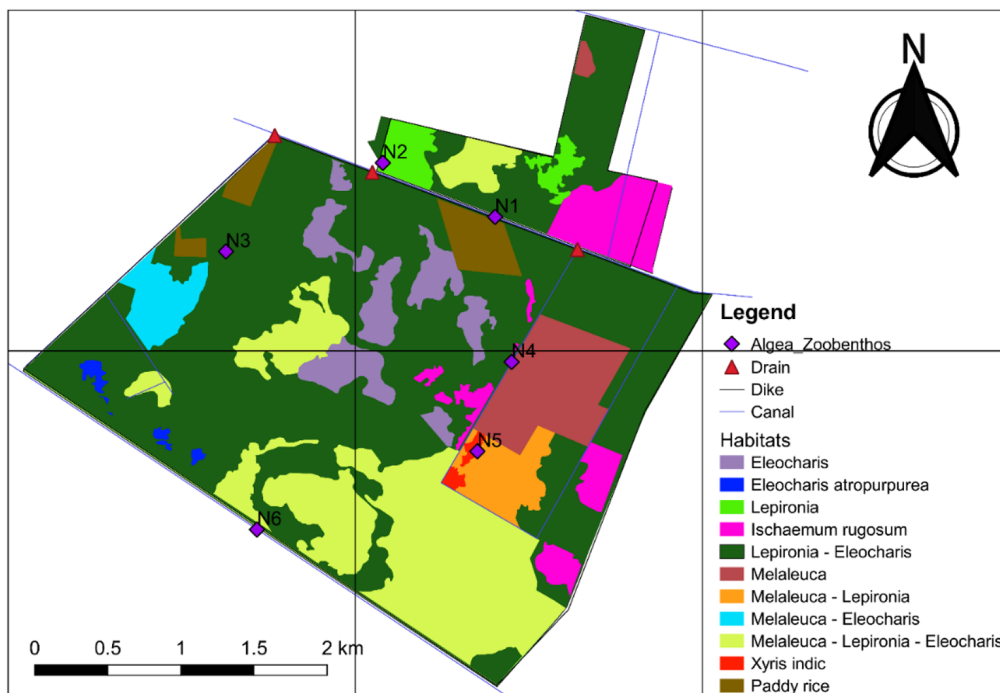

Figure 1. Map of biodiversity sample collection

RESULTS AND DISCUSSION

Phytoplankton

Composition of phytoplankton

The study results showed that a total of 71 species belonging to 5 phyla of algae appeared in the Phu My species-habitat conservation area (Figure 2). The percentages of the Chlorophyta, Euglenophyta, Bacillariophyta, Dinophyta and Chrysophyta were 37%, 38%, 18%, 4% and 3%, respectively. Euglenophyta dominated with 27 species, followed by Chloriphyta with 26 species and Bacillariophyta with 13 species. In addition, there are very few phytoplankton species belonging to the Dinophyta and Chrysophyta, with 3 species and 2 species, respectively. However, these are two new phyla appearing in water at the reserve compared to previous research of Ni (2018) in the PMCA.

The study results also showed that Euglenophyta was dominated by the presence of algae species belonging to the genera *Euglena*, *Lepocinclis*, *Phacus* and *Trachelomonas*. According to Salman et al. (2013) and Srichandan et al. (2015), Euglenophyta grows and develops best in fresh water, low salinity, and nutrient-rich, a biological indicator of organic pollution in water bodies. This has been demonstrated in previous research that Euglenophyta was the dominant species in nutrient-rich water bodies and agricultural farming areas (Kemka et al., 2006; Khanh et al., 2021). While the presence of Chlorophyta reflects an aquatic environment with high concentrations of nitrogen and phosphorus (Zhu et al., 2010; Sulastri et al., 2020), Bacillariophyta is the dominant species in brackish water when salinity increases (Ut et al., 2013; Hoa & Thanh, 2014). In addition, Dinophyta grows in a high nutrient environment with high P content and low N:P ratio and Dinophyta is considered a toxic and harmful algae species for cultured subjects when the density of Dinophyta algae is high (Hoa & Thanh, 2014; Srichandan et al., 2015). Compared with the study of Lien et al. (2022) and Yen et al. (2021), the structure of phytoplankton species composition (95 species belonging to 6 phyla and 112 species belonging to 5 phyla) was more diverse and more affluent. It can be seen that depending on the geographical location, the nature of the water environment creates conditions for different phytoplankton species to grow and develop.

The total number of phytoplankton species belonging to different phyla ranged from 4 to 58 species (Figure 3). In which, HT6 canal (N1), Lepironia-Eleocharis habitat (N2) and infield canals (N3) appeared algae species belonging to all five phytoplankton phyla. Particularly, the remaining three locations (i.e., N4, N5, and N6) belong to the habitats of Melaleuca, Melaleuca-Lepironia and Melaleuca-Lepironia-Eleocharis, only a few species of Chlorophyta and Bacillariophyta appear. The results also showed that there was the highest number of phytoplankton species present (58 species) in the HT6 canal, of which Euglenophyta, Chlorophyta and Bacillariophyta appeared, accounting for the highest proportion at the monitoring site. Specifically, the species dominated by *Chodatella subsalsa*, *Spirogyra azygospora*, *Spirogyra prolifica*, *Pandorina morum* (Chlorophyta), *Trachelomonas hispida*, *Phacus torta*, *Trachelomonas volvocina*
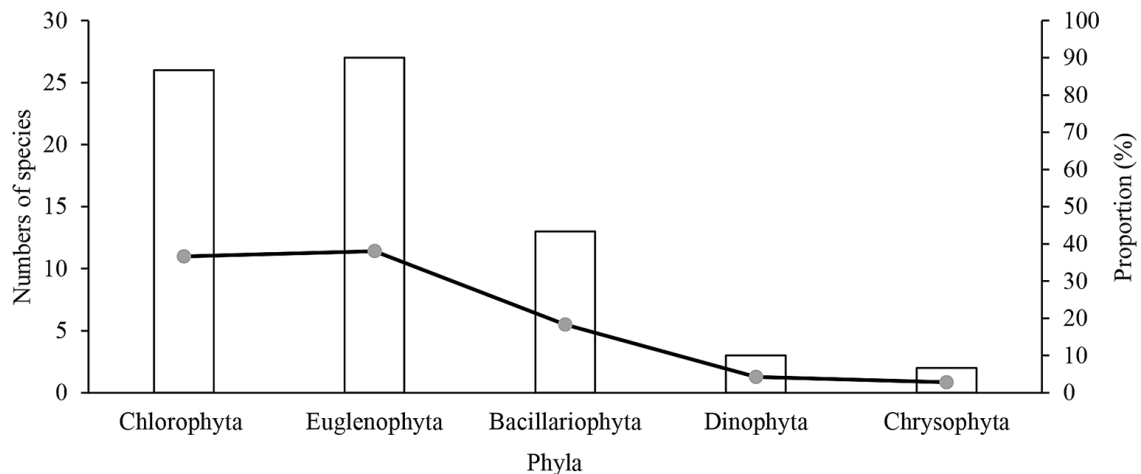

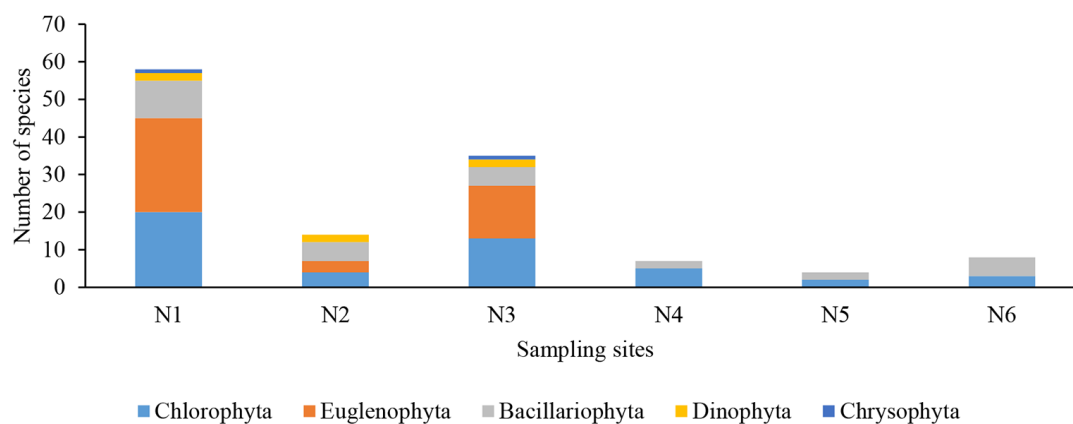**Figure 2.** Number of phytoplankton species in the study area

Figure 3. Composition of phytoplankton at the sampling locations

(Euglenophyta), *Eunotia* sp., *Desmogonium transfugum* (Bacillariophyta) predominates. In addition, the appearance of genera *Euglena*, *Phacus, Trachelomonas* (Euglenophyta), *Scenedesmus* (Chlorophyta) and *Nitzschia* (Bacillariophyta) were indicators of water quality with organic matter content at the location of the HT6 canal, Lepironia-Eleocharis and the infield canal habitats (Mach et al., 2013; Lien et al., 2022). At the same time, the two locations of the infield canal (N3) and Lepironia-Eleocharis (N2) also have many phytoplankton species present. The above locations have regular water exchange, which could be why the phytoplankton composition is more diverse and richer than the rest of the habitats in the surveyed protected area. In addition, the HT6 canal, Lepironia-Eleocharis and the infield channel also appeared with a species of algae belonging to the genus *Glenodinium*, showing that the environment has a high nutrient content. Some species of algae, *Cylindrocystis brebissonii*, *Zygnemopsis americana* (Chlorophyta), and *Desmogonium ossiculum* (Bacillariophyta) are common in the water bodies of the habitat in the reserve (N4-N5). The appearance of the diatom *Desmogonium ossiculum* indicated a low-pH water body and an acidic environment.

Density of phytoplankton

The research results showed that the total density of phytoplankton at each monitoring location and each phylum fluctuated relatively large in the range of 958–13,766 individuals/L and 128–16,694 individuals/L (Table 1). Although Euglenophyta has a dominant number of species (in terms of the whole study area), the individual density was relatively low. Chlorophyta has a high total density of algae in the reserve (accounting for 49% of total density). In addition, Melaleuca-Lepironia (N5) had the highest density of phytoplankton, which *Zygnemopsis americana* dominated, with 12,731 individuals/L (accounting for 92%). The filamentous *Zygnematophyceae* usually predominate in freshwater habitats where they can rapidly generate large amounts of biomass (Pichrtova et al., 2018); it could be demonstrated that this site has a salinity in water is lower than other locations in the reserve. HT6 canal (N1) in the presence of *Chodatella subsalsa*, *Trachelomonas hispida* and *Eunotia* sp. were high density at 250 individuals/L, 1,138 individuals/L and 1,499 individuals/L, respectively. In the Lepironia-Eleocharis habitat (N2), there was a high density of *Glenodinium sp*. (1,742 individuals/L). The results

Table 1. Phytoplankton density at each location (individuals/L)

Phyla	N1	N2	N3	N4	N5	N6	Total
Chlorophyta	1,077	124	331	912	13,674	578	16,694
Euglenophyta	4,641	48	1,327	-	-	-	6,015
Bacillariophyta	2,246	2,787	202	46	92	3,935	9,307
Dinophyta	83	1,758	180	-	-	-	2,021
Chrysophyta	56	-	72	-	-	-	128
Total	8,102	4,715	2,111	958	13,766	4,512	-

also show that the Melaleuca habitat has the lowest individual density, this could be explained that this is an area where frequent exploitation affects the development of phytoplankton species. In addition, according to Sulastri et al. (2020), phytoplankton abundance levels of more than 15,000 individuals/L are commonly found in eutrophication, thereby showing that the surface water environment of the reserve tends to be rich in nutrients.

Zooplankton

Composition of zooplankton

At Phu My species-habitat conservation area, a total of 57 species belonging to 4 phyla of zooplankton were recorded (Figure 4). The phylum Rotifera dominates with the appearance of 35 species (63% of the total). Arthropoda and Protozoa accounted for 21% (12 species), 11% (6 species) and 7% (4 species) of the remaining phyla. The results show a decline in species composition compared to 2018; about 10 species were not recorded in 2021, mainly belonging to the Arthropoda.

The species of *Brachionus bidentata*, *Cephallodella gibba*, *Lecane bulla*, *Lecane hastata*, *Lecane pyriformis*, *Polyarhtra vulgaris* and *Chydorus alexandrovi* and *Diaphanosoma brachyurum* (Arthropoda) and *Arcella vulgaris* (Protozoa) were recorded at most monitoring sites in reserve. The dominant phylum in the study area shows that the aquatic environment is eutrophic, as they can feed on small particles such as bacteria and detritus that are often abundant in nutrient-rich water bodies (Ismail & Adnan, 2016). Moreover, Rotifera is widely distributed in all types of freshwater and brackish water bodies (Xiong et al., 2016); this was consistent with the results of the current study. In addition, the appearance of *Brachionus* species reflects the algal bloom in the study area (Ceirans, 2007). Protozoa are often used to indicate organic pollution in water (An et al., 2012). In aquatic ecosystems, Cladocera belonging to the phylum Arthropoda, which is the most crucial group providing nutrition for higher organisms, especially in the fish food chain, and they are susceptible to water pollution even when the contaminant concentration is very low, so Cladocera usually grows well in clean water (Meshram et al., 2017). In addition, Copepoda belonging to the phylum Arthropoda form a group of zooplankton predominating in freshwater or marine environments (Meshram et al., 2017). Compared to the study in Cai Lon River, Kien Giang province, the zooplankton composition is more diverse and richer, with 105 species recorded, including 47 species of phylum Rotifera, 21 species of phylum Protozoa, 14 species of Cladocera and 23 species of Copepod (Phuoc et al., 2018). It can be seen that the above studies showed that the Rotifera dominated all phyla occurring in the water bodies. The distribution and abundance of zooplankton species in the study sites can be influenced by various environmental factors such as water clarity and chlorophyll content (Ismail & Adnan, 2016), as well as the degree of pollution in each water body determines the density of plankton (Dorak, 2013).

The total number of species belonging to the zooplankton phyla at each location ranges from 11–37 species (Figure 5). The HT6 canal (N1), Lepironia-Eleocharis (N2), Melaleuca (N4) and Melaleuca-Lepironia-Eleocharis (N6) have five groups of zooplankton. Particularly, there were no species belonging to Copepoda and other phyla were recorded inland canal and Melaleuca-Lepironia. The analysis results also show that the number of species was low and less abundant in the
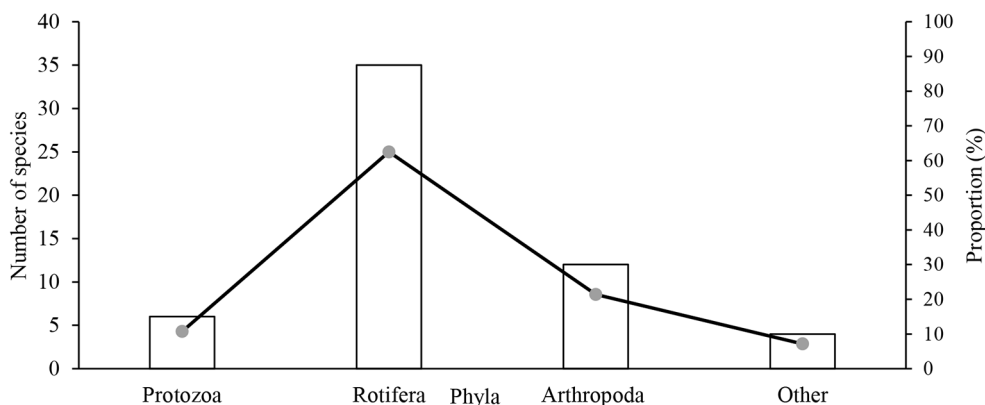

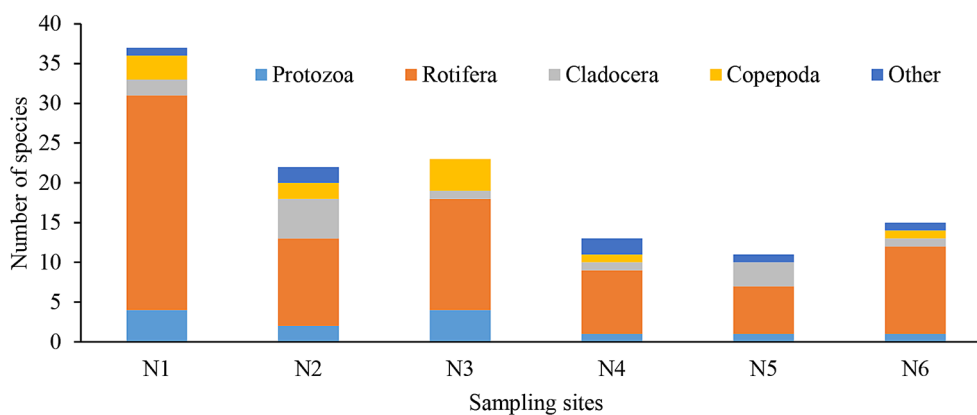**Figure 4.** Composition of zooplankton in the study area

Figure 5. Composition of zooplankton at the sampling locations

habitats of Melaleuca, Melaleuca-Lepironia, Melaleuca-Lepironia-Eleocharis; this was similar to the research results on the composition of phytoplankton species. In addition, the Melaleuca-Lepironia habitat was determined to have a low species diversity and was similar to the results reported in 2018 (Ni, 2018). For the HT6 canal, the number of zooplankton species was the highest, followed by the infield canal and Lepironia-Eleocharis. Species of the genus Asplanchna (*Asplanchna priodonta*), Brachionus (*Brachionus angularis*), Filinia (*Filinia opoliensis, Filinia longiseta, Filinia terminalis*), genus Polyarhtra (*Polyarhtra vulgaris*) and Trichocera (*Trichocera similis and Trichocerca* sp.) were found mainly at HT6 and infield canals, which were good indicators of eutrophication (An et al., 2012; Ismail & Adnan, 2016). This could be explained that these two locations receive wastewater from domestic and agricultural activities in the area, contributing to enriching organic nutrients in the water. In addition, Copepoda (especially *Nauplius*) appeared in 4 per 5 locations (except N5 Melaleuca-Lepironia habitat), a group with high nutrient content and an essential food for many fish and seafood species (Van et al., 2012). *Arcella vulgaris* (Protozoa) was found at all sampling sites, the existence and development of this species

shows that the water body is in a state of organic pollution (Dung & Oanh, 2011).

Density of zooplankton

The density of zooplankton fluctuated relatively large from 17,483–758,282 individuals/L and the total density of each also varied considerably from 15,933–876,008 individuals/L (Table 2). Compared with some other studies, the density of zooplankton in the reserve was higher (Van et al., 2012; Trinh & Vinh, 2019). Table 2 shows that the phylum Rotifera dominated in species composition; however, Protozoa was the phylum with the predominant density of organisms in the reserve, accounting for 47% of the density. *Arcella vulgaris* was the species with the highest density, with 777,194 individuals/L (accounting for 89%), contributing to the density advantage of Protozoa. Besides, the Melaleuca-Lepironia and Melaleuca-Lepironia-Eleocharis habitats had low species composition, but these locations had high zooplankton density. *Anuraeopsis fissa, Filinia opoliensis, Filinia terminals, Polyarhtra vulgaris* and *Nauplius* at HT6 canal have the dominant species density, reaching 33,750; 14,063; 14,063; 30,938; and 36,563 individuals/L, respectively. Besides

Table 2. Zooplankton density at each location (individuals/L)

Phyla	N1	N2	N3	N4	N5	N6	Total
Protozoa	9,984	8,747	108,575	43,750	294,286	410,667	876,008
Rotifera	152,438	4,587	135,450	37,800	191,286	309,467	831,027
Cladocera	1,125	1,675	7,167	350	80,929	29,333	120,578
Copepoda	11,250	533	25,442	525	0	1,467	39,217
Others	2,850	1,942	23	2,288	1,482	7,348	15,933
Total	177,646	17,483	276,656	84,713	567,982	758,282	

that, *Arcella vulgaris* (8,533 individuals/L), *Lepadella ovalis* (1,067 individuals/L), *Chydorus alexandrovi* (1,067 individuals/L) and *Chironomidae* (1,067 individuals/L) were predominant densities at the Lepironia-Eleocharis. The infield canal recorded the best-growing species of *Diffugia lebes, Filinia camasecla, Filinia opoliensis, Mongolodiaptomus gladialus* and *Nauplius,* with the dominant species density. In the remaining habitats in reserve, such as Melaleuca, Melaleuca-Lepironia, Melaleuca-Lepironia-Eleocharis, the dominant species density belongs to *Arcella vulgaris, Brachiomus bidentata, Lecane bulla* and *Chydorus alexandrovi*. Generally, the species with the predominant density at each monitoring location are mostly in the group well adapted to the water environment rich in organic nutrients.

Composition of zoobenthos

The study results show that the composition of benthic species at the Phu My species-habitat reserve in 2021 was relatively low, with only two benthic species *Tubifex sp.* belonging to the phylum Oligochaete and the larvae of *Chironomidae* belonging to the phylum Insecta. This result reduced 6 species compared to 2018; however, all species in 2018 were not recorded in 2021 (Ni, 2018). The appearance of the species *Tubifex* sp. indicates that the environment was likely to be contaminated with organic matter concentrated in the habitat with a density of 20 individuals/m² (Table 3). Lepironia-Eleocharis was the highest density of benthic animals with 40 individuals/m², followed by Melaleuca-Lepironia-Eleocharis habitat (10 individuals/m²) and Melaleuca and Melaleuca-Lepironia (5 individuals/m²). There were no species found at the HT6 canal and the infield canals. Oligochaeta could tolerate adverse environmental conditions such as low DO and high pollutant concentrations. In some other water

bodies, it was found that benthic animals developed relatively richly and diversely. According to Dung & Minh (2013), 30 benthic species belonging to 5 classes were detected, including Oligochaete, Polygochaete, Bivalvia, Gastropoda and Insecta. *Limnodrilus hoffmeisters* appeared on all survey sites, indicating organic pollution and high nutrient content (mainly TP and TOC) (Dung & Minh, 2013; Peng et al., 2020). It can be seen that the current study area has a less diverse benthic species composition than other areas, which can be explained by the collected samples having many plant residues, mainly grass, grass and leaves. Therefore, the bottom sediment quality in the reserve is unsuitable for benthic species life.

Evaluating surface water quality using biodiversity indices

The study was based on phytoplankton, zooplankton and benthic to calculate the Shannon-Wiener biodiversity index (H'), Pielou index (J) and average scoring per taxon (ASPT). The analysis results show that H' and J reflected the level of water pollution based on phytoplankton composition at each monitoring location (Figure 6). The Shannon-Wiener index at each location ranges from 0.29 to 3.0 (Figure 6a), indicating the surface water quality in the PMCA was in the range of medium pollution from β to heavy pollution. Similarly, the Pielou index at 6 monitoring locations fluctuated from 0.21 to 0.78 (Figure 6b), reflecting the polluted water environment from moderate (β) to severe. The results of H' and J illustrate that in two water bodies the Melaleuca-Lepironia and Melaleuca-Lepironia-Eleocharis have a heavy pollution level, and the medium pollution of the Lepironia-Melaleuca habitat at α level, whereas HT6 and in-field canals were polluted at β level. The Shannon-Wiener index (H') based on zooplankton shows that the water environment in the

Table 3. Composition of zoobenthos in the study area

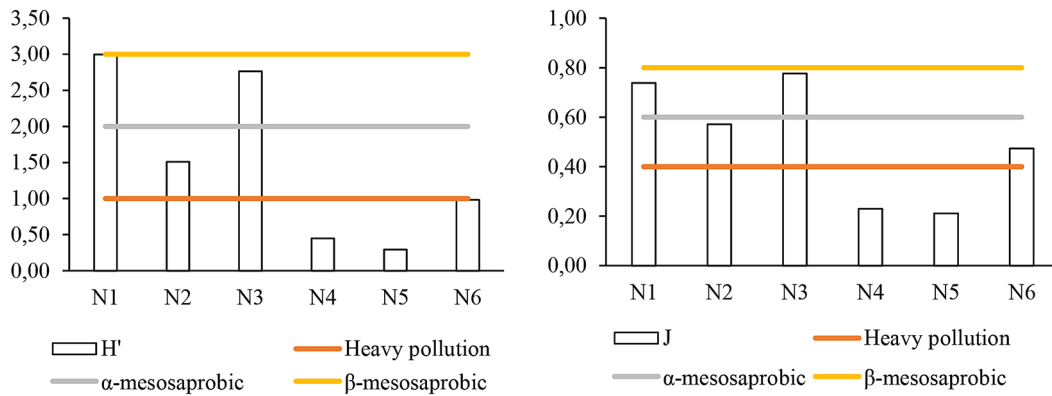| No.	Composition	Sampling sites					
		N1	N2	N3	N4	N5	N7
	Oligochaeta	0	1	0	0	0	0
1	*Tubifex* sp.		20				
	Insecta	0	1	0	1	1	1
2	Chironomidae		20		5	5	10
	Total	0	2	0	1	1	1
	Density (individuals/m²)	0	40	0	5	5	10

Figure 6. The indices of H' and J based on phytoplankton

NR has moderate pollution from β to heavy pollution, ranging from 1.55 to 2.88 (Figure 7a). The Pielous index (J) also indicates that the water environment in the study area varied from moderate pollution at level β to severe pollution (0.60–0.80) (Figure 7b). Melaleuca-Lepironia and Melaleuca-Lepironia-Eleocharis were heavily polluted, followed by the Lepironia-Eleocharis and Melaleuca with moderate pollution at α level, while HT6 and the infield canals were less polluted (moderate pollution at β level). It can be seen that the use of zooplankton and phytoplankton in the reserve reflects the pollution status of the water body at the same

level, from moderate pollution at level β to heavy pollution. The analysis of the H' index and ASPT showed that the water environment was heavily polluted and very dirty (Table 4). However, calculating the biological index based on benthic animals to assess the water quality in the reserve was generally not feasible and not objective because the benthic species composition here is very low. In some locations, no species could be detected due to the influence of the bottom sediment. From the above analysis, it can be found that the phytoplankton and zooplankton composition at the Phu My species-habitat conservation area can be used
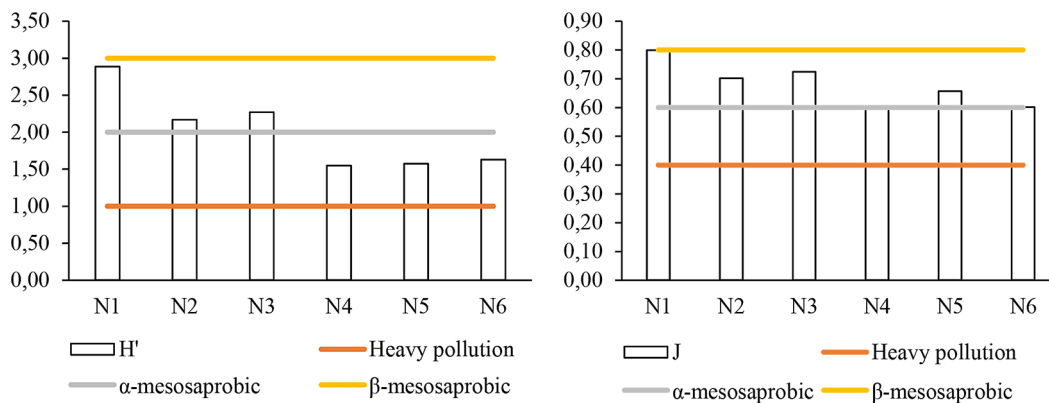

Figure 7. The indices of H' and J based on zooplankton

Table 4. Values of H' and ASPT basing on zoobenthos

No.	Sites	H'	Level of pollution	ASPT	Level of pollution
1	N1	-	-	-	-
2	N2	0,69	Heavy pollution	1,5	Very dirty
3	N3	-	-	-	-
4	N4	0	Heavy pollution	2	Very dirty
5	N5	0	Heavy pollution	2	Very dirty
6	N6	0	Heavy pollution	2	Very dirty

to assess the quality of the water environment in the study area, reflecting the current situation of the surface water environment being moderately polluted from β to severe pollution.

CONCLUSION

There were 71 species of phytoplankton belonging to 5 phyla, 57 species of zooplankton belonging to 4 phyla and 2 species of zoobenthic belonging to two groups. The Euglenophyta and Rotifera dominate in the species composition structure and the Chlorophyta and Protozoa dominate in the individual density, indicating that the water quality in the area is organic and nutrient-polluted. Typically, some species with high density and frequency include *Trachelomonas volvocina*, *Phacus torta*, *Euglena oxyuris*, *Arcella vulgaris*, *Brachionus bidentata*, *Lecane hastata*, *Lecane bulla*, *Lecance pyriformis*, *Lecance pyriformis* and *Polyarhtra vulgariis*. The Shannon-Wiener biodiversity index (H') and Pielou index (J) based on phytoplankton and zooplankton composition both determine the water environment from moderate pollution at β levels to heavy pollution. The results of the water quality classification based on ASPT showed that the surface water quality in the reserve is very dirty. For the study area, water quality assessment based on the composition and density of phytoplankton and zooplankton species should be given priority should be given over zoobenthic.

REFERENCES

1. An, X.P., Du, Z.H., Zhang, J.H., Li, Y.P., Qi, J.W. 2012. Structure of the zooplankton community in Hulun Lake, China. Procedia Environmental Sciences, 13, 1099-1109.

2. Bhadrecha, M.H., Khatri, N., Tyagi, S. 2016. Rapid integrated water quality evaluation of Mahisagar river using benthic macroinvertebrates. Environ Monit Assess, 188, 254-260.

3. Boyd, C.E., Tucker, C.S. 1992. Water quality and pond soil analyses for aquaculture. Auburn University, Alabama, 36849, 139-148.

4. Ceirans, A. 2007. Zooplankton indicators of trophy in Latvian lakes. Acta Universitatis Latviensis, 723, 61-69.

5. Dorak, Z. 2013. Zooplankton abundance in the lower Sakarya River Basin (Turkey): Impact of environmental variables. J. Black Sea/Mediterranean Environment, 19(1), 1-22.

6. Dung, D.T., Oanh, N.H. 2011. Characteristics of animals floating on polluted canals and canals in Can Tho in the dry season. Scientific Journal of Ho Chi Minh City University of Education, 30, 108-116.

7. Gao, H., Zhang, S., Zhao, R., Zhu, L. 2018. Plankton community structure analysis and water quality bioassessment in Jiulong Lake. In IOP Conference Series: Earth and Environmental Science, IOP Publishing, 199(2), 022031.

8. Ha, N.T.T., Yen, T.T.H., Dung, D.T., Nguyen, D.T., Huy, T.Q. 2016. Using zooplankton to indicate nutrient levels in Gia Lam district, Hanoi irrigation canals. Vietnam Journal of Agricultural Science, 14(11), 1753-1763.

9. Hoa, N.V., Thanh, D.K. 2014. Species composition and density of algae at different salinities in the Biofloc system. Can Tho University Journal of Science, 32, 113-122.

10. Ismail, A.H., Adnan, A.A.M. 2016. Zooplankton composition and abundance as indicators of eutrophication in two small Man-made Lakes. Tropical Life Sciences Research, 27(1), 31-38.

11. Jakhar P. 2013. Role of phytoplankton and zooplankton as health indicators of aquatic ecosystem: A review. International Journal of Innovation Research Study, 2(12), 489-500.

12. Jiang, Y., He, W., Liu, W., Qin, N., Ouyang, H., Wang, Q., Kong, X., He, Q., Yang, C., Yang, B., Xu, F. 2014. The seasonal and spatial variations of phytoplankton community and their correlation with environmental factors in a large eutrophic Chinese lake (Lake Chaohu). Ecological Indicators, 40, 58-67.

13. Kemka, N., Njine, T., Togouet, S.H.Z., Menbohan, S.F., Nola, M., Monkiedij, A., et al. 2006. Eutrophication of lakes in urbanized areas: The case of Yaounde Municipal Lake in Cameroon, Central Africa. Lakes & Reservoirs: Research and Management, 11, 47-55.

14. Khanh, H.C., Dung, D.T., Nam, T.S., Thuan, N.C., Chiem, N.H., Cong, N.V. 2021. Diversity of floating plants inside and outside the closed dike in Vong Dong commune, Thoai Son district, An Giang province. Can Tho University Journal of Science, 1, 170-183.

15. Lien, N.T.K., Giang, H.T. & Ut, V.N. 2014. The composition of zoobenthos (Zoobenthos) in Hau River. Can Tho University Journal of Science: Seafood(2), 239-247.

16. Lien, N.T.K., Nhu, N.T.T., Hoa, A.V, Giang, H.T., Dong, N.M., Dung, T.V. 2022. Phytoplankton composition in wetlands in Tri Ton district, An Giang province. Can Tho University Journal of Science, 58(3B), 240-250.

17. Luu, P.T. 2017. Phytoplankton area and water quality of Thi Vai River before and after detecting incidents of environmental violations of Vedan. Journal of Science and Technology, 27, 24-34.

18. Mach, P.V., Tao, N.D. 2015. Using zooplankton,

phytoplankton and benthic fauna to assess water quality in the confluence of Nhue Day River in Ha Nam province. The 5th National Scientific Conference on Ecology and Biological Resources.

19. Meshram, D., Catherine, D., Badh, N., Khedkar, S., Vijay, R., & Nandy, T. 2018. Zooplankton diversity as indicators of pollution in warm monomictic Dal-Nigeen Lake. Sustainable Water Resources Management, 4, 897-904.

20. Ni, D.V. 2018. Project report detailed functional zoning of Phu My Species-Habitat conservation area. Department of Natural Resources and Environment of Kien Giang province.

21. Peng, F., Pan, C., Zhang, N., Braak, C.J.F., Salvito, D., Selck, H., Ying, G., Brink, P.J.V.D. 2020. Benthic invertebrate and microbial biodiversity in subtropical urban rivers: Correlations with environmental variables and emerging chemicals. Science of the Total Environment, 709, 136281-136291.

22. Phuoc, T.V., Hong, T.T.B., Silk, L.T.M. 2018. Zooplankton composition in Cai Lon River, U Minh Thuong district, Kien Giang province. Can Tho University Journal of Science, 2, 1-6.

23. Pielou, E.C. 1975. Ecological diversity. John Wiley & Sons, New York

24. Quyen, L.C., Lan, T.T., Ut, V.N. 2011. Distribution of benthic animals in Cai Sao canal, An Giang province. Can Tho University Journal of Science, 18b, 127-136.

25. Quynh, N.X., Pinder, C., Tilling, S. 2001. Classification of groups of freshwater invertebrates commonly encountered in Vietnam, Hanoi National University Publishing House.

26. Ren, L., Zhang, Z., Zeng, X., Ma, Y., Zeng, Y., Zhou, C. 2011. Community structure of zooplankton and water quality assessment of Jialing River in Nan Chong. Procedia Environmental Sciences, 10, 1321-1326.

27. Salman, J.M., Jawad, H.J., Nassar, A.J. 2013. A study of phytoplankton communities and related environmental factors in Euphrates River (between tor cities: Al-Musayyab and Hindiya), Irap. Journal of Environmental Protection, 4(10).

28. Shannon, C.E., Weaver, W. 1949. A Mathematical Model of Communication. Urbana, IL: University of Illinois Press.

29. Sharma, M.P., Sharma, S., Goel, V., Sharma, P., Kumar, A. 2006. Water quality assessment of Behta River using benthic macroinvertebrates. Life Science Journal, 3(4), 68-74.

30. Sihombing, V.S., Gunawan, H., Sawitri, R. 2017. Diversity and community structure of fish, plankton and benthos in Karangsong Mangrove Conservation Aresa, Indramayu, West Java, Indonesia. Biodiversitas, 18(2), 601-608.

31. Srichandan, S., Kim, J.Y., Bhadury, P., Barik, S.K., Muduli, P.R., Samal, R.N., Pattnaik, A.K., Rastogi, G. 2015. Spatiotemporal distribution and composition of phytoplankton assemblages in a coastal tropical lagoon: Chilika, India. Environ Monit Assess, 187, 47-64.

32. Sulastri, Akhdiana, Khaerunissa, N. 2020. Phytoplankton and water quality of three small lakes in Cibinong, West Java, Indonesia. Earth and Environmental Science, 477, 12016-27.

33. Thakur, R.K., Jindal, R., Singh, U.B., Ahluwalia, A.S. 2013. Plankton diversity and water quality assessment of three freshwater lakes of Mandi (Himachal Pradesh, India) with special reference to planktonic indicators. Environ Monit Assess, 185, 8355-73.

34. Thuan, N.C., Chiem, N.H., Dung, D.T. 2010. Assessment of water quality by biological monitoring index $BMWP_{VIETNAM}$ in Cai May canal, Phu Tan district, An Giang province. Can Tho University Journal of Science, 15b, 125-131.

35. Tien, D.D., Hanh V. 1997. Classification of Chlorococcales. Agricultural Publisher.

36. Trinh, T.S.H., Vinh, N.T. 2019. Biodiversity of zooplankton in Cu Lao Cham Biosphere Reserve – Hoi An, 2015-2016. Journal of Marine Science and Technology, 19(4A), 273-285.

37. Tuyen, N.V. 2003. Algae biodiversity in the inland waters of Vietnam. Agriculture Publishing House, Ho Chi Minh City.

38. Ut, V.N., Oanh, D.T.H., Giang, H.T. 2013. Species composition and density of microalgae in coastal salt and artemia production area Vinh Chau district, Soc Trang province. Anthology of Marine Studies, 19, 202-214.

39. Van, L.T.H., My, T.N.D. 2020. Survey on phytoplankton composition and surface water quality at some points around the aquaculture area in Ben Tre province. Journal of Science and Technology Development, 4(1), 1-10.

40. Van, M.V., Dinh T.D., Tuan N.A. 2012. Species composition and density of plankton distributed in the coastal area of Soc Trang - Bac Lieu. Can Tho University Journal of Science, 23a, 89-99.

41. Xiong, W., Li J., Chen, Y., Shan, B., Wang, W., Zhan, A. 2016. Determinants of community structure of zooplankton in heavily polluted river ecosystems. Scientific Reports, 6, 22043-22053.

42. Xiong, W., Ni P., Chen, Y., Gao, Y., Li S., Zhan, A. 2019. Biological consequences of environmental pollution in running water ecosystems: A case study in zooplankton. Environmental Pollution, 252, 1483-1490.

43. Yen, T.T.H., Thai, T.T., Yen, N.T.M., Quang, N.X., Luu, P.T. 2021. Biodiversity of phytoplankton in Tri An Lake, Dong Nai province. Life Science, 342-350.

44. Zhu, W., Wan, L., Zhao, L. 2010. Effect of nutrient level on phytoplankton community structure in different water bodies. Journal of Environmental Sciences, 22(1), 32-3.