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Effects of Water Stratification and Mixing on Plankton Community Structure in a Floating Solar Power Plant

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Abstract: Plankton community structure play pivotal roles in aquatic ecosystems, influencing their structure, function and services. However, little is known about the effects of water stratification and mixing on the dynamics of aquatic ecosystems. The influence of water stratification and mixing on plankton community structure was studied in the Floating Da Mi Solar Power Plant was done between March 2020 and September 2022, encompassing both dry and rainy seasons. Data from 4 sites were used as a representative example for the study area to conduct a qualitative study. To implement this assessment, the analyses were based on MRC methods and classifications, these improved by the scientific group. The results showed that 86 species of phytoplankton and 23 species of zooplankton were found in the study area. The density of phytoplankton at each site ranged from 279 to 32,282 individuals/sample, while the density of zooplankton at each site fluctuated from 5 to 33 individuals/sample. The calculated values for the diversity index (H') of phytoplankton and zooplankton fluctuated from medium to quite high levels from 1.55 to 3.69; 1.56÷2.95 respectively. The results also showed that several environmental variables, including temperature, dissolved oxygen, and chlorophyll-a were correlated with species richness, density and diversity index of phytoplankton and zooplankton. The obtained results will be useful for the monitoring of changes of aquatic ecosystem at the study area, in particular the sensitivity of aquatic flora and fauna to changes in environmental variables.

Keywords: Plankton Community Structure, Water Stratification and Mixing, Phytoplankton, Zooplankton, Environmental Variables

1. Introduction

In Vietnam, the demand for electricity has been increasing rapidly along with economic development since the introduction of the doi moi policy in 1986. At the time of the project appraisal (1994), it was estimated that the power supply (12kWh/day/customer) did not meet the potential demand (14-14.4kWh/day/customer) in the southern Vietnam. It was projected that during the period from 1995 to 2000, the power demand would increase by 15.5% p.a. in the entire country and by 17.3% p.a. in the south [1]. In 2019, Vietnam overtook Thailand as the country with the largest installed capacity for solar and wind power in Southeast Asia. By the following year, the country's total solar power capacity reached 16,500 MW, far surpassing the government's target of 850 MW [2]. The Da Mi Solar Power Plant with installed capacity of 47.5 MW solar photovoltaic (PV) was built on the surface of Da Mi Hydro Power Plant at Tanh Linh district and Ham Thuan Bac district, Binh Thuan province. The project is currently active. It has been developed in multiple phases. Post completion of construction, the project got commissioned in May 2019 [3]. The whole project was built on 56.65 ha, in which 50 ha on water surface to install PV arrays and 6.65 ha onshore to build 110 kV station, 2 inverter stations and one 110kV transmission lines with length of 3.5 km [4]. The Da Mi Solar Power Plant is helping Vietnam promote clean energy and meet its climate-action goals. More importantly, the successful financing of the project provides lessons and a model for others. Solar power is one of the main sources of renewable energy in the country. However, the nature of solar power plants typically have site-specific impacts on the environment and surrounding communities. The construction phase will involve site preparation (e.g. grading and levelling) and installation and commissioning of infrastructure (including the floats, PV panels, inverters, transformers, access road and transmission lines). These activities are likely to generate air and noise emissions, impacts on aquatic habitats and present occupational and community health and safety risks [5].

Because of year-round high air temperatures, the total temperature difference in the water column of stratified tropical lakes is typically much smaller than in dimictic cold-temperate lakes during summer stratification. Tropical lakes are fundamentally monomictic and characterized by an annually recurring episode of deep, but not necessarily complete, mixing of the water column during the period when surface-water temperature is lowest [6]. In tropical latitudes, the amplitude of seasonal variation in solar insolation is drastically reduced, with only 12% difference between lowest and highest monthly insolation at the equator compared to 43% at 20° and 170% at 50° latitude. Near the equator, not one but two fairly similar annual minima in solar irradiance occur in June and December [7]. Therefore, local and temporary weather factors such as cloud cover, air humidity, and the speed and direction of surface winds can significantly affect the exact timing, duration and extent of deep mixing; and hence produce considerable inter-annual variation in both the seasonal timing and maximum depth of deep mixing [8].

Y et al (2014) explored vertical and seasonal patterns of microbial diversity in the Dongzhen Reservoir (southeast China). Quantitative PCR, quantitative RT-PCR, and 454 pyrosequencing were used for an in-depth characterization of the bacterial community across time (every three months for one year) and space (five different water depths of 0 m, 10 m, 20 m, 26 m and 33 m). These results indicated that thermal and oxygen stratification shaped the phylogenetic composition of microbial communities in the reservoir. There were significant differences in physical, chemical, and microbiological parameters between epilimnion and hypolimnion ($P < 0.05$). The RNA: DNA ratios were significantly lower in epilimnion and metalimnion but rapidly increased in hypolimnion ($P < 0.05$), suggesting that microorganisms were more active at low temperatures, low dissolved oxygen concentrations and high TN/TP ratios [9]. In the study of Wang et al (2019) analyzed the mixing processes in a shallow subtropical reservoir. Analysis indicated that the persistent high air temperature and stable reservoir water depth lead to a prolonged thermal stratification. The heavy rainfalls had a significant impact on water quality when the dam level is low. The peak value of Dissolved Organic Carbon (DOC) concentration occurred in the wet season, while the specific UV absorbance (SUVA) value decreased when solar radiation increased from spring to summer [10].

Direct observations from literature as well as classifications based on climate and/or morphometry suggest that most, if not all, low latitude reservoirs will stratify on at least a seasonal basis. This finding suggests that low latitude dams have the potential to discharge cooler, anoxic deep water, which can degrade downstream ecosystems by altering thermal regimes or causing hypoxic stress. Many of these reservoirs are also capable of efficient trapping of sediments and bed load, transforming or destroying downstream ecosystems, such as floodplains and deltas [11]. Generally, artificial mixing causes an increase in the oxygen content of the water, an increase in the temperature in the deep layers but a decrease in the upper layers, while the standing crop of phytoplankton (i.e. the chlorophyll content per m^2) often increases partly due to an increase in nutrients entrained from the hypolimnion or resuspended from the sediments. A change in composition from cyanobacterial dominance to green algae and diatoms can be observed if the imposed mixing is strong enough to keep the cyanobacteria entrained in the turbulent flow, the mixing is deep enough to limit light availability and the mixing devices are well distributed horizontally over the lake [12].

The objectives of this research were to: (1) evaluate the effects of water stratification and mixing on the aquatic ecosystem in the Da Mi Solar Power Plant; and, (2) provide useful information on this area for local managers to control the water quality and the ecological health for the Da Mi Lake.

2. Materials and Methods

2.1. Study Sites and Sample Collection

The Da Mi Dam impounds the Da Mi River The main dam is a 72-metre (236 ft) high rockfill dam and it creates the Da Mi Reservoir with a maximum capacity of 141,000,000 cubic meters. The reservoir is daily regulated from the Ham Thuan Reservoir. The main dam is located at 11°14′22″N 107°50′17″E [13]. The sampling sites were located in the Da Mi Solar Power Plant is about from 20 m to 35 m. The sample locations were taken at four different depths (0 m, 10 m, 20 m, and 30 m), respectively. The samples at 04 sites were collected in 6 times of March (2020, 2021, 2022) and September (2020, 2021, 2022) (Figure 1).

2.2. Sample Collection

2.2.1. Water Physiochemical Parameters

The water physiochemical parameters measured in the Project Area included Secchi transparency, temperature, DO and Chlorophyll a. The transparency of water column was measured using a Secchi dish (20 cm diameter) with alternating black and white quadrants that was lowered into the water column until it could no longer be seen from the surface. Light penetration could change with depth in that column of water. All light being reflected from the Secchi disk was passing through the water from the surface. The point at which the disk disappears is a function of the lake turbidity. Slowly lower the Secchi disk into the water on the shady side of the boat until it was no longer visible, known as the Secchi depth. This depth was recorded. This was a measure of the transparency of the water. The Secchi disk transparency protocol used one of two measurements: 1) the distance between the water surface and where the disk disappears; and, 2) the distance between the water surface and where the disk reappears [14].

Temperature measurement systems generally consisted of a sensor, a transmitter, an external power supply (for some types of systems), and the wiring that connects these components. Before measuring temperature, devices must be calibrated in accordance with protocol's specifications as necessary to ensure their accuracy. Read with a thermometer or immersion device in water long enough to allow complete equilibrium. Results to the nearest 0.1°C or 1.0°C were reported, depending on need. Hach HQ30d Portable Meters are used in conjunction with IntelliCAL™ digital electrodes to measure various parameters in water; including the temperature parameter [15, 16].

Measuring DO with a membrane electrode method that was based on the rate of diffusion of molecular oxygen across a membrane. With film-coated electrode systems, the sensor was protected by an oxygen-permeable plastic film that acts as a diffusion barrier against impurities. At steady state, the current was proportional to the DO concentration. Hach HQ30d Portable Meters are used in conjunction with IntelliCAL™ digital electrodes to measure various parameters in water; including the DO parameter [15, 16].

Algal pigments, particularly chlorophyll a, fluoresce in the red wavelengths after extraction in acetone when they are excited by blue wavelengths of light. The principle was collection of algae by filtration, extraction of algal pigments, spectrometric determination of the chlorophyll-a concentration in the extract, evaluation of the chlorophyll-a and phaeopigment concentration from the difference of absorbance at 665 nm prior to and after acidification of the extract [17].

2.2.2. Plankton Organisms

Samples were taken at least 1 m from potential contaminants such as debris and aquatic plants. 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 four different depths (0, 10, 20, and 30 m) was collected in a water sampler. The 10 L of river water was filtered slowly through a plankton net (with a mesh size of 20 μm) to avoid any overflow from the net. Water was splashed on the outside of the net to wash down any phytoplankton and zooplankton adhering to the inner parts of the net [15, 18-20].

When the water volume remaining in the net was only about 150 mL, the water (which contains the plankton sample) was transferred to a 200 mL plastic jar. The sample was immediately fixed in the field by adding ~75 mL of 10% formaldehyde to achieve a final concentration of 4÷5% formaldehyde. The sample jars were labeled with the site name, the site code, the sampling position, and the sampling date. These information was also noted in the field notebook, as was any information about the site that could be influencing the presence or abundance of different types of phytoplankton and zooplankton [15, 18-20].

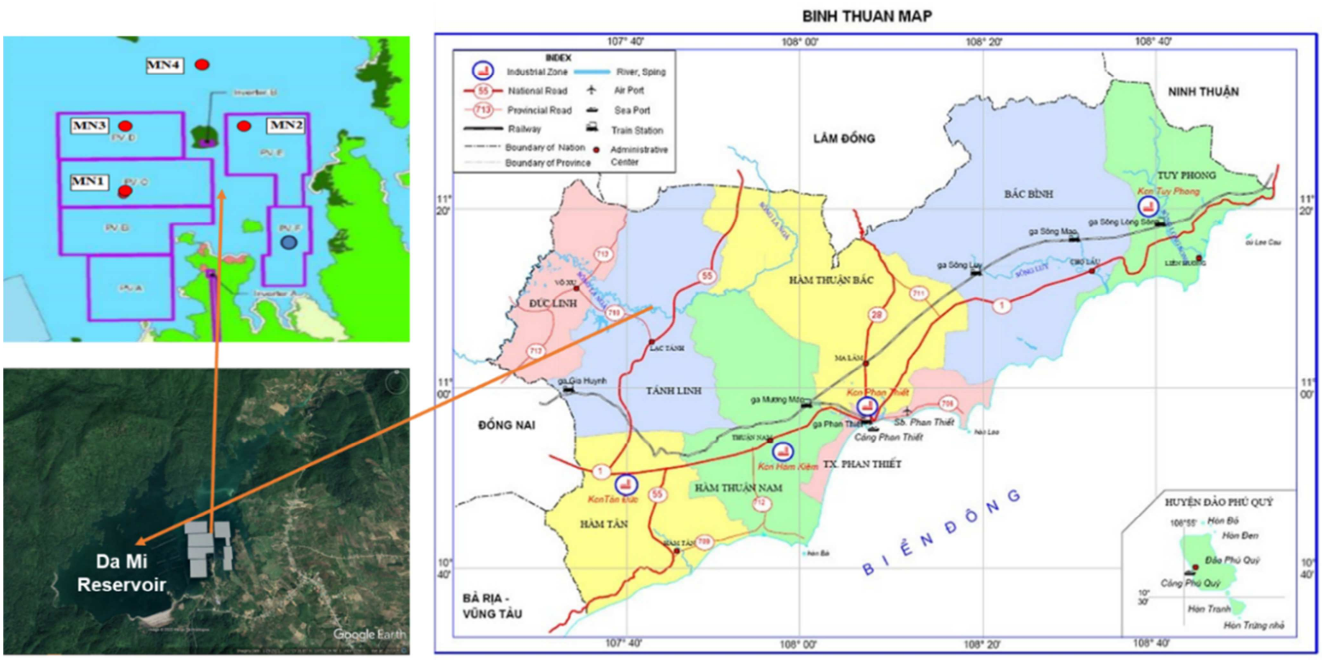


Figure 1. Map of sample sites.

2.3. Analytical Methods

Algae and suspended matter in the water sample were collected by filtration. Then the algae pigment was extracted from the remainder of the filtration into hot ethanol. Spectrophotometric determination of the concentration of chlorophyll-a in the extract [17]. Chlorophyll-a and phaeopigments were analyzed by spectrophotometry (665 nm and 750 nm absorbance, respectively) after acetone (90%) extraction according to the method described by Aminot and Kerouel (2004) [21].

Phytoplankton qualitative samples were observed under microscope (Optika B150). Identification of phytoplankton was based on morphology and taxonomy books. The quantitative analysis of phytoplankton in the samples was performed with a Sedgewick Rafter counting chamber [15, 18].

Zooplankton quantitative samples were observed under microscope (Olympus). Identification of zooplankton was based on morphology and taxonomy books. The quantitative analysis of phytoplankton in the samples was performed to the species level where possible [15, 19].

2.4. Data Analysis

The following metrics of zooplankton and benthic macroinvertebrates at different depths (0 m, 10 m, 20 m, 30 m) of 04 sites sampled in 06 times from March 2020 to September 2022 were calculated (i) taxonomic richness (i.e. number of taxa); (ii) abundance (i.e. numbers of individuals per site); and, (iii) the Shannon-Wiener Diversity Index [19, 20, 22-25]. The obtained data were subject to statistical analysis to test the analysis of variance (ANOVA) and the Pearson correlation among all the parameters using R-statistical software. Significant or highly significant positive or negative correlations were assumed when the p-calculated value was < 0.05 or 0.01, respectively. The three metrics were tested for their potential as indicators of human impact by regressing values for 2020 and 2022 (96 sampling events at 04 different depths for 04 sites) against the water quality variables (temperature, DO, chlorophyll-a).

3. Results and Discussion

3.1. Spatial and Temporal Environmental Heterogeneity

Da Mi Reservoir is a typical tropical warm-monomictic reservoir. The temperature values at the Project Area from March 2020 to September 2022 fluctuated from 24.6°C (Middle the E photovoltaic array – at a depth of 30 m) – 28.8°C (Middle of Da Mi Lake – at a depth of 0 m) (Figure 2a). Thermal stratification of Da Mi Reservoir adapted to temperature changes at different depths and to changes in water density with temperature. By Da Mi was a shallow lake, stratification into epilimnion, metalimnion, and hypolimnion often does not occur, as wind or cooling causes regular mixing throughout the year. This reservoir was called polymictic. There was not a fixed depth that separates polymictic and stratifying lakes, as apart from depth, this is also influenced by turbidity, lake surface area, shape, and climate [26]. Some small, shallow lakes could not experience seasonal thermal stratification because the wind mixed the entire lake. Noted that in the South of Vietnam, there were no large natural lakes, only swamps, such as Bau Sau in Cat Tien National Park. This result was also true with the record of temperature change according to water column in artificial reservoirs such as Tri An, Dau Tieng, Thac Mo, Yaly [27]. For artificial lakes for multipurpose as water supply, flood control, hydropower, there was usually still a flow due to water entering and leaving the lake. Therefore, there was no phenomenon of thermal stratification similar to natural lakes in the temperate region. Temperature tends to decrease gradually from the water surface to the bottom of the lake.

The DO values measured at the Project Area in Da Mi Reservoir fluctuated from 4.48 mg/L (Middle the E photovoltaic array – at a depth of 30 m) – 6.95 mg/L (Middle of Da Mi lake – at a depth of 0 m). Because the bottom flow in the Da Mi Lake was quite strong, especially in the flood season, the DO concentration did not differ much between the water layers (Figure 2b). The monitoring results of water temperature and DO at the Project Area from March 2020 to September 2022 show that the variation of temperature and DO was consistent with the natural conditions of the type of artificial reservoir in tropical region. Water temperature and DO tended to decrease along the gradient from the top to the bottom of the lake. There was not much difference between the photovoltaic arrays. The temperature and DO fluctuation between the surface layer and the bottom layer measured during this monitoring were about 3.0°C and 1.5 mg/L.

This result showed that DO concentration in surface water in the Da Mi Solar Power Plant area met the technical regulation of QCVN 08/MT:2015BTNMT A1 – water used for domestic water supply purposes (after applying normal water treatment technology) and for conservation of aquatic flora and fauna; and the water layers of 10 m and 20 m met the technical regulation of QCVN 08/MT:2015BTNMT A2 – water for domestic water supply purposes but must apply appropriate treatment technology. While the water layer of 30 m only met the technical regulation of QCVN 08/MT:2015BTNMT B2 – water for irrigation and other purposes. While the values of Chlorophyll a measured at the Project Area from March 2020 to September 2022 fluctuated from 1.72 µg/L (Middle of Da Mi lake – at a depth of 30 m) – 2.61 µg/L (Middle the F photovoltaic array – at a depth of 0 m). The monitoring results of Chlorophyll a concentration showed that the water of the Da Mi Lake tended to gradually decrease the concentration from the top to the bottom of the lake (Figure 2c). This result was also consistent with the common characteristics, the deeper the water layer, the lower the density of algae was because of the less light penetration. The biomass of the lake was greatly affected the water quality, the effects of which were be different depending on the age of the lake or the problems related to the water quality.

The concentration of Chlorophyll a indicated that nutrient content in the Da Mi Lake fluctuated from nutrient-poor (Oligotrophic) to moderate nutrient (Mesotrophic) conditions. Chlorophyll a concentrations in 0m and 10m layers tended to be higher than 20m and 30m layers. This was consistent with the natural conditions of the reservoir, the surface layer received a lot of light, so it promoted the growth of algae stronger than the bottom layer [12]. Additionally, the values of Secchi transparency measured at the Project Area of Da Mi Reservoir was quite similar, fluctuated from 1.0 m (Middle of the Da Mi Lake) – 2.1 m (Middle the C photovoltaic array). The results indicated that the values of Secchi transparency in the Da Mi Lake at this time was rather high (Figure 2d). The transparency of the Da Mi Reservoir recorded in the rainy season was lower than this in the dry season due to the high flow from upstream to the lake. Transparency decreased more during the wet season than during the dry season due to flooding from adjacent catchment areas [28].

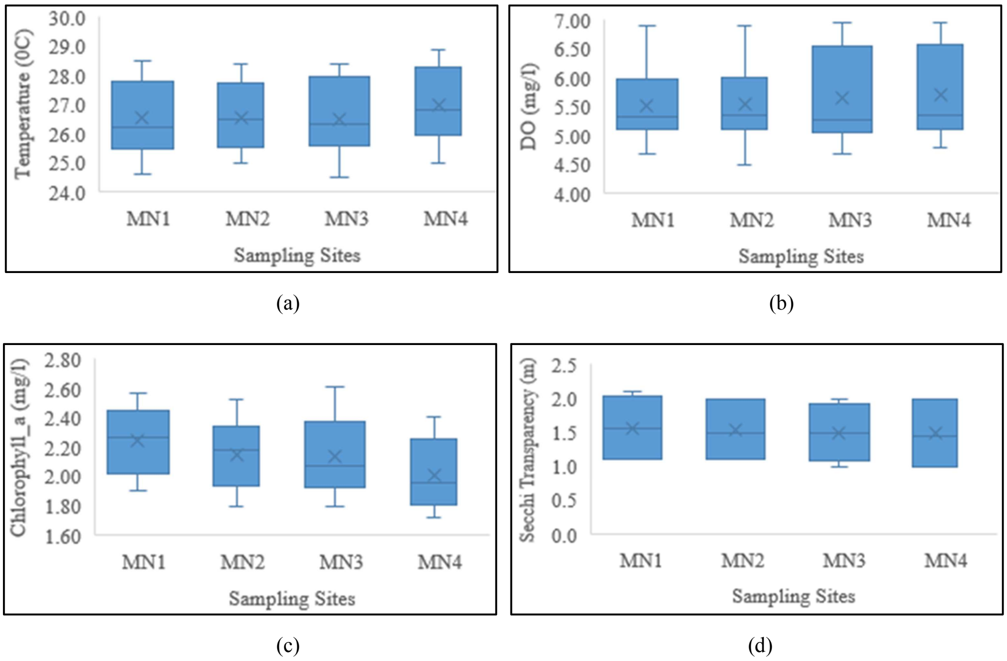


Figure 2. *Temperature (a), DO (b), chlorophyll-a (c), and Secchi transparency (d) profiles of Da Mi Reservoir during 6 sampling times from March 2020 to September 2022.*

3.2. Plankton Community Structure

During the four monitoring times, there were 86 species of phytoplankton and 23 species of zooplankton in the Project Area. Among the phytoplankton, the number of Chlorophyceae species was dominant in species composition, with 36 species in total, gaining around 41.9% of the total (Table 1). Dao (2016) also provide information about more abundant species of Chlorophyceae than other classes [23]. While the number of Eurotatoria species was highest in the species composition of zooplankton, with 9 species in total, accounting for 33.3% of the total (Table 1). The Eurotatoria had more abundant species than other organisms [25].

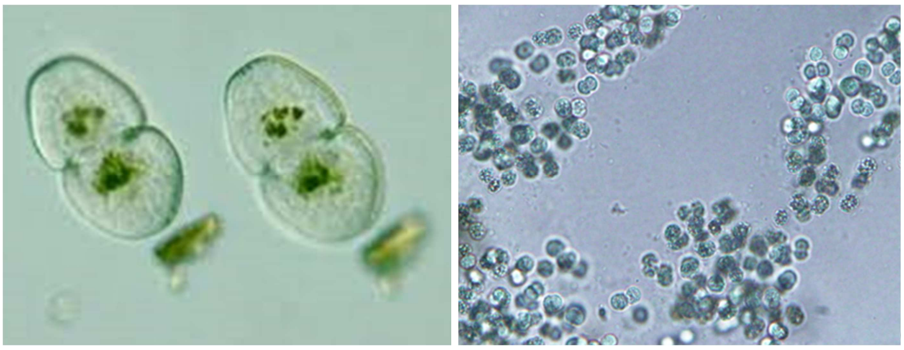
Table 1. *Communities of phytoplankton and zooplankton in the Project Area during March 2020 to September 2022. Numbers in the table indicated the species number of each class/order of phytoplankton and zooplankton.*

Phytoplankton	No. species	%	Zooplankton	No. species	%
Cyanophyceae	13	15.1	Eurotatoria	9	33.3
Chrysophyceae	2	2.3	Cladocera	6	27.8
Baccilariophyceae	25	29.1	Copepoda	3	16.7
Chlorophyceae	36	41.9	Ostracoda	1	22.2
Euglenophyceae	6	7.0	Larva	4	
Dinophyceae	4	4.6			
Total species	86	100	*Total species*	23	100

All species recorded being freshwater phytoplankton. This revealed that all sites located at freshwater area. These species were characterized for the still water conditions (lakes). Among the phytoplankton species found, there was the presence of some species of the genera that was typical for nutrient-poor condition (Oligotrophic) such as *Dinobryon, Mallomonas, Staurastrum, Desmidium, Cosmarium* (Figure 3a); species of the genera indicated for the moderate nutrient (Mesotrophic) conditions as *Microcystis, Pediastrum, Scenedesmus, Dictyosphaerium, Oocystis* (Figure 3b).

In each site, taxon richness ranged from 13 to 43 taxa. The highest richness occurred at the Site MN2 (Middle the E photovoltaic array – at a depth of 0 m), while the lowest richness at the Site MN4 (Middle the Da Mi Lake – At a depth of 20 m). Among the water layers at each sampling site, there was the fluctuation of the species number of phytoplankton also. In the list of species recorded in the Project Area, most species of the genera had the characteristics of floating and freedom types in water column, and incapable of active movement such as *Coelastrum, Ankistrodesmus, Dictyosphaerium, Pediastrum, Scenedesmus, Staurastrum.* However, some other species of the genera found in the lake had the ability to move very actively such as *Dinobryon, Mallomonas, Euglena, Phacus, Ceratium,* *Peridinium*. Additionally, there were some phytoplankton species of the genera in the lake that could move slowly or adjusted their position in the water column such as *Navicula, Pinnularia, Microcystis, Woronichinia*. This contributed to the difference in the number of phytoplankton species among the water layers in the Da Mi Lake, from the surface water (0m layer) to the depth of 30 m at each sampling site. In addition, the difference of species number among the sampling sites and layers was strongly influenced by physiochemical factors and biological organisms (zooplankton).

The quantity of phytoplankton at sites in the Project Area fluctuated from 279 (MN1-1) to 38,292 cells x liter^{-1} (MN2-3). In general, the density of phytoplankton at the Project Area from March 2020 to September 2022 was not high in reservoir conditions in Vietnam. This value was much lower than the phytoplankton density in some reservoirs in the South and the North of Vietnam. The density of phytoplankton was significantly different among the sampling sites (from MN1 to MN4). Besides, the density of phytoplankton changed between water columns at each site was also quite clear.



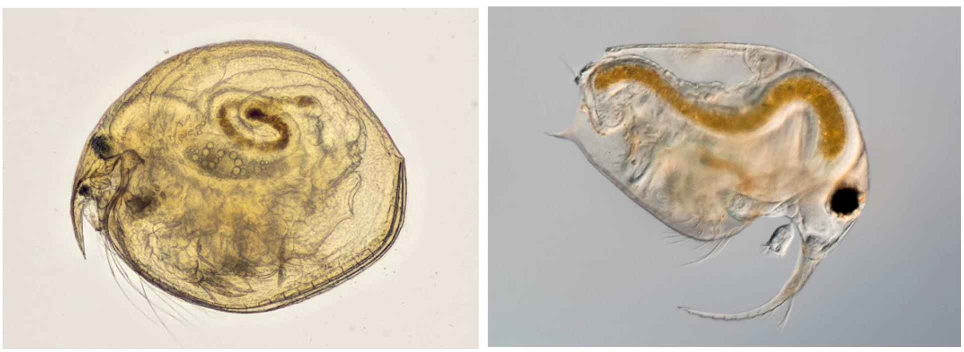
a. *Cosmarium granatum* b. *Microcystis aeruginosa*

Figure 3. *Phytoplankton species indicated for nutrient-poor condition (a) and moderate nutrient (b) in the Da Mi Lake.*

All species recorded being freshwater zooplankton. This revealed that all sites located at freshwater area. Lavae of nauplius copepod had the widest distribution of any taxon collected in 6 sampling times from March 2020 to September 2022, and occurred at all water columns (4/4) and sites (4/4). In addition, *Bosmina longirostris* was distributed widely in most at water columns and sites.

Among the zooplankton species found, there was the presence of some species that was typical for nutrient-poor condition (Oligotrophic) such as *Keratella cochlearis, Ceriodaphnia rigaudi, Chyrorus sphaericus, Allodiaptomus mieni* (Figure 4a); species indicated for the moderate nutrient (Mesotrophic) conditions as *Brachionus calyflorus, Bosmina longirostris, Mesocyclops leuckarti, Thermocyclops hyalinus* (Figure 4b).

Taxon richness in 16 samples of water columns and sites ranged from 3 to 11 taxa. The highest richness occurred at the sites of water column 10m, while the lowest richness at the sites of surface water MN1-1 and MN3-1. Generally for each site, Site MN2 recorded the highest and lowest number of species at Site MN1. Quantity of zooplankton in the Project Area fluctuated from 7 (Sites MN1-1 and MN3-1) to 33 individuals/sample (Site MN2-2). In general, the density of zooplankton was not high. Nauplius copepod were dominant in the species composition.



a. *Chydorus sphaericus* b. *Bosmina longirostris*

Figure 4. *Zooplankton species indicated for acid sulfate water (a) and moderate nutrient (b) in the Da Mi Lake.*

3.3. Diversity Index

The H’ values of phytoplankton at a site ranged from 1.55 to 3.69. The diversity of phytoplankton in the Site MN4-1 was lowest, while the highest diversity was at the Site MN2-1. In general, on the basis of phytoplankton diversity, it could be concluded that the nutrient contents at the Project Area in Da Mi Lake fluctuated from nutrient-poor (oligotrophic) to nutrient-rich (eutrophic) conditions.

The H' values of zooplankton at a site ranged from 1.56 to 2.95. The diversity of zooplankton in the Sites MN1-1 and MN3-1 was lowest, while the highest diversity was at the Site MN2-2. In general, on the basis of zooplankton diversity, it could be concluded that the water environment at the Project Area in Da Mi Lake fluctuated from the moderate nutrient level (mesotrophic) to nutrient-rich (eutrophic).

3.4. Relations Between Plankton Communities and Physicochemical Variables

The results showed that the correlation between environmental and biological parameters was rather high. The Figure 5 showed that the species richness of phytoplankton got the significant negative correlations with the density (-0.44), while there was a strong positive correlation between the species richness of zooplankton with the density (0.85). The monitoring results of phytoplankton and zooplankton in the Da Mi Reservoir indicated that the climatic changes were the fundamental causes determining the processes leading to changes in zooplankton composition (in qualitative and quantitative terms), but anthropogenic factors may considerably influence and change the shape of these processes as Kovalev et al. (1998) [29]. Joshi et al. (2007) concluded the level of species richness was found to be dependent on abiotic factors like temperature, hardness, pH, dissolved oxygen, and chloride [30].

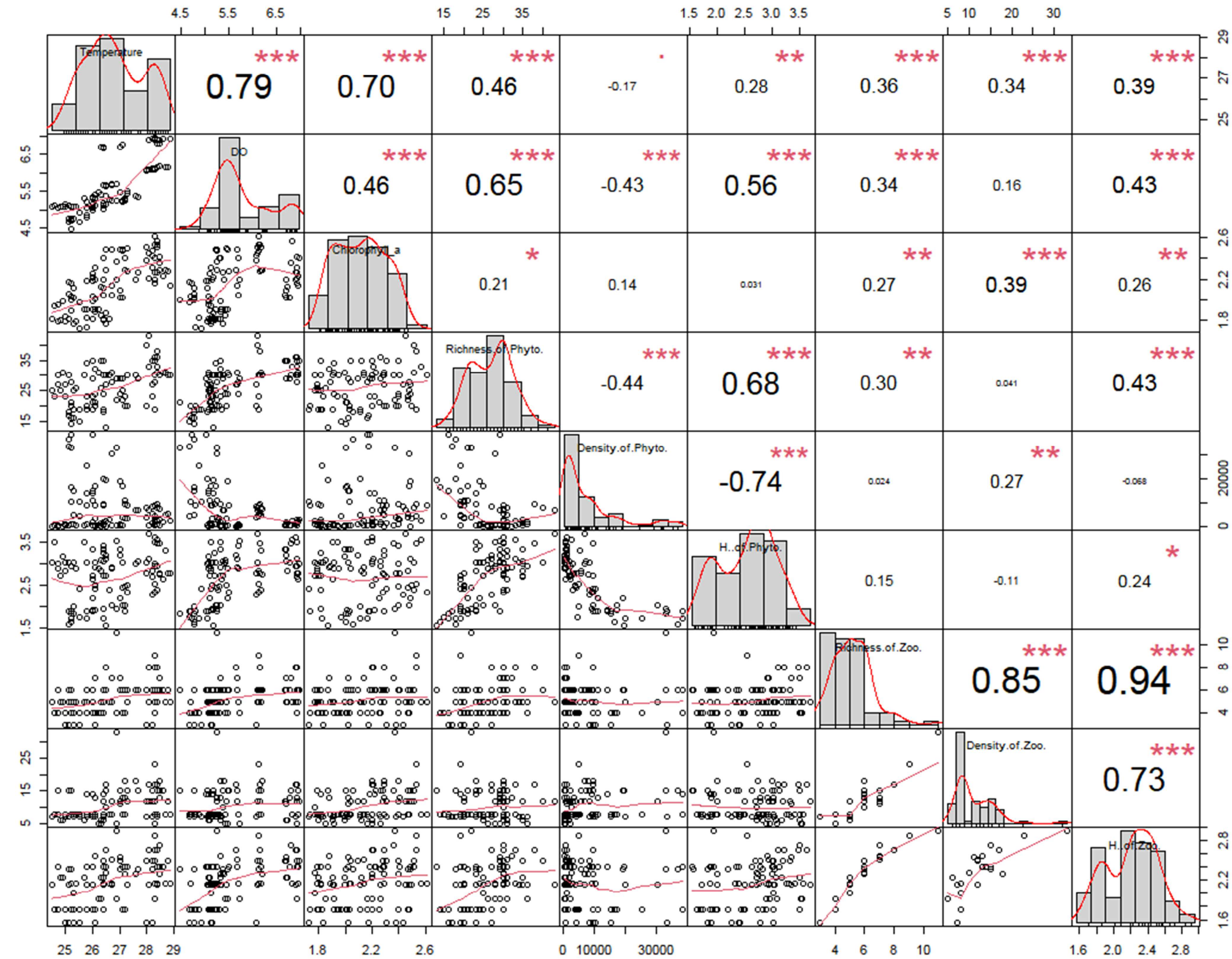


*Figure 5. Relationships between the metrics of physiochemical variables and aquatic ecosystems for sites sampled in the Da Mi Reservoir during 2021 and 2022. "***": the correlation coefficient was greater than 0.40; "**": the correlation coefficient was between 0.25 and 0.40; "*": the correlation coefficient was less than 0.25.*

The study results also indicated that the environmental variables got the significant positive correlations with phytoplankton and zooplankton. Additionally, there was the strong positive correlation between temperature with DO (0.79) and Chlorophyll a (0.70); and, DO was a significant positive correlation with Chlorophyll a (0.46) (Figure 5). Similar to the study of Florescu et al. (2022), the ecological status assessed by Chlorophyll-a (μL−1) highlights that most of the investigated lakes were eutrophic and hypereutrophic. The phytoplankton were influenced by lake types, seasonal variations and nutrient input. The dominance of the Chlorophyceae, Cyanobacteria and Bacillariophyceae influenced the zooplankton's development. The rotifers were the most represented in both species richness and abundance in zooplankton, followed by young stages of copepod [31].

4. Conclusion

During the four monitoring times, we found 86 species of phytoplankton and 23 species of zooplankton in the Project Area. Among the phytoplankton, number of Cyanophyceae species was dominant in species composition with 36 species in total, while the number of Eurotatoria species was highest in the species composition of zooplankton with 9 species in total. The density of phytoplankton ranging from 279 to 38,292 individuals/sample. The dominant species in the monitoring area were *Dinobryon, Coelastrum reticulatum* and *Dictyosphaerium pulchellum*. The densities of benthic macroinvertebrates fluctuated from 5 to 33 individuals/sample. The species of *Paracalanus parvus, Acartia clausi, Oithona similis* and nauplius copepods were dominant. The water quality in this study fluctuated from nutrient-poor (oligotrophic) to nutrient-rich (eutrophic) conditions. The biodiversity of phytoplankton was higher than this comparison with zooplankton.

The results of observations in the study area during 6 times of March (2020, 2021, 2022) and September (2020, 2021, 2022) indicated that the correlation between environmental variables with phytoplankton and zooplankton was rather high. The species richness of phytoplankton got the significant negative correlations with the density (-0.44), while There was a strong positive correlation between zooplankton abundance and density (0.85). While environmental variables were significantly positively correlated with phytoplankton and zooplankton. In addition, there is a strong positive correlation between temperature and DO (0.79) and Chlorophyll a (0.70); and DO have a significant positive correlation with Chlorophyll a (0.46).

The results indicated that interactions between phytoplankton and zooplankton with related environmental variables were highly sensitive to seasonal periodicity, which improved understanding of different roles of biotic and abiotic variables upon phytoplankton and zooplankton variability, and hence, advances management methods for artificial lakes. Moreover, biological monitoring and assessment based on plankton organisms constitutes a step towards the development of effective monitoring strategies and water quality control for aquatic ecosystems.

From the results of the assessment of effects of water stratification and mixing on plankton community structure in the Da Mi Floating Solar Power Plant, some recommendations for control solutions can be made as follows: (i) monitor the water quality and quantity regularly to promptly warn the risks of local people; (ii) through the mass media, propagate to the local people about the importance of water usage and the natural resource protection in this area; (iii) it is necessary to conduct planning on the use of lake water sources for multi-sectors in the local area based on the principles of ecological options, water security, and prior purposes for drinking and daily life; (iv) there must be close and effective coordination between departments, agencies and businesses in the management, exploitation, and protection of water resources; and (v) last but not least, more extensive research is needed to have the best insight into changes of the water quality and the ecological health for Da Mi Lake.

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