RESEARCH ARTICLE

Abundance and diversity of phytoplankton and zooplankton in selected village tanks in Vavuniya, Sri Lanka

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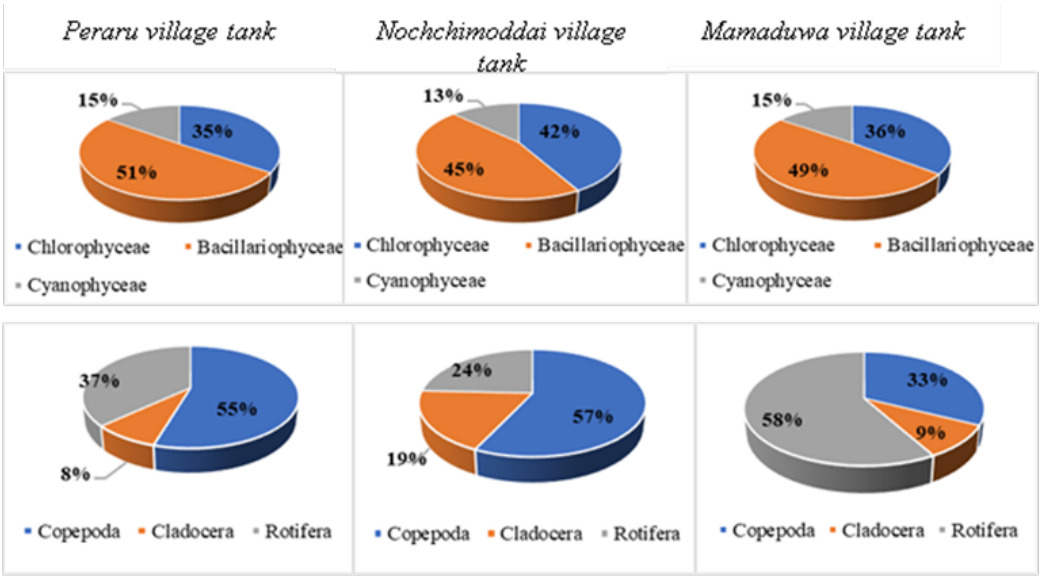

Highlights

- Twenty-nine phytoplankton genera were identified in the three village tanks during the study.
- Phytoplankton belongs to Class Bacillariophyceae dominated in the selected village tanks.
- Fourteen species of zooplanktons were identified in the three village tanks during the study.
- Copepods were dominant in Peraru and Nochchimoddai tanks while Rotifers were dominant in Mamaduwa tank.

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Abundance and diversity of phytoplankton and zooplankton in selected village tanks in Vavuniya, Sri Lanka

R. A. D. Samarawickrama[1,*], A. Nanthakumaran[1], P. Sivakumar[2] and S. Saravanan[3]

[1]Department of Bio-science, Faculty of Applied Science, University of Vavuniya, Pampaimadu, Vavuniya, Sri Lanka
[2]Department of Zoology, Faculty of Science, University of Jaffna, Sri Lanka
[3]National Water Supply and Drainage Board, Vavuniya, Sri Lanka

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Abstract: The abundance and diversity of planktons in selected village tanks namely Peraru, Nochchimoddai and Mamaduwa in the Vavuniya district were studied from March to April, 2021. The objectives of the study were to identify the phyto- and zooplanktons, and to estimate their abundance and diversity in the selected village tanks. Planktons were sampled weekly using a plankton net. Based on the morphological features, samples were initially identified up to the genus level using standard keys and their respective abundance was estimated using Sedgewick- rafter counting cell. Simultaneously, water samples were also collected at each location to determine the water quality parameters such as dissolved oxygen, electrical conductivity, pH, turbidity, temperature, and, nitrate and phosphate concentrations. The results showed that there were 16 genera of Chlorophyceae, six genera of Bacillariophyceae and seven genera of Cyanophyceae, while three species of Copepods, one species of Cladocerans and 10 species of Rotifers were identified. The dominant phytoplanktons belonged to Bacillariophyceae, and represented about 50% of total population of phytoplanktons while Cyanophyceae as the least abundant. Copepods were dominant in Peraru and Nochchimoddai tanks, representing more than 50% of the total zooplankton population while Rotifers were dominant in Mamaduwa village tank, with a 58% of total zooplankton population.

Keywords: phytoplankton; zooplankton; village tanks; Sri Lanka

INTRODUCTION

Planktons are passively drifting animals or plants in a water body. Phytoplankton are the primary producers and act as the foundation of the aquatic food web. Phytoplankton are responsible for approximately 45% of global annual food production (Brierley, 2017). Zooplanktons are small, non-motile or very weak swimmers, and also primary consumers in aquatic ecosystems. They found in the photic zone where food resources are in abundance, and also in deep waters. Protozoa, Rotifers, Cladocerans, Copepods and Ostracods are the major groups of zooplankton with heterotrophic nature. Zooplanktons are the major organisms responsible for the energy flux in aquatic food webs. Zooplanktons play a vital role in biogeochemical cycles including carbon and nitrogen cycle (Keister *et al.*, 2012).

Vavuniya is one of the 25 districts in Sri Lanka that consists of one major, 21 medium and 674 minor irrigation tanks (village tanks) including 26 anicuts (Akther *et al.*, 2014). National Water Supply and Drainage Board (NWSDB) converted Peraru village tank as a constructed reservoir for a special purpose as it now considered as a source of water supply to the local public in the Vavuniya district. The Peraru village tank receives water from two other village tanks viz., Mamaduwa and Nochchimoddai. Presence of planktons are essential for ecosystem development in recently constructed reservoir like Peraru. However, phytoplanktonic algae and zooplanktons can affect the water quality and water treatment processes by clogging filters, forming toxic blooms and controlling the abundance of other species by predation. Hence, it is very much essential to study the abundance and diversity of planktons of tanks that are used as drinking water sources.

MATERIALS AND METHODS

The present study was carried out in three selected village tanks situated in the Vavuniya district located in the Northern Province of Sri Lanka. The samples were collected from the village tanks such as Peraru (8°50'8.00"N 80°27'13.00"E), Nochchimoddai (8°49'25.20"N 80°29'50.40"E) and Mamaduwa (8°49'3.41"N 80°32'40.73"E).

Water samples were collected weekly from Peraru, Nochchimoddai and Mamaduwa village tanks for a period of two months (1st March to 30th April 2021). Three sampling points in each village tank were selected randomly for sampling. Surface water samples were collected from three sampling locations of each village tank by filtering 10 L of water through plankton nets and rinsed into a 10 ml vial. The phytoplankton and zooplankton samples were preserved immediately with the help of 4% formalin. Based on microscopic morphological features, collected samples were initially identified using standard keys up to the genus level. With the help of widely used references, the planktons were confirmed at genus and species level (APHA, 2017; Chengalath *et al.,* 1973). Sedgewick – Rafter Cell was used for the quantitative estimation and abundance was expressed as organisms per cubic meter. Statistical analysis was done using Minitab 17.0 and MS Excel.

The physicochemical properties including Dissolved Oxygen (DO), pH, Electrical Conductivity (EC), turbidity,

**Corresponding Author's Email: rashmikadis1995@gmail.com*
https://orcid.org/0000-0002-8839-4643

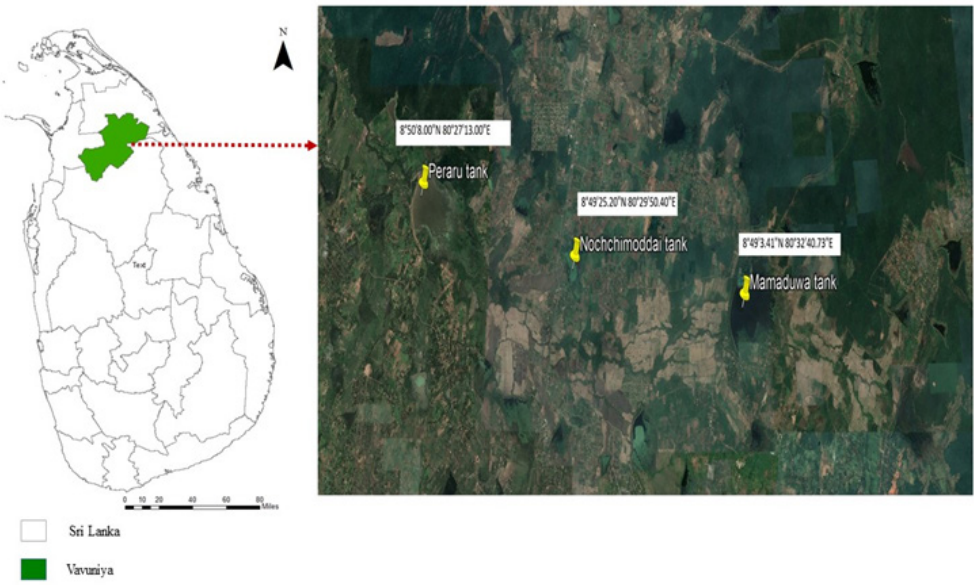

Figure 1: Geographic locations of Peraru, Nochchimoddai and Mamaduwa village tanks.

and temperature were measured at the laboratory of National Water Supply and Drainage Board, Vavuniya. Nitrate and phosphate contents were analyzed in the Environmental Chemistry Laboratory, University of Vavuniya using standard procedures.

Dissolved oxygen and temperature were analyzed using portable DO meter. pH and electrical conductivity were determined by the pH meter and the EC meter respectively. Turbidity of water samples were measured using turbidity meter consisting of nephelometer.

The nitrate concentrations of the samples were determined by the Phenol Disulphonoic Acid method. The intensity of yellow colour was measured by using spectrophotometer at 420 nm. Concentration series of standard nitrate solution were used to prepare a calibration curve.

The phosphate concentrations of the samples were measured by Ammonium Molybdate – Ascorbic acid method. The absorbance of the sample was measured by using spectrophotometer at 882 nm. Concentration series of standard phosphate solution were used to prepare a calibration curve.

RESULTS AND DISCUSSION

Physical and chemical quality parameters of water in Peraru, Nochchimoddai and Mamaduwa village tanks were presented in Table 1.

Table 1: Mean values of physico- chemical parameters of Peraru, Nochchimoddai and Mamaduwa village tanks.

Variables	Mean ± SE		
	Peraru village tank	Nochchimoddai village tank	Mamaduwa village tank
DO (mg/L)	6.68 ± 0.19	3.70 ± 0.20	6.46 ± 0.05
pH (at 25 ^{0}C)	7.45 ± 0.13	7.54 ± 0.17	7.41 ± 0.13
EC (µS/cm)	504.60 ± 31.30	238.1 ± 11.5	280.70 ± 28.60
Turbidity (NTU)	4.86 ± 0.45	9.45 ± 2.91	7.53 ± 0.68
Temperature (^{0}C)	28.35 ± 0.48	28.38 ± 0.45	29.11 ± 0.30
Nitrate (mg/L)	1.30	6.00	2.80
Phosphate (mg/L)	1.55	0.68	1.79

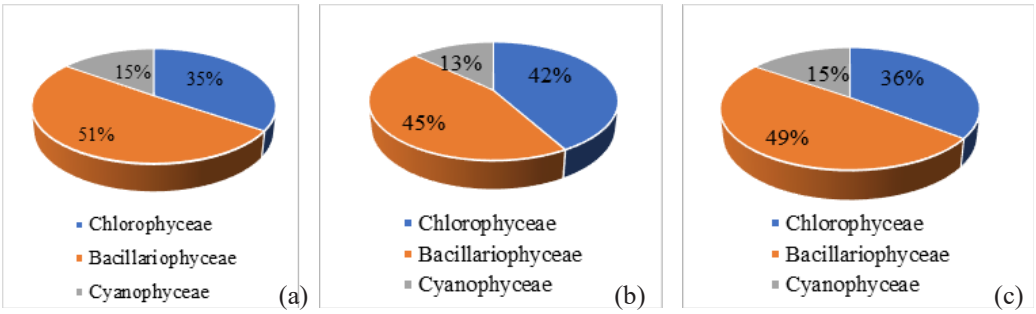

Figure 2: (a) Percentage of abundance of phytoplankton in Peraru village tank, (b) Percentage of abundance of phytoplankton in Nochchimoddai village tank, (c) Percentage of abundance of phytoplankton in Mamaduwa village tank.

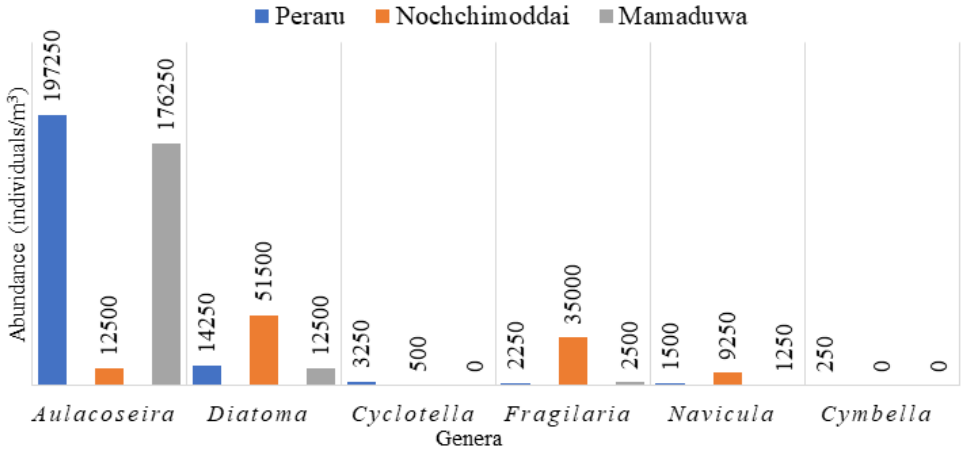

Figure 3: Abundance (individuals per m³) of genera belonging to the Class Bacillariophyceae in Peraru, Nochchimoddai and Mamaduwa village tanks.

Class Bacillariophyceae was the most abundant group found in all three village tanks (Figure 2). The highest number of phytoplankton belonging to the genus *Aulacoseira* was recorded in Peraru village tank followed by Mamaduwa village tank. *Aulacoseira* was relatively less in abundance in Nochchimoddai tank (Figure 3). According to Silva *et al*., (2013), *Aulacoseira granulata* was common in dammed reservoirs and water bodies with intermediate nutrient levels.

Abundance of genus *Diatoma* was high in Nochchimoddai village tank. Genus *Cyclotella* was found in Peraru and Nochchimoddai village tanks (Appendix 1), however, the abundance was high in Peraru village tank. The highest abundance of genus *Fragilaria* was recorded in Nochchimoddai village tank. According to Ferreira and Moreira (1999), the irrigation channels created conditions for algal proliferation which was dominated by diatoms such as *Fragilaria construens*, *Achnanthes subhudsoni* and *Navicula goeppertiana*. Genus *Navicula* was found in all three tanks and highest number was recorded in Nochchimoddai village tank. Genus *Cymbella* was only recorded in Peraru village tank with less abundance (Figure 3). Samarawickrama *et.al. (2022)* reported that the nitrate was significantly high in Nochchimoddai village tank whereas phosphate was significantly high in Mamaduwa village tank. According to unpublished data (Samarawickrama et al., 2022) the nitrate level at Nochchimoddai village tank 6mg/L while it was 2.8mg/L and 1.3mg/L respectively at Mamaduwa village tank and at Peraru village tank. The phosphate content at Nochchmoddai village tank was 0.68 mg/L while it was 1.79 mg/L and 1.55 mg/L respectively at Mamaduwa village tank and at Peraru village tank. The highest level of nitrate content at Nochchimoddai tank might be due to the fact that the farmers living in the surroundings involved in crop cultivation in the land belongs to Nochchimoddai village tank and also involved in rearing cattle. These cattle graze in the tank bed most of the time and the possibilities of mixing of cattle manure with the tank water was very high. As a result, the abundance of diatoms may be found to be high at Nochchimoddai village tank.

The abundance of genus *Chlorella* was recorded as the highest numbers in Peraru village tank followed by Mamaduwa village tank. This may be due to the fact that

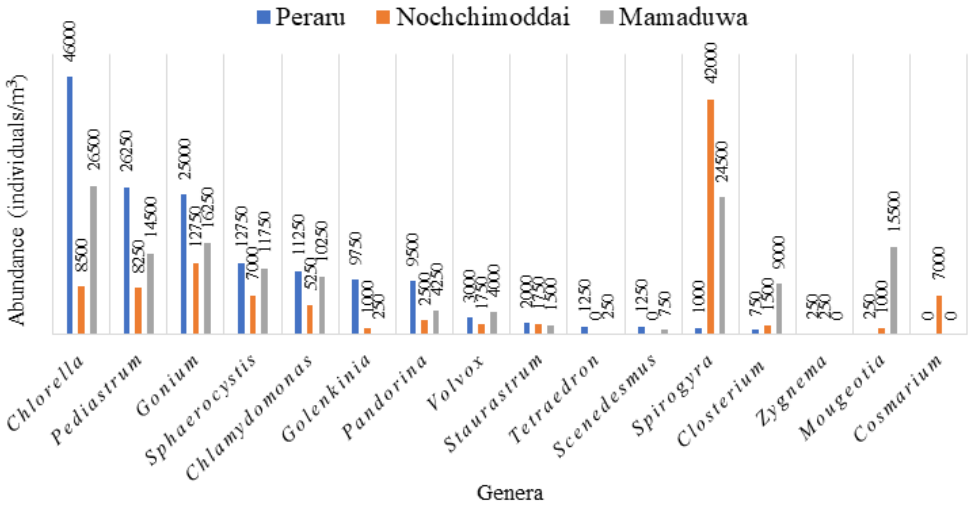

Figure 4: Abundance (individuals per m³) of genera belonging to the class Chlorophyceae in Peraru, Nochchimoddai and Mamaduwa village tanks.

sufficient amount of light penetration, higher concentration of phosphate and lower concentration of nitrate in Peraru village tank compared to that in the other two village tanks. This finding was supported by Wu *et.al.* (2014) who reported that *Chlorella vulgaris* could live at the lower nitrate concentration, and it was very difficult to survive in the absence of Phosphate. It indicates that the level of Phosphate was the limiting factor for its growth. According to Guo and Fang (2020) increasing light intensity increased the growth rate of micro-algae up to a certain point.

Abundance of genus *Pediastrum,* genus *Gonium,* genus *Sphaerocystis,* genus *Chlamydomonas,* genus *Golenkinia,* genus *Pandorina,* genus *Volvox,* genus *Staurastrum,* genus *Tetraedron*, genus *Scenedesmus,* genus *Closterium* and genus *Mougeotia* were found to be substantial in Peraru village tank and Mamaduwa village tank (Figure 4). The reason may be, Peraru and Mamaduwa village tanks provided favorable environmental conditions for photosynthesis mainly the sufficient light penetration into the water body, as there was not much floating aquatic weeds on the surface of the water body. The abundance of genus *Spirogyra* and genus *Cosmarium* was high in Nochchimoddai village tank because genus *Spirogyra* was commonly found to be occurred in shallow water bodies with neutral pH levels and with high nutrient content (Vuuren, 2006). Nochchimoddai tank is a shallow water body with high nitrate content (6.00 mg/l).

Genus *Merismopedia,* genus *Chlorococcus*, and genus *Microcystis* were found to be the common genera of Class Cyanophyceae in Peraru village tank. Genus *Lyngbya* was found in Peraru and Nochchimoddai village tanks while genus *Nostoc* was only identified in Nochchimoddai village tank (Appendix 1). The abundance of genus *Dolichospermum* was high in Nochchimoddai village tank. According to Vuuren (2006), genus *Microcystis* and other members of Class Cyanophyceae prefer to high temperature. Genus *Microcystis* was recorded in all three tanks because water temperature of Peraru, Nochchimoddai and Mamaduwa village tanks were quite high (Figure 5). However, the abundance of genus *Microcystis* and other members of Phylum Cyanophyta were found to be less because of low nutrient content. Presence of *Microcystis* and *Dolichospermum* blooms produced lethal levels of microcystin might cause taste, and odor issues while causing dangers to livestock and human beings (Dreher *et al*., 2019).

The Abundance of zooplankton

The abundance of Copepods was recorded as the highest (57%) in Nochchimoddai village tank. This may be due to the high turbidity levels, which might hinder the visualization of prey by the predators, and the presence of organic matter may be a good food sources for copepods.

According to Solanki *et al.* (2015), Rotifers flourished well

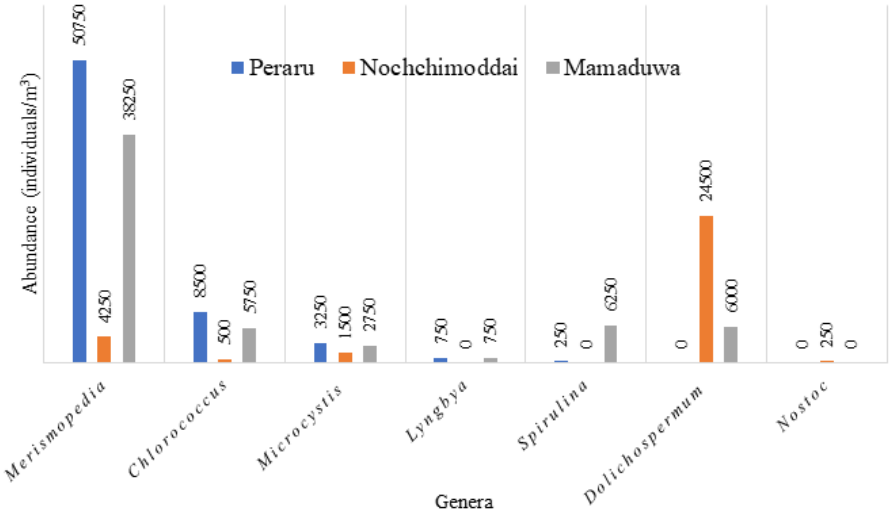

Figure 5: Abundance (individuals per m^3) of genera belonging to the Class Cyanophyceae in Peraru, Nochchimoddai and Mamaduwa village tanks.

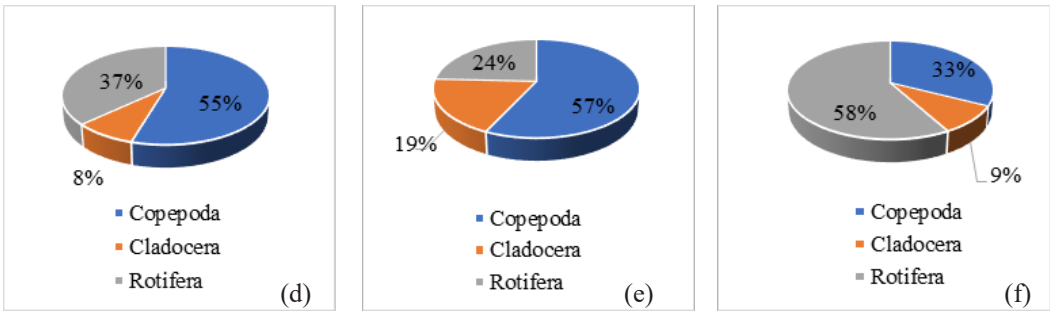

Figure 6: (d) Percentage of abundance of zooplankton in Peraru village tank, (e) Percentage of abundance of zooplankton in Nochchimoddai village tank, (f) Percentage of abundance of zooplankton in Mamaduwa village tank.

with high phosphate concentration whereas prevented the growth of the same in high nitrate concentration. Rotifers are not visible to predatory fish due to the low water transparency and their small size (Ismail and Adnan, 2016). In this study, the abundance of Rotifera was recorded as the highest (58%) in Mamaduwa village tank where phosphate concentration was high and nitrate concentration was low. Such trophic state is often favourable for Rotifers (Ismail and Adnan, 2016). In Mamaduwa village tank, turbidity and phosphate contents were reported to be slightly high and the nitrate content was low compared with other tanks (Table 1). These may be the reasons for the presence of more number of rotifers species in the present study.

Order Cladocera was recorded as with the highest abundance (19%) in Nochchimoddai village tank. Large Cladocera like genus *Ceriodaphnia* fed on Rotifers because of the small size and slow motion of Rotifers (Wallace and Smith, 2009). This may be the reason for the highest abundance of Cladocera and the lowest abundance of Rotifers in Nochchimoddai village tank.

Percentage of abundance of Cladocerans was low compared to other groups of zooplankton (Figure 6). Both groups (Cladocerans and Copepods) are larger in size compared to Rotifers. The large size of Cladocerans and Copepods may decrease their abundance due to fish predation (Karus *et al*., 2014). Based on the present study, the most common types of fish were present in the water body. It might be predators to both groups. Presence of Planktivorous fish may probably be a major reason for the observation of less abundance of Cladocerans and Copepods in the study sites. Therefore, the small composition of larger sized zooplankton resulted in large number of smaller species particularly Rotifers.

CONCLUSION

There were 16 genera of class Chlorophyceae, six genera of class Bacillariophyceae and seven genera of class Cyanophyceae identified as phytoplankton and three species of Copepods, one species of Cladocerans and ten species of Rotifers identified as zooplankton from planktonic samples of Peraru, Nochchimoddai and Mamaduwa village tanks during March-April, 2021. Most of the species identified in Peraru village tank, either identified in Nochchimoddai village tank or Mamaduwa village tank, or both. Since these village tanks are interconnected, species in Mamaduwa and Nochchimoddai village tank influenced on the presence of those species in Peraru village tank. The abundance of Rotifers is highly dependent on the trophic state of the water bodies. The community structure may be used as bio-indicator of water quality; however, their long-term changes need to be monitored.

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Appendix 1

The Presence of phytoplankton

Table : Presence or absence of phytoplankton genera in Peraru, Nochchimoddai and Mamaduwa village tanks.

Class	Genus	Peraru village tank	Nochchimoddai village tank	Mamaduwa village tank
Bacillariophyceae	Aulacoseira	✓	✓	✓
	Cyclotella	✓	✓	×
	Cymbella	✓	×	×
	Diatoma	✓	✓	✓
	Fragilaria	✓	✓	✓
	Navicula	✓	✓	✓
Chlorophyceae	Chlamydomonas	✓	✓	✓
	Chlorella	✓	✓	✓
	Closterium	✓	✓	✓
	Cosmarium	×	✓	×
	Golenkinia	✓	✓	✓
	Gonium	✓	✓	✓
	Mougeotia	✓	✓	✓
	Pandorina	✓	✓	✓
	Pediastrum	✓	✓	✓
	Scenedesmus	✓	×	✓
	Sphaerocystis	✓	✓	✓
	Spirogyra	✓	✓	✓
	Staurastrum	✓	✓	✓
	Tetraedron	✓	×	✓
	Volvox	✓	✓	✓
	Zygnema	✓	✓	×
Cyanophyceae	Chlorococcus	✓	✓	✓
	Dolichospermum	×	✓	✓
	Lyngbya	✓	×	✓
	Merismopedia	✓	✓	✓
	Microcystis	✓	✓	✓
	Nostoc	×	✓	×
	Spirulina	✓	×	✓

Appendix 2

The presence of zooplankton

Table: Presence of zooplankton species in Peraru, Nochchimoddai and Mamaduwa village tanks.

Rank	Family	Species	Peraru village tank	Nochchimoddai village tank	Mamaduwa village tank
Class Copepoda	Calanoidae	*Calanus sp.*	✓	✓	✓
	Cyclopoidae	*Cyclopoid sp.*	✓	✓	✓
		Copepod nauplii	✓	✓	✓
Order Cladocera incertae sedis	Sididae	*Ceriodaphnia sp.*	✓	✓	✓
Phylum Rotifera	Asplanchnidae	*Asplanchna sp.*	✓	✓	×
	Brachionidae	*Brachionus caudates*	✓	×	✓
		Brachionus falcatus	✓	×	×
		Brachionus forficula	✓	×	✓
		Brachionus rotundiformis	×	×	✓
		Keratella cochlearis	✓	✓	✓
		Keratella qudrata	×	✓	×
		Keratella tropica	×	×	✓
	Testudinellidae	*Filinia longiseta*	✓	×	×
	Trichocercidae	*Trichocerca bicristata*	✓	✓	×