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PHYTOPLANKTON DIVERSITY AND ABUNDANCE IN WATER BODIES AFFECTED BY ANTHROPOGENIC ACTIVITIES IN NEYYATTTINKARA MUNICIPALITY: THIRUVANANTHAPURAM

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Abstract: Anthropogenic activities deteriorate water bodies through the process of pollution. The study deals with pollution subjected to water sources like car wash (CW), municipal wastes (MW), agricultural runoff (AR), cattle and human wastes (CM), and household domestic waste (DW). Phytoplankton occurrence and abundance in these sites revealed pollution tolerant algae indicating organic pollution.

Key words: phytoplankton, water, diversity, anthropogenic, pollution

INTRODUCTION

Water constitutes part of the dynamic aquatic life supporting system in which organic and inorganic constituents are dissolved or suspended and in which a wide variety of organisms live and interact with each other (Awah, 2008). Environmental pollution is a modern day evil affecting all ecosystems including aquatic ecosystems (Begum, 2010). Anthropogenic activities deteriorate surface waters (Chukwu *et al*., 2008) and impair their basic use through the process of pollution (Wu, 2005; Hur and Jung, 2009; Zhang *et al*., 2009). Unplanned urbanization rapid industrialization and indiscriminate use of artificial chemicals in agriculture are causing heavy and varied pollution in aquatic environments leading deterioration of quality and depletion of aquatic biota (Yeole and Patil, 2005). Water pollution is an important problem as the population and industrialization expands and it must be taken seriously if aquatic life resources are to be saved and their productivity is to be maintained (Barwant and Sanap, 2020). Freshwater habitats are among the most threatened and valuable ecosystems (De Meester and Declerck, 2005) and water bodies have fallen into disrepair, misuse and most of them are used as dump garbage.

Biodiversity is the level of variation in life forms within a specified ecosystem (Arulmurugan *et al*., 2011). Algae are naturally abundant, mostly autotrophic, found in all kinds of aquatic bodies, with different environmental conditions. Increase in the algal population would be enrichment of nutrients in the water, this enrichment could either by organic or inorganic (Bavithra *et al*., 2017). The planktonic study is a very useful tool for the assessment of water quality in any type of water body (Pawar *et al*., 2006). The environmental pollution can be measured using the phytoplankton community because they are the best indicators (Hosmani and Bharathi, 1982). Biomass and community composition of phytoplankton is important to understand the structure and dynamics of an ecosystem (Roy *et al*., 2006). Various scientists used algae for assessing the degree of pollution or as indicator of water pollution or for eutrophication studies of water bodies (APHA 1998, Munshi & Munshi 1995, Hynes 1978, Palmer 1969, Khan 1991, Biswas & Konar 2000). The physico-chemical properties will also help in the identification of sources of pollution, for conducting further investigations on the exobiological impacts and also for initiating necessary steps for remedial actions in case of polluted water bodies (Adhoni *et al*., 2015).

This rise in population leads to a concomitant increase in domestic and municipal wastes, which are not properly disposed. Studies have pointed out that water resources in the area are threatened both in quality and quantity, due to anthropogenic influences (Lambi and Kometa, 2009). This study was designed to determine the phytoplankton diversity and abundance in water bodies exposed to different anthropogenic pressures.

MATERIALS AND METHODS

Study site

Neyyatinkara is a municipality on the slope of mountain with a rapid population growth. It is a Municipal Town and a major industrial and commercial hub located at the southern tip of Thiruvananthapuram metropolitan area in Trivandrum, the capital of Kerala State. The town is situated on the banks of Neyyar River, one of the principal rivers in the district and hence its name. Neyyatinkara in Malayalam literally means "the shore of the river Neyyar". Neyyattinkara is the second most densely populated municipality in the district.

Sample collection and analysis

Five different ponds were sampled in March (transition between the dry and rainy season), based on anthropogenic interactions: Points exposed to car wash (CW), those subjected to municipal wastes deposition (MW), that subjected to agricultural runoff (AR), cattle and human wastes deposition (CM), and those household domestic waste deposition (DW). Farming as an activity cut across all the categories. The number of sampling sites per category was determined by availability of such sites within the study area.

At each sampling site, two sets of water samples (one for chemical analysis and the other for phytoplankton analysis) were collected in triplicates, in 50 mL sterilized plastic bottles following standard procedures (Bellinger and Siegee, 2010). Each sample for phytoplankton analysis was treated with three drops 10% Lugol's Iodine and transported in ice containers to the laboratory for phytoplankton analysis. Nitrate, ammonium, sulphate and phosphates in water samples were analysed (APHA 1998).

Phytoplankton identification

Slides of each sample were prepared in triplicate and observed under the microscope. Phytoplankton species were identified and counted by the use of a binocular light microscope (Olympus BH2), at a magnification of 1000 x. Algae were scored for absence (-) and presence (+) in the different water sources for each category. The number of particular alga in the mount was also noted. The identification of different algal species was based on the keys given in the taxonomic publications (Anand 1989, 1998, Prasad & Misra 1992, Prasad & Srivastava 1992, Prescott 1982, Sarode & Kamat 1984, Smith 1920, 1924, Venkataraman 1939, Turner 1978, West & West 1907) and ICAR monographs (Desikachary 1959, Iyengar & Desikachary 1981, Philipose 1967) on algae.

Palmer's pollution index based on algal genera was used in rating the water samples for organic pollution. Algae were assigned pollution index values from 1 to 6. Following analysis, the values were totaled and a score of 20 or more was regarded as confirmation of high organic pollution in the water body while scores 0 to 9 indicated no organic pollution.

RESULTS AND DISCUSSION

Phytoplankton occurrence and abundance overall, 68 phytoplankton species belonging to were identified from the sample points (Table1). Of these, none of the species were cosmopolitan while, one species (*Sphaerocystis sp*), three species (*Diatoma vulgare*, *Chodatella* sp. and *Cylindrospermopsis sp.*), four species (*Amphipleura pellucida*, *Hantzchia amphioxys*, *Pinnularia sp.* and *Nostoc sp.*) and one species (*Chlorogonium* *sp*.) were unique to CW, MW, AR and DW categories respectively, were as no species unique to CM category (Fig. 2). *Nitzschia* was the most abundant genus while the Bacillariophyta was the most abundant group in all the sites (Fig.1 & 2).

The occurrence of these algae was however not uniform among categories and sites, with mean number of phytoplankton species per category for CW, MW, CM and DW varies. *Nitzschia*. (18.55 %) was the most abundant in while, *Chlorogonium*, were the least abundant with 0.10% (Table 1). In the MW category, *Chlorella* sp. scored 17.57% while *Achnanthes* sp., *Anabaena* sp., *Cocconeis* sp., *Microcystis* sp., *Navicula cucpidata*, *Pinnularia* sp. and *Stauroneis producta* were the least abundant with 0.54% each. The CM category had *Nitzschia* as the most abundant (14.48%) while *Ceratium*, *Cosmarium*, *Oscillatoria* and *Tetraedron* were the least abundant with 1.72 % each. Chlorella was the most abundant (13.27 %) in the agriculture runoff water category, while *Amphipleura pellucida*, *Closterium abruptum*, *Hantzchia amphioxys*, *Nitzschia constricta*, *Pediastrum duplex*, *Prorocentrum minimum* and *Synedra ulna* were the least (0.22% each).

Diversity and similarity of phytoplankton within and between categories

The different water sources had very little similarity in phytoplankton composition with very few species common to all sites within a category. In the pond water sources there was species that occurred in all the sites. Algal diversity was generally high within water sources in each category from CW to MW. There were however no significant differences in diversity between the categories of water sources.

Among Baccilariophyta, Chlorophyta, Cyanophyta and Euglenophyta *Nitzschia sigma*, *Chlamydomonas sp.*, *Scytonema sp.*, *Euglena sp.* reported with highest value of 4.03%, 4.44%, 2.32 %, 2.42% and least value by *Hantzchia amphioxys. Chlorogonium sp.*, *Merismopedia punctata* and *Phacus sp.* of 0.20% , 0.10%, 0.30% and 0.30%.

Water physico-chemical parameters and their relationship with phytoplankton diversity and abundance

There were variations in physico-chemical parameters among sites and categories. In the car wash category, the highest phosphate (0.73 mg/l), ammonium (3.36 mg/l) and nitrate (1.92 mg/l). CW had the least phosphate (0.61 mg/l) while CW had the least ammonium and nitrate (0.56 and 0.89 mg/l, respectively). Temperature and pH were highest in CW (23.1 and 7.8 respectively) and lowest in CW (22.1) and CW (7.3) respectively. The electrical conductivity and total dissolved solids were highest in CW (255 µS/cm and 125 mg/l respectively) and lowest in CW (205.7 µS/cm and 105 mg/l respectively). In the municipal waste category, phosphates were highest in MW (0.80 mg/l) and lowest in MW (0.59 mg/l). Ammonium was 0.67 mg/l for all sites except MW with the least value of 0.53 mg/l. Nitrates were highest in MW (1.32 mg/l) and least in MW (0.87 mg/l). Sulphates ranged between 0.16 mg/l (MW and MW) and 0.13 mg/l (MW). Temperature was in the range 21.4 (MW) and 24.1 (MW). pH ranged between 6.6 (MW and MW) and 7.7 (MW) Electrical conductivity and total dissolved solids were highest in MW (226.7 µS/cm and 108.3 mg/l, respectively) and least in MW (141 µS/cm and 73.3 mg/l, respectively). In the drinking water category, phosphates were highest in DW and DW (0.75 mg/l) and lowest in DW (0.45 mg/l). Ammonium was highest in DW (0.83 mg/l) and lowest in DW (0.57 mg/l). Nitrates were highest in DW (1.43 mg/l) and lowest in DW18 (0.62 mg/l). Sulphates were highest in DW (0.15 mg/l) and lowest in DW (0.11 mg/l). Temperature ranged between 20.5 (DW) and 22.9 (DW). pH was highest in DW (7.5) and lowest in DW (6.1). Total dissolved solids ranged between 74.7 mg/l (DW) and 141.7 mg/l (DW) while electrical conductivity was in the range 146.3 µS/cm (DW) and 288.3 µS/cm (DW). Mean values of the different parameters for the different categories ranged between 0.65 mg/l (DW) to 0.71 mg/l (MW and CM) for phosphates, 0.64 mg/l (MW) to 2.24 mg/l (CM) for ammonium, 1.08 mg/l (DW) to 1.53 mg/l (CW) for nitrates, 0.13 mg/l (DW) to 0.14 mg/l (other categories) for sulphate, 21.8 (DW) to 22.9 (CM) for temperature, 6.9 (other categories) to 7.6 (CW) for pH, 197.4 µS/cm (MW) to 233.3 µS/cm (CM) for electrical conductivity and 92.3 mg/l (MW) to 111.8 mg/l (DW) for total dissolved solids. Phytoplankton abundance had a significant positive correlation with pH.

Pollution status of the different water sources

At these sites pollution tolerant genera are recorded indicating the organic pollution. Presence of pollution tolerating algae like *Oscillatoria*, *Spirogyra*, *Scenedesmus*, *Pinnularia*, *Gomphonema* and *Euglena* can be used as the pollution indicators. The study revealed a total of 11 pollution tolerant genera following Palmer's (1969) (organic pollution) list, in the four categories. The observed pollution tolerant genera belong to the Bacillariophyta having the highest number across the different categories and the Euglenophta, the least. The pollution index values for the different sites ranged from 11 to 22 (CW category), 12 to 16 (MW category), 16 to 23 (CM category), 8 to 24 (DW category) and 13 to 15 (AR category) respectively.

There has been a rapid growth of pollution of aquatic environment, mostly from anthropogenic sources, and chief sources of the aquatic pollution are either direct dumping of industrial effluents or spills or indirect, via leaching or runoff (Das and Choudhury, 2016). Research regarding the harmful effect of pollutants on aquatic ecosystems, the physiological and ecological responses of aquatic organisms to pollutants was usually used to indicate the degree of water pollution (Chapman, 2010). The pollutants that enter into water via various channels are first to have an impact on the primary producers (Zhao *et al*., 2018). Therefore, algae are often used as a crucial indicator for monitoring changes of water environments. Although algae have the characteristics of fast growth and short growth cycle, long-term continuous observation of algae reveal chronic toxicity in aquatic water bodies.

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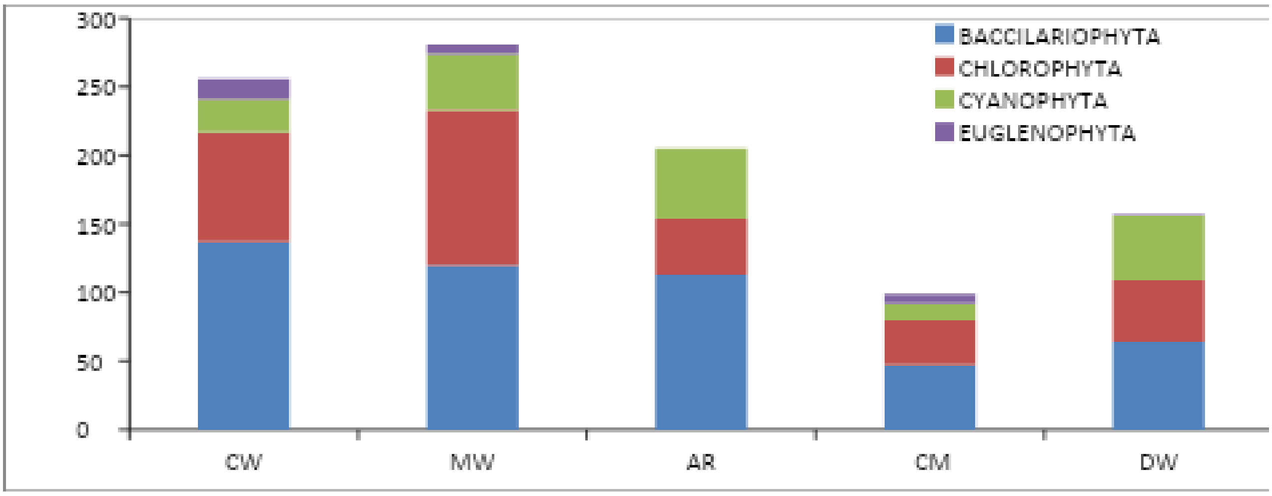
Figure 1: Phytoplankton distribution in different anthropogenic polluted water bodies in Municipality



CW=Car wash, MW=Municipal wastes, AR=agricultural runoff , CM=Cattle + Human wastes, DW= Domestic water

Figure2: Phytoplankton unique to water of different anthropogenic influence in the Municipality

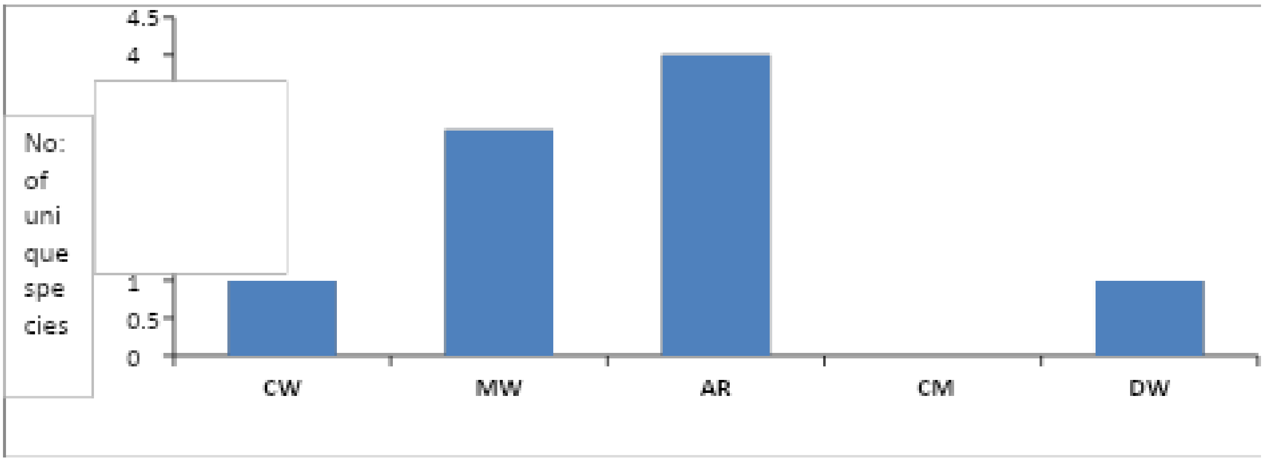


Figure 3: Phytoplankton distribution in anthropogenic influenced water bodies in Municipality

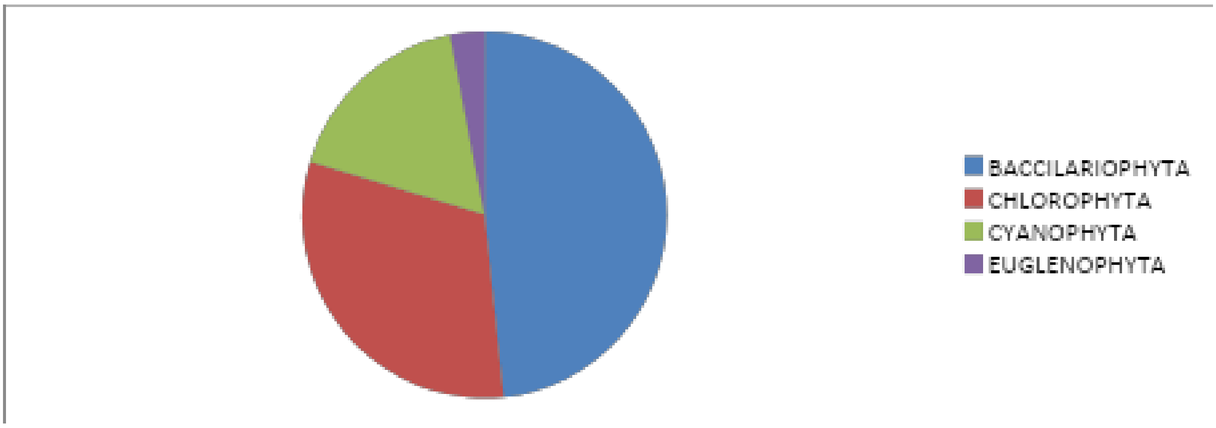


Table1: Occurrence and abundance of phytoplankton in water bodies with anthropogenic activities

Phytoplankton	Categories of pollution sites					Relative Abundance. (%)
	CW	**MW**	**AR**	**CM**	**DW**	
BACCILARIOPHYTA						
Achnanthes sp	+	+	-	-	+	2.12
Amphipleura pellucida	-	-	+	-	-	0.71
Cocconeis sp.	+	+	-	-	-	1.11
Cyclotella sp.	+	+	-	+	-	0.91
Cymbella cesatii	-	-	+	-	+	0.60
Cymbella cuspidata	-	-	-	+	+	0.40
Diatoma sp.	+	+	-	+	-	1.61
Diatoma vulgare	-	+	-	-	-	1.21
Diatomella balfouriana	+	+	-	-	-	1.71
Fragilaria sp.	+	+	-	-	-	2.02
Gomphonema sp.	+	+	+	-	-	2.62
Hantzchia amphioxys	-	-	+	-	-	0.20
Navicula cucpidata	-	-	+	-	+	0.81
Navicula sp.	-	-	+	+	+	3.13
Nitzschia closterium	+	+	+	-	+	1.21
Nitzschia constricta	+	+	-	+	+	0.71
Nitzschia foliformis	+	+	-	-	-	1.31
Nitzschia linearis	+	+	-	-	-	1.11
Nitzschia palea	-	+	-	+	-	2.92
Nitzschia scalaris	+	-	+	-	-	2.02
Nitzschia seriata	+	+	+	-	+	2.82
Nitzschia sigma	+	+	-	+	+	4.03
Nitzschia sp	+	+	-	-	-	2.42
Pinnularia sp.	-	-	+	-	-	1.41
Pleurosigma angulatum	-	-	+	-	+	0.30
Pleurosigma sp.	-	-	+	-	-	0.30
Stauroneis producta	+	+	-	+	-	2.12
Surirella minuta	-	+	-	-	+	1.71
Surirella ovalis	+	+	-	-	-	0.30
Synedra ulna	+	-	+	-	+	3.53
Tabellaria sp	+	+	-	-	-	0.60
Thalassionema sp.	+	+	+	-	-	0.50

CHLOROPHYTA						
Chlamydomonas sp.	+	+	+	-	+	4.44
Chlorella sp.	+	+	+	+	+	2.52
Chlorogonium sp.	-	-	-	-	+	0.10
Chodatella sp.	-	+	-	-	-	0.20
Closterium abruptum	+	+	-	+	-	1.31
Closterium arcuarium	-	+	-	-	+	0.91
Closterium gracile	+	+	-	-	-	0.81
Closterium sp.	-	+	-	-	-	1.71
Coelastrum- sp.	-	-	+	-	+	0.91
Cosmarium constrictum	+	+	-	+	-	2.52
Cosmarium gerdae	-	+	-	-	+	0.60
Cosmarium minulum	+	+	-	-	-	0.60
Cosmarium moniliforme	+	-	+	-	+	1.71
Cosmarium sp.	-	-	+	-	+	0.81
Haematococcus sp	-	-	+	-	+	1.71
Micrasterias sp	+	+	-	+	-	1.51
Oocystis sp.	+	+	+	+	-	2.02
Pediastrum duplex	+	+	-	+	+	5.14
Sphaerocystis sp.	+	-	-	-	-	0.81
Spirogyra sp	-	-	+	-	+	0.71
Scenedesmus sp.	-	+	+	-	+	0.40
CYANOPHYTA						
Anacyctis sp.	+	+	-	+	+	1.61
Anabaena sp.	+	+	-	-	-	1.31
Microcystis sp.	+	-	+	-	+	1.81
Oscillatoria sp.	-	-	+	-	+	1.81
Spirulina sp	-	-	+	-	+	1.31
Gleocapsa magma	+	+	-	+	-	2.12
Nostoc sp.	-	-	+	-	-	0.81
Scytonema sp.	-	-	+	-	+	2.32
Phormidium sp.	-	+	+	-	+	1.31
Chrococcus turgidus	+	+	-	+	-	1.61
Merismopedia punctata	-	+	-	-	+	1.31
Cylindrospermopsis sp.	-	+	-	-	-	0.30
EUGLENOPHYTA						
Euglena sp.	+	+	-	+	-	2.42
Trachelomonas sp	-	+	-	-	+	0.30
Phacus sp	+	-	-	-	-	0.30

+ Present__- Absent