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CORRELATION BETWEEN PHYSICOCHEMICAL WATER PARAMETERS WITH PLANKTON DIVERSITY

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ABSTRACT

Present work was carried out to assess the correlation between water parameters and seasonal variations of plankton diversity of manmade lakes in Anandwan, Warora Dist. Chandrapur (Maharashtra).These lakes were used for irrigation and aquaculture purposes. The water samples were collected from three lakes in the Anandwan regionfrom January 2022 to December 2022. Physicochemical parameters show a positive correlation between temperature and dissolved oxygen. Other parameters viz COD, and BOD are also showing correlation. There exists a significant correlation between the plankton count and the Physico chemical parameter. Total phytoplankton count ranges from 216-5011.2 no/ml belonging to class Chlorophyceae, Cyanophyceae, Bacillariophyceae, Cryptophyceae, Euglenophyceae, Florideophyceaeand zooplankton ranges from 155-685no/mlfrom Protozoa (paramecium) and Arthropoda phylum viz, Copepods, Cladocera and Rotifera. In Phytoplanktons, out of 12 genera, Closterium was found dominant followed by Cylinderospermum, Fragillaria, and Phacus as well as Batrachospermum. While in Zooplankton Nauplius was reported as dominant followed by Paramecium, Ceriodapnhia dubia, and Branchionus caudatus. Diversity indices, Dominance, and richness index were also calculated.The trend of dominance is as follows:

Phytoplankton: Chlophyceae >Cyanophyceae > Bacillariophyceae > Euglenophyceae = Florideophyceae

Zooplankton: Copepods > Protozoa > Rotifera> Cladocera

INTRODUCTION

According to the majority of evolutionary hypotheses, life first appeared in water. Water has been a vital component of life from the beginning of time. Groundwater, lakes, and rivers all provide usable freshwater(Meshram et al., 2024). Plankton is the basic food source in any aquatic ecosystem for fish and other aquatic animals. The tiny aquatic microorganisms known as plankton are found in the water column at varying depths. When evaluating water quality, one of the most crucial ecological factors is plankton diversity.Because plankton communities are extremely sensitive to changes in the environment, research on them may help predict long-term changes in lake ecosystems (Verma & Chaudhari, 2011). Plankton communities are also sensitive to anthropogenic influences. Since they are the most delicate floating population and are the primary target of water pollution, any unfavorable changes to the aquatic ecosystem have an impact on the community's biomass and variety. Phytoplankton, with their short generation time and quick population renewal, are regarded as effective indicators of water quality and trophic conditions.

An ecosystem that is in balance is one in which beneficial interactions occur between the environment and living organisms. Since water quality is critical to maintaining an environment in balance, it is obvious that it plays an important part in this interaction (Jeyaraj et al., 2016).

Lakes are a major source of water and play a crucial role in enhancing aesthetic values, providing habitat for aquatic animals, and also helping to maintain underground water levels. The present investigation was carriedout season-wise viz winter, monsoon, and summer at AnandwanWaroraman-made waterbodies, to assess the water quality of three lakes.

METHODOLOGY

Study area:

Warora is a Taluka place in Chandrapur district, situated in eastern Maharashtra. It is about 44km from Chandrapur. In north northwest direction, lies at latitude 200 23'N and Longitude 790 0' E. Warora is a township worldwide known for great socialist Baba Amte's Anandwan and its natural beauty and pollution-free environment. Anandwan Lake is very close to Warora City. Anandwan Lake is a manmade lake built for irrigation purposes in Anandwan in 1975. The lake is located between 200 15'31"E to 790 1'27" E longitude. Anandwan Lake is mostly used for irrigation and fishery activities and receives domestic wastes from nearby resident peoples.

Water samples were collected between 8:00 am to 10:00 am during winter, summer, and Monsoon seasons from three lakes of the Anandwan region. From each lake, four accessible sites were selected for sampling.Samples were collected from each corner and mixed to prepare composite samples for physicochemical and plankton analysis during the study period.

Physico-Chemical Characterization

Coolers were used to store the water samples as soon as they were collected to preserve their physical integrity. The samples were then brought to the lab for examination. On-site temperature readings were taken using a mercury-in-glass thermometer. A pH meter was also used on-site to measure pH. The remaining eight parameters were ascertained using the procedures outlined by APHA (1995); total suspended solids (TSS), total dissolved solids (TDS), chemical oxygen demand (COD), biological oxygen demand (BOD), conductivity, dissolved oxygen, alkalinity and Hardness (total).The temperature was measured with a thermometer and pH and T.D.S. were measured on-site using digital pH meters and T.D.S. meters, respectively. Water samples were obtained, and dissolved oxygen was fixed by applying Winkler A and Winkler B solutions to the locations using DO bottles. After arriving at the laboratory, the dissolved oxygen was calculated using Winkler's technique. Hardness, alkalinity, and dissolved carbon dioxide were measured in the laboratory using APHA-approved procedures.

Plankton sampling:

Phytoplankton samples were obtained directly from waterbodies, and a 20ml composite sample was added, along with 0.5ml of Lugol's solution, which serves as both a fixative and preservative. Zooplankton samples were obtained using a plankton net with a mesh size of 50µm. 50 liters of water were passed through the net, and the final quantity of plankton sample was 15 ml. 1 ml of 4% formalin was applied as a fixative and preservative.

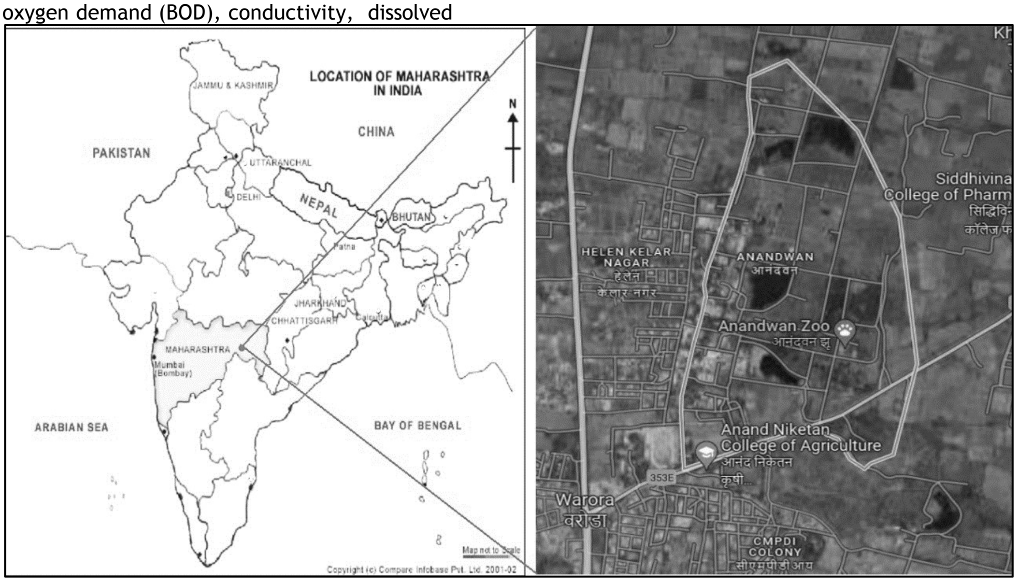


Figure 1: Satellite View of Study area Anandwan

Identification and counting of plankton

i. **For Zooplankton:**Sedgwick rafter counting cell is used to count the plankton. Sedgwick rafter cell is approximately 50mm long, 200mm wide, and 1mm deep. A trinocular compound microscope (Model No. Olympus CH20i) is used to count the zooplankton using 40x eyepieces. The microscope is calibrated using a micrometer. The following formula is used for quantities analysis of zooplankton.

Number/ml= $\frac{Cx1000}{AxDxF}$

where,

C= no. of organisms counted
A= an area of field
D= depth of field(mm)
F= no. of fields counted

Density was expressed on individual/ liter. Finally, zooplankton were identified in the laboratory with the help of keys provided by(Ward and Whipple, 1962)

For phytoplankton:The drop-count method was used to analyze phytoplankton. An ordinary 4 ml dropper was used, samples were sucked into it, and 2-3 drops were placed on the slide for inspection. The organisms present in this drop were counted in high power, and when the number of deep-forming 1 ml droppers was taken into account, the following formula was applied. The density of phytoplankton was given in units per liter (Prescott, 1962).

Phytoplankton (density): N= abc/ml

where,

N= no. of phytoplankton/ml.
a= average number of individuals in one drop
b= number of drops forming 1ml
c= volume of concentration
L= original water sample(liter)

Finally, zooplanktons were identified in the laboratory with the help of keys provided by(Bay Saldanha, 2001; Slotwinski et al., 2014).

Diversity indices analysis:

Plankton diversity indices were calculated using various formulas, including the Shannon Diversity Index, Equitability Index, Simpson Diversity Index, Simpson Dominance Index, and Margalef Richness Index. The indexes are as follows:

a. Shannon Diversity Index

H = Σ - (Pi * ln Pi)
i=1

Where,

H = the Shannon diversity index
Pi = fraction of the entire population
S = number of species encountered

b. Equitability Index (EH)

EH= $\frac{H}{lnS}$

Where

EH=Equability index
H=Shannon Index
S= max is the maximum possible value of H and it is equivalent to lnS.

c. Simpson Index (D)

$$\text{Simpson Index (D)} = \frac{1}{\sum_{i=1}^{s} p_i^{\,2}}$$

Where

P = proportion (n/N) of individuals of one particular species (n) divided by the total number of individuals found (N)

Σ = sum of the calculations, and

s = the number of species

d. Simpson Dominance Index (D)

H = Σ (ni/n) 2

i=1

Where

ni= number of individuals of species i

n=total number of individuals

Σ = sum from species

RESULT

Throughout the study period, variations of physico-chemical parameters were recorded. Physico-Chemical Characterization of samples was analyzed as per the standard APHA method (Baird et al., 2017). Statistical analyses were also determined using mean and standard deviation(**Table 1.1-1.3**).

A variety of physicochemical elements have an impact on lakes. The lake's biota is affected by fluctuations in these factors. Temperature ranges between 25ºC-27ºC (Monsoon season) 20ºC-27ºC (Winter) and 29ºC-30ºC (Summer). Through the metabolic rate and concentration of dissolved gases including carbon dioxide, oxygen, and chemical solutes, water temperature affects aquatic life.pH ranged from 6.69-7.8 (Monsoon season), 7.26-8.0 (Winter), and 7.5- 8.2 (Summer).A pH of 6.5 to 9.0 can promote healthy fishing since lake water in this range is advantageous for fishing as well as being suitable for irrigation and other household uses.

Turbidity was reported as 10.9- 15.01(Monsoon season) 8.9-12.01(Winter) and 9.79-13.01 NTU(Summer) showing high turbidity in Lake 2 in all seasons. Concentration of conductivity varied from 747-847µS/cm(monsoon), 807-847µS/cm(winter), 819-847µS/cm(Summer). Lake water is loaded with TDS varied from 614-690mg/L (Monsoon season), 629-618mg/ml(Winter), and 632-650mg/ ml (Summer). Dissolve oxygen 3.4-5.5mg/L(monsoon), 2.4-3.7mg/ml(Winter) and2.4-2.9mg/ml(Summer). Hardness 239-272mg/ml(monsoon), 262-339mg/ml(Winter), and 241-275mg/ml(Summer).Fish and other aquatic life can perish from low oxygen levels. Water should have a minimum of 4 mg/L of DO for live organisms. The compounds that deplete oxygen lower the DO that is accessible. The rate of biological oxidation is significantly higher in the summer. Regretfully, the rising temperature has caused the DO concentration to be at its lowest (Omid Bozorg-Haddad et al; 2021River water that has BOD >15 mg/L and DO <2 mg/L is deemed seriously contaminated, making it difficult for aquatic organisms to survive (Lai et al., 2013).BOD 3.5-7.8mg/L(monsoon), 4-8mg/ml(Winter) and 5-14 mg/ml(Summer)and COD 8.8-13mg/L(monsoon), 9-15mg/ml(Winter) and9.9-15.8mg/ml(Summer).Dissolve oxygen was found very low while BOD and COD values are higher values in lake 2 indicating the presence of organicpollution (Thakare et al, 2013).

Table 1.1 Physico-Chemical Characterization of Anandwan Lake in Monsoon Season

Sr. No.	Test Parameter	Desirable Limit as per IS 10500:1991	Lake 1 (Mean+_ SD)	Lake 2 (Mean+_ SD)	Lake 3 (Mean+_ SD)
1.	pH	6.5-8.5	6.69±0.03	7.2 ±0.06	7.8±0.05
2.	Temperature (°C)	40°C	26±2.31	25±1.63	27±2.1
3.	Conductivity (µS/cm)	---	847±19.24	747±6.65	847±7.6
4.	Turbidity (NTU)	25 NTU	10.95± 0.46 3	15.01± 0.71	10.9±0.9
5.	Alkalinity (mg/L)	Max. 200 mg/L	207±18.74	221±14.71	213±12.2
6.	Dissolved Oxygen (mg/L)	Min. 5.0 mg/L	5.5±.0.39	3.4± 0.45	4.7±0.34
7.	Biochemical Oxygen Demand (mg/L)	Max. 3.0mg/L	3.5±0.04	7.8± 0.08	3.7±0.04
8.	Chemical Oxygen Demand (mg/L)	Max. 10 mg/L	8.8±0.09	13±0.1	9.0±0.2
9.	Total Hardness (mg/L)	Max 300 mg/L	272± 2.3	239±3.3	272±2.5
10.	Total dissolved solids (mg/L)	Max 500 mg/L	688±7.95	614±14.3	690±5.41
11.	Total suspended solids (mg/L)	mg/L	18±4.3	32±2.5	20±3.2

Table 1.2: Physico-Chemical Characterization of Anandwan Lake in the Winter Season

Sr. No.	Test Parameter	Desirable Limit as per IS 10500:1991	Lake 1 (Mean+_ SD)	Lake 2 (Mean+_ SD)	Lake 3 (Mean+_ SD)
1.	pH	6.5-8.5	7.69±0.05	7.26 ±0.02	8±0.04
2.	Temperature (°C)	40°C	27±2.31	20±1.63	25±2.1
3.	Conductivity (µS/cm)	---	807±19.24	847±6.65	827±7.6
4.	Turbidity (NTU)	25 NTU	8.9± 0.46 3	12.01± 0.87	8.9±0.9
5.	Alkalinity (mg/L)	Max. 200 mg/L	337±18.74	321±14.71	337±12.2
6.	Dissolved Oxygen (mg/L)	Min. 5.0 mg/L	3.5± 0.39	2.4± 0.45	3.7±0.34
7.	Biochemical Oxygen Demand (mg/L)	Max. 3.0mg/L	4±0.04	8± 0.08	5±0.04
8.	Chemical Oxygen Demand (mg/L)	Max. 10 mg/L	9±0.09	15±0.1	10±0.2
9.	Total Hardness (mg/L)	Max 300 mg/L	292± 2.3	339±3.3	262±2.5
10.	Total dissolved solids (mg/L)	Max 500 mg/L	681±7.95	664±14.3	629±5.4
11.	Total suspended solids (mg/L)		19±4.3	31±2.5	24±3.2

Table 1.3Physico-Chemical Characterization of Anandwan Lake in Summer Season

Sr. No.	Test Parameter	Desirable Limit as per IS 10500:1991	Lake 1 (Mean+_ SD)	Lake 2 (Mean+_ SD)	Lake 3 (Mean+_ SD)
1.	pH	6.5-8.5	7.5±0.05	8.2 ±0.02	8.1±0.04
2.	Temperature (°C)	40°C	29±2.31	30±1.63	29±2.1
3.	Conductivity (µS/cm)	---	819±19.24	867±6.65	847±7.6
4.	Turbidity (NTU)	25 NTU	9.79± 0.46 3	13.01± 0.87	9.9±0.9
5.	Alkalinity (mg/L)	Max. 200 mg/L	317±18.74	329±14.71	327±12.2
6.	Dissolved Oxygen (mg/L)	Min. 5.0 mg/L	2.9.± 0.39	2.4± 0.45	2.7±0.34
7.	Biochemical Oxygen	Max. 3.0mg/L	5±0.05	14± 0.07	7±0.054

	Demand (mg/L)				
8.	Chemical Oxygen Demand (mg/L)	Max. 10 mg/L	9.9±0.09	15.8±0.1	10.2±0.2
9.	Total Hardness (mg/L)	Max 300 mg/L	275± 2.3	241±3.3	262±2.5
10.	Total dissolved solids (mg/L)	Max 500 mg/L	638±7.95	644±14.3	650±5.4
11.	Total suspended solids (mg/L)		19.3±4.3	32.1±2.5	24.9±3.2

Phytoplankton Composition:

Every organic entity in a biological system gives information about the state of its surroundings. For example, plankton responds quickly to changes in the environment and is a valuable biomarker for determining the quality of water as well as a sign of pollution. Plankton is the best indicator of the health of aquatic flora and serves as an early warning system(Verma and Chaudhari, 2013; Wadjikar et al., 2017) In addition to responding to natural changes in the lakes, phytoplankton communities may also exhibit fluctuations as a result of human interventions that affect the water body directly or indirectly through activities conducted throughout the basin. The structure and composition of the phytoplankton shift as a result of these influences on the lakes. These modifications can manifest as variations in the taxa that make up the algal associations, their relative abundance, the associations' richness and diversity, and other community parameters.

A total of 18 genera belonging to 5 groups (Chlorophyceae, Cyanophyceae, Bacillariophyceae,Euglenophyceae, Florideophyceae) of Phytoplankton were identified from three sampling sites. Out of the 18 genera, 11 belong to Chlorophyceae, 2 belong to Cyanophyceae, 3 belong to Bacillariophyceae, 1 belongs to Euglenophyceae and 1 belongs to Florideophyceae (**Fig 2-4**). Total phytoplankton count ranges from 216 -4989.6 no/ml in monsoon, 842.4.2-5011.2 no/ml in winter, and 799-5011.2 no/ml in summer (**Fig. 5**). Seasonal variations show slightly higher count during winter than summer and monsoon(**Fig. 6**). In chlorphycease total 11 genera were reported, closterium and desmidium shows the dominance followed by subdominant microspora, spirogyra, odogonium and ulothrix. In cyanophyceae, cylindrospermum were dominant, fragillaria and Navicula from Bacillariophyceae. The total count in Lake 2 was found low as compared to other lakes, however, a higher euglena count was observed during monsoon season. The trend of dominance and subdominant is almost similar in all lakes for Phytoplankton **as** Chlophyceae > Cyanophyceae > Bacillariophyceae > Euglenophyceae > Florideophyceae

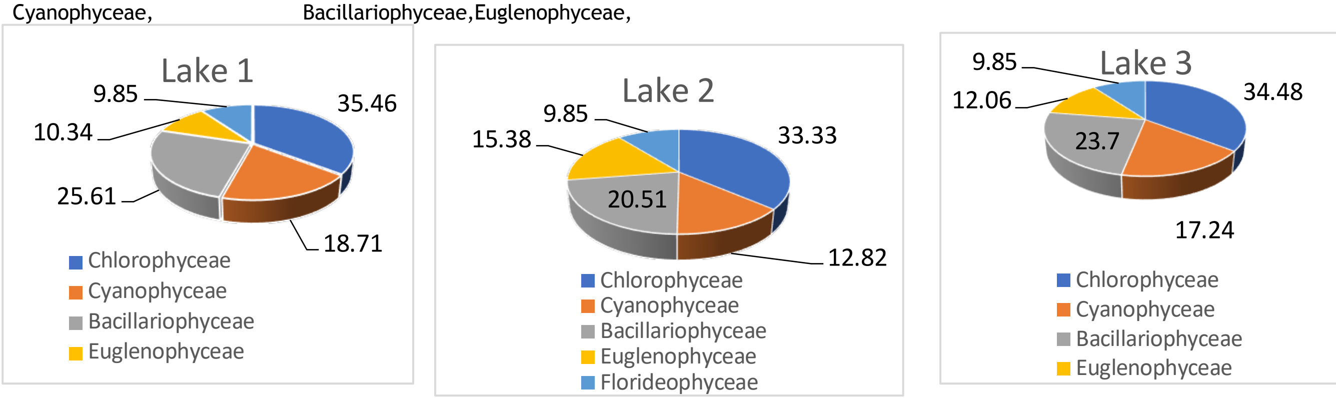


Fig.2: Phytoplankton Distribution during Monsoon season

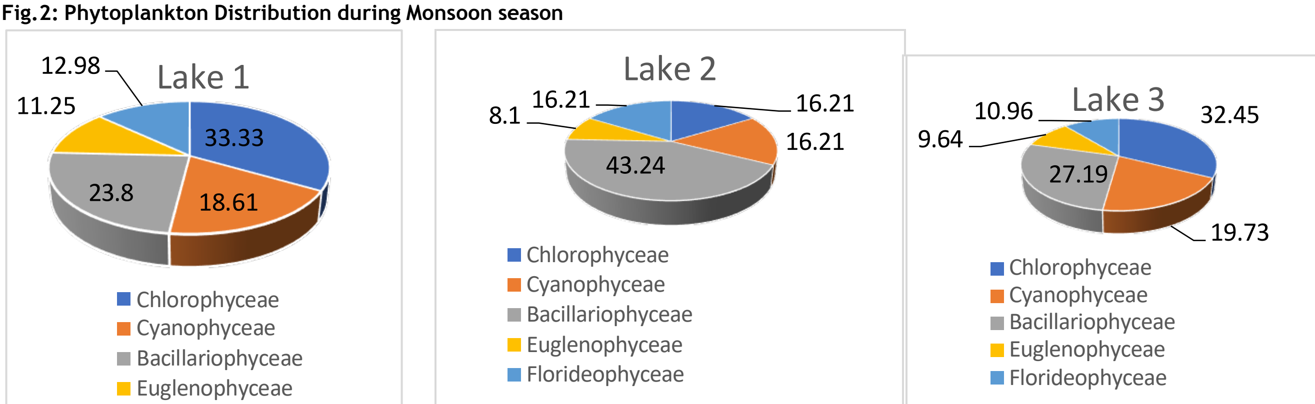


Fig 3: Phytoplankton Distribution during the Winter season

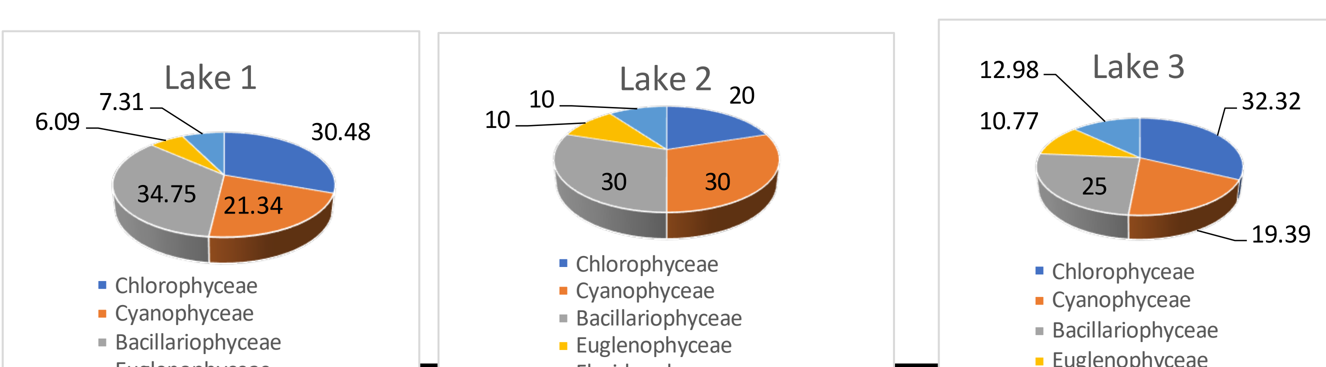
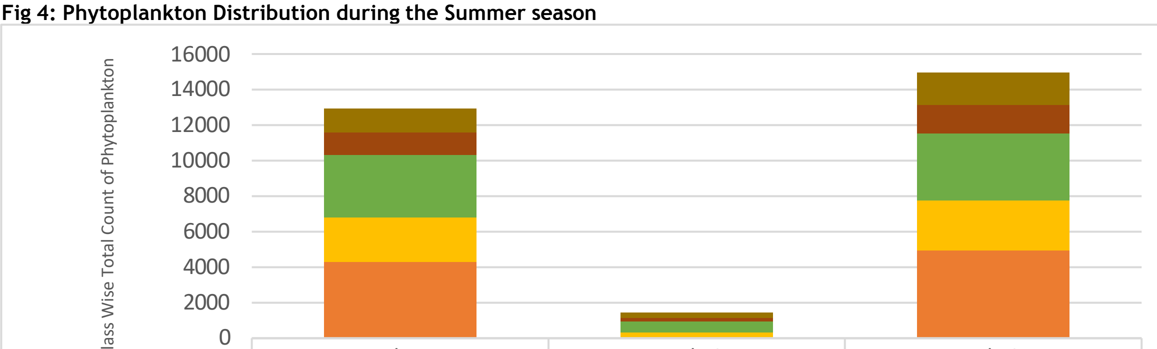
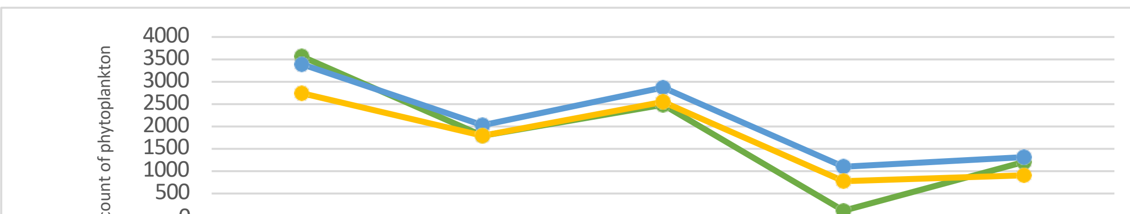


Fig 4: Phytoplankton Distribution during the Summer season



	Lake1	Lake2	Lake3
Florideophyceae	1339.2	302.4	1792.8
Euglenophyceae	1231.2	216	1620
Bacillariophyceae	3542.4	583.2	3780
Cyanophyceae	2505.6	302.4	2808
Chlorophyceae	4298.4	45.3	4946.6

Fig. 5: Total Phytoplankton in Sampling Location



	Chlorophyceae	Cyanophyceae	Bacillariophyceae	Euglenophyceae	Florideophyceae
Monsoon	3564	1792	2484	118	1209.6
Winter	3391.2	2030.4	2872.8	1101.6	1317.6
Summer	2743.2	1792.8	2548.8	777.6	907.2

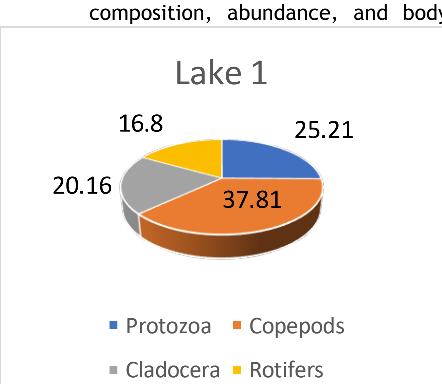
Fig. 6: Seasonal Variations of Phytoplankton

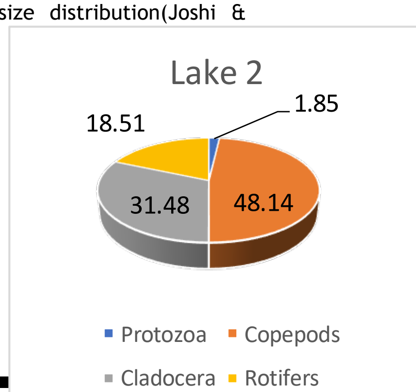
Zooplankton Composition:

Heterotrophic organisms, such as zooplankton, use phytoplankton as food, regenerating nutrients through metabolic processes and transferring energy to higher trophic levels. Not only do zooplankton aid in the transfer of food from the primary to secondary levels, but they also play a role in the transformation of waste materials into edible food for animals. By transferring energy from the larger predatory invertebrates and fish that devour the main producers, planktonic algae, these species serve as a link in the food chain (Kumari et al., 2008). Macróplankton (200-2000 µm), microplankton (20-200 µm), nanoplankton (2-20 µm), picoplankton (0.2-2 µm), and femtoplankton (0.02-0.2 µm) are the different sizes of plankton(Kumar et al., 2023).

The degree to which zooplankton is susceptible to changes in aquatic habitats is substantial. The effects of environmental disturbances can be distinguished by differences in species composition, abundance, and body size distribution(Joshi & Joshi, 2011). Several variables, including temperature, sunlight, ocean currents, and nutrition availability, affect plankton populations. They are vital to ecosystems because they support carbon cycling, global biodiversity, and the general health of the water bodies (Cottenie et al., 2001). An evaluation of the pollution state heavily depends on the interaction between plankton diversity, physicochemical water parameters, and environmental conditions. A total of 12 genera belonging to 4 groups (Protozoa, Copepods, Cladocera, Rotifers) of Zooplankton were identified from three sampling sites. Out of the 12 genera, 1 belongs to Protozoa, 5 belongs to Copepods, 5 belongs to Cladocera, and 1 belongs to Rotifers(Fig. 7-9).Nauplius were reported as dominant followed by Paramecium, Ceriodapnhia dubia, and Branchionus caudatus. Lake 2 showed a low count of zooplankton in all seasons except the rotifer indicating the presence of organic pollution. However, the dominant trends almost remain the same as follows:

Zooplankton: Copepods > Protozoa > Rotifera> Cladocera





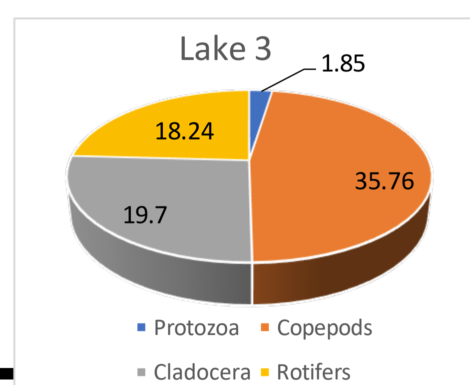


Fig. 7: Distribution of Zooplanktons in Monsoon season

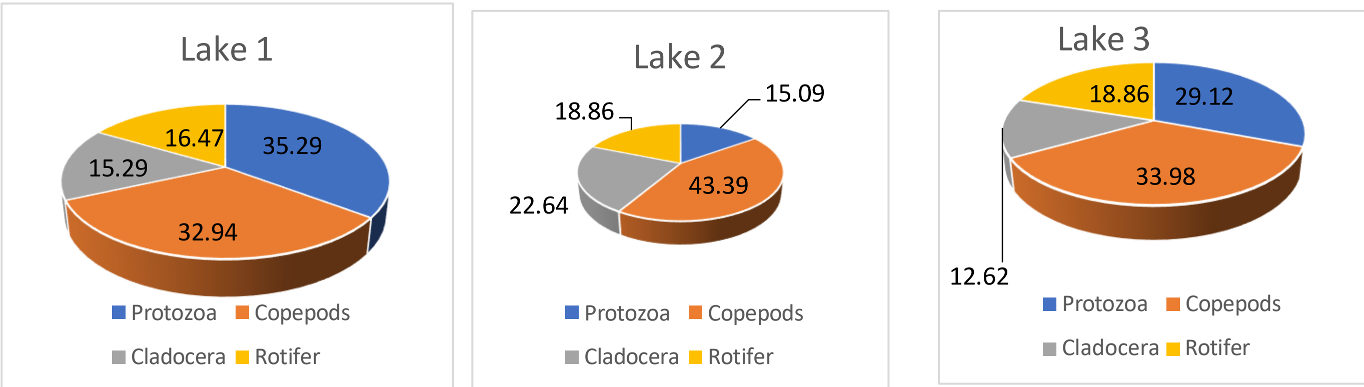


Fig. 8: Distribution of Zooplankton in the Winter season

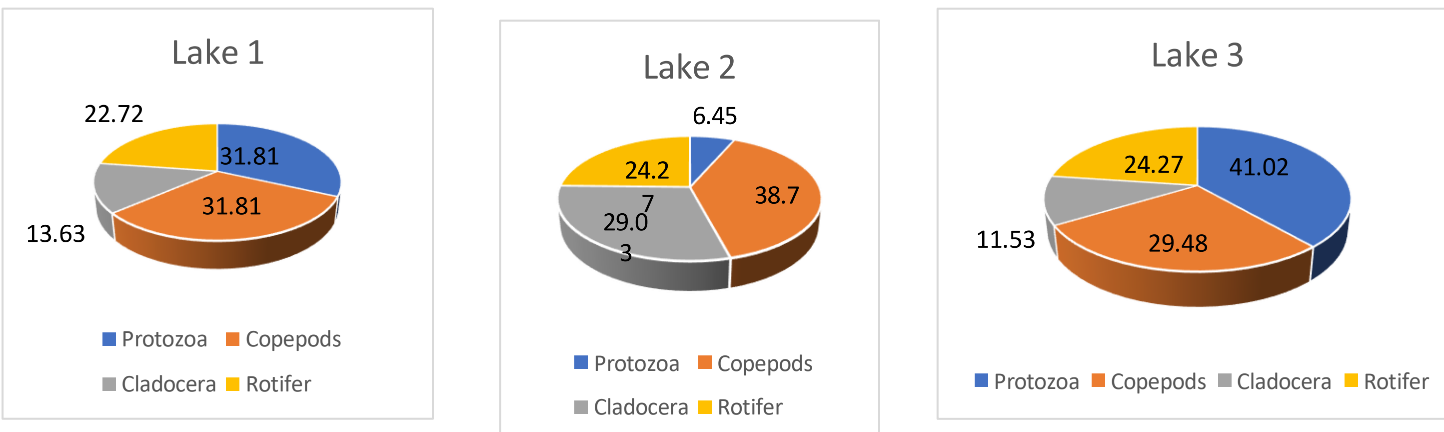
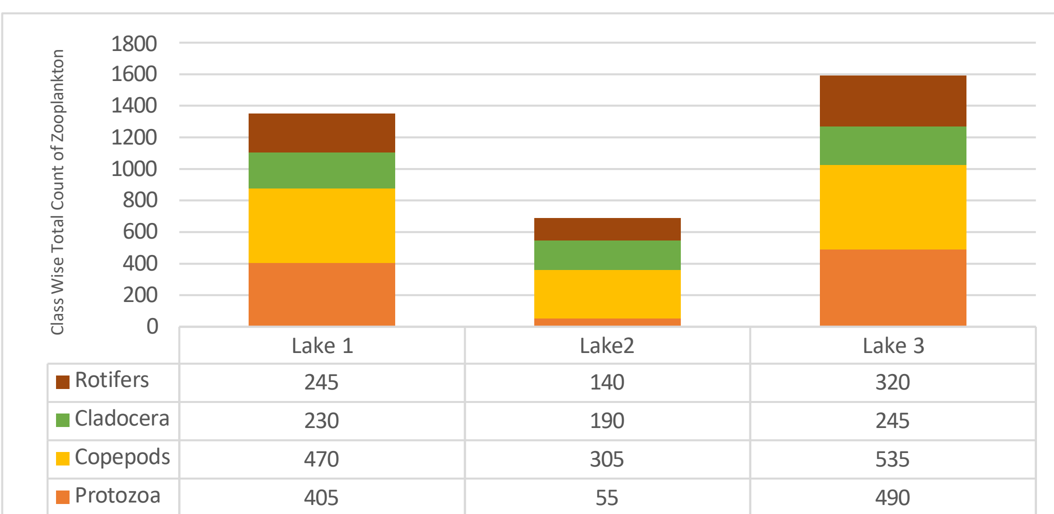


Fig. 9: Distribution of Zooplanktons in Summer season



	Lake 1	Lake2	Lake 3
Rotifers	245	140	320
Cladocera	230	190	245
Copepods	470	305	535
Protozoa	405	55	490

Fig. 10: Total Count of Zooplankton in Sampling

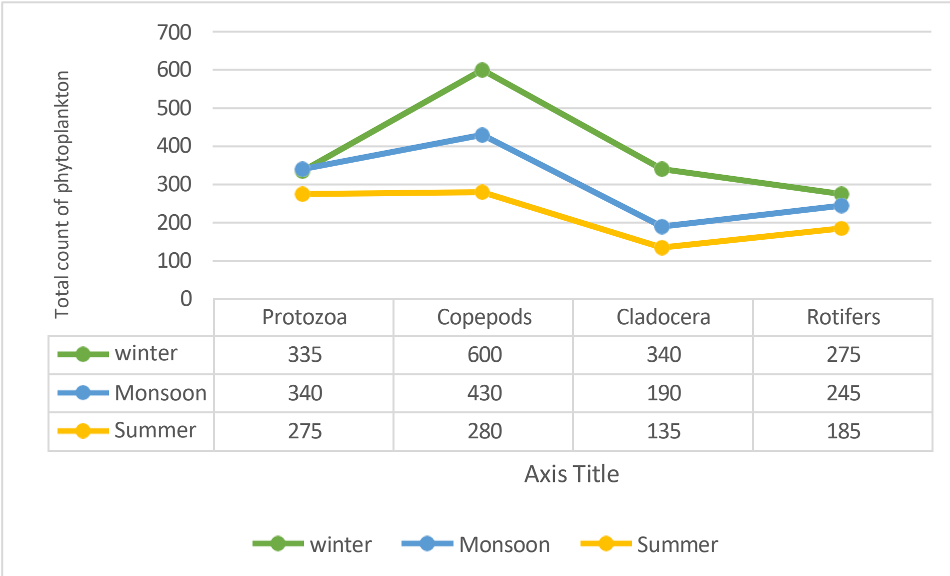


Fig. 11: Seasonal Variations ofZooplankton

The diversity of algae found in the Chlorophyceae family is a key sign of the quality of the water(Ganai et al, 2010). The differences in water quality can be attributed to a combination of natural and human-caused factors. Since most rivers, lakes, estuaries, and seas are affected by a large amount of human activity, anthropogenic inputs from different sources are usually the primary factors affecting the water quality of most of these bodies of water, especially those beside populous areas (Jeyaraj et al., 2016). Bioindicators are living organisms such as bacteria, plants, plankton, and animals that are used to track the health of the natural ecosystem in their surroundings. They are referred to as aquatic pollution indicator species everywhere in the world.

The varying characteristics of the water bodies, variances in the makeup of abiotic elements in the soil and water, and fluctuations in the productivity of various water bodies could all be contributing factors to the changes in the occurrence of peaks in zooplankton(Hasan & Tewari, 2023). From an ecological standpoint, zooplankton are among the most significant biotic elements that impact every aspect of an aquatic ecosystem's functioning, including food webs, food chains, energy exchange, and matter cycling(Ismail & Adnan, 2016). The pre-monsoon season had a strong phytoplankton dominance, but the monsoon season has the largest diversity compared to the other seasons, according to the examination of the diversity indices of Shannon-Weiner, and Simpson's index of diversity(Nath et al., 2020). During the summer, zooplankton predominated, and the presence of indicator species at the sampling station, such as Moina micrura, suggests that the river is contaminated(Dahegaonkar, 2023). Winter was the season with the highest plankton population, followed by the monsoon and Summer. It was also determined that the biological and physicochemical parameters were appropriate for fish culture(Kumar Verma, 2020). Climate variations, physical and chemical properties, and the amount of vegetation all have an impact on the spread of the zooplankton population. Most species of planktonic organisms are widespread(Perumal et al., 2009).

Shannon Diversity Index (H)

A popular diversity index that considers both species' evenness and abundance in the community is the Shannon Diversity Index. It is often used to describe the variety of species within a community.

The Shannon Weiner Index for Indian lakes reported the highest values. The proposed diversity index states that water with a value greater than (>4) indicates clean water, water with a value between 3-4 shows slightly polluted water, and water with a value less than 2 (<2) indicates heavily polluted water(Shekhar et al., 2008). The site-selected water body in the current study has a Shannon-Weiner diversity index ranging from 1.672 to 2.206, indicating that it is a moderately to severely polluted body of water (Tables 12&13)

Equitability Index (EH)

The Shannon diversity index divided by the greatest diversity yields the Equitability index. The values for this equitability index range from 0 to 1. Greater diversity is indicated by higher values, whereas lower values suggest greater diversity. The phytoplankton equitability index ranged between 0.811-1.007and zooplankton ranged as0.93-0.98 i.e. near to 1 indicating low diversity in Lakes 1 and 2 and very low in lake 2 for phytoplankton and low diversity in all lakes for zooplankton(Table 12 &13)

Statistical Analysis:

pH showed significant positive correlation with Temperature (r = 0.47),TDS(r = 0.62), Phytoplankton(r = 0.99) and negative correlation with BOD (r= -0.99),Alkalinity(0.99).Temperature showed a positive correlation with DO (0.86), Phytoplankton (r = 0.5), and a negative correlation with TSS(r = -0.86), Hardness(-0.98).TSS showed a strongly positive correlation with TDS(r = 0.8), COD(r = 0.86), Conductivity (r = 0.91), Hardness (r = 0.94), and Zooplankton (r = 0.86).COD showed a positive correlation with BOD(r = 0.5), Conductivity(0.59), Alkalinity(0.5), Hardness(0.98), and a negative correlation with DO(r = -0.86), and Phytoplankton(r = -0.5).BOD showed a positive correlation with Zooplankton (r = 0.5).Conductivity showed a Positive correlation with hardness(r = 0.74), Zooplankton(r = 0.59), and a negative correlation with DO(r = -0.92).DO showed a strongly negative correlation with Hardness(r = -0.94) and Zooplankton(r = -0.89).Alkalinity showed a positive correlation with Zooplankton(r = 0.5).Hardness showed a strongly positive correlation with Zooplankton (r = 0.98).Zooplankton showed a negative correlation with Phytoplankton(r = -0.50.)

DISCUSION

Throughout the study period, the lakes' average water temperature ranged from 20 to 30 degrees Celsius. The lake had an alkaline pH. D.O. is a crucial sign of a body of water's capacity to sustain aquatic life (Reddy et al., 2021)The trophic levels of lakes determine the dissolved oxygen (DO) content, with the most common consequence of water pollution likely being the decrease of DO in the water(Jeyaraj et al., 2016). During the study, it was reported 2.4- 5.5 mg/l. In freshwater aquatic systems, low D.O. concentrations (less than 3 mg/lit) are indicative of increased pollution in the aquatic ecosystem.

In addition to being a common food source for many omnivorous and carnivorous fish, zooplanktons are significant aquatic animals that are found in large quantities in many kinds of aquatic habitats. Higher plankton count was observed in winter followed by monsoon and summer. Lake 3 was found to have high diversity and total count in almost all seasons, indicating good quality while Lake 2 indicates the presence of some organic pollution.

CONCLUSION

The water quality of the lakes mentioned above is deteriorating due to negligence; hence, significant attention is required. According to practically all of the water quality measures examined, the current study found that the lake's water quality is contaminated. According to WHO recommendations and drinking water regulations, the surface water of the lakes in our study area in the Anandwan region is unfit for residential use. We can gather fundamental information on the diversity of phytoplankton and zooplankton from the current study, which advances our understanding of the condition and biodiversity of the aquatic ecosystem. A total of 11 species of Zooplankton and 19 species of Phytoplankton were recorded Numerous environmental circumstances can support the existence of zooplankton. They are also excellent bioindicators for determining the level of pollution in any freshwater body(Wadjikar et al., 2017). The presence of copepods, Cladocera, and rotifers reveals that the Lakes are being organically polluted. During the investigation presence of plankton maximum in the January month and minimum in February.

Table 12: Phytoplanktons Diversity and Equatibility Indices

Lakes	Total Count (no./L)	Shannon Diversity Index	Equitability Index
Monsoon			
Lake1	3.495	2.71	0.84
Lake2	0.6	2.3	
Lake3	4.02	2.68	
Winter			
Lake1	3.915	2.68	1.00
Lake2	0.675	2.28	
Lake3	3.87	2.7	
Summer			
Lake1	2.775	2.64	0.81
Lake2	0.18	2.14	
Lake3	3.96	2.64	

Table 13: Zooplankton Diversity and Equatibility Indices

Lakes	Total Count (no./L)	Shannon Diversity Index	Equitability Index
Monsoon			
Lake1	445	2.08	0.96
Lake2	265	2.10	
Lake3	505	2.17	
Winter			
Lake1	275	2.12	0.93
Lake2	225	2.02	
Lake3	365	1.97	
Summer			
Lake1	225	2.05	0.98
Lake2	150	2.07	
Lake3	230	2.04	

Table 14: Zooplankton Identified During Study and Its Indication.

Sr. No.	Names of Zooplankton	Indications	References
1.	*Diptomus*	Eutrophic	(V, 2023)
2.	*Aeanthocyclops sp.*	Polluted	(Sinha, 2003)
3.	*Mesocyclops*	Polysaprobic	(Kumari et al., 2008)
4.	*Tropocyclops*	Polluted	(Sinha, 2003)
5.	*Ceriodaphnia*	Eutrophic	(Ismail & Mohd Adnan, 2016)
6.	*Daphnia*	Polluted	(V, 2023)
7.	*Leptodioptomus sp.*	Polysaprobic	(Sinha, 2003)

8.	*Oithona*	Polluted	(Srichandan et al., 2018a)
9.	*Brachionuscaudatus*	Eutrophic	(Srichandan et al., 2018b)
10.	*Chilomonas*	Organic polution	(Hemraj et al., 2017)
11.	*Paramecium*	Organic polution	(Hemraj et al., 2017)

Table 15: Phytoplanktons Identified During Study and Its Indication.

Sr. No.	Name of Phytoplankton	Indications	References
1.	*Chlamydomonas*	Polluted	(V, 2023)
2.	*Pediastrum duplex*	Organic polution	(Perumal et al., 2009)
3.	*Ulothrix*	Polluted	(Brasil et al., 2020)
4.	*Cladophora*	Polysaprobic	(Kumari et al., 2008)
5.	Filamentous algae	Organic pollution	(Sharma et al., 2013)
6.	Non-filamentous algae	Eutrophic	(Gao et al., 2018)
7.	*Microspora*	Organic pollution	(Malik & Bharti, 2012)
8.	*Odogonium*	Polluted	(Thakur et al., 2013)
9.	*Spirogyra*	Polluted	(Brasil et al., 2020)
10.	*Cylindrospermum*	Sewage pollution	(Sharma et al., 2013)
11.	*Anacystis*	Eutrophic	(Hemraj et al., 2017)
12.	*Melosira*	Eutrophic	(Thakur et al., 2013)
13.	*Diatom*	Deteriorate	(Malik & Bharti, 2012)
14.	*Fragilaria capucina*	Polluted	(Parmar et al., 2016)
15.	*Closterium*	Polluted	(Gao et al., 2018)
16.	*Desmidium*	Polysaprobic	(Bay Saldanha, 2001)
17.	*Phacus*	Polluted	(V, 2023)
18.	*Batrachospermum*	Polysaprobic	(Brasil et al., 2020)

FUTURE PROSPECTIVES

Continuous monitoring of plankton diversity and abundance in aquatic ecosystems can provide valuable insights into seasonal and long-term variations. This data can be used to understand the impact of climate change, pollution, and other environmental factors on the lakes' ecosystem over time. The study can contribute to the development of effective water quality management strategies. Understanding the relationship between plankton and water quality can help in devising measures to maintain or improve water quality, which is crucial for both ecological health and human use. Investigating plankton diversity can provide insights into the overall biodiversity of the lakes. Future research could explore how changes in plankton populations might affect other species in the ecosystem, including fish, birds, and aquatic plants.

The data collected can be used to assess the risk of eutrophication in the lakes. Eutrophication is the process of water quality deterioration caused by excess nutrients, and understanding how plankton responds to nutrient inputs can help in preventing or mitigating eutrophication. The findings can be used for educational purposes to raise public awareness about the importance of preserving water bodies and their ecosystems. Outreach and education programs can still foster a sense of responsibility and engagement in local communities. Research findings can inform local and regional policies and regulations related to water quality and ecosystem conservation. Scientists can collaborate with policymakers to implement measures aimed at protecting these lakes.

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