STATUS OF PLANKTONIC COMMUNITY IN THE KANEWAL COMMUNITY RESERVOIR IN CENTRAL GUJARAT, INDIA

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Original scientific paper
Received: August 17th, 2023
Accepted: October 21st, 2023
HAE-2387
https://doi.org/10.33765/thate.14.4.2

ABSTRACT

A two-years study (March 2021 to February 2023) was carried out at the Kanewal Community Reservoir, an important water storage reservoir in central Gujarat, to assess the diversity and seasonal variation of the planktonic community. During the study period, a total of 60 phytoplankton species were recorded, belonging to 9 classes, 25 orders and 39 families. Class-wise percentage composition of phytoplankton showed a diverse array during the study period. The species gradient of phytoplankton was as follows: Bacillariophyceae (20) > Zygnematophyceae (14) > Cyanophyceae (10) > Chlorophyceae (9) > Euglenophyceae (2) > Trebouxiophyceae (2) > Dinophyceae (1) > Klebsormidiophyceae (1) > Ulvophyceae (1). Thirty (30) different zooplankton species were recorded during this study, belonging to 11 classes, 14 orders and 19 families. The number of abundant species remained constant throughout the study period. The recorded number of common zooplanktonic species also remained steady (14). However, the number of rare species slightly increased to two (2), which indicates a slight increase in the occurrence of less prevalent species. The highest density of zooplankton was observed during the summer, and the lowest in the monsoon season. Overall, it was found that KCR (Kanewal Community Reservoir) contains a higher number of phytoplankton species (60) compared to zooplankton (30), which could be a consequence of the voluminous hydrological regime with abundant occurrence of macrophyte elements.

Keywords: *diversity, seasonal variation, phytoplankton, zooplankton, Kanewal Community Reservoir*

INTRODUCTION

Freshwater wetlands are considered vital ecological systems that are situated at the interface between terrestrial and aquatic environments [1]. These unique ecosystems are characterized by the presence of stagnant water or waterlogged soils, which persist for a minimum period of time each year [2]. Habitats consist of a wide range of ecosystems, including marshes, swamps, bogs, and floodplains [3]. Wetland ecosystems play a crucial role in the conservation of biodiversity due to their ability to support a wide range of plant, animal, and microbial species. In addition, it is important to note that these ecosystems provide a diverse array of ecosystem services. These services encompass crucial functions such as water purification, flood mitigation, carbon sequestration, and recreational opportunities [4]. Plankton are tiny, immobile organisms found in the upper photic zone of aquatic environments, unable to actively swim against prevailing currents. They play a critical role in aquatic ecosystems by facilitating energy and material flow processes [5]. Furthermore, plankton are sensitive indicators of environmental changes and are considered vulnerable components of aquatic ecosystems [6].

In the aquatic environment, phytoplankton is a highly prevalent life form that is characterized by its ubiquity, unicellular form, and microscopic size. Phytoplankton, as a collective group, constitutes approximately 50 % of the primary producers within the Earth's biosphere [7]. Phytoplankton, as a crucial component of aquatic ecosystems, has a dual role as it contributes to primary production and serves as a significant food source for herbivorous organisms. In addition, these organisms play a crucial role as important biological indicators in research studies that aim to investigate and assess water quality and pollution levels [8]. Zooplankton occupies a key position in the trophic structure of aquatic ecosystems and has a significant influence on the dynamics of energy transfer [9]. The limited understanding of plankton and their dynamics represents a significant obstacle to the understanding the natural processes occurring in freshwater ecosystems [10]. The current investigation aims to provide a comprehensive assessment of the diversity of plankton, including phytoplankton and zooplankton.

The study intends to concentrate on examining the species composition, population density, and community characterization of these organisms. Planktons are recognized for their significant role as bioindicators in the assessment of nutrient content and habitat suitability of lakes as feeding grounds for migratory water bird populations. The aim of this study is to focus on the examination of species composition, community characterization, species abundance, and seasonal variation of plankton species.

MATERIALS AND METHODS

Study area

Kanewal Community Reservoir (KCR) is an important water storage reservoir situated between 22^0 28' N latitude and 72^0 32' E longitude at an altitude between 14 to 15 m above mean sea level, covering an area of approximately 625 km^2. It falls under 4-B Gujarat Rajwara region of central Gujarat. It lies in a natural depression, surrounded by embankment with a circumference of about 15 km, it contains 3 small islands in the centre of the wetland. It has a total catchment area of 8 - 18 Mm^3 (million cubic meters) with a maximum depth of 12 m (Table 1).

Table 1. Profile of Kanewal Community Reservoir

Location	Central Gujarat
Wetland type	Community water reservoir
Longitude	72° 32' 00 E
Latitude	22° 28' 00 N
Altitude	Between 14 to 15 m above mean sea level
Bio-geographic region and province	Semi-arid (4), Gujarat-Rajwara (4B)
Catchment area	8 -18 Mm^3
Maximum depth	12 m
Area	625 km^2
Source of water	Mahi River Branch Canal of Wanakbori weir raised on Mahisagar River

It is abundant with lush aquatic vegetation, e.g. Ipomoea aquatica, Marsilea quadrifolia, Nymphaea stellata, Nelumbo officinalis, and Typha angustata. In addition, it is home to some domestic bird species, such as moorhens, egrets, ibises, lapwings, etc., and also attracts various migratory species of birds from distant countries such as Europe, Russia, Siberia, China, etc., e.g. waterfowls such as coots, plovers, spoonbills, migratory ducks, etc. during the peak of the winter period (Figure 1). The physicochemical parameters for Kanewal Community Reservoir during the study period reveal important insights into the water quality of the reservoir. The physicochemical parameters provide an overview of the water quality in Kanewal Community Reservoir, with some parameters showing stability while others exhibit variations (Table 2).

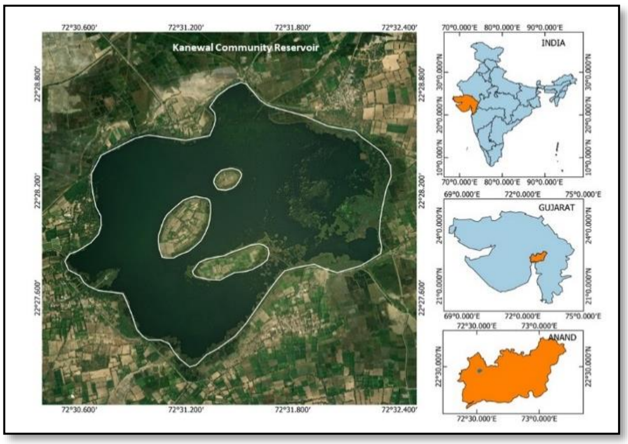


Figure 1. Study area (Kanewal Community Reservoir - KCR)

Table 2. Physicochemical parameters at Kanewal Community Reservoir (mean)

Parameter	2021-22	2022-23	2021-23
Temperature (^{0}C)	26.85	26.86	26.85
Electrical conductivity (µs/cm)	335.83	336.11	335.97
Total solids (mg/L)	804.07	877.22	840.65
Total suspended solids (mg/L)	558.45	609.28	583.87
Total dissolved solids (mg/L)	245.62	267.94	256.78
Turbidity (NTU)	7.10	6.04	6.57
pH	8.15	8.16	8.15
Dissolved oxygen (mg/L)	7.21	6.97	7.09
Free CO_2 (mg/L)	11.75	12.59	12.17
Chloride (mg/L)	26.42	27.07	26.74
Total hardness (mg/L)	166.35	167.56	166.95
Ca hardness (mg/L)	95.68	97.64	96.66
Mg hardness (mg/L)	70.67	69.92	70.30
Sulphate (mg/L)	9.53	14.37	11.95
Phosphate (mg/L)	7.32	9.23	8.28
Nitrate (mg/L)	7.20	7.19	7.19

The research was carried out over a period of two years, from March 2021 to February 2023. Surface water samples were collected monthly for the purpose of analysing the planktonic community. The water samples were collected between 8:00 am and 1:00 pm. A plankton net with a mesh size of 20 microns was used to collect plankton samples. The net was towed on the surface of the upper photic zone, reaching a depth of nearly one feet. This process was repeated approximately 25 times to obtain more diverse plankton species. The collected plankton samples were then transferred to pre-cleaned polyester bottles with a capacity of 500 ml. To preserve the samples, 4 % formaldehyde was added immediately after the collection [11]. In this study, a water sample with a total volume of 50 l was taken and filtered through plankton net. The concentrated samples obtained by this procedure were subsequently transferred to the laboratory for further analysis. Collected plankton samples were subjected to microscopic analysis using a Labomed Lx400 microscope at magnifications of 10X, 40X, and 100X. The identification of the observed plankton species was carried out with the help of standard published reference literature [12 - 20]. Abundance criteria of the species was used to assess the probability of plankton occurrence. Those with an occurrence greater than or equal to 89 % were categorized as abundant, while those with an occurrence between 43 % and 88 % were classified as common. Phytoplankton with an occurrence of less than 43 % was considered rare.

RESULT AND DISCUSSION

Phytoplankton

During the study period, a total of 60 species belonging to 9 classes, 25 orders and 39 families were recorded (Figure 2, Figure 3). Among the phytoplankton, class-wise percentage composition showed a diverse array of phytoplankton classes. The species gradient of phytoplankton was as follows: Bacillariophyceae (20) > Zygnematophyceae (14) > Cyanophyceae (10) > Chlorophyceae

(9) > Euglenophyceae (2) > Trebouxiophyceae (2) > Dinophyceae (1) > Klebsormidiophyceae (1) > Ulvophyceae (1). A similar pattern was reported in plankton studies at Veeranam lake in the Cuddalore district of Tamil Nadu [21]. Of the total recorded species, the Bacillariophyceae class showed the greatest dominance, with a significant share resulting from a total of 20 species (33.3 %) [22, 23]. High dominance of Bacillariophyceae indicates the unpolluted nature of the water [24]. The Zygnematophyceae class was represented by a total of 14 species, which accounted for 23.3 %. Several research studies have shown that the members of the Zygnematales serve as indicators of oligotrophic to mesotrophic lakes [25]. The Chlorophyceae class was represented by 9 species, which accounted for approximately 15.0 %. Previous research studies suggested that Chlorophyceae remains dominant in moderately polluted waterbodies. Therefore, the lower occurrence of Chlorophyceaen members also supports non-eutrophic status of KCR [26]. Cyanophyceae was represented by 10 species, which accounted for 16.7 %. Similar results were documented in the Ukkadam Lake of Coimbtore, Tamil Nadu [27]. Klebsormidiophyceae, Dinophyceae and Ulvophyceae showed minimal occurrence, each represented by one species, which accounts for only 1.7 %. The classes Euglenophyceae and Trebouxiophyceae were represented by two species each, which accounted for 3.3 % of all species recorded at KCR (Figure 4).

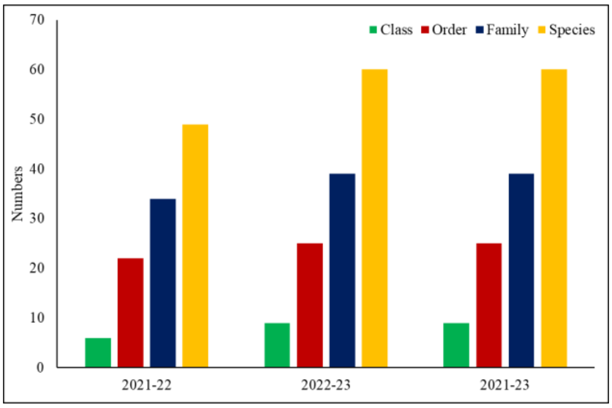


Figure 2. Phytoplankton diversity in KCR

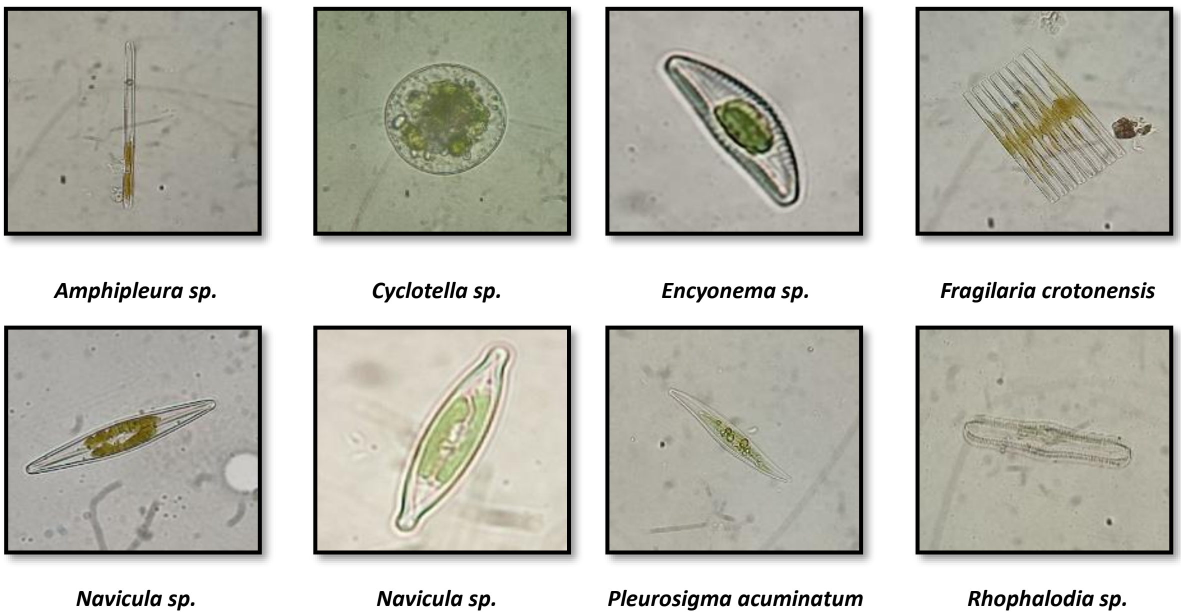
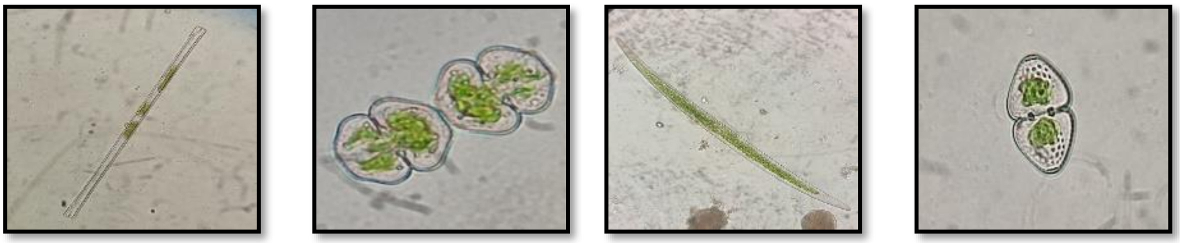
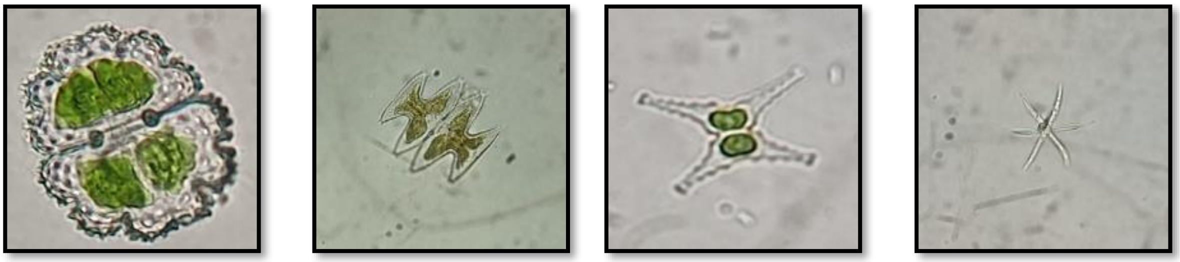


Figure 3. Phytoplankton diversity in KCR

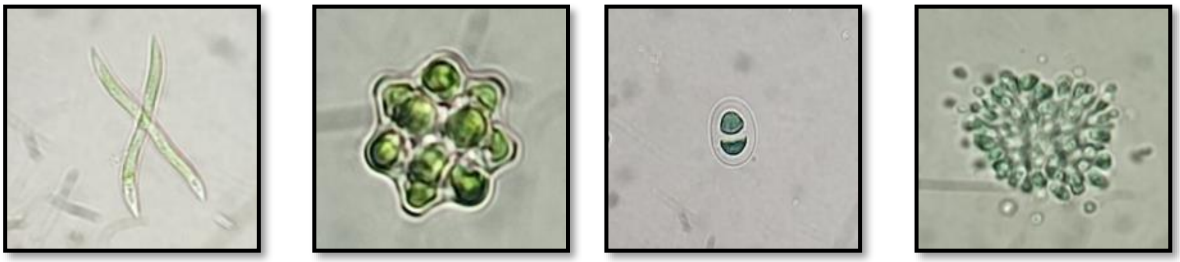


Synedra ulna | ***.Cosmarium sp.*** | ***Closterium parvulum*** | ***Cosmarium granatum***

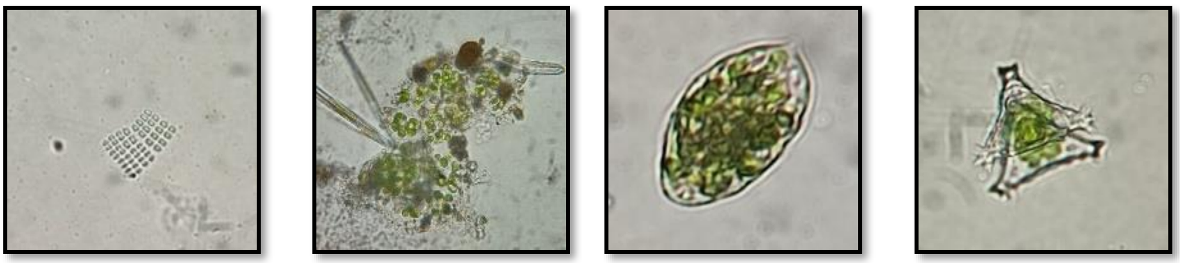
Cosmariummargaritatum | ***Cosmarium spinuliferum*** | ***Desmidium aptogonum*** | ***Euastrumdivaricatum***



Euastrum dubium | ***Micrasteria sp.*** | ***Staurastrumanatinum*** | ***Ankistrodesmus spiralis***



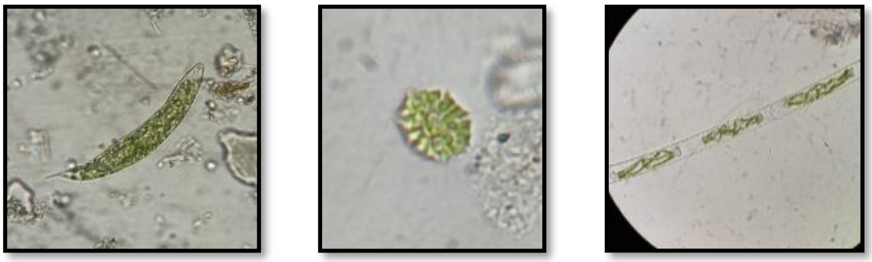
Ankistrodesmus sp. | ***Coelastrum microporum*** | ***Chroococcus tenax*** | ***Coelosphaeriumsp***



Merismopedia glauca | ***Microcystis aeruginosa*** | ***Phacus sp.*** | ***Staurastrum sp.***

Figure 3 (continued). Phytoplankton diversity in KCR

Cymbella gastroides ***Nitzschia sp.*** ***Closterium acutum*** ***Cosmarium vexatum***



Euglena agilis ***Pediastrum tetras*** ***Spirogyra porticalis***

Figure 3 (continued). Phytoplankton diversity in KCR

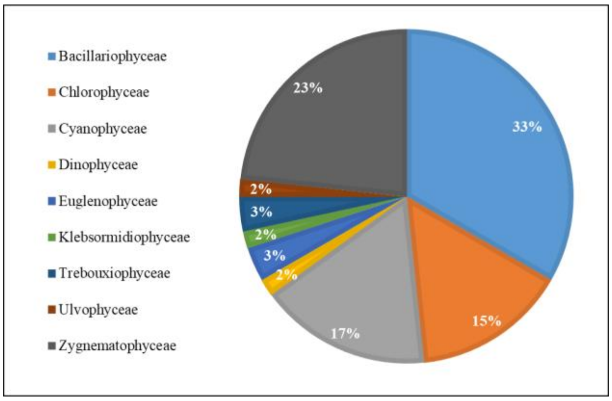


Figure 4. Class-wise percentage composition of phytoplankton

During the first year (2021-22), a total of 49 species of phytoplankton were recorded. Among them, 27 species were abundant, 20 were common, and 2 were rare (*Chlamydomonas sp.*, *Desmidium aptogonum*). This distribution indicates that most of phytoplankton was abundant during this period, which could be an indicator of favourable environmental conditions, nutrient availability, and other factors that support plankton growth. During the second year (2022-23), the total number of phytoplankton species increased to 60. A significant increase in the number of abundant species from 27 to 46 species indicates a significant growth in plankton population during this period. Number of common species was reduced from 20 to 12. However, the number of rare species remained unchanged (2 species) during both years. Accentuated number of phytoplankton species indicates deterioration of water quality and induced trophic level of the water body [28, 29].

This shift in abundance levels could be due to fluctuations in environmental factors, such as temperature, nutrient availability, and other ecological dynamics. During the study period (2021-23), a total of 60 species of phytoplankton were recorded in KCR. Out of these, 52 species were abundant, while seven (7) species were common, and only one (1) species was rare. Some research studies have also suggested that the ecosystem conditions may have remained relatively favourable for the growth of abundant plankton [30, 31] (Figure 5). Seasonal fluctuations in the phytoplankton species richness were also significant during two consecutive years. Overall, the highest number of phytoplankton species (60) was recorded in April and June of the second year, and the lowest (31) was recorded in October of the first year. During summer season, species richness showed a gradual increase, starting from March, which remained almost stable in April, May and June without major deviation. Phytoplankton abundance is high during summer due to the influence of abiotic factors such as increased temperature, availability of nutrient, and sunlight [32, 33]. During monsoon season, a gradual downward trend was observed as the number of phytoplankton was 58 in July, 53 in August, and 50 in September (Figure 6). This could be due to turbidity caused by surface runoff. Turbidity reduces the availability of light to phytoplankton, which can drastically affect their growth [34, 35].

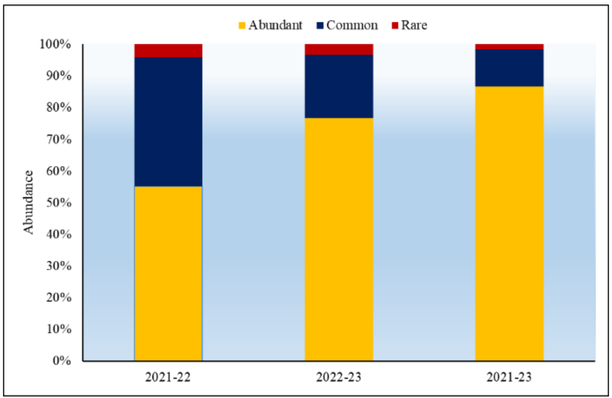


Figure 5. Phytoplankton abundance in KCR

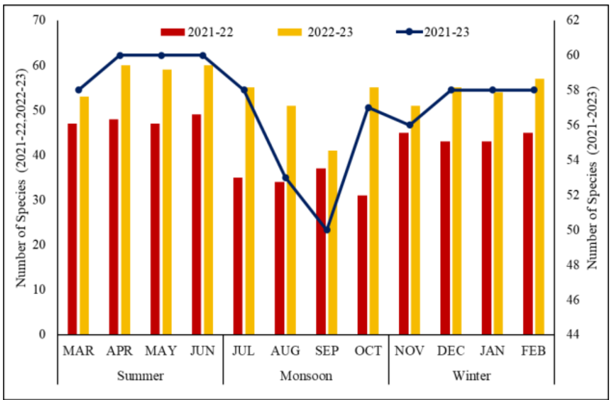


Figure 6. Seasonal variation of phytoplankton

Zooplankton

A total of 30 different species of zooplankton were recorded during the study period of two years belonging to 11 classes, 14 orders and 19 families (Figures 7 and 8). Among the identified zooplankton classes, the Euglenoidea was the most represented with 10 species, making up about 33.33 % of the total population, followed by Copepoda (9, 30.0 %) and Branchiopoda (4) which make up 13.33 % of the total recorded species [36, 37]. On the other hand, the classes Monogononta, Tubulinea, Ostracoda, Oligohymenophorea, Kinetoplastida, Raphidophyceae, Imbricatea and Bdelloidea were represented by only one species from each class, which accounts for approximately 3.33 % of the total recorded species (Figure 9).

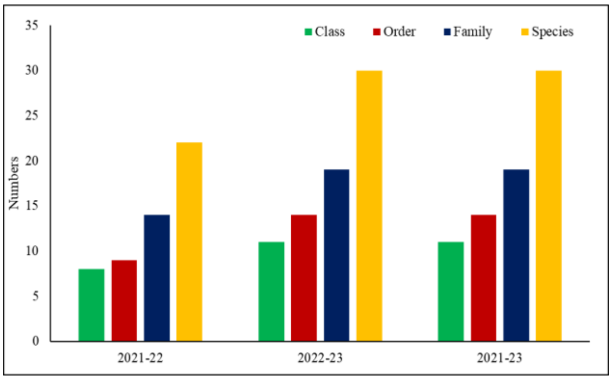


Figure 7. Zooplankton diversity in KCR

During the first year (2021-22) of the study, the zooplankton community exhibited a total of 22 different species. Among them, 4 species were abundant, 17 were common, and only one species was rare. During the second year (2022-23), zooplankton population showed a slight increase in species diversity. The total number of identified species was 30, indicating a more diverse community compared to the previous year (2021-22). The increasing diversity of zooplankton from year to year can be attributed to the abundant organic detritus, water inflow with high organic load as recorded in the freshwater pond in Bhadrawati town in Chandrapur district in Maharashtra, India [38, 39]. Among them, 6 species were abundant, 21 were common, and the number of rare species also increased to 3. Considering the cumulative data for both the years (2021-23), the zooplankton community showed a total of 30 different species. The number of abundant species remained constant (4), indicating a consistent high presence over the two-years period. The common species also remained steady (14), indicating a consistent moderate prevalence. However, the number of rare species slightly increased to 2, indicating a smaller increase in the occurrence of less prevalent species (Figure 10). During the summer season, the zooplankton richness showed a progressive increase from the first to the second year. Zooplankton population density was highest during summer and lowest in monsoon. Similar data on zooplankton diversity were recorded in Osmansagar Reservoir, Telangana, India [40]. In the first year (2021-22), richness ranged from 19 to 22 species, and reached its peak in April with 22 species. In the second year (2022-23), richness further increased, showing higher number of species compared to the previous year. The maximum richness during this period was recorded in April in both years (26 species). High zooplankton abundance can be attributed to the increase in atmospheric temperature, food availability and favourable environmental conditions during hot summer days [41].

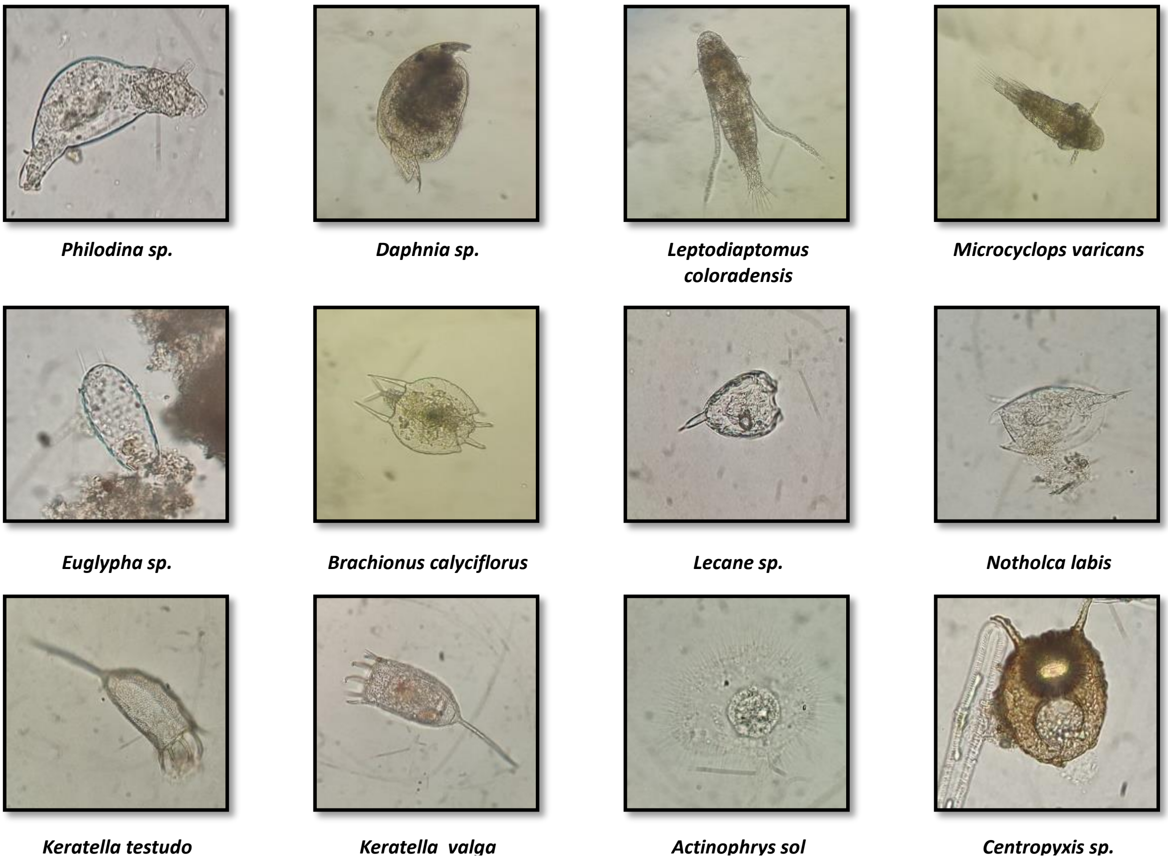


Figure 8. Zooplankton diversity in KCR

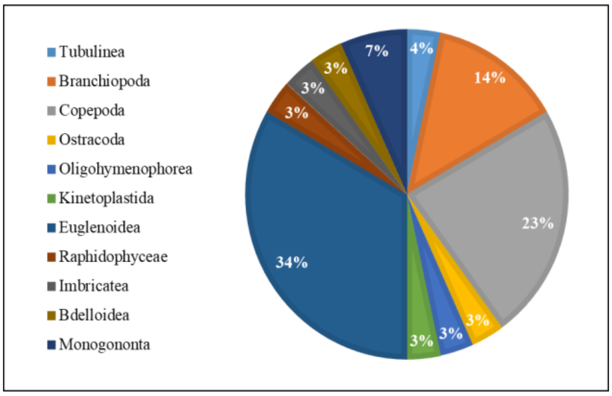


Figure 9. Class-wise percentage composition of zooplankton

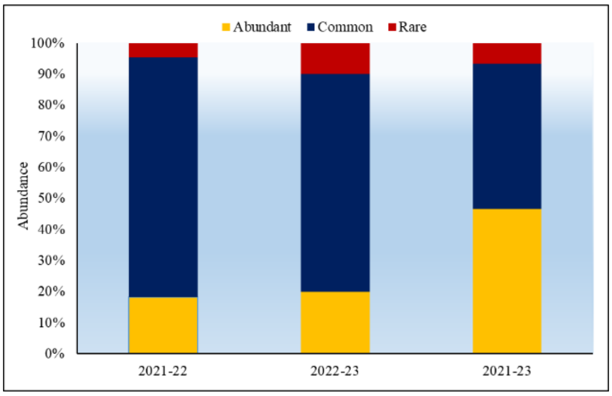


Figure 10. Zooplankton abundance in KCR

In the monsoon season, zooplankton richness fluctuated significantly over two years. In the first year (2021-22), species richness ranged from 11 to 21. The month of June had the highest richness, while July showed the lowest number of species. Similarly, in the second year (2022-23), richness ranged from 13 to 23 species. The month of June had the highest number of species, and July the lowest. The impact on water turbidity by run-off from the adjacent area is a well-documented phenomenon. It has been observed that increase in turbidity has negative consequences on the diversity of phytoplankton populations [42]. As a result, the availability of food resources for zooplankton is significantly reduced. This chain of events highlights the interconnected nature of aquatic ecosystems, which emphasizes the importance of managing run-off to maintain a healthy and balanced food web. In past, various researchers have observed that zooplankton populations tend to decline during the monsoon season [43, 44]. However, unlike summer, there was no significant increase in species richness from the first to the second year in case of monsoon season.

In the winter season, the level of zooplankton richness showed a consistent and minimal fluctuation over the span of two years. The study recorded variations in species richness, ranging from 10 to 21 in the first year and from 13 to 21 in the second year. In both years, the month of February showed comparably the highest richness with 21 species. On the other hand, November and December showed the lowest richness in both years, with 10 and 13 species, respectively (Figure 11). Several research studies have shown a comparable pattern. The winter season is characterized by reduced fluctuations in circulations and the presence of calm water, particularly in lentic wetlands [45].

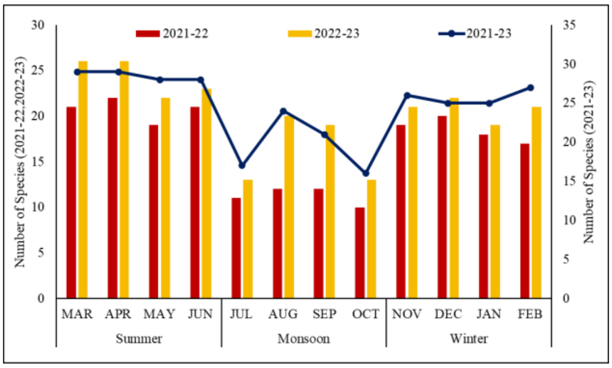


Figure 11. Seasonal variation of zooplankton

CONCLUSION

The Kanewal community reservoir exhibits a rich and diverse plankton community, which contributes significantly to its ecological health. The phytoplankton population consists of 60 species belonging to 9 classes, 25 orders, and 39 families. Among them, 52 species were abundant, highlighting their importance in the ecosystem. In contrast, 7 species were common, and 1 species was rare, providing a balanced diversity structure. The zooplankton community was also well represented in this environment, with 30 species belonging to 11 classes, 14 orders, and 19 families. 14 species were abundant and 2 were rare, highlighting the intricate web of life within the wetland. Seasonal variations in plankton diversity showed the resilience of the ecosystem, with consistent numbers of 60 species during the summer and monsoon, and a slightly reduced diversity of 29 species during winter. Overall, the Kanewal wetland serves as a vital habitat for a wide array of planktonic organisms, highlighting the need for its preservation and continued research to ensure the long-term sustainability of this intricate aquatic ecosystem.

REFERENCES

[1] P. Horwitz, Wetlands as social ecological systems, and relationality in the policy domain, Marine and Freshwater Research 74(2022) 3, 281-285. https://doi.org/10.1071/MF22018

[2] F.R. Zaidel'man, A.P. Shvarov, T.M. Ginzburg, Genesis, hydrology, and properties of soils in mesodepressions waterlogged by surface water in the northern Ryazan forest-steppe, Eurasian Soil Science 40(2007), 917-927. https://doi.org/10.1134/S1064229307090013

[3] K. Reddy, R.D. DeLaune, Biogeochemistry of Wetlands: Science and Applications, 1st Edition, CRC Press, Boca Raton, 2008. https://doi.org/10.1201/9780203491454

[4] W.J. Mitsch, J.G. Gosselink, L. Zhang, C.J. Anderson, Wetland ecosystems, 1st Edition, John Wiley & Sons, Canada, 2009.

[5] H.J. Chaudhari, H.B. Soni, Review on Interplay between Hydro-geochemistry, Plankton dynamics and Avifaunal assemblage of two Significant freshwater inland wetlands of national Importance, Gujarat, India, Life sciences leaflets 148(2022),14-36.

[6] S. Chen, B.D. Fath, B. Chen, Information-Based Network Environ Analysis: A system perspective for ecological risk assessment, Ecological indicators 11(2011) 6, 1664-1672. https://doi.org/10.1016/j.ecolind.2011.04.013

[7] M.D. Giripunje, A.B. Fulke, K. Khairnar, P.U. Meshram, W.N. Paunikar, A Review of Phytoplankton Ecology in Freshwater Lakes of India, Lakes Reservoirs and Ponds 7(2013) 2, 127-141.

[8] T.K. Parmar, D. Rawtani, Y.K. Agrawal, Bioindicators: The Natural Indicator of Environmental Pollution, Frontiers in Life Science 9(2016) 2, 110-118. https://doi.org/10.1080/21553769.2016.1162753

[9] S. Lomartire, J.C. Marques, A.M.M. Gonçalves, The key role of zooplankton in ecosystem services: A perspective of interaction between zooplankton and fish recruitment, Ecological Indicators 129(2021), Article ID: 107867. https://doi.org/10.1016/j.ecolind.2021.107867

[10] J. Waterhouse, J. Brodie, D. Tracey, R. Smith, M. VanderGragt, C. Collier, C. Petus, M. Baird, F. Kroon, R. Mann, T. Sutcliffe, D. Waters, F. Adame, 2017 Scientific Consensus Statement: A synthesis of the science of land-based water quality impacts on the Great Barrier Reef, Chapter 3: The risk from anthropogenic pollutants to Great Barrier Reef coastal and marine ecosystems, State of Queensland, 2017.

[11] S.K. Battish, Freshwater Zooplanktons of India, Oxford and IBH Publishing Co. Pvt. Ltd., Calcutta, 2000.

[12] M.T. Philipose, Chlorococcales, I.C.A.R Monographs on Algae, New Delhi, India, 1967, 365.

[13] T.V. Desikachary, Cyanophyta, Indian Council of Agriculture Research, New Delhi, India, 1959.

[14] G.W. Prescott, The Algae: A Review, Lubrecht & Cramer Ltd, 1st Edition, Colombia, 1984.

[15] M.R. Broschart, Abundance, Biomass, and Diversity of Aquatic Invertebrates in level ditches and adjacent natural emergent marsh in an Eastern South Dakota Wetland, Thesis, Wildlife and Fisheries Science, 1984.

[16] J.A. Downing, F.H. Rigler, A manual on methods for the assessment of secondary production in fresh waters, IBP Handbook No.17, 2nd Edition, Blackwell Scientific Publication, Oxford, 1984.

[17] G.T. Tonapi, Fresh Water Animals of India, An Ecological Approach, Oxford & IBH, New Delhi, India, 1980.

[18] R.W. Pennak, Diurnal Movements of Zooplankton Organisms in Some Colorado Mountain Lakes, Ecology 25(1994) 4, 387-403. https://doi.org/10.2307/1932014

[19] G.W. Edmondson, Freshwater Biology, John Wiley Publications, USA, 1998.

[20] S.K. Battish, Freshwater Zooplanktons of India, Oxford and IBH Publishing Co. Pvt. Ltd., Calcutta, 2000.

[21] R. Senthilkumar, K. Sivakumar, Studies on phytoplankton diversity in response to abiotic factors in Veeranam Lake in the Cuddalore district of Tamil Nadu, Journal of Environmental Biology 29(2008) 5, 747-752.

[22] J.I. Nirmal Kumar, C. Oommen, Phytoplankton composition in relation to hydrochemical properties of tropical community wetland, Kanewal, Gujarat, India, Applied Ecology and Environmental Research 9(2011) 3, 279-292.

[23] H.B. Soni, S. Thomas, Preliminary Observations on Phytoplankton at Sacred palustrine habitat, Central Gujarat, India, International Journal of Environment 2(2013) 1, 115-126. http://dx.doi.org/10.3126/ije.v2i1.9215

[24] K. Thakur, H.B. Soni, A Prelude of Phytoplankton at Eco-Sensitive Zone, Beyt Dwarka, Southern Gulf of Kachchh, Western Gujarat, India, International Journal of Life Sciences Leaflets 75(2016), 147-158.

[25] T.K. Mhaske, D.S. Talwankar, Occurrence of Cosmarium species in Khadakpurna reservoir, Buldana district, Maharashtra, India, GSC Biological and Pharmaceutical Sciences 5(2018) 3, 20-24. https://doi.org/10.30574/gscbps.2018.5.3.0136

[26] P.P. Baruah, B. Kakati, Water quality and phytoplankton diversity of Gopeswar temple freshwater pond in Assam (India), Bangladesh, Journal of Botany 41(2012) 2, 181-185. https://doi.org/10.3329/bjb.v41i2.13446

[27] N. Manickam, P.S. Bhavan, P. Santhanam, R. Bhuvaneswari, T. Muralisankar, V. Srinivasan, A. Asaikkutti, G. Rajkumar, R. Udayasuriyan, M. Karthik, Impact of seasonal changes in zooplankton biodiversity in Ukkadam Lake, Coimbatore, Tamil Nadu, India, and potential future implications of climate change, The Journal of Basic and Applied Zoology 79(2018), Article number: 15. https://doi.org/10.1186/s41936-018-0029-3

[28] E.A. Dembowska, T. Mieszczankin, P. Napiórkowski, Changes of the phytoplankton community as symptoms of deterioration of water quality in a shallow lake, Environmental Monitoring and Assessment 190(2018), Article number: 95. https://doi.org/10.1007/s10661-018-6465-1

[29] D. Dubey, V. Dutta, Nutrient Enrichment in Lake Ecosystem and Its Effects on Algae and Macrophytes, in: Environmental Concerns and Sustainable Development, Volume 2: Biodiversity, Soil and Waste Management, eds.: V. Shukla, N. Kumar, Springer, Singapore, 2020, 81-126. https://doi.org/10.1007/978-981-13-6358-0_5

[30] W. Zhu, L. Wan, L. Zhao, Effect of nutrient level on phytoplankton community structure in different water bodies, Journal of Environmental Sciences 22(2010) 1, 32-39. https://doi.org/10.1016/S1001-0742(09)60071-1

[31] H.B. Soni, S. Thomas, Associative Dependence among Plankton and Macrophytes as Pollution Markers at Tropical Lentic Environ, Gujarat, India, International Journal of Environment 3(2014) 2, 175-191. https://doi.org/10.3126/ije.v3i2.10528

[32] S. Dash, S. Padhan, G. Rajhans, P.K. Mohapatra, R.K. Sarangi, D. Raut, B. Mohanty, S. Nayak, L. Patnaik, Abundance and Diversity of Plankton in the Coastal Waters of Chandipur, Bay of Bengal, Russian Journal of Marine Biology 45(2019), 252-261. https://doi.org/10.1134/S106307401903009X

[33] B.J. Hu, Y.Y. Huang, L.Z. Wu, H.M. Qin, Y.J. Hong, Seasonal phytoplankton community patterns and influencing factors in fish-mussel systems, Applied Ecology and Environmental Research 18(2020) 2, 3387-3408. https://doi.org/10.15666/aeer/1802_33873408

[34] M. Guenther, R. Bozelli, Effects of inorganic turbidity on the phytoplankton of an Amazonian Lake impacted by bauxite tailings, Hydrobiologia 511(2004), 151-159. https://doi.org/10.1023/B:HYDR.0000014095.47409.39

[35] L.L. Yuan, Continental-scale effects of phytoplankton and non-phytoplankton turbidity on macrophyte occurrence in shallow lakes, Aquatic sciences 83(2021), Article number: 14. https://doi.org/10.1007/s00027-020-00769-1

[36] N.O. Nweze, Algal diversity of Adada River, Nigeria, Chlorophyta (green algae) and euglenophyta (euglenoids), Plant Products Research Journal 13(2009), 24-30. https://doi.org/10.4314/pprj.v13i1.65812

[37] H.B. Soni, S. Thomas, Preliminary Data on Occurrence of Zooplanktons of Freshwater Lentic Ecosystem: A Case Study of Dakor Sacred Wetland, Central Gujarat, India, International Journal of Environment 1(2013) 1, 46-55.

[38] S.R. Stire, Zooplankton fauna of a freshwater pond in Bhadrawati town of Chandrapur District in Maharashtra State (India), Online International Interdisciplinary Research Journal 4(2014), 219-226.

[39] H.B. Soni, S. Thomas, Occurrence of Zooplanktons at Sacred Palustrine Habitat, Central Gujarat, India, with Conservation and Management Strategies, International Journal of Environment 3(2014) 1, 111-121. https://doi.org/10.3126/ije.v3i1.9948

[40] M. Karuthapandi, D.V. Rao, B.X. Innocent, Zooplankton Diversity of Osmansagar Reservoir, Telangana, India, Proceedings of the Zoological Society 71(2018), 229-238. https://doi.org/10.1007/s12595-016-0194-7

[41] R.R. Ramachandra, M. Chapara, D.V.S.N. Raju, Zooplankton Diversity in Madduvalasa Reservoir, India, The International Journal of Life-Sciences Scientific Research 3(2017) 1, 771-778.

[42] E.T. Peltomaa, S.L. Aalto, K.M. Vuorio, S.J. Taipale, The importance of phytoplankton biomolecule availability for secondary production, Frontiers in Ecology and Evolution 5(2017), Article ID: 128. https://doi.org/10.3389/fevo.2017.00128

[43] B.N. Pandey, R. Siddhartha, K.D. Tanti, A.K. Thakur, Seasonal variation of zooplanktonic community in swamp of Purnia (Bihar) India, Aquatic Biology Research 1(2013) 1, 1-9.

[44] D.N. Pandit, P. Kumari, S.K. Sharma, Ecology and diversity of Zooplankton of the river Ganga at Bihar, India in Relation to Water Quality, Current World Environment 15(2020) 2, 305-313. https://doi.org/10.12944/CWE.15.2.18

[45] A.K. Verma, S. Prakash, Zooplankton diversity in Guthiataal, Wetland of Bahraich (U.P.), India, International journal of Zoology and Research 10(2020) 2, 9-18.

Acknowledgements

The authors are grateful to Knowledge Consortium of Gujarat (KCG), Government of Gujarat, Gandhinagar, for financial assistance under SHODH (ScHeme Of Developing High quality research) and Institute of Science and Technology for Advanced Studies and Research (ISTAR), Vallabh Vidyanagar, Gujarat, India, for providing logistic support and state-of-art infrastructure.