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***Research Article** (Open Access)*

PHYSICO-CHEMICAL CHARACTERISTICS AND ICHTHYOFAUNAL DIVERSITY IN NAVEGAONBANDH LAKE NEAR ARJUNI/ MORGAON, GONDIA, MAHARASHTRA

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ABSTRACT
Navegaonbandh Lake is a large historic freshwater reservoir located in Arjuni Morgaon taluka of Gondia district, Maharashtra and was investigated in detail during three sampling seasons: Winter, Summer and Monsoon in terms of limnological and ichthyofaunal parameters. The ten spatially distributed sampling locations (L1 to L10) were used to sample five physico-chemical parameters: water temperature, pH, dissolved oxygen (DO), free carbon dioxide (free CO_2) and total dissolved solids (TDS) using standard analytical procedures. Spatial and seasonal variations were calculated by statistical analysis: mean ± standard deviation, standard error, coefficient of variance (CV), one-way ANOVA and Pearson correlation coefficients. Water temperature had significant differences among seasons ($F = 128.67$; $P < 0.001$), ranging from 21.0°C in winter to 32.8°C in summer, which is in accordance with the typical thermal regime of subtropical regions. The pH of the lake was mildly alkaline (7.01–7.54) during all seasons, which represents a good buffering capacity of the lake. Dissolved oxygen levels were lowest in the summer (6.15 ± 0.30 mg/L) and highest in winter (7.47 ± 0.45 mg/L), was negatively correlated with temperature ($r = -0.893$; $p < 0.01$). Free CO_2 showed strong positive correlation with temperature (0.941) and negative correlation with DO (−0.978), both being significant at $p < 0.01$. The seasonal variation of TDS (65.9mg/l during monsoon and 82.6mg/l during Summer) is due to concentration caused by evaporation in warm months. 13 species of fish, representing 9 orders and 9 families, were recorded by the ichthyofaunal survey and Cyprinidae was the most dominant family, accounting for 5 species of fish. There were two species of Near Threatened (NT) conservation status, *Anguilla bengalensis* and *Notopterus chitala*. The lake has mesotrophic water quality and high ecological and fisheries value.

Keywords: *Physico-chemical parameters, Ichthyofauna, Navegaonbandh Lake, Limnology.*

INTRODUCTION
Water is the basic element in fish culture and its biodiversity. It is essential for the survival of any plankton (Plant and animal), but as human populations grow their domestic use of water reservoirs is increasingly being threatened. Water, a worthwhile and precious gift of nature, is a basic necessity for the sustenance of life on Earth (Chidambaram, 2010). Freshwater lakes and reservoirs are essential elements of the global hydrological cycle and are vital for human development and use for irrigation, potable water and fisheries production, as well as for sustaining terrestrial and aquatic biota. India's extensive riverine, lacustrine, wetland and reservoir resources are home to one of the world's richest and most varied freshwater fauna. But human activities, such as agricultural activities, urban effluents, deforestation and over-exploitation of fishery resources are now putting unprecedented stress on these ecosystems and reducing water quality and diversity of life (Weinke & Biddanda, 2018). The physico-chemical properties of water bodies play a basic regulatory role over the biological communities that

these water bodies support. Stressful environmental conditions can affect the immune system of fishes (Deshmukh *et al, 2024*). Water temperature, pH, dissolved oxygen, free carbon dioxide, and total dissolved solids are important parameters that determine species composition, abundance and distribution in aquatic systems (Akbulut, 2009). Specifically, temperature influences metabolic rates, reproductive cycles and gas solubility, and thus indirectly impacts the productivity of the entire aquatic food web (Filik *et al.*, 2008). Dissolved oxygen which is closely related to temperature, photosynthetic activity, organic decomposition and atmospheric exchange processes (Dhawan & Karu, 2002). Therefore, observing these parameters over seasons and spatial areas offers a critical reference for ecological investigation and fisheries management. All these water quality, habitat structure, food availability and anthropogenic disturbance factors are reflected in Ichthyofaunal Diversity, which is a strong bioindicator of the health of an ecosystem. The diversity of the freshwater fish species in India is about 2,700, which is close to 10% of the total number of freshwater fish species present in the world (Jayaram, 1999). The Vidarbha region of Maharashtra which includes the Gondia district has many natural and artificial water bodies and harbours a rich ichthyofaunal assemblage which is influenced by the Deccan Plateau drainage system.

Navegaonbandh Lake, a big historic lake (1305 ha) constructed in the 18th century, is ecologically valuable and is a wetland site of avifaunal and ichthyofaunal diversity. Even though it has high ecological and socio-economic value, there have been very few systematic studies that documented its physico-chemical dynamics and ichthyofaunal status. The fish diversity data of freshwater bodies of Maharashtra and Central India have been reported in several studies (Reddy *et al*., 2015; Kadye *et al.,* 2008), but there are no detailed seasonal data on fish diversity that include physico-chemical data and diversity indices for this lake. Hence, the present study was designed to characterize seasonal and spatial variability of the major physico-chemical parameters at ten sampling points, document the diversity of fish fauna with taxonomic identification and conservation status as per IUCN and assess the ecological health and trophic status of Navegaonbandh Lake using common diversity indices and statistical analysis.

MATERIALS AND METHODS

Study area

The Navegaon bandh (1305 hectares) is located between latitude 20º53' N and 20º56' N and longitude 80º06'E and 80º09' E in the Arjuni Morgaon taluka of Gondia district (National Wetlands Atlas, 2010).

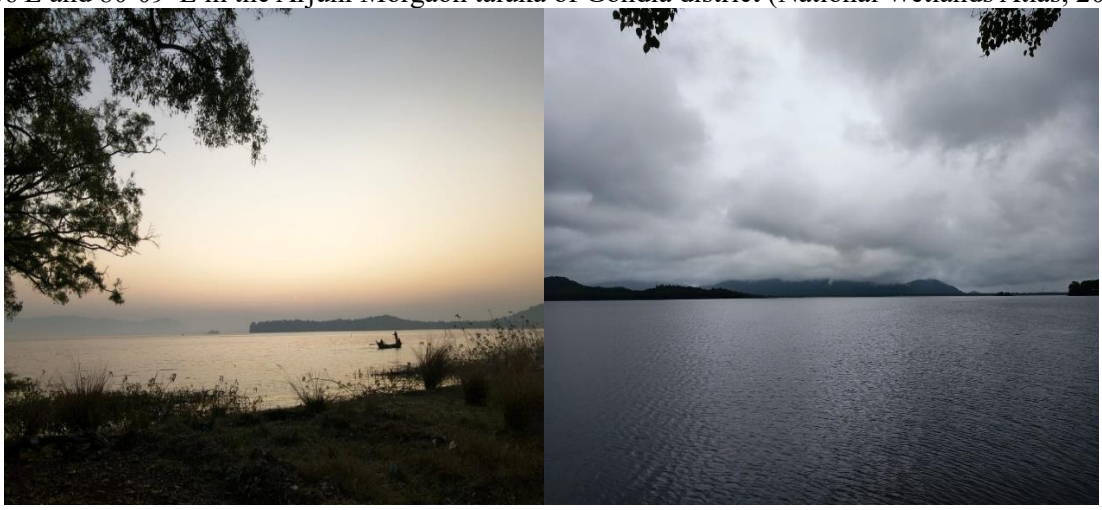

Fig. 1: Study area: Navegaonbandh lake

It is surrounded by seven hills from which many streams pour into this Rocky basin bandh, which has two this Rocky basin bandh, has two embankments, having lengths of 100.56m and 684m (Russell, 1908; Pathak, 1979). The climate of the catchment is humid tropical with hot summer from March to May, well-defined South West monsoon season (June to October) and cool dry and cold winter months (November to February). The average rainfall in the Gondia district is more than 1,400 mm annually

with most of the rain falling during June to September. The water level fluctuations, hydraulic residence time and dilution–concentration of dissolved constituents are strongly influenced by this seasonal precipitation regime.

The lake is designated as an Important Bird Area (IBA), and has a Dr. Salim Ali Bird Sanctuary, which provides essential nesting and foraging habitat for many migratory and resident waterbird species. The surrounding land use is mainly agricultural paddy fields, mixed forests and scattered settlements of villages, which are associated with sources of agricultural fertilizers, pesticides and domestic wastewater as potential pollution vectors. The lake is home to an artisanal fisheries sector, where fisherfolk are able to catch commercially viable fish using traditional netting gear.

Methodology

Collection of water samples

The water samples were taken from Navegaonbandh Lake in three different sampling seasons, Winter, summer and monsoon at ten locations (L1–L10) throughout the lake from June 2025 to July 2026. Water samples were taken at the sampling site and season, in pre-cleaned (acid-washed) 1-litre polyethylene bottles. Dissolved oxygen samples were taken in special 300 mL BOD bottles equipped with glass stoppers to keep air out of the sample.

To minimize the effects of heat exchange with the surface, water temperature was immediately recorded on site at each sampling station with a calibrated mercury thermometer with a precision of 0.1°C. The pH of water samples was measured by a digital pH meter (Elico model), which was calibrated daily with pH 4.0, 7.0 and 9.2 buffer solutions with an accuracy of 0.02 pH units. The free carbon dioxide (CO_2) was estimated by titrating with 0.05 N sodium hydroxide (NaOH) solution using phenolphthalein indicator and the results obtained were expressed in mg/L as per standard titrimetric procedure. Free carbon dioxide (CO_2) was estimated by titrating with 0.05 N sodium hydroxide (NaOH) solution using phenolphthalein indicator as per the standard titrimetric procedure. The total dissolved solids were measured gravimetrically after filtering through Whatman filter paper No. 1 and evaporation at 105°C to a specified weight (mg/L).

Collection of fish identification

In collaboration with the licensed local fisherfolk who are under permit conditions in Navegaonbandh Lake, fish were sampled. The method used was a multiple-gear sampling design to increase capture efficiency across microhabitats, including gill nets (mesh size 20–120 mm), drag nets, cast nets, hand nets, and push nets. Early morning and late evening of the day were the times for sampling, when fish activity is high. The captured specimens were identified in the field when possible and kept in 10% buffered formalin for laboratory examination. Species identification was carried out by referring to the standard taxonomic keys and Ichthyological references like Day (1878), Jayaram (1981, 1999), Jhingran (1991), Talwar and Jhingran (1991), Nelson *et al.* (2016), and Darshan *et al.* (2019). Morphometric measurements taken according to Hubbs and Lagler (1947) were total length, standard length, fork length, body depth, and head length. The scientific names were checked against Catalogue of Life (2023) and FishBase (Froese & Pauly, 2023). The conservation status of each species was assessed based on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (IUCN, 2023).

Statistical Analysis

Extensive statistical analysis was performed on physico-chemical data. All ten of the sampling locations and three seasons were used to compute descriptive statistics: arithmetic mean, standard deviation (SD), standard error (SE), variance, range, median and coefficient of variation (CV%). These were calculated with the aid of Microsoft Excel 2019 and PAST (Paleontological Statistics) software version 4.03. One-way Analysis of Variance (ANOVA) was used to evaluate the significance of the seasonal differences for each physico-chemical parameter and Tukey's Honestly Significant Difference (HSD) test was used for post hoc comparisons if F-ratios were statistically significant at $p < 0.05$ and $p < 0.01$ levels. Pearson product-moment correlation coefficients were estimated for all possible combinations of pairwise parameters to study the inter-parameter relationship and to make sure about the absence of multicollinearity among parameters.

RESULTS AND DISCUSSION

The seasonal variations of water temperature in Navegaonbandh lake were found to be very significant (one-way ANOVA, $F_{2,27} = 128.67$, $p < 0.001$) at all 10 sampling points of the lake. During winter, temperatures ranged from 21.0°C (L7) to 26.2°C (L2), yielding a seasonal mean of 24.41 ± 1.59°C (Table 3). Thermal stratification effects are observed as the lowest winter temperature recorded at L7, the deepest station available, is relatively colder compared to the other stations. The temperatures were uniformly high during summer with ranges of 30.6°C (L3) to 32.8°C (L6); the highest was during summer with a mean temperature of 31.97 ± 0.66°C (highest temperature recorded across all seasons). The relatively low coefficient of variation in summer (CV = 2.06%) is due to the fact that the sun shone equally during this period and strong convective mixing. The moderating effect of monsoon precipitation, reduced insolation and higher cloud cover resulted in intermediate temperatures, 25.4°C (L10) to 29.3°C (L6) for monsoon temperatures with a mean of 28.22 ± 1.06°C. The location-wise temperature mean varied from 26.87 ± 5.39°C (L7) to 29.10 ± 3.80°C (L6) and the largest inter-seasonal temperature variability occurred at L7 (SD = 5.39) which is deepest with higher thermal stratification. The overall trend (Summer>Monsoon>Winter) is consistent to the Central Indian subtropic climate and the results reported from the freshwater reservoirs of Vidarbha and nearby areas (Reddy *et al.*, 2015).

The pH of Navegaonbandh Lake was found to be consistently alkaline throughout the study period and all the recorded pH values ranged from 7.01 to 7.54 which is well within the alkaline, well buffered water chemistry range. The results of one-way ANOVA showed that the pH significantly different in the seasons ($F_{2,27} = 32.81$; $p < 0.001$). Winter pH values ranged from 7.31 (L4) to 7.54 (L8), with a seasonal mean of 7.43 ± 0.07. Summer pH exhibited marginally lower values (range: 7.19–7.51; mean: 7.36 ± 0.10), while monsoon pH was consistently the lowest (range: 7.01–7.24; mean: 7.14 ± 0.07). The seasonality of the pH reduction during monsoons is due to the dilution effect of precipitation and the addition of slightly acidic rainwater and humic contents from the surrounding forested catchment.

Across all seasons, the pH values were highest at Location L5 (7.51, 7.51, 7.22) which may be due to increased photosynthesis and CO_2 uptake by macrophytes in the littoral zone. L4 and L6, which are close to stream inlets, on the other hand, had consistently low pH, reflecting the surface runoff with increased CO_2 loading. The location-wise mean pH ranged from 7.18 ± 0.13 (L4) to 7.42 ± 0.16 (L8). This study also shows a mild alkaline pH (6.5–8.5) which is within optimum range for production of freshwater fisheries and the same has been observed in similar reservoirs in Central India.

The concentration of dissolved oxygen is probably one of the most ecologically important parameters that affects the life of fish, their growth and composition of fish communities. It was found that significant seasonal variation ($F_{2,27} = 24.15$; $p < 0.001$) and spatial variation were found in the DO of Navegaonbandh lake. Winter DO was the highest of the three seasons, ranging from 6.65 mg/L (L1) to 8.10 mg/L (L7), with a seasonal mean of 7.47 ± 0.45 mg/L. The increase in winter DO is due to the increased solubility of oxygen at colder temperatures and because water has fewer microbes using oxygen and decomposing. The highest DO was observed at location L7 and L8 in winter (8.10 and 8.00 mg/L, respectively), reflecting their location in deeper cooler waters where photosynthetic productivity by phytoplankton was active.

Summer DO values decreased significantly at all sites from 5.80 mg/L (L2) to 6.74 mg/L (L5) to a seasonal mean of 6.15 ± 0.30 mg/L. The decrease is mechanistically explained by the inverse relationship between the saturation concentration of oxygen and water temperature: For higher water temperature up to the boiling point of water, the oxygen concentration decreases significantly. In addition, the biochemical oxygen demand (BOD) increases with increasing temperatures, due to increased microbiological activity, further reducing dissolved oxygen levels. The Pearson correlation coefficient was used to determine the relation between the different variable. The temperature and DO relationship were strong negative in all seasons ($r = -0.893$; $p < 0.01$) and the DO and free CO_2 relationship was strong negative ($r = -0.978$; $p < 0.01$).

Monsoon DO values recovered from summer lows, ranging from 6.20 to 7.61 mg/L (mean: 7.16 ± 0.44 mg/L). Partial recovery of DO during monsoon can be explained by the drop in water temperature due to the monsoon rain, increase in surface aeration due to wind driven turbulence and increased photosynthetic activity in the early monsoon. The lowest recorded DO concentration was 5.80 mg/L

(L2, summer) which is above the minimum concentration for physiological stress (4.0 mg/L) to most fish species (APHA, 2017), indicating that the lake is well oxygenated and supports its fish community year-round.

Free CO_2 in a natural water body is the result of the equilibrium between the consumption due to photosynthesis, the aerobic respiration, the decomposition of organic matter and the exchange with the atmosphere. The trend of free CO_2 was exactly the opposite to that of dissolved oxygen in Navegaonbandh Lake and went from high in winter to high in summer and falling in monsoon. Winter free CO_2 ranged from 2.65 mg/L (L8) to 3.10 mg/L (L6), with a seasonal mean of 2.86 ± 0.14 mg/L, the lowest of all three seasons. Summer CO_2 concentrations were markedly elevated, ranging from 4.08 (L5) to 4.91 mg/L (L6), with a mean of 4.45 ± 0.27 mg/L. During monsoon, values occupied the intermediate range of 3.43–4.12 mg/L (mean: 3.76 ± 0.21 mg/L).

The negative correlation between free CO_2 and DO ($r = -0.978$; $p < 0.01$) and the strong positive correlation between free CO_2 and temperature ($r = 0.941$; $p < 0.01$) and free CO_2 and TDS ($r = 0.934$; $p < 0.01$) show the classical thermodynamic relationships that rising temperature speeds up CO_2 production by respiration, which in turn leads to an increase in free CO_2, and that rising water temperature decreases its capacity to hold dissolved gas—such as CO_2—along with higher water hardness. The highest CO_2 measurements in all seasons occurred at location L6 close to a tributary inlet, indicating the potential load of allochthonous carbon from agricultural discharges. The values of CO_2 recorded during this study were found to be within acceptable limits for fish culture, since higher concentrations than 20 mg/L will result in CO_2 narcosis in sensitive species.

The TDS stands for the total dissolved solids found in a water sample and includes all inorganic and organic substances that are dissolved in the water; therefore, it can be used as a composite indicator for all aspects of water quality and mineralization. TDS shows highly significant variation among the seasons of Navegaonbandh Lake ($F_{2,27} = 162.37$; $p < 0.001$). Maximum TDS was recorded in summer season ranging from 76.8 (L5) to 82.6 (L6) mg/L with an average of 79.49 ± 1.78, which means that it is increased during peak insolation months due to evaporation of dissolved solutes. The intermediate value of 70.9-75.3 mg/L (mean 72.85 ± 1.44 mg/L) for winter TDS and the lowest TDS value of 65.9-70.5 mg/L (mean 68.32 ± 1.52 mg/L) during monsoons is due to the dilution processes during winter and monsoons, respectively, where precipitation and relatively lower TDS surface runoff enter the stream.

Table 1: Physical and chemical parameters of water

Parameter	Locations	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10
Temperature (°C)	Winter	23.4	26.2	24	25.8	24.2	25.2	21	22.8	24.9	25.6
	Summer	32.1	31.8	30.6	32.4	31.2	32.8	31.6	32	31.9	32.3
	Monsoon	28.2	28.5	28.8	28.4	27.9	29.3	28	28.7	29	25.4
pH	Winter	7.42	7.38	7.45	7.31	7.51	7.36	7.48	7.54	7.4	7.47
	Summer	7.35	7.28	7.42	7.19	7.51	7.24	7.38	7.47	7.31	7.41
	Monsoon	7.12	7.08	7.19	7.05	7.22	7.01	7.16	7.24	7.1	7.18
DO (mg/L)	Winter	6.65	7.52	7.78	7.43	7.12	6.9	8.1	8	7.56	7.63
	Summer	5.9	5.8	6.0	6.1	6.74	5.96	5.9	6.58	6.24	6.31
	Monsoon	6.2	7.21	7.48	7.15	7.56	7.08	7.39	7.61	7.26	6.7
CO_2 (mg/L)	Winter	2.85	2.91	2.76	3.02	2.69	3.1	2.81	2.65	2.94	2.88
	Summer	4.32	4.58	4.15	4.73	4.08	4.91	4.4	4.21	4.63	4.51
	Monsoon	3.76	3.88	3.64	3.95	3.51	4.12	3.72	3.43	3.84	3.79
TDS (mg/L)	Winter	72.4	73.1	71.8	74.5	70.9	75.3	72.6	71.2	73.8	72.9
	Summer	78.6	80.1	77.5	81.4	76.8	82.6	79.3	78.2	80.7	79.8
	Monsoon	68.4	67.2	69.1	66.8	70.2	65.9	68.7	70.5	67.5	68.9

The highest TDS was recorded at location L6 for all seasons (75.3, 82.6 and 65.9 mg/L) while comparatively lower TDS was recorded in L5 and L3. This spatial distribution is probably attributable to the distance from agricultural fields of fertilizer-loaded ions. However, all the TDS values recorded in the present study (65.90–82.60 mg/L) are considerably lower than the BIS permissible limit of drinking water (500 mg/L) and are in the optimum range for freshwater fishes (< 400 mg/L), which substantiates the generally oligotrophic–mesotrophic nature of the lake.

Table 2. Location-wise mean ± standard deviation of physico-chemical parameters across all three seasons at Navegaonbandh Lake.

Location	Temperature (°C) Mean ± SD	pH Mean ± SD	DO (mg/L) Mean ± SD	CO_2 (mg/L) Mean ± SD	TDS (mg/L) Mean ± SD
L1	27.90 ± 4.39	7.30 ± 0.16	6.25 ± 0.38	3.64 ± 0.74	73.13 ± 5.11
L2	28.83 ± 2.83	7.25 ± 0.15	6.84 ± 0.93	3.79 ± 0.84	73.47 ± 6.46
L3	27.80 ± 3.41	7.35 ± 0.14	7.09 ± 0.95	3.52 ± 0.71	72.80 ± 4.29
L4	28.87 ± 3.32	7.18 ± 0.13	6.89 ± 0.69	3.90 ± 0.86	74.23 ± 7.36
L5	27.77 ± 3.49	7.41 ± 0.17	7.14 ± 0.41	3.43 ± 0.71	72.63 ± 3.60
L6	29.10 ± 3.80	7.20 ± 0.18	6.65 ± 0.61	4.04 ± 0.91	74.60 ± 8.39
L7	26.87 ± 5.39	7.34 ± 0.16	7.13 ± 1.12	3.64 ± 0.80	73.53 ± 5.36
L8	27.83 ± 4.62	7.42 ± 0.16	7.40 ± 0.74	3.43 ± 0.79	73.30 ± 4.24
L9	28.60 ± 3.63	7.27 ± 0.15	7.02 ± 0.69	3.80 ± 0.85	74.00 ± 6.64
L10	27.77 ± 3.87	7.35 ± 0.15	6.88 ± 0.67	3.73 ± 0.82	73.87 ± 5.49

Table 3. Seasonal descriptive statistics (Mean, SD, SE, Variance, CV%, Median) for physico-chemical parameters in Navegaonbandh Lake.

Parameter	Season	Min	Max	Mean	SD	Variance	CV (%)	Median	SE
Temperature (°C)	Winter	23.81	25.60	24.41	1.59	2.52	6.68	24.05	0.50
	Summer	30.60	32.80	31.97	0.66	0.43	2.06	31.88	0.21
	Monsoon	25.40	29.30	28.22	1.06	1.12	3.75	28.12	0.33
pH	Winter	7.31	7.54	7.43	0.07	0.005	0.96	7.41	0.022
	Summer	7.19	7.51	7.36	0.10	0.010	1.36	7.37	0.032
	Monsoon	7.01	7.24	7.14	0.07	0.005	0.98	7.14	0.022
DO (mg/L)	Winter	6.65	8.10	7.47	0.45	0.204	6.03	7.47	0.143
	Summer	5.80	6.74	6.15	0.30	0.091	4.88	6.16	0.095
	Monsoon	6.20	7.61	7.16	0.44	0.195	6.15	7.14	0.141
Free CO_2 (mg/L)	Winter	2.65	3.10	2.86	0.14	0.020	4.96	2.85	0.046
	Summer	4.08	4.91	4.45	0.27	0.073	6.07	4.47	0.086
	Monsoon	3.43	4.12	3.76	0.21	0.044	5.56	3.77	0.066
TDS (mg/L)	Winter	70.90	75.30	72.85	1.44	2.075	1.98	72.77	0.456
	Summer	76.80	82.60	79.49	1.78	3.168	2.24	79.45	0.562
	Monsoon	65.90	70.50	68.32	1.52	2.306	2.22	68.22	0.480

Table 4. One-way Analysis of Variance (ANOVA) results for seasonal variation of physico-chemical parameters in Navegaonbandh Lake. **p < 0.01 (highly significant).

Parameter	Source of Variation	df	SS	MS	F-value	p-value
Temperature	Between Seasons	2	476.28	238.14	128.67	< 0.001**
Temperature	Within Locations	27	49.99	1.85	—	—
pH	Between Seasons	2	0.348	0.174	32.81	< 0.001**
pH	Within Locations	27	0.143	0.005	—	—
DO	Between Seasons	2	8.621	4.311	24.15	< 0.001**
DO	Within Locations	27	4.818	0.178	—	—
Free CO_2	Between Seasons	2	11.024	5.512	134.22	< 0.001**
Free CO_2	Within Locations	27	1.109	0.041	—	—
TDS	Between Seasons	2	784.90	392.45	162.37	< 0.001**
TDS	Within Locations	27	65.24	2.42	—	—

Table 5. Pearson correlation matrix among physico-chemical parameters of Navegaonbandh Lake (n = 30; pooled across all locations and seasons). *p < 0.05; **p < 0.01.

Parameter	Temperature	pH	DO	Free CO_2	TDS
Temperature	1.000	−0.621*	−0.893**	0.941**	0.847**
pH	−0.621*	1.000	0.752**	−0.832**	−0.511
DO	−0.893**	0.752**	1.000	−0.978**	−0.921**
Free CO_2	0.941**	−0.832**	−0.978**	1.000	0.934**
TDS	0.847**	−0.511	−0.921**	0.934**	1.000

Diversity of ichthyofauna

During the study period, total of 13 species of fish belonging to 9 orders and 9 families were recorded from Navegaonbandh lake (Table 6). The dominant order was Cypriniformes, representing five species (38.46% of total species richness), of which *Catla catla* (Catla), *Ctenopharyngodon idella* (Grass Carp), *Cyprinus carpio* (Common Carp), *Cirrhinus mrigala* (Mrigal), and *Labeo rohita* (Rohu) were the predominant species. The other eight orders contained only a single species each, and had a very variable taxonomic composition, including Siluriformes (*Heteropneustes fossilis*, Heteropneustidae), Anabantiformes (with two families: *Nandus nandus*, Nandidae; *Anabas testudineus*, Anabantidae), Perciformes (*Channa marulius*, Channidae), Beloniformes (*Xenentodon cancila*, Belonidae), Anguilliformes (*Anguilla bengalensis*, Anguillidae), and Osteoglossiformes (*Notopterus chitala*, Notopteridae).

In terms of IUCN conservation status, eleven species (84.6%) were rated to be Least Concern (LC) and two species, *Anguilla bengalensis* and *Notopterus chitala*, were rated as Near Threatened (NT) and require targeted conservation efforts. There were no records of Endangered or Critically Endangered species, although this could be due to a local extinction, such as from historical fishing pressure, rather than absence from the regional fauna. An introduced exotic species of African origin *Oreochromis mossambicus* was recorded at moderate abundance and is a potential concern due to being an invasive alien species that is known to compete with native cyprinids for food and breeding habitat.

The five species of Cyprinidae, in particular *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* (known as the Indian Major Carps, IMC), were the most common and were also found to have high relative abundance, which is in line with their importance as the main target species of artisanal fisheries in the lake. Moderate abundance of *Heteropneustes fossilis*, *Channa marulius* and *Anabas testudineus* were recorded, which are frequently found in vegetated shallow littoral zones. *Xenentodon cancila*, *Nandus nandus, Anguilla bengalensis* and *Notopterus chitala* were found at low abundance, which is indicative of their particular habitat needs and nocturnal behaviour.

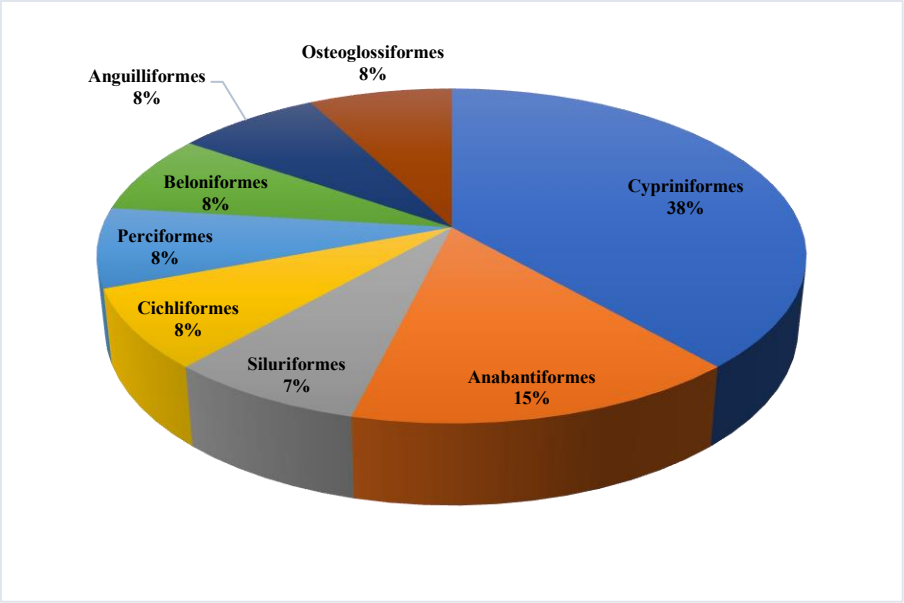

Fig. Order-wise ichthyofaunal diversity in Navegaonbandh

Table: Fish diversity of Navegaonbandh Lake, Gondia

Sr. No.	Order	Family	Scientific Name	Common Name
1.	Cypriniformes	Cyprinidae	*Catla catla*	Catla
2.			*Ctenopharyngodon idella*	Grass carp
3.			*Cyprinus carpio*	Common carp
4.			*Cirrhinus mrigala*	Mrigal
5.			*Labeo rohita*	Rohu
6.	Siluriformes	Heteropneustidae	*Heteropneustes fossilis*	Singhi
7.	Anabantiformes	Nandidae	*Nandus nandus*	Gangetic leaffish, Mud perch
8.	Cichliformes	Cichlidae	*Oreochromis mossambicus*	Tilapia
9.	Perciformes	Channidae	*Channa marulius*	Great snakehead, Murrel fish
10.	Beloniformes	Belonidae	*xenentodon cancila*	Needlefish
11.	Anguilliformes	Anguillidae	*Anguilla bengalensis*	Indian mottled eel
12.	Osteglosssiformes	Notopteridae	*Notopterus chitala*	Indian knifefish
13.	Anabantiformes	Anabantidae	*Anabas testudineus*	Climbing perch

Figure X. Fish species recorded from Navegaonbandh Lake, Arjuni/Morgaon, Gondia, Maharashtra: **(A)** *Catla catla*, **(B)** *Ctenopharyngodon idella*, **(C)** *Cyprinus carpio*, **(D)** *Cirrhinus mrigala*, **(E)** *Labeo rohita*, **(F)** *Heteropneustes fossilis*, **(G)** *Nandus nandus*, **(H)** *Oreochromis mossambicus*, **(I)** *Channa marulius*, **(J)** *Xenentodon cancila*, **(K)** *Anguilla bengalensis*, **(L)** *Notopterus chitala*, and **(M)** *Anabas testudineus*.

The physico-chemical characteristics of Navegaonbandh Lake indicate that the lake's seasonal variation is typical of the Central Indian subtropical reservoirs and are in line with the theoretical limnological concepts. The thermal regime (winter mean of 24.41°C to summer peak of 31.97°C) is similar to that reported from Nizam Sagar Dam, Telangana (Reddy *et al.*, 2015) and the major reservoirs of the Vidarbha region. Temperature is the most important variable in aquatic systems, affecting the rates of all the biological and chemical activity such as photosynthesis, respiration, nutrient cycling, etc., including fish reproduction. The moderate temperatures in the winter season (21.0-26.2°C) fall during the breeding season of Indian Major Carps and the high temperatures in summer may induce physiological stress in stenothermal species.

The water pH ranges from 7.01 to 7.54 observed throughout the study period suggest that Navegaonbandh Lake is well buffered by carbonates and bicarbonates typical of water bodies which lie over basaltic Deccan trap geology. This pH range is the best for the culture of Indian Major Carps and the most native cyprinids (Jhingran 1991) and this is one of the reasons for the high species richness observed in this investigation. Decrease in pH during monsoon season, observed in all 10 sampling sites, is a well-documented phenomenon in tropical reservoirs and can be explained by the addition of slightly acidic precipitation, the dissolution of organic acids from terrestrial litter and the short-term reduction in CO_2 consumption during photosynthesis due to occasional cloudiness and turbidity. Lake pH changes following a similar seasonal pattern have been reported for the lakes of the Western Ghats (Filik *et al.*, 2008) and for the freshwater bodies in Madhya Pradesh.

The dissolved oxygen in Navegaonbandh Lake is of special ecological significance. The DO mean for the winter was 7.47mg/L, which is significantly higher than the critical level for most fish species and is indicative of active metabolism and growth. The summer depression to 6.15 mg/L indicates a statistically significant reduction but it is still above the sublethal hypoxic threshold of about 5 mg/L for sensitive species like *Catla catla* and *Labeo rohita*. The very strong negative correlation ($r = -0.893$; $p < 0.01$) between temperature and DO, as obtained here, is also in agreement with the fundamental thermodynamic principles of gas solubility, and similar to those observed in other comparable Indian reservoirs. The strong negative correlation between the concentration of free CO_2 and DO is consistent with the coupling of the two processes in the lake's carbon cycle, and indicates that photosynthesis is active (low CO_2; high DO) and respiration is active (high CO_2; low DO) in opposite halves of the year. The close linkage of these systems indicates that the phytoplankton community in the lake is an important regulator of dissolved gas behavior.

The TDS recorded during the study (65.9-82.6mg/L) is much lower than observed in similar Central Indian reservoirs with similar human effluents. The TDS concentration recorded in Nizam Sagar Reservoir is between 120-280mg/l by Reddy *et al.*, 2015 and Filik *et al.*, 2008, who observed the TDS content more than 500mg/l in eutrophic lakes of Turkey. Agricultural activities with negligible industrial activities in the catchment of Navegaonbandh lake are responsible for comparatively low TDS in the lake which is also classified as an oligotrophic–mesotrophic lake. The increase in TDS in summer is due mainly to evaporative concentration and increased chemical weathering at higher temperatures, as indicated by the positive correlation between TDS and temperature ($r = 0.847$; $p < 0.01$) and between TDS and free CO_2 ($r = 0.934$; $p < 0.01$).

More than 2700 species of Indian freshwater fish fauna were taxonomically documented by Jayaram (1999). In recent years, between 8 and 28 species have been reported from individual water bodies in Central Indian freshwater bodies depending upon the intensity of the survey, size of the habitat and anthropogenic pressure. Indian freshwater fish fauna is dominated by Cyprinidae (5 species, 38.46% of species richness) which are historically targeted by both capture fisheries and stocking programs in aquaculture, which are based on Indian Major Carps. The order Cypriniformes recorded dominant in various studies in Maharashtra (Achegawe *et al,2026)*.

The conservation importance of Navegaonbandh Lake as a haven for a range-restricted or declining species is highlighted by the presence of Anguilla bengalensis (IUCN – Near Threatened – NT) and *Notopterus chitala* (IUCN Near Threatened: NT). *Anguilla bengalensis* is a catadromous species, with its spawning location in the sea and its growth habitat in freshwater, which is why it is especially sensitive to the fragmentation of river-lake connectivity resulting from dam construction. *Notopterus chitala* is also a highly specialised species, and is confined to slow-moving, vegetatively rich backwaters, and is similarly vulnerable to habitat loss, siltation and competition from introduced species. The presence of these species in Navegaonbandh lake suggests that the lake is still connected with the Wainganga River drainage, thus representing a remarkable ecological finding that has to be accorded priority for conservation.

In the light of the physico-chemical parameters presented in this study, Navegaonbandh lake can be categorized as mesotrophic with some of the physico-chemical parameters moving towards the oligotrophic state. The low TDS values (HQ lower than 83 mg/L), relatively high DO values (HQ minimum 5.80 mg/L), and slightly high pH values (HQ), all suggest moderate nutrient loading and good

water quality. The lake receives diffuse agricultural runoff from the adjacent farms and is also within the reach of monsoon rains, which give it a degree of enrichment that allows it to support rich communities of phytoplankton and macrophytes and consequently its rich fish fauna, without it becoming eutrophic. The fact that the lake did not experience severe hypoxic events (DO never dropped below 5.80 mg/L) and no extreme pH deviations (all values stayed within 7.01–7.54) indicates the lake has good ecological buffering capacity. The overall water quality is appropriate for the Category A+ freshwater use classification (BIS, 2012), which allows for purification of drinking water, fisheries production and recreation.

CONCLUSION

In the present study, a comprehensive baseline study of physico-chemical dynamics and ichthyofaunal diversity in Navegaonbandh lake, a historically and ecologically important freshwater reservoir in Gondia district of Maharashtra, has been carried out. The following main findings are drawn: The five physico-chemical parameters (water temperature, pH, dissolved oxygen, free carbon dioxide and total dissolved solids) showed highly significant seasonality (one-way ANOVA, p-value <0.001 for all parameters) with seasonal variation of Summer>Monsoon>Winter for water temperature, free carbon dioxide and TDS, and Monsoon>Summer>Winter for dissolved oxygen. The levels of all the parameters did not exceed the permissible limits for freshwater fisheries during the study period and no acute pollution was observed at any of the ten sampling sites.

High and statistically significant intercorrelations, especially the negative correlation between DO and free CO_2 ($r = -0.978$; $p < 0.01$), and the positive correlation between temperature and free CO_2 ($r = 0.941$; $p < 0.01$) indicate that the dissolved gas dynamics of the lake are mainly controlled by physico-chemical processes driven by temperature (thermodynamic effect) and by the interaction between photosynthesis and respiration, with little present influence from point source pollution.

A total of 13 species of fish belonging to 9 orders and 9 families were recorded in the ichthyofaunal survey and dominated by the Cyprinidae. The overall water quality of the Navegaonbandh Lake is mesotrophic (moderately eutrophic), ecologically healthy and good for maintaining the existing aquatic resources and fisheries. However, several management interventions are proposed to maintain the ecological integrity of the lake in the long term: (i) regular seasonal monitoring of other water quality parameters such as total alkalinity, total hardness, nitrate, phosphate and turbidity to detect early signs of eutrophication; (ii) monitoring and if possible management of *Oreochromis mossambicus* population to avoid competitive displacement of native species; (iii) legal protection and habitat management of the Near Threatened species *Anguilla bengalensis* and *Notopterus chitala*; (iv) buffer zone of native riparian vegetation around the lake edge to limit sedimentation and agricultural runoff; (v) participatory conservation with local fisher folk communities on sustainable fishing practices. The study serves as scientific basis for the scientific management of Navegaonbandh Lake as a regionally important source of biodiversity in a freshwater lake.

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