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ECO-BIOLOGICAL STATUS OF KALANKAR LAKE DHORO NARO SANGHAR UMERKOT WITH REFERENCE TO NATURAL RESOURCES MANAGEMENT PLANT

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Abstract

Kalankar Lake is a natural freshwater wetland located at coordinates 25°34′43.07" N latitude and 69°35′28.99" E longitude, near the community of Dhoro Naro, situated in Sanghar and Umerkot districts, Sindh Pakistan. The Lake provides habitat to diversity of aquatic, amphibian and terrestrial biota. Physico-chemical and biological status of the lake has been studied to find out the impacts of climate change and freshwater scarcity issues. The water temperature was between 29-31°C, Transparency/ Turbidity of water 18-39 cm, pH 7.3-7.7, Alkalinity 145-180mg/l, Salinity 330-360 ppm, TDS 855-942mg/l and Conductivity (405-476µc/m. 21 species of phytoplankton and algal belong to three classes with great representation of Cyanophyta (51.5), Chlorophyta (32.5) and Bacillariophyta (16%). Invertebrate fauna consisting of Rotifer 47.5%, Arthropoda 31% and Mollusca 21.5% were reported. 13 macrophyte were existing during study. 18 fish species were observed from the lake. The dominant species belonged to Cypriniforms, Cichilidiformes and Anabantiformes.

Very few species of aquatic fauna and flora have been reported from the lake, it may be due to insufficient supply of freshwater in the lake. The authorities are urged to give special attention to the eco-biological status of the lake for conservation, protection and restoration purposes of this natural heritage of Sindh Pakistan.

INTRODUCTION

Kalankar Lake is a natural freshwater wetland located on global map latitude 25°34′43.07” N and longitude 69°35′28.99” E in between near the community of Dhoro Naro Districts of Sanghar and Umerkot. The lake area starts near to the Ghulam Nabi Shah village in Sanghar, where the desert landscape meets the barrage system. Kalankar Lake is part of the network of natural water bodies in the Achhro Thar (White Desert) region. It is near the community of Haji Khamiso Rajar and around 8 km from Dhoro Naro. Dhoro Naro is around 30 km away from Umerkot and can be reached by road in about an hour. Kalankar Lake has a maximum length of roughly 31 km and a maximum width of about 6 km, according to secondary sources that are now accessible. It is estimated to have a surface area of 24,320 acres (9,842 hectares). A maximum depth of roughly 7.9 meters (26 feet) and an average depth of roughly 6 meters (20 feet) are likewise reported by the available sources. About 15 meters (49 feet) above sea level is the stated surface elevation. The size and depth of the lake can vary significantly with seasonal and long-term shifts, so it is best to confirm these geographical data using current field measurements and GIS analysis. Kalankar Lake is an important natural wetland in the Umerkot region. It is connected to many other natural water bodies, including Modhakar, Kharor, Loon Khann, Ghurjee, Bando, Sunahro, and Bhorur. This network of interconnected wetlands is ecologically significant because changes in water availability in one body of water may influence the surrounding aquatic system (Scott et al., 1990). The natural lakes of Sindh are important from an ecological and socioeconomic perspective. In the past, Kalankar Lake has benefited the surrounding community by providing fishing opportunities and other benefits to local fishermen. However, it appears that the freshwater supply and water level of Kalankar Lake have considerably decreased in recent years. One of the primary problems is the lake's declining freshwater input. Local fisherman claim that a reduction in freshwater supplies has resulted in a drop in water levels and an increase in salinity in a few natural lakes in Umerkot and Sanghar, most notably Kalankar Lake.

The literature review indicates that there is a lack of scientific information about Kalankar Lake, particularly about the distribution of aquatic macrophytes, fish population density, plankton variety, and other elements of aquatic biodiversity. There aren't many thorough scientific investigations on the ecological condition and biodiversity of this important wetland. Therefore, the goal of this study is to assess the ecological condition and aquatic biodiversity of Kalankar Lake. The study's primary focus will be on fish, plankton, aquatic plants, and other important components of the lake ecosystem. The lake's ecological benefits, the primary problems endangering its natural resources, and the reasons for its environmental degradation will all be examined. The study will lead to the development of research-based recommendations for the sustainable management and conservation of Kalankar Lake. A participatory approach to natural resource management will also be considered to involve residents in the lake's sustainable usage and preservation. The findings of this study are expected to provide useful baseline data for researchers, local communities, government agencies, and other relevant organizations. The study may also help responsible authorities develop suitable policies for the sustainable management, conservation, and preservation of Kalankar Lake, a major wetland in Sindh, Pakistan (Fig. 1).

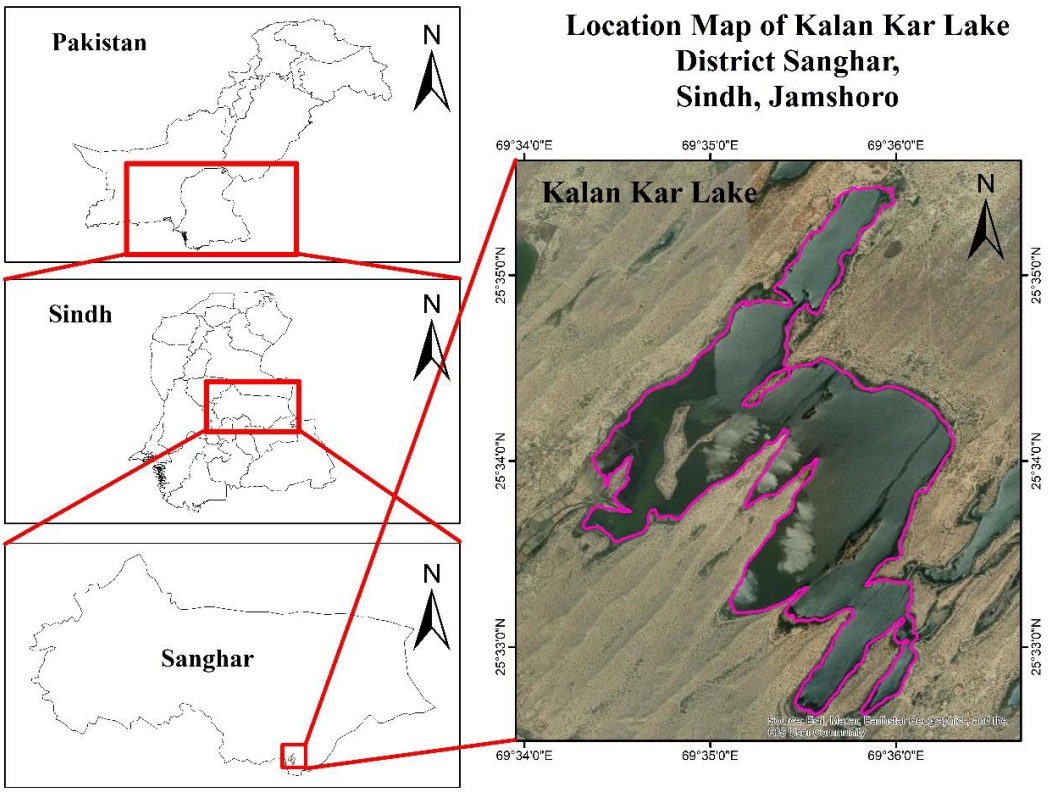


Fig.1. Map of Kalankar lake Dhoro Naro Sanghar Umerkot Sindh Pakistan

MATERIALS AND METHODS

Field data collection usually started between 10:30 a.m. to 5:15 p.m. two sampling stations were selected namely st.1: village Haji Khamiso Rajar and St. 2: village Mallah at western side of Lake During each visit, samples of water, plankton, aquatic plants, and fish were collected using the appropriate field methods and equipment, and observations were recorded. To investigate their physico-chemical characteristics, water samples were collected in sterile plastic bottles. The samples were carefully collected from parts of the lake and preserved for further analysis. For this reason, local farmers, fishermen, stakeholders, and working women who shared financial responsibilities with males and engaged in lake-related activities were approached. Eight important communities close to Kalankar Lake were visited during the field survey. Conversations with locals made it easier to understand their observations, experiences, resource utilization patterns, and concerns about the lake's future status. To collect as much information as possible about the water biodiversity and ecological condition of Kalankar Lake, seasonal field trips were planned. Four field visits were conducted during the study period. During these visits, the primary scientific facets of the lake were to be discussed, including fish diversity, plankton, aquatic vegetation, water quality, and the socioeconomic conditions of the surrounding communities. During the field visits, primary and community-based data were collected. Key informant interviews and focus groups were conducted to obtain information from local communities about the lake's condition, fisheries, natural resources, important environmental challenges, and the local population's dependence on lake resources. Emphasis was placed on developing recommendations for a natural resource management (NRM) strategy, especially for the sustainable management of fisheries. The Secchi disc was immersed in the water, and the depth at which it disappeared was recorded. At specific sampling locations, the water depth was measured using a wooden bamboo rod. Many water quality parameters were measured during field visits. A WTW 330i/Set conductivity meter was used to measure the temperature, salinity, electrical conductivity, and total dissolved solids (TDS). The pH of the water was measured using pH strips. The alkalinity of the water was determined by titrating it with 0.01 N hydrochloric acid (HCL), Methyl orange and phenolphthalein were used as indicators during the titration. Water hardness was measured using a water hardness titration kit using the method recommended by the kit. The analytical procedures and parameters were validated using published findings (Boyd and Tucker, 1998).

Plankton samples were collected from the selected sites using a 55 µm plankton net. The net was passed through the water to gather aquatic microorganisms, including zooplankton, phytoplankton, and other microscopic organisms. The materials were immediately placed in sterile plastic bottles after collection and stored in 5% formalin until laboratory examination. The preserved samples were examined with a Swift M.3300D binocular microscope. Phytoplankton and zooplankton were identified at approximately 100× and 400× magnification using a DCM 35 digital camera system (350 pixels, USB 0.1) for observation and recording. The identification of specimens were done with various taxonomic keys Ward and hipple (1959), Precott(1962), Battish(1992), Yungfang(1995), and Cook(1996).

Aquatic plant samples were collected from different parts of Kalankar Lake to examine the diversity and distribution of aquatic plants. A plant gripper and a hand net were used to collect a variety of aquatic plants. They included submerged, attached-floating, emergent, and free-floating plants. Lake edges, shallow water areas, and other locations with aquatic vegetation were among the suitable environments from which the samples were collected. The collected specimens were examined for taxonomic identification after being preserved. The identification process was aided by reference books, taxonomy keys (Nazir & Younis, 1979), and available botanical literature. Fish samples were collected from a few locations, and landing spots close to Kalankar Lake.

Various fishing methods often used by local fishermen were considered during the study. Gill nets, cast nets, and hook-and-line techniques were used to gather representative fish specimens. The types of fish that are commonly caught in the lake and the local fishing practices were also revealed by these methods. The gathered fish specimens were preserved in 10% formalin for further examination and identification. Fish were identified using standard taxonomic keys and identification guides. The descriptions and illustrations from the relevant taxonomic literature were compared to the morphological characteristics of the specimens. The fish taxonomic keys (Talwar and Jhingran, 1991; Ali, 1999) were the two primary references for fish identification.

Data on the socioeconomic conditions of the villages around Kalankar Lake was gathered through focus groups and key informant interviews. Local stakeholders, farmers, fishermen, and women involved in family and income-generating activities were consulted. The main topic discussed included the lake's importance for local livelihoods, fishing activities, farming practices, water availability, fluctuating fish populations, environmental concerns, and community dependence on natural resources. Research-based suggestions for Kalankar Lake conservation, restoration, natural

resource management, and sustainable development were developed with the aid of data gathered from nearby communities. Overall, a comprehensive method for evaluating the ecological state and biodiversity of Kalankar Lake was made possible by the combination of field observations, water-quality analysis, plankton sample, aquatic plant collection, fish sampling, and community-based data. The procedure of data analysis was compared with a study (Mahar et al., 2023).

RESULTS AND DISCUSSIONS

(i). Water Quality Parameters

Several physico-chemical criteria were used to evaluate Kalankar Lake's water quality. The findings revealed differences between various sampling locations and times of year. Air temperature, water temperature, clarity, pH, alkalinity, total dissolved solids (TDS) were the main parameters examined. The average air temperature during the study period was between 30°C and 36°C, while in August and September, the water temperature was between 30°C and 32°C. There was a slight temperature difference between the two months, which was mostly caused by seasonal variations. Temperature is one of the most important environmental factors in aquatic habitats since it influences several biological and chemical processes. Variations in water temperature can affect the growth, metabolism, reproduction, and spread of aquatic species. Similar relationships between temperature and aquatic biological processes were demonstrated (Mashori et al., 2024). Seasonal and weather-related variations in water temperature have also been reported by numerous researchers (Baqai et al., 1974; Korai et al., 2008; Jahangir et al., 2013).

A Secchi disc was used to measure the clarity of water. The average Secchi disc readings varied from 18 to 39 cm across various sampling locations and months. Secchi disc depth is correlated with water turbidity and gives an indication of light penetration into the water. Suspended elements such fine clay and soil particles, algae, and other microorganisms may cause lower transparency. As a result, variations in the amount of suspended material and organic matter in the lake water may be reflected in variations in Secchi disc measurements by appearance of plankton population and turbidity by flash floods and river water entrance by Nara Canal. Greater light penetration and clearer water are typically indicated by higher Secchi disc values described by different workers (Laghari et al., 2000). Lower readings, on the other hand, signify more turbidity and decreased light penetration. As a result, the transparency results offer valuable insights into the physical state of the water in Kalankar Lake.

During the sampling period, the pH of the water at Kalankar Lake varied between 6.8 and 7.6. These numbers show that the lake's water was typically between slightly acidic and slightly alkaline. Because pH can affect aquatic species' dispersion, growth, reproduction, and survival, it is a crucial water-quality measure. In aquatic ecosystems, pH variations can also have an impact on a number of chemical and biological processes (Mahar et al., 2000a, 2000b; Mahar et al., 2007b; Korai et al., 2010).

The alkalinity of the lake water was measured using standard reagents. The measured alkalinity as $CaCO_3$ ranged from 145 to 180 mg/L. The results indicate that the water in Kalankar Lake had a relatively high alkalinity. The alkaline content of the water may be related to the surrounding geological and environmental characteristics, such as the sandy and arid environment. The obtained alkalinity values were compared with the findings of previous studies conducted in Sindh's aquatic habitats and the pertinent water-quality parameters. Similar results have been reported by (Laghari et al., 2000; Jafri et al., 2000).

The water in Kalankar Lake had salinity (NaCl) ranging from 330 to 360 ppm total dissolved solids (TDS) ranged from 855–942 mg/L, and electrical conductivity (EC) ranging from 405 to 476 µS/cm. The concentration of dissolved salts may increase in areas with limited freshwater supplies because there is less dilution and evaporation. Similar relationships between TDS and environmental factors have been reported (Ali, 1999; Jahangir et al., 2000; Mahar et al., 2007; Mahar et al., 2023; Lashari et al., 2024). A lake's TDS concentration may be impacted by a number of factors, including the decomposition of plants and animals, soil and mineral inputs, floodwater, evaporation, reduced freshwater intake, and limited water drainage. The results were also compared with recommended methods (NEQS, 1993 and WHO, 1993; Mahar et al., 2000a, 2000b, 2007; Abbasi et al., 2025, 2026).

Table1. Water quality parameters of Kalankar Lake recorded during 2026.

S. No.	Parameters	St.1	St.2	Mean	SD (±)
1	Temperature of air (˚C)	35	34	34.5	0.707107
2	Temperature of Water (◦C)	31	29	30	1.414214
3	Transparency/ Turbidity of water (cm)	18	39	28.5	14.84924
4	pH	7.3	7.7	7.5	0.282843
5	Alkalinity (mg/L)	145	180	162.5	24.74874

6	Salinity (ppm)	330	360	345	21.2132
7	TDS (mg/L)	855	942	898.5	61.51829
8	Conductivity (µS/cm)	405	476	440.5	50.20458

(ii). Phytoplankton and algal fertility in lake

Thirty-two species of filamentous algae and phytoplankton were identified from Kalankar Lake throughout the study period. Table 2 displays the recorded abundance and taxonomic classification of algae from the three major phyla: Bacillariophyta, Chlorophyta, and Cyanophyta. It shows the recorded values for two sampling sites St. 1 and St. 2 together with the mean and standard deviation (SD ±) for each type of algae. The average abundance at the two sampling stations is St.1 and St.2. /2. The standard deviation displays the variation between the two station values. A low standard deviation indicates similar counts, while a high value indicates greater variation between the stations. According to Table 2 and Figure 2, cyanophytes (blue-green algae) had the highest reported total with a combined mean of 51.5, followed by chlorophytes (green algae) with a mean of 32.5 and bacillariophytes (diatoms) with a mean of 16.0. *Pediastrum simplex* displayed the greatest variation across the two sites, with a standard deviation of about 6.36, while *Nostoc commune* and *Oscillatoria amphibia* had comparatively high mean values of 7.0. The standard deviation for *Merismopedia glauca* was zero because the counts at both locations (3 and 3) were the same. The distribution, composition, and variation of algal species between the two sampling locations are shown in the table. Different sampling locations have different phytoplankton abundances (Lashari et al., 2021). Locations where organic and inorganic waste entered or collected in the lake showed increased phytoplankton growth. This could suggest that phytoplankton species can be encouraged to develop by nutrient enrichment from waste products (Lashari et al., 2014). Most of the known phytoplankton belonged to the phyla Cyanophyta, Chlorophyta, and Bacillariophyta. The principal Cyanophyta species in the lake were *Anabaena, Chroococcus, Merismopedia*, *Microcystis,* and *Oscillatoria*. *Microcystis* was shown to be more common in areas with organic pollution. The presence and number of these organisms may be connected to changes in the quality of the water and the availability of nutrients. Among the known members of Chlorophyta were *Chlorococcus, Chlorococcum, Oocystis, Pediastrum, Scenedesmus,* Tetraedron, *Staurastrum*, and *Closterium*. These green algae are essential components of freshwater ecosystems and sustain primary production in aquatic settings. Three genera of

Bacillariophyta (diatoms) were recognized from the collected samples. They included *Amphora*, *Gyrosigma*, and *Cyclotella.* Diatoms are important primary producers as well as useful indicators of changes in water quality. However, continuous monitoring is necessary since excessive nutrient enrichment and organic pollution may alter the plankton's composition and lead to the overgrowth of algal species. All things considered, the phytoplankton and zooplankton data provide important information about the biological productivity and ecological condition of Kalankar Lake. The observed plankton diversity can serve as a useful baseline for future studies and long-term monitoring of the lake environment (Mahar et al., 2026 and Odum, 1971).

Table 2. Phytoplankton species recorded from Kalankar Lake.

#	Group Thallophyta: Algae	St.1	St.2	Mean	SD (±)
*	Phylum: Cyanophyta	-	-	-	-
*	Class: Chroocophyceae	-	-	-	-
*	Order: Chroococcales	-	-	-	-
*	Family: Chroococcaceae	-	-	-	-
1	*Chroococcus tenax*	6	5	5.5	0.70710678
2	*Merismopedia glauca*	3	3	3	0
3	*M. punctata*	6	5	5.5	0.70710678
4	*Microcystis aeruginosa*	5	6	5.5	0.70710678
*	Class: Nostocophyceae	-	-	-	-
*	Order: Nostocales	-	-	-	-
*	Family: Nostocaceae	-	-	-	-
5	*Anabaena limnetica*	4	6	5	1.41421356
6	*A. plantonica*	6	4	5	1.41421356
7	*Nostoc commune*	8	6	7	1.41421356
*	Family: Oscillatoriaceae	-	-	-	-
8	*Oscillatoria amphibia*	6	8	7	1.41421356
9	*O. limosa*	3	2	2.5	0.70710678
10	*Lyngbya bergei*	8	3	5.5	3.53553391
	Total	**55**	**48**	**51.5**	**4.94974747**
*	Phylum: Chlorophyta	-	-	-	-

*	Class: Chlorophycea	-	-	-	-
*	Order: Chlorococcales	-	-	-	-
*	Family: Oocystaceae	-	-	-	-
13	*Chlorococcum minor*	8	7	7.5	0.70710678
14	*Chlorococcum umicida*	7	4	5.5	2.12132034
*	Family: Hydrodictyaceae	-	-		
15	*Pediastrum simplex*	2	11	6.5	6.36396103
*	Order: Zygnematales	-	-	-	-
*	Family: Zygnemataceae	-	-	-	-
16	*Scenedesmus dimorphus*	6	7	6.5	0.70710678
17	*Tetraedron hemiphaerium*	3	2	2.5	0.70710678
18	*Closterium* sp.	3	5	4	1.41421356
	Total	**29**	**36**	**32.5**	**4.94974747**
*	**Phylum: Bacillariophyta**	-	-	-	-
*	Class: Bacillariophyceae	-	-	-	-
*	Order: Centrals	-	-	-	-
*	Family: Coscinoiscoideae	-	-	-	-
19	*Amphora ovalis*	3	4	3.5	0.70710678
20	*Cyclotella stelligeria*	6	8	7	1.41421356
21	*Gyrosigma accuminutum*	7	4	5.5	2.12132034
	Total	**16**	**16**	**16**	**4.242640687**

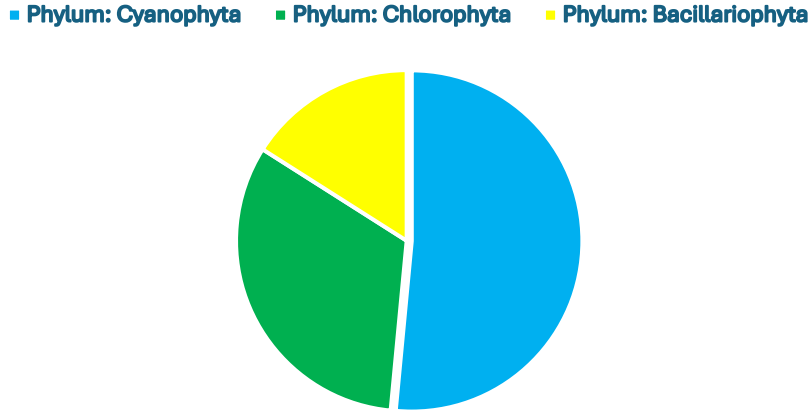


Fig. 2. Phytoplankton and algal percentage appearance in Lake Kalankar

(iv) Invertebrate Fauna

Thirteen distinct zooplankton species were found in Kalankar Lake throughout the study period. Rotifers were found to be the most common group at each sampling point. Conversely, cladocerans and copepods were less prevalent. The substantial plankton biomass indicates that Kalankar Lake supports a productive population of zooplankton. The invertebrate fauna observed at the two sampling stations included members of the phylum Rotifera, Arthropoda, and Mollusca. Rotifer had the highest recorded abundance, with 47 individuals at Station 1 and 48 at Station 2. Among the recorded rotifer species, *Brachionus caudatus* had the highest mean abundance (10.5 individuals), while *Testudinella mucronata* had the lowest mean abundance (3.5 individuals). Arthropoda had a higher reported abundance at Station 1 (33 individuals) than at Station 2 (29 individuals), whereas Mollusca displayed the opposite trend, with recorded totals of 20 and 23 individuals, respectively. These differences demonstrate that the documented composition of the invertebrate community differed between the two sampling sites. The reported totals for Arthropoda and Mollusca must be verified against individual taxonomic counts before drawing definitive conclusions. To better understand the observed distribution, detailed information on habitat characteristics, water quality, sample effort, and replication would be beneficial. Zooplankton is a vital part of the aquatic food chain and is consumed by many fish species, particularly planktivorous fish (Lashari et al., 2024). Planktivorous fish can find suitable eating conditions in the lake due to its rather rich plankton environment. An essential part of freshwater

ecosystems are macroinvertebrates. Molluscs, aquatic insects, worms, and other bottom-dwelling creatures are among them. The information that is currently accessible indicates that there have never been comprehensive scientific investigations on the diversity and abundance of macroinvertebrates in Kalankar Lake. As a result, nothing is currently known about the lake's macroinvertebrate community. The ecology of freshwater lakes can be greatly impacted by molluscs, particularly bivalves and freshwater snails (Gastropoda). They eat algae, periphyton, and organic debris in addition to feeding fish and waterbirds. The shallow-water areas and aquatic vegetation of Kalankar Lake may provide adequate habitats for freshwater molluscs and other macro-invertebrates. More comprehensive field surveys are required to determine the actual species, abundance, distribution, and ecological significance of macroinvertebrates in Kalankar Lake. Such data would provide useful baseline information for assessing the overall ecological health and richness of the lake.

Table 3. Invertebrate species are recorded from Kalankar Lake.

#	Group: Invertebrate	St. 1	St. 2	Mean	SD (±)
I	**Phylum: Rotifer**	-	-	-	-
1	*Brachionus caudatus* Hauer	10	11	10.5	0.70710678
2	*Brachionus quadridentatus* Hermann	9	8	8.5	0.70710678
3	*Filinia longiseta* Ehrenberg	8	9	8.5	0.70710678
4	*Keratella tropica* Apstein	5	8	6.5	2.12132034
5	*Lecane luna* O.F. Muller	7	5	6	1.41421356
6	*Monostyla bulla* Gosse	6	2	4	2.82842712
7	*Testudinella mucronata* Gosse	2	5	3.5	2.12132034
%	**Total number**	**47**	**48**	**47.5**	**0.70710678**
II	**Phylum: Arthropoda**	-	-	-	-
*	Class: Crustacea	-	-	-	-
*	Order: Cladocera	-	-	-	-
*	Suborder: Cladocera	-	-	-	-
*	Family: Alonidae	-	-	-	-
8	*Alona Karua* King	5	5	5	0

*	Family: Bosminidae	-	-	-	-
9	*Bosmina longirostris* Muller	6	6	6	0
*	Family: Daphnidae	-	-	-	-
10	*Ceriodaphnia reticulate* Jurine	9	5	7	2.82842712
*	Order: Copepoda	8	5	6.5	2.12132034
11	*Mesocyclops leuckarti* Claus	5	8	6.5	2.12132034
%	**Total percentage**	**33**	**29**	**31**	2.82842712
III	**Phylum: Mollusca**	-	-	-	-
*	Class: Gastropoda	-	-	-	-
*	Family: Lymnaeidae	-	-	-	-
12	*Lymnaea stagnalis*	-	-	-	-
13	*Lymnaea Auricularia*	-	-	-	-
14	*Physa acuta*	6	6	6	0
15	*Indoplanorbis exustus*	7	11	9	2.82842712
16	*Melanoides tuberculata*	7	6	6.5	0.70710678
%	**Total percentage**	20	23	21.5	2.12132034

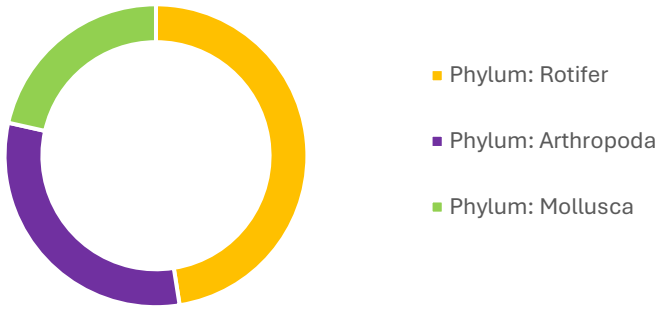


Fig.3. Invertebrate population estimation in percentage occurrance in Kalankar lake

(iii). Macrophyte Distribution

Around Kalankar Lake, there are sand dunes and natural vegetation that reflect the region's arid climate. This vegetation serves as a natural barrier surrounding some parts of the lake and

contributes to the preservation of the lake habitat. Vegetation was seen in shallow-water zones, damp and marshy areas, and lake margins during the field survey. The emergent and submerged plants made up mats of aquatic vegetation. *Typha domingensis* and *Phragmites communis* were found among the emergent macrophytes along the lake borders. The aquatic macrophytes at the two sample locations were classified into three ecological groups: submerged, floating, and marshy/emergent plants. The percentages indicate that marshy / emergent plants were more common at Station 2 (52%) than at Station 1 (33%). However, Station 1 reported a higher percentage of floating plants (34%) than Station 2 (26%). Similarly, 33% of plants at Station 1 and 22% of plants at Station 2 were submerged. These findings demonstrate that the relative distributions of aquatic plant families varied between the two sampling locations. These differences may be related to variations in habitat elements such as water depth, light penetration, substrate characteristics, and nutrient availability. However, additional environmental data and confirmation of the abundance estimates are required to determine the factors influencing macrophyte dispersal. In the deepest areas of the lake, major patches of *Najas* were also seen as submerged vegetation. Because local and migrating birds can find food and refuge in the seeds, leaves, and other plant components of these water plants, they are ecologically significant. Additionally, aquatic vegetation enhances the overall productivity of the lake environment by serving as a habitat for fish, invertebrates, and other aquatic organisms. Higher aquatic vegetation predominated in Kalankar Lake's shallow regions.

Table 4. Macrophytes in Kalankar Lake recorded during the present study.

#	Aquatic Plants: Macrophytes	St. 1	St. 2	Mean	SD (±)
I	**Marshy / Emergent Plants**	*	*	*	*
*	Class: Monocots (Monocotyledonae)	-	-		
*	Order: Poales	-	-		
*	Family: Cyperaceae	-	-		
1	*Cyperus difformis*	15	1	12.5	3.535534
*	Class: Equisetopsida (Monocotyledons)	-	-		
*	Order: Poales	-	-		
*	Family: Cyperaceae (sedge family)	-	-		
*	Genus: Schoenoplectus (Reichenb)	-	-		

2	*Scripus litoralis*	5	20	12.5	10.60661
*	Class: Magnoliopsida (Angiosperms)	-	-	-	-
*	Class: Tracheophytes (Vascular plant)	-	-	-	-
*	Order: Poales	-	-	-	-
*	Family: Poaceae (Grass family)	-	-	-	-
*	Genus: Phragmites Adans	-	-	-	-
3	*Phragmites vallatoria*	4	7	5.5	1.5
4	*P. karka*	3	5	4	0.707
*	Class: Liliopsida (monocotyledons)	-	-	-	-
*	Order: Poales	-	-	-	-
*	Family: Typhaceae	-	-	-	-
5	*Typha domingensis*	3	5	4	1
6	*Typha elephantina*	3	5	4	0.707
%	**Total percentage**	**33**	**52**	**42.5**	**13.44**
II	**Floating Plants**	**-**	**-**	**-**	**-**
*	Order: Alismatales	-	-	-	-
*	Family: Araceae (Aroid Family)	-	-	-	-
*	Genus: Lemna (Duckweed)	-	-	-	-
7	*Lemna minor*	13	10	11.5	2.121321
*	Class: Tracheophytes	-	-	-	-
*	Order: Proteales (or nelumbonalea)	-	-	-	-
*	Family: Nelumbonaceae	-	-	-	-
8	*Nelumbo nucifera*	9	8	8.5	0.707107
9	*Nymphya nouchali*	7	5	6	1.41422
10	*Ipomoea aquatica*	5	3	4	1.414213
%	**Total percentage**	**34**	**26**	**30**	**5.66**
III	**Submerged Plants**	-	-	-	-
*	Class: Equisetopsida/ liliopsida (monocots)	-	-	-	-
*	Order: Alismatales (Hydrocharitales)	-	-	-	-

*	Family: Hydrocharitaceae	-	-	-	-
11	*Hydrilla verticillata*	19	8	13.5	7.778175
*	Class: Angiosperms	-	-	-	-
*	Order: Alismatales	-	-	-	-
*	Family: Hydrilloideae	-	-	-	-
12	*Najas major*	8	7	7.5	0.70711
13	*Najas minor*	6	7	6.5	0.70711
%	**Total percentage**	**33**	**22**	**27.5**	**7.778**

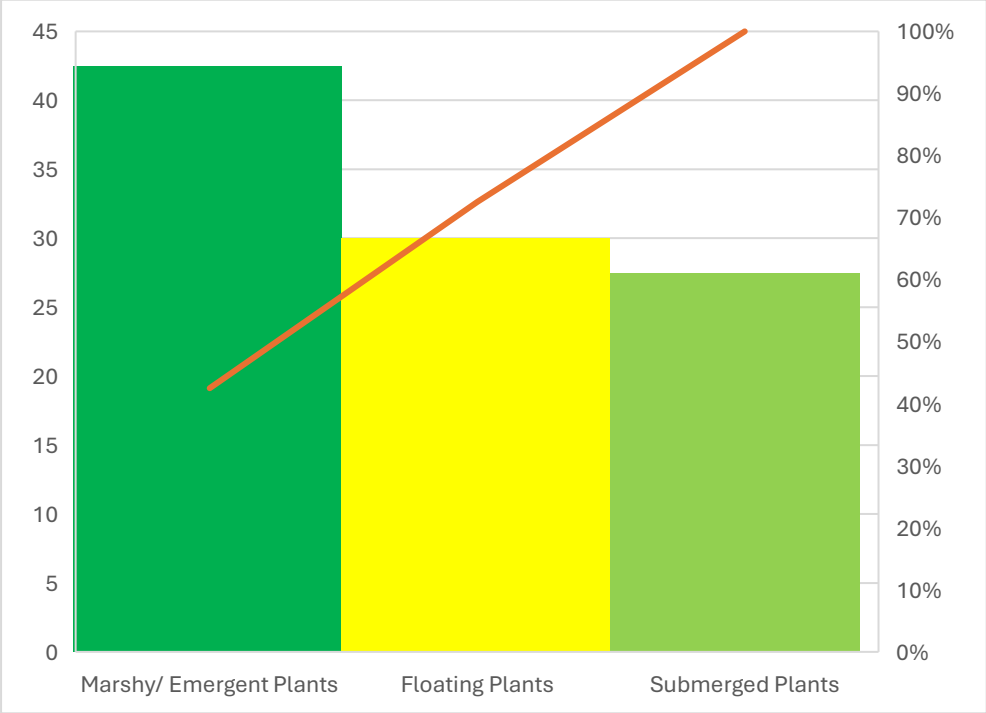


Fig. 4 Population estimation of macrophytes distribution in Lake Kalankar

(v) Fish Population

Fish are one of Kalankar Lake's most important biological and commercial resources. Based on information collected from multiple fish landing locations and neighboring fishing towns, a limited number of fish species were reported from the lake. The documented fish belonged to several families, including the Cyprinidae, Channidae, Schilbeidae, Mastacembelidae, Notopteridae, Belonidae, and Gobiidae. Local fisherman and other sources recorded about eighteen species in

all. Cyprinidae, Channidae, Schilbeidae, and Mastacembelidae were comparatively well-represented among the documented families. The composition of fish species and the percentage of their recorded abundance at two sampling points are shown in Table 5 and Figure 5. The variety of the fish assemblage is demonstrated by the fact that the reported species are members of multiple taxonomic orders and families. *Oreochromis niloticus* had the highest mean abundance (20) among the individual species, followed by *Labeo rohita* (15) and *Gibelion catla* (11). Cypriniformes (41) had the highest reported mean total, followed by Cichliformes (24.75). The two sites differed in terms of species-specific abundance. Species with a standard deviation of zero had the same recorded values at both locations, whereas species with higher standard deviations showed greater fluctuations in their recorded abundance. Taking everything into account, the table provides a comparison of fish abundance and distribution between the two sampling sites. Local fishermen preferences, abundance, and economic significance varied among fish species. According to reports (Mahar et al., 2014). One of the lake's most economically significant fish species is *Labeo rohita*, also referred to as Dhambhro locally. Because of its market worth and demand, local fishermen thought it was especially valuable.

Table 5. Qualitative and quantitative status of fish species in Kalankar Lake

#	Fish species	St. 1	St. 2	Mean	SD (±)
I	**Class: Actinopterygii**	-	-	-	-
i	**Order: Cypriniformes**	-	-	-	-
*	Family: Cyprinidae	-	-	-	-
1	*Labeo rohita*	14	16	15	1.414213562
2	*Cirrhinus mrigala*	9	12	10.5	2.121320344
3	*Giblian catla*	12	10	11	1.414213562
4	*Puntius ticto*	4	3	3.5	0.707106781
*	Family: Danionidae	-	-	-	-
5	*Chela laubuca*	1	1	1	0
%	Total	**40**	**42**	**41**	1.414213562
ii	**Order: Anabantiformes**	-	-	-	-
*	Family: Channidae	-	-	-	-
6	*Channa marulius*	9	7	8	1.414213562

7	*Channa striata*	5	4	4.5	0.707106781
%	Total	**14**	**11**	**12.5**	2.121320344
iii	**Order: Cichliformes**	-	-	-	-
*	Family: Cichlidae	-	-	-	-
8	*Oreochromis mossambicus*	5	4.5	4.75	0.353553391
9	*Oreochromis niloticus*	19	21	20	1.414213562
%	Total	**24**	**25.5**	**24.75**	1.060660172
iv	**Order: Synbranchiformes**	-	-	-	-
*	Family: Mastacembelidae	-	-	-	-
10	*Mastacembelus armatus*	2	2.5	2.25	0.353553391
%	**Total**	**2**	**2.5**	**2.25**	**0.353553391**
*	**Order: Osteoglossiformes**	-	-	-	-
*	Family: Notopteridae	-	-	-	-
11	*Notoperus notopterus,*	2	2	2	0
12	*Notopetrus chitala*	2	2	2	0
%	Total	**4**	**4**	**4**	**0**
*	**Order: Siluriformes**	-	-	-	-
*	Family: Siluridae	-	-	-	-
13	*Wallago attu*	5	3	4	1.414213562
*	Family: Bagridae	-	-		
14	*Aorichthys aor*	4	6	5	1.414213562
%	Total	**9**	**9**	**9**	**0**
*	**Order: Perciformes**	-	-	-	-
*	Family: Ambassidae	-	-	-	-
15	*Chanda ranga*	1	1	1	0
	Total	1	1	1	0
*	**Order: Clupeiformes**	-	-	-	-
*	Family: Clupeidae	-	-	-	-
16	*Gadushia chapra*	1.5	1.7	1.6	0.141421356

%	Total	**2.5**	**2.7**	**2.6**	**0.141421356**
*	**Order: Mugiliformes**	-	-	-	-
*	Family: Mugilidae	-	-	-	-
17	*Mugal cephalus*	3	1.8	2.4	0.848528137
%	Total	**3**	**1.8**	**2.4**	**0.848528137**
*	**Order: Beloniformes**	-	-	-	-
*	Family: Belonidae	-	-	-	-
18	*Xenentodon cancilla*	1.5	1.5	1.5	0
%	**Total**	**1.5**	**1.5**	**1.5**	**0**

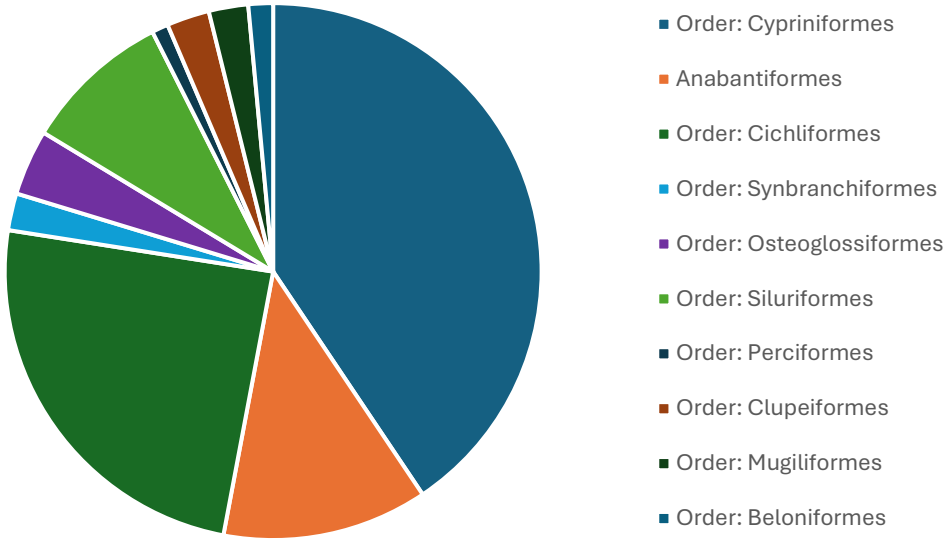


Fig.5. Fish production in percentage recorded from Kalankar lake

CONCLUSION

Kalankar Lake is an important reservoir of water for ecology, economics, and civilization in the remote region of Sindh. However, there has not been much scientific research done on the lake. There is limited scientific knowledge about its ecological condition, biodiversity, water quality, and the effects of climate change. This knowledge gap makes it difficult for policymakers, environmental authorities, researchers, and local communities to make well-informed decisions about the lake's conservation and sustainable management. The lake is home to numerous aquatic and wetland fauna, including fish, phytoplankton, zooplankton, aquatic macrophytes, migrating

birds, and many more. The richness and ecological productivity of the lake ecosystem are greatly influenced by these biotic conditions. Kalankar Lake also provides the locals with essential supplies. Lake water is used for domestic purposes, agriculture, and cattle farming, even though fishing is a major source of income and a means of livelihood, particularly for the local fishermen fishing population. The social, cultural, and economic lives of the surrounding communities have also been greatly impacted by the lake. Because Kalankar Lake is in a semi-arid region, it is vulnerable to environmental changes such as droughts, low rainfall, high temperatures, and fluctuations in water availability. These elements may have an impact on plankton communities, fish populations, aquatic vegetation, water quality, and other elements of the lake environment. As a result, the current study is crucial for generating baseline scientific data regarding Kalankar Lake's ecological state and biodiversity. The study offers data that can be utilized to comprehend the lake's current state and pinpoint significant environmental issues. Policymakers, environmental authorities, and local communities can use the study's findings to help establish sustainable management, conservation, and restoration initiatives. Appropriate management is necessary to maintain the lake's ecological stability and ensure that the local community uses its resources responsibly. The suggestions for improvement and restoration of the lake ecosystem are given in following matrix Table-6.

Table 6. Proposed Participatory NRM Plan for Kalankar Lake, Dhoro Naro Sanghar, Sindh Pakistan

No.	Proposed Activity	Timeline	Funding	Responsibility	Targets/ Indicators	Comments
1	Support Literacy, Vocational Training and other Educational Programmes in Fishing Communities	1-5 Years	Provincial and Federal Govts., Doner Agencies and NGOs.	Sindh Fisheries Department, WWF-Pakistan, IUCN-Pak, NGOs	Literacy, Vocational Training Programmes	Some activities should be related to income generation for women.

2	Reactivate the flow of freshwater from Nara canal	1-2 Years	Federal Government, or Sindh Irrigation Department any Donner Agencies	Sindh Irrigation Department		To ensure adequate supply of freshwater for restoration of lake productivity and water quality.
3	Establishment of a Fish Hatchery on the bank of the lake	1-3 Years	Federal and Provincial, Fisheries Department, HEC, Doner of any donor agencies,	Sindh Fisheries Department, or any donor organization	To ensure sustainable Ecosystem and Biodiversity friendly fisheries and Aquaculture development	To enhance fish production in the sector
4	A water filtration RO plant may be installed for drinking water purposes	1-2Years	Federal, Provincial and District Govt., FAO, any donor agency, NGO	Any government department CBO/ NGO/ donor agency or local community	A significant target must of set to management the plant	Such activities help people have a healthy life.
5	Raise Awareness among fishermen and fish farmers about Conservation	1-5 Years	Federal and Provincial Govts., IUCN and WWF	Sindh Fisheries Department, WWF Pak and IUCN	Awareness Programmes must be launched to fishing	Education training and research with continuing monitoring

	and Sustainable Management Principles				communities of rural areas	by community.
6	Educate and Train Fish Trade on the use of improved fish transportation methods	1-3 Years	Federal and Provincial Govts, IUCN and WWF	Sindh Fisheries Department, WWF Pak	Fish traders and middlemen are included in such trainings.	Such training Programmes are linked with post-harvest losses
7	Lobby for ban on use of polythene bags	1-5 Years	Sindh-EPA, WWF and IUCN	Sindh-EPA and WWF	Impacts of polythene bags on inland fisheries are reduced.	Raise awareness of the problem they cause when disposed in waterways and water bodies. Only biodegradable bags should be used.
8	Conduct resource survey and species stock assessments	3-5 Years	Sindh Fisheries Department, District Govt. PARC, Universities	Sindh Fisheries Department, WWF Pak and IUCN	Data base of fisheries resources must set	
9	Monitor the spread and impacts of	2-5 Years	IUCN, WWF, Sindh Fisheries	Sindh Fisheries	Impacts of exotic species must	*Silvinia molesta* problem in

	introduced plants and fish species such as Tilapia etc.		Department, Universities and FAO	Department and WWF Pak	be studied before release into waters	Keenjhar lake.
10	Restock Freshwater bodies with seeds/fingerlings of commercially important carp species.	1-5 Years	Federal, Provincial and district government	Sindh Fisheries Department	Infrastructure of seed production and stocking must be initiated	Ensure that scientific protocols of free stocking are followed to restore or enhance biodiversity
11	Declare zones as reserved areas for fish breeding and survival	1-3 Years	Provincial Govt., fish contractors and NGOs	Sindh Fisheries Department and CBOs	Fish production will be increased	
12	Establish a registration system for all fisherfolk	1-2 Years	Provincial and District Govts	Sindh Fisheries Department	Directory of registered fishermen will be available	
13	Ensure that all hatcheries enhance biodiversity to the fish seed	3-5 Years	Provincial, PARC, Universities, Donor Agencies	Sindh Fisheries Department	Fish seeds will be available	Involvement of private sector should be promoted and will be possible as fish seed becomes available for

						culture of these species
14	Install quality ice making plants and cold storage facilities at all major fish landing points	1-3 Years	Banks and other investing agencies	Sindh Fisheries Department and WWF	Plants should be installed based on capacity of landing point	
15	Establishment of pen and cage culture	1-3 Years	Sindh Fisheries Department, WWF, UNDP	Sindh Fisheries Department, NGOs/CBOs	Pen and cage culture should be set up through the active participation of local community to get desirable size for release in the lake.	To promote sustainable community-based aquaculture.

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