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ECOLOGICAL SURVEY OF MACROPHYTES AND FISH DIVERSITY IN HALEJI LAKE THATTA SINDH PAKISTAN WITH REFERENCE TO NATURAL RESOURCES MANAGEMENT AND CONSERVATION ASPECTS

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Abstract

Haleji lake is one of the famous Ramsar site conservative wetland in Thatta Sindh Pakistan existing under control of Sindh Wildlife Department Government of Pakistan. The Lake is located 24˚48'25.08" N and 67˚46'27.44" E on a global map. Water quality variables, macrophyte community and fish population were examined to find out the ecological condition of the lake. Five sampling stations were selected for collection of samples to cover whole area of the lake situation. The average air and water temperatures are 34.5±0.43 and ±30.34 ˚C, the water's transparency is 71.8±9.75705 cm, the pH is 8.2±0.1, the alkalinity (CaCO3) is 71.4±3.5 mg/l, the salinity (NaCl) is 985.8±3639.98 ppm/l, the TDS is 284.1±293.252 µs/cm/l, the nitrogen (nitrates) is 2756.8±404.832 µm/l, and the orthophosphate is 3936.8±2083.6 µm/l. The results of water quality parameters analysis indicated higher side values when compared with NEQS and WHO Limits.

Therefore, the lake needs quick supply of freshwater for dilution and maintaining sustainable ecosystem. A Total of 12 macrophyte species were recorded from entire lake, the species were; *Azolla pinnata, Cyperus difforms, Eichhornia crassipes, Limna minor, Hydrilla verticillata, Nelumbo nelumbo, Nijas major, Phragmites vallatoria, Potomogeton pectinatus, Pistia stratiotes, Scripus littorals* and *Typha domogensis*. Fish population of the lake is also affected due to water scarcity. 18 fish species were recorded during the study period. The species were present in the water *Labeo rohita, Cirrhinus mrigala, Giblian catla, Channa marulia, Channa striata, Oreochromus mossambicus, Oreochromus niloticus, Mastacembilus armatus, Notoperus notopterus, Notopetrus chitala, Aorichthys aor, Chanda ranga, Chela labuca, Gadushia chapra, Gadushia chapra, Punctus ticto, Mugal cephalus, Wallago attu,* and *Xanantodon cancilla*. Most of fish species that occur in the lake are the ecological indicators of semi-eutrophic water bodies. The analysis of GIS shows that 12% of lake areas covered with marshy erect plants such as *Typha* and *Phragmites*, 8% *Scripus* and *Cyprius* plants, 3% Attached and 2% free floating. However, 65% lake area is covered with open water and 10% land was recorded dried or barren in nature. The results of Haleji lake indicate that the lake is currently characterized at semi-eutrophic stage. Therefore, adequacy supply of freshwater may be ensured for a healthy sustainable ecosystem of microphytes, barren soil, and little areas of vegetation, birds, fish, crocodiles and invertebrates which shows the natural fertility of the lake.

INTRODUCTION

Haleji Lake is located 91 kilometers from Karachi and about 30 kilometers from Thatta. The Lake is located on a globe map are 24˚48’25.08” N and 67˚46’27.44” E as per its coordinates. Lake water covers an area that is around 6.58 kilometers. From an ecological perspective, the lake is surrounded by marshes and seepage water basins (Hassan, 2026). The water board department uses the lake, an artificial freshwater reservoir, to supply water to Karachi and the surrounding areas. The lake was recognized as wildlife sanctuary in March 1977 under section 14 of the Sindh wildlife Protection Ordinance (1972) (Scott, et al., 1990). Enclosed by a perimeter with suitable inlets and exits, the lake underwent renovations in 1930. The lake is fed from river Indus via Jam branch through the branch of KB lower fed canal during the flood season (Fig.1).

The mass growth of macrophytes in Haleji is composed of free-floating, attached-floating, emergent, and submerged plants, including *Azolla pinnata*, *Pistia stratiotes*, *Salvinia molesta*, *Lemna minor, and Lemna major* reported in one of research findings (Baqai et al., 1974). The species of marshy emergent plants *Ipomea aquatica*, *Typha domingensis, Phragmites karka, Cyperus sp*., and *Scirpus* sp. are examples of marginal vegetation. There were patches of submerged plants, such as *Najas minor, Myriophyllum verticillatum, Potamogeton natans* and *Salvinia molesta* were found, especially on the western side, whereas *Nelumbo* offered floating habitat according to a study carried out (Jehangir et al., 2013). Freshwater scarcity led to the death and decomposition of emergent and submerged plants, which released nutrients into the lake which encouraged the overgrowth of algae and phytoplankton (Mahar et al., 2007). In result light penetration in water greatly disturbed as cause of death of several animals and bottom dwellers. The research indicates that the macrophyte population is under stress and changing rather than continually healthy, even though macrophytes still play a major role in the ecosystem of Haleji Lake (Jehangir et al, 2013). The main problems include shifting water levels and supplies, shallow water growth, fertilizer enrichment, excessive aquatic vegetation in some areas, and eventual decomposition (Hassan, 2026). The aim of proposed work is to find out the ecological and economical importance of macrophytes growing in Lake Haleji along with suggestions and recommendations for aquatic natural resources management and conservation aspects. The objectives of the study are to find out water quality variables, qualitative and quantitative assessments of macrophytes along with the beneficiary biota.

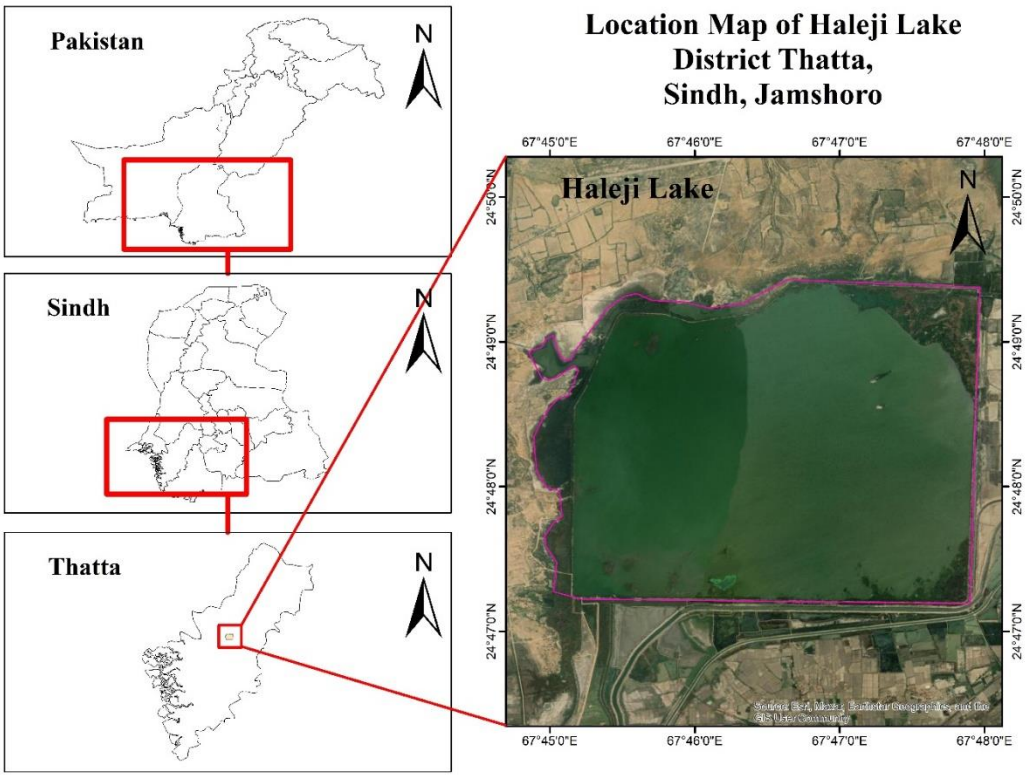


Fig.1. Location Map of Haleji Lake, Thatta, Sindh Pakistan

MATERIALS AND METHODS

The visit team made a program of samples from 9:30 am to 4:45 pm to gather data and conduct assessments during June 2026. To gather as many data and samples as possible regarding the scientific and socioeconomic aspects of Haleji Lake, in this regard a field tour was planned for June 15, 2026. Samples were gathered from five sampling stations starting from southern site st.1, Westen side st.2, central side station 3, Eastern side sample 4 and Northern site st.5. An analysis of the biological and physico-chemical characteristics of the water in Haleji Lake was also done. Water samples were collected in sterile plastic bottles to analyze their chemical properties. By immersing the Secchi disc in water and tracking its presence and departure, the clarity of water and light penetration were observed. Wooden bamboo was used to gauge the water's depth. The WTW 330i/Set conductivity meter was used to detect temperature, salinity, conductivity, and total dissolved solids (TDS). Chemical strips were used to measure the pH of the water. Methyl orange and phenolphthalein were used as indicators in a standard solution of HCl 0.01N to assess the alkalinity of the water. A titration kit was also used to determine the water's hardness. Using a

standard reagent and the Kjeldhal titration method, nitrates and nitrogen findings were obtained from collected water samples. For confirmation, the titration kits were also utilized. The APHA 1982-recommended atomic absorption spectrometer standard method was used to measure orthophosphate in water samples. A variety of aquatic plants were gathered using a hand net while macrophytes were harvested using a plant-gripner. Fish samples were collected using gillnets, cost nets, and hook lines. While large fish samples were collected from local landing centers and native fishing communities living surrounding villages of the lake. Photography of the specimen of small and large fish was done on spot. However, unidentified and doubtable specimens were preserved in plastic bags and jars with 5% formalin solution. Some of the medium samples were kept in an ice box at 4˚C. Taxonomic keys published by various authors were used for indentation of the specimen. The list of taxonomic keys which were referred to; Cook (1996), Nazir and Younis (1979), Talwar and Jhingran (1991), Ward and Whipple (1959) and Yungfang (1995). The Microsoft Excel Worksheet program was used to analyze the work's data. Using Google Earth Engine (GEE) and Geographic Information System (GIS) software like ArcGIS and QGIS, the industry-standard platform for analyzing satellite data of aquatic vegetation, barren land, and lake water bodies was used to analyze the macrophyte distribution abundance in the lake.

RESULTS AND DISCUSSION

i. Water Quality Variables

Water quality characteristics of the lake were observed from water samples taken from five lake's main locations. The results are given in table 1. The average air and water temperatures are 34.5±0.43 and ±30.34 ˚C, the water's transparency ranges 71.8±9.75705 cm, the pH records 8.2±0.1, the alkalinity values of water samples (CaCO3) 71.4±3.5 mg/l, the salinity of the water (NaCl) 985.8±3639.98 ppm/l, total dissolved solids of the lake water (TDS) 284.1±293.252 µs/cm/l, nitrogen concentration of water samples 2756.8±404.832 µm/l, and the orthophosphate amount was noted in 3936.8±2083.6 µm/l. The results are shown in figures No.4 and 5. During the visit to the Haleji Lake, physical observations were also made, including temperature, wind action, watercolor, water test, water organic odor, movement, water flow in or out of the lake, plant mat formation, fishing activities, water level, and depth. The results of water quality parameters were found beyond the permissible limits for drinking water when compared with WHO-recommended drinking water standards. Therefore, Haleji Lake needs adequate supply of

freshwater quality to maintain the satisfactory characteristics to be somewhat higher than freshwater utilized for human consumption. The factor which are responsible for the deterioration water quality of the lake could be brought on by death of the lake's biota (Plants and animals) due to water evaporation and out flow for supply to Karachi through the Water Board. Low water level is main cause of providing growth grounds to cyanobacteria and other harmful bacteria and fungi such as *Vibrio cholerae* (cholera), *Escherichia coli* (E. coli), *Legionella* (legionellosis), and *Mycobacterium* species (nontuberculous mycobacterial illnesses). The findings are confirmed with one of the research reports published on Keenjhar lake and Haleji lake (Jehagir et al., 2000; Mahar et al, 2000), the toxicity of gases, organic and inorganic materials, and rainwater intrusion, which periodically causes washdown of the surrounding areas. Important elements include seasonal variation, species composition, and animal and plant life spawning. As a result, it is recommended that the regular inflow of freshwater from rivers be guaranteed. This will preserve both the natural productivity and the dilution mechanism of the freshness of the lake water, supporting the operation of sustainable ecosystem members. Several workers have conducted studies on Haleji Lake's water quality.

Table 1. Water quality variables recorded from Haleji lake during study period.

S. #	Parameter	St. 1	St. 2	St. 3	St. 4	St. 5	Average	Std (±)	SEQS
1	Time of collection	9:30 am	11:25 am	1:55 pm	3:40 pm	4:45 pm	6.15 hours	0	0
2	Temperature air (^{0}C)	30.5	34.9	35.2	35.5	35.6	34.5	2.16	15-40
3	Temperature water (^{0}C)	28.5	29.9	30.2	31.5	31.6	30.34	1.28	15-40
4	Transparency of water Seechi Disc (cm)	78	56	80	76	69	71.8	9.7571	90
5	pH	7.9	7.9	8.1	8.0	8.1	8.2	0.1	6.5 - 8.5

6	Alkalinity (mg/l)	77.4	73.8	69.6	78.4	74.6	71.4	3.5	
7	Salinity NaCl (ppm)	936.2	1004	1674	1705	9429	985.8	3639.9	1000
8	TDS (mg/l)	750	840	1350	1300	790	740	293.48	1000
9	EC (µs/cm)	1510	1620	2700	2750	1520	1590	645.25	
10	Nitrogen (Nitrates) (µm)	2320	3401	2620	2841	2602	2756.8	404.83	-
11	Orthophosphate (Phosphate) (µm)	5729	4581	3820	5126	428	3936.8	2083.66	-

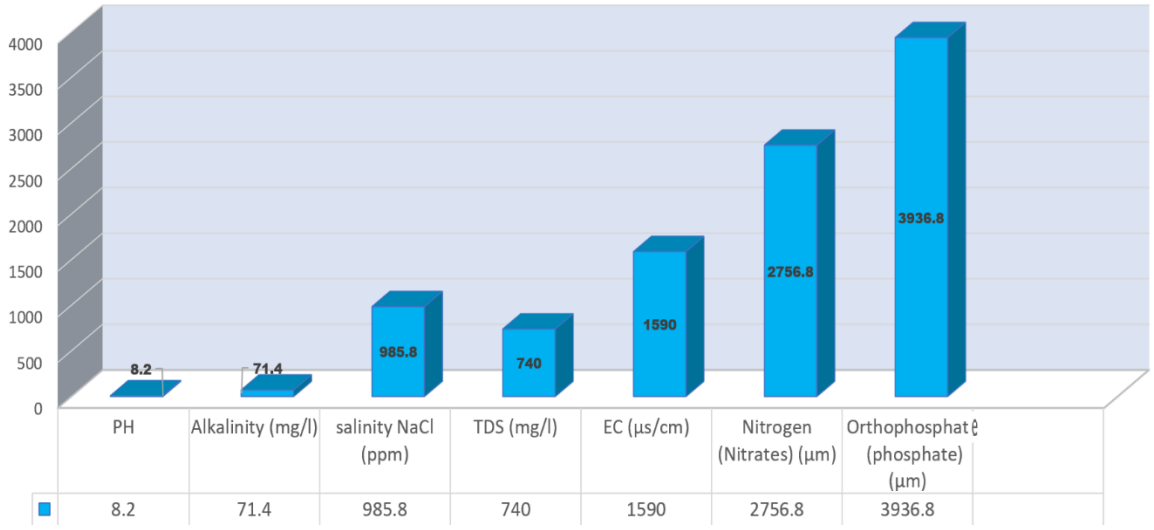


Fig.2. Water quality parameters of Haleji lake Thatta Sindh Pakistan.

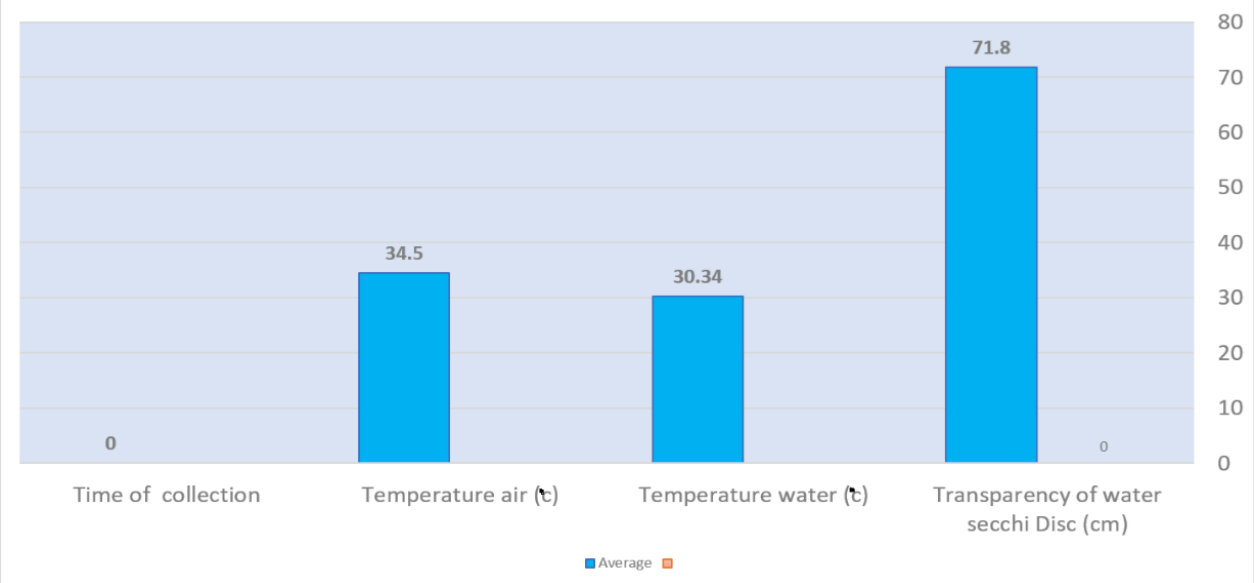


Fig.3. Water quality variable of Haleji lake, Thatta, Sindh, Pakistan.

ii. Macrophytes Diversity

This lake is shielded by ground that is arid and has ancient natural vegetation above the water's surface. On the lake's edge, certain vegetation is shown to thrive on wet, soggy soil, marshy terrain, and the water's edges. The analysis shows that the land-cover class of Haleji Lake, which is approximately 3.527 sq. km, is mostly composed of water. The 1.226 square kilometers of flora and the 0.824 square kilometers of bare land show that the lake is surrounded by vegetation. Microphytes occupy the smallest area (0.569 square kilometers), suggesting a relatively tiny amount of aquatic vegetation compared to the open-water environment. All things considered, the results show that Haleji Lake is mostly characterized by open water, microphytes, bare soil, and little areas of vegetation (Fig.2). Emergent plants included *Ipomoea aqutica, Cyprus* sp., *Scripus* sp., *Phragmits karka*, and *Typha domognsin*. There is just one species of Lotus *Nelumbo nelumbo* that is connected to the bottom and has larger leaves, a colorful blossom, and appearance of three emergent plant species *Najas major, Najaz minor*, and *Potamogeton pactinatus* were discovered in patches together with their seeds. There is just one species of Lotus *Nelumbo nelumbo* that is anchored to the bottom and has larger leaves, a colorful flower, and fruit that floats above the water's surface. Average percentage of the macrophytes given in table 2. The study found twelve species of aquatic plants, or biota. Their relative percentages varied among the species, indicating differences in their abundance within the study area. *Azolla pinnata*, a rather uncommon plant,

accounted for 3% of the total biota. At 8% of the recorded biota, *Cyperus difformis* was a relatively common species. 3% of *Eichhornia crassipes.* This species accounted for 3% of the biota. *Lemna minor* contributes only 2%, making it one of the less common species. The comparatively common species accounted for 13% of the whole biota. *Hydrilla verticillata* and *Nelumbo nelumbo* comprised 3% of the observed biota. 14% of this species came from *Najas major*, one of the more common species in the research area. At 13% of the whole biota, *Phragmites vallatoria* had a rather high abundance. *Potamogeton pectinatus* accounted for 7% of the total biota. *Pistia* sp. 1% had the lowest recorded abundance, contributing only 1%. With 12% of the total, *Scirpus* sp. littoralis was a common species. *Typha domingensis* had the largest percentage, accounting for 21% of the entire biota. The data showed that *Typha domingensis* (21%) was the most common species, followed by *Phragmites vallatoria* (13%), *Hydrilla verticillata* (13%), and *Najas major* (14%). *Scirpus littoralis* (12%) was also rather prevalent. On the other hand, species that were somewhat less common included *Pistia* sp. (1%), *Lemna minor* (2%), *Azolla pinnata, Eichhornia crassipes*, and *Nelumbo nelumbo* (3% each). Overall, the results indicate that the aquatic vegetation community was dominated by a few species, most notably *Typha domingensis*, whereas many other species were present in relatively small quantities. This variation in abundance may be caused by differences in habitat conditions, water depth, competition, nutrient availability, and environmental tolerance (Table 2).

Table 2. List of macrophytes recorded in Haleji lake.

#	Biota	St.1	St.2	St.3	St.4	St.5	Percentage (%)
1	*Azolla pinnata*	-	-	-	+	++	03
2	*Cyperus difforms*	+	+	-	-	+++	08
3	*Eichhornia crassipes*	-	-	-	+	++	03
4	*Limna minor*	-	-	-	+	++	02
5	*Hydrilla verticillata*	+++	++++	++	+	-	13
6	*Nelumbo nelumbo*	+++	+	-	-	-	03
7	*Nijas major*	-	+	+++++	+++	+	14
8	*Phragmites vallatoria*	++	++	-	-	++	13
9	*Potomogeton pectinatus*	+	++	-	++	++	07

10	*Pistia stratiotes*	-	-	-	++	-	01
11	*Scripus littorals*	+	+	-	+++++	+++++	12
12	*Typha domogensis*	+++++	+++	-	+	++	21

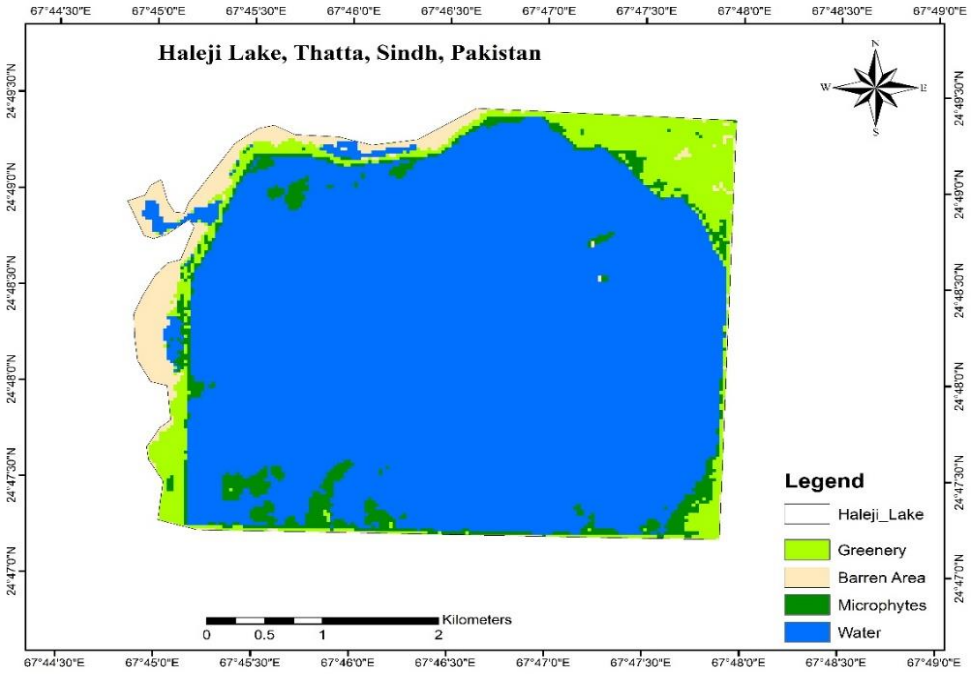


Fig.4. Sat light image of Haleji lake showing dispersal status of emergent plants, floating plants and barren area.

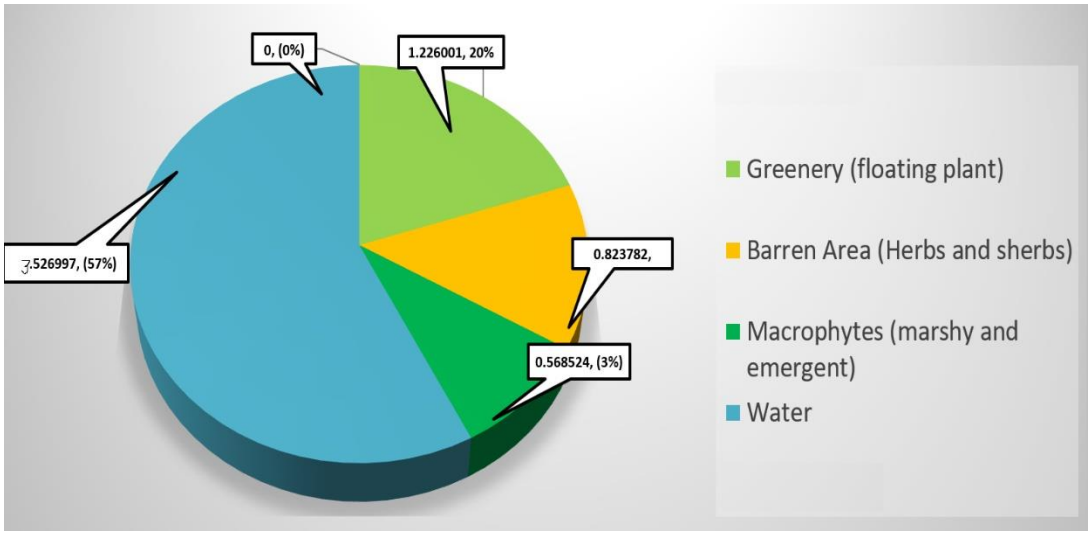


Fig.5. Sat light imaginary percentage and quantity of emergent plants, floating plants, barren area and open water of Haleji lake.

iii. Fish Population Estimation

Haleji Lake in Thatta District, Sindh, continues to support fish production, however the fishery is under ecological stress and appears to be losing production potential. During the current examinations 17 different species of fish were identified. *Tilapia zilli Channa striatus, Channa punctatus, Oreochromous nilioticus,* and *Oreochromous mossambicus*. In one of the studies a total collection of fish was made consisting of 28 kinds related 11 families from Haleji lake during 2019-2021 (Leghari 2024). The major species in the lake were *Xenntodon cancelia, Channa marulius Gudusi chapra,* and *Chanda ranga*. However, according to native community statements, *Labeo rohita, L. gonious, Cirrhina mirigala, Cirrhinus reba, Notopeterous notopeterous,* and *Wallago attu* were found extremely sparingly. The most current data indicates that Haleji Lake is experiencing ecological degradation, with the primary reasons influencing its aquatic flora being decreasing water levels, stagnation, and lower water quality (Ali,1999). Due to a shortage of freshwater intake from the Indus, the lake has been largely stagnant and has been drying up since 2018 (Lashari et al., 2021). The reported biota included fourteen fish species in varying proportions. *Labeo rohita* accounted for 8% and *Cirrhinus mrigala* for 6% of the total biota. *Gibelion catla* contributed 5%. Of the snakehead fish, 8% were *Channa marulia* and 11% were *Channa striata*. With 14% of the total biota, *Oreochromus niloticus* was the most common species, followed by *Oreochromus mossambicus* with 12%. *Mastacembelus armatus* accounted for 4%, *Notopterus chitala* for 2%, and *Notopterus notopterus* for 3%. *Aorichthys aor* and *Chanda ranga* each made up 5% of the biota. 3% came from *Gadusia chapra* and 4% from *Chela labuca. Oreochromus niloticus* (14%) was the most common species overall, followed by *Oreochromus mossambicus* (12%) and *Channa striata* (11%). *Notopterus chitala* was the least common species, with a recorded percentage of 2%. The results are summarized in table 3.

iv. Ecological Overview of Haleji Lake

The primary problem is that there doesn't seem to be a comprehensive, current botanical study from 2025–2026 that measures the quantity or range of every species of water plant. As a result, providing current percentages for each species would be deceptive. In the past, a decrease in freshwater supplies led to the death and decomposition of aquatic plants, which increased nutrients and promoted the growth of phytoplankton. Observations revealed significant invasion, and Salvinia molesta has already been recognized as an invasive/free-floating plant in Haleji (Baqai et

al., 1974). As the lake deteriorated, the lotus population was said to have drastically decreased. *Typha domingensis* and *Pharagmite communis* are the predominant marshy plants in the Haleji reservoir. *Nelumbo Nelumbo*, a lotus plant, floats on the lake's bottom. Most of the vegetation of higher aquatic plants is found in shallow areas. Cutting the plant below the water's surface and releasing herbivorous fish is advised. Silver carp and grass carp are used to regulate growth. Due to the lack of water, emergent and submerged plants die and decay, releasing a significant amount of nutrients into the water. Currently, Haleji Lake is not supplied by Jam Branch or the lower K.B. Feeder. When compared to WHO Limits, the metrics are within the acceptable levels for drinking, despite the water quality evaluation indicating a slightly eutrophic character. Macrophytes are important stakeholders into Haleji Lake environment, because they provide food, habitat, improve water quality, stabilize sediments, and support animal biodiversity especially the lake residence and migratory bird groups (Mahar et al., 2007). They serve food, shelter, and breeding sites for fish, aquatic invertebrates, and waterbirds. Microbes and algae at the base of aquatic food chains are supported by macrophytes, which also provide food for herbivorous animals (Nazir and Younis, 1979). By absorbing fertilizers like nitrogen and phosphorus, they reduce excessive nutrient enrichment and algal growth. Their roots and stems reduce sediment disturbance in addition to reducing erosion and excessive turbidity (Jehangir et al., 2000). Photosynthesis supplies oxygen to the water, especially in well-lit areas. Because of the abundant aquatic vegetation in Haleji Lake's many migratory and permanent birds have areas to rest, nest, and feed. Through their growth, death, and decomposition, plants help the wetland's nutrient movement and recycling. Variations in macrophyte abundance and species composition can be used as indicators of changes in water quality and wetland health.

CONCLUSION

Haleji is one of the most important lake among the wetlands in Sindh, Pakistan. Nowadays it faces the problem of eutrophication, so it requires quick ecological rehabilitation. The native community people said that since 2018, there seems to have been no freshwater inflow from the Indus River even from some one other source. Results indicated that ecological conditions of the lake are declining due to none of freshwater supply and decreasing stagnant water levels. It is fact that Haleji lake is home of fish, aquatic vegetation, reptiles, waterbirds, and crocodile population. If situation remains same as a result natural biodiversity will suffer a lot. The most important long-term action is to restore a stable freshwater regime. Recent scientific research specifically

recommends connecting the Haleji wetland complex with the Indus to restore freshwater storage, habitat, and biological functions. This should be accompanied by the restoration of freshwater inflows. Water quality and levels are regularly checked. control of pollution and solid waste. stronger actions to stop illegal hunting. restoration of reeds, aquatic vegetation, and fish populations. controlled and environmentally responsible travel. enhanced participation in the community. long-term scientific monitoring of animals, such as migratory birds.

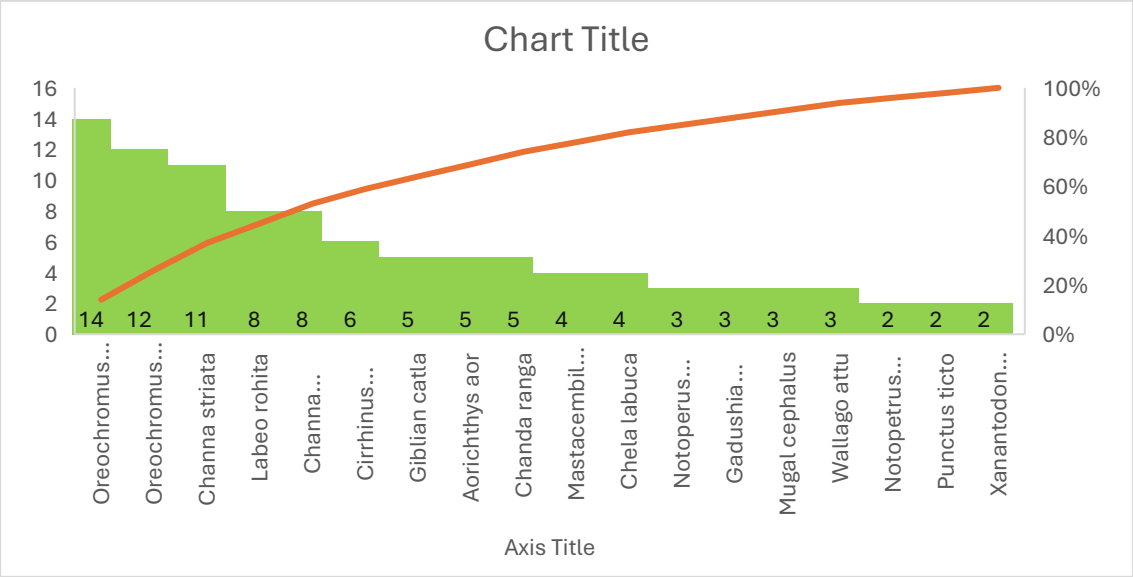
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Table 3. List of fish species recorded from Haleji Lake

#	Biota	St.1	St.2	St.3	St.4	St.5	Percentage (%)
1	*Labeo rohita*	-	++	+++	++	-	08
2	*Cirrhinus mrigala*	-	++	+++	+	-	06
3	*Giblian catla*	-	+	++	++	-	05
4	*Channa marulia*	+	++	-	-	+++	08
5	*Channa striata*	+	+	+	+++	++++	11
6	*Oreochromus mossambicus*	++++	+++	+++	+++	++	12
7	*Oreochromus niloticus*	++++	++++	++++	++++	++++	14
8	*Mastacembilus armatus*	+	++	-	-	+	04
9	*Notoperus notopterus,*	-	+	-	+	-	03
10	*Notopetrus chitala*	-	-	+	-	-	02
11	*Aorichthys aor*	+	++	++	-	+	05

12	*Chanda ranga*	+	+	+	+	+	05
13	*Chela labuca*	++	++	++	+++	+	04
14	*Gadushia chapra*	-	+	+	++	+	03
15	*Punctus ticto*	-	-	-	+	+	02
16	*Mugal cephalus*	-	-	+	+	+	03
17	*Wallago attu*	-	-	+++	+	+	03
18	*Xanantodon cancilla*	++++	-	-	-	+	02



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