



Ecological status and conservation of Kondakarla freshwater lake, Visakhapatnam district, Andhra Pradesh, India

B Madhavi¹, M Bharani², PS Raja Sekhar³

Assistant Professor, Department of Environ. Studies, L.B.College, Visakhapatnam, Andhra Pradesh, India

Assistant Professor, Department of Basic Sciences & Humanities, N.S.R.I.T College, Visakhapatnam Andhra Pradesh, India

Professor, Department of Environ. Sciences, Andhra University, Visakhapatnam, Andhra Pradesh, India

Abstract

Studies on water quality, habitat conditions and aquatic vegetation were assessed between December, 2014 and January, 2017 to know the present ecological status and state of environment of Kondakarla lake. Habitat of the lake environments were distributed into: (i) wet meadows; (ii) littoral shallow waters ;(iii) limnetic open waters and (iv) euphotic lake bed areas. Aquatic vegetation was classified into: (a) emergent forms; (b) floating leaved; (c) submerged; and (d) free-floating hydrophytes. A total of 24 aquatic plants consisting: 4-species emergent forms; 5-species floating leaved; 7-species submerged macrophytes and 8-species free-floating hydrophytes were enumerated from lake habitats. Among these, the submerged and free floating hydrophytes were the dominant group (63.0%) rather emergent and floating leaved category (37.0%). The phosphates(P) were recorded in highest amounts (15-40 mg/l) and nitrates (N) were shown in lowest ranges (2.2 to 4.3 mg/l) in lake waters. The ecological status indicate that lake environments are at advanced stages of eutrophication due to changes in water quality, composition of aquatic communities and degradation of habitats. Conservation strategies have been formulated for restoration of Kondakarla lake ecosystem.

Keywords: Kondakarla Lake, ecological study, aquatic vegetation, eutrophication and conservation

1. Introduction

Wetlands in India occupy 58 million hectares and estimated that fresh water wetlands alone support 20 percent of the known range of bio-diversity in India. Today wetlands (naturals or human modified) provide staple food (rice and fish) for more than half of the world's human population. In spite of several benefits that fresh water wetlands have become prime targets from many human activities and now they are listed in threatened status category (Deepa and Ramachandra, 1999) ^[1]. Over-exploitation of wetland biological resources causes decline of many species (plants & animals) and reclamation of lake areas for construction of fish ponds, agriculture practices combined with pollution due to agrochemicals and industrial effluents has resulted eutrophication (Gopal, 1995) ^[6] of lake ecosystems.

Earlier studies on Kondakarla freshwater lake were mostly focused on Aquatic Plant Communities (Seshavataram, 1982); Ecological assessment & Ecotourism development (Jayathi, 2001) ^[8]; Taxoecological (Chandrasekhar and Siddiqi, 2004) ^[2]; Ichthyofaun (Chandrasekhar, 2003) ^[3] and Biodiversity of faunal groups (Jagatheeswari, 2012) ^[7]. However studies related to present ecological status and eutrophication are lacunae. Therefore, an attempt has been made to assess the present ecological status of Kondakarla freshwater lake through evaluation of water quality, habitat conditions and vegetation communities in order to suggest conservation measures for restoration and management of important natural resources of lake Ecosystem.

2. Materials and Methods

2.1.1 Study area & Geography

Kondakarla lake is a freshwater lake spread to an area of 6.5 Sq.km situated between 17°36'38"N latitudes and 82°59'53"E longitudes in Visakhapatnam district of Andhra Pradesh, India (Figure 1). It is classified under lacustrine of littoral category encompassed by small hillocks of Eastern ghats and vast plains interspersed by tree species such as *Cocos nucifera*, *Borassus flabellifer*, *Acacia nilotica* and *Azadirachta indica* with dense growth of shrub and herbaceous communities are of typical coastal littoral vegetation. The lake received freshwater flows through an inlet Munagapaka channel of Sarada river and flooded waters in rainy season reached to the Bay of Bengal by creeks, which is about 10 km distance from the lake. The details of geographical and physical features of Kondakarla are given Table 1.

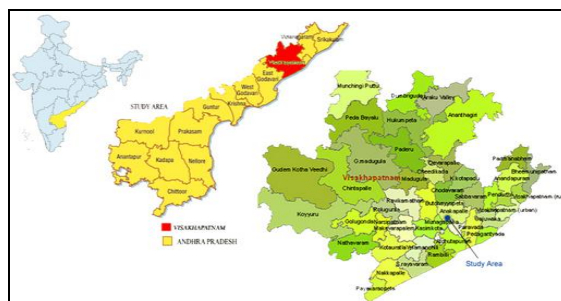


Fig 1: Map showing the location of Lake Kondakarla in Visakhapatnam district, Andhra Pradesh, India

Table 1: Details of geography and physical features of lake Kondakarla

Lake parameters	Characteristic Features
Geographical location	17°36'38" N Latitude & 83°08'53" E longitude
Area (Hectares)	450 (4.5 Sq.km)
Maximum depth(meters)	0.5 to < 3.5
Surface temp (°C)	22.0 – 38.5
Lake type of origin	Riverine- Lacustrine system
Bottom type	Silt & clayey-Muddy-soft bottom
Dominant vegetation	Macrophytes and Submerged hydrophytes

2.1.2 Distribution of lake habitats

Survey of the lake environments was conducted during the period from December, 2014 to January, 2017 in a country made dugout canoe of Palmyra tree (*Borassus flabellifer*) for water quality analysis, studying the habitat features, distribution patterns and vegetation communities. As per the descriptions of Ramachandran and Ahalya (2002) [9] the lake environments are categorized in to four habitats: (i) wet meadows of lake fringes: (ii) littoral shallow waters; (iii) limnetic open waters and (iv) euphotic deep waters.

2.1.3 Vegetation analysis

Aquatic vegetation of lake was classified into: (I) Rooted plants attached to the substratum divided into: (a) Emergent forms: (b) Floating leaved: (c) Submerged and (II) Non-rooted category are: (d) Free floating hydrophytes. Plant species identification was done after verification with voucher specimens of herbarium collections in the Dept. of Botany, Andhra University, Visakhapatnam.

2.1.4 Threats and water pollution

Threats to Kondakarla lake related to human impacts, water pollution and other factors were assessed on a 10.0 point scale (between 1.0 and 10.0) and converted into their percentage

Table 3: Habitat types, hydrological features and wetland communities of Lake Kondakarla

Habitat type	Hydrological features	Water depth (meters)	Wetland community	Dominant vegetation
(i) Fringes	Wet meadows	<1.0m	Emergent marsh	<i>Typha, Ipomoea</i>
(ii) Littoral	Shallow waters	1.0 to 2.0m	Free floating	<i>Pistia, Lemna</i>
(iii) Limonitic	Surface waters	2.0 to 3.0m	Floating leaved	<i>Nymphaea, Ludwigia</i>
(iv) Benthic	Lake bed areas	>3.0m	Submerged	<i>Hydrilla, Chara</i>

3.3 Vegetation communities

A total of 24 aquatic plant species belongs to 15 families consisting: (a) emergent forms, 4-species; (b) floating leaved, 5-species; (c) submerged plants, 7-species and (d) free-floating macrophytes, 8-species were enumerated from lake habitats. Among these, the submerged and free floating category were the dominant group (63.0%) rather emergent and floating leaved (37.0%) hydrophytes (Table 4).

Distribution of aquatic communities shows variation among lake habitats: (i) The emergent species were in highest density at lake fringes, (iii) free floating hydrophytes were abundant in littoral shallow areas, (ii) floating leaved plants were closely associated to limnetic waters at a depth of about 0.25

contributions. The water quality parameters were analyzed and correlated as per the standards of APHA, (2005) [1].

3. Results and discussion

3.1 Lake water quality

The physico-chemical parameters of lake waters indicated that a water depth between 0.4 to 3.0 meters, dissolved oxygen (DO) levels 2.5 to 5.6 mg/l, water temperatures between 27.3-35.2°C, pH ranges are fluctuated from 4.0 to 9.2 was observed during summer and rainy months. The organic nutrients of phosphates (P) were recorded highest between 15 and 40 mg/l during rainy and winter months and nitrates (N) were fluctuated from 1.5 to 4.3 mg/l in all the seasons (Table 2)

Table 2: Water analysis of physico-chemical parameters of Kondakarla lake.

Temp (°C)	Depth (meters)	Phosphates (mg/l)	Nitrates (mg/l)	pH	DO(mg/l)
27.3-38.2	0.5-<3.0	15 to 40	1.5-4.2	4.0 to 9.2	2.5 to 5.6

3.2 Habitats category

The lake habitats were recognized into: (i) Wet meadows are the shallow water areas of lake fringes occupied by dense thickets of emergent forms of *Typha angustata* and *Scirpus articulata*; (ii) Littoral shallow waters of the near shore areas, where sunlight penetrates up to the lake substratum with thick mats of free floating hydrophyte species: *Nechamandra alternifolia*, *Hydrilla verticillata* and *Limnophila indica*; (iii) Limnetic open waters, where sun light does not reached to the bottom contains dense growth of floating leaved macrophytes: *Nymphaea nouchali* and *Aponogeton crispus*; (iv) Euphotic area of lake bed occupied by sparse floating leaved and dense submerged hydrophytes, *Vallisneria spiralis*, *Najas graminea* and *Ottelia alismoides*. The description of habitat types and wetland communities are given in Table 3.

to 2.50 meters (iv) Submerged hydrophytes were observed at deep waters of 3.0 meters depth in euphotic lake bed areas As per findings of Seshavataram (1982) that Kondakarla lake support a good macrophytic vegetation of 20 species due to its muddy bottom with rich organic matter. Chandra Sekhar and Siddiqi (2005) recorded 26 species include two rare species *Alternanthera sessilis* and *Ipomoea fistula*. These findings are supporting to our observations that lake Kondakarla contains diversified flora of 24 species with important endemics such as: *Scirpus articulatus*; *Ottelia alisimoides*; *Vallisneria spiralis* and *Nymphaea nouchali*. However, the species *Utricularia stellaris* and *Utricularia speciosa* were absent and inconspicuous in lake waters.

Table 4: Vegetation communities and associated plant species in Kondakarla Lake

Community	Family wise	Scientific name	Common name
I. Plants attached to the substratum:			
a) Emergent Forms:	Cyperaceae	<i>Scirpus articulatus</i>	Bull rush
		<i>Elacocharis plantaginea</i>	Water Chestnut
	Polygonaceae	<i>Polygonum glabrum</i>	Dense lower Knot weed
	Typhaceae	<i>Typha aungustata</i>	Reed mace
b) Floating leaved:	Aponogetonaceae	<i>Aponogeton crispus</i>	Wavy edged grass
	Nymphaeaceae	<i>Nymphaea nouchali</i>	Star lotus-water lilly
	Menyanthaceae	<i>Nymphoides indica</i>	Water snow flake
	Onagraceae	<i>Ipomoea aquatic</i>	Water spinach
		<i>Ludwigia adscendens</i>	Water prime rose
c) Submerged Macrophytes:	Characeae	<i>Chara vulgaris</i>	Common vulgaris
	Hydrocharitaceae	<i>Hydrilla verticillata</i>	Indian star grass
		<i>Ottelia alismoides</i>	Duck lettuce
		<i>Nechamandra alternifolia</i>	Indian elodea
	Fabaceae	<i>Neptunia oleracea</i>	Sensitive water plant
	Najadaceae	<i>Najas graminea</i>	Water nymph
		<i>Vallisneria spiralis</i>	Tape /Eel grass
II. Plants not attached to substratum:			
d) Free floating:	Araceae	<i>Spirodela polyrhiza</i>	Duck weed
	Salviniaceae	<i>Pistia stratiotes</i>	Water lettuce
		<i>Azolla filiculoides</i>	Water fern
		<i>Limnophila indica</i>	Marsh weed
	Lemnaceae	<i>Salvinia auriculata</i>	Butterfly fern
		<i>Lemna perpusilla</i>	Common duck weed
	Poaceae	<i>Pseudorphis spinescens</i>	Spiny mud grass
		<i>Echinochloa stagnina</i>	Hippo grass

4. Conservation of Kondakarla lake

Before designing the strategies and action plans, it is necessary to identify the human activities and impacts that may alter the lake environments to be considered for developing large lake conservation planning and action plans (Gopal, 1995) [6].

4.1 Human activities

Major human activities and associated impacts to the lake

ecosystem was mainly due to reclamation of lake habitats for intensive agriculture and fish farming practices are estimated that wetland areas reduced from 650 to 460 hectares (area loss 30%) over a period of time. The threats to the lake habitats were identified as: Aquaculture practices 35.0%; Agriculture farming 25.0%; Siltation and Organic matter deposition, 15.0%; Pollution of lake waters (12.0%); Bioresources use (8.0%) and Eco-tourism, 5.0% respectively (Figure 2).

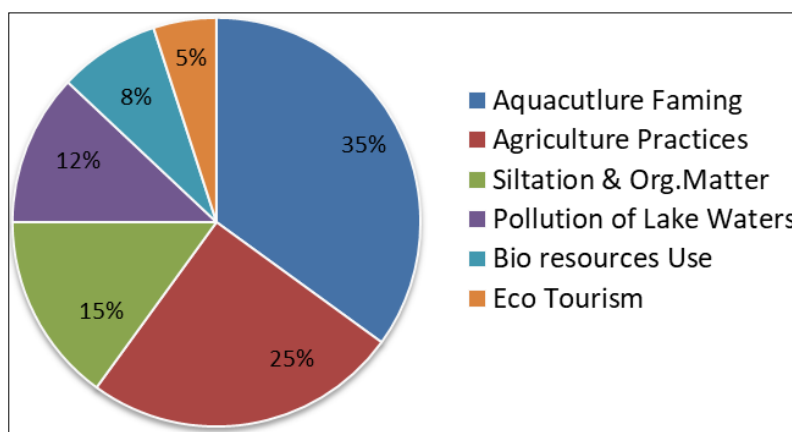


Fig 2: Showing Major Threats for Loss of Kondakarla wetland habitats

4.2 Pollution of lake waters

Even though the lake received national recognition as a wetland habitat for migratory water fowl (Choudhury and Divya, 1995) [4] the lake waters are polluted from sugar

factories and agriculture practices. Besides, a comparison with present and earlier studies revealed that changes were noticed in physico-chemical factors over a period of time are as follows:

Table 3

Water Temp (0 ^c)	Lake depth (meters)	Phosphates (mg/l)	Nitrates (mg/l)	pH	DO (mg/l)	Author/Year
22.0- 32.5	1.0-4.5m	10-30	2.6-9.5	6.0-8.2	3.5-6.8	Seshvatharam (1982)
26.2-34.3	0.5-3.5.m	12-35	2.4-5.3	4.8-9.0	2.3-6.2	Jagtheeswari (2012)
27.3-35.2	0.4-<3.0m	15-40	1.5-4.2	4.0-9.2	2.5-5.6	Present study (2017)

As per Ramachandran and Ahalya (2002) ^[9] observations that in many shallow lakes eutrophication may be manifested in macrophytic growth rather than phytoplankton and efficient utilization of nutrients, which defines growth and biomass production at primary producer level. Further he noticed that lake Kondakarla is greatly influenced by and associated with human activities leading to eutrophication. Similar findings were also observed in our present studies on Kondakarla lake with abundant growth of macrophytes, enrichment of nutrients, human related activities and eutrophication processes in lake Ecosystem. In view of the above the following strategies are recommended for immediate

conservation and management as suggested by Gopal, (1995) ^[6] to the Indian freshwater lakes.

4.1.3 Restoration of lake habitats

1. The silt and organic matter is depositing in the lake bed every year and the depth of the lake is decreasing year by year gradually. To prevent siltation, take up strip dredging and removal of heavy weed growth is the appropriate management interventions.
2. In controlling eutrophication of lake the plant species which are most efficient nutrient removing are recommended to propagate in the lake habitats are as follows:

Table 6

Habitat type	Plant community	Recommended species
Wet meadows :	Emergent forms:	<i>Scirpus articulatus, Typha angustifolia</i>
Littoral slope:	Free floating:	<i>Azolla filiculoides, Salvinia auriculata</i>
Limnetic open:	Floating leaved:	<i>Nelumbo nucifera, Nymphoides indica</i>
Euphotic deep:	Submerged rooted:	<i>Hydrilla verticellata, Najas graminea</i>

3. Kondakarla lake is a naturally formed lake that provides an important biological resource consisting fauna of mollusks, crustaceans and fishes. Therefore rational utilization of bioresources and sustainable ecotourism practiced are to be initiated.

5. Summary and Conclusion

Ecological succession of marsh plant communities were at their climax stages at wet meadows of lake fringes and shallow waters of littoral habitats >Emergent communities < Rooted floating hydrophytes < Free floating < Submerged macrophytes. Further noticed that upland plant species like *Ipomoea cornea* (Pink morning glory) and *Lantana camera* (Sage plant) were established in density and abundance.

Species once commonly found in this wetland are: *Azolla filiculoides*, *Nymphaea stellata*, *Nymphoides indicum*, *Neptunia oleraceae*, *Pseudorhis spinescens* and *Echinochloa staginina* are now become rare and inconspicuous in their presence. The species *Utricularia stellaris*, *Utricularia speciosa*, *Ipomoea fistula* and *Alternanthera sessilis* are reported by earlier studies did not shown their presence and now absent in the lake ecosystem.

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