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Bio-ecological study of Kavoor tank in Dakshina Kannada, Karnataka, India

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Abstract
Hydrological parameters along with the diversity of flora and fauna of Kavoor tank in Mangalore city, Dakshina Kannada district of Karnataka state, India was studied during February 2012-January 2013. Seasonal variation in physico-chemical parameters were analysed. Surface water temperature varied between 23.7 to 32.5 °C and pH was slightly acidic. Transparency and dissolved oxygen was low. The concentration of nitrate, sulphate, sodium and potassium were close to the permissible limits. Phytoplankton abundance is in the order of Cyanophyceae> Bacillariophyceae> Chlorophyceae> Desmidaceae. Of the six species of blue-green algae, *Oscillatoria* sp. and *Anabaena* sp.; of the seven species of Desmids, *Fragilaria* sp.; of the six species of green algae, *Spirogyra* sp. and *Pediastrum* sp.; and of the four species of Desmids, *Cosmarium* sp. were found to be more abundant. Zooplankton abundance is in the order of Copepoda> Rotifera> Cladocera> Ostracoda. Among four species of copepods, *Mesocyclops* sp. and *Heliodiaptomus* sp.; of the seven species of rotifers, *Brachionus* sp. and *Keratella* sp.; of the five species of cladocera *Diaphanosoma* sp.; and of the two species of ostracoda *Stenocypris* sp. were predominant. 15 species of aquatic plants, 10 species of fish belonging to order Cypriniformes and 17 species of birds were also recorded. Current threat status and conservation strategies are discussed.

Keywords: Hydrology, biodiversity, Kavoor tank, Dakshina Kannada, India.

1. Introduction
A tank is a small body of water behind an earthen embankment. They are the traditional source of irrigation and drinking water. They are a common feature in South Indian states mainly because of the topographical features. Presently, these inland lentic ecosystems have an alarming rate of loss and degradation despite their innumerable importance [1, 2]. In spite of this, the studies and information on these water bodies are scanty [3]. This may be because of the limited resources for the study and most of the water bodies exist for a short period of time [4]. It is important to study and protect these fragile and rapidly shrinking wetland ecosystems before they are lost forever [5].
The inland lentic resource of Dakshina Kannada (D.K.) district in Karnataka constitutes tanks, of less than 5 hectare area. Some 50 years ago there were at least 598 tanks or approximately 1 tank per square kilometre in this district. However, more than a half of these have shrunken or lost. Now, on record there are only 245 tanks in D.K. district. There is only a single report on the status of the tanks, wherein the need for ecological studies in these water bodies was emphasised particularly on Kavoor tank in the district [6]. Some unpublished works and the local media have shown that this tank has undergone degradation in terms of quality and quantity over a period of time. Hence, this study was undertaken to critically document the hydro-biological components for the first time which will help in conservation strategies to be adopted and for further policy decision.

1.1 Study area
Kavoor tank (12°55’48” N, 74°51’34”E) is situated in Mangalore taluk which is the only taluk of D.K. district having a coastline bordering the Arabian Sea. The district is characterized by high humidity (58-75%) and temperature (25 - 35 ºC) and heavy rainfall (average 4119 mm). The seasons can be distinctively divided as summer (pre-monsoon), rainy (monsoon) and winter (post-monsoon).
The tank is located in Mangalore city at an altitude of 38m from the mean sea level. There is a temple on the south-west bank of the tank which has a history of 15th century.

Hence, it is estimated that this tank was built during that period. Presently, the tank occupies basin of about 3.39 hectares. It is elongated in shape with a length of 300 m. The eastern side of the tank is occupied by plantation crops of arecanut and coconut while the western side has an asphalted road. The northern and southern banks had forest cover in the past but now it has been occupied by human settlement. The tank has a gradient towards the north-west region. The south-east part has an inlet point through which the drainage from the catchment area flows into the tank. At the north-west region there is an outlet point from where water overflows into a stream which irrigates the adjacent lands. A check dam has been constructed to control the outflow from this tank. The south-west bank near the temple was covered with wild varieties of bushes and trees. But now there is a 4 feet road around the tank (Fig. 1).

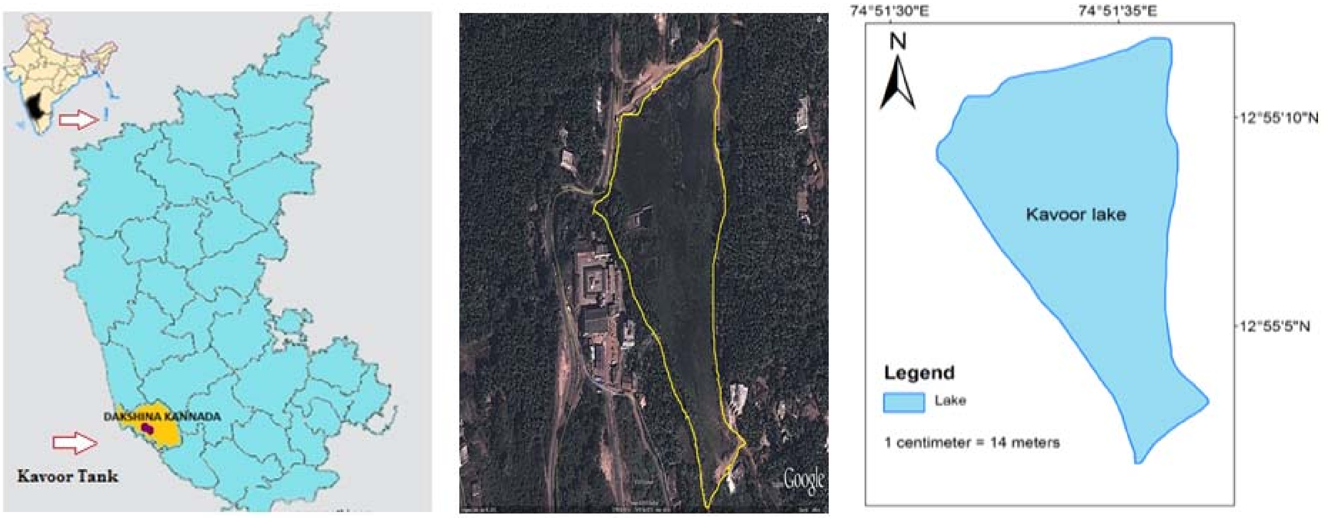

Fig 1: Map of Kavoor tank.

Being one of the closest tank to a rapidly developing city, this tank has not only been used as dumping ground for various types of wastes but also has repeatedly faced de-siltation, rejuvenation, renovation programmes. During heavy rains a large amount of silt and soil as well as other solids flow into the tank. They get accumulated on the banks year by year reducing the area of water. The ecological succession gradually proceeds into transformation of the tank into a terrestrial environment.

2. Materials and methods

Sampling for hydro-biological parameters was done from four different sites at monthly intervals for a period of one year from February 2012 to January 2013. Colour was determined by visual comparison of the sample with distilled water and transparency was determined using Secchi disc. Temperature (air and surface water) was recorded on the spot using centigrade thermometer. The pH was measured by using the pH paper on the spot and then it was checked again in the laboratory. Total Dissolved Solids (TDS), Electrical conductivity (EC) and salinity were analysed using water quality analyzer kit (Systronic water analyzer kit). Chemical parameters such as sodium, potassium, nitrate and sulphates were analyzed according to standard methods [7].

For plankton analysis, sampling was carried out by sweeping 55 µm mesh size plankton net across the water surface at selected sampling sites in the tank and emptying the contents into a collecting bottle. Both phytoplankton and zooplankton were fixed using 4% formalin (APHA, 1998). The morphological details were observed under the microscope and the identification was done according to the standard taxonomic criteria [8, 9]. Percentage composition in planktons was calculated for the study period. Aquatic macrophytes were collected by hand from different zones in the tanks and were identified using standard books [10, 11, 12]. Fishes were collected with the help of local people using drag nets and cast nets of varying mesh sizes and by traditional methods using plastic trays, plastic covers, baskets and dip nets. They were preserved in plastic containers using 4% formalin solution. Species were identified following the standard keys [13, 14, 15]. Birds found in and around the tank were recorded and identified by passive survey and confirmed using identification keys [16, 17].

3. Results and Discussion

The monthly values of the hydrological parameters were compiled into three seasons pre-monsoon (February-May), monsoon (June-September) and post-monsoon (October-January). The seasonal variations in various hydrological parameters are given in Table 1, Fig. 2. The colour of the water in the tank was greenish all the year round. Air temperature near the tank varied from an average of 25.6 °C to 33.5 °C, while the surface water temperature varied from 23.7 to 32.5 °C. Warmer waters were encountered during the pre-monsoon months of April and May could be due to the confined nature and shallowness of the tanks in addition to the solar radiation [18]. The water temperature was around 1-3 °C less than the air temperature [19]. The pH of the water in the study area fluctuated between 3.6 and 7.0 indicating the water was slightly acidic throughout the study period. This agrees with observations made in earlier studies [20]. The pH values were higher during monsoon period than in other two seasons.

Table 1: Seasonal values of physico-chemical parameters from Kavoor tank (n=16) (Mean ± SD)

Parameters	Pre - monsoon	Monsoon	Post -monsoon
Colour	**Green**	**Green**	**Green**
Air Temperature (ºC).	31.58 ± 1.06	28.26 ± 0.72	26.98 ± 1.52
Water Temperature (ºC)	29.03 ± 2.31	25.00 ± 0.73	24.74 ± 1.06
pH	4.90 ± 1.05	6.83 ± 0.12	6.67 ± 0.12
Transparency (cm)	29.19± 23.84	87.81 ± 10.32	76.56 ± 3.97
Electrical Conductivity (µmhos/cm)	149.16 ± 14.74	108.03 ± 4.89	119.45 ± 8.07
Total Dissolved Solids (mg/l)	102.59 ± 26.43	57.73 ± 6.94	50.28 ± 6.69
Dissolved Oxygen (mg/l)	4.77 ± 0.83	6.4 ± 0.19	6.71 ± 0.09
Nitrates (mg/l)	7.29 ± 1.86	2.31 ± 0.31	4.69 ± 0.81
Sulphates (mg/l)	8.27 ± 0.73	7.86 ± 0.12	7.90 ± 0.19
Sodium (mg/l)	36.49 ± 5.16	28.03 ± 2.49	30.00 ± 1.65
Potassium (mg/l)	4.63 ± 0.75	5.16 ± 0.21	4.66 ± 0.14

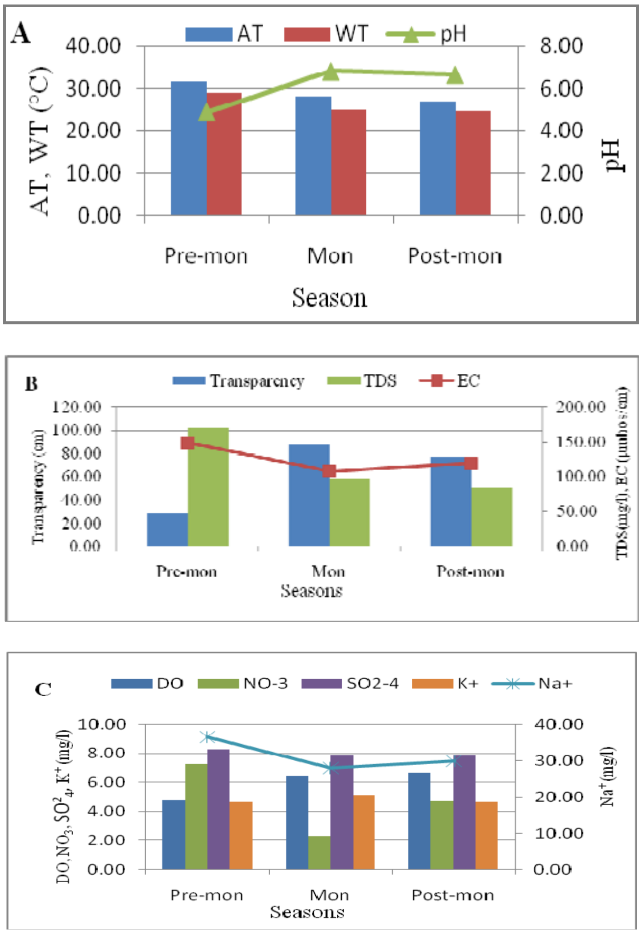

Fig 2: Graph showing seasonal values of water quality parameters from Kavoor tank.

A. Air temperature (AT), Water temperature (WT) and pH;
B. Transparency, Total Dissolved Solids (TDS) and Electrical Conductivity (EC);
C. Dissolved Oxygen (DO), Nitrates (NO^-_3), Sulphates (SO^{2-}_4), Sodium (Na^+) and Potassium (K^+).

The transparency of water was generally low with the lowest Secchi disc value of 3.5 cm recorded in April, while the highest value of 97.5 cm was obtained in August during peak monsoon. The latter part of pre-monsoon (April and May) recorded low values of transparency due to low water depth and the bloom of phytoplankton and zooplankton [21]. The electrical conductivity showed highest value during pre-monsoon with its peak in May (168.40 µmhos/cm) and lower value in monsoon (100.90 µmhos/cm). The increase in conductivity in pre-monsoon period may be due to evaporation and the decrease in rainy season may be due to precipitation leading to dilution [22, 23]. The TDS ranged between 41.90 – 136.90 mg/l. The maximum was seen during pre-monsoon period which is again due to evaporation and concentration of dissolved solids [24].

The dissolved oxygen level ranged from 3.45 to 6.78 mg/l with higher values during post-monsoon and less during pre-monsoon. This may be due to the higher photosynthesis and dissolution of oxygen in water during post-monsoon period. The low value of dissolved oxygen can be attributed to significant levels of organic pollution probably by faecal contamination [23]. Also, low values during pre-monsoon may be attributed to low oxygen dissolution and low water level as reported in previous studies [24]. The average amount of nitrate was 2.31 mg/l during monsoon, 4.69 mg/l during post-monsoon and 7.29 mg/l during pre-monsoon. However, the monthly values showed a wide fluctuation from 1.80 mg/l in July to 12.50 mg/l in May. Reduction in nitrate content may be due to utilisation by algae and macrophytes [25]. However, the increase may be attributed to anthropogenic influences such as discharge of municipal wastes and urban and agricultural run-off [24]. The value of sulphate in the water body is a matter of concern as it can be reduced to hydrogen sulphide creating and anoxic condition. The average amount of sulphate in the tank was found to be 8.01 mg/l which may be due to influx of fertilisers through agricultural run-off and domestic wastes from the catchment area [26]. The sodium concentrations varied slightly between seasons from 26.60 mg/l to 46.80 mg/l which was different from the observations made in polluted waters wherein wide variations in sodium concentration was recorded during different seasons [25]. Potassium concentration showed very little fluctuation between different seasons (4.50 - 5.73 mg/l) and was within the permissible limits [27]. The percentage composition of planktons recorded during the study period in Kavoor tank is given in Table 2.

Table 2: Percentage composition of planktons in Kavoor tank.

Taxa	Percentage
Phytoplankton	
Cyanophyceae (*Anabaena* sp., *Nostoc* sp., *Oscillatoria* sp., *Microcystis* sp., *Spirulina* sp., *Phormidium* sp.)	34.11
Bacillariophyceae (*Melosira* sp., *Navicula* sp., *Synedra* sp., *Gyrosigma* sp., *Ceratium* sp., *Fragillaria* sp., *Cymbella* sp.,)	31.72
Chlorophyceae (*Ankistrodesmus* sp., *Spirogyra* sp., *Ulothrix* sp., *Scenedesmus* sp., *Protococcus* sp., *Pediastrum* sp.)	22.33
Desmidaceae (*Closterium* sp., *Cosmarium* sp., *Arthrodesmus* sp., *Staurastrum* sp.)	11.85
Zooplankton	
Copepoda (*Rhinediaptomus* sp., *Heliodiaptomus* sp., *Neodiaptomus* sp., *Mesocyclops* sp.)	33.79
Rotifera (*Asplanchna* sp., *Brachionus* sp., *Euchlanis* sp., *Filinia* sp. *Keratella* sp., *Mytilina* sp., *Trichocera* sp.)	30.43
Cladocera (*Daphnia* sp., *Diaphanosoma* sp., *Echinisca* sp., *Macrothrix* sp., *Moina* sp.)	27.25
Ostracoda (*Cypris* sp., *Stenocypris* sp.)	8.53

Four classes of phytoplankton in the order of Cyanophyceae> Bacillariophyceae > Chlorophyceae> Desmidaceae were recorded in this tank. Of the six species of blue-green algae, *Oscillatoria* sp. and *Anabaena* sp. constituting about 70% of the class. Desmids were represented by seven species among which *Fragillaria* sp. was found more abundant with a peak during post-monsoon season. Of the six species of green algae, *Spirogyra* sp. and *Pediastrum* sp. pre-dominated. Desmids were represented by four species of which *Cosmarium* sp. were found to be more abundant. Zooplankton abundance is in the order of Copepoda> Rotifera> Cladocera > Ostracoda. Among four species of copepods, *Mesocyclops* sp. and *Heliodiaptomus* sp.; of the seven species of rotifers, *Brachionus* sp. and *Keratella* sp.; of the five species of cladocera *Diaphanosoma* sp.; and of the two species of ostracoda *Stenocypris* sp. were predominant. As reported by earlier workers plankton population were influenced by seasonal variations [28].

The checklist of the aquatic macrophytes, fish and birds observed during the study period is given in the Table 3.

Table 3: Recorded Aquatic plants, Fish and Birds in Kavoor tank.

A	Aquatic plants		B	Fish		C	Birds
1	*Azolla pinnata*		1	Minnow (*Barilius barila*)		1	Large Cormorant -(*Phalacrocorax fuscicollis*)
2	*Eichhornia crassipes*		2	Common carp (*Cyprinus carpio*)		2	Open Bill Stork- (*Anastomus oscitans*)
3	*Lemna minor*		3	Sucker head (*Garra gotyla*)		3	Grey Heron - (*Ardea cinerea*)
4	*Pistia stratiotes*		4	Rasbora (*Rasbora rasbora*)		4	Pond Heron- (*Ardeola striatus*)
5	*Salvania molesta*		5	South Indian barb (*Esomus barbatus*)		5	Cattle egret - (*Bubulcus ibis*)
6	*Nelumbo nucifera*		6	Swamp barb (*Puntius chola*)		6	Little Egret – (*Egretta garzetta*)
7	*Nymphaea stellata*		7	Ticto barb (*Puntius ticto*)		7	Common Teal - (*Anas crecca*)
8	*Nymphoides hydrophylla*		8	Glass fish (*Ambassis ambassis*)		8	White breasted Water hen- (*Amaurornis phoenicurus*)
9	*Hydrilla verticillata*		9	Tilapia (*Oreochromis mossambicus*)		9	Bronze Winged Jacana - (*Metopidius indicus*)
10	*Vallisnaeria spiralis*		10	Guppy (*Poecilia reticulata*)		10	Common sandpiper – (*Tringa hypoleucos*)
11	*Chara* sp.					11	Little Ringed Plover – (*Charadrius dubius*)
12	*Cyperus rotundus*					12	Small Blue Kingfisher - (*Alcedo atthis*)
13	*Ipomoea aquatica*					13	Swallow - (*Hirundo rustica*)
14	*Scirpus lacustris*					14	Red whiskered Bulbul (*Pycnonotus jocosus*)
15	*Colocasia esculenta*					15	House sparrow - (*Passer domesticus*)
						16	House crow - (*Corvus splendens*)
						17	Common Myna –(*Acridotheres tristis*)

The tank is facing a serious threat of fast spreading vicious weed *Salvinia molesta*. Explosiveness of floating leaf plant *Eichhornia crassipes*, *Hydrilla verticillata*, *Azolla pinnata*, *Pistia stratiotes*, *Lemna minor* show that they are not only a nuisance infesting the temporary waters and thus constitute a major problem towards effective utilization of such water bodies and gradually reducing it into a dry land. Apart from these, submerged and emergent vegetation like *Nymphaea stellata*, *Nelumbo nucifera*, *Vallisneria spiralis*, *Colocassia esculentum* and grasses serve as breeding sites for the insects found in the tank which are sometimes vectors of most prevalent diseases in the area such as malaria and filaria [29].

A total of 10 species of fish which are of less commercial value belonging to the order Cypriniformes were recorded. *Cyprinus carpio*, *Oreochromis mossambicus* and *Poecilia reticulata* was found only once during January which may have been introduced by the local authority. Small weed fishes such as small minnows and barbs were found near the edges of the tank all the year round. This attracted the birds towards the tank [17]. Many birds both resident and migrants were observed to come near the tank. Of these, *Amaurornis phoenicurus* and *Ardeola striatus* were found near the tank in maximum numbers all the year round while *Anastomus oscitans, Metopidius indicus* and *Hirundo rustica* only during post-monsoon. Resident birds like *Corvus splendens, Passer domesticus, Pycnonotus jocose* and *Acridotheres tristis* were more common during pre-monsoon season. However, during monsoon the number of birds was very less.

4. Conclusion
Situated in the heart of Mangalore city, the Kavoor tank faces great threat from pollution due to urban wastes. Non-biodegradable materials like plastic covers, bottles, metal, glass pieces, garbage, etc., are thrown near the tank bund which gradually enters into the tank. The human dwellings around the tank are increasing day by day which will add up to the pollution due to domestic wastes. This boosts the growth of algae and other macrophytes in the tank. Also, the agriculture land nearby contributes substantially to inorganic pollution through surface run-offs. During the de-siltation programme undertaken by the government, in the west side of the tank a new road has been formed which has given way for further encroachment of the tank area in view of widening of existing road. Thus, the tank is losing its original ecological characteristics that supported abundant biodiversity. Hence, there is an urgent need to protect this tank from further degradation.

5. Conservation methods
To conserve this tank, wise-use method need to be adopted [30]. During the study period, it is observed that Kavoor tank has great potential to act as water supply source for the surrounding area due to its vast area. It plays a major role in maintaining the groundwater table in watershed area. Water from this tank flows continuously through the check dam into a small stream and this is used for irrigation of areca, coconut and other horticulture plantations. It is also an important feeding and roosting ground for many birds. A part of this tank is used by the nearby temple for religious rituals which gives it strength for its existence till date.

There is scope for protecting this tank by educating local public regarding the usefulness of this tank. This can be done with the help of temple authorities. The tank can be used as a source of city water supply chain after proper disinfection and purification. Since this tank supports large numbers of birds of resident species and also passage migrants, a walk-path and a beautiful garden can be developed around the tank as an ecotourism spot. This will enhance the beauty of the surrounding and attract a lot of nature-lovers and tourists which will in turn help in protecting the tank ecosystem.

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