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Foraging ecology of birds in Kole wetlands of Thrissur, Kerala

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Foraging ecology of birds in Kole-wetlands of Thrissur, Kerala

(FINAL REPORT OF THE RESEARCH PROJECT RP 687/2014)

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ABSTRACT OF THE PROJECT PROPOSAL

1.	Project No.	:	KFRI/687/2014
2.	Title of the Project	:	Foraging ecology of birds in Kole-wetlands of Thrissur, Kerala
3.	Objectives	:	1. To elucidate the food and feeding behaviour of wetland birds. 2. To assess the food availability of wetland birds. 3. To assess the extent of crop loss due to birds and to understand people's perception on conservation of birds
4.	Date of commencement	:	June 2014
5.	Scheduled date of completion	:	September 2017
6.	Funding agency	:	Plan Fund
7.	Project team		
	Principal Investigator	:	Dr. E. A. Jayson
	Associate Investigator	:	Nil
	Research Fellow	:	Mrs. Greeshma P.
8.	Study area	:	Kole wetlands, Thrissur
9.	Duration of the study	:	3.5 years
10.	Project budget	:	Rs. 8 Lakhs

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ABSTRACT

Foraging ecology of birds in Kole wetlands of Thrissur, Kerala was studied from June 2014 to September 2017. The Kole Wetlands is one of largest, highly productive and threatened wetlands in Kerala and has been declared as Ramsar Site in 2002 and it comes in the Central Asian Flyway of migratory birds. The Malayalam word Kole indicates bumper yield, which refers to a particular type of cultivation method adopted in backwaters from December to April. The Kole wetlands lies between 10° 20' and 10° 40' N latitudes and 75° 58' and between 76° 11' E longitudes. The Kole wetlands are low lying tracts located 0.5 to 1 m below Mean Sea Level (MSL) and remain submerged for about six months in a year. The major objectives of the study were to (a) elucidate the food and feeding behaviour of selected wetland birds (b) to assess the food availability of selected wetland birds and (c) to assess the extent of crop loss due to birds and to understand people's perception on conservation of birds.

The intensive study areas were selected after a reconnaissance survey and observations on feeding behaviour was made with the help of spotting scope (10x- 45x), HD Video cam and binocular (7 X 50). In order to study the feeding behaviour of birds in the Kole wetlands two methods were employed. Direct observation method was used for studying the food and feeding patterns of selected species and among the methods focal-Animal Sampling method was adopted. All occurrences of specified (inter) actions of an individual was recorded during each sample period. Sequence sampling method was also adopted to observe the interaction sequence. The sample period begins when an interaction begins and during this all behaviours under the study was recorded in the order of occurrence. Roosts in the vicinity of the Kole wetlands were observed and the leftover food materials which are seen in the roosts was collected and identified. Apart from observational study, a refined data regarding their diet composition during breeding season was also recorded. Diet composition of breeding birds was studied by the analysis of regurgitated materials and also by direct observation. A total of 214 samples were collected from the heronries. Bird community of Kole wetlands of Thrissur was also studied during January 2015 to December 2016. The methodology followed was direct observation with the help of binocular and spotting scope.

Water analysis was carried out to check the aquatic health status. Important physicochemical properties like pH, temperature, total dissolved solids, total hardness, turbidity, Total alkalinity, Chloride, Sulphate, Iron, Dissolved Oxygen, Biological Oxygen Demand, Salinity, Electrical Conductivity, Nitrate-N, Fluoride, Phosphate and Total Suspended Solids were analysed during March 2016 to November 2017. Water samples were collected from 10 different areas of Pullazhi, Adatt, Enamavu, Manakody and Kanimangalam Kole wetlands of Thrissur. Water sampling was carried out during three months- March (Pre-monsoon), July (Monsoon), November (Post-Monsoon).

In order to estimate the food availability of birds in the Kole wetlands, resource quantification was done. Pullazhi, Adatt, Enamavu, Kanjany, Manakody and Kanimangalam were the intensive study areas and from each area four samples were collected using gill net and "*petty and para*" system (during the dewatering period) in a year. Collections were done during pre-monsoon, monsoon and post-monsoon seasons from 2015 April to 2017 December. Collected fishes were identified up to species level.

A structured questionnaire survey was conducted among the farmers and people surrounding the Kole wetlands to assess the extent of crop loss due to birds and to understand people's perception on conservation of birds.

Kole wetlands is least polluted compared to other aquatic systems of Kerala and favours a moderate medium for the fish growth. Salinity was high during the pre-monsoon period in both the years 2016 and 2017. Similarly Total Hardness was also high during pre-monsoon period. Chloride and sulphate were having high values during pre-monsoon period. Fluoride content of the water is very low compared to the standard values. BOD values showed that the aquatic systems is healthy

A total of 55 fish species belonging to 44 genera among 23 Families of 10 Orders were recorded from the study area. The abundant fish species recorded were *Amblypharyngodon melettinus* (2171 individuals) and *Systomus subnasutus* (1622 individuals). The study revealed that the order Perciformes (17) and Cypriniformes (17) were having the highest number of species followed by Siluriformes (8) Synbranchiformes (4), Beloniformes (3), Anguilliformes (2), Elopiformes (1), Tetraodontiformes (1), Clupeiformes (1), and Cyprinodontiformes (1).

A total of 155 species of birds belonging to 15 Orders and 49 Families were recorded from the area. Among the 15 Orders, Passeriformes, Charadriiformes and Pelecaniformes dominated with 46, 30 and 25 species respectively. Of these 104 species were wetland birds and 51 terrestrial birds. Feeding behaviour of Oriental darter, Little cormorant and Asian openbill stork were studied. Oriental darter is a diurnal feeder and foraged solitary most of the time in water with a depth more than 30 cm (n=184). They consumed varieties of fishes like Silver carplet *Amblypharyngodon melettinus* (Valenciennes, 1844), Mahe Barb *Puntius mahecola* (Valenciennes, 1844), Swamp Barb *Systomus subnasutus* (Valenciennes, 1842), Climbing Perch *Anabas testudineus* (Bloch, 1792), Rohu *Labeo rohita* (Hamilton, 1822), Pearl Spot *Etroplus suratensis* (Bloch, 1790) and Striped Snakehead *Channa striata* (Bloch, 1793). Little cormorant is an exclusively piscivorous bird belongs to the family Phalacrocoracidae. Little cormorant is a diurnal feeder, forages solitary as well as in group (group of 300-847 individuals) and foraged in all waters like small ditches, pools, canals, open waters and river as well as in various depth of water (> 10 cm). They feed on fishes like Green Stripe Barb *Puntius vittatus* (Day, 1865), Silver carplet *Amblypharyngodon melettinus* (Valenciennes, 1844), Mahe Barb *Puntius mahecola* (Valenciennes, 1844) Swamp Barb *Systomus subnasutus* (Valenciennes, 1842) and Stinging Catfish *Heteropneustes fossilis* (Bloch, 1794). Asian openbill stork foraged in Kole Wetlands in different microhabitats like mudflats, shallow water streams, paddy fields, small ditches, and along the bank of small canals characterized by diurnal feeding. Asian Openbill stork feed on molluscs like snail (*Pila globosa)* and freshwater mussel (genus *Unio*). The favourite food item was *Pila globosa* which are abundantly distributed throughout the wetlands.

Leftover food items were collected from the heronries of Thrissur. Heronries consisted of Oriental darter, Little cormorant, Indian cormorant, Black-crowned night heron, Indian pond heron and Median egret. Sixteen species of fishes, one species of shrimp and 2 species of frogs were identified from the left over analysis. It was observed that, only few samples fell down during regurgitation and it was difficult to collect samples due to the pestering of crows, Night herons and domestic cats picked up the prey items dropped from the nest.

A total of 304 people were surveyed including farmers from 11 Panchayaths, living in and around the Kole wetlands. Fifty three per cent of the respondents reported that there is no damage to their crops and 45.7 % people revealed that they are affected by crop damage due to birds. Of the crop raiders, teals were the major problem followed by pigeon. Thirty four per cent of people reported the presence of Peafowl and among them only 2.6 % considered it as menace to plantain and paddy cultivation. Only 30 respondents reported that poaching still

exists in Kole wetlands. Two hundred and twenty respondents opinioned there is no poaching and 54 respondents are unaware of poaching. About 41.45 % know that poaching will affect the migratory population and only 42.11 % people are aware about the arrival of migratory birds and its importance.

The study indicated that the wetland ecosystems is in healthy condition. As other wetlands, Kole wetlands is also under high pressure of habitat alteration, infestation of aquatic weeds, habitat loss and change in land use pattern. Many of the tourism activities could be a hindrance to the free-ranging migratory birds and the Wetland Authority should restrict activities inside a Ramsar Site.

1. INTRODUCTION

A wetland is a land area that is saturated with water, either permanently or seasonally, such that it takes on the characteristics of a distinct ecosystem. The major factor that distinguishes wetlands from other land forms or water bodies is the characteristic vegetation that is adapted to its unique soil conditions. According to the Ramsar International Wetland Conservation Treaty (1971), wetlands are defined as " areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres". Wetlands are considered as the transitional areas, sandwiched between permanently flooded deep water environments and well-drained uplands, which support a diverse range of plant and animal life and are important to humans in many ways. Wetlands are extremely important areas throughout the world for wildlife protection, recreation, sedimentation control, flood prevention, educational and scientific uses. It also plays an important role in the socio-economic stability of local community activities such as fisheries (freshwater and salt water). Wetlands prevent flooding by holding water much like a sponge, helps to counter balance the human effect on rivers by rejuvenating them and surrounding ecosystems. Because of its many cleansing benefits, wetlands have been considered as the kidneys of our earth. Birds serve as the good indicators of changes in the environment by responding to the small changes in habitat structure and composition (Gupta *et al*. 2011). By virtue of occupying the apex of aquatic food chains, water birds are considered as a vital component of the wetland ecosystem. Wildfowl, waterfowl, shore birds and waders belong to the commonly recognized groups. Across the geographical regions inhabited by human beings, water bird use of agricultural wetlands has increased as natural wetlands continue to decline.

1.1 Literature review

1.1.1 Rice fields as wetlands

Across the geographical regions inhabited by human beings, water bird use of agricultural wetlands has increased as natural wetlands continue to decline. The Indian subcontinent has the world's highest cropland cover per unit area with rice (*Oryza sativa*) being the second-most important crop, and is home to nearly 1,300 species of birds. Rice fields in the subcontinent are used by at least 351 species, although only 2.7 % of birds occurring in the subcontinent breed in rice fields (Sundar and Subramanya, 2010). Flooded fields apparently provide equivalent foraging habitat to semi natural wetlands and because of reduced predation

threat is a safer habitat for water birds (Chris, 2000). Studies conducted by Sunder and Subramanya (2010) in the Indian Subcontinent opinioned that most work in the region has focused on birds as pests of rice. Information exists on water birds use of rice field especially by herons and egrets. Recent studies in Gujarat by Munjpara and Gadhvi (2013) concluded that the main food of the species is insects and also the birds were recorded taking food from the ground, grass root and from clumps of grasses from its foraging habitat. Fields planted with rice are used by a wide variety of bird species during the non-growing season and play an important conservation role in many parts of the world (Elphick, 2010). Worldwide, rice agriculture typically involves seasonal flooding and soil tillage, which provides a variety of microhabitats and potential food for birds. Water management in rice fields creates conditions ranging from saturated mud flats to shallow (<30 cm) water, thereby attracting different guilds of birds. Rice fields provide a good foraging habitat for the Cattle egret in South eastern Australia (Richardson and Taylor, 2003).

Rice production continues to be greatest in Asia, where 90 % of the crop is grown. Waterfowl, wading birds, shorebirds and other waterbirds use rice fields, foraging on a variety of prey, nesting in the crop and in fringing vegetation, and staging during migration. Conflicts also exist, with some cropping practices harmful to birds and some bird activity detrimental to yield production (Elphick, 2010). However, most waterbirds prefer rice fields in wide, open plains rather than narrow rice fields surrounded by forest. The fields serve primarily as foraging habitat, providing aquatic prey for passage, summer and resident species and residual grains for winter visitors (Fujioka *et al*., 2010). The effect of rice cultivation on water bird populations has rarely been assessed. A study in north western Italy by Fasola and Brangi, (2010) estimated that breeding herons and egrets obtained 80 % of their food from agricultural habitats. Water management in rice fields creates conditions ranging from saturated mud flats to shallow (<30 cm) water, thereby attracting different guilds of birds. Grain not collected during harvest (i.e. waste rice) is typically the most abundant potential food of birds in rice fields, with estimates of seed mass from North America ranging from 66-672 kg/ha (Stafford *et al*., 2010). Not only rice fields, estuarine tidal flats are also a vital habitat to many aquatic bird species during much of the yearly cycle. The influence of drainage channels on the quality of feeding habitat for waders in the Tagus estuary, Portugal was studied by Lourenco *et al*., (2005). Also, Common reed *(Phragmites australis*) forms dense stands with deep layers of residual organic matter that forms a habitat for many Waterbirds (Meyer *et al*., 2010). Foraging guilds of waterbirds wintering in a Mediterranean coastal wetland was studied and it concludes that the 2 main

habitats, shallow waters and intertidal mudflats, were the most important for waterbirds, with halophytic vegetation being important only for Little egrets (*Egretta garzetta)* (Liordos, 2010).

1.1.2 Foraging ecology

Foraging ecology is one of the most advanced areas of modern Ornithology. Bird behaviour depends on several meteorological factors and in several species the digestive system is modified in winter to aid energy level (Elkins, 2004). Karpu (1974) during his study on feeding ecology of Pintail hens in North Dakota suggested that food supply has been considered as one of the eight major external factors regulating the sexual cycles in birds. Calcium is an essential nutrient for avian reproduction. Calcium rich foods are consumed by breeding birds for production of egg shells and for provisioning chicks that are mineralizing skeletal tissues **(**Reynolds *et al.,* 2004). A condition of hyperthyroidism was noted in the nestlings of cattle egrets in Texas. The main reason for this diseased condition was the decreased consumption of calcium rich food like vertebrate prey items. The gut content analysis of these infected nestlings was brought under study and they found that grasshopper and crickets were the only food items consumed by them. Diversity, feeding guild and abundance of wetland birds at Sompeta Beela was done by Rao, (2014). Bhitarkanika mangroves in Orissa harbours one of the largest mixed-species heronries in the country with more than 30,000 birds of 11 species breeding annually in a small mangrove patch of 0.5 ha area between June and December. Considering the nesting biology it was observed that Asian openbill (*Anastomus oscitans*), Large egret (*Ardea alba*), Intermediate egret (*Egretta intermedia*), Little cormorant *(Phalacrocorax niger)* and Little egret *(Egretta garzetta)* were associated more frequently than they would be expected at random. There was a significant avoidance trend between Grey (*Ardea cinerea)* and Purple (*Ardea purpurea*) herons and between Darter (*Anhinga melanogaster*) and Asian openbill stork (Gopi and Pandav, 2011).

The response of Great blue herons, Great egrets, Wood storks and White ibises to water level and vegetation in northern Everglades of Florida showed that bird abundance is related to both water level and the vegetation community, but water level generally had the greatest effect (Bancroft *et al*., 2002). During the breeding season, the Purple heron *Ardea purpurea* is a central place forager and periodically visits the nest with the food necessary for nestling development (Campos and Lekuona, 2000) and the captured fish were grouped into three size classes: small (1-12.5 cm), medium (12.525 cm) and large (25-37.5 cm). Water depth appears to be the key environmental factor controlling the availability of food for the birds. The depth of water selected by waterbirds for foraging was correlated with tarsus length. Black-

necked storks *Ephippiorhynchus asiaticus* mostly foraged using a tactile technique (>90%), but sometimes foraged visually. When the water level was estimated to be less than 60 cm, the storks foraged using tactile techniques **(**Maheswaran and Rahmani, 2008). Studies conducted in Uttar Pradesh by Chauhan and Andrews (2006) observed that Black-necked storks *Ephippiorhynchus asiaticus* and Sarus cranes *Grus antigone* eating riverine turtle eggs, previously unknown in the diet of either species. Storks fed on a variety of vertebrate and invertebrate prey caught in water, usually between 50–300 mm deep (Clancy, 2011). Painted storks are known to have a strong fidelity to their breeding sites. Painted stork is thought to be declining, particularly on the periphery of its range, and it is considered "near threatened" by Birdlife International (Bryan, 2011).

The value of foraging studies in developing conservation strategies for storks is important because their breeding is often limited by food distribution. Trophic adaptations among *Mycteria* and other storks, the importance of prey capture by tacto-location and various aspects of foraging behaviour including diet, prey size, foraging and nesting correlates, variations in foraging activity, nocturnal foraging and kleptoparasitism were examined by Urfi (2011). Extensive studies on Painted stork *Mycteria leucocephala* was done by Kalam and Urfi (2008) in the Delhi region of North India concluded that the Delhi Zoo is an important breeding ground (Urfi, 2010) for the near Threatened Painted stork (Birdlife International, 2001). This is a flagship species which is a tactile forager and being exclusively piscivorous and its nesting is strongly tied to the performance of the monsoon, since fish production in local rivers and wetlands is itself monsoon dependant (Urfi, 1998). Moorhens are group of birds which are seen usually in waste lands devoid of agriculture. Monthly variations in the activity patterns and time budgeting of Purple moorhen was studied by Menon (2007) and no significant monthly variation in the feeding pattern was observed. Pond heron is yet another common waterbird. Breeding ecological studies of Indian Pond heron conducted by Seedikkoya *et al.*, (2012) in Malappuram and Kozhikode Districts, observed that the food of pond heron nestlings was mainly fishes. Ibis foraged using both nonvisual tactile probing and surface pecking. Tactile probing is the primary foraging technique used by the White ibis in the water or soil, with the bill held 1-2 cm agape at the tip. In the wild, Ibis fed mostly on prey small enough to be consumed almost instantaneously after capture. Such fish and crustaceans were only about 2 cm long (Kushlan, 1979). Ninety per cent of prey longer than 10 cm being handled by White ibis feeding in aggregations were stolen by Great egrets and such robbing was averted by the White ibis by flying out of the feeding area.

Most of the birds are observed actively feeding in the early morning. Nocturnal respiration of the macrophytes depleted the water of oxygen which forced the fish to concentrate at the surface in the few areas of open water to perform surface respiration. This increased the predation risk and the egrets showed a remarkable ability to exploit this ephemeral super-availability of food day after day. Soon after sunrise, the dissolved oxygen level started to increase which enabled the fish to disperse again into the vegetated parts of the marsh (Hafner, 1997). Successful foraging by avian predators is influenced largely by prey availability, which encompasses not only the density of prey but also its vulnerability to capture. For wading birds (Ciconiiformes), habitat features such as water depth and density of vegetation are thought to affect the vulnerability of their aquatic prey (Lantz *et al*., 2010). Competition may occur when two species with similar feeding ecologies exploit the same limited resources in time and space (Zhao *et al.,* 2015). Egrets and herons are the most abundant birds over large areas of the agricultural land in central and southeast China. They are extremely abundant in the areas where rivers, fishponds, rice paddies and other water bodies provide foraging habitat (Fasola *et al*., 2004). "Sit and wait" predatory patterns are especially useful, in the case of wading birds like large egrets and Purple herons (Katzir, 1994).

Cattle egrets is one of the most widely distributed heron in our country. Cattle egrets are known to be well adapted to agricultural and disturbed habitats. Cattle egrets generally seemed to take advantage of periodic anthropogenic disturbances that may have created surges in prey availability. The use of rice fields by Cattle egrets also showed a strong seasonal pattern. The heaviest use occurred during winter, and was often associated with post-harvest ploughing (by tractors), Cattle egrets also use rice fields during the breeding season (Lombardini *et al.,* 2001). Another study conducted by Seedikkoya *et al.,* (2007) on Cattle egrets in North Kerala recorded that the major food item of Cattle egrets in waste yards were insects. Maggots of housefly and blue bottle fly are abundant in the decomposing wastes and they form the chief food of Cattle egrets in waste dumps.

Kirby (1996) reported that Cormorant *Phalacrocorax carbo,* as fish predators and argued that the available studies of cormorant diet showed that they exploit a wide range of fish species, according to locality and season but often concentrate on locally dominant species. Diving patterns of Little cormorant, Common coot, Little grebe and Oriental darter observed in Vadavoor Lake recorded that the mean bout/dive time varied between 12.6 s and 26.7 s in little grebe, 10.7 s to 24.3 s in Little cormorant, 11.7 s to 85.0 s in coot and 19.2 s to 91.0 s in darters (Vachanth *et al.,* 2012). Another study conducted in Delhi region by Mahendiran and

Urfi, (2010) described that Cormorants as foot-propelled pursuit drivers, constitute an important component of aquatic food webs and exhibit unique foraging behaviour patterns. Kleptoparasitic attacks were noted among three sympatric Cormorants as well as other birds. Cormorants are the main predators in the pelagic region of wetlands. Energy management during the breeding season is crucial for central place foragers since parents need to feed themselves and their offspring. Cormorants and Darters are diving birds with similarities in behaviour patterns. Both the groups feed mostly on fishes. The Little cormorant, *Phalacrocorax niger* (Vieillot), one of the commonest aquatic birds in Kerala occur in most of the wetland habitats including paddy fields (Ali and Ripley, 1983). The Darter or Snake bird, *Anhinga melanogaster* (Pennant) is the only representative of the group in India (Ali, 2002). The foraging behaviour and diving patterns of Little cormorant *Phalacrocorax niger* at Kallampara River near the Kadalundy Bird Sanctuary were studied by Zeenath and Zacharias (2010).

Water is one of the most important compounds of the ecosystem as it is necessary for the survival and existence of all living beings. A minute change in the water quality leads to a change in entire food web associated with that ecosystem. In this scenario, to understand the health and population status of wetland birds, water quality should be analysed. The relationship between physico-chemical parameters and bird diversity was studied in of the Udhayamarthandapuram bird sanctuary and the study concluded that the abiotic factors were significantly influenced for the density, diversity and richness of the water bird groups (Rajakumar, 2012, Ramamurthy and Rajakumar, 2014). Detergent pollution is a major threat for fishery potential of the country. Changes in the physico – chemical factors of water leads to changes in the physiology of the fish body. Fishes are the major components of wetlands and are a key unit in many natural food webs (Anan *et al*., 2010). Studies conducted in Gujarat region (Sonal *et al*., 2010), Barna Reservoir in Narmada Basin and revealed, 14 environmental variables of water were positively correlated with bird species richness and negatively correlated with water depth, dissolved oxygen, total hardness and chloride (Balapure *et al.*, 2013). Alejandro *et al*., (2008) revealed that wetlands are critical foraging areas for many water bird species and their relatively high productivity often determines the coexistence of several species using food resources for breeding and/or refuelling during migration. Apart from these, water bird guilds specifically Anseriformes and Ciconiiformes are used as evaluation tools for the Kissimmee River restoration (Weller, 1995).

Jayson and Sivaperuman, (2005) during their avifaunal studies in various regions of Thrissur District concluded that the highest number of birds was reported from Kole wetlands. Earlier studies in Thrissur Kole wetlands by Sivaperuman and Jayson (2000) reported that Little egret, Cattle egret, Little cormorant, Pond heron, Median egret and Whiskered tern were the most abundant species in the Kole wetlands. According to Nameer (2010) during avifaunal survey in Kole wetlands concluded that Gargeney was the most abundant bird, followed by Little egret, Cattle egret, Wood sandpiper and Small pratincole. Jayson and Sivaperuman (2010) reported that, the availability and preference of the food organisms, feeding behaviour and utilization of the habitat for feeding and reproduction differ in co-existing animal species. Greeshma and Jayson (2018) studied the foraging behaviour of Asian openbill stork and also recorded the scavenging behaviour of Indian pond heron (Greeshma and Jayson (2017), Floating behaviour of Indian pond heron (Greeshma and Jayson (2016 a) and Asian Openbill stork (Greeshma and Jayson, 2016 b) were also reported by the same authors. Narayanan and Vijayan, (2007) studied the status of breeding waterbirds in the Kumarakom Heronry, Kerala and recorded ten species of waterbirds belonging to the families Anhingidae, Phalacrocoracidae, Ardeidae and Threskiornithidae were breeding in the study area.

Another survey conducted by Narayanan *et al*., (2011) recorded two-hundred-and-twenty-five taxa of birds belonging to 15 Orders and 59 Families from the Kuttanad wetlands, in the southern portion of Vembanad Kole wetland. Recent studies by Francis and George (2013) stated that the Kole wetlands of Thrissur supported a good number of migrants as well as residents. The present dewatering schedule implemented in the Kole wetlands by district administration helped a lot in the distribution of birds in the Kole wetlands, especially during the migratory period, which coincides with paddy cultivation. Little egret, Little cormorant, Purple moorhen, Purple heron, Black-crowned Night-heron, Indian pond-heron, Little grebe, Lesser whistling-duck, River tern, Whiskered tern, Garganey were the most abundant resident and migrant species found in the Mavoor wetlands (Aarif and Basheer, 2012). Kole wetlands is one among the richest Ichthyofaunal diversity areas and only limited studies were done. Nine hundred and five species of fishes were recorded from the inland and marine waters of Kerala comprising of 41 Orders and 172 Families (Biju Kumar and Raghavan, 2015). Raju *et al*., (2002) reported a total of 112 species of freshwater fishes, belonging to 57 genera, 26 Families and 10 Orders from the rivers flowing through Thrissur District, Kerala and thirteen species of fishes were reported from the Kole wetlands of Thrissur, Kerala (Sivaperuman, 2004). Later

Shaji *et al*., (2010) reported 43 species of fishes belonging to 23 genera and 21 families from Kole wetlands of Kerala.

1.2 Study area

1.2.1 Location

Thrissur District is situated in the central region of the State of Kerala. The total geographic area of Thrissur District is 3,032 sq km. The wetland area estimated is 13285 ha. Small wetlands, which are less than minimum units, are 271 in the District. The Kole Wetlands is one of largest, highly productive and threatened wetlands in Kerala and has been declared as Ramsar Site in 2002 and it comes in the Central Asian Flyway of migratory birds. The Malayalam word Kole indicates bumper yield, which refers to a particular type of cultivation method adopted in backwaters from December to April. The Kole wetlands lies between 10° 20' and 10° 40' N latitudes and 75° 58' and between 76° 11' E longitudes. The Kole wetlands are low lying tracts located 0.5 to 1m below Mean Sea Level (MSL) and remain submerged for about six months in a year.

These lands were formerly shallow lagoons, which gradually got silted up. Two rivers mainly bring the floodwaters into the area, namely Kechery and Karuvannur, which finally empty into the Arabian Sea. The Kole wetlands cover an area of 13, 632 ha spread over Thrissur and Malappuram Districts, extending from the northern banks of Chalakudy River in the south to the southern banks of Bharathapuzha River in the North. The intensive study areas were Enamavu, Adatt, Pullazhi, Kanjany, Manakody and Palakkal (Fig. 01). Three rivers are the draining water in to the Kole wetlands namely Vazhani River, Manali River, and Chimmony River. Details are provided in Jayson and Sivaperuman (2010). Due to the poor condition of shutters, every year, a large quantity of fresh water is emptied to the sea. In each year, temporary barrages' are built at Enamavu, which is a wastage of resources.

1.2.2 Agricultural pattern

The area is saucer shaped with low lands at the centre with elevation gradually increasing towards the fringes. The land around the rice fields are put under perennial crops like arecanut and coconut and annual crops like banana, yams and vegetables. The Kole wetlands are low lying tracts located 0.5 to 1 m below MSL and it remains submerged for about 6 months in a year (Plate 01). Water level in Kole wetlands was controlled to suit the paddy cultivation. From June to September no activity was carried out in the Kole wetlands. Excess

water was allowed to the sea through the Enamavu Bund. After the South-West monsoon, the high areas are taken up for dewatering and paddy cultivation. Excess water in the paddy fields were pumped to the canals using electric motors and "Petty para" system (Lift irrigation). The water in the canals were reserved for later use. These water is allowed to the paddy field as and when required, depending on the growth of paddy. Towards the ripening stage of paddy, the land is completely drained and kept dry. The different stages of paddy cultivation and associated bird community in each stage is described by Jayson and Sivaperuman (2010). As the water level is managed in small compartments (Padasekaram) the birds could utilize the resources and the habitat as a whole provided a mosaic of microhabitats, at a given time. After dewatering ploughing is carried out and the ground levelled and sprouted seeds are sowed (Plate 02).

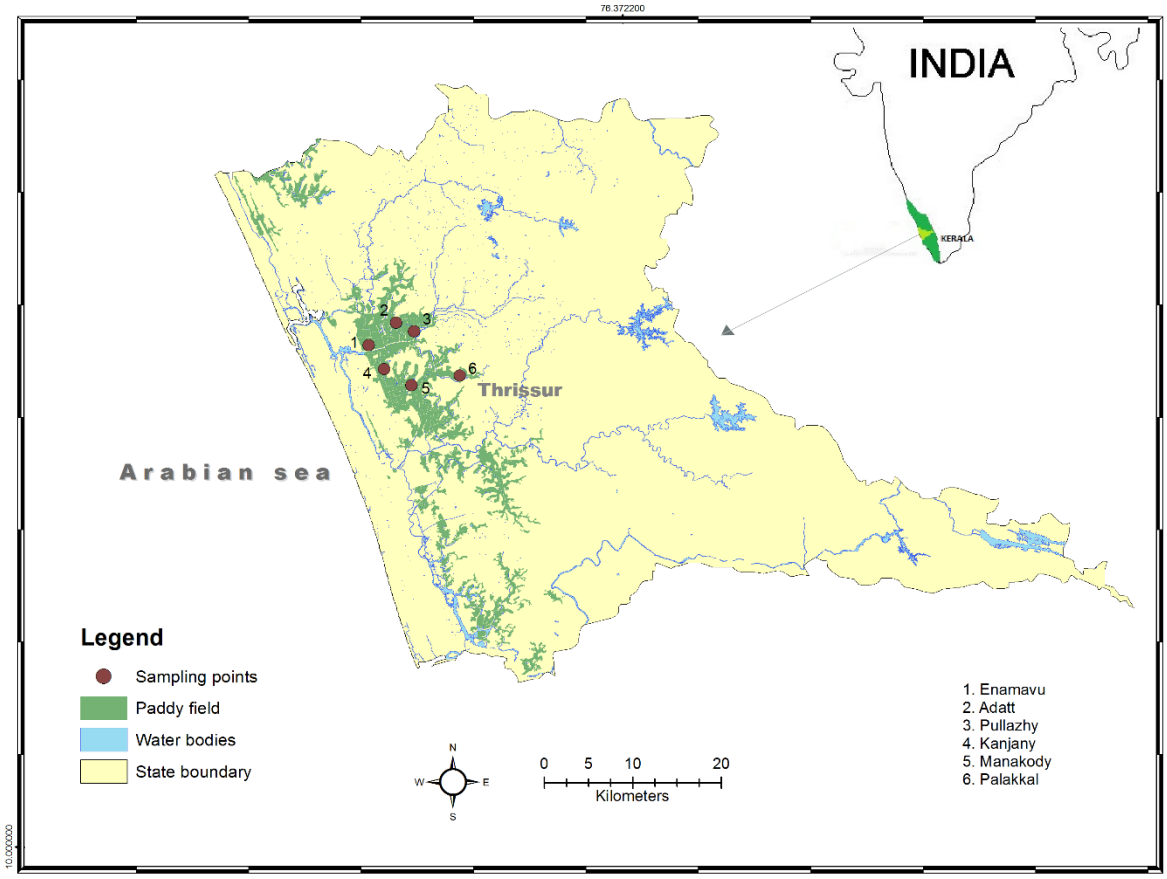

Fig.1 Kole wetlands showing the intensive study areas

Earlier crop was harvested in May, but nowadays due to the scarcity of water and the high temperature, affecting the paddy growth, Harvest is done during March-April (Plates 03

& 04). Double cropping system is also done very rarely and after the harvest, field will get flooded and entire Kole wetlands will be submerged.

Plate 1. Kole Wetlands in Wet Season I

Plate 2. Kole Wetlands in Wet Season II

Plates 3 & 4. Kole wetlands in dry season

1.2.3 Climate

The climate of the area is moderate and there are three different seasons. The Dry season (December-April), Wet season I (May-August) during South-west monsoon and Wet season II (September-November) during the Northeast monsoon. Highest temperature is recorded in the month of January 2014 (Fig. 02) and Relative humidity in the months of June and July (Fig. 03). Similarly maximum rainfall is obtained in the months of June and July (Fig. 04).

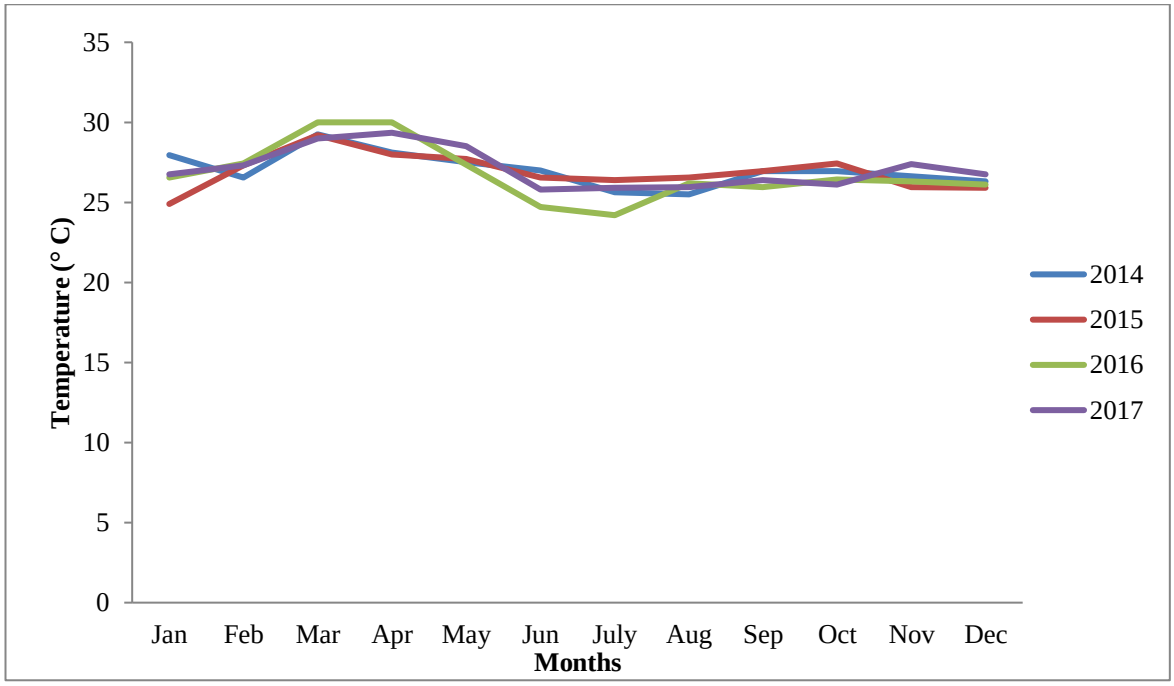

Fig. 02 Mean monthly Temperature over the years

(Source: Kerala Agricultural University)

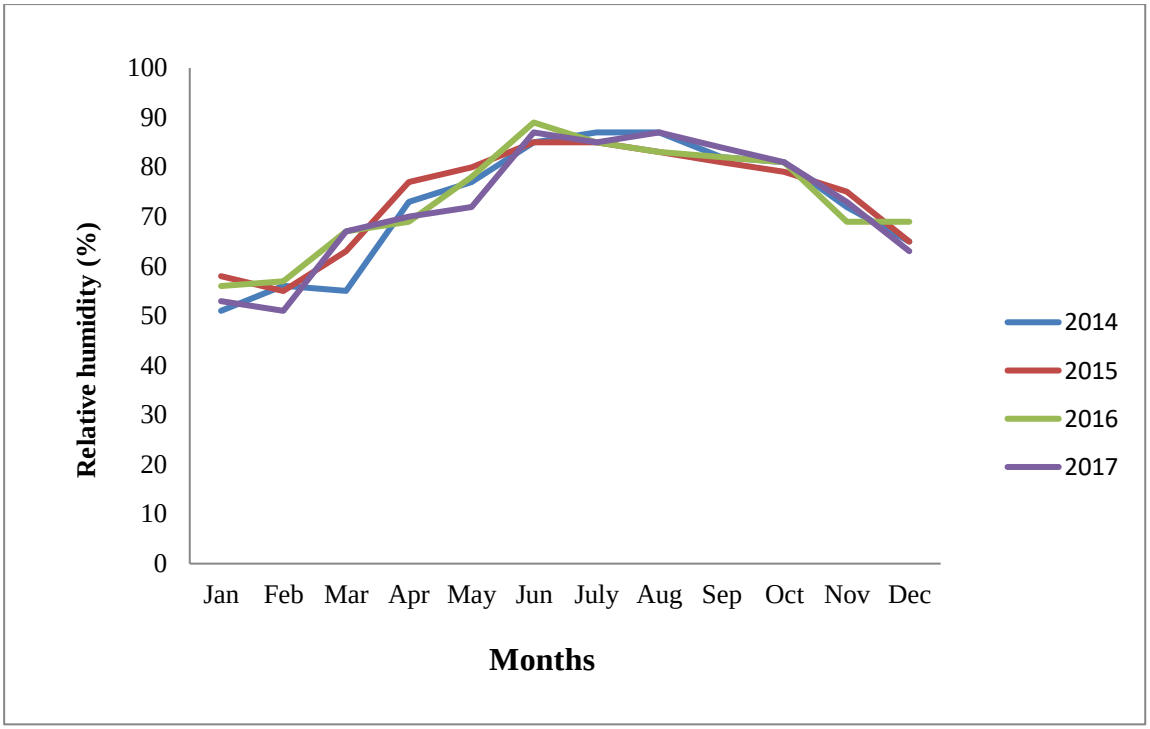

Fig. 03 Mean monthly relatively humidity over the years

(Source: Kerala Agricultural University)

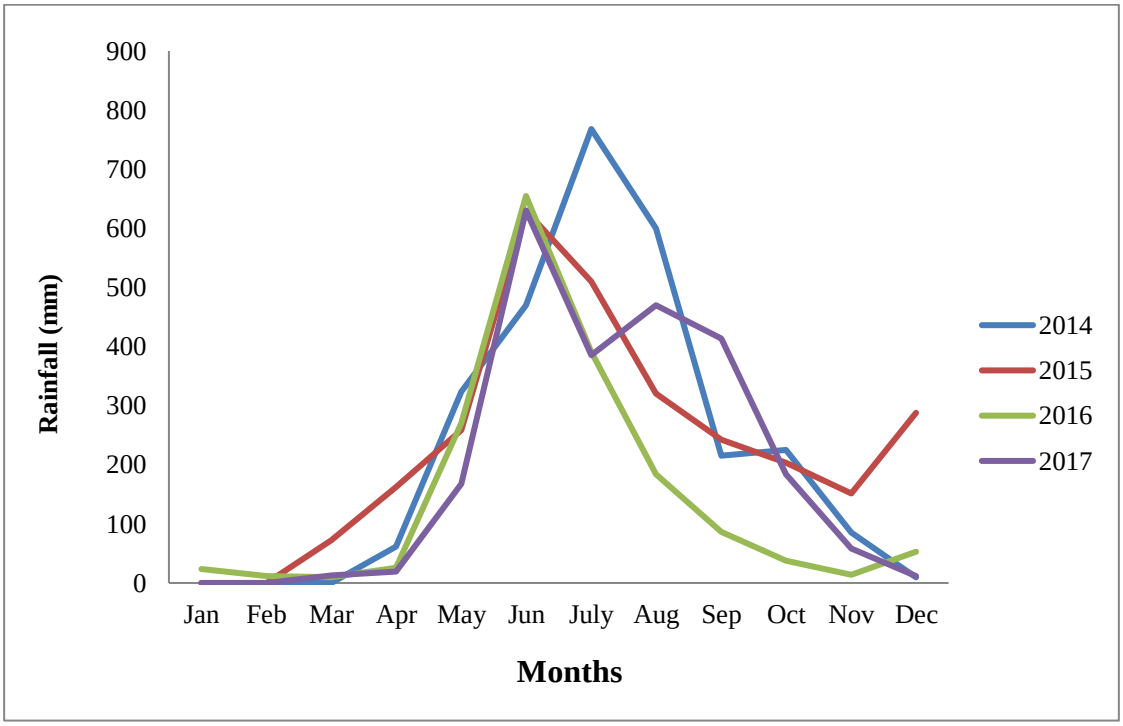

Fig. 04 Monthly Rainfall over the years

(Source: Kerala Agricultural University)

1.2.4 Flora and fauna

Kole wetland vegetation is peculiar and apart from the truly aquatic marshy forms like *Hydrilla, Eichhornia,* water ferns and algae, and it also comprises of many small trees on the bunds that can withstand inundation with water over long periods. Numerous herbaceous plants, submerged or free floating, rooted floating leaved or emergent, occupy different niches in wetlands. A total of 140 species belonging to 23 families of Dicotyledons and 11 families of Monocotyledons and 5 families of Water fern were recorded from the Kole wetlands (Sujana and Sivaperuman 2008). Prominently represented family is Cypreceae (27 genera) followed by Poaceae (25 genera) and other dominant families are Asteraceae, Fabaceae and Hydrocharitaceae. Kole wetlands abodes more than 240 species of birds and about 53 species of fishes. No other studies have been carried on the fauna of the Kole wetlands. The area is a good habitat for Otter (*Lutra lutra*), Mongoose (*Herpestes edwardsii*) and several other species of rodents and herpetofauna also.

1.2.5 Objectives

The objectives of the study were

1. To elucidate the food and feeding behaviour of selected wetland birds.
2. To assess the food availability of selected wetland birds.
3. To assess the extent of crop loss due to birds and to understand people's perception on conservation of birds.

2. METHODOLOGY

Bird community of Kole wetlands of Thrissur was studied during January 2015 to December 2016. The intensive study areas were selected after a reconnaissance survey and observations on feeding behaviour was made with the help of spotting scope (10x- 45x), HD Video cam and binocular (7 X 50). Birds were identified using physical features with the help of field guides and reference books (Ali and Ripley, 1983; Grimmett *et al.*, 2001, Sashikumar *et al.*, 2011). The study was mainly based on observational methods.

2.1 Assessment of water quality

Important physicochemical properties like pH, temperature, total dissolved solids, total hardness, turbidity, Total alkalinity, Chloride, Sulphate, Iron, Dissolved Oxygen, Biological Oxygen Demand, Salinity, Electrical Conductivity, Nitrate-N, Fluoride, Phosphate and Total Suspended Solids were analysed during March 2016 to November 2017. Water samples were collected from two sites from each location namely Pullazhi, Adatt, Enamavu, Manakody and Palakkal Kole wetlands of Thrissur (Total ten samples, Fig. 01). Water samples were collected in 03 litres polythene containers below the depth of 5- 10 cm and collection was usually done during morning hours between 08 AM and 10 AM. Water sampling was done in three months- March (Pre-monsoon), July (Monsoon), November (Post-Monsoon). The results were compared with surface water standards recommended by BIS [14] and CPCB [15] (APHA, 2005).

2.2 Food availability

In order to estimate the food availability of birds in the Kole wetlands, resource quantification was done. Sampling of fish was done in an interval of 4 months. Pullazhi, Adatt, Enamavu, Kanjany, Manakody and Kanimangalam were the intensive study areas and from each area four catches were collected using gill net and "*petty and para*" system (during the dewatering period). Collected fishes were identified up to species level and the total number of each species recorded. Collections were made during pre-monsoon, monsoon and post-monsoon seasons from 2015 April to 2017 December. Fishes were preserved in 10 % formalin and were deposited in the Wildlife Biology Museum of Kerala Forest Research Institute, Peechi, Thrissur.

2.3 Feeding behaviour

In order to study the feeding behaviour of birds in the Kole wetlands two methods were employed, namely the observational studies and the method of the leftover analysis.

2.3.1Observational study

Direct observation method was employed for studying the food and feeding patterns of selected species. Among the methods, Focal-Animal Sampling method was adopted (Altman 1974). All occurrences of specified (inter) actions of an individual was recorded during each sample period. A record was made of the length of each sample period and for each focal individual, the amount of time during sample that is actually in view. With the help of a stop watch the time was recorded. Bill length and the size of the prey were estimated from field observations and from literature. The water depth, where the foraging occurred also was measured (Altmann, 1974). Sequence Sampling method was adopted to observe the interaction sequence. The sample period begins when an interaction begins. During this all behaviours under the study was recorded in the order of occurrence. The sample continued until the interaction sequence terminates or is interrupted and the next sample begins with the onset of another sequence of interactions.

2.3.2 Leftover analysis

Roosts in the vicinity of the Kole wetlands were observed and the leftover food materials which are seen in the roosts was collected and identified. Apart from observational study a refined data regarding their diet composition during breeding season was also recorded. Leftover food items were collected from the heronries of Thrissur. Heronries consisted of Oriental darter, Little cormorant, Indian cormorant, Black-crowned night heron, Indian pond heron and Median egret. Diet composition of breeding birds was studied by analysis of regurgitated materials and also by direct observation. The heronries were observed from 6.00 am to 6.00 pm once in a week and fallen food materials were collected. The information such as number, size and weight of the fish samples were also recorded and species were identified up to species level. The per cent composition of different prey items of bird species was estimated.

2.4 People's perception of conservation

A structured questionnaire survey was conducted among the farmers and people surrounding the Kole wetlands. The houses for the questionnaire survey was selected using grids and random numbers (Fig. 05) specifically, the following information was collected on the following aspects:

a. Details of the area: Name of the Padavu and Panchayat.

b. Demographics: Name, age, occupation, education

c. Details about cultivation: Land holding, details of the species involved in the crop damage, the seasonal variations of crop raiders, extent of crop damage, mode of raiding, annual loss, perception of damage, ranking of crop raiding species, details of protective methods to mitigate crop raiding and conservation attitudes was collected.

d. Details such as the usage of pesticides, importance of Kole wetlands, migratory birds, poaching, fire, fishing and fishing gears were also collected.

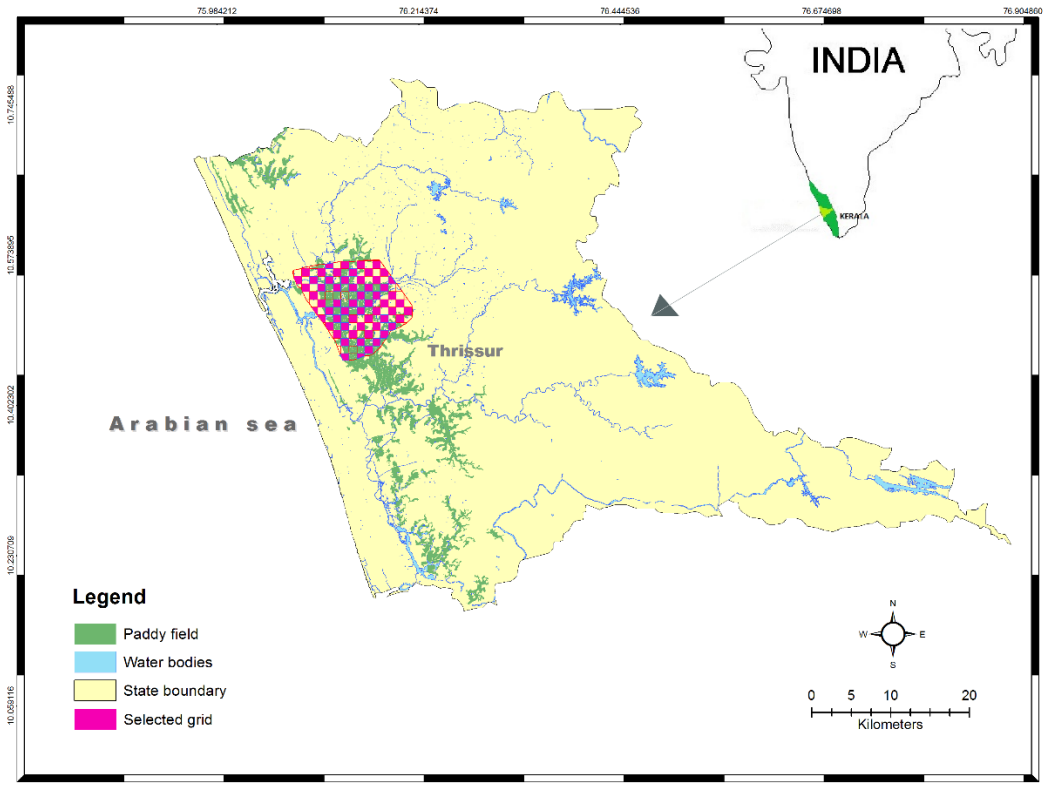

Fig. 05 Grids showing the locations of focus group discussion

3. RESULT

3.1 Avifaunal diversity of Kole wetlands

Birds serve as good indicators of changes in the environment by responding to the small changes in habitat structure and composition (Gupta *et al.*, 2011). By virtue of occupying the apex of aquatic food chains, water birds are considered as a vital component of the wetland ecosystem. Wildfowl, waterfowl, shore birds and waders belong to the commonly recognized groups. Across the geographical regions inhabited by human beings, water bird use of agricultural wetlands has increased as natural wetlands continue to decline. Studies conducted by Sundar and Subramanya (2010) revealed that the Indian subcontinent has the world's highest cropland cover per unit area with rice (*Oryza sativa)* being the second-most important crop, and is home to nearly 1,300 species of birds. Avifaunal studies in various regions of Thrissur District concluded that the highest number of birds was reported from Kole wetlands (Jayson and Sivaperuman, 2005). Earlier studies were mainly conducted by Sivaperuman and Jayson (2000) and Asian Waterfowl Census in various years. Avifaunal studies on birds of Kole wetlands were conducted as a part of the detailed study on the foraging ecology of wetland birds of Kole, Thrissur.

A total of 155 species of birds belonging to 15 Orders and 49 families were recorded from the area. Among the 15 Orders, Passeriformes, Charadriiformes and Pelecaniformes dominated the list with 46, 30 and 25 species respectively (Fig. 06). Of these 104 species were wetland birds and 51 species terrestrial birds. Glossy ibis *Plegadis falcinellus*, Wood sandpiper *Tringa glareola,* Whiskered tern *Chlidonias hybrida*, Grey wagtail *Motacilla cinerea*, Barn swallow *Hirundo rustica*, Rosy starling *Pastor roseus* were the migratory birds recorded in abundance. Whereas Indian pond heron *Ardeola grayii*, Little cormorant *Microcarbo niger*, Black-headed ibis *Threskiornis melanocephalus*, Cattle egret *Bubulcus ibis,* Grey-headed swamphen *Porphyrio poliocephalus,* Intermediate egret *Mesophoyx intermedia*, Little egret *Egretta garzetta,* White-throated kingfisher *Halcyon smyrnensis,* Black drongo *Dicrurus macrocercus,* Asian openbill stork *Anastomus oscitans* were the most abundant resident birds. Forty three per cent comprised of resident birds followed by 32 % of migratory birds, 23 % of local migrants and 2 % of stragglers. Of these 37 % of birds were common. Thirty three taxa of birds not reported earlier are reported during this study (Fig. 07).

The birds were classified as Stragglers (S), Migratory (M), Resident (R) and Local Migrant (LM) and also based on IUCN status (Sivaperuman and Jayson, 2000; Praveen, 2015**).**

A = Abundant (found in all suitable habitats and seen in all the habitats, every visit)

C = Common (found in all suitable habitats and seen in all the habitats, most of the visit)

U = Uncommon (seen in specific habitat on a few visits)

O = Occasional (seen in suitable habitat once or twice)

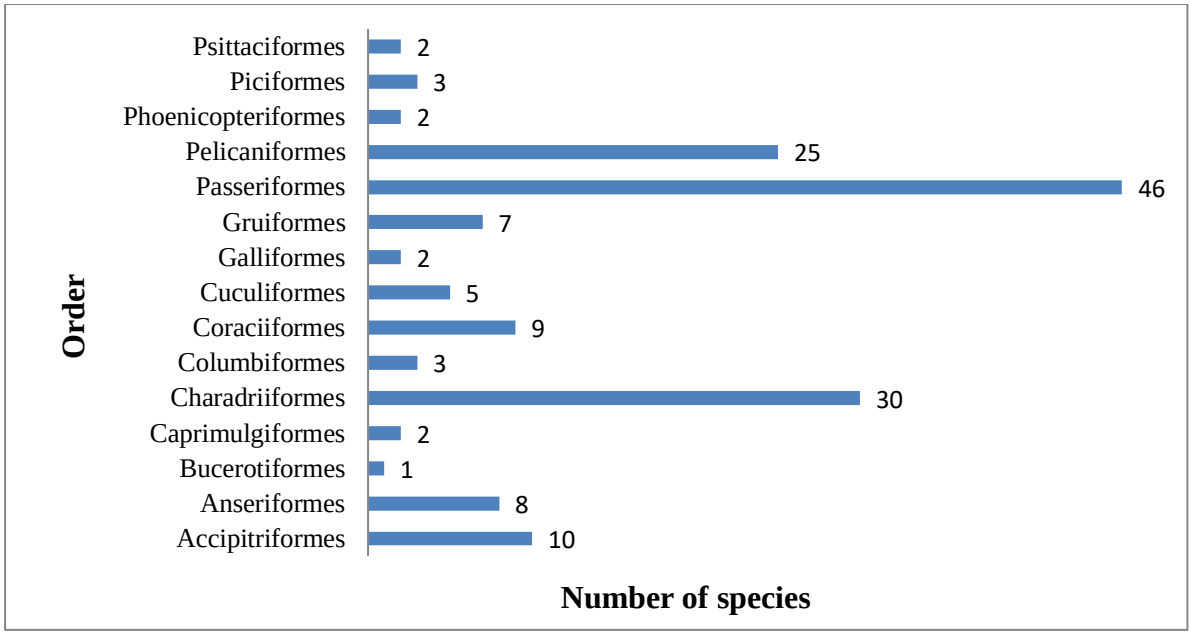

Fig. 06 Number of bird species representing the respective orders in the Kole wetlands

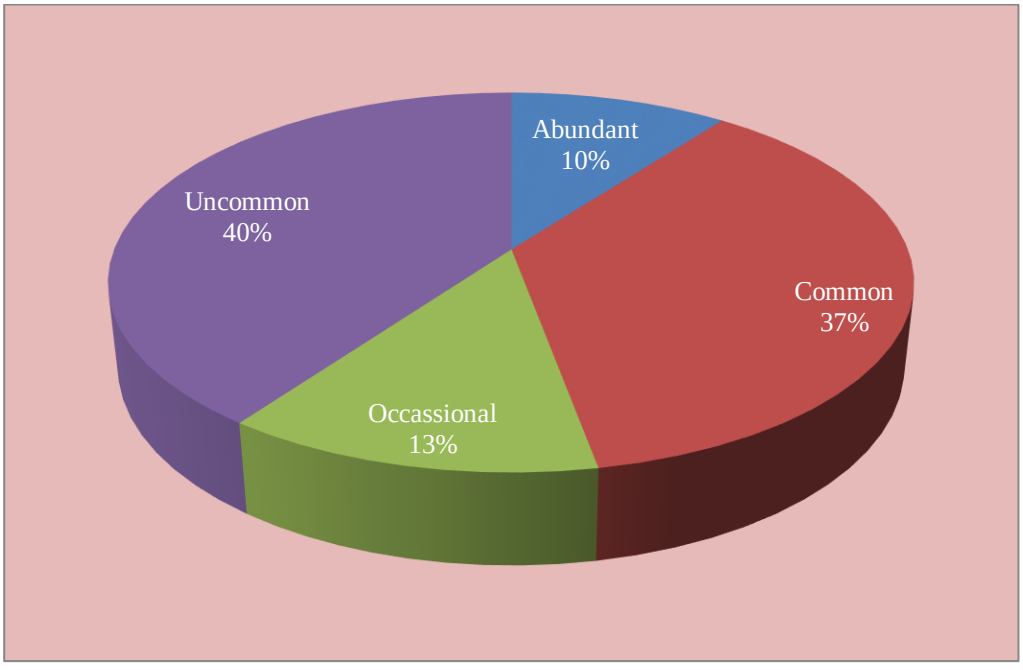

Fig. 07 Abundance of birds in the Kole wetlands

Thirty three taxa of birds are newly reported from the Kole wetlands which are not reported in the previous studies (Sivaperuman and Jayson, 2000). Bar-headed goose *Anser*

indicus, Indian peafowl *Pavo cristatus,* Greater flamingo *Phoenicopterus roseus,* Yellow-footed pigeon *Treron phoenicopterus,* Baillon's crake *Zapornia pusilla,* Watercock *Gallicrex cinerea,* Striated heron *Butorides striata,* Glossy ibis *Plegadis falcinellus,* Great thick-knee *Esacus recurvirostris,* Pacific golden-plover *Pluvialis fulva,* Grey-headed lapwing *Vanellus cinereus,* Greater painted-snipe *Rostratula benghalensis,* Little tern *Sternula albifrons,* Gull-billed tern *Gelochelidon nilotica,* River tern *Sterna aurantia,* Steppe eagle *Aquila nipalensis,* Greater spotted eagle *Clanga clanga,* Booted eagle *Hieraaetus pennatus,* Crested serpent eagle *Spilornis cheela,* Common hoopoe *Upupa epops,* Common golden-backed woodpecker *Dinopium javanense,* Chestnut-headed bee-eater *Merops leschenaultia,* Greater racket-tailed drongo *Dicrurus paradiseus,* Brown shrike *Lanius cristatus,* Long-tailed shrike *Lanius schach,* Wire-tailed swallow *Hirundo smithii,* Rosy starling *Pastor roseus,* Chestnut-tailed starling *Sturnia malabarica,* Bluethroat *Luscinia svecica,* Siberian stonechat *Saxicola maurus,* Malabar lark *Galerida malabarica* and Oriental skylark *Alauda gulgula* are the newly reported species (Table 01).

Important sightings

Bar-headed goose *Anser indicus*- Once spotted, in Adatt Kole, with a group of 3 individuals in 2015. (Rarely recorded from the Kole wetlands)

Great thick-knee *Esacus recurvirostris*- Once spotted, in Adatt Kole, with a single individual in 2016. (Near Threatened, IUCN 2017, Version 3)

Spot-billed pelican *Pelecanus philippensi*- Two sightings, one in 2015 from Karippadam Kole during flight and second from Palakkal Kole in 2016. (Near Threatened, IUCN 2017, Version 3)

European white stork *Ciconia ciconia*- A group of 26 individuals sighted in 2016, December from Palakkal Kole. (Rarely recorded from the Kole wetlands)

Table 01. Checklist of birds recorded from the Kole wetlands of Thrissur

Order	Family	Sl.no.	Common name	Scientific name	IUCN (2017, Version 3)	Abundance	Status
Anseriformes	Anatidae	1.	Lesser Whistling-Duck	*Dendrocygna javanica*	LC	C	R
		2.	Bar-headed Goose	*Anser indicus*	LC	O	S
		3.	Garganey	*Spatula querquedula*	LC	C	M
		4.	Northern Shoveler	*Spatula clypeata*	LC	U	M
		5.	Cotton Pygmy-Goose	*Nettapus coromandelianus*	LC	U	LM
		6.	Common Teal	*Anas crecca*	LC	U	M
		7.	Northern Pintail	*Anas acuta*	LC	U	M
		8.	Indian Spot-billed Duck	*Anas poecilorhyncha*	LC	U	LM
Galliformes	Phasianidae	9.	Indian Peafowl	*Pavo cristatus*	LC	U	R
		10.	Grey Francolin	*Francolinus pondicerianus*	LC	O	LM
Phoenicopteriformes	Phoenicopteridae	11.	Greater Flamingo	*Phoenicopterus roseus*	LC	O	M
	Podicipedidae	12.	Little Grebe	*Tachybaptus ruficollis*	LC	C	R
Columbiformes	Columbidae	13.	Blue Rock Pigeon	*Columba livia*	LC	C	R
		14.	Spotted Dove	*Streptopelia chinensis*	LC	C	R

		15.	Yellow-footed Pigeon	*Treron phoenicopterus*	LC	U	R
Caprimulgiformes	Apodidae	16.	Indian House Swift (Little Swift)	*Apus affinis*	LC	C	R
		17.	Asian Palm-Swift	*Cypsiurus balasiensis*	LC	C	R
Cuculiformes	Cuculidae	18.	Greater Coucal	*Centropus sinensis*	LC	C	R
		19.	Pied Cuckoo	*Clamator jacobinus*	LC	U	LM
		20.	Asian Koel	*Eudynamys scolopaceus*	LC	C	R
		21.	Common Hawk Cuckoo	*Hierococcyx varius*	LC	U	LM
		22.	Indian Cuckoo	*Cuculus micropterus*	LC	C	R
Gruiformes	Rallidae	23.	Ruddy-breasted Crake	*Zapornia fusca*	LC	U	R
		24.	White-breasted Waterhen	*Amaurornis phoenicurus*	LC	C	R
		25.	Baillon's Crake	*Zapornia pusilla*	LC	O	M
		26.	Watercock	*Gallicrex cinerea*	LC	U	LM
		27.	Gray-headed Swamphen	*Porphyrio porphyrio*	LC	A	R
		28.	Common Moorhen (Eurasian Moorhen)	*Gallinula chloropus*	LC	U	R
		29.	Common Coot (Eurasian Coot)	*Fulica atra*	LC	U	M
Pelicaniformes	Ciconiidae	30.	Asian Openbill Stork	*Anastomus oscitans*	LC	A	LM
		31.	Woolly-necked Stork	*Ciconia episcopus*	VU	U	M
		32.	Painted Stork	*Mycteria leucocephala*	NT	U	LM
		33.	Black Stork	*Ciconia nigra*	LC	O	M

		34.	European White Stork	*Ciconia ciconia*	LC	O	M
	Pelicanidae	35.	Spot-billed Pelican	*Pelecanus philippensi*	NT	O	S
	Ardeidae	36.	Yellow Bittern	*Ixobrychus sinensis*	LC	U	LM
		37.	Black Bittern	*Ixobrychus flavicollis*	LC	U	LM
		38.	Cinnamon Bittern	*Ixobrychus cinnamomeus*	LC	U	LM
		39.	Black-crowned Night Heron	*Nycticorax nycticorax*	LC	C	R
		40.	Grey Heron	*Ardea cinerea*	LC	U	LM
		41.	Striated Heron	*Butorides striata*	LC	U	LM
		42.	Purple Heron	*Ardea purpurea*	LC	C	R
		43.	Great Egret	*Ardea alba*	LC	U	R
		44.	Intermediate Egret	*Ardea intermedia*	LC	A	R
		45.	Little Egret	*Egretta garzetta*	LC	A	R
		46.	Western Reef-Heron	*Egretta gularis*	LC	O	LM
		47.	Cattle Egret	*Bubulcus ibis*	LC	A	LM
		48.	Indian Pond-Heron	*Ardeola grayii*	LC	A	R
	Threskiornithidae	49.	Glossy Ibis	*Plegadis falcinellus*	LC	A	M
		50.	Black-headed Ibis	*Threskiornis melanocephalus*	NT	A	R
		51.	Eurasian Spoonbill	*Platalea leucorodia*	LC	U	M
	Phalacrocoracidae	52.	Little Cormorant	*Microcarbo niger*	LC	A	R

		53.	Indian Cormorant	*Phalacrocorax fuscicollis*	LC	U	LM
	Anhingidae	54.	Oriental Darter	*Anhinga melanogaster*	NT	C	R
Charadriiformes	Recurvirostridae	55.	Black-winged Stilt	*Himantopus himantopus*	LC	C	M
		56.	Pied Avocet	*Recurvirostra avosetta*	LC	O	M
	Burhinidae	57.	Great Thick-knee	*Esacus recurvirostris*	NT	O	S
	Charadriidae	58.	Pacific Golden-Plover	*Pluvialis fulva*	LC	U	M
		59.	Kentish Plover	*Charadrius alexandrinus*	LC	O	M
		60.	Little Ringed Plover	*Charadrius dubius*	LC	U	M
		61.	Red-wattled Lapwing	*Vanellus indicus*	LC	C	R
		62.	Yellow-wattled Lapwing	*Vanellus malarbaricus*	LC	O	R
		63.	Grey-headed Lapwing	*Vanellus cinereus*	LC	O	M
	Rostatulidae	64.	Greater Painted-snipe	*Rostratula benghalensis*	LC	U	LM
	Jacanidae	65.	Pheasant-tailed Jacana	*Hydrophasianus chirurgus*	LC	U	LM
		66.	Bronze-winged Jacana	*Metopidius indicus*	LC	C	R
	Scolopacidae	67.	Eurasian Curlew	*Numenius arquata*	NT	C	M
		68.	Temminck's Stint	*Calidris temminckii*	LC	U	M
		69.	Little Stint	*Calidris minuta*	LC	U	M
		70.	Pintail Snipe	*Gallinago stenura*	LC	U	M
		71.	Common Snipe	*Gallinago gallinago*	LC	C	M

		72.	Whimbrel	*Numenius phaeopus*	LC	C	M
		73.	Black-tailed Godwit	*Limosa limosa*	NT	O	M
		74.	Common Sandpiper	*Actitis hypoleucos*	LC	C	M
		75.	Green Sandpiper	*Tringa ochropus*	LC	C	M
		76.	Common Greenshank	*Tringa nebularia*	LC	C	M
		77.	Common Redshank	*Tringa totanus*	LC	U	M
		78.	Marsh Sandpiper	*Tringa stagnatilis*	LC	C	M
		79.	Wood Sandpiper	*Tringa glareola*	LC	A	M
	Glareolidae	80.	Little Pratincole	*Glareola lactea*	LC	C	LM
	Laridae	81.	Little Tern	*Sternula albifrons*	LC	U	M
		82.	Whiskered Tern	*Chlidonias hybrida*	LC	A	M
		83.	Gull-billed Tern	*Gelochelidon nilotica*	LC	U	M
		84.	River Tern	*Sterna aurantia*	NT	U	LM
Accipitriformes	Pandionidae	85.	Osprey	*Pandion haliaetus*	LC	U	M
	Accipitridae	86.	Steppe Eagle	*Aquila nipalensis*	EN	O	M
		87.	Black-winged Kite	*Elanus caeruleus*	LC	U	LM
		88.	Greater Spotted Eagle	*Clanga clanga*	VU	O	M
		89.	Booted Eagle	*Hieraaetus pennatus*	LC	U	M
		90.	Crested Serpent Eagle	*Spilornis cheela*	LC	U	R
		91.	Eurasian Marsh-Harrier	*Circus aeruginosus*	LC	U	M

		92.	Shikra	*Accipiter badius*	LC	U	R
		93.	Brahminy Kite	*Haliastur indus*	LC	C	R
		94.	Black Kite	*Milvus migrans*	LC	C	R
Bucerotiformes	Upupidae	95.	Common Hoopoe	*Upupa epops*	LC	U	LM
Piciformes	Picidae	96.	Lesser Golden-backed Woodpecker	*Dinopium benghalense*	LC	C	R
		97.	Common Golden-backed Woodpecker	*Dinopium javanense*	LC	U	R
	Ramphastidae	98.	White-cheeked Barbet	*Psilopogon viridis*	LC	C	R
Coraciiformes	Meropidae	99.	Green Bee-eater	*Merops orientalis*	LC	U	R
		100.	Chestnut-headed Bee-eater	*Merops leschenaulti*	LC	O	LM
		101.	Blue-tailed Bee-eater	*Merops philippinus*	LC	C	M
	Coraciidae	102.	Indian Roller	*Coracias benghalensis*	LC	U	R
	Alcedinidae	103.	Common Kingfisher	*Alcedo atthis*	LC	C	R
		104.	Stork-billed Kingfisher	*Pelargopsis capensis*	LC	C	R
		105.	White-throated Kingfisher	*Halcyon smyrnensis*	LC	A	R
		106.	Black-capped Kingfisher	*Halcyon pileata*	LC	U	LM
		107.	Pied Kingfisher	*Ceryle rudis*	LC	C	R
Psittaciformes	Psittaculidae	108.	Rose-ringed Parakeet	*Psittacula krameri*	LC	U	R
		109.	Plum-headed Parakeet	*Psittacula cyanocephala*	LC	U	R

Passeriformes	Artamidae	110.	Ashy Woodswallow	*Artamus fuscus*	LC	C	R
	Oriolidae	111.	Indian Golden Oriole	*Oriolus kundoo*	LC	C	R
		112.	Black-hooded Oriole	*Oriolus xanthornus*	LC	C	R
	Dicruridae	113.	Black Drongo	*Dicrurus macrocercus*	LC	A	R
		114.	Greater Racket-tailed Drongo	*Dicrurus paradiseus*	LC	U	R
	Laniidae	115.	Brown Shrike	*Lanius cristatus*	LC	U	M
		116.	Long-tailed Shrike	*Lanius schach*	LC	U	LM
	Aegithinidae	117.	Common Iora	*Aegithina tiphia*	LC	U	LM
	Corvidae	118.	Rufous Treepie	*Dendrocitta vagabunda*	LC	C	R
		119.	House Crow	*Corvus splendens*	LC	C	R
		120.	Large-billed Crow	*Corvus macrorhynchos*	LC	U	R
	Nectariniidae	121.	Purple-rumped Sunbird	*Leptocoma zeylonica*	LC	C	R
		122.	Purple Sunbird	*Cinnyris asiaticus*	LC	C	R
		123.	Long-billed Sunbird	*Cinnyris lotenius*	LC	C	R
	Ploceidae	124.	Baya Weaver	*Ploceus philippinus*	LC	C	R
		125.	Streaked Weaver	*Ploceus manyar*	LC	C	R
	Estrildidae	126.	Scaly-breasted Munia	*Lonchura punctulata*	LC	C	R
		127.	Tricolored Munia	*Lonchura malacca*	LC	C	R
		128.	Red Munia (Red Avadavat)	*Amandava amandava*	LC	U	LM
		129.	White-rumped Munia	*Lonchura striata*	LC	C	LM

	Motacillidae	130.	Western Yellow Wagtail	*Motacilla flava*	LC	C	M
		131.	Grey Wagtail	*Motacilla cinerea*	LC	A	M
		132.	White-browed Wagtail	*Motacilla maderaspatensis*	LC	O	LM
		133.	Paddyfield Pipit	*Anthus rufulus*	LC	U	LM
	Cisticolidae	134.	Common Tailorbird	*Orthotomus sutorius*	LC	C	R
		135.	Zitting Cisticola	*Cisticola juncidis*	LC	U	LM
		136.	Ashy Prinia	*Prinia socialis*	LC	C	R
		137.	Plain Prinia	*Prinia inornata*	LC	C	R
	Hirundinidae	138.	Barn Swallow	*Hirundo rustica*	LC	A	M
		139.	Wire-tailed Swallow	*Hirundo smithii*	LC	U	LM
		140.	Red-rumped Swallow	*Cecropis daurica*	LC	U	LM
	Acrocephalidae	141.	Blyth's Reed-Warbler	*Acrocephalus dumetorum*	LC	C	M
	Pycnonotidae	142.	Red-vented Bulbul	*Pycnonotus cafer*	LC	C	R
		143.	Red-whiskered Bulbul	*Pycnonotus jocosus*	LC	C	R
	Leiothrichidae	144.	Yellow-billed Babbler	*Turdoides affinis*	LC	C	R
		145.	Jungle Babbler	*Turdoides striata*	LC	C	R
	Sturnidae	146.	Rosy Starling	*Pastor roseus*	LC	A	M
		147.	Chestnut-tailed Starling	*Sturnia malabarica*	LC	U	M
		148.	Common Myna	*Acridotheres tristis*	LC	C	R

		149.	Jungle Myna	*Acridotheres fuscus*	LC	U	R
	Muscicapidae	150.	Oriental Magpie-Robin	*Copsychus saularis*	LC	C	R
		151.	Bluethroat	*Luscinia svecica*	LC	O	M
		152.	Pied Bushchat	*Saxicola caprata*	LC	U	LM
		153.	Siberian Stonechat	*Saxicola maurus*	LC	O	M
	Alaudidae	154.	Oriental Skylark	*Alauda gulgula*	LC	U	LM
		155.	Malabar Lark	*Galerida malabarica*	LC	U	LM

R= Resident; S= Straggler; M= Migrant; LM= Local migrant

LC= Least concern; VU= Vulnerable; NT= Near threatened; EN= Endangered

A= Abundant; C= Common; U= Uncommon; O= Occasional

3.2 Water quality and food availability

Various physiochemical properties of water and abundance of fish in various seasons is presented in this section

3.2.1 Water quality of Kole wetlands

Sixteen parameters of water were analysed namely pH, Electrical conductivity, Total dissolved solids, Turbidity, Salinity, Total hardness, Total alkalinity, Chloride, Sulphate, Iron, Nitrate, Phosphate, Fluoride, Total suspended solids, Biological Oxygen Demand and Dissolved oxygen. Temperature is a thermal gradient of water and it governs the dissolution of several gasses, survival and biological activity of aquatic organism. In our present study mean temperature was observed as 30.41±1.32 ^{0} C and 30 ^{0}-35 ^{0}C is optimal temperature for fish growth. pH is a measure of the hydrogen ion concentration of a solution and also a figure expressing the acidity or alkalinity of a solution on a logarithmic scale on which 7 is neutral, lower values are more acid and higher values more alkaline. pH between 7 to 8.5 is ideal for biological productivity, fishes can become stressed in water with a pH ranging from 4.0 to 6.5 and 9.0 to 11.0 and death is almost certain at a pH of less than 4.0 or greater than 11.0. In the present study pH of water was found to be 7.03.±0.33. Electrical Conductivity is the measure of water's ability to conduct electricity, depending on the concentration of dissolved ions in the water and in the study we observed *242.37*±110.97µS/cm (100-2000 µS-normal) (Fig. 08).

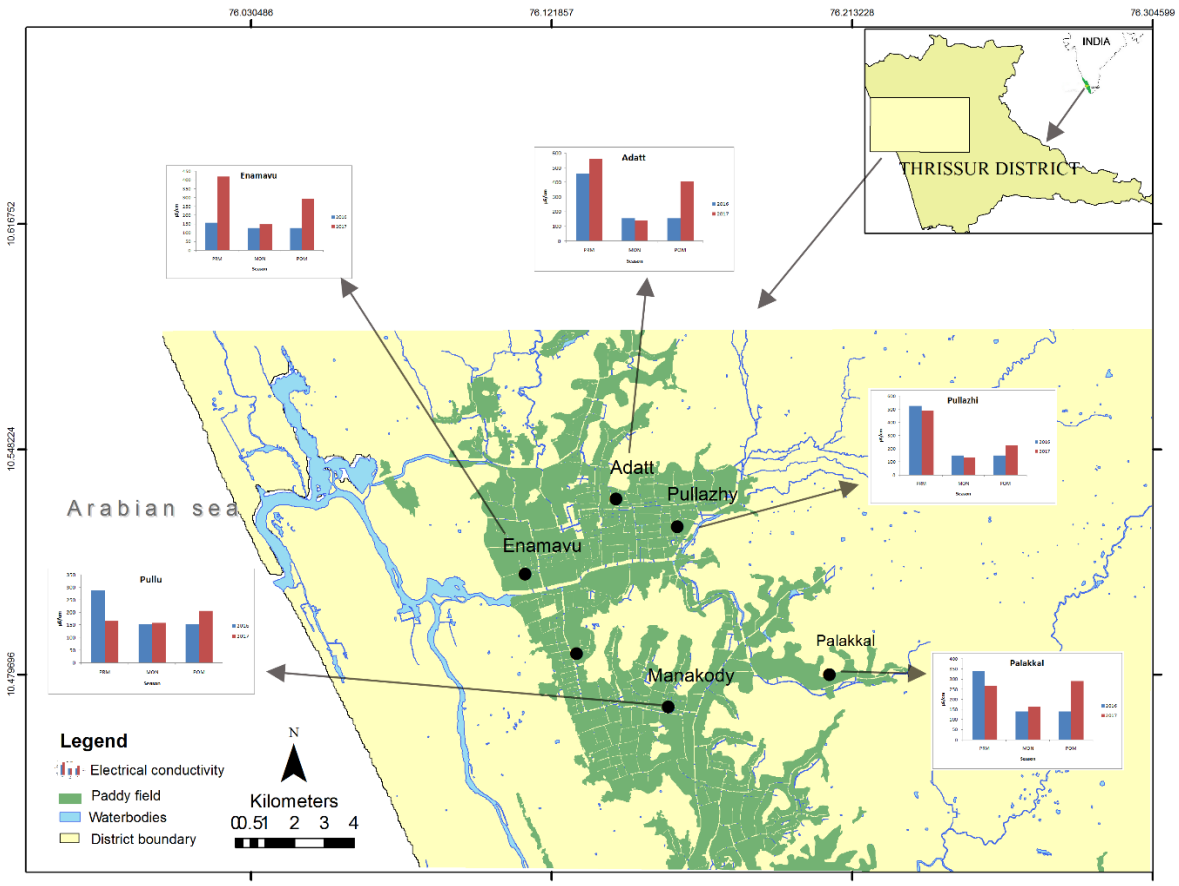

Fig.08 Values of electrical conductivity observed in different areas

Turbidity is the cloudiness of water caused by suspended particulate matter and phytoplankton which decreases the light penetration in the water. Higher turbidity chock the gill rockers of juvenile fish and reduces the photosynthesis process in autotrophs thus reduce the primary production of water body (Verma *et al.*, 2012). According to WHO the turbidity permissible limit is up to 5 NTU and Indian Standards up to 10 NTU for drinking water and our value is 3.81±0.58, thus revealing that the health status of water is safe (Fig. 09).

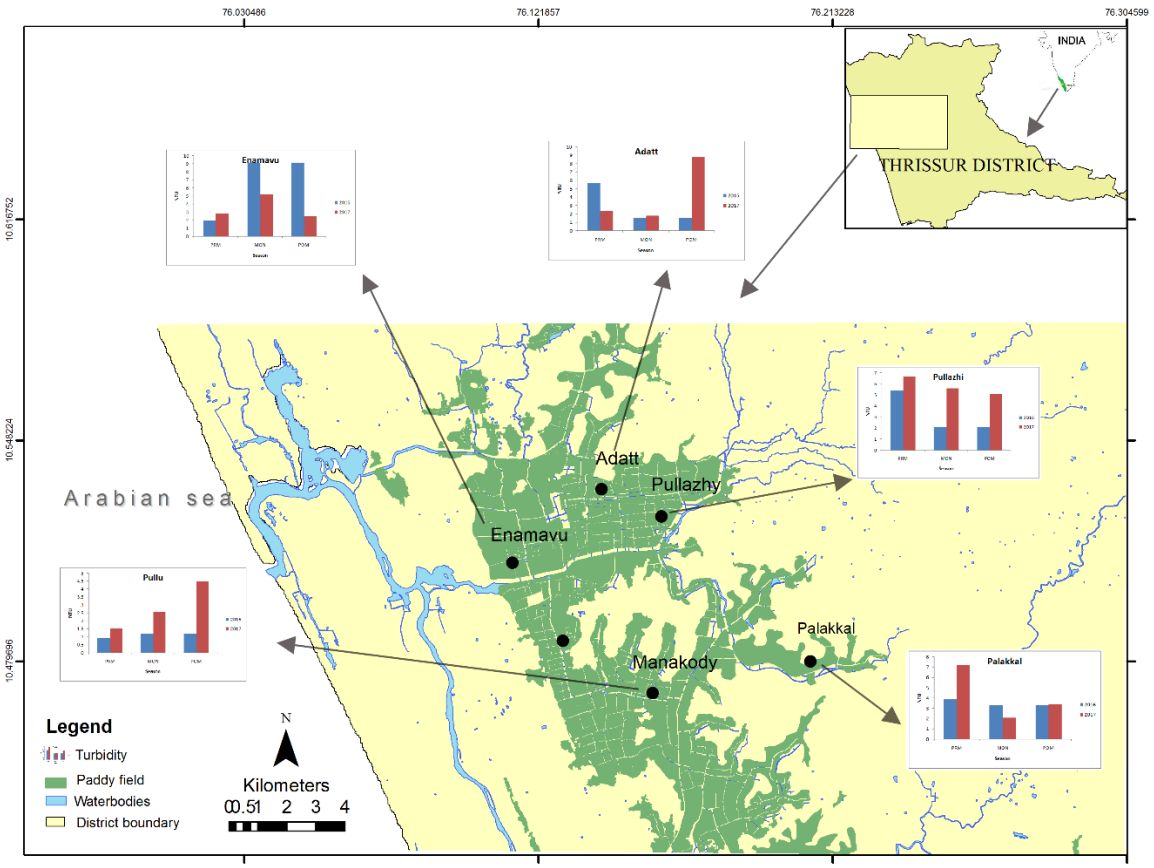

Fig.09 Variations in turbidity in the intensive study area

Total Suspended Solids and Total Dissolved Solids are the solids that are suspended as well as dissolved state in the water. Alikunhi (1957) reported that TDS below 200 mg/l promoted healthier spawning conditions and the observed TDS value and TSS value of water from Kole wetlands were 171.95±83.75 mg/l and 16.88±9.50 mg/l. Total alkalinity is the sum of hydroxides, carbonates and bicarbonates. Permissible limit of alkalinity is 200-600 units as per IS: 10500 but the observed value (27.79 ± 6.55 mg/l) is much lower than the normal range. Salinity is the saltiness or amount of salt dissolved in a body of water. Here we observed only 0.13±0.10 ppt (Fig. 10).

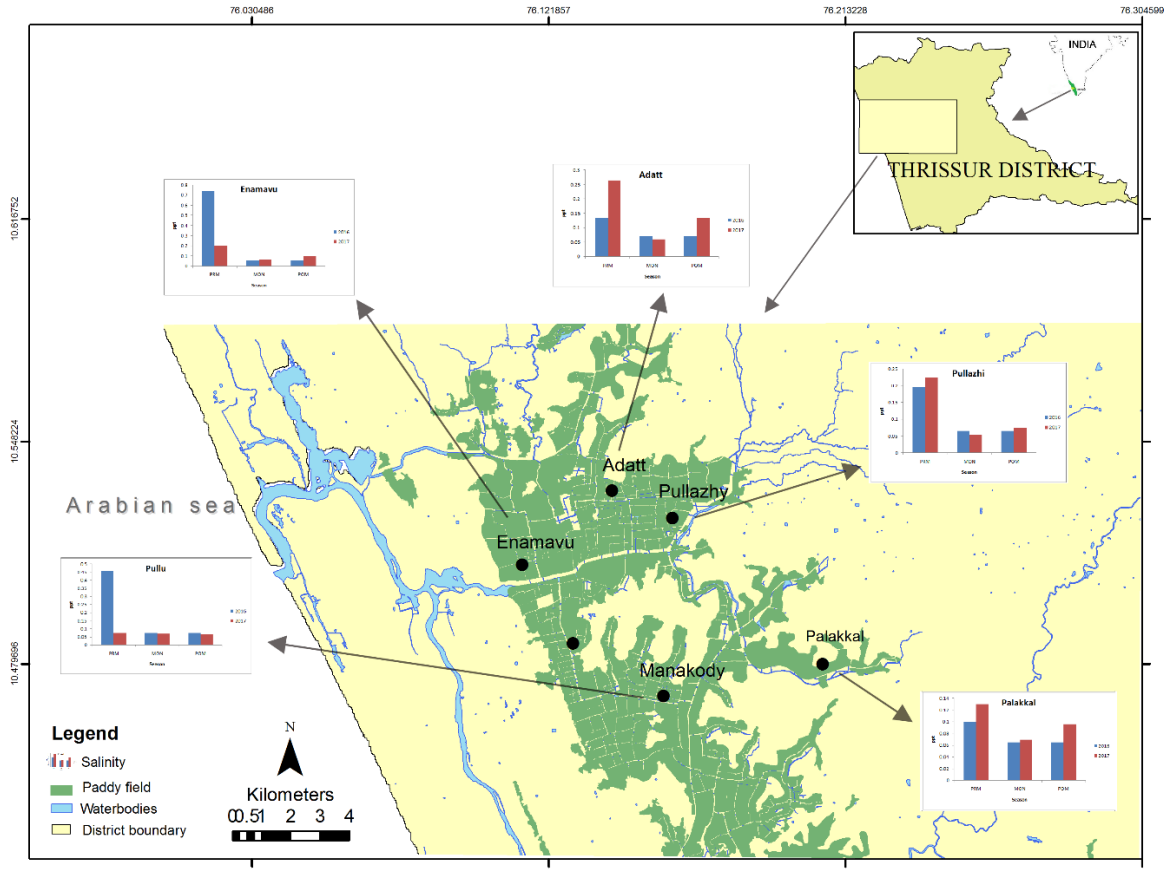

Fig. 10 Values of salinity for different areas sampled

Hardness is the presence of divalent alkaline earth metal such as calcium and magnesium with the combination of aluminium, manganese, strontium, zinc, and hydrogen ions in water. These divalent cations are essential to fish for bone and scale formation. According to Bhatnagar and Devi, (2013) hardness range 75-150 mg/l is optimum for fish culture and in the present study 54.85±15.8 mg/l was recorded. Chloride is a component of most waters and is essential in helping fish maintain their osmotic balance. Chloride concentration observed was 37.25±21.56 mg/l, which is less than the required level (100 mg/l). Naturally occurring fluoride concentrations in surface waters depend on location but are generally low and usually do not exceed 0.3mg/l and the observed value from Kole wetland is too low as 0.10 ±0.04 mg/l. Dissolved oxygen level (>5 mg/l) promote the fish growth. The lower the concentration, the greater the stress. When comparing with the required limit, Kole wetland water is under mild stress as with the value 4.85±0.21mg/l and BOD value as 1.65±0.58 mg/l, indicating that aquatic system is healthy (Bhatnagar *et al*., 2004) (Fig. 11).

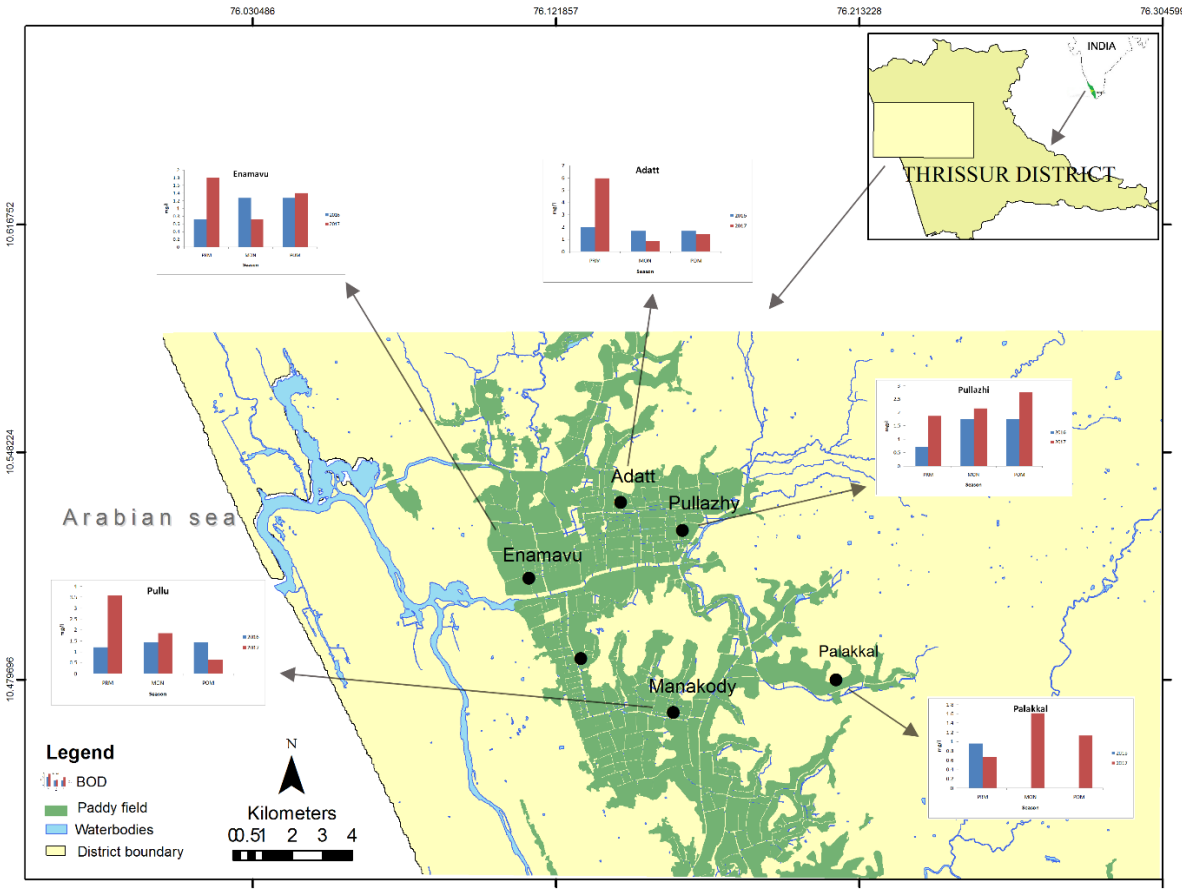

Fig. 11 Variations in BOD in the intensive study area

Sulphate is a common compound in water and it results from the dissolution of minerals from soil and rocks. Typical levels are between 0 and 1,000 mg/L. Fish tolerate a wide range of sulphate concentrations, and levels of sulphate greater than 500 mg/L are a concern only if the water is used for other purposes such as watering cattle or irrigating crops. The present value from Kole wetlands is 26.93 ± 14.44 mg/l. Phosphate is one of the essential plant nutrients which enhances algal growth and increases the primary productivity. During the current study phosphate value of Kole wetlands was 0.06 ± 0.04 mg/l, not conducive for fish culture. Algae and other plants use nitrates as a source of food. The presence of nitrates usually does not have a direct effect on aquatic insects or fish. However, excess levels of nitrates in water can create conditions that make it difficult for aquatic insects or fish to survive. Natural levels of nitrate are usually less than 1 mg/l and the observed value from Kole wetlands is 0.72 ± 0.50 mg/l and that of Iron is 1.29 ± 0.55. The results of various Physico-chemical and microbial parameters of the water samples of the wetland are presented in Figures 12 to 27.

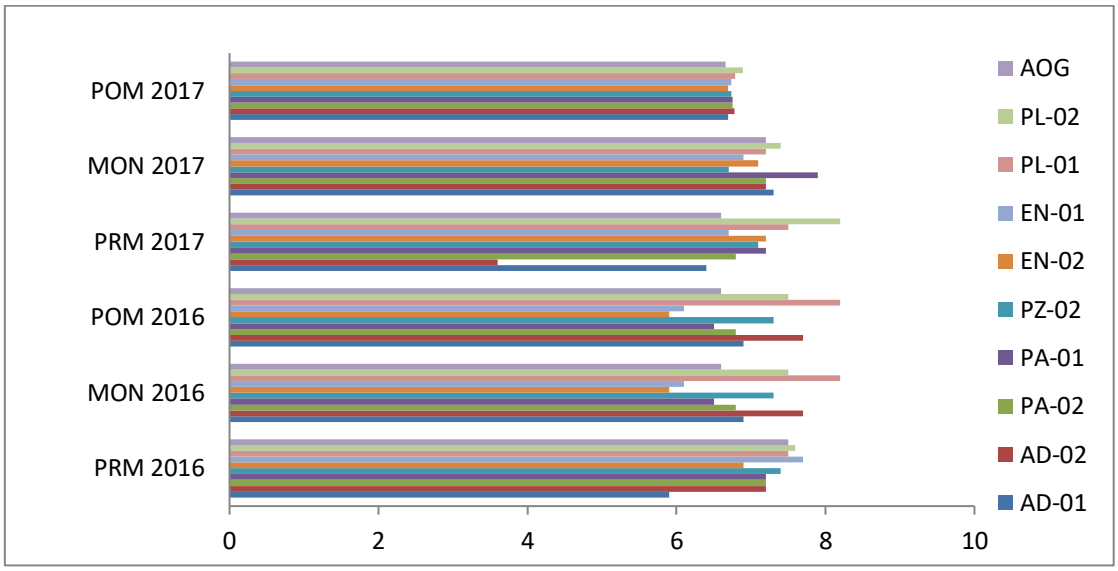

Fig. 12 pH of water from Kole wetlands of Thrissur

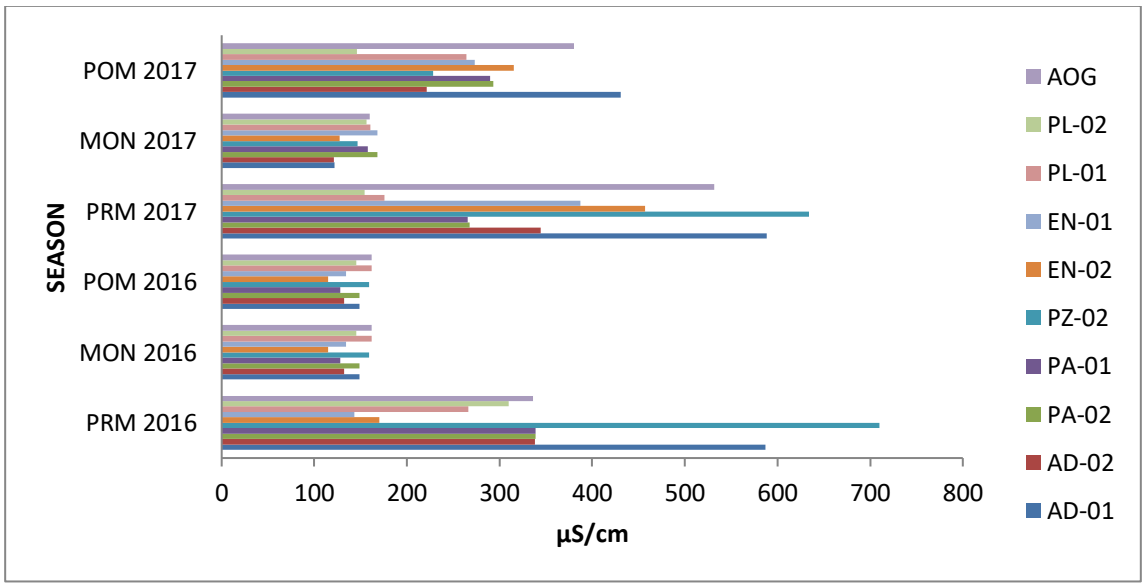

Fig. 13 Electrical Conductivity in water from Kole wetlands of Thrissur

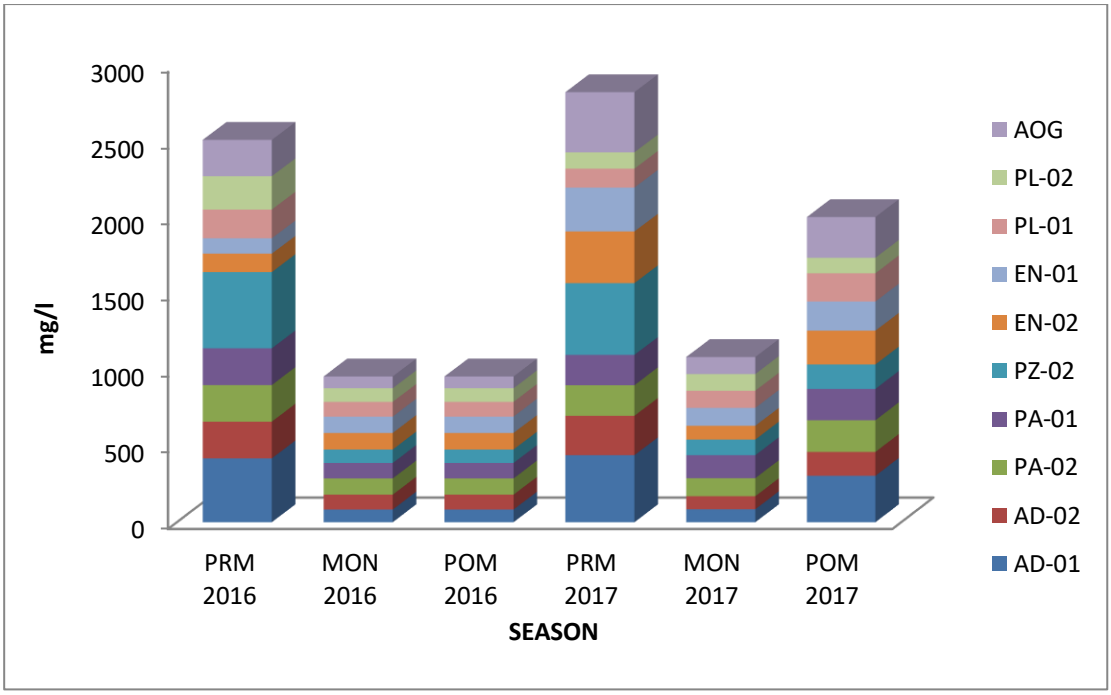

Fig. 14 Total Dissolved Solids in water from Kole wetlands of Thrissur

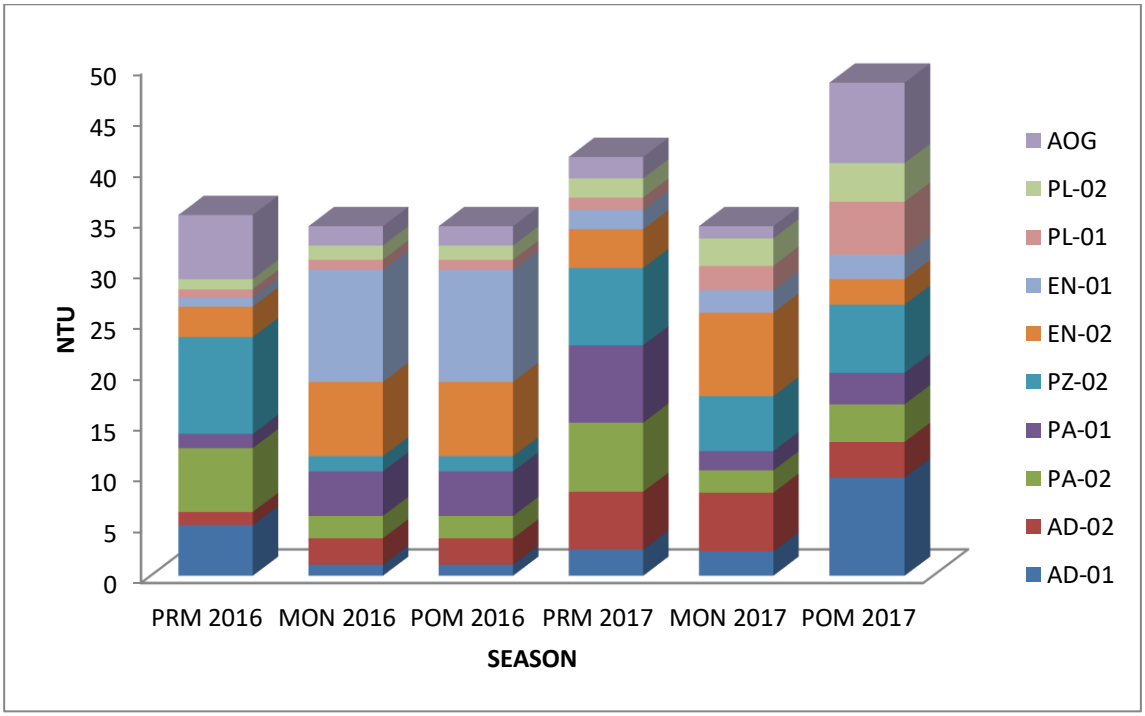

Fig. 15 Turbidity in water from Kole wetlands of Thrissur

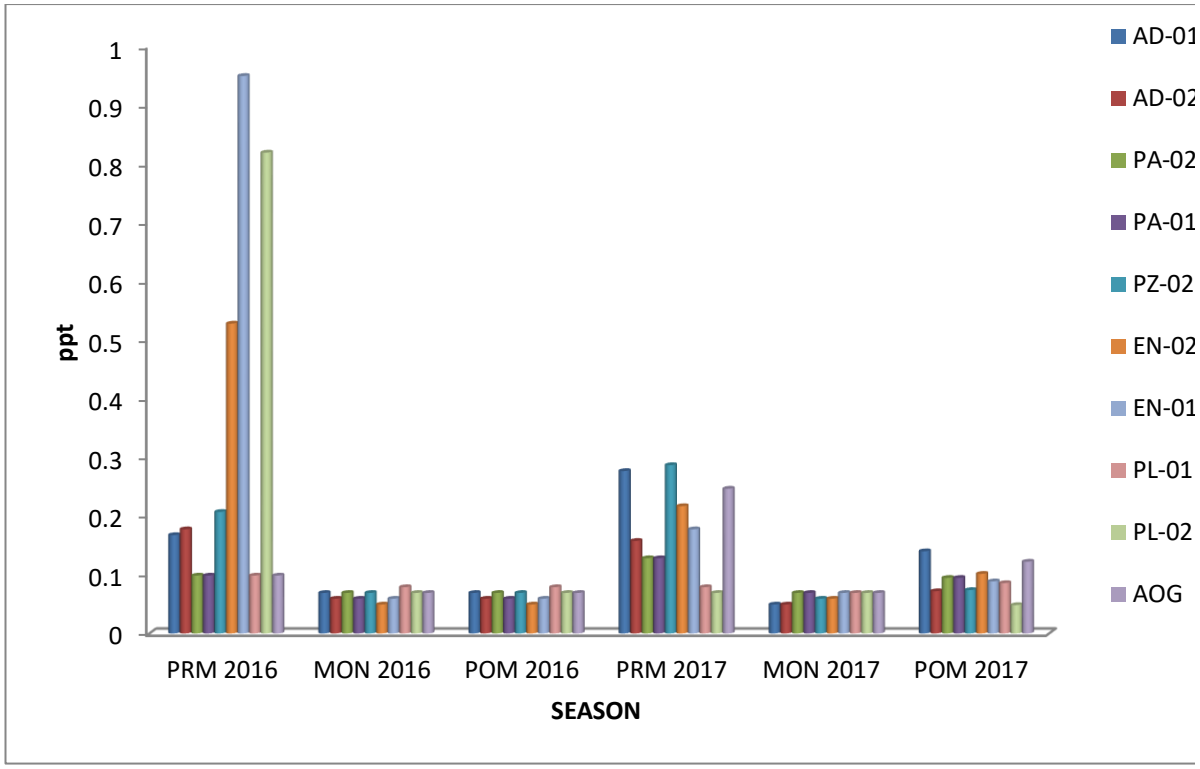

Fig. 16 Salinity in water from Kole wetlands of Thrissur

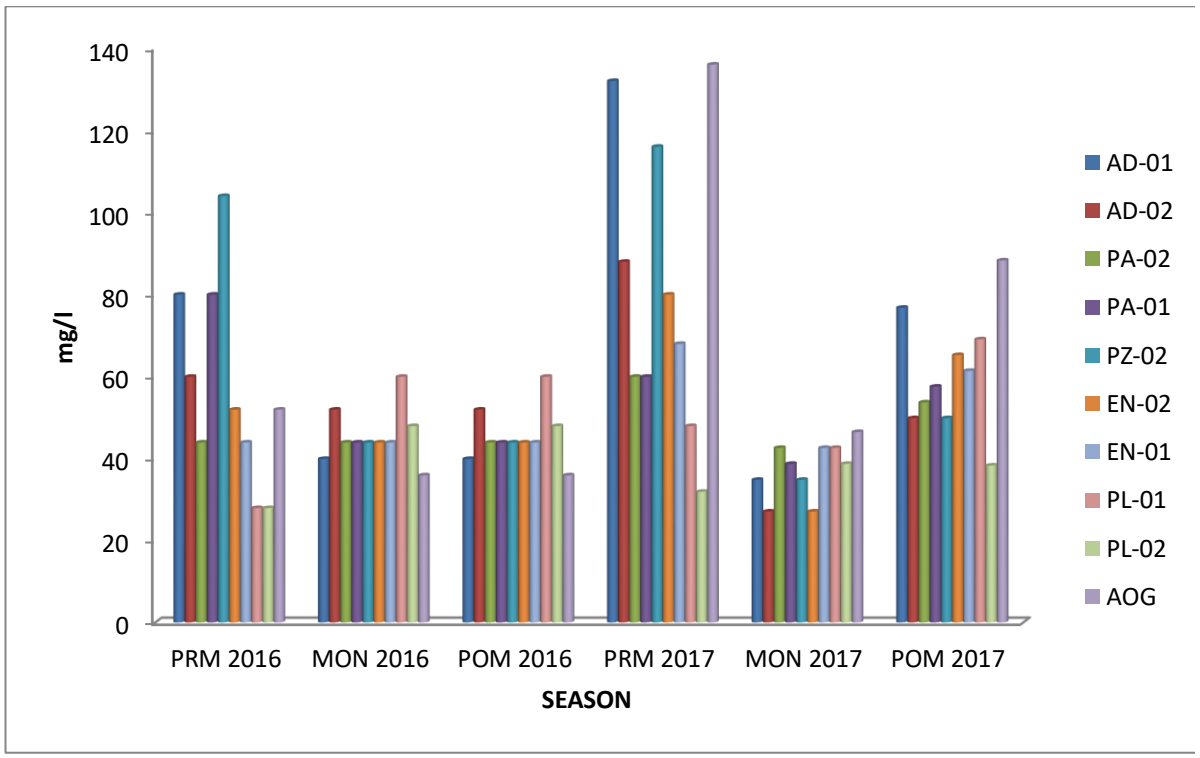

Fig. 17 Total Hardness in water from Kole wetlands of Thrissur

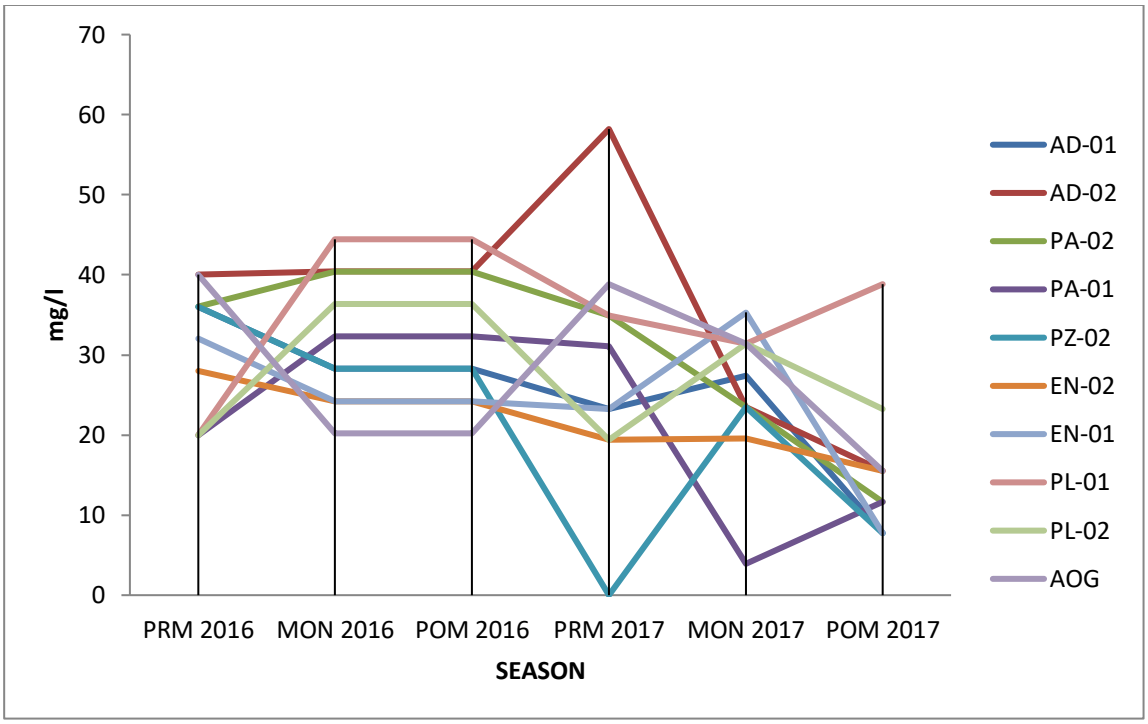

Fig.18 Total Alkalinity in water from Kole wetlands of Thrissur

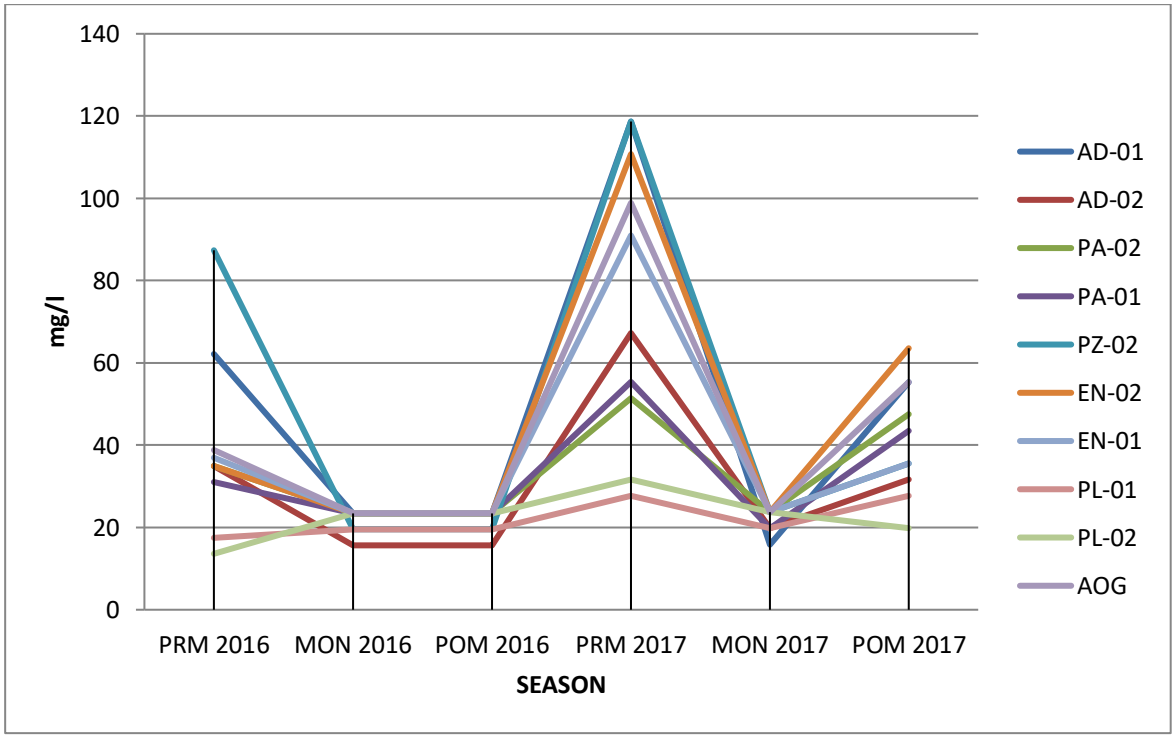

Fig.19 Chloride in water from Kole wetlands of Thrissur

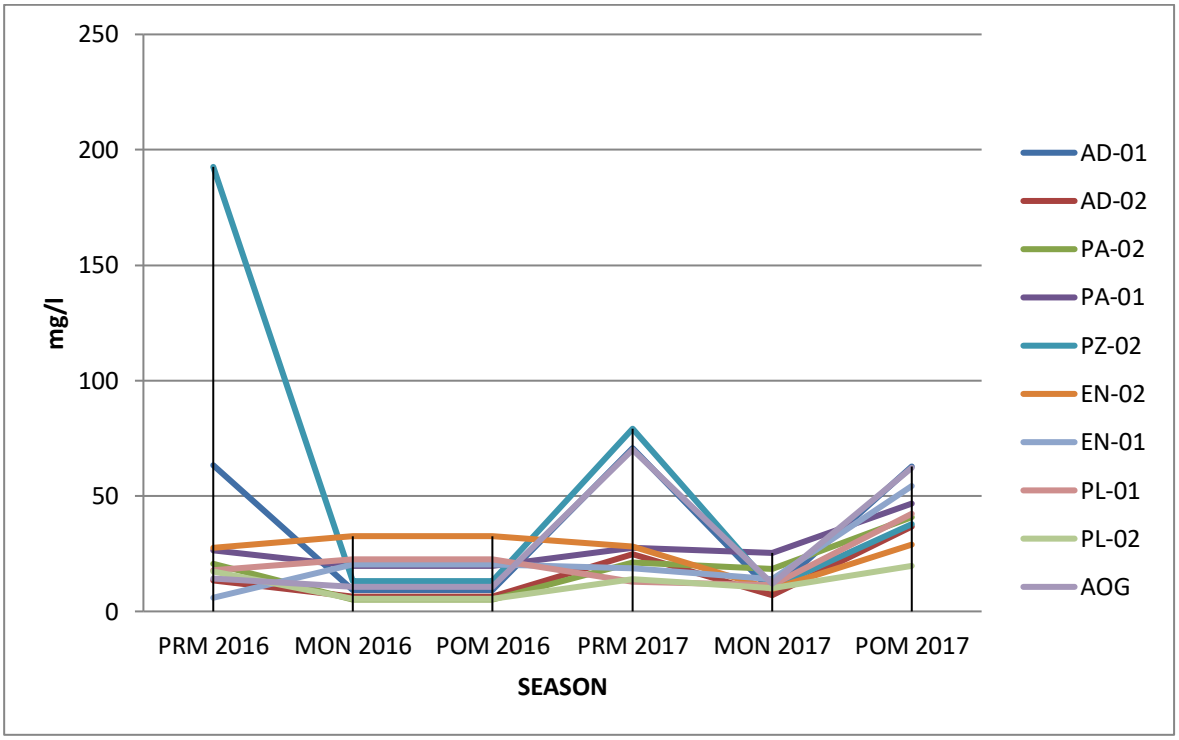

Fig. 20 Sulphate in water from Kole wetlands of Thrissur

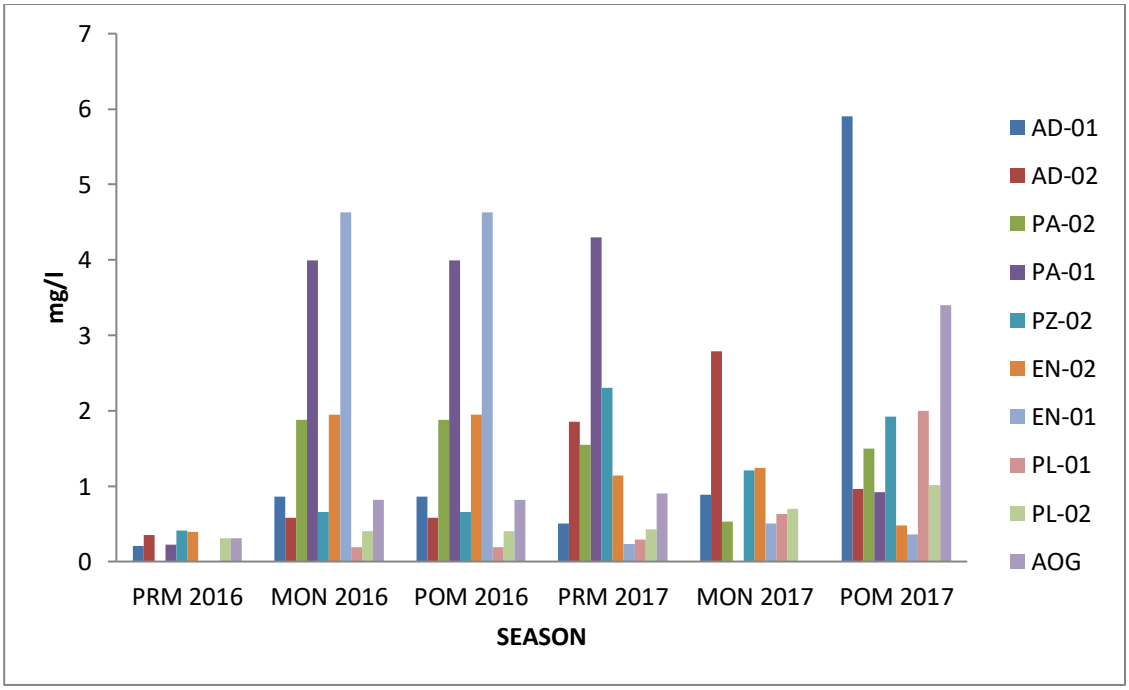

Fig. 21 Iron in water from Kole wetlands of Thrissur

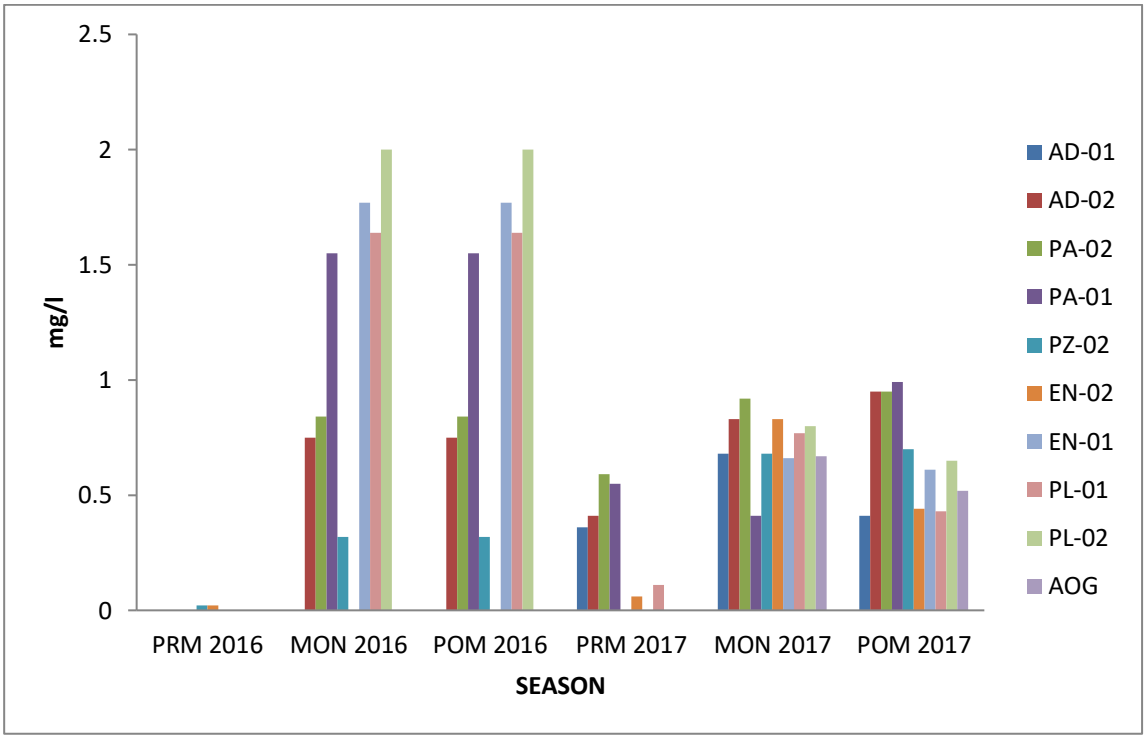

Fig. 22 Nitrate in water from Kole wetlands of Thrissur

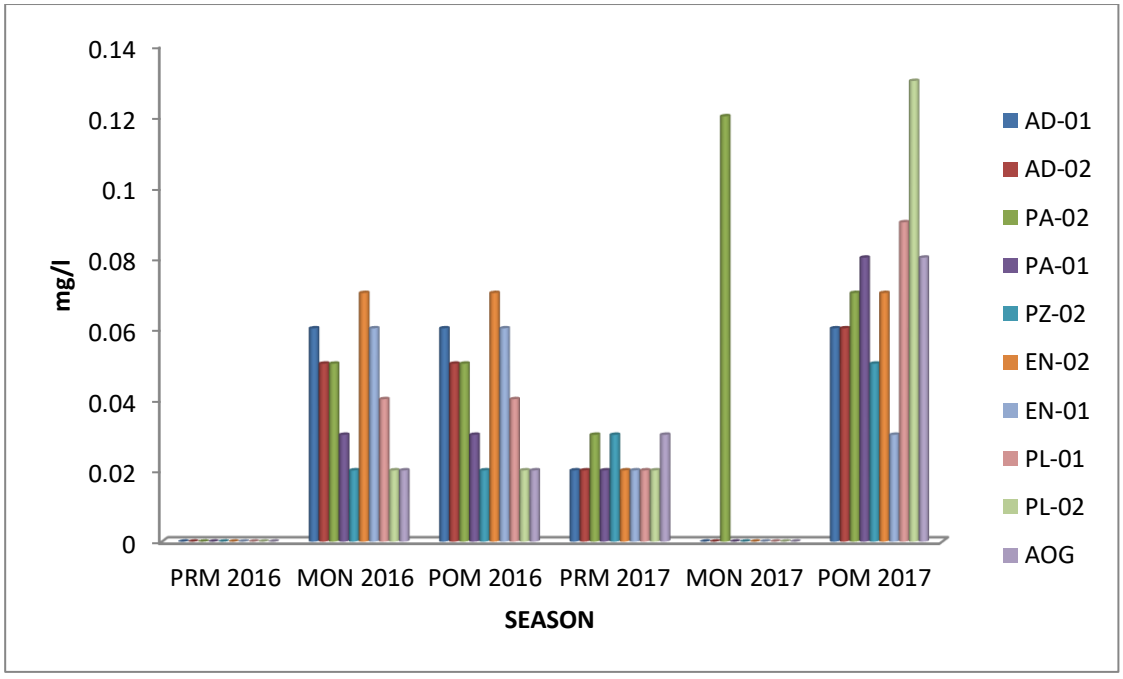

Fig. 23 Phosphate in water from Kole wetlands of Thrissur

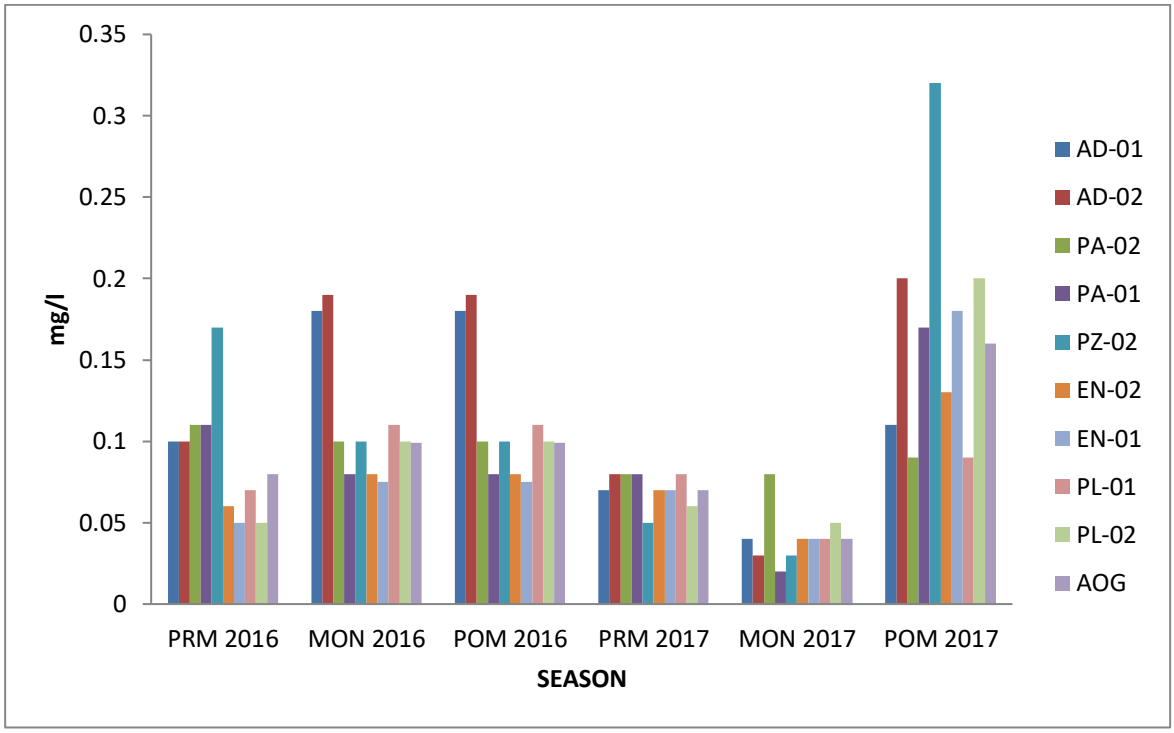

Fig. 24 Fluoride in water from Kole wetlands of Thrissur

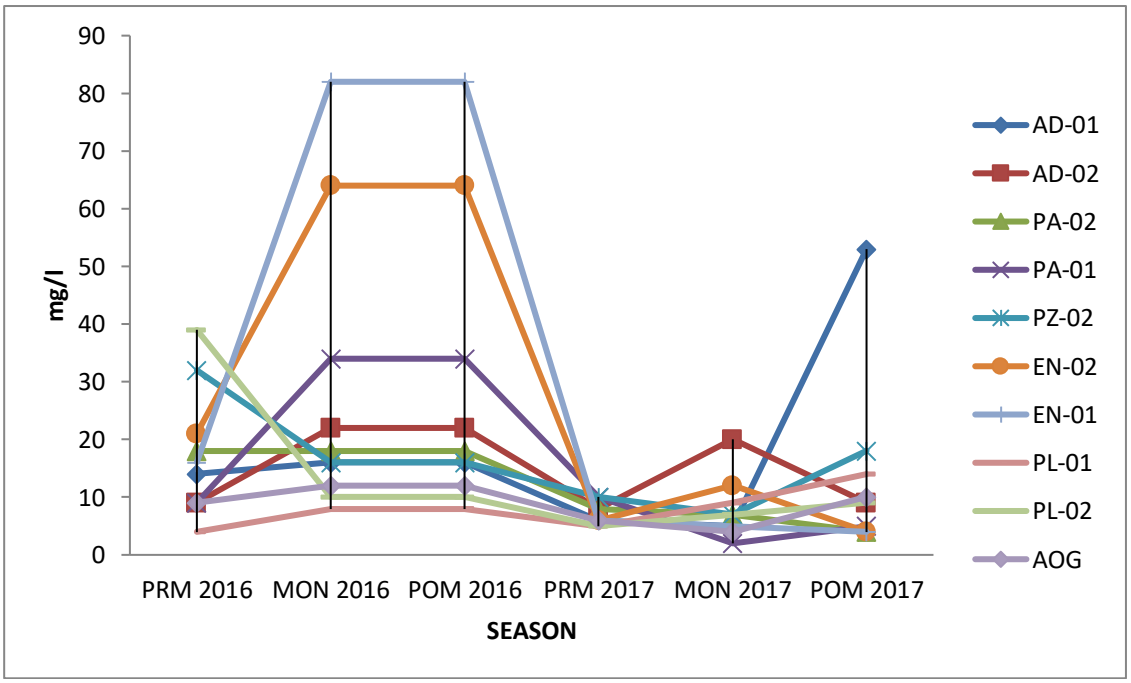

Fig. 25 Total Suspended Solids in water from Kole wetlands of Thrissur

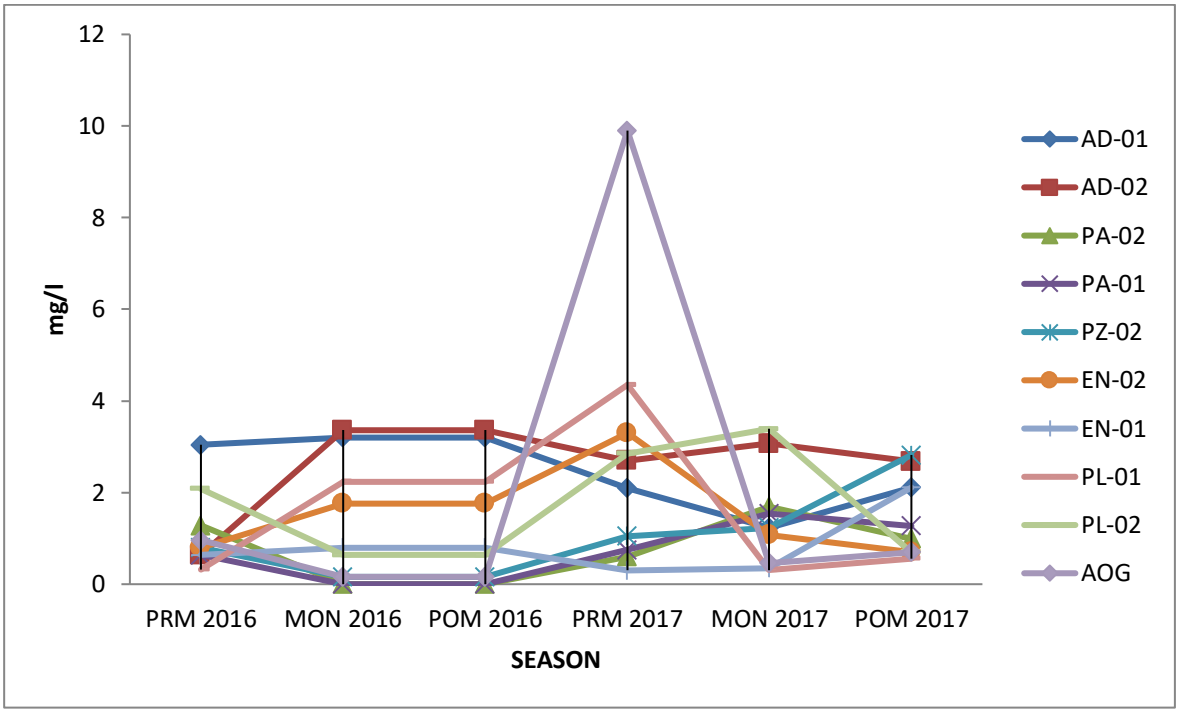

Fig. 26 Biological Oxygen Demand in water from Kole wetlands of Thrissur

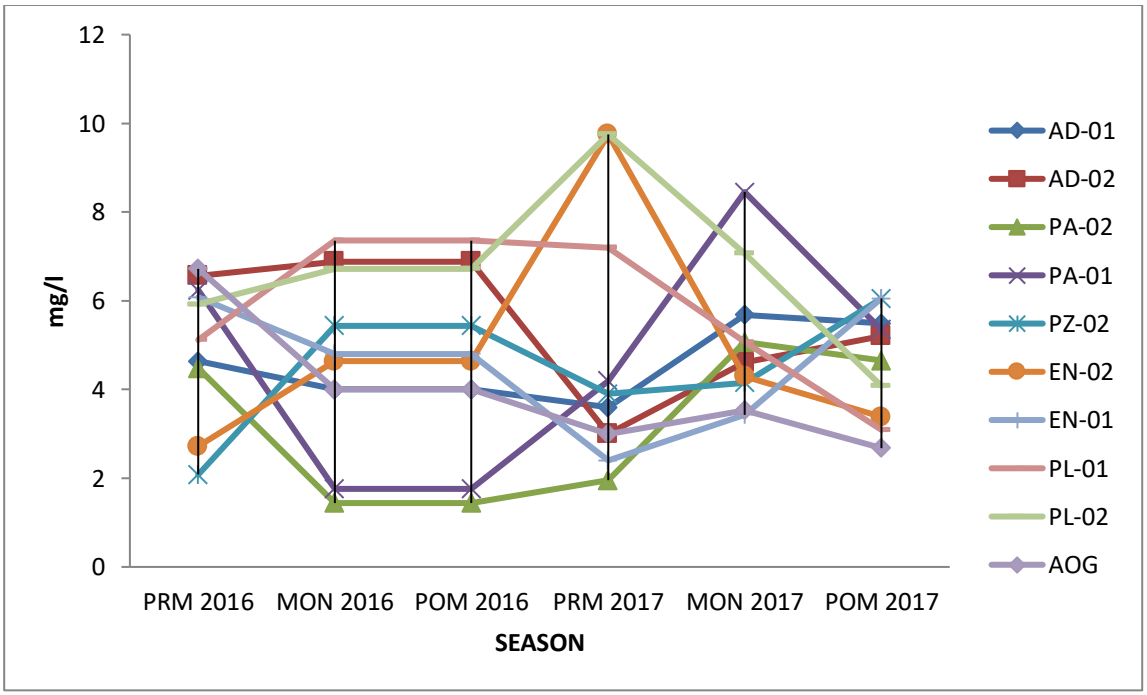

Fig. 27 Dissolved Oxygen in water from Kole wetlands of Thrissur

Discussion

Wetlands are patchy and dynamic ecosystem, with a high number of species diversity. In the present scenario of water scarcity in our country, conservation of our existing wetlands is the sole requirement to save our environment. Assessment of water quality is an indicator of health status of our wetlands. India has totally 27,403 wetlands of which 23,444 are inland wetlands and remaining 3,959 are coastal wetlands. Most of them are directly or indirectly linked with major river systems, such as Ganges, Cauvery, Godavari and Tapti. Domestic sewage, hospital wastes and industrial waste are causing pollution to the aquatic ecosystem in a large extent, there by leading to eutrophication. Present study was undertaken to assess the water quality of Kole wetlands of Thrissur. Fish perform its physiological activities like breathing, excretion of waste, feeding, salt balance, reproduction etc. in water thus the water quality is the major determining factor for fish farming or aquaculture. The results indicated that Kole wetlands is least polluted compared to other aquatic systems of Kerala and favours a moderate medium for the growth of fish.

3.2.2 Fish diversity of Kole wetlands

Fishes are the keystone species which determine the distribution and abundance of other fauna in the ecosystem. Most of the wetlands in Kerala are degraded and converted to monoculture for cultivation and so most of the indigenous flora and fauna including fishes are now restricted to protected areas (Raju *et al*., 2002). Kole wetlands are one among the richest areas with high biodiversity. Ichthyofaunal studies in Kole wetlands are low compared to the other studies like ornithology. This section deals with the food availability of birds in Kole wetlands of Thrissur. A total of 55 fish species belonging to 44 genera in 23 families of 10 orders were recorded from the study area (Table 02).

Table 2. Fishes recorded from Kole wetlands of Thrissur

Family	Order	Sl.no.	Common name	Scientific name
Anguilliformes	Anguillidae	1.	Indian Mottled Eel	*Anguilla bengalensis* (Gray, 1831)
		2.	Indonesian Shortfin Eel	*Anguilla bicolor* McClelland, 1844
Beloniformes	Hemiramphidae	3.	Congaturi Halfbeak	*Hyporhamphus limbatus* (Valenciennes, 1847)

	Belonidae	4.	Needlefish	*Xenentodon cancila* (Hamilton, 1822)
		5.	Spottail Needlefish	*Strongylura strongylura* (van Hasselt, 1823)
Clupeiformes	Clupeidae	6.	Day's Round Herring	*Dayella malabarica* (Day, 1873)
Cypriniformes	Cyprinidae	7.	Wild Common Carp	*Cyprinus* carpio Linnaeus, 1758
		8.	Striped Stone Sucker	*Garra mullya* (Sykes, 1839)
		9.	Swamp Barb	*Systomus subnasutus* (Valenciennes, 1842)
		10.	Black Line Rasbora	*Rasbora dandia* (Valenciennes, 1844)
		11.	Grass carp	*Ctenopharyngodon idella* (Valenciennes, 1844)
		12.	Malabar Danio	*Devario malabaricus* (Jerdon, 1849)
		13.	Silver Carplet	*Amblypharyngodon melettinus* (Valenciennes, 1844)
		14.	Catla	*Catla catla* (Hamilton, 1822)
		15.	Green Stripe Barb	Puntius vittatus Day, 1865
		16.	Filament Barb	*Dawkinsia filamentosa* (Valenciennes, 1844)
		17.	Mahe Barb	*Puntius mahecola* (Valenciennes, 1844)
		18.	Parrah Barb	*Puntius parrah* Day, 1865
		19.	Ticto Barb	*Pethia ticto* (Hamilton, 1822)
		20.	Rohu labeo	*Labeo rohita* (Hamilton, 1822)
		22.	Mrigal carp	*Cirrhinus cirrhosus* (Bloch, 1795)
		23.	Silver carp	*Hypophthalmichthys molitrix* (Valenciennes, 1844)
	Cobitidae	21.	Common Spiny Loach	*Lepidocephalichthys thermalis* (Valenciennes, 1846)
Cyprinodontiformes	Aplocheilidae	24.	Striped Panchax	*Aplocheilus lineatus* (Valenciennes, 1846)
Elopiformes	Megalopidae	25.	Indo-Pacific Tarpon	*Megalops cyprinoides* (Broussonet, 1782)

Perciformes	Ambassidae	26.	Day's Glassy Perchlet	*Parambassis dayi* (Bleeker, 1874)
		27.	Highfin Glassy Perchlet	*Parambassis lala* (Hamilton, 1822)
		28.	Western Ghats Glassy Perchlet	*Parambassis thomassi* (Day, 1870)
		29.	Indian Glassy Fish	*Parambassis ranga* (Hamilton, 1822)
	Anabantidae	30.	Climbing Perch	*Anabas testudineus* (Bloch, 1792)
	Carangidae	31.	Giant Trevally	*Caranx ignobilis* (Forsskal 1775)
	Channidae	32.	Striped Snakehead	*Channa striata* (Bloch, 1793)
		33.	Giant Snakehead	*Channa marulius* (Hamilton, 1822)
		34.	Spotted Snakehead	*Channa punctata* (Bloch, 1793)
		35.	Dwarf Snakehead	*Channa gachua* (Hamilton 1822)
	Cichlidae	36.	Pearl Spot	*Etroplus suratensis* (Bloch, 1790)
		37.	Mozambique Tilapia	*Oreochromis mossambicus* (Peters, 1852)
		38.	Orange Chromide	*Pseudetroplus maculatus* (Bloch, 1795)
	Gobiidae	39.	Tank Goby	*Glossogobius giuris* (Hamilton, 1822)
	Nandidae	40.	Gangetic Leaf fish	*Nandus nandus* (Hamilton, 1822)
	Osphronemidae	41.	Three spotted gourami	*Trichopodus trichopterus* (Pallas, 1770)
		42.	Spike Tailed Paradise Fish	*Pseudosphromenus cupanus* (Cuvier, 1831)
Siluriformes	Bagridae	43.	Wynad Mystus	*Mystus montanus* (Jerdon, 1849)
		44.	Spotted Mystus	*Mystus oculatus* (Valenciennes, 1840)
		45.	Yellow Catfish	*Horabagrus brachysoma* (Günther, 1864)
	Heteropneustidae	46.	Stinging Catfish	*Heteropneustes fossilis* (Bloch, 1794)
	Loricariidae	47.	Suckermouth catfish	*Plecostomus sp.*

	Siluridae	48.	Freshwater Shark	*Wallago attu* (Bloch & Schneider, 1801)
		49.	Butter Catfish	*Ompok bimaculatus* (Bloch, 1794)
		50.	Malabar Butter Catfish	*Ompok malabaricus* (Valenciennes, 1840)
Synbranchiformes	Mastacembelidae	51.	Zig-zag Eel	*Mastacembelus armatus* (Lacepède, 1800)
		52.	Malabar Spiny Eel	*Macrognathus guentheri* (Day, 1865)
	Synbranchidae	53.	Bengal Swamp Eel	*Ophisternon bengalense* McClelland, 1844
		54.	Malabar Swamp Eel	*Monopterus fossorius* (Nayar, 1951)
Tetraodontiformes	Tetraodontidae	55.	Malabar Puffer Fish	*Carinotetraodon travancoricus* (Hora & Nair, 1941)

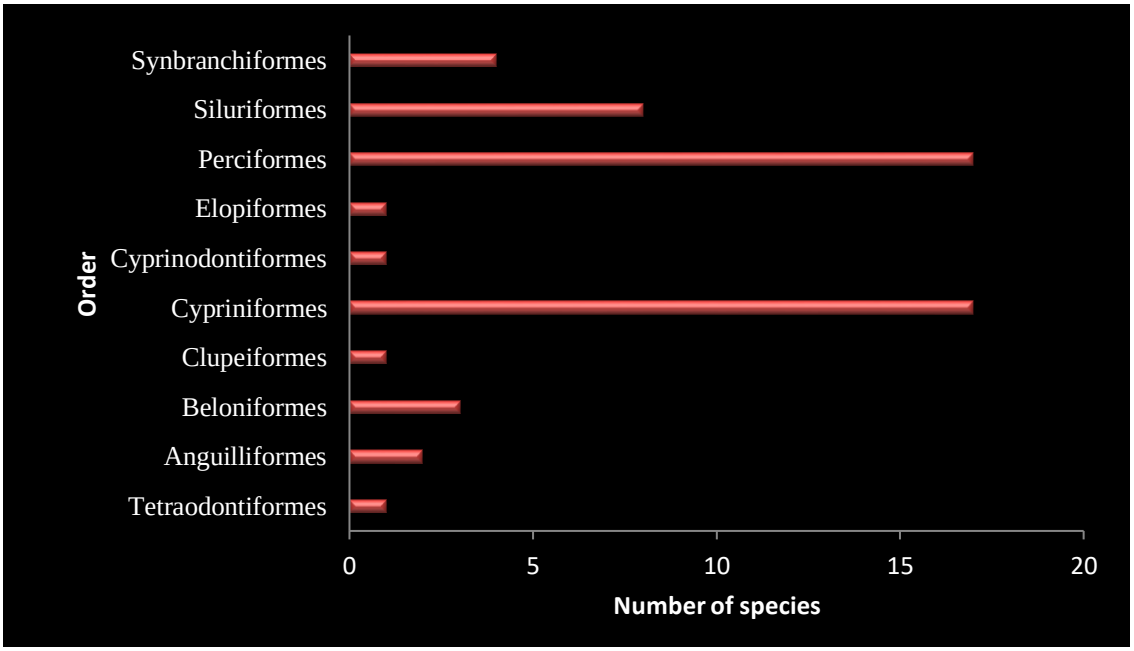

Fig. 28 Species wise abundance of fish Orders from the Kole wetlands

Table 3. Abundance of fishes collected from the Kole wetlands

Sl.no.	Species name	Scientific name	Number of fishes collected
1.	Indian Mottled Eel (Indian Longfin Eel)	*Anguilla bengalensis* (Gray, 1831)	6
2.	Indonesian Shortfin Eel (Shortfin Eel)	*Anguilla bicolor* Mc Clelland, 1844	3

3.	Congaturi Halfbeak	*Hyporhamphus limbatus* (Valenciennes, 1847)	57
4.	Needle fish	*Xenentodon cancila* (Hamilton, 1822)	735
5.	Spottail Needlefish	*Strongylura strongylura* (van Hasselt, 1823)	124
6.	Day's Round Herring	*Dayella malabarica* (Day, 1873)	13
7.	Wild Common Carp	*Cyprinus* carpio Linnaeus, 1758	39
8.	Striped Stone Sucker	*Garra mullya* (Sykes, 1839)	7
9.	Swamp Barb	*Systomus subnasutus* (Valenciennes, 1842)	1622
10.	Black Line Rasbora	*Rasbora dandia* (Valenciennes, 1844)	31
11.	Grass carp	*Ctenopharyngodon idella* (Valenciennes, 1844)	47
12.	Malabar Danio	*Devario malabaricus* (Jerdon, 1849)	188
13.	Silver Carplet	*Amblypharyngodon melettinus* (Valenciennes, 1844)	2171
14.	Catla	*Catla catla* (Hamilton, 1822)	87
15.	Green Stripe Barb	Puntius vittatus Day, 1865	33
16.	Filament Barb	*Dawkinsia filamentosa* (Valenciennes, 1844)	612
17.	Mahe Barb	*Puntius mahecola* (Valenciennes, 1844)	173
18.	Parrah Barb	*Puntius parrah* Day, 1865	210
19.	Ticto Barb	*Pethia ticto* (Hamilton, 1822)	63
20.	Rohu labeo	*Labeo rohita* (Hamilton, 1822)	32
21.	Mrigal carp	*Cirrhinus cirrhosus* (Bloch, 1795)	51
22.	Silver carp	*Hypophthalmichthys molitrix* (Valenciennes, 1844)	19
23.	Common Spiny Loach	*Lepidocephalichthys thermalis* (Valenciennes, 1846)	239

24.	Striped Panchax	*Aplocheilus lineatus* (Valenciennes, 1846)	141
25.	Indo-Pacific Tarpon	*Megalops cyprinoides* (Broussonet, 1782)	3
26.	Day's Glassy Perchlet	*Parambassis dayi* (Bleeker, 1874)	17
27.	Highfin Glassy Perchlet	*Parambassis lala* (Hamilton, 1822)	517
28.	Western Ghats Glassy Perchlet	*Parambassis thomassi* (Day, 1870)	11
29.	Indian Glassy Fish	*Parambassis ranga* (Hamilton, 1822)	65
30.	Climbing Perch	*Anabas testudineus* (Bloch, 1792)	109
31.	Giant Trevally (Yellowfin Jack)	*Caranx ignobilis* (Forsskal, 1775)	4
32.	Striped Snakehead	*Channa striata* (Bloch, 1793)	8
33.	Giant Snakehead	*Channa marulius* (Hamilton, 1822)	13
34.	Spotted Snakehead	*Channa punctata* (Bloch, 1793)	2
35.	Dwarf Snakehead	*Channa gachua* (Hamilton, 1822)	3
36.	Pearl Spot	*Etroplus suratensis* (Bloch, 1790)	238
37.	Mozambique Tilapia	*Oreochromis mossambicus* (Peters, 1852)	66
38.	Orange Chromide	*Pseudetroplus maculatus* (Bloch, 1795)	479
39.	Tank Goby	*Glossogobius giuris* (Hamilton, 1822)	6
40.	Gangetic Leaf fish	*Nandus nandus* (Hamilton, 1822)	179
41.	Three spotted gourami	*Trichopodus trichopterus* (Pallas, 1770)	41
42.	Spike Tailed Paradise Fish	*Pseudosphromenus cupanus* (Cuvier, 1831)	34
43.	Wynad Mystus	*Mystus montanus* (Jerdon, 1849)	9
44.	Spotted Mystus	*Mystus oculatus* (Valenciennes, 1840)	19

45.	Yellow Catfish (Gunther's Catfish)	*Horabagrus brachysoma* (Günther, 1864)	311
46.	Stinging Catfish	*Heteropneustes fossilis* (Bloch, 1794)	117
47.	Suckermouth catfish	*Plecostomus sp.*	67
48.	Freshwater Shark	*Wallago attu* (Bloch & Schneider, 1801)	19
49.	Butter Catfish	*Ompok bimaculatus* (Bloch, 1794)	13
50.	Malabar Butter Catfish	*Ompok malabaricus* (Valenciennes, 1840)	4
51.	Zig-zag Eel (Tyre-track Eel)	*Mastacembelus armatus* (Lacepède, 1800)	28
52.	Malabar Spiny Eel	*Macrognathus guentheri* (Day, 1865)	46
53.	Bengal Swamp Eel	*Ophisternon bengalense* McClelland, 1844	7
54.	Malabar Swamp Eel	*Monopterus fossorius* (Nayar, 1951)	3
55.	Malabar Puffer Fish	*Carinotetraodon travancoricus* (Hora & Nair, 1941)	933
Total number of individuals			**10074**

Species wise abundance of fish Orders from the study area is summarized in the Fig.28. The study revealed that the Order Perciformes (17) and Cypriniformes (17) were having the highest number of species followed by Siluriformes (8) Synbranchiformes (4), Beloniformes(3), Anguilliformes (2), Elopiformes (1), Tetraodontiformes (1), Clupeiformes (1), Cyprinodontiformes (1). The most abundant fish species recorded were *Amblypharyngodon melettinus* (2171 individuals) and *Systomus subnasutus* (1622 individuals) (Table 03).

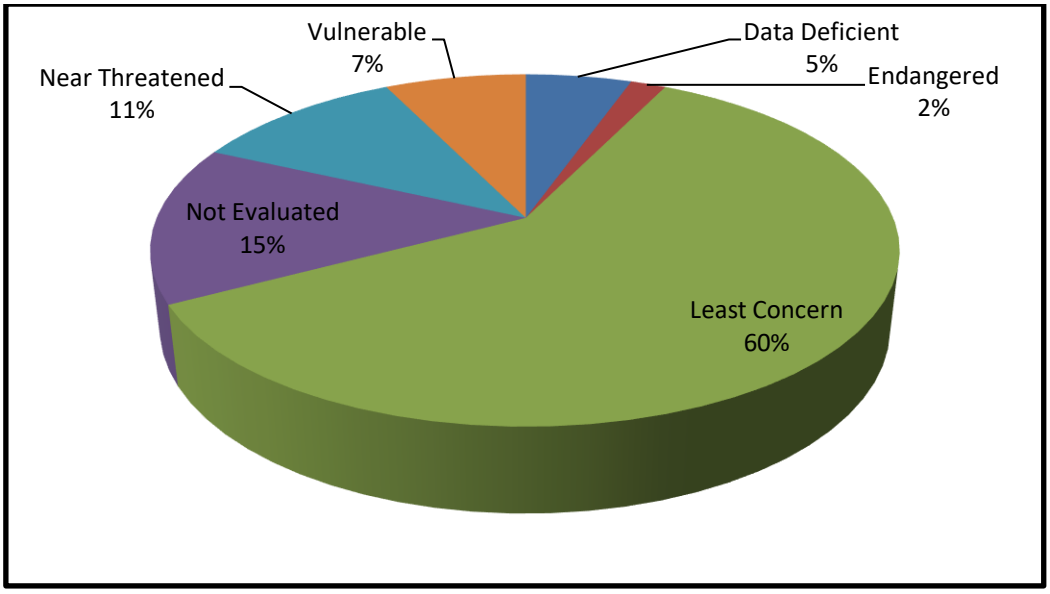

Fig. 29 IUCN based classification of fishes of Kole wetlands

Based on IUCN status (2017) (Fig. 29) *Monopterus fossorius* belonged to Endangered category and endemic to Kerala, while *Anguilla bengalensis, Anguilla bicolor, Hypophthalmichthys molitrix, Wallago attu, Ompok bimaculatus* and *Oreochromis mossambicus* are the Near Threatened Category. Kerala is well known for endemism and four endemic species namely *Dayella malabarica, Puntius mahecola, Puntius parrah* and *Monopterus fossorius* were recorded from Kole wetlands. Similarly 11 species endemic to Western Ghats were also recorded from Kole wetlands and they are *Garra mullya, Systomus subnasutus, Devario malabaricus, Dawkinsia filamentosa, Parambassis thomassi, Mystus montanus, Mystus oculatus, Horabagrus brachysoma, Macrognathus guentheri, Ompok malabaricus* and *Carinotetraodon travancoricus.*

3.2.3 Seasonal variation in fish abundance

Abundance of fish varied depending on the season and year. Fish abundance was lowest in the year 2016 compared to 2015 and 2017 (Fig. 30). Similarly in monsoon the abundance of fish was high and pre monsoon period it was lowest (Fig. 31).

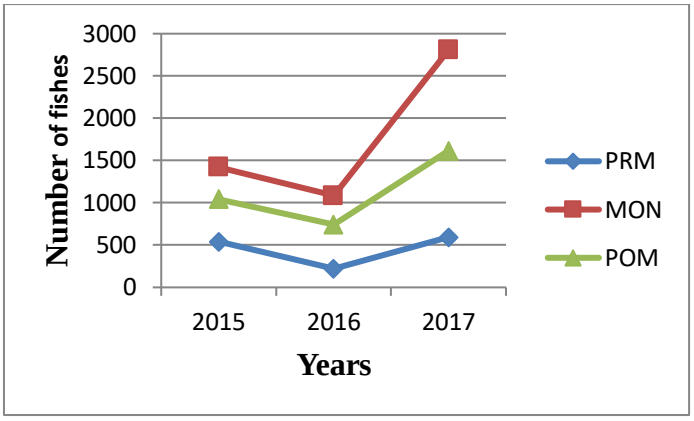

Fig. 30 Seasonal variation of fishes during the study period (2015 to 2017)

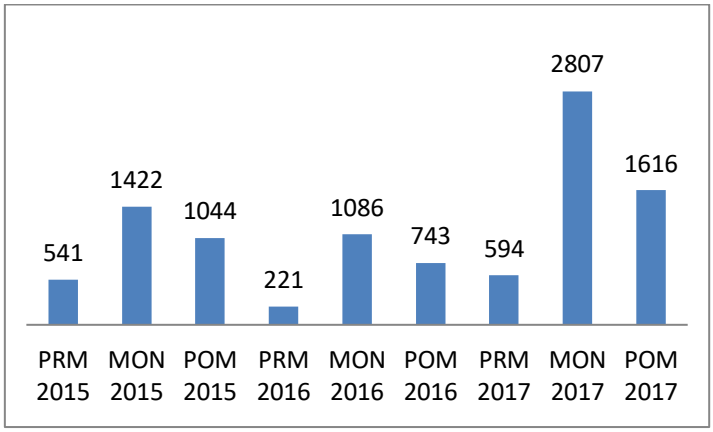

Fig. 31 Seasonal variation of fishes during different seasons

The introduction of exotic fishes as part of fish cultivation during monsoon season has resulted in the competition of fish for food and space and ultimately resulting in the decline of indigenous species. The presence of exotic species of fishes namely *Oreochromis mossambica, Catla catla, Cyprinus carpio, Labeo rohita, Ctenopharyngodon idellus* and *Cirrhinus mrigala* were noticed in the habitat. Along with this 3 invasive species; Highfin Glassy Perchlet *Parambassis lala,* African Sailfin Suckermouth catfish *Plecostomus* sp. and Three spotted gourami *Trichopodus trichopterus* were also recorded during 2017 monsoon season. Mozambique Tilapia *Oreochromis mossambicus* is one of the most harmful invasive species in aquatic ecosystems worldwide and it was introduced to India for aquaculture in 1952. Now tilapia occupies wide variety of aquatic habitats both lentic and lotic. Studies show that Mozambique Tilapia have a predatory effect on Common spiny loach *Lepidocephalichthys thermalis,* an indigenous fish there by reducing the loach population. Three spotted gourami, an ornamental species have already recorded in Vembanad Lake in Kerala. This species is an

opportunistic carnivore and is suspected to be a competitor for the native species. Being an air breather, gourami has the potential to live in different pH conditions. Similarly sucker mouth catfish was introduced to several Asian countries for the aquarium trade. The ecological effects of this species include disruption of aquatic food chain by overgrazing on the benthic algae and detritus thereby leading to the decline of native species. Highfin Glassy Perchlet *Parambassis lala* another exotic/ornamental, listed as 'Near Threatened', is a carnivorous fish species is a native of North-east India, Bangladesh and Myanmar.

Kerala Fisheries Department is distributing seeds to the farmers for fish cultivation and the seeds were imported from Bengal through Andhra Pradesh, *Paramabassis lala*, being a local fish of Bengal was also unknowingly packed up with the seeds to Kerala. According to the fisherman of Pullazhi, Puzhakkal and Adatt Kole wetlands, *Parambassis lala* is a first sighting for them, with a number of about 200-300 in a single catch (from Pullazhi Kole wetland). Earlier these exotic as well as ornamental species were fascinating creatures to the fishermen, later on raising concern about its impact on the indigenous fish wealth. According to them Ichthyofaunal diversity and fish wealth of Kole wetlands was reduced drastically.

3.3 Feeding behaviour of wetland birds

3.3.1 Oriental Darter (*Anhinga melanogaster)*

Plate 05. Oriental darter (*Anhinga melanogaster*)

Oriental darter is a piscivorous bird belongs to the family Anhingidae. It belongs to the Near Threatened category of IUCN (2017) (Plate 05). Oriental darter is a diurnal feeder, forages solitary most of the time. Like cormorants, they did not forage in all water sources like small ditches and pools etc. They forage mainly in water depth more than 30 cm (n=184). Large population of Oriental darter was seen during the monsoon and post-monsoon season and least during pre-monsoon. July – November is the most active season for Oriental darter. Like cormorants these birds do not breed in all heronries. They prefer to breed in heronries with tall trees and large canopy cover. May-September is the breeding season and they collect food for their mates and young ones from the Kole wetlands. They forage solitarily and in a silent mode. After completing the feeding activities they were seen basking in the bund, spreading the wings. They feed varieties of fishes like Silver carplet *Amblypharyngodon melettinus* (Valenciennes, 1844), Mahe Barb *Puntius mahecola* (Valenciennes, 1844), Swamp Barb *Systomus subnasutus* (Valenciennes, 1842*)*, Climbing Perch *Anabas testudineus* (Bloch, 1792), Rohu *Labeo rohita* (Hamilton, 1822), Pearl Spot *Etroplus suratensis* (Bloch, 1790) and Striped Snakehead *Channa striata* (Bloch, 1793).

Oriental darter is a long distance diver, and dives in a linear manner and takes 18-57 minutes to complete a feeding bout. Darters are good divers, which dive very slowly under the water (100-160 seconds) and lift their neck and beak while placing their body under the water. They catch their prey under the water, lift their neck toss their prey and open their beak and swallow it immediately. Fishermen consider Darter as a threat to their fish farms, because they feed Rohu and other farm specific species in an enormous quantity. The most actively feeding hours were from 06.00-10.00 and 16.00- 18.00 and it takes around 18-57 minutes to complete a feeding bout.

3.3.2 Little cormorant (*Microcarbo niger)*

Plate 06. Little cormorant (*Microcarbo niger)*

Little cormorant is also an exclusively piscivorous bird belongs to the family Phalacrocoracidae (Plate 06). It belongs to the Least Concern category of IUCN. Little cormorant is a diurnal feeder, forages solitary as well as in group (group of 300-847 individuals). They forage in all water sources like small ditches, pools, canals, open waters and river as well as in various water depth (> 10cm). Large population of Little cormorant was seen during the monsoon and post-monsoon season and least during pre-monsoon. With the advent of monsoon, they were seen in a flock of thousands of individuals. July –November is the most active season for Little cormorants. These birds also breeds in several areas near the Kole wetlands during May-September and during 2017 and the breeding period extended to

October too. During the monsoon season irrespective of rain, large flock of cormorants were seen foraging in the Kole wetlands and nearby streams.

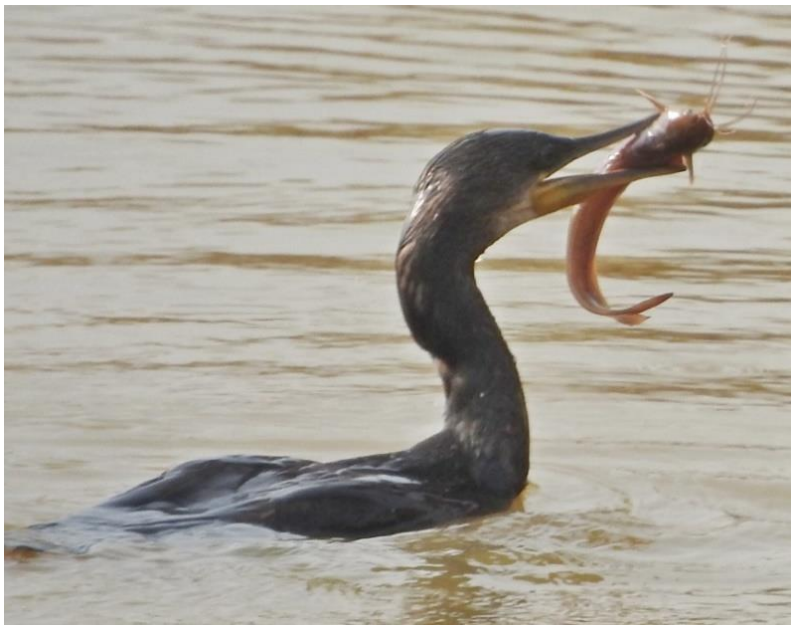

Plate 07. Little cormorant with a catch

They forage in groups and a typical sound was also made while swimming and diving through the water. Feeding activity was highest during morning hours (06.30–8.00) and evening (16.30–18.30) hours. After completing the feeding activities they were seen basking in the bund, spreading the wings. They feed varieties of fishes like Green Stripe Barb *Puntius vittatus* (Day, 1865), Silver carplet *Amblypharyngodon melettinus* (Valenciennes, 1844), Mahe Barb *Puntius mahecola* (Valenciennes, 1844*)* Swamp Barb *Systomus subnasutus* (Valenciennes, 1842) and Stinging Catfish *Heteropneustes fossilis* (Bloch, 1794). Little cormorants are short distance divers, and dive in an irregular manner and take 20-35 minutes to complete a feeding bout. Cormorants are good divers, which dive very fastly under the water (10-52 seconds) and lift their neck and beak while placing their body floating in the water. They catch their prey under the water, hold the prey for few seconds (2-49 seconds), kill the prey by pressing its head and engulfs the fish (first head portion) and dip the beak to have a sip of water. Kleptoparasitism is well displayed by the Little cormorants. They dive by keeping the prey in the beak and also it was observed that they catch the fish from water and feed the fish from land. Along with Oriental darter, fishermen consider Little cormorants (Plate 07) as a major threat to their fish farms, as they feed almost all varieties of indigenous

fishes as well as farm specific species. Covering of fish farms with nets and bursting of crackers are mainly done to deter the cormorant flocks from fish farms.

3.3.3 Asian Openbill Stork (*Anastomus oscitans*)

Plate 08. Asian openbill stork with the catch

The Asian openbill stork is a large wading bird with greyish or white with glossy black wings and tail characterized by long legs, neck, and bill, which meets together only at the tip (Hancock *et al.* 1993). The peculiar name "open bill" is derived because of the presence of the distinctive gap formed between the recurved lower and arched upper mandible of the beak in adult storks (Plate 08). Young storks do not have this gap. The fine brush like structure at the cutting edges of the mandible gives them better grip while holding the snails (Gosner 1993). Asian openbill stork (*Anastomus oscitans*) is known as "*Njhaunipottan*" (one who cracks snail) and "*Cherrakokkan*" (without a closed bill). Asian openbill storks forage in Kole Wetlands in different microhabitats like mudflats, shallow water streams, paddy fields, small ditches, and along the bank of small canals characterized by diurnal feeding. In response to habitat conditions, Openbill stork displayed local movements. Large population of Openbill stork was seen during the post-monsoon period and least during monsoon. With the advent of post-monsoon, dewatering of paddy fields started, and Openbill storks were seen in a flock of 63–378 individuals. September–January is the most active season for Openbill storks.

Dewatered Kole lands and harvested paddy fields are the favourite foraging ground for the storks. During the dewatering time, it was seen that Openbill storks reached the feeding ground after 10 to 25 m after sunrise. They arrived the Kole lands as solitary and in groups of three to seven individuals and immediately started feeding. During the month of December and January, it was observed that Openbill stork arrived as one by one to the harvested paddy field and they stood idle on a heap of hay or in a raised mudflat by drooping their head and beak. Usually the individuals stood in a group (inter-bird distance of 2.0–10.0 m) and they started feeding only after 30–55 m, one by one individually. Moreover they always keep a distance and get scattered away to choose different feeding areas within the same habitat. Feeding activity was highest during morning (06.30–09.30) and evening (15.30–18.30) hours. In between, the activity was less, and most of the individuals went for roosting in the nearby trees in the bund. It had been observed that after the morning feeding bout, they exhibit preening, basking, and soaring behaviour and they changed the feeding ground. The selection of feeding ground mainly depended on the foraging success (prey-capturing success and with least disturbance). Asian openbill stork feed on molluscs, mainly snail *Pila globosa* and freshwater mussel (genus *Unio*). The favourite food item was *Pila globosa* which are abundantly distributed throughout the wetlands.

They undergo group foraging in shallow waters (water depth < 15 cm), while solitary in mudflats and in small canals. In case of apple snails of small size, with the support of upper mandible, the Openbill stork insert their lower mandible into the snail's shell and wave their beak to right and left direction very fast (3-7 times) take up the flesh out and swallow within 1-2 seconds. While in the case of apple snails of large size, with the support of upper mandible, the Openbill stork insert their lower mandible into the snail's operculum, keeping the snail inside the water itself, so that it is easy to open the shell. Kleptoparasitism is well displayed by Openbill storks also. They keep the prey in the gap of the bill and sometimes flew away to another location and feed it. The shells of *Pila* and *Unio* discarded by the storks were collected from the Kole lands and measured using vernier callipers and it was seen that *Pila* shell size ranged from 2.53 to 8.3 cm in length and 4.83 to 3.92 cm in breadth (n = 206) and *Unio* ranges from 4.7 to 6.15 cm in length and 2.94 to 3.36 cm in breadth (n = 113). Feeding on crab by Openbill stork was recorded only in a single occasion. Openbill stork feeding on fishes was not supported from the observations from Kole lands. *Anastomus oscitans* forage in groups as well as in single and also with mixed flock consisting of Painted storks (*Mycteria leucocephala*), Black-headed ibis (*Threskiornis melanocephalus*), Grey heron (*Ardea cinerea*), Purple heron (*Ardea purpurea*), Indian pond heron (*Ardeola grayii*), Little egret

(*Egretta garzetta*), Intermediate egret (*Mesophoyx intermedia*), and Great egret (*Ardea alba*). Openbill stork was a long-distance walker and generally walks forward in a linear fashion and thoroughly wades in the substrate. It walks continuously probing in the substrate, up to a distance of more than 60–110 m, touches the end of the paddy field, and returns back after moving straight through the vegetation side along the bunds. This zigzag movement pattern is found to be a simple strategy to find almost every patch of food.

Floating behaviour of the Asian open bill stork was reported for the first time from Kole wetlands (Greeshma and Jayson, 2016 b). Crushing of shells and feeding on fishes by Asian open bill stork were not supported from observations of this study. A detailed report on feeding behaviour of Asian open bill stork is already published from this study (Greeshma and Jayson, 2018).

3.3.4 Leftover analysis from roosts

A total of 214 samples were collected from the heronries and the samples consisted of 16 species of fishes, one species of shrimp and 2 species of frogs (Table 04). Per cent composition of different prey items collected from the roosts showed that *Amblypharyngodon melettinus* represented the maximum numbers (Fig. 32). When biomass is considered highest biomass was obtained for the species *Euphlyctis hexadactylus* (Fig. 33). In several occasions it was seen that, the food was regurgitated as a bolus consisting of several types of fishes (Plates 9 and 10). It was observed that only few samples fell down during regurgitation. Also, it was too difficult to collect samples due to the pestering crows, Night herons and cats picked up the prey items fallen from the nest.

Table 04. Species of fishes and frogs identified from the left over analysis from heronries

Sl. no.	Species	Number	Weight (gm)
1.	*Channa striata*	4	234
2.	*Euphlyctis hexadactylus* (Frog)	7	1143
3.	*Hoplobatrachus tigerinus* (Frog)	2	103.3
4.	*Heteropneustes fossilis*	3	73.5
5.	*Etroplus suratensis*	4	65
6.	*Anabas testudineus*	5	86
7.	*Puntius vittatus*	5	6.3
8.	*Amblypharyngodon melettinus*	85	80.5
9.	*Systomus subnasutus*	2	93
10.	*Etroplus maculatus*	34	25
11.	*Puntius parrah*	29	26.6

12.	*Puntius filamentosus*	3	5.1
13.	*Nandus nandus*	2	34
14.	Shrimp	8	35.3
15.	*Labeo dussumieri*	2	153
16.	*Puntius mahecola*	6	9.2
17.	*Caranx melampygus*	1	1.5
18.	*Channa marulinus*	3	159
19.	*Xenentodon cancila*	9	12.4
	Total	**214**	**2345.7**

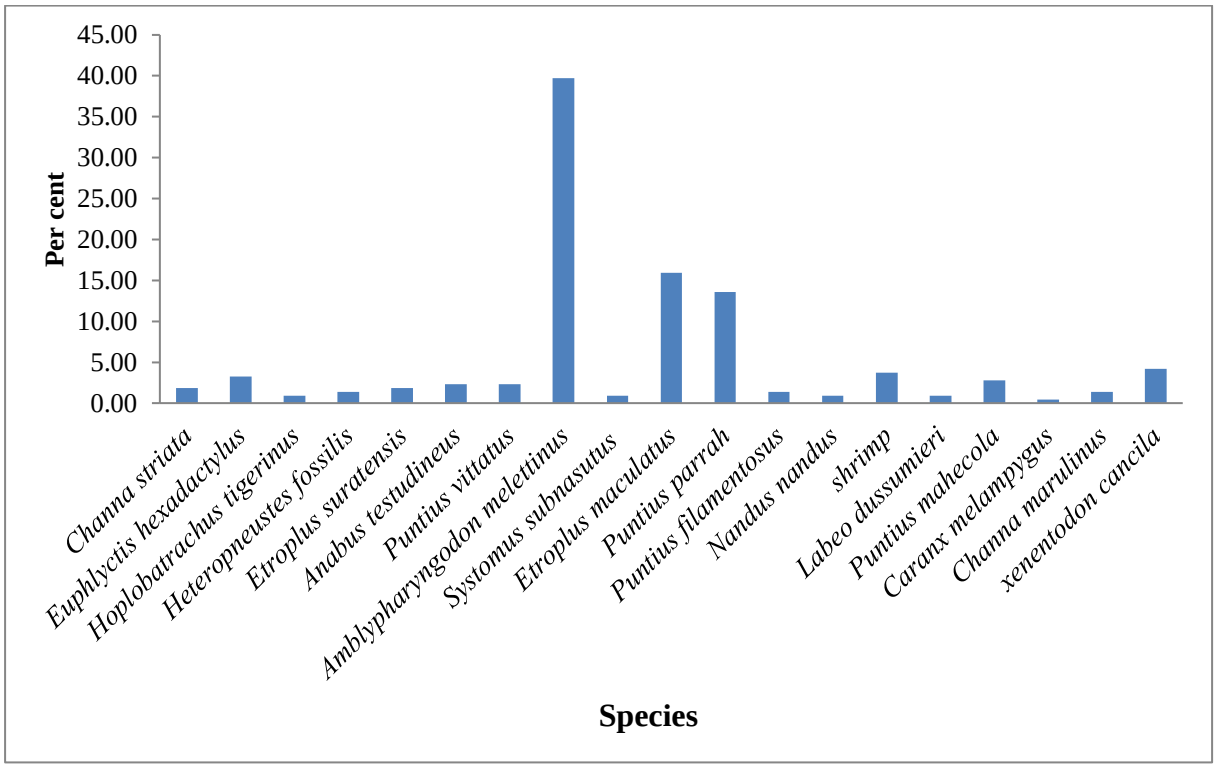

Fig. 32 Per cent composition of different prey items collected from the roosts

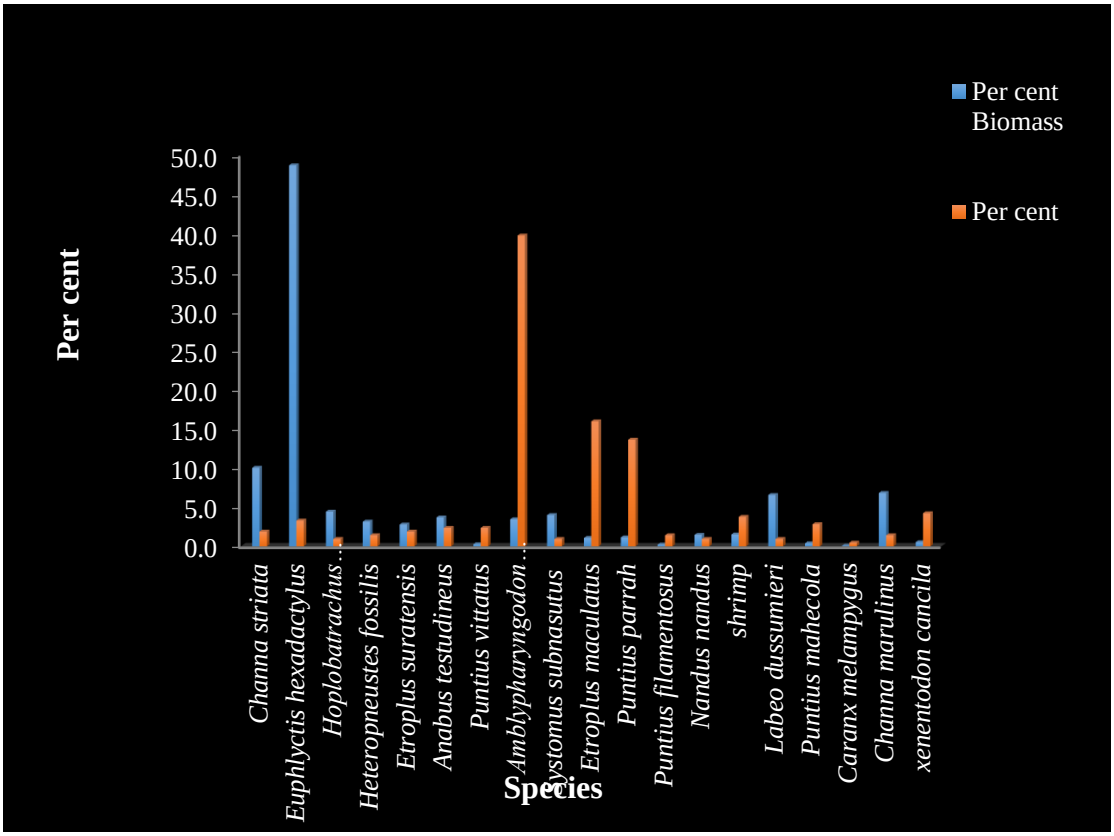

Fig. 33 Comparison between number of prey items and biomass of different prey species

Plate 09. Bolus collected from the heronry

Plate 10. Leftout food material collected from the heronry

3.4 Attitude towards conservation

All over, the world, in all ecosystems, human population is affected by the misuse of natural resources in one way or the other. In many places it even leads to severe conflict also. Wetlands in the world are under great pressure and destruction and Kole wetlands of Thrissur is not an exception. Habitat destruction and alteration, change in land use pattern, illegal fishing activities, threats due to alien fauna and flora, poaching are the major problems leading to the destruction of Kole wetlands. Compared to the past, several people are engaged in the conservation efforts and the people are becoming aware of the importance of the Kole wetlands and Ramsar Site.

In order to understand the conservation problems and the attitude of the people living near the Kole wetlands, towards the conservation goal a structured questionnaire survey was conducted. The structured questionnaire survey format is given in the Appendix-I. A total of 304 people were surveyed including farmers from 11 Panchayaths, living in and around the Kole wetlands (Table 05). Age-wise distribution (Fig. 34) and educational status of the respondents is given below (Fig. 35). Majority (33.9%) of the respondents were farmers followed by Private officials (30.6%), unemployed (29.3%), undergoing cultivation and job (3.6%) and least were Govt. officials (2.6%).

Table 5. Sex-wise distribution of respondents in different Panchayaths

Sl. no.	Panchayaths	Male	Female	Total
1.	Adatt	33	26	59
2.	Anthikad	4	3	7
3.	Arimboor	26	34	60
4.	Chazhoor	3	8	11
5.	Thrissur Corporation	20	31	51
6.	Elavally	3	9	12
7.	Manalur	9	15	24
8.	Mullassery	15	21	36
9.	Paralam	2	5	7
10.	Tholoor	5	13	18
11.	Venkidangu	4	15	19
Total		**124**	**180**	**304**

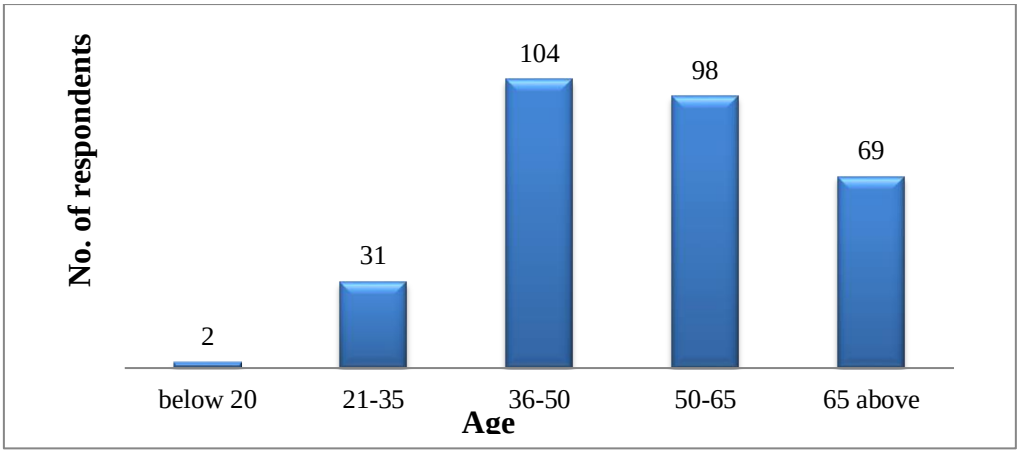

Fig. 34 Age-wise distribution of the respondents participated in the questionnaire survey

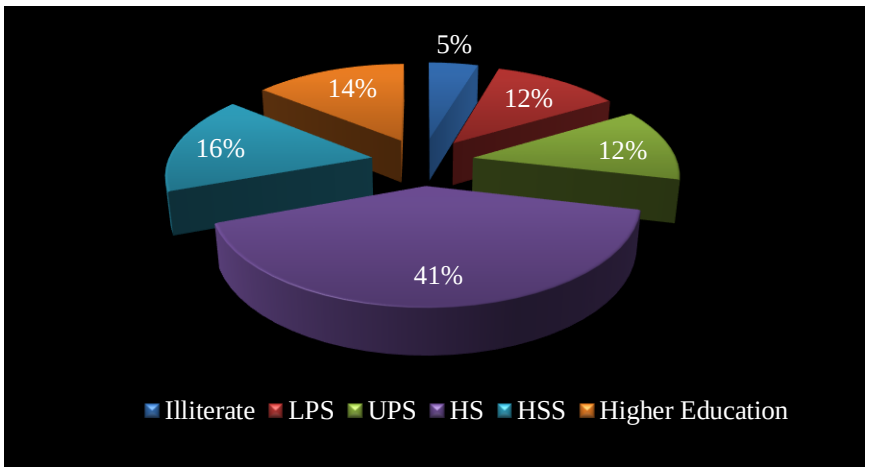

Fig. 35 Educational status of the respondents

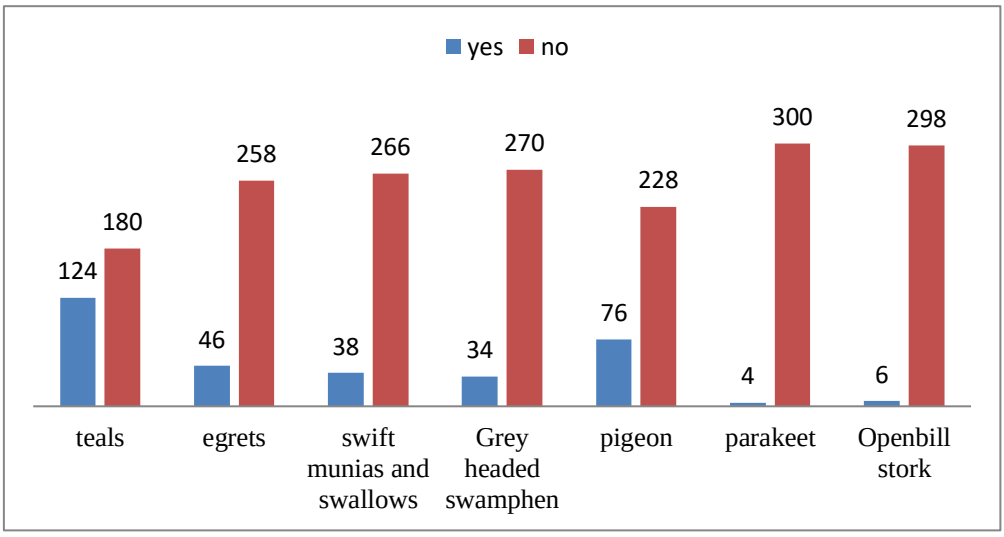

Fig. 36 Status of crop depredating species

3.4.1 Crop loss due to birds

Fifty three per cent of the respondents reported that there is no damage to their crops and 45.7 % people revealed that are affected by crop loss due to birds. Of the crop raiders, teals were the major problem next to Pigeon (Fig. 36). Thirty four per cent of people revealed about the presence of Peafowl and of these only 2.6 % reported it a menace to plantain and paddy cultivation. Most (44.8 %) of the respondents land was inside the Kole wetlands and 59.5% respondents do not use any protective measures and 40.5% use several protective measures like watch and ward system, throwing stones, cracking fire etc. (Fig. 37). Twenty three respondents opinioned that the crop damage by birds is on an increasing trend and the increase in bird population due to the decreased poaching rate as the major reason. Government should take care of the paddy fields and sufficient subsidies should be given to the farmers to enhance the farming and crop insurance on a minimum premium is the demand of the farmers. While 56 respondents told that, the crop loss is decreased compared to the past, because of the shift in agricultural pattern and time and also because of the efficacy of control measures to check bird population inside the paddy fields.

3.4.2 Poaching

Only 30 respondents reported that poaching still exists in Kole wetlands. Two hundred and twenty respondents told there is no poaching and 54 respondents are unaware of poaching. Details of poachers (Table 06) and preferred bird species is listed below (Table 07). While 92 % responded that hunting is reduced from the past and now also people are using air gun and furadan for bird poisoning, as a time pass, for pot and to reduce the crop damage, people are involved in poaching. About 41.45 % know that poaching will affect migratory population and only 42.11 % people are aware about the arrival of migratory birds and its importance. The practice of keeping birds as pets were also observed (Fig. 38).

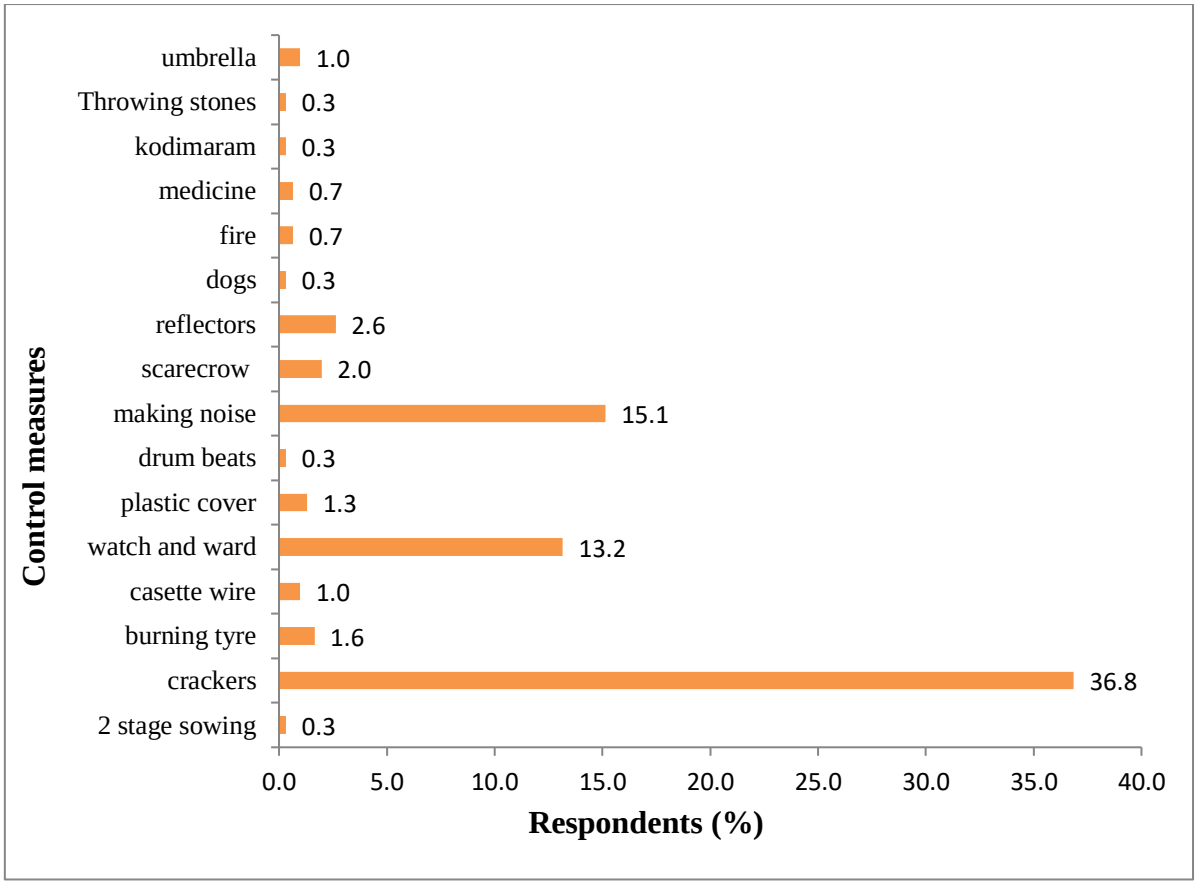

Fig. 37 Preventive measures employed by the respondents to deter birds

Table 06. Details of poaching reported from the Kole wetlands

Sl.no.	Category of Poachers	Number of Respondents	%
1	Farmers and youngsters	4	13.3
2	Farmers, people from outside, youngsters	1	3.3
3	Don't know	10	33.3
4	Farmers, workers, youngsters	1	3.3
5	People	4	13.3
6	Youngsters	9	30.0
7	Youngsters, people from outside area	1	3.3
	Total	**30**	**100**

Table 07. Bird species preferred by poachers

Sl.no.	Preferred bird species	Number of respondents	%
1	Ducks	3	10
2	Don't know	22	73.3

3	Egrets	1	3.3
4	Egrets, Ducks	3	10
5	Egrets, Ducks, Storks	1	3.3
	Total	**30**	**100**

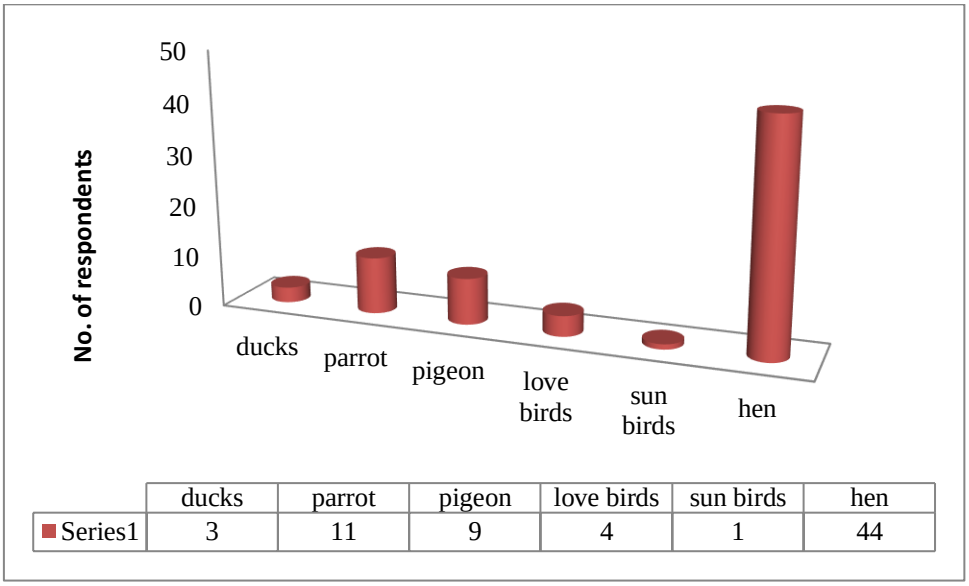

Fig. 38 Pets kept by respondents

3.4.3 Fishing

Except 11.5 %, all those interviewed were non-vegetarian and 79.93% consumed fish. Sixty one per cent preferred sea fish, 26% preferred both freshwater and sea fish, whereas only 13 % consumed freshwater fishes. Only 41.45% responded that catching of small fishes is essential while 58.55% do not support catching small fishes. Most of the respondents used fishing gears (Fig. 39). Pesticides (37.83%), organic manure (3.62%) and a combination of both pesticide and organic matter were used by some respondents (0.98%) for their agricultural proposes. Many (178) of the respondents know that pesticide will affect the birds, followed by 116 respondents who believe that there is no affect to birds and 10 are unaware of the pesticide effect.

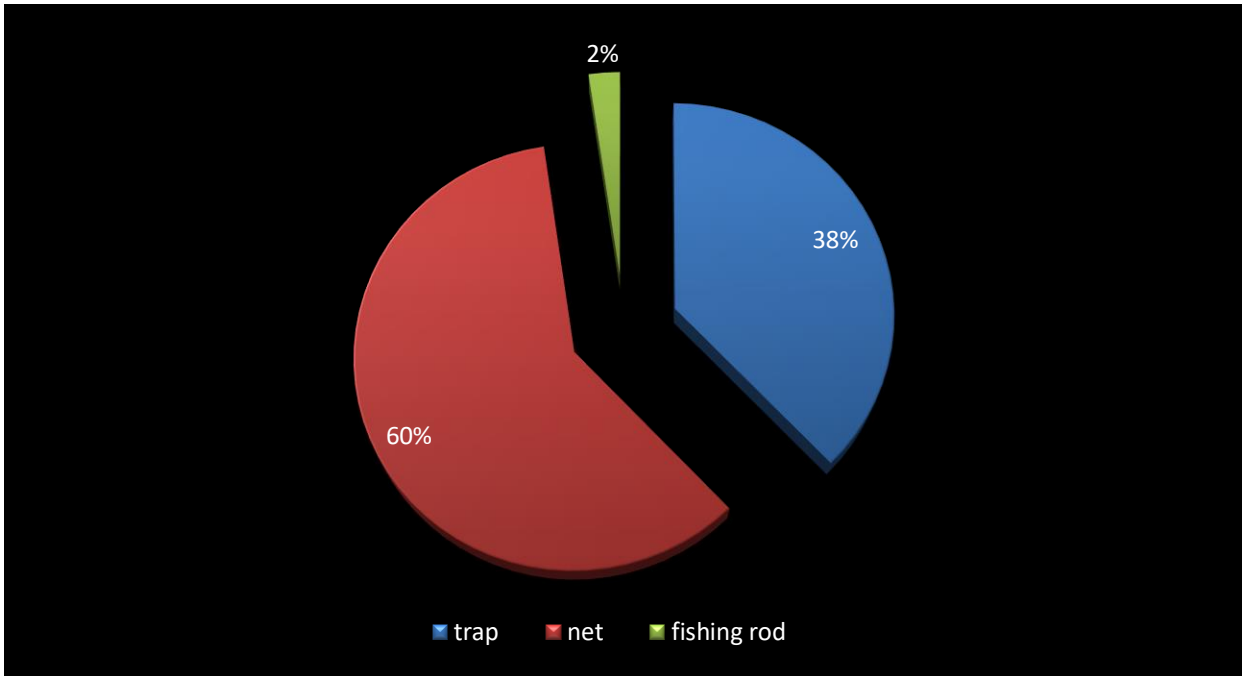

Fig. 39 Fishing gears used by the respondents

Thirty per cent of the respondents reported that burning is done every year before the beginning of paddy cultivation and also after harvesting. Usually fire was set for making the pathways on the bunds and to clear paddy fields after harvest. Fifty four per cent of the respondents are aware of the extinction of the birds. Even though these respondents are living next to the wetlands, only 12% of them know that Kole wetlands is a Ramsar Site and only 7% support to make Kole wetlands as a Community Reserve. Only 28% of them reported that they are benefitted with birds, acting as an insect control agent and manure for the crops as well as cleaning the home gardens. The need of conservation of birds for the betterment of human beings was also assessed and the awareness level was classified based on their occupational (Table 08) and educational level (Table 09).

Table 08. Conservation awareness according to the occupation of the respondents

Sl. no.	Conservation awareness	PO	UN	BFO	GO	F	Total
1.	Highly essential	39	35	8	5	40	127
2.	Essential	0	0	0	0	1	1
3.	Not needed	9	4	1	1	11	26
4.	Don’t know	4	8	0	0	1	13
5.	Good	41	42	2	2	50	137

Total	93	89	11	8	103	304

PO-Private Official; UN-Unemployed; Both farmer and official; GO- Govt. Official; F-Farmer

Table 09. Conservation awareness according to the educational level of the respondents

Sl. no.	**Conservation awareness**	**Illiterate**	**LPS**	**UPS**	**HS**	**HSS**	**HE**	**Total**
1.	Highly essential	5	14	10	50	25	23	127
2.	Essential	0	0	0	1	0	0	1
3.	Not needed	2	3	5	13	3	0	26
4.	Don't know	0	1	1	10	1	0	13
5.	Good	7	18	21	50	21	20	137
Total		14	36	37	124	50	43	304

As other wetlands, Kole wetlands is also under high pressure of habitat alteration, infestation of aquatic weeds, habitat loss and change in land use pattern. The area should be maintained in the frame work of stringent and active laws by the Kerala Forest and Wildlife Department. Several groups like Kole birders and Kole Karshakasangam are doing several activities for cleaning the Kole wetlands. Tourism activities should not be a hindrance to the free-ranging migratory population of birds and the Wetland Authority approval should be obtained for any activities inside a Ramsar Site.

4. DISCUSSION

A total of 155 species of birds belonging to 15 Orders and 49 Families were recorded from the area during the study period whereas earlier study reported 167 species of birds belonging to 16 Orders and 39 Families. The avian diversity have changed and the present study concluded that among the 15 Orders, Passeriformes, Charadriiformes and Pelecaniformes dominated the list with 46, 30 and 25 species respectively. Of these 104 species were wetland birds and 51 species terrestrial birds. Little egret, Cattle egret, Little cormorant, Indian pond heron, Median egret and Whiskered tern were the most abundant birds earlier, while the present study revealed that Indian pond heron *Ardeola grayii*, Little cormorant *Microcarbo niger*, Black-headed ibis *Threskiornis melanocephalus*, Cattle egret *Bubulcus ibis*, Grey-headed swamphen *Porphyrio poliocephalus*, Intermediate egret *Mesophoyx intermedia*, Little egret *Egretta garzetta*, White-throated Kingfisher *Halcyon smyrnensis*, Black drongo *Dicrurus macrocercus*, Asian openbill stork *Anastomus oscitans* were the most abundant resident birds. Bar-headed goose *Anser indicus* and Great thick-knee *Esacus recurvirostris* were reported in the present study. Thirty three taxa of birds are newly reported from the Kole wetlands which are not reported earlier (Sivaperuman and Jayson, 2000).

Water quality parameters were analysed and the values of some parameters seem to be slightly deviated from the optimum levels. DO and BOD are the most essential requirements for the healthy existence of the benthic faunal diversity. When compared with the optimum values the water is under mild stress with the value of 4.85±0.21mg/l and BOD value of 1.65±0.58 mg/l, indicating that the aquatic system is healthy.

Earlier studies (Francis and George, 2013) reported 59 fish species belonging to 47 genera and 31 Families of 10 Orders and during the present study 55 fish species belonging to 44 genera among 23 Families of 10 Orders were recorded from the study area. A total of 23 fish species reported in the earlier study was not observed during the present study. Whereas 17 species which were not reported earlier was newly reported in this study. *Paramabassis lala, Plecostomus* sp., *Trichopodus trichopterus* were the newly reported invasive species of the Kole wetlands. Thirteen species of fishes were reported from the Kole wetlands of Thrissur (Sivaperuman, 2004). The dominant species reported were *Garra mullya, Etroplus suratensis* and *Puntius* species. Four species of fishes namely *Chela clupeoides, Chanda thomassi, Mystus gulio* and *Puntius pinnauratus* reported by Sivaperuman were not recorded in the present study. Shaji *et al.*, (2010) reported 43 species of fishes belonging to

23 genera and 21 families from kole wetlands. The family Cyprinidae and genus Puntius were represented with more species. Fish species like *Amblypharyngodon microlepis, Esomus danricus, Puntius fasciatus, Puntius dorsalis, Mystus keletius, Clarias dussumieri* and *Monopterus fossorius* reported by Shaji *et al.* (2010) were not recorded in the present study. Being an air breather, Gourami has the potential to live in different pH conditions. Similarly sucker mouth catfish was introduced to several Asian countries for the aquarium trade. The ecological effects of this species include disruption of aquatic food chain by overgrazing on the benthic algae and detritus thereby leading to the decline of native species.

Only seven species of fishes were consumed by Oriental darter whereas earlier studies from Vembanad ecosystem reported that Oriental darter feeds on 17 species of fishes and shrimps. The abundance of fishes in Kole wetlands is less compared to the Vembanad ecosystem. The farm specific species Rohu *Labeo rohita* (Hamilton, 1822) is a new addition to the diet of Oriental darter which was not reported in any of the earlier studies. Similarly earlier studies on Little cormorant showed that Shrimps, *Aplocheilus* species, *Puntius mahecola,* and *Etroplus maculatus* were reported in the diet of Little cormorant but the present study reported Green Stripe Barb *Puntius vittatus* (Day, 1865), Silver carplet *Amblypharyngodon melettinus* (Valenciennes, 1844), Swamp barb *Systomus subnasutus* (Valenciennes, 1842) and Stinging Catfish *Heteropneustes fossilis* (Bloch, 1794), which was not recorded earlier. Along with the Oriental darter, fishermen consider Little cormorant as a major threat to their fish farms, as the species feed on almost all varieties of indigenous fishes as well as farm specific species. Similar case of Little cormorant as threat to the commercial shrimp farms was also reported from Kannur region. The diet of Asian openbill stork included mainly Snail *Pila globosa* and freshwater mussel (genus *Unio*). A single observation of Openbill stork feeding on crab was also recorded. Asian openbill stork feeding on fishes were reported from Assam but similar observations were not supported from observations from Kole lands.

A total of 214 samples of leftover food items were collected from the heronries and the samples consisted of 16 species of fishes, one species of shrimp and 2 species of frogs. Almost all the fish species and frogs were found to be occurring in the Kole wetlands and the regurgitated samples provided the diet composition of heronry birds. The heronry census revealed that there is an increase in the population of waterbirds during the study period.

Abundance of fishes increased as salinity reduced (Fig. 40). Similar trend was recorded in the in the years 2016 and 2017.

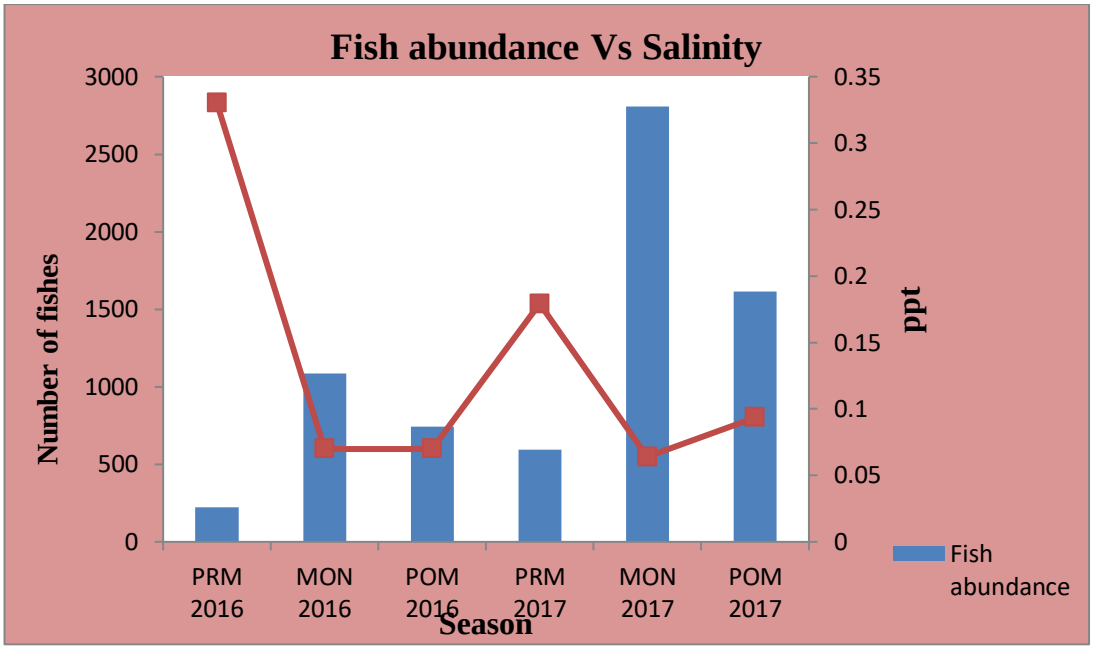

Fig. 40 Abundance of fishes and Salinity during the years 2016 and 2017

Pollution of water resources is a major problem of any wetland. As heavy industries are not present major pollution of water was not recorded. Municipal sewage entering the Kole wetlands without treatment is a problem. Polluted water enters mainly from the Thrissur Corporation through many entry points like Puzhakkal and Kokkala.

Fifty three per cent of the respondents reported that there is no damage to their crops and 45.7 % people opinioned that they are affected by crop loss due to birds. One of the main reason for the crop loss due to birds is the attitude of the people. Due to the social changes, people are not ready to go to the field once in a day and to make preventive measures to deter the crop depredators. Earlier, watch and ward system round the clock was prevalent and attention was there in the paddy lands. Among the crop raiders, teals were the major problem followed by pigeon. In some areas farmers shifted the cultivation pattern and instead of sowing seeds they are planting the saplings with machines or by manually, thereby reducing the attack of teals.

In some areas people are sowing seeds twice. First stage sowing is for teals and pigeons, once they have moved from the field by eating all the seeds, second level of sowing were done. Several instances of Grey-headed Swamphen invading paddy fields and feeding the rice plants were observed. It was observed that they consumed the rice plant during the vegetative growth

phase, when the seedling grows and develop branched tillers. The branched tiller contains fibrous roots, culm and leaves, hence easy to detach the plant from the soil. Eighty five acres of paddy cultivation was destroyed due to the feeding of this species and farmers considered Grey-headed swamphen as a menace to the paddy cultivation. Wide variety of mitigative measures like plastic sheets, hanging bottles, bursting crackers, reflector lines were used and they were found to be success only during the initial period. The areas devoid of cultivation and the thicket of reeds provide a safe habitat for breeding and roosting activities. Earlier it was observed that the paddy fields immediate to their habitat are being attacked rampantly, but this year irrespective of distance, all the paddy fields where the Grey-headed swamphen population known to exist was destroyed due to their foraging.

Kole wetlands are also under high pressure of habitat alteration, infestation of aquatic weeds, habitat loss and change in land use pattern. The Kole wetland as a whole is undergoing many changes. Many new roads have been built during the period and Pullu to Kanjany road is one example. Similarly other roads are also planned by the local bodies, crossing the wetlands. Kerala Land Developing Corporation (KLDC) is strengthening many bunds along the wetlands and all these widened bunds will become new roads in the future.

Tourism activities will create many problems to the farmers as well as to the biodiversity. Now the wetlands are being used for dumping the biomedical waste, septic waste and slaughter waste. The dumped waste is attracting the scavenging birds and dogs, creating several safety problems to the farmers as well as to the local people living near the Kole wetlands.

5. RECOMMENDATIONS

Based on the study the following action plan for the conservation of avifauna and Kole wetlands is recommended.

1. Erect warning boards all over the Kole wetlands and in the heronries, giving the details and importance of the avifauna and details of punishment for poaching of birds and other animals.

2. Prevent dumping of hospital waste and sewage from the town into the water bodies.

3. Paddy and wetland conservation Act should be strictly implemented

4. Evaluate the plans and proposals of all Departments of the Kerala Government that will affect the future of the Kole wetlands.

5. In order to check the intrusion of invasive fishes, Kerala Fisheries Department should provide indigenous fish varieties to the farmers for aquaculture activities.

6. Strict ban on illegal fishing activities in the Kole wetlands during the monsoon should be implemented.

7. Compensation to the farmers affected with the bird menace should be provided without delay.

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Plate 11. Field work in progres

Plate 12. White stork flock at Kole wetland

Plate 13. Mixed flock of water birds

Plate 14. Mixed flock of egrets

Plate 15. Flock of Tri-coloured munia

Plate 16. Mixed flock of storks

Plate 17. Fishes of Kole wetlands

Plate 18. Fisherman with a traditional fishing gear

Plate 19. Little cormorant with a catch

Plate. 20 Asian openbill stork with a catch

Plate 21. Measuring left out materials from the vicinity of roosts

Plate 22. Breeding of Median egret

Plate 23. Baya weaver nest in Kole wetlands

Plate 24. Indian pond heron in breeding plumage

Plate 25. Heronry census team

Plate 26. Water sampling at Kole wetlands

Plate 27. Poaching of Cormorant in Kole wetlands

Plate 28. Measuring the size of *Pila* using vernier callipers

7. APPENDICES

7.1 Format structured questionnaire survey

KFRI/687/2014

FORAGING ECOLOGY OF SELECTED BIRDS IN THE KOLE WETLANDS OF THRISSUR

QUESTIONNAIRE SURVEY ON CONSERVATION OF BIRDS

Location :

Date :

Time :

A. Identification details

1. Name of the area :
2. Panchayath/ municipality :
3. Ward no. :

B .Profile of the respondent

4. Name of the respondent
5. Age:
6. Sex: male/female
7. Education: LPS/UPS/HSC/VHS/Illiterate
8. Occupation: Cultivation/farm labour/motor shed worker/fisherman/shopkeeper/govt/private officials

C. Crop damage

9. (Yes/No/ don't know)

If yes, give details

Birds	Type of damage	Season
Teals		
Egrets		
Swift and swallows		
Grey headed swamphen		
Parakeet		
Pigeon		

10. How much is the approximate damage? (5%,10%,15%, don't know, negligible)
11. How much area you own?
12. How far it is from Kole wetlands?
13. What are the preventive measures used against the crop damage?

Preventive measures	Bird species

1

14. While comparing with the past what is the present situation of the crop damage caused by birds? (no change, increased, decreased, others) by birds
15. If there is a change, what is the possible reason?
16. What can the government do to solve this problem?

C. Poaching

17. Is there any poaching on the birds in your area?(yes/no/don't know)
18. Whether hunting is reduced from the past? (Not applicable, very high, high, medium , low, don't know)
19. What are the methods used for poaching? (Not applicable/air gun/firadan/shot gun/nets)
20. Who is engaged in poaching?(farmers/people from outside area/youngsters/workers/don't know)
21. What are the preferred species for poaching?(egrets/ducks/storks/waders/little cormorant/don't know)
22. Do you know that poaching will affect the migratory birds? (yes/no/don't know)
23. How can be poaching prevented?(by law/ by education/don't know)
24. Do you know that poaching is punishable with 6 months imprisonment? (yes/no/don't know)
25. What is the objective of poaching? (time pass/food/to reduce crop damage, professional hunting/others/don't know)
26. How many people are engaged in poaching in your area?
27. What are the other species of animals poached?(Mongoose/otter/snakes/others)
28. Do you know that migratory birds coming from other countries stay 3-4months in Thrissur Kole wetland? (yes/no/don't know)
29. Are you aware about the importance of migratory birds?(yes/no)
30. What are the pets kept in your house?
31. If yes what are the bird species?

D. Fishing

32. Are you a vegetarian or a non-vegetarian?
33. Do your family members consume fish? (yes/no/don't If know)
34. yes , what type of fish you prefer?(sea fish from market/ fresh water fish)

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35. What are the methods used for catching the fish? (net/trap/fish poison/others)
36. What is the opinion of catching small fish? (essential/non-essential)
37. Do you use any pesticides?
38. Do you know that the heavy dosage of pesticides will destroy the bird fauna? (yes/no/don't know)

E. Fire

39. Is burning done every year? (yes/no/don't know)
40. Bund clearing Season
41. Are you aware that the burning will destroy the bird nests and eggs? (yes/no/don't know)
42. What is the reason for burning? (clearing the grass for way/for reducing birds/others)
43. Are you aware that some of the bird species are extinct? (yes/no/don't know)
44. How you came to know the migratory birds and awareness regarding Kole wetlands? (Radio, media, press, meeting)
45. Do you know wetlands are Ramsar sites? (Yes/No)
46. Do you support to declare Kole wetlands as a Community Reserve? (Yes/No/Not applicable)
47. Is there any need for bird conservation? (highly essential/good/not needed/don't know)
48. Is there any benefit derived from birds? (yes/no/don't know)
49. If yes, what is the use? (manure/insect control/others)

Remarks:

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7.2 Values of different parameters obtained in analysis of water from Kole wetlands.

Table 1 pH of water from Kole wetlands of Thrissur

	PRM 2016	MON 2016	POM 2016	PRM 2017	MON 2017	POM 2017
AD-01	5.9	6.9	6.9	6.4	7.3	6.69
AD-02	7.2	7.7	7.7	3.6	7.2	6.78
PA-02	7.2	6.8	6.8	6.8	7.2	6.75
PA-01	7.2	6.5	6.5	7.2	7.9	6.75
PZ-02	7.4	7.3	7.3	7.1	6.7	6.74
EN-02	6.9	5.9	5.9	7.2	7.1	6.69
EN-01	7.7	6.1	6.1	6.7	6.9	6.74
PL-01	7.5	8.2	8.2	7.5	7.2	6.79
PL-02	7.6	7.5	7.5	8.2	7.4	6.89
AOG	7.5	6.6	6.6	6.6	7.2	6.66

Table 2 Temperature of water from Kole wetlands of Thrissur

	PRM 2016	MON 2016	POM 2016	PRM 2017	MON 2017	POM 2017
AD-01	30.5	31	31	31	29	28.3
AD-02	31	32	32	29	30	29
PA-02	29.5	27	27	28	28.5	27.9
PA-01	32	28	28	27.5	29	28
PZ-02	30	30	30	30	30	28
EN-02	34	32.5	32.5	31	29	28.2
EN-01	34	33	33	32	29	30
PL-01	32	32.5	32.5	33.5	28.5	29.4
PL-02	32.5	33	33	33.5	28.5	28.5
AOG	31.5	34	34	30	29	28

Table 3 Electrical Conductivity of water from Kole wetlands of Thrissur

	PRM 2016	MON 2016	POM 2016	PRM 2017	MON 2017	POM 2017
AD-01	587	149	149	588.6	122.1	431
AD-02	338	132	132	344.2	121.2	221
PA-02	339	149	149	267.5	167.8	293
PA-01	339	128	128	265.7	157.8	290
PZ-02	710	159	159	634	146.5	228
EN-02	170	115	115	456.8	127.6	315
EN-01	143	134	134	387	167.8	273
PL-01	266	162	162	176	160.3	264
PL-02	310	145	145	154.2	156.5	146
AOG	336	162	162	531.6	159.7	380

Table 4 Total Dissolved Solids in water from Kole wetlands of Thrissur

	PRM 2016	MON 2016	POM 2016	PRM 2017	MON 2017	POM 2017
AD-01	417	83	83	438	85	303
AD-02	240	97	97	257	85	156
PA-02	239	106	106	200	118	207
PA-01	241	101	101	199	150	205
PZ-02	502	88	88	472	102	160
EN-02	121	108	108	340	90	222
EN-01	101	107	107	289	117	192
PL-01	189	96	96	124	112	186
PL-02	220	89	89	108	109	102
AOG	239	77	77	396	112	268

Table 5 Turbidity in water from Kole wetlands of Thrissur

	PRM 2016	MON 2016	POM 2016	PRM 2017	MON 2017	POM 2017
AD-01	5	1.1	1.1	2.6	2.4	9.7
AD-02	1.3	2.6	2.6	5.7	5.8	3.5
PA-02	6.3	2.2	2.2	6.8	2.2	3.7
PA-01	1.4	4.4	4.4	7.6	1.9	3.1
PZ-02	9.5	1.5	1.5	7.6	5.4	6.7
EN-02	3	7.3	7.3	3.8	8.2	2.5
EN-01	0.9	11	11	1.9	2.2	2.4
PL-01	0.8	1	1	1.2	2.4	5.2
PL-02	1	1.4	1.4	1.9	2.7	3.8
AOG	6.3	1.9	1.9	2.1	1.2	7.9

Table 6 Salinity in water from Kole wetlands of Thrissur

	PRM 2016	MON 2016	POM 2016	PRM 2017	MON 2017	POM 2017
AD-01	0.17	0.07	0.07	0.28	0.05	0.142
AD-02	0.18	0.06	0.06	0.16	0.05	0.073
PA-02	0.1	0.07	0.07	0.13	0.07	0.096
PA-01	0.1	0.06	0.06	0.13	0.07	0.096
PZ-02	0.21	0.07	0.07	0.29	0.06	0.075
EN-02	0.53	0.05	0.05	0.22	0.06	0.103
EN-01	0.95	0.06	0.06	0.18	0.07	0.09
PL-01	0.1	0.08	0.08	0.08	0.07	0.087
PL-02	0.82	0.07	0.07	0.07	0.07	0.049
AOG	0.1	0.07	0.07	0.25	0.07	0.124

Table 7 Total hardness in water from Kole wetlands of Thrissur

	PRM 2016	MON 2016	POM 2016	PRM 2017	MON 2017	POM 2017
AD-01	80	40	40	132	34.92	76.8
AD-02	60	52	52	88	27.16	49.92
PA-02	44	44	44	60	42.68	53.76
PA-01	80	44	44	60	38.8	57.6
PZ-02	104	44	44	116	34.92	49.92
EN-02	52	44	44	80	27.16	65.28
EN-01	44	44	44	68	42.68	61.44
PL-01	28	60	60	48	42.68	69.12
PL-02	28	48	48	32	38.8	38.4
AOG	52	36	36	136	46.56	88.32

Table 8 Total Alkalinity in water from Kole wetlands of Thrissur

	PRM 2016	MON 2016	POM 2016	PRM 2017	MON 2017	POM 2017
AD-01	36	28.28	28.28	23.28	27.44	7.76
AD-02	40	40.4	40.4	58.2	23.52	15.52
PA-02	36	40.4	40.4	34.92	23.52	11.64
PA-01	20	32.32	32.32	31.04	3.92	11.64
PZ-02	36	28.28	28.28	BDL	23.52	7.76
EN-02	28	24.24	24.24	19.4	19.6	15.52
EN-01	32	24.24	24.24	23.28	35.28	7.76
PL-01	20	44.44	44.44	34.92	31.36	38.8
PL-02	20	36.36	36.36	19.4	31.36	23.28
AOG	40	20.2	20.2	38.8	31.36	15.52

Table 9 Chloride in water from Kole wetlands of Thrissur

	PRM 2016	MON 2016	POM 2016	PRM 2017	MON 2017	POM 2017
AD-01	62.17	23.47	23.47	118.68	15.82	55.38
AD-02	34.97	15.65	15.65	67.25	19.78	31.65
PA-02	34.97	23.47	23.47	51.43	23.74	47.47
PA-01	31.08	23.47	23.47	55.38	19.78	43.52
PZ-02	87.43	19.56	19.56	118.68	23.74	35.6
EN-02	34.97	23.47	23.47	110.77	23.74	63.6
EN-01	36.91	23.47	23.47	90.99	23.74	35.6
PL-01	17.48	19.56	19.56	27.69	19.78	27.69
PL-02	13.6	23.47	23.47	31.65	23.74	19.78
AOG	38.86	23.47	23.47	98.9	23.74	55.38

Table 10 Sulphate in water from Kole wetlands of Thrissur

	PRM 2016	MON 2016	POM 2016	PRM 2017	MON 2017	POM 2017
AD-01	63.44	9.2	9.2	70.72	8.48	62.88
AD-02	13.4	6.4	6.4	24.84	7.16	36.76
PA-02	20.6	5.12	5.12	21.28	18.28	40.84
PA-01	26.36	19.72	19.72	27.52	25.24	46.72
PZ-02	192.6	13.04	13.04	79.04	10.36	37.68
EN-02	27.68	32.6	32.6	28	9.68	28.96
EN-01	5.92	20.4	20.4	18.64	13.96	54.32
PL-01	17.8	22.48	22.48	12.76	11.4	42.32
PL-02	17.36	5.44	5.44	14.04	10.2	19.72
AOG	14.2	10.64	10.64	70.08	12.12	62.32

Table 11 Iron in water from Kole wetlands of Thrissur

	PRM 2016	**MON 2016**	**POM 2016**	**PRM 2017**	**MON 2017**	**POM 2017**
AD-01	0.21	0.86	0.86	0.5	0.89	5.9
AD-02	0.35	0.58	0.58	1.85	2.79	0.96
PA-02	BDL	1.88	1.88	1.55	0.53	1.5
PA-01	0.22	3.99	3.99	4.3	BDL	0.92
PZ-02	0.41	0.66	0.66	2.3	1.21	1.92
EN-02	0.39	1.95	1.95	1.14	1.24	0.48
EN-01	BDL	4.63	4.63	0.23	0.5	0.36
PL-01	BDL	0.19	0.19	0.29	0.63	2
PL-02	0.31	0.4	0.4	0.43	0.7	1.01
AOG	0.31	0.82	0.82	0.9	BDL	3.4

Table 12 Nitrate in water from Kole wetlands of Thrissur

	PRM 2016	**MON 2016**	**POM 2016**	**PRM 2017**	**MON 2017**	**POM 2017**
AD-01	BDL	BDL	BDL	0.36	0.68	0.41
AD-02	BDL	0.75	0.75	0.41	0.83	0.95
PA-02	BDL	0.84	0.84	0.59	0.92	0.95
PA-01	BDL	1.55	1.55	0.55	0.41	0.99
PZ-02	0.02	0.32	0.32	BDL	0.68	0.7
EN-02	0.02	BDL	BDL	0.06	0.83	0.44
EN-01	BDL	1.77	1.77	BDL	0.66	0.61
PL-01	BDL	1.64	1.64	0.11	0.77	0.43
PL-02	BDL	2	2	BDL	0.8	0.65
AOG	BDL	BDL	BDL	BDL	0.67	0.52

Table 13 Phosphate in water from Kole wetlands of Thrissur

	PRM 2016	MON 2016	POM 2016	PRM 2017	MON 2017	POM 2017
AD-01	BDL	0.06	0.06	0.02	BDL	0.06
AD-02	BDL	0.05	0.05	0.02	BDL	0.06
PA-02	BDL	0.05	0.05	0.03	0.12	0.07
PA-01	BDL	0.03	0.03	0.02	BDL	0.08
PZ-02	BDL	0.02	0.02	0.03	BDL	0.05
EN-02	BDL	0.07	0.07	0.02	BDL	0.07
EN-01	BDL	0.06	0.06	0.02	BDL	0.03
PL-01	BDL	0.04	0.04	0.02	BDL	0.09
PL-02	BDL	0.02	0.02	0.02	BDL	0.13
AOG	BDL	0.02	0.02	0.03	BDL	0.08

Table 14 Fluoride in water from Kole wetlands of Thrissur

	PRM 2016	MON 2016	POM 2016	PRM 2017	MON 2017	POM 2017
AD-01	0.1	0.18	0.18	0.07	0.04	0.11
AD-02	0.1	0.19	0.19	0.08	0.03	0.2
PA-02	0.11	0.1	0.1	0.08	0.08	0.09
PA-01	0.11	0.08	0.08	0.08	0.02	0.17
PZ-02	0.17	0.1	0.1	0.05	0.03	0.32
EN-02	0.06	0.08	0.08	0.07	0.04	0.13
EN-01	0.05	0.075	0.075	0.07	0.04	0.18
PL-01	0.07	0.11	0.11	0.08	0.04	0.09
PL-02	0.05	0.1	0.1	0.06	0.05	0.2
AOG	0.08	0.099	0.099	0.07	0.04	0.16

Table 15 Total Suspended Solids in water from Kole wetlands of Thrissur

	PRM 2016	MON 2016	POM 2016	PRM 2017	MON 2017	POM 2017
AD-01	14	16	16	6	5	53
AD-02	9	22	22	8	20	9
PA-02	18	18	18	8	7	4
PA-01	9	34	34	10	2	5
PZ-02	32	16	16	10	7	18
EN-02	21	64	64	6	12	4
EN-01	16	82	82	6	5	4
PL-01	4	8	8	5	9	14
PL-02	39	10	10	5	7	9
AOG	9	12	12	6	4	10

Table 16 Biological Oxygen Demand in water from Kole wetlands of Thrissur

	PRM 2016	MON 2016	POM 2016	PRM 2017	MON 2017	POM 2017
AD-01	3.04	3.2	3.2	2.1	1.23	2.11
AD-02	0.64	3.36	3.36	2.7	3.07	2.68
PA-02	1.28	nil	nil	0.6	1.69	0.99
PA-01	0.64	nil	nil	0.75	1.54	1.27
PZ-02	0.8	0.16	0.16	1.05	1.23	2.82
EN-02	0.8	1.76	1.76	3.3	1.08	0.7
EN-01	0.64	0.8	0.8	0.3	0.35	2.11
PL-01	0.32	2.24	2.24	4.35	0.31	0.56
PL-02	2.08	0.64	0.64	2.85	3.39	0.7
AOG	0.96	0.16	0.16	9.9	0.46	0.7

Table 17 Dissolved Oxygen in water from Kole wetlands of Thrissur

	PRM 2016	MON 2016	POM 2016	PRM 2017	MON 2017	POM 2017
AD-01	4.64	4	4	3.6	5.68	5.49
AD-02	6.56	6.88	6.88	3	4.61	5.21
PA-02	4.48	1.44	1.44	1.95	5.07	4.65
PA-01	6.24	1.76	1.76	4.2	8.45	5.35
PZ-02	2.08	5.44	5.44	3.9	4.15	6.05
EN-02	2.72	4.64	4.64	9.75	4.3	3.38
EN-01	6.08	4.8	4.8	2.4	3.43	6.05
PL-01	5.12	7.36	7.36	7.2	5.07	3.09
PL-02	5.92	6.72	6.72	9.75	7.07	4.08
AOG	6.72	4	4	3	3.53	2.68