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Assessment of seasonal variations in water quality parameters of Kadamba tank in Thoothukudi district of Tamil Nadu, India

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Abstract
Freshwater lakes are significant not only for human populations but also essential for plant and animal diversity. These aquatic systems are unique and are rich in biodiversity at the same time are under constant threat due to bludgeoning human populations and their demand for land. Water quality plays an important role in productivity of lakes. Physical and chemical parameters of the water body such as temperature, pH, turbidity, conductivity, TDS, along with primary productivity vary seasonally and regular monitoring of these parameters may through light into the productivity of the system. The present investigation was carried out in Kadamba Tank, Thoothukudi District, to assess the seasonal variations in water quality parameters (Temperature, pH, dissolved oxygen, ammonia (NH_3-N), nitrite (NO_2-N), nitrate (NO_3-N), phosphate (PO_4-P), biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS) and chlorophyll '*a*', variations in lake morphology and changes in fish assemblages. On the whole study revealed that there was no significant change in water quality parameters between the stations and seasons in the Kadamba tank, with the exception of phosphate and chlorophyll 'a'. There existed no positive correlation between phosphate and chlorophyll 'a' content of the water in the tank. Higher chlorophyll 'a' values of the lake in the range of 48.59 mg/m^3 to 105.15 mg/m^3 indicated the lake to be in the hyper eutrophic condition.

Keywords: Seasonal variations, water quality, Kadamba tank, productivity of lakes

Introduction
Freshwater lakes are the wealth of a nation, being a source of water for both irrigation and drinking. The lakes are considered important for freshwater biodiversity conservation. Industrialization and rapid development of human settlements are constant threat to lakes as more and more water is being used for drinking, domestic use and irrigation. Most of the lakes in peninsular India are seasonal and almost dry during the summer season. These lakes are not only heavily out sourced for water, they are also dumping sites for the unsurmountable pollutants generated by the human community living on its shores. The ecological structure and functioning of lakes provide a wide range of services that can be valued in conventional monetary terms. However, many values such as scenic, cultural, and biodiversity values, are more difficult to quantify. In India river and lake pollution is very severe and critical problem due to huge amount of pollutants discharged by urban activities (Vyas *et al*., 2016, Pani and Mishra, 2000) [22]. Lakes and ponds cover only a very small portion of the earth's surface, yet their study has played a disproportionately large role in the development of ecological theory. It is difficult to understand the biological phenomenon fully because the chemistry of water revels much about the metabolism of the ecosystem and explain the general hydro - biological relationship (Basavaraja *et al*. 2011) [5].
In rural areas, lakes are acting as a hub of domestic activities and contribute to the fisheries of the region. In Thoothukudi district, there are 15 major irrigations tanks and Kadamba tank is one of the perennial water tanks, which receives water from the Thamirabarani River system. The environmental destruction caused by anthropogenic factor lead to further destruction of aquatic fauna and especially the fishes (Vidyarani *et al*., 2010) [41]. Due to unplanned management, industrial developmental work, agricultural activity, public sewage and other anthropogenic activity, water quality and biotic resources of river, lakes, reservoirs and other water bodies are continuously deteriorating (Venkatesan, 2007; Elmaci *et al*.,

2008) [39, 7]. It is in this light that the present study was undertaken to assess the seasonal variations of water quality parameters of Kadamba tank which is located on, Thoothukudi District, Tamilnadu, India.

Materials and Methods

The present investigation was under taken to assess the environmental variables in relation to productivity. Six stations were identified for routine monthly sampling in the Kadamba tank, for studying the water quality parameters and productivity. The study was conducted for a period of 12 months between June 2015 and June 2016.

Kadamba tank, is located in Thoothukudi District, it is a shallow lake, with water present throughout the area. The tank receives water from the Thamirabarani River, through a channel from the nearby Srivaikundam Dam. Six stations where selected, Station 1 Kadayanodai, (N 08 35.643, E 077 58.459) was the inlet channel, which received fresh water from the Srivaikundam Dam. Station 2 was near a village Kulathukudiruppu (N 08 35.651 E 077 58.591, the water is stagnant, and rich in aquatic weeds. Stations 3 Pattakkarai, (N 08 34.202 E 078 00.397) Station 4 Vadalivilai, (N 08 34.800 E 078 01.075) were lake shore near villages, Station 5 Keelakalambarai, (N 08 35.398 E 078 00.898) and Station 6 Melakadamba, (N 08 35.587 E 078.00.163) were outlet channels were water was taken for agriculture purpose.

Collection of water samples

Monthly water samples were collected from the selected stations, from June 2015 to June 2016. The sample containers which were washed with tap water, and thoroughly washed with distilled water then dried before sampling and tightly sealed after collection and labeled prior to transport to lab in an ice box.

Analysis of physico – chemical parameters of water sample

Temperatures of water sample were measured in the field by using mercury thermometer with a range of 0 to 100 ^{0}C and with 0.1 ^{0}C graduations. The pH was measured by using 'ELICO' pH meter. For the estimation of dissolved oxygen, the water samples were collected in a 150 ml BOD bottle. The sample was fixed immediately after the collection of water and the estimated adopting modified Winkler's method (APHA, 1995) [4]. The other parameters like BOD, COD, TDS, TSS and salinity were analyzed for their dissolved nutrients like ammonia-N (NH_3-N), nitrite-N (NO_2-N), nitrate-N (NO_3-N) and phosphate-P (PO_4-P), using spectrophotometer (Perkin Elmer-Model Lamda 25) as per the procedure of (APHA, 1995) [4] with each analysis done in duplicates and the mean values were taken for consideration.

Statistical analysis

Based on the data derived from water quality parameters, the statistical relationship in terms of two way Analysis of Variance for the said different parameters was analyzed. All the statistical analysis was performed using the SPSS (version 16.0). Mean and standard deviation of collected data were calculated.

Result and Discussion

Water Temperature

The water temperature recorded in all the selected stations ranged from 25 to 32 ^{0}C. The minimum water temperature recorded was 25 ^{0}C in station 3 during January 2016 and maximum water temperature recorded was 32 ^{0}C in station 1 during April 2016. In the present study temperature was observed to be maximum during April 2016, the summer season and minimum during January, the post monsoon season in all the stations. Similar temperature pattern was observed in many water bodies (Narayana *et al*., 2008; Lianthumluaia *et al*., 2013) [21, 15]. In shallow ponds the temperature is usually dependent on the air temperature, and such dependent changes have been reported in Nagchoon pond, Madhya Pradesh (Mahajan and Billimore, 2014) [16]. The mean air and water temperature values are generally high during summer season, and such seasonally changes have been recorded in Thirparappu reservoir, Kanyakumari (Prakash *et al*., 2007) [25]. However, statistical analysis of the temperatures recorded during the different seasons at each station, showed no significant difference (p>0.05) between the months during the study period (Table 1).

pH

The pH indicates the intensity of acidic or base character of a solution and it is controlled by the dissolved chemical compounds and biochemical processes in the solution. The pH values ranged from the Kadamba tank 6.76 to 8.10. The minimum pH recorded was 6.76, in station 6 during May 2016 and maximum pH recorded was 8.10, in station 2 during October 2016 (Table 1). According to Goldman and Horne (1983), low pH < 5.0 can severely reduce aquatic species diversity. Since a low/high pH were never reported during the study period and the pH values were in the optimal range. Seasonal variations in the levels of pH in all the stations with maximum value during the summer months and minimum value during post monsoon months in all the stations. Similar observation are occur in the Anchar lake (Kashmir) post monsoon whereas highest was recorded in the pre-monsoon period (Gupte and Shaikh, 2013) [11]. Silambarasan *et al*. (2014) [34] reported higher values in Temperature, dissolved oxygen and alkalinity were higher in summer season and lower in monsoon season on contrary pH value was higher in monsoon and low in summer season. The higher pH value in winter might be due to high photosynthetic activity. Similar observations were also reported by Roy (1955) [29], (Tiwari and Chauhan, 2006) [37] and Aher *et al* (2007) [2]. However, statistical analysis of the pH recorded during the different seasons at each station showed no significant difference (p>0.05).

Dissolved Oxygen

Dissolved oxygen (DO) is an important parameter in water quality assessment and reflects the physical and biological processes prevailing in the aquatic ecosystem. Tamot *et al* (2008) [36] reported that DO concentration in water was primarily dependent upon temperature, dissolved salts, wind velocity, pollution load, photosynthetic activity and respiration rate. The optimum DO value for good water quality was 4 to 6 mg/l, which ensures healthy aquatic life in an ecosystem (Santosh and Shrihari, 2008). The dissolved oxygen (DO) values recorded in the selected stations ranged from 3.57 to 7.70 mg/l. The minimum DO was recorded 3.57 mg/l in station 6 during May 2016 and maximum DO was recorded 7.70 mg/l in station 2 during July 2015 (Table 1). In the present study, DO level was invariably more than 4 mg/l at all stations except stations 6, which recorded a low of 3.57 mg/l during the months of October 2015 and May

2016. Station 6 being an outlet channel for agriculture, the water released from the bottom was dark and loaded with organic matter. This may be one of the reasons for low DO compared to other stations of the tank. Further, DO level was high during winter followed by summer and rainy season. During summer the long days and intense sunlight seem to accelerate photosynthesis by phytoplankton, utilizing CO_2 and giving off oxygen. This possibly accounts for the greater qualities of O_2 recorded during summer (Krishnamurthy, 1990) [13]. The reason could be low temperature, and turbulence of surface water by high wind action. Agitation and turbulence due to monsoon rains may explain the highest record of dissolved oxygen during monsoon. This characteristic feature of the lake, is in agreement with the findings of (Sehgal, 1980) [33]. Massive plankton growth can cause problems of DO depletion at night and the production of ammonia and other toxins (Soemarwoto *et al*., 1990) [35]. However statistical analysis of DO recorded during the different seasons at each station showed no significant difference (p>0.05).

Biochemical Oxygen Demand (BOD)

The BOD values recorded in all the selected stations ranged from 0.83 to 2.76 mg/l. The minimum BOD recorded was 0.83 mg/l in station 3 during July 2015 and maximum BOD recorded was 2.76 mg/l in station 3 during January 2016. High levels of pollutants mainly organic matter in river water cause an increase in biological oxygen demand (Kulkarni 1997) [14], Seasonal variations in BOD maximum value during monsoon months and minimum value during pre-monsoon months in all the stations. (Table 1). Lake surface water containing BOD values 10 mgL-1 were considered to be moderately and more than 20 mgL-1 as to be highly polluted water (Paul, 1999) [23]. The greater the decomposable matter present, greater the oxygen demands and greater the BOD values (Admoroti, 1996) [1]. During winter season, the BOD content in lake water is high whereas it becomes low in the summer season. However the BOD recorded during the different seasons showed no significant difference (p>0.05) at all stations.

Chemical Oxygen Demand (COD)

The COD values recorded in Kadamba tank in all selected stations ranged from 1.83 mg/l to 4.68 mg/l and minimum COD recorded was 1.83 mg/l in station 3 during July 2015 and maximum COD recorded was 4.68 mg/l in station 4 during June 2016. Routine monitoring revealed seasonal variations in the levels of COD in all the stations with maximum value during the pre-monsoon months and minimum value during post monsoon months in all the stations (Table 1). Meshram *et al* (2014) [17] studied that of Ambazari Lake and Futala Lake at Nagpur District, Maharashtra they examined seasonal changes in COD loads showed insignificant changes in both lakes. The studied sites in Futala and Ambazari Lake showed a general increase in COD in summer and rainy season. This is an indication of increased organic loads due to increased household wastewater and waste discharges. However, statistical analysis of the COD recorded during the different seasons showed no significant difference (p>0.05) at all the stations.

Ammonia (NH_3-N)

The ammonia values recorded in all the selected stations ranged from 0.01 to 1.92 µg at NH_3-N/l. The minimum ammonia level recorded was 0.01 µg at NH_3-N/l in stations 1, 3 and 5 during December and February 2016 respectively and maximum ammonia recorded was 1.92 µg at NH_3-N /l in station 3 during June 2016. Seasonal variations in the levels of ammonia (NH_3-N) maximum value during the post-monsoon months and minimum value during summer months in all the stations (Table 1). Similar observation were reported in Lake Vembakottai water reservoir, Virudhunagar district Tamil Nadu (Pulugandi, 2014) [26] and Lake Mogan, Turkey (Yerli *et al*., 2012) [43] with maximum ammonia concentrations recorded during spring and summer. However, statistical analysis of ammonia values recorded during the different seasons showed no significant difference (p>0.05) at all the stations.

Nitrite (NO_2-N)

Nitrite (NO_2-N/l) is an intermediate product in the de-nitrification and nitrification reactions in nitrogen cycle. It is very unstable ion and gets converted into either ammonia or nitrate, depending upon the conditions of the water. The nitrite values recorded in all the selected stations ranged from 0.09 to 2.64 µg at NO_2-N/l. The minimum nitrite recorded was 0.09 µg at NO_2-N/l in station 6 during June 2015 and maximum nitrite recorded was 2.64 µg at NO_2-N/l in station 2 during October 2016. In the levels of nitrite seasonal variations in all the stations with maximum value during the pre-monsoon months and minimum value during post monsoon months. (Table 1). Statistical analysis of the nitrite values recorded during the different seasons showed no significant difference (p>0.05) at all the stations.

Nitrate (NO_3-N)

Nitrate (NO_3-N/l) is one of the most important of the nutrients which accounts for the productivity in water. In the present study nitrate values recorded in all the selected stations ranged from 0.01 to 0.17 µg at NO_3-N/l. The minimum nitrate recorded was 0.01µg at NO_2-N/l in station 1, 2, 3, 4, 5 and 6 during March, September, October 2015 and January 2016 and maximum nitrate recorded was 0.17 µg at NO_3-N/l in station 3 during April 2016. The low levels of Nitrate indicates, the need from improving oxygenation of pond, as it can result in improvement of nitrite conversion into nitrite. Similar pattern of nitrate was observed by other researchers (Raj and Jayasekher, 2007; Pawar and Shembekar and 2012; Yerli *et al*., 2012) [27, 24, 43]. Mohammad *et al* (2015) [19] studied in Wyra reservoir, Telengana, reported that nitrate fluctuated between 0.01 to 0.04 mg/l. these values are much lower than the Chisty (2002) [6] and Rani *et al* (2004) [28]. High concentration of nitrate in drinking water is toxic (Umavathi *et al* 2007) [38]. Seasonal variations in the levels of Nitrate in all the stations with maximum value during the summer months and minimum value during post monsoon months in all the stations (Table 1). However the nitrate recorded during the different seasons showed no significant difference (p>0.05) at each stations.

Phosphate (PO_4-P)

Phosphate (PO_4-P/l) is one of the major nutrients responsible for biological productivity. The phosphate values recorded in all the selected stations ranged from 1.02 to 4.93 µgat PO_4-P/l. The minimum phosphate recorded was 1.02 µgat PO_4-P/l in station 6 during May 2016 and maximum phosphate recorded was 4.93 µgat PO_4-P/l in station 3 during April 2016. According to (Jhingran, 1991) [12] phosphorus content more than 0.2 mg/l are likely to be

quite productive. Seasonal variations in the levels of Phosphate in all the stations (Table 1). Statistical analysis of the phosphate levels recorded during the different seasons showed no significant difference (p>0.05) at each stations while there existed significant difference in the mean phosphate levels between the station (p<0.05) Similar results were also observed by (Salaskar and Yeragi, 1997) [30] at Shenala Lake, Kalyan, Maharashtra. Kagzipura lake Phosphate concentration ranged between 0.47 to 3.40 mg/L, being higher in monsoon low in winter season. The higher phosphate concentration in monsoon might be owing to influx through rain water as has already been reported by Munawar, (1970) [20] and Aher *et al* (2007) [2]. Thus phosphates in low levels is desirable and at higher concentrations results in eutrophication.

Total Dissolved Solids (TDS)

Total Dissolved Solids are present in the water and consists of inorganic salts and dissolved salts. Major source of TDS in lakes, are solid waste disposal in lake religious activities, domestic washing, bathing, cattle wadding and death and decay of macrophytes (Verma *et al*., 2011) [40]. The TDS analysis plays an important role in the control of Biological and physical wastewater treatment processes. The TDS values recorded in Kadamba tank in all selected sampling stations ranged from 0.06 to 1.37mg/l. The minimum TDS recorded was 0.06mg/l in station 3 during July 2016 and maximum TDS recorded was 1.37mg/l in station 3 during May 2016. Mohammad *et al* (2015) [19] studied in wyra reservoir, Telangana, reported that the total dissolved solids were high in summer followed by winter and rainy. Fotache *et al*., (2013) [8] reported that ichthyofauna can also affect sediments structure and nutrients exchange within the lake sediments. Seasonal variations in the levels of TDS in all the stations with maximum value during the summer months and minimum value during pre-monsoon months in all the stations were recorded (Table 1). However statistical analysis of the TDS recorded during the different seasons showed no significant difference (p>0.05) at between stations.

Table 1: Water quality parameters at six stations in Kadamba tank, Thoothukudi District Tamilnadu

Months\parameter	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Temperature (°C)	26 °C – 32 °C	27 °C - 29 °C	29°C - 25 °C	26°C - 29 °C	27°C - 31 °C	26°C - 31 °C
pH	7.02 - 7.80	7.50 - 8.10	7.12 - 8.0	6.89 - 7.90	6.99 - 7.60	6.76 - 7.80
Dissolved oxygen (mg/l)	4.32 - 5.89	3.70 - 7.70	4.24 - 6.08	4.08 - 6.32	4.24 - 6.25	3.57 - 5.92
Ammonia (µg at NH_3-N/l)	0.01 - 1.76	0.11 - 1.70	0.12 -1.09	0.02 -1.04	0.01 - 0.82	0.02 - 0.89
Nitrite (µg at NO_2-N/l)	0.47 - 1.78	0.65 - 2.64	0.61 - 2.40	0.10 - 1.65	0.17 - 1.96	0.09 - 1.19
Nitrate (µg at NO_3-N/l)	0.01 - 0.19	0.02 - 0.09	0.01 - 0.09	0.01 - 0.10	0.01 - 0.08	0.01 - 0.10
Phosphate (µg at PO_4-P/l)	1.15 - 3.76	1.25 - 4.08	1.29 - 4.27	1.08 - 4.07	1.28 - 3.83	1.02 - 4.39
BOD (mg/l)	0.98 - 2.52	1.02 - 2.38	1.83 - 2.76	1.41 - 2.68	1.21 - 2.42	1.04 - 2.14
COD (mg/l)	2.13 - 4.12	2.12 - 4.32	1.83 - 3.84	2.26 - 4.68	2.21 - 3.68	1.98 - 3.56
TDS (ml/l)	0.02 - 0.60	0.06 -1.16	0.02 - 1.12	0.08 -1.17	0.12 - 1.20	0.4 - 0.84
Chlorophyll 'a' (mg/m^3)	21.42-206.40	16.41-136.21	22.29-130.2	48.78-166.84	37.34-209.82	13.32-143.23

Chlorophyll ' a '

The plant pigments of algae consist of the chlorophylls (green color) and carotenoids (yellow color). Chlorophyll-a is the most dominant chlorophyll pigment in the green algae (Chlorophyta) but is only one of several pigments in the blue-green algae (Cyanophyta), yellow- brown algae (Chrysophyta), and others. Despite this, chlorophyll-'a' is often used as a direct estimate of algal biomass although it might underestimate the production of those algae that contain multiple pigments (Gorde and Jadhav 2013) [10]. The chlorophyll 'a' values recorded in all selected sampling stations ranged from 13.32 to 209.82 mg/m^3. Mean Chlorophyll levels in the present study ranged from 48.59 mg/m^3 to 105.15 mg/m^3. Based on the chlorophyll levels, the lake can be categorized as hyper eutrophic due to very dense aquatic vegetation found all along the shore line. Many human activities that affect chlorophyll in water, such as sewage inputs and destruction of lake and river shorelines (Mitchell, 1990). The minimum chlorophyll 'a' recorded was 13.32 mg/m^3 in station 6 during February 2016 and maximum chlorophyll 'a' recorded was 209.82 mg /m^3 in station 5 during July 2015. Routine monitoring revealed seasonal variations in the levels of Chlorophyll ' a 'in all the stations with maximum value during the post monsoon months and minimum value during summer months in all the stations (Figure 2 – 25). (Yerli *et al*., 2012) [43] observed a mean range between 2.28 and 17.86 mg/m^3, in Lake Mogan, Turkey, with lowest values observed during the late autumn, early winter and early spring. The highest Chlorophyll concentrations where observed in a station located near water inlet channel. In the present study however maximum values of chlorophyll were observed in Station 1 and Station 5. Statistical analysis of the chlorophyll 'a' recorded during the different seasons showed significant difference (p<0.05) at all stations, further the chlorophyll 'a' was also significantly different (p< 0.05) between the different stations of Kadamba Tank. This indicates the impact of chlorophyll 'a' was influenced by various environmental parameters.

Conclusion

The tank water quality parameters are well within the prescribed levels, and is suitable for fisheries and other domestic human activities. Seasonal changes in environmental were observed but these were however not statistically not significant. Chlorophyll 'a' content indicated significant changes between stations indicating a direct link between environmental characteristics and productivity.

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