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Investigations of physico-chemical parameters and its pollution implications of Kolleru lake, Andhra Pradesh: A case study.

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A B S T R A C T

Kolleru Lake is the largest freshwater lake in India. It is recognized as wetland of international significance and is one of the 27 Ramsar wetlands in India. Designated as a sanctuary in 1999 Kolleru Bird Sanctuary (KBS) provides habitat to diverse flora and fauna including some rare and threatened fauna. Seventy eight fish species belong to fourteen orders, 37 families and 57 genera's were identified in the Kolluru Lake and Upputeru Creek diversity. Various samples were collected from different areas in and around Kolleru Lake analyzed for their physicochemical characteristics such as pH, total dissolved solids, Dissolved Oxygen, Biological Oxygen Demand, Chemical Oxygen Demand, NO_3, PO_4 etc.,. The results of this analysis were compared with the water quality standards of BIS. The quality of water samples were discussed with respect to these parameters and thus an attempt was made to ascertain the quality of water in the sampling areas.

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Introduction:

India is facing a serious problem of natural resource scarcity, especially that of water in view of population growth and economic development. Most of fresh water bodies all over the world are getting polluted, thus decreasing the potability of water. All life is depend on water and exists in nature in many forms like ocean, river, lake, clouds, rain, and snow etc. However, strictly speaking chemically pure water does not exist for any appreciable length of time in nature. A lake is a large body of water surrounded by land, inhabited by various aquatic life forms. Human civilization developed near the rivers or source of water. It is also known that some of the ancient civilizations perished due to unexpected droughts representing climate variability. The health of lakes and their biological diversity is directly related to health of almost every component of the ecosystem. Lakes are also subjected to various natural processes taking place in the environment like the hydrological cycle, with unprecedented development activities; human beings are responsible for choking several lakes to demise. Storm water runoff and discharge of sewage and effluents into the lakes are few of the common causes where various nutrients enter the aquatic ecosystems resulting in their death. Lakes in many parts of the world are under great pressure. The main stresses on lakes are chemical physical and biological. The lake resources are over exploited due to increased population, urbanization and globalization. Utilization of lakes water for irrigation and industry, contamination by agricultural runoff, domestic waste through municipal sewage and industrial effluents may deteriorate the water quality and destroy the ecological integrity. Therefore, the assessment and monitoring of lake water quality is very important. Hence a serious need is felt for the study of the water quality of Kolleru lake which could prove beneficial for the Environment.

Study Area and methodology:

The Kolleru Lake is the largest fresh water body in Andhra Pradesh India, located between the deltas of two major rivers Godavari and Krishna in the state of

Andhra Pradesh. It acts as a flood balancing reservoir for western Godavari Delta and Eastern Krishna Delta. It lies between longitude 81°5' and 81°20' East and latitudes of 16°32' and 16°51' North with total catchment area of 6,121 Sq. Km. in the districts of Krishna and West Godavari (Figure 1). This lake is fed by 2 rivers, 15 irrigation channels and 15 drains from Krishna and Godavari barrage irrigation system (Figure 2). The lake could extend to an area falling below +10 feet contour with a water spread over 901 Sq. Kms during S- W monsoon period from August to December and could recede to 135 Sq. Kms at +3 feet contour during May and June (Figure 3).

There are 50 lake bed islands and 98 bordering habitations in the lake region having a total population of 2.16 lakhs. The foreshore area is under cultivation up to +5 M.S.L. The area below +5 M.S.L. is generally free from any cultivation, but this area is used for capture fishery. The foreshore area is presently under accelerated conversion into fish ponds for culture fisheries.

The lake is presently facing a ecological crisis being situated in the deltaic region between Krishna and Godavari rivers central to highly agriculturally and industrially developed area. The industrial pollutants are mainly of organic nature and the agricultural runoff containing nutrients and pesticide residues enter the lake. In addition, the improvements to drainage to remove flood waters by deepening, widening and straightening the out-let creek, has resulted in faster drying up of the lake since 1986 after monsoon. Until 70's the lake level was maintained at more than +5 M.S.L. from July to February and with lesser water level at +3 M.S.L. during March to June. The present situation of longer period of low-level and drying and influx of nutrients, has resulted in coverage of almost the entire area with water hyacinth and other floating weeds, apart from submerged and emergent weeds. This has resulted in reduction of capture fishery of about 4,000 MT. within 10 years period. This lake also is the largest freshwater fish producing center in the country harbouring about 63 species of fish.

Twenty sampling stations were selected for the present study The sampling locations in Krishna district are Chandraiah drain, Budameru drain, Narasannapalem drain, West tammileru, Pedaedlagadi, Chinaedlagadi, Polaraj drain, Kolletikota, Circar canal, Srungavarappadu drain, Upputeru and in West Godavari district sampling locations are Gudivakalanka, Kokkirayalanka, Chettunnapadu, Tokalapalli drain, Pandikodu drain, Bulusuvagu, Kovvali drain, Mondikodu, East tammeleru (Table 1).

Sampling collection and analysis:

Samples (Drain, Lake and outlet) were collected from the twenty stations monthly in two districts during 2016 to 2019. The samples were collected in morning in between 7 to 9 am. Water samples collected by using sterilized 300 ml glass bottle and one liter wide mouth plastic container at each sampling station. Water quality parameters were analyzed as per standard methods of APHA. Dissolved oxygen was fixed at sampling stations itself and further analysis was done in the laboratory.

Table: 1. Sampling locations and collection points in Krishna and West Godavari districts

Krishna district		
S. No	**Sampling station**	**From**
1	West tammileru	Drain
2	Budameru drain	Drain
3	Chandraiah drain	Drain
4	Polaraj drain	Drain
5	Narasannapalem drain	Drain
6	Pedaedlagadi	Lake
7	Chinaedlagadi	Lake
8	Circar canal	Lake
9	Srungavarappadu drain	Lake
10	Kolleti kota	Lake
11	Upputeru	Outlet
West Godavari district		
S. No	**Sampling station**	**From**
1	East Tammileru	Drain
2	Bulusuvagu	Drain
3	Tokalapalli drain	Drain
4	Pandikodu drain	Drain
5	Kovvali drain	Drain
6	Mondikodu	Drain
7	Gudivakalanka	Lake
8	Kokkirayalanka	Lake
9	Chettunnapadu	Lake

Results and Discussions:

It is observed that the values of physico-chemical parameters such as pH, Total dissolved solids, Dissolved oxygen, Biological Oxygen Demand, Chemical Oxygen Demand, NO_3, PO_4 are shown in the Figures 4-10. Six year annual average variations were observed in various physico chemical parameters of lake water during the study period from 2014 to 2019 and the values are tabulated in Table 2.

pH:

Details of pH of the samples of the surface water collected at different stations during different years are given in Figure 4 and a comparison of the six-year average of pH surface-water are given in Table 2 . In the present study the values of pH ranged between 7.3 (Narsannapalem drain) -7.6 (Srungavarappadu drain). Variations of pH over a high range are often observed in the lake due to numerous factors such as influence of fresh water inputs, pollution, photosynthesis interaction with suspended matter etc. The present values recorded in all the study sites are in agreement with the findings of Qadri and Yousuf in Lake Malpur Sar, Kashmir, Qadri and Yousuf in Lake Manasbal, Kashmir, Devi in Loktak Lake, Manipur (7.4 to 8.9), Vyas et al. in Udaipur (7.1 to 9.1) and Billore and Vyas in pichhola lake, Udaipur (7.46 to 8.64). Mohan and Babu (2018) in Errarajan Lake, Karnataka (6.6 to 5.9).

Total Dissolved Solids (TDS):

Details of TDS levels in the samples of the surface water collected at different stations during different

years are given in Figure 5 and a comparison of the seven-year average of total dissolved solids are given in Table-2. In the present work total dissolved solids ranged from 215 to 8884.7mg/l in all the study sites. Six years average TDS was found high and exceed the permissible limit i.e, Circar canal 3172 mg/l, Srungavarappadu 3114 mg/l, Upputeru 2970 mg/l, Kolleti kota 2899 mg/l, Chinnaedlagadi 2624 and Polaraju drain 2439 mg/l and at Krishna district. Remaining all is low within the desirable limit.

Tiwari (1999) observed TDS of 150 to 192 mg/l (mean value 170 mg/l) in the 'Upper Lake' water of Bhopal. Dwivedi and Sonar (2004) reported a TDS of 150 mg/l in a small reservoir in eastern Himalayan State of Arunachal Pradesh in India. Gupta and Gupta (1999) reported the TDS of 175-414 mg/l in drinking waters in Satna, MP State of India. Rauf et al., (2015) reported that the highest amount of total hardness in the water was recorded during monsoon as 278 mg/l. Compared to those reports TDS at Kolleru Lake was found very high at all the stations during the entire period of study. However, the increase in TDS noticed at study areas by the increased influence of waste water, which is a tendency of pollution and must be seriously curbed.

Dissolved oxygen (DO):

Details of DO levels in the samples of the surface water collected at different stations during different years are given in Figure 6 and a comparison of the six-year average of DO water are given in Table-2. The lowest DO content in all stations, except in Polaraju drain 6.2 mg/l, Circar canal 5.9 mg/l and Srungavarappadu drain 5.8 mg/l belongs to Krishna district and Tokalapalli drain 6.1 mg/l, Kovvali drain 6.0 mg/l, Mondikodu drain 6.0 mg/l, East thammileru 5.9 mg/l and Bulusuvagu drain 5.9 mg/l belongs to West Godavari district. Dissolved oxygen is one the most significant parameters in water quality assessment and important regulator of metabolic processes of organisms and also the community as a whole. DO reflect the water quality status and physical and biological processes in waters and show the metabolic balance of a lake. DO is an important water quality parameter in assessing water pollution (Laluraj et al., 2002).In the present work, the DO concentration in all the study sites varied from 0.2 to 7.07mg/l during the study period. The maximum concentration of D.O. was observed due to attributed by vigorous photosynthetic activity of the autotrophs. A marked decrease of DO can be the result of increasing water temperature and rate of consumption. Fluctuation in DO is also due to fluctuation in water temperature and addition of sewage waste demanding oxygen (Koshy and Nayar, 2000).The present findings are in wide-ranging with Wanganeo and Wanganeo and Wanganeo. Mohamed et al., (2019) reported that maximum mean value of dissolved oxygen was (17 ± 0.57 mg/l) in Qaran Lake.

Chemical Oxygen Demand (COD):

Chemical Oxygen Demand (COD) is the measure of oxygen consumed during the oxidation of oxidizable organic matter by a strong oxidizing agent. Therefore, unlike the BOD, COD gives an idea of not only the biodegradable organic material, but also all kinds of organic material including the oil and grease in the water. Details of the COD levels in the samples of the surface water collected at different stations during different years are given in Figure 7.

Six year annual average of COD in Kolleru Lake in the districts of Krishna and West Godavari district is given in Table-2. COD of the surface water having no limits as per water quality criteria by CPCB. COD in all sites maximum 47.5 at Srungavarappadu drain and minimum 23.3 at West thammileru belongs to Krishna district, in West Godavari COD maximum 42.6 at Kokkirayalanka bridge and minimum 19.6 at Mondikodu drain.

The COD level indicates the presence of all forms of organic matter, both biodegradable and non-biodegradable and hence the degree of pollution in waters. Singh and Rai (1999) recorded 26.16 mg/l (monsoon) to 3.2 mg/l (winter) in river *Ganga* at Varanasi. Adak et al., (2002) found COD of 32 to 44 mg/l in river *Bramhani* and 9.8 to 12 mg/l in water of a tube well in Orissa. Adedeji et al., (2019) reported that the biochemical oxygen demand varied between 2.17 mg/l in Lake Ribadu.

According to the Indian Standards, desirable limit of COD in freshwaters is 2.72 mg/l, whereas the maximum permissible limit is 100 mg/l (BIS, 1992). Organic matters of natural as well as anthropogenic inputs were the main contributory factors for the high COD values in natural waters. When compared to existing values of COD, with the natural waters of *Karamana* River is 4.8 to 374 mg/l (Jayaraman et al., 2003) the COD of Kolleru Lake was found normal.

Biological Oxygen Demand:

BOD at different stations of different years are given in Figure 8 and a comparison of the seven-year average of BOD is tabulated in Table 2. In the present work BOD is highest value 8.8 mg/l at Polaraju drain and lowest value 2.0 mg/l at West Thammileru in Krishna district with respect to the water quality criteria class-C is 3 mg/l by CPCB. In West Godavari district along with the sampling stations BOD is high of 7.0 mg/l at Chettunnapadu Bridge and lowest value of 3.3 mg/l at Tokalapalli drain. Nitrate is varied from 0.4 to 2.5 mg/l and it's completely low in all sampling stations with two districts. Phosphate is varied from 0.2 to 1.3 mg/l in all the sampling stations with respect to water quality criteria by CPCB.

BOD is the measure of degradable organic matter present in a water sample and is defined as the amount of oxygen required by microorganisms in stabilizing biologically degradable organic matter under aerobic

conditions. BOD was found comparatively high in the all sampling locations. Bhatt *et al.* (1999) observed a variation in BOD of 32 mg/l (in summer) to 6.5 mg/l (in winter) in *Taudaha* lake, Katmandu, and the gradual decline of BOD from monsoon followed by winter was attributed to decrease in temperature which in turn retards microbial activity. In *Tawa* reservoir, M.P State, India, Kataria et al., (1995) reported BOD of 1.64 to 5.54 mg/l. Compared to the reports of BOD from Lakes in different parts of India, the Kolleru Lake was found unique with one of the lowest BOD values in all seasons throughout the period of study.

Nitrate nitrogen:

Details of Nitrate nitrogen levels in the samples of the surface water collected at different stations during different years are given in Figure 9 and a comparison of the six-year average of Nitrate nitrogen in surface-water are available in Table 2. In the present investigation period Nitrate nitrogen ranged from 0.1 to 4.77 mg/l. In the present study period an increase in concentration of nitrate nitrogen was observed, can be related to oxidation of ammonical nitrogen to nitrate (Quastle, 1951), In natural waters 150 mg/l of N is a critical value and when the content crosses the limit algal blooms occur (Sawyer et al., 1945). Nitrate nitrogen is an unstable product of either nitrification of free ammonia or denitrification of nitrates.

Phosphate phosphorus:

Details of Phosphate phosphorus levels in the samples of the surface water collected at different stations during different years are given in Figure 10 and a comparison of the six-year average of Phosphate phosphorus in surface-water are available in Table 2. In natural waters P exists as soluble phosphates. P is the nutrient considered to be the critical limiting nutrient, causing eutrophications of fresh water systems (Rabalais, 2002). It is a major nutrient that triggers eutrophications and required by algae in small quantities (Bandela, et al., 1999). In the present work Phosphate phosphorus ranged from 0.05 to 4.34 mg/l in all the study sites. This may be due to both allochthonous and autochthonous inputs, when the metabolic activity in the water starts to gear up[18].

Conclusion:

In the present study, the physico-chemical parameters at different sampling locations varied considerably during the study period. The high values of the physico-chemical parameters obtained in the present study indicate that the anthropogenic activities leading to the eutrophic status of the Lake. The levels of various physico-chemical parameters reported in the inlet drains establish the discharged sewage from the urban areas like Gudivada, Eluru and Vijayawada municipal corporations of Andhra Pradesh reaching the lake. Apart from this, the high TDS levels reported in the lake sampling points and Upputeru indicate the discharge of exchange water from the Aqua culture units located below +10 feet contour. Hence immediate remedial measures should be taken up for protection and conservation of Kolleru lake in order to save it from further deterioration.

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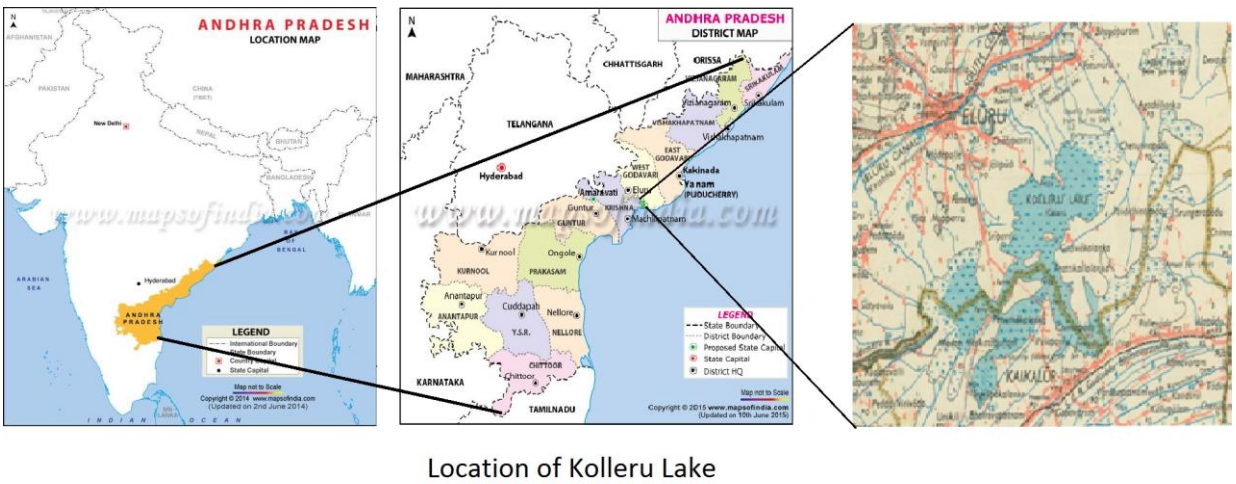

Figure: 1. Location of Koleru Lake

Table: 2. Six-year (2014 to 2019) average values of physical chemical parameters

S. No	Sampling station	pH	TDS (mg/l)	DO (mg/l)	COD (mg/l)	BOD (mg/l)	NO_3 (mg/l)	PO_4 (mg/l)
	Krishna district							
1	West Thammileru	7.4	509	2.5	23.3	2.0	0.4	1.3
2	Budameru drain	7.4	906	5.4	27.4	4.8	2.2	0.7
3	chandraiah drain	7.5	574	4.2	21.4	3.5	1.5	0.7
4	Polaraju drain	7.5	2439	6.2	46.0	8.8	2.3	0.9
5	Narsannapalem drain	7.3	838	5.6	25.1	4.1	1.7	0.7
6	Peddaedlagadi	7.4	1621	5.5	33.7	5.8	2.0	0.8
7	Chinnaedlagadi	7.5	2624	5.0	42.2	6.3	2.5	1.2
8	Circar canal	7.5	3172	5.9	46.6	8.3	2.5	1.0
9	Srungavarappadu drain	7.6	3114	5.8	47.5	8.3	2.3	0.8
10	Kolleti Kota	7.5	2899	5.6	45.5	8.0	2.1	0.9
11	Upputeru (outlet)	7.5	2970	5.7	33.7	6.0	2.0	0.9
	West Godavari district							
1	East Thammileru	7.4	681	5.9	20.1	3.6	1.8	0.5
2	Bulusuvagu drain	7.3	2048	5.9	34.1	5.8	2.0	0.8
3	Tokalapalli drain	7.5	618	6.1	18.6	3.3	1.1	0.3
4	Pandikodu drain	7.4	875	5.4	24.1	4.3	1.1	0.4
5	Kovvali drain	7.4	557	6.0	19.8	3.6	1.2	0.4
6	Mondikodu drain	7.4	596	6.0	19.6	3.4	1.2	0.2
7	Gudivaka lanka bridge	7.3	1363	5.4	34.4	6.3	1.5	0.8
8	Kokkiraya lanka bridge	7.3	2093	5.3	42.6	6.9	2.0	0.8
9	Chettunnapadu bridge	7.4	1788	5.5	40.1	7.0	2.5	1.1

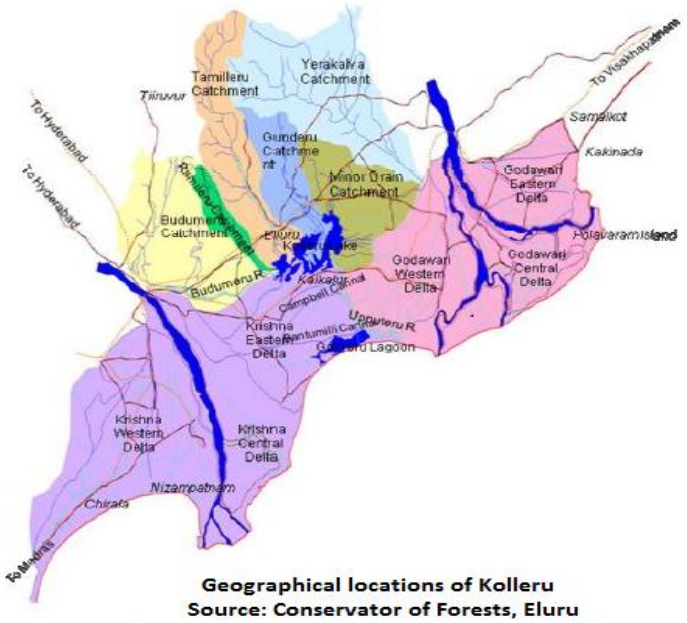

Figure: 2. Geographical locations of Kolleru

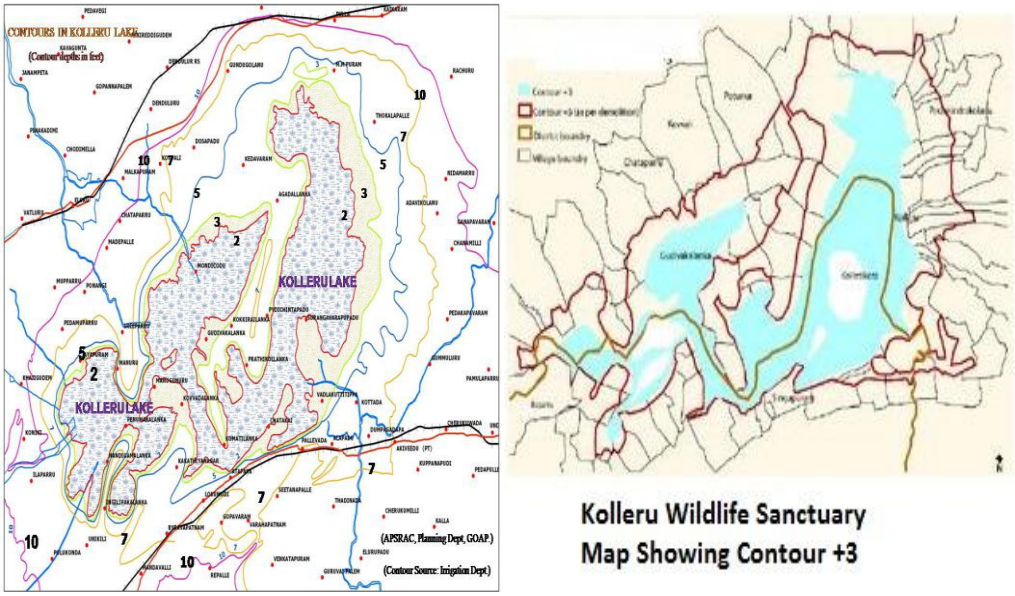

Figure: 3. The contours in Kolleru Lake

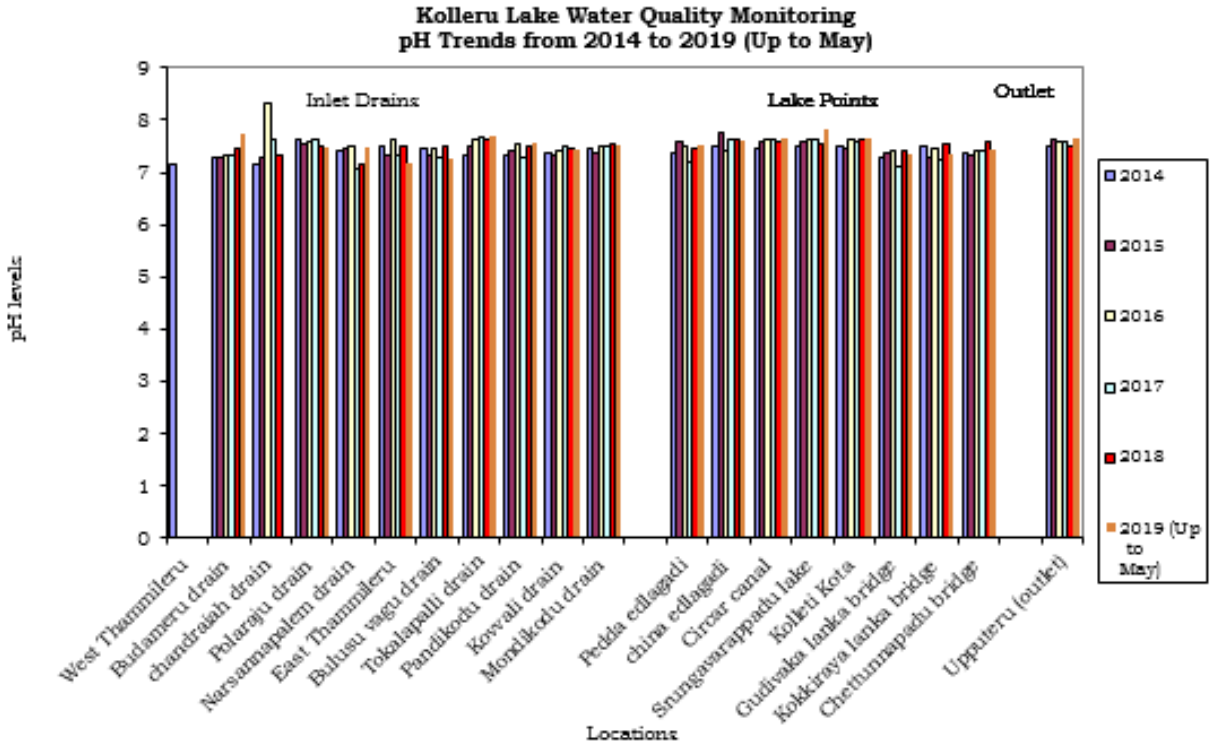

Figure: 4. Average values of pH levels of Kolleru Lake from 2014 to 2019

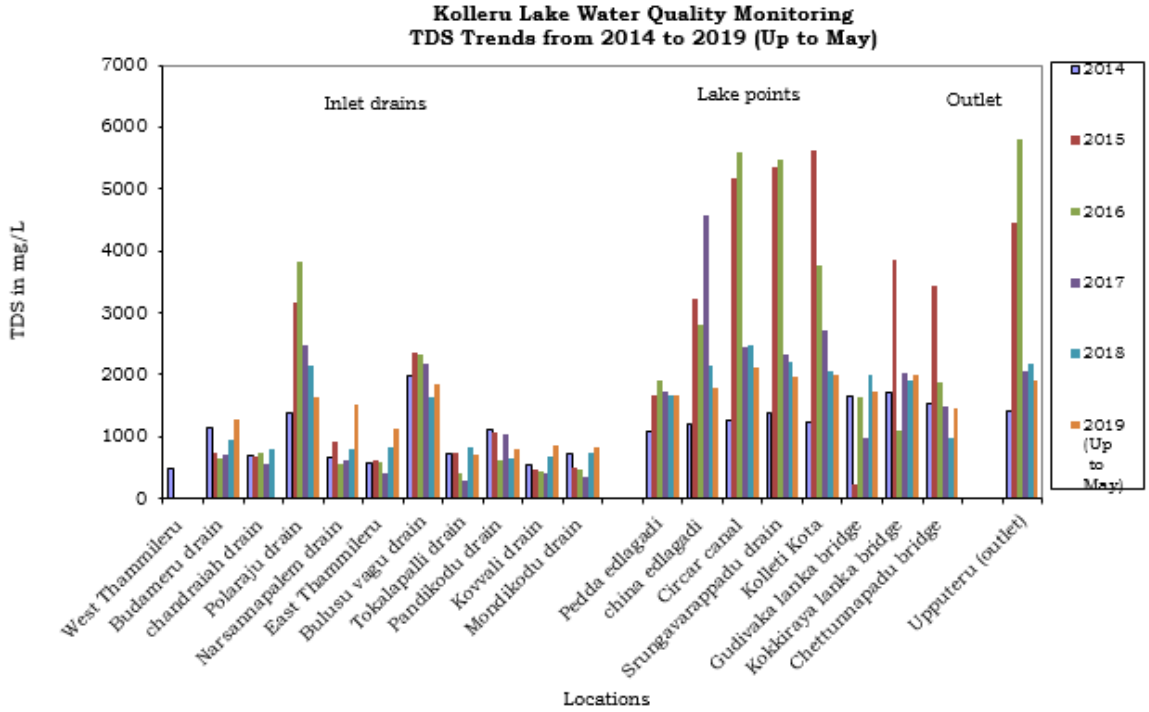

Figure: 5. Average values TDS levels of Kolleru Lake from 2014 to 2019

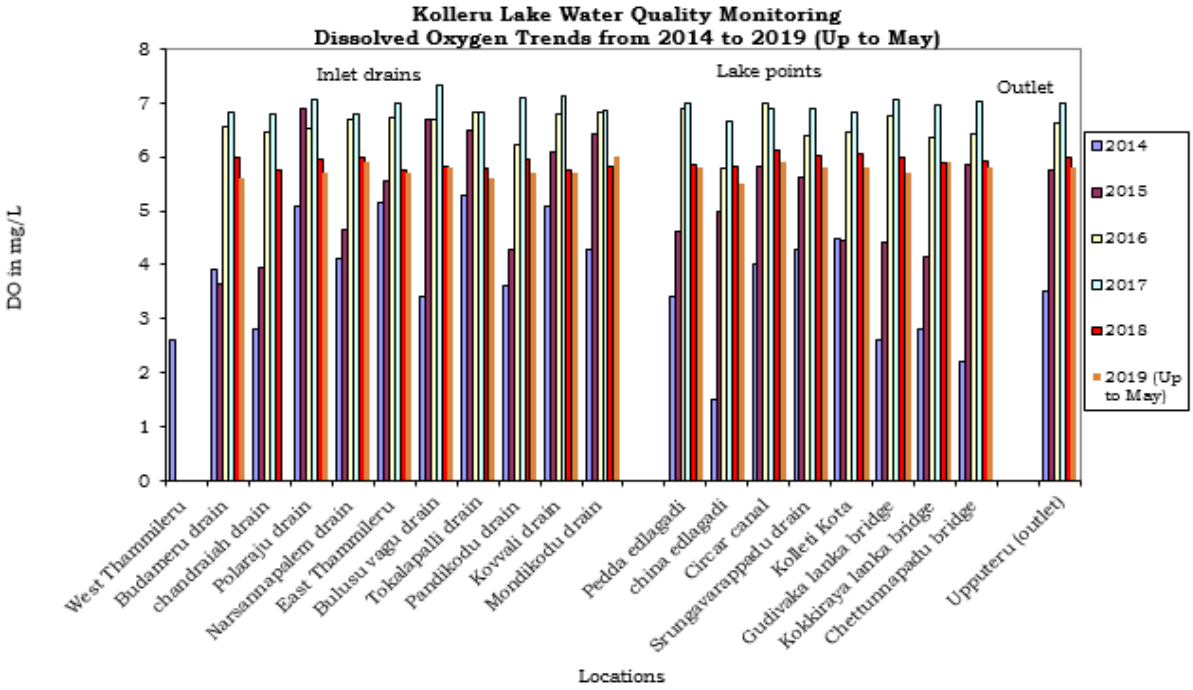

Figure: 6. Average values DO levels of Kolleru Lake from 2014 to 2019

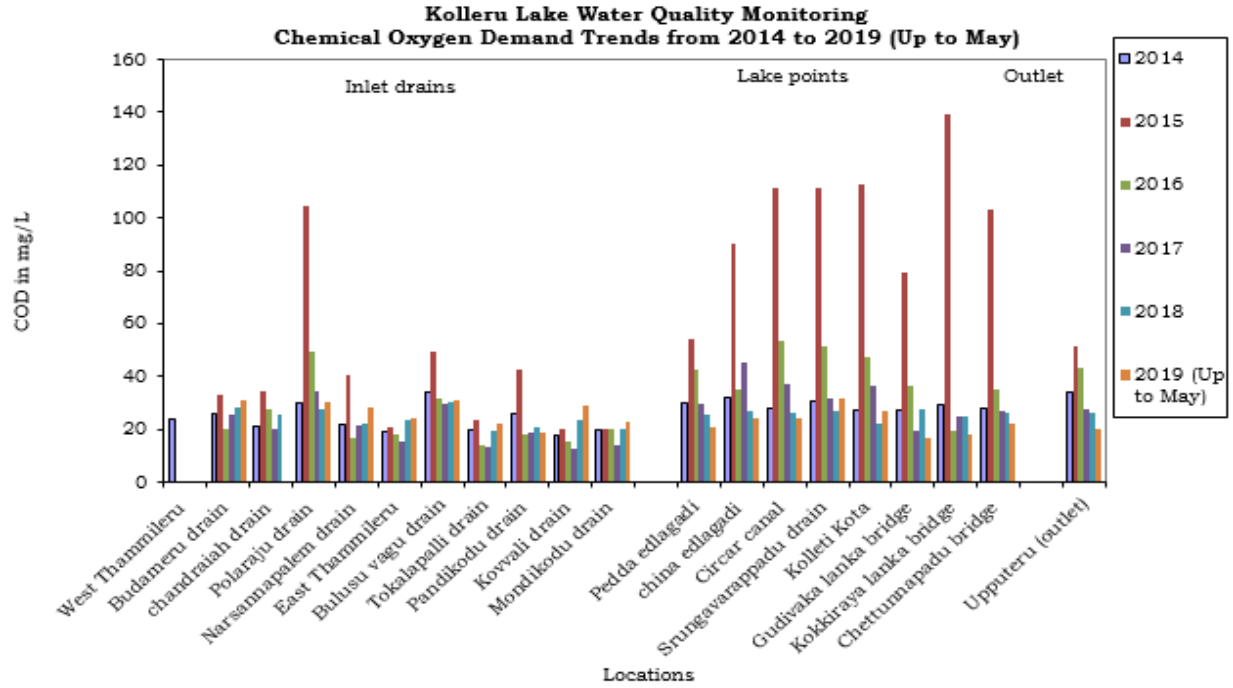

Figure: 7. Average values COD levels of Kolleru Lake from 2014 to 2019

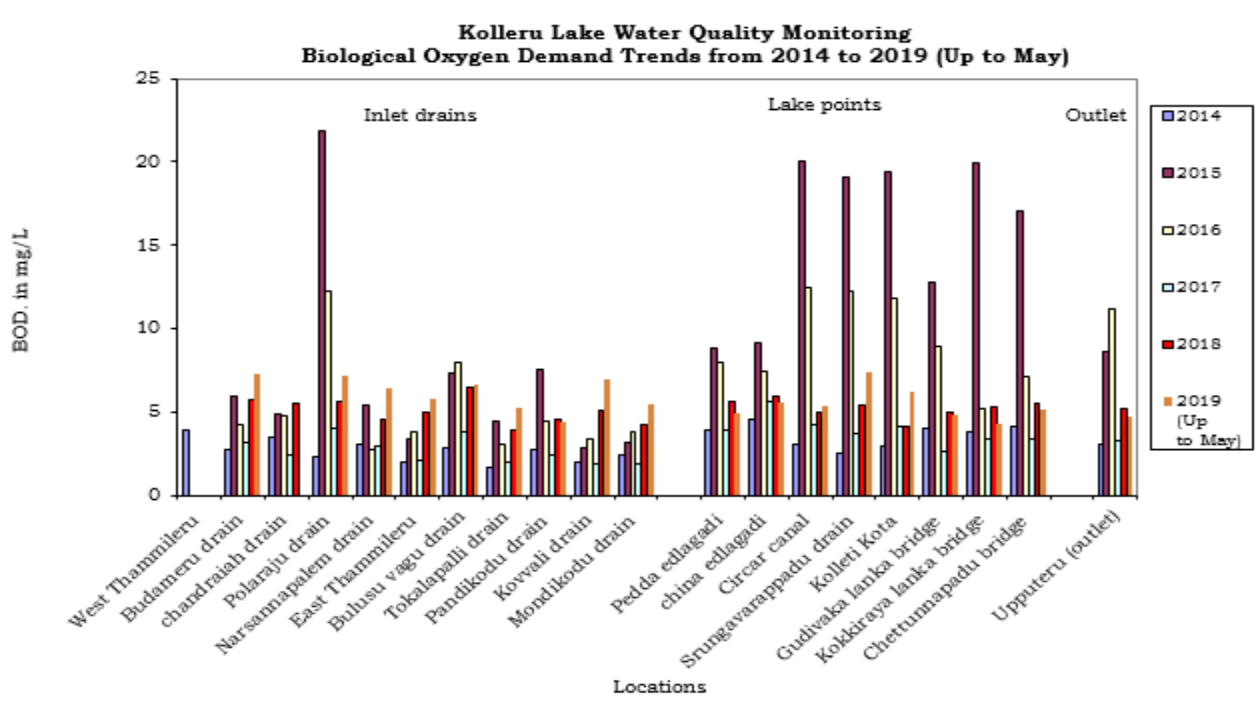

Figure: 8. Average values BOD levels of Kolleru Lake from 2014 to 2019

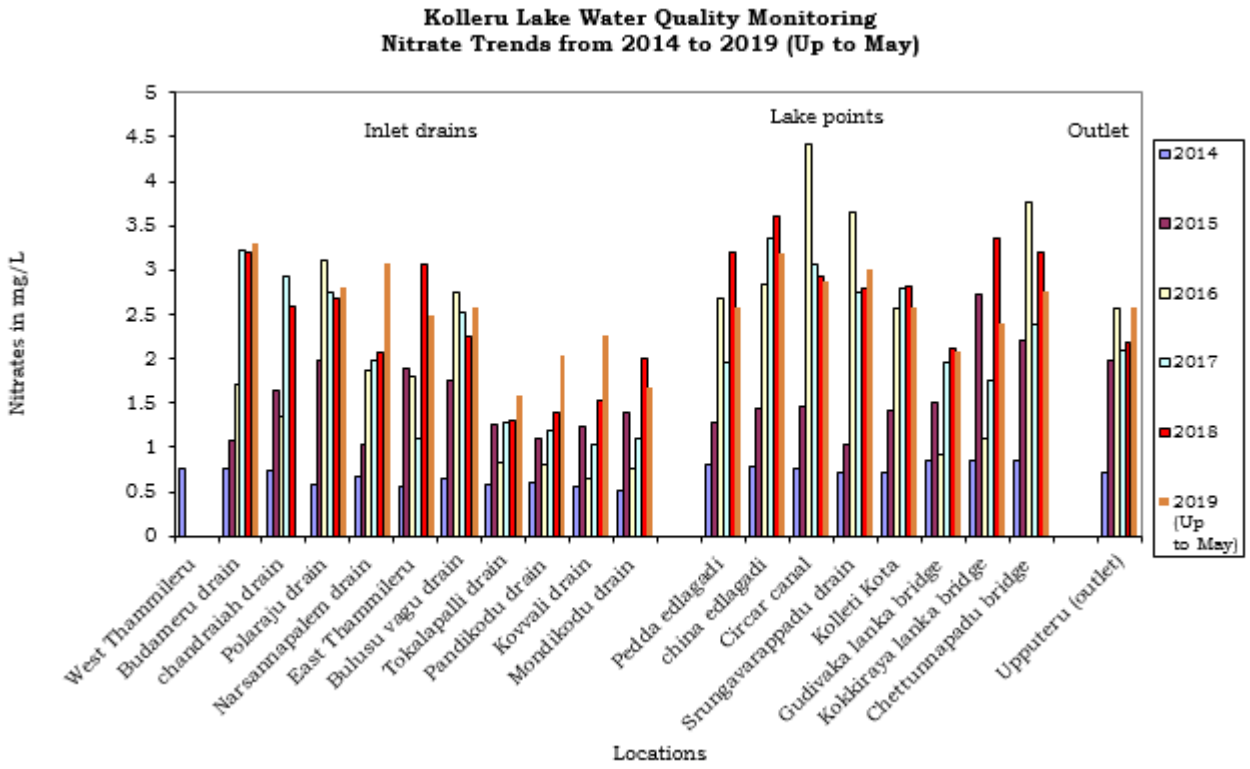

Figure: 9. Average values Nitrate levels of Kolleru Lake from 2014 to 2019

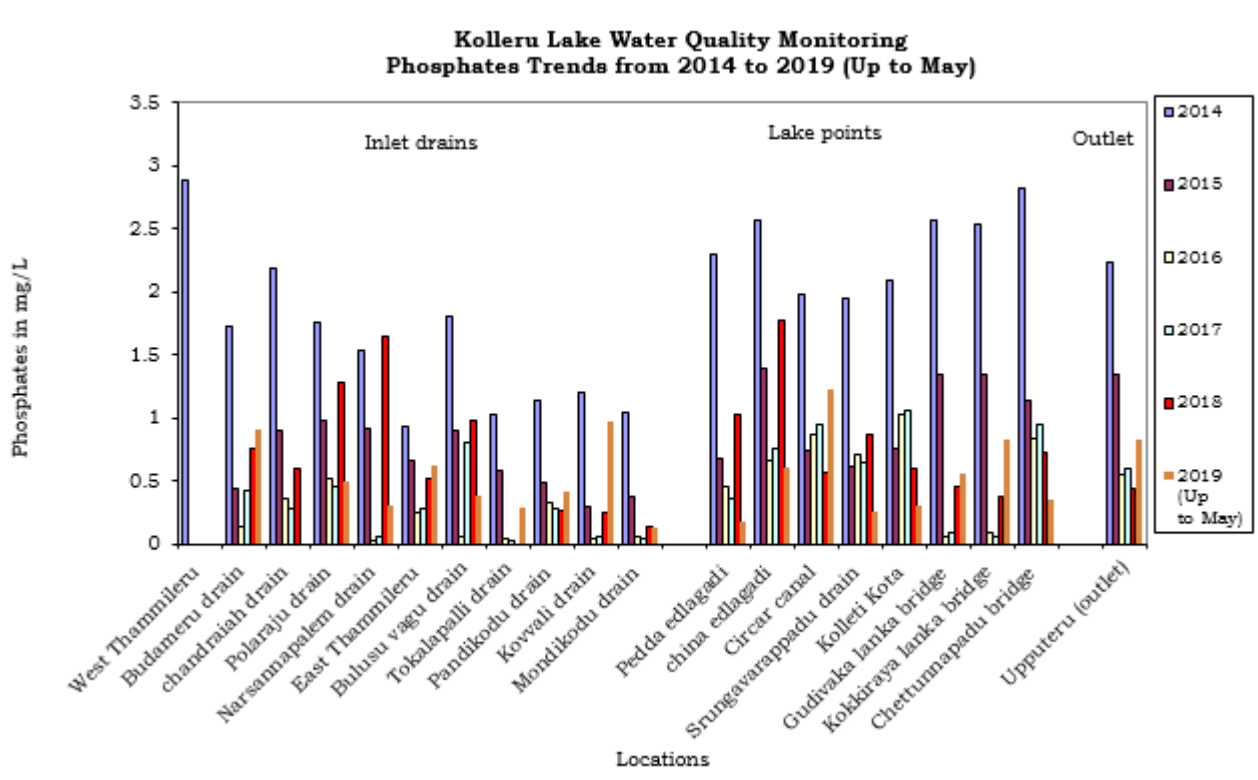

Figure: 10. Average values Phosphate levels of Kolleru Lake from 2014 to 2019

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