Indian Journal of Geo Marine Sciences
Vol. 49 (07), July 2020, pp. 1280-1285

Assessment of water quality status in the inland lakes of Coimbatore, Tamil Nadu, India

S Dineshkumar[a] & N Natarajan*,[a]

[a]Department of Civil Engineering, Dr. Mahalingam College of Engineering and Technology, Pollachi, Tamil Nadu – 642 003, India

*[E-mail: itsrajan2002@yahoo.co.in]

Received 22 July 2019; revised 09 August 2019

In this study, the physical, chemical and biological characteristics of the surface water of various inland lakes situated in Coimbatore have been analysed. The physico-chemical and biological parameters, such as pH, TDS, electrical conductivity, total hardness, chlorides, sulphates, sodium, potassium, BOD, COD, total alkalinity and *E. coli* concentration were analysed. The water quality of Selvampathy lake has drastically reduced as TDS, total hardness, BOD and COD values are beyond the permissible limit for this lake. This is due to discharge of industrial effluents and dumping of solid wastes. The chloride concentration of all the lakes has increased considerably. The low sulphate concentration in all these lakes indicates that there is no agricultural runoff and animal wastes being dumped into these lakes. The BOD concentration of Ukkadam lake has increased by an order of magnitude within the past three years. Ukkadam and Selvachintamani lake has faecal contamination as the *E. coli* concentration is beyond the permissible limit. The degradation of the quality of these lakes poses a major threat for the aquatic biota, public health and ground water quality.

[**Keywords**: Coimbatore, Domestic dumping, Industrial effluents, Lakes, Water quality]

Introduction

India is the home for 1.2 billion people[1]. Although India consists of 16 % of the global population, it possesses only 4 % of the world's water resources[2]. India has been making tremendous efforts to develop its water resources, but rapid industrialization and urbanization, along with population growth and unequal water distribution has resulted in demand excess of the available water supply[3]. As per the current scenario, water availability per capita is around 1700 m^3 per person per year[4], emphasizing that India is only just above the water stressed criteria of 1000 m^3 per person[5]. Other challenges that are facing India include uneven distribution of rainfall, prolonged droughts, illegal exploitation of groundwater resources, and poor management of municipal solid wastes.

As per the earlier studies, it is approximately estimated that 38,000 million litres of wastewater is generated in a day and it is accounting for about 29 % of wastewater generation in urban regions every year with respect to increase of population. From this it can be clearly projected that the wastewater from urban centres may increase about two times of the wastewater generated now and this would cause the demand of freshwater to increase manifold. According to the World Health Organization statistics, half of India's morbidity is due to water borne diseases which can be controlled by management of human activities, solid waste management, waste disposal, proper treatment of waste and protection of natural sources of water from contamination and this is the key to protect and preserve ecosystem, environment and natural water sources.

Natural water sources such as rivers, lakes, wetlands are crucial and enormously contribute to human development, which ironically has become a major cause of their degradation and decimation[6]. The reason for the degradation of these lakes and wetlands is waste dumping, deforestation, industrial discharges and large-scale reclamation for other uses[7]. Coimbatore is one of the fast growing cities in Tamil Nadu and also has been named in the list of smart cities by the government of India. There are numerous wetlands in and around the city of Coimbatore and the lakes are mainly fed by the river Noyyal flowing alongside the city. Mohanraj *et al.*[8] assessed the physico-chemical characteristics of eight lakes in Coimbatore. Mathew *et al.*[9,10] analysed the quality of sediments in the wetlands of urban Coimbatore. Jebastina & Arulraj[11] performed multivariate statistical analysis of twenty seven water samples collected within Coimbatore district during the pre-monsoon period of years 2012 and 2013 to study the hydrogeochemical regimes. Selvakumar *et al.*[12] investigated the hydrogeochemical characteristics and groundwater contamination in the Singanallur sub-basin of Coimbatore city. Their multivariate statistical analysis revealed that most of the variations in the water quality were elucidated by the anthropogenic pollutants due to population growth, industrial effluents and irrigation water return flow. Jiji & Devi[13] introduced colour models for performing change detection for water pollution and concluded that other colour models like YCbCr and YIQ can be used as substitution to the RGB colour model for analysing the change detection with regard to water pollution. Jeyaraj *et al.*[14] performed chemical analysis of surface water quality of river Noyyal connected tabk in Tiruppur district of Tamil Nadu, India and they found a strong correlation among the parameters for both the monsoon and summer seasons.

As the lakes and wetlands in Coimbatore form the major sources of water supply for various uses of the population situated around the city and recharge zones for groundwater, it is necessary to continuously monitor the quality of these lakes. The objective of the present study is to analyse the water pollution status of five selected lakes in Coimbatore so as to assess the changes in the water quality over the last decade.

Materials and Methods

The present study was carried out in Coimbatore, Tamil Nadu (Fig. 1). The metropolitan city is situated at 11° N latitude and 77° E longitude. The district receives rain both in south-west and north-east monsoon. The north-east monsoon contributes the maximum of 328.2 mm during October to December. The average annual rainfall of this district is 647.2 mm from four distinct seasons. The area represents flat topography with gentle slope.

Out of 7469 km^2 (2001 census) of Coimbatore district geographic area, 8070 ha area is wetland which includes 304 small wetlands (< 2.25 ha). 0.89 % of Tamil Nadu state wetland area is in Coimbatore, among which 1.08 % of Coimbatore district's geographic area is wetland.

Inland wetlands (natural) occupy 44.30 %, lakes/ponds occupy 14.89 % and river/stream occupies 29.41 % of area. Artificial inland wetlands

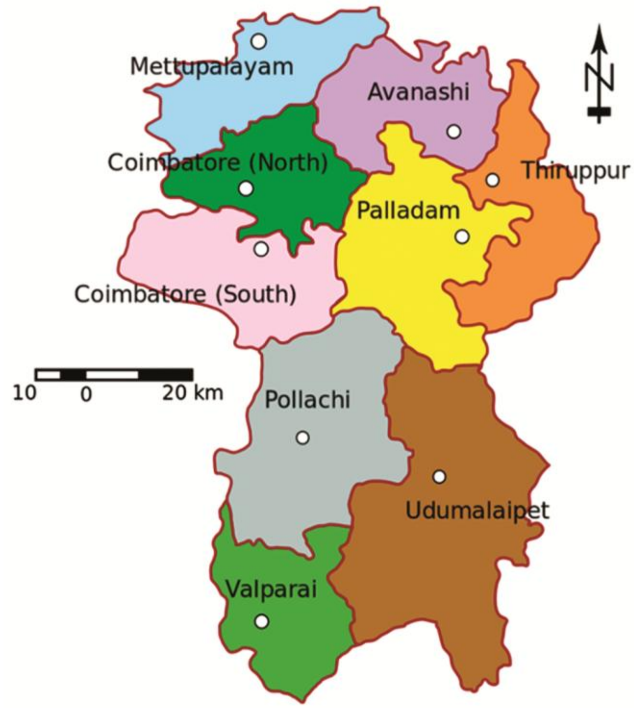

Fig. 1 — Map of Coimbatore district

occupy 55.70 %, reservoirs occupy 42.39 %, tanks/ ponds occupy 9.54 % and other small wetlands occupy 3.77 % of the area. Most of the villages, towns and cities are located near wetlands. Similarly, Coimbatore also developed around the Noyyal river basin and consists of several lakes and canals which form a network of surface water resources. In the past, there were numerous lakes in the surrounding areas but most of them were eventually filled up. Currently, in the Noyyal river basin, there are 24 lakes in Coimbatore. Among these 24 lakes, five lakes, namely, Sulurlake, Singanallur lake, Ukkadam lake, Selvachintamani lake and Selvampathy lake were considered for this study as they are situated in the heart of the city. The site location of these lakes in the city of Coimbatore is shown in Figure 2 below.

Samples of the selected sampling points were collected in pre-treated clean bottles. The bottles were rinsed thoroughly with the sample. During transportation the water sample bottles were kept in ice. The various physical, chemical and biological analyses were conducted as soon as the samples were taken to the laboratory. Laboratory tests were conducted for pH, Total dissolved Solids (TDS), electrical conductivity, total hardness, chlorides, sulphates, sodium, potassium, biological oxygen demand (BOD), chemical oxygen demand (COD), total alkalinity and *E. coli* concentration were analysed. The test method and code adopted for each test is provided in Table 1 below.

Results and Discussion

The physical, chemical and biological characteristics of the lakes varied based on their pollution levels in the surroundings. Table 2 gives the summary of the various parameters which were tested on the water samples collected for each of the lakes considered in this study.

Physico-chemical characteristics

Figure 3(a-l) provide the comparison of each water quality parameter in the five lakes. The permissible limit for drinking water supply for each parameter is

Fig. 2 — Location of the lakes selected for this study (L1. Sulur lake, L2. Singanallur lake, L3. Ukkadam lake, L4. Selvachintamani lake, and L5. Selvampathy lake)

Table 1 — Test method and code adopted for each water quality parameter

S. No	Name of the Test	Test Method	IS Code
1	Ph at 27.0 °C	Electrometric Method	IS:3025 (Part 11):1984
2	Total Dissolved Solids	Oven Method	IS:3025 (Part 16):1984
3	Electrical Conductivity	Specific Conductance Method	IS:3025 (Part 14):2002
4	Total Hardness as $CaCO_3$	Titration with EDTA Solution	IS:3025 (Part 21):2002
5	Chloride as Cl	Argentometric Method	IS:3025 (Part 32):1988
6	Sulphate as So	Gravimetric Method	IS:3025 (Part 24):1986
7	Sodium as Na	Flame photometric Method	
8	Potassium as K	Flame photometric Method	
9	BOD	Incubator method	IS:3025 (Part 44):1993
10	COD	Titration	IS:3025 (Part 58):2006
11	Total Alkalinity	Titration	IS:3025:1964
12	*E. coli*	Membrane filtration method	IS 15185 – 2002

Table 2 — Comparison of various water quality parameters

Name of the Lake / Test	pH at 27 °C	TDS	Electrical conductivity	Total Hardness as $CaCO_3$	Chloride as Cl	Sulphate as SO_4	Sodium as Na	Potassium as K	BOD	COD	Total Alkalinity	*E. coli* (10^3)
Permissible limit for drinking water (WHO[15])	7-8.5	1000 mg/l	469.2 -1173 µS/cm	200 mg/l	250 mg/l	250 mg/l	200 mg/l	600 mg/l	0 mg/l	0 mg/l	600 mg/l	30x10^3 cfu/ml
Sulur Lake	8.3	1107.0	2014.0	450.0	496.3	39.0	195.0	23.0	12.0	80.0	487.5	12.0
Singanallur Lake	8.3	1381.0	2511.0	570.0	567.2	43.1	205.0	25.1	23.0	190.0	592.5	19.0
Ukkadam Lake	8.4	887.8	1608.0	210.0	439.6	32.0	92.5	12.0	28.0	210.0	315.0	33.0
Selvachinthamani lake	8.4	887.8	1608.0	210.0	439.6	32.0	92.5	12.0	28.0	210.0	315.0	33.0
Selvampathy Lake	8.6	1062.0	1938.0	310.0	453.8	38.9	177.5	33.0	60.0	320.0	527.5	23.0

shown with a red line on the graph. It is observed from the table that the pH value varies from 8.3-8.6. Only Selvampathy lake (Fig. 3a) has exceeded the permissible range of 6.5-8.5 provided by WHO[15]. The high pH range may be due to various human activities[16]. The pH of the Ukkadam lake has dropped to 8.4 from 8.62 reported by Chandra *et al*.[7] but still higher when compared to that reported by Mohanraj *et al.*[8]. The TDS of Sulur, Singanallur and Selvampathy lakes are beyond the permissible limit of 1000 mg/l[11]. The TDS is highest in the Singanallur lake (1381 mg/l), followed by Sulur lake (1107 mg/l) and Selvampathy lake with 1062 mg/l (Fig. 3b). This may be due to pollution from dyeing and bleaching industries present in the vicinity of the lakes. The TDS values in Ukkadam and Selvachintamani lakes are within the permissible limit. In comparison with the results of Mohanraj *et al.*[8], the TDS values have significantly dropped in Selvachintamani lake (9233 mg/l to 888 mg/l) and marginally reduced in Singanallur (from 1553 to 1381 mg/l), Ukkadam lakes (1056 to 888 mg/l). On the other hand, the TDS value has considerably increased in the Selvampathy lake from 326 mg/l to 1062 mg/l. This confirms the dumping of effluents in the Selvampathy lake. The electrical conductivity is a measure of the TDS in the tested water. It is evident from the table that the lakes that have high TDS values also have high electrical conductivity and vice-versa.

The total hardness value is higher than the permissible limit of 200 mg/l in all the lakes (Fig. 3d). Ukkadam and Selvachintamani lakes are marginally beyond the limit with 210 mg/l while Selvampathy lake has a hardness value of 310 mg/l, Sulur lake has 450 mg/l and Singanallur has the highest value of 570 mg/l. The hardness values have decreased when compared to Mohanraj *et al*.[8] but the hardness of the water sampled at Selvampathy lake has increased from 200 to 310 mg/l. From the comparison, it can be concluded that the dumping of solid wastes in these lakes has reduced over the years except for Selvampathy lake. The chloride concentration varied from 453.8 to 567.2 mg/l. The chloride concentration is higher than the permissible limit of 250 mg/l in all the lakes (Fig. 3e). Only in Selvachintamani lake the chloride concentration has reduced from 1470 mg/l reported by Mohanraj *et al*.[8] to 439.6 mg/l in the current study. While in all other lakes the chloride concentration has increased over the years. The high chloride concentration could be due to dumping of domestic waste by the occupants in the surroundings of the lake.

The sulphate concentration varies from 32 to 43.1 mg/l. The sulphate concentration is within the permissible limit of 250 mg/l (Fig. 3f). The low sulphate concentration indicates that there is no agricultural runoff and animal wastes being dumped into these lakes. The sulphate concentration has drastically reduced when compared to the results reported by Mohanraj *et al.*[8]. The sodium concentration has varied from 92.5 to 205 mg/l. The concentration is within the permissible limit of 200 mg/l[ref.11] for all the lakes (Fig. 3g). The potassium concentration has varied from 12 to 33 mg/l and this is also found to be within the permissible limit (Fig. 3h).

Biological characteristics

The BOD values have varied from 12 to 60 mg/l. The BOD values are beyond the permissible range of 1-5 mg/l. The highest BOD was reported in Selvampathy lake and the lowest was recorded in Sulur lake. Ukkadam and Selvachintamani lakes have 28 mg/l as BOD while Singanallur has 23 mg/l (Fig. 3i). This indicates the organic pollutant concentration is very high. This may be due to discharge of effluents into the lakes. Selvampathy lake is being heavily contaminated (BOD = 60 mg/l), which is in accordance with the earlier observations of other parameters for this lake. The BOD values have increased by an order of magnitude compared to those reported by Mohanraj *et al.*[8]. For Ukkadam lake, a BOD of 2.1 mg/l was reported by Chandra *et al.*[7] but the BOD of Ukkadam lake has increased to 28 mg/l. This indicates that dumping in the Ukkadam lake is very intense which has caused the BOD to increase by an order of magnitude within 3 years. The COD ranges from 80 to 320 mg/l. The highest COD was observed at Selvampathy lake and the lowest at Sulur lake (Fig. 3j). The COD in Ukkadam and Selvachintamani lakes were estimated to be 210 mg/l and the COD for Singanallur was found to be 190 mg/l. The COD values for all the lakes were found to be within the permissible limit of 250 mg/l except at Selvampathy. The total alkalinity ranges from 315 to 592.5 mg/l. Alkalinity is highest in Singanallur lake with 592.5 mg/l and lowest at Ukkadam as well as Selvachintamani lake with 325 mg/l (Fig. 3k). The alkalinity at all sites are within the permissible limit of 600 mg/l. Alkalinity has increased at Singanallur

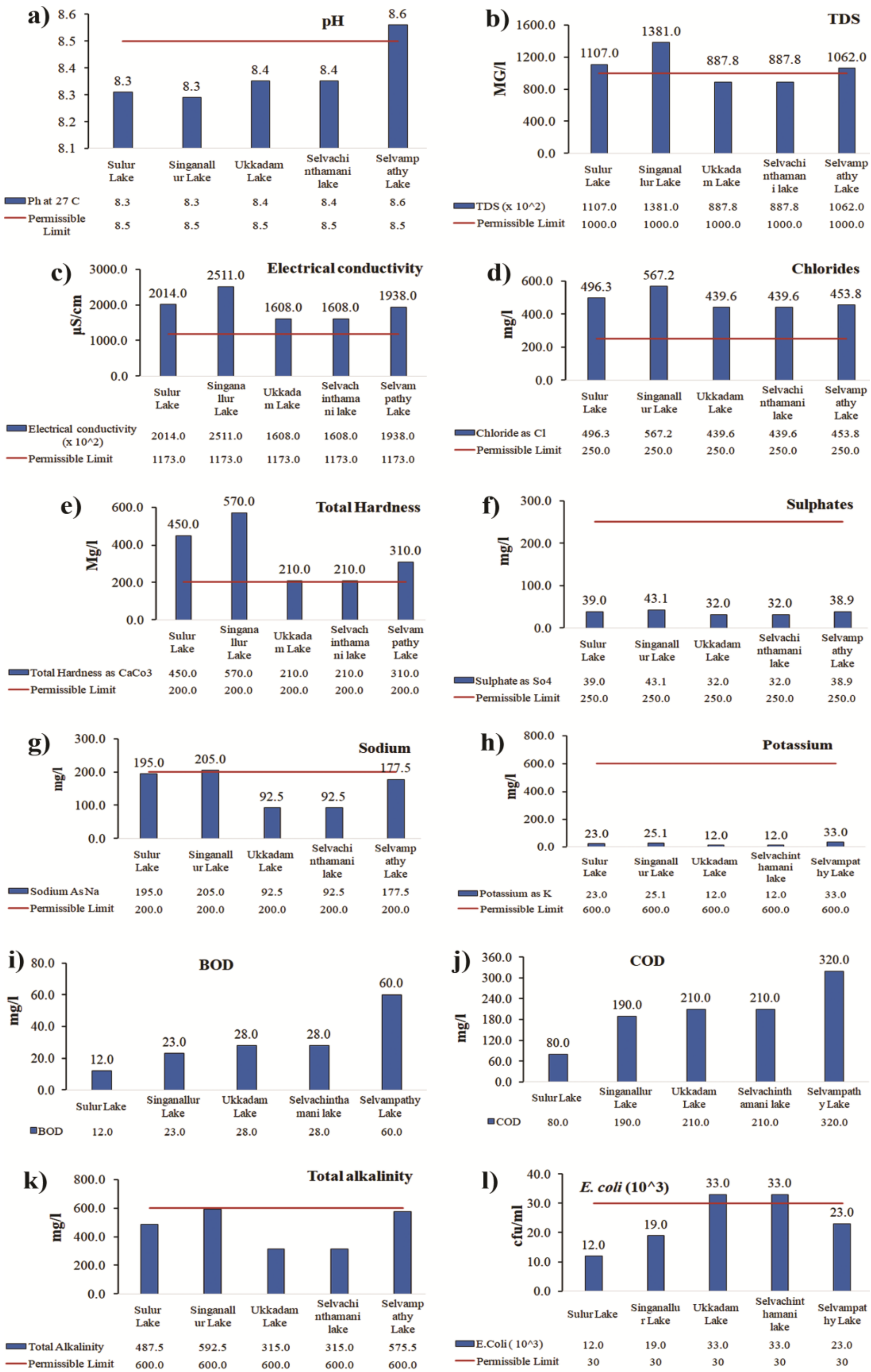

Fig. 3 — (a-l) Schematic representation of the comparison of water quality parameters of the five lakes

lake and Selvampathy lake compared to the values reported by Mohanraj *et al.*[8]. Higher alkalinity values could be due to domestic dumping and open defacation[7]. *E. coli* was measured to determine the biological contamination in the collected water samples. It was found that Ukkadam and Selvachintamani lakes have *E. coli* concentration beyond the permissible limit of $30x10^3$ cfu/ml (Fig. 3l). The contamination of *E. coli* is due to discharge of black water from the adjacent houses into these lakes. The reason for both these lakes possessing similar physico-chemical and biological characteristics is because both of them are in close vicinity.

Conclusion

The physico-chemical and biological characteristics of five lakes, namely, Sulur, Singanallur, Ukkadam, Selvachintamani and Selvampathy were analysed. The water quality of Selvampathy lake has drastically reduced as TDS, total hardness, BOD and COD values are beyond the permissible limit for this lake. This is due to discharge of industrial effluents and dumping of solid wastes. The chloride concentration of all the lakes has increased considerably. The low sulphate concentration in all these lakes indicates that there is no agricultural runoff and animal wastes being dumped into these lakes. The BOD concentration of Ukkadam lake has increased by an order of magnitude within three years. Ukkadam and Selvachintamani lake has faecal contamination as the *E. coli* concentration is beyond the permissible limit. The degradation of the quality of these lakes poses a major threat for the aquatic biota, public health and ground water quality. Although the water from these lakes may not be used for drinking water supply, they can neither be used for other purposes like irrigation, domestic, etc. Contamination of the Noyyal river could be one of the causes of depletion of water quality in these lakes. Discharge of industrial effluents and dumping of solid wastes at the boundary of the lakes is another cause of concern for the deteriorating water quality. These lakes are a major source for groundwater recharge and severe contamination of these lakes defeats this purpose. For the conservation of these lakes, regular water quality monitoring, stopping the dumping of solid wastes, clearing the encroachments and prevention of the release of industrial effluents is mandatory. Treating the industrial effluents before discharging them into the lakes can prevent contamination of the lakes to a large extent.

Conflict of Interest

Authors have no conflict of interest.

Author Contributions

Conceptualization and design of the work: SD; Data analysis and interpretation: NN; Supervision and Writing - review, editing and final approval: SD and NN.

References

1 Government of India (GoI), *Census of India*, (Office of the Registrar General and Census Commissioner, Government of India, New Delhi) 2011.
2 Government of India (GoI), *Integrated Water Resource Development: A Plan for Action. Report of the National Commission on Integrated Water Resources Development (NCIWRD)*, (Ministry of Water Resources, Government of India) 1999, pp. 1.
3 Cronin A A, Prakash A, Priya S & Coates S, Water in India: situation and prospects, *Water Policy*, 16 (2014) 425-441.
4 National Institute of Hydrology, *Water Resources of India*, (NIH, Roorkee, Uttarakhand) 2010.
5 World Resources Institute, Estimates of Water Resources and Freshwater Ecosystems – Actual Renewable Water Resources for 2007, (WRI, Washington, DC) 2007.
6 Prusty B A K, Role of detritus in trace metal dynamics of a wetland system: A case study of Keoladeo National Park, Bharatpur, (Report to Council of Scientific and Industrial Research, New Delhi, India) 2008.
7 Chandra R, Nishadh K A & Azeez P A, Monitoring water quality of Coimbatore wetlands, Tamil Nadu, India, *Environ Monit Assess*, 167 (2010) 671-676.
8 Mohanraj R, Sathishkumar M, Azeez P A & Sivakumar R, Pollution status of wetlands in urban Coimbatore, Tamil Nadu, India, *B Environ Contam Tox*, 64 (2000) 638–643.
9 Mathew M, Mohanraj R, Azeez P A & Pattabhi S, Speciation of heavy metals in bed sediments of wetlands in urban Coimbatore, *B Environ Contam Tox*, 70 (2003) 800– 808.
10 Mathew M, Satish Kumar M, Azeez P A, Siva Kumar R & Pattabi S, Sediment quality of wetlands in Coimbatore, Tamil Nadu, India, *B Environ Contam Tox*, 68 (2002) 389– 393.
11 Jebastina N & Arulraj G P, Contamination analysis of groundwater in Coimbatore district, India: a statistical approach, *Environ Earth Sci*, 75 (2016) 1447.
12 Selvakumar S, Chandrasekar N & Kumar G, Hydrogeochemical characteristics and groundwater contamination in the rapid urban development areas of Coimbatore, India, *Water Resour Ind*, 17 (2017) 26-33.
13 Jijin G W & Devi R V, Change detection analysis of water pollution in Coimbatore region using different colour models, *J Inst Eng India Ser B*, 99 (2018) 87-95.
14 Jeyaraj M, Mahalingam V, Indhuleka A, Sennu P, Ho M-S, *et al.*, Chemical analysis of surface water quality of river Noyyal connected tank in Tirupur district, Tamil Nadu, India, *Water Energy Int*, 62 (2019) 63-68.
15 World Health Organization, *The world health report, 1997, conquering suffering, enriching humanity / report of the Director-General*, (World Health Organization) 1997.
16 Skoulikidis N T, Bertahas I & Koussouris T, The environmental state of freshwater resources in Greece (rivers and lakes), *Environ Geol*, 36 (1998) 1–2.