J. Mater. Environ. Sci. 5 (4) (2014) 1119-1124
ISSN : 2028-2508
CODEN: JMESCN

Potential ecological assessment of sediment quality and heavy metals contamination in Kuruchi Lake, Tamil Nadu, India

R. Manikandan[1], S. Kalaichelvi[2], N. Ezhili*[3]

[1]*Department of Biotechnology, Periyar University, Salem-11, Tamil Nadu, India*
[2]*Department of Zoology, Sri G.V.G. Visalakshi College for Women, Udumalpet - 11, Tamil Nadu, India*
[3]*Department of Zoology, PSGR Krishnammal College for Women's, Peelamedu, Coimbatore - 04, Tamil Nadu, India*

Received 11 Jan 2014, Revised 28 Mar 2014, Accepted 28 Mar 2014
** For Correspondence: E-mail: ezhilinatarajan@gmail.com*

Abstract

Kuruchi Lake is an important freshwater body of Coimbatore City, Tamil Nadu, India. This lake receives municipal wastes and industrial effluents which contain heavy metals. Therefore, the present study was aimed to investigate the status of physicochemical properties and heavy metal levels in surface sediments of Kuruchi Lake. The result of physicochemical parameters such as pH, Electro Conductivity (EC), chloride, calcium, magnesium, phosphate, sulphate, sodium, potassium, total nitrogen, iron, total alkalinity and total organic carbon concentrations were found to be higher in sediment sample of station 4. The heavy metals concentration showed variations with Cd 4-14 mg/kg, Cr 2295-3198 mg/kg, Cu 872-1199 mg/kg, Ni 964-1520 mg/kg, Mn 4996-5820 mg/kg and Pb 999-1489 mg/kg, respectively. The highest concentrations of Cr, Pb, Ni and Cu were found to be higher in station 4, when compared to other study stations. Cd and Mn levels were found within the normal range. The cluster analysis was used for determining the similarity of heavy metals concentrations in different study stations. This study reveals that sediments of Kuruchi Lake were partially polluted with heavy metals. This study provides the baseline data for future sediment quality assessment of this lake and regular monitoring of sediment quality in this lake is highly recommended.

Key words: heavy metal, Kuruchi Lake, physicochemical parameters, Sediment, Coimbatore

1. Introduction

The Kuruchi Lake is a large fresh water lake which plays important role in intensive commercial fishing and irrigation purpose by local people at Kuruchi in Coimabatore, Tamil Nadu, India with latitude of 10° 58' 38'' and longitude of 76° 55' 44'' (Fig. 1). It is having a registered ayacut of 452 acres with the catchment area of 6.272 Sq.km of free and 12.162 Sq.km of combined area. This lake receives various types of industrial effluents, domestic's sewage and urban runoff, which resembles as large number of point sources of pollution.

The toxic levels of heavy metal contamination in sediment may impose critical threat to aquatic species as well as human health [1, 2]. Heavy metals naturally occurred in all agricultural soils and lake sediments most of them are either essential or beneficial to all living organisms. However they can become toxic, if accumulated in excess amount in the food chains [3]. Its harmful effects could cause dangerous situations sometimes affecting the ecological balance of these ecosystems. Heavy metals are not removed or degraded by biologically and it was fact promotes their cumulative aspect in the various compartments of the ecosystem (water, fauna and flora) [4]. Due to the anthropogenic activity as well as increasing of usage of industrial products, gradually huge amount of heavy metal containing industrial wastes discharged into land and water bodies without proper treatment [5]. That may be one of the reasons for increase in heavy metal contamination in lake sediments.

The determinations of heavy metal contamination in sediments are fundamental to the solution of many environmental problems [6] and can be of great importance for local people's health [7]. Nowadays, massive economic growth and urban development of Coimbatore city has led to excessive release of waste into Kuruchi Lake, including heavy metal from industrial and urban sources. However, there is no information available about

the sediment quality and heavy metal contamination levels in Kuruchi Lake sediments. Therefore, the main objectives of this study are to investigate the physicochemical properties and heavy metal contamination levels in sediments of Kuruchi Lake.

2. Materials and methods

2.1. Sample collection and analysis

The present study was conducted in Kuruchi Lake of Coimbatore District of Tamil Nadu, India. The surface sediment samples (approximated 3-5 cm in depth) were collected by using a pre-cleaned, acid washed PVC corer from 4 selected stations in Kuruchi Lake during February 2013. Samples were placed in pre-cleaned polythene bags and transferred to the laboratory and then thoroughly mixed to create composite samples of each station. These sampling stations were selected based on the human activities, which were Stations 1 and 3 which received sewages and located nearby the household area. The station-2 is located nearby agricultural area. Station 4 receives municipal sewage and effluents from many industries and it is located opposite to Ukkadam Main Road. Sediment samples were defrosted at room temperature and air-dried in a controlled dark and ventilated clean environment. Then, they were ground evenly an agate pestle and mortar and sieves with a screen of 100 meshes before the analysis.

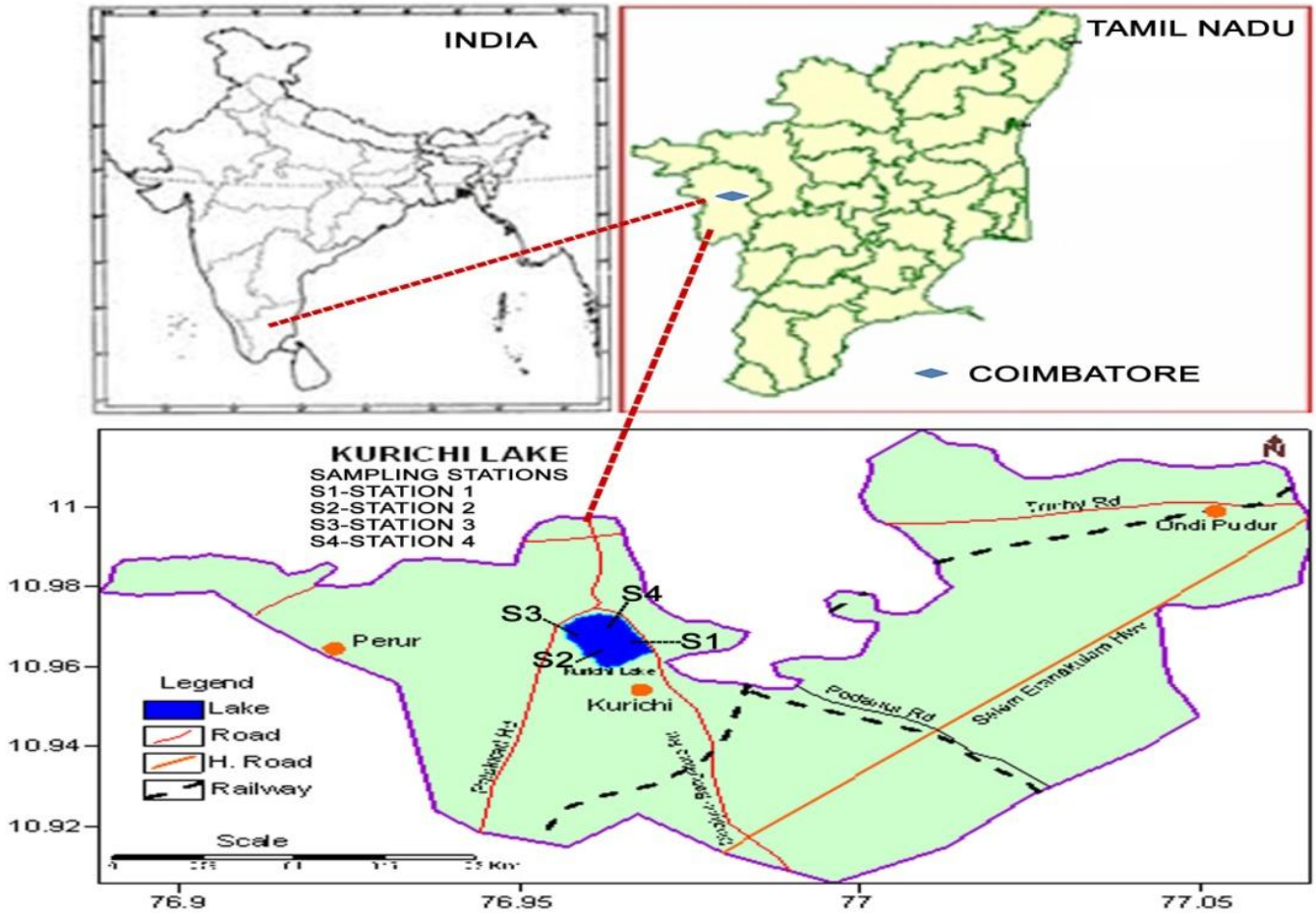

Figure 1: Study area map

2.2. Physicochemical parameters of sediment samples

Sediment Samples (10.0 g) through 100mm mesh were put into a 50-mL beaker containing 25 mL of distilled water. The solution was sharply agitated for 2 minutes and deposited for 30 minutes. Then, the pH and Electrical conductivity (EC) values were determined by the respective meters. Chloride was determined argentometrically by using $AgNO_3$. Sulphate was analyzed turbidometrically using $BaCl_2$. Sodium and potassium was estimated using flame photometer after extracting with neutral ammonium acetate. For Total alkalinity analysis, titration method was used with phenolphthalein and methyl orange

as indicators. Calcium, magnesium, phosphate and total available nitrogen were estimated by method of Methew et al. [8]. Total organic carbon (TOC) concentration was determined by potassium dichromate titration method [9].

2.3. Determination of heavy metal content in sediment samples

The sediment samples were dried at 75 °C for 2 days and then ground to fine powder. Sediment sample (0.5g) was dried and digested with mixing solution of 1:3 HNO_3: HCl for 1 h. The solution was cooled, filtered and diluted with 25 ml of distilled water. The heavy metal concentrations (Cd, Cr, Cu, Fe, Ni and Pb) were determined using Atomic Absorption Flame Emission Spectrophotometer (AAFES – 6200 Shimadzu).

2.4. Statistical Analysis

Statistical analysis of the present data were interpreted using single factor analysis of variance (one way – ANOVA, $p<0.05$ (SPSS Version 15.0)) to analyze the difference of physicochemical properties and heavy metal levels at different stations. Cluster analysis was applied to evaluate the similarity of sampling stations with respect to concentrations of total heavy metals in sediments (SPSS Version 15.0).

3. Results and discussion

3.1. Physicochemical properties of Kuruchi Lake sediment

The mean values of physicochemical properties in sediment samples of Kuruchi Lake were given in table 1. In the present study no notable variation was seen in the pH levels among the study stations. The lowest pH was recorded in station 2 (Table 1). Shanthi et al. [10] reported that, the pH levels in sediment of Singanallur wetland and it was ranged between 7.7 to 8.3. Electrical conductivity (EC) in the sediment samples ranged from 127.4 to 450.3 (µmhos/cm), respectively. This parameter level was seen to be higher in station 1 and lowest in station 3. Chloride (Cl) and Sodium (Na) concentrations in the sediment ranged from 245.1 – 607.1 mg/L and 300 – 660 mg/L, respectively and it was seen to be higher in station 1 and lowest concentration in station 3. The nutrients such as sulphates and phosphates were presented in the sediment ranges of 200 – 350 mg/L and 900 – 1200 mg/L, respectively.

Table 1: Physicochemical properties of Kuruchi Lake sediments

Parameters	**Station 1**	**Station 2**	**Station 3**	**Station 4**
Ph	7.37 ± 0.22	7.18 ± 0.08	7.31 ± 0.20	7.68 ± 0.14
EC (µmhos/cm)	450.3 ± 8.02	222.1 ± 4.46	127.4 ± 5.57	330.8 ± 4.96
Chloride mg/Kg	607.2 ± 5.58	285.82± 5.63	245.1 ± 4.65	245.1 ± 4.65
Calcium mg/Kg	10171 ± 1.77	4781 ± 8.35	3042 ± 1.49	6757 ± 3.41
Magnesium	1960 ± 3.90	921 ± 0.51	597 ± 4.05	1621 ± 0.43
Phosphate	1200 ± 5.77	1000 ± 5.77	900 ± 0.00	1200 ± 5.29
Sulphate	200.0 ± 5.77	350.0 ± 5.19	220.0 ± 11.54	300.0 ± 2.0
Sodium	660.0 ± 2.88	420.0 ± 5.77	320.0 ± 11.54	300.0 ± 2.80
Potassium	320.0 ± 5.77	480.0 ± 5.77	560.0 ± 5.77	180.0 ± 5.77
Available Nitrogen	10212 ± 4.52	11098 ± 4.61	9623 ± 2.02	9812 ± 1.48
Iron	10.0 ± 0.57	14.0 ± 1.55	12.0 ± 1.15	12.0 ± 1.15
TOC (%)	14.68 ± 0.29	15.86 ± 0.18	17.54 ± 0.31	17.78 ± 0.34
TA (%)	0.035 ± 0.08	0.040 ± 0.10	0.045 ± 0.14	0.037 ± 0.09

Data are means $\pm$ SE (n=3), Electro conductivity (EC), Total Organic Carbon (TOC), Total Alkalinity (TA)

The maximum sulphate and phosphate values were noticed from station 1 and 2 of Kuruchi Lake sediments. The highest nutrients such as Cl, Na, phosphate and sulphate contents were found in station 1, it may due to dye effluents discharged from various industries [11], which leads to deposition of high salt content in sediments. The lowest concentration of Calcium (Ca) and Magnesium (Mg) were observed in station 3, while highest Ca and Mg concentrations was found in station 1 compared to other two stations. A study by Mathew et al. [8] have showed that the physicochemical parameters such as Cl, Na, sulphates and phosphate were found to be higher in sample 1

and lowest in sample 4 of lake sediments. The total organic carbon (TOC) concentration was ranged between 14.6- 17.8 %, in all the study stations. The maximum level of TOC (17.8 %) was noticed in station 4, which may be due to the continuous dumping and accumulation of organic matter at this study station. A similar result was reported by Swarnalatha et al. [12] in sediment of Akkulam-veli Lake. The total alkalinity (TA) and nitrogen (TN) levels were ranged between 0.035 – 0.045 % and 9623 – 11098 mg/L in all the study stations. Compared to other stations the highest TN concentration (11098 mg/L) was observed in station 2. However, this study station was located nearby agricultural lands.

3.2. Total heavy metal concentrations in surface sediments of Kuruchi Lake

The total heavy metal concentrations in surface sediments of all studied stations were presented in Fig.2. The normal and critical range of these metals as per report of Alloway [13] is given in table 2. The heavy metals concentration showed variations with Cd 4-14 mg/kg, Cr 2295-3198 mg/kg, Cu 872-1199 mg/kg, Ni 964-1520 mg/kg, Mn 4996-5820 mg/kg and Pb 999-1489 mg/kg. The highest concentration of Cd and Mn (0.0141 mg/kg and 5820 mg/kg) were noticed in station 4 (Fig.2 a, d), these metal concentrations were found within the normal range (0.01- 2.0 mg/kg and 20-10000 mg/kg) (Table 2). The highest concentrations of Cr, Pb, Ni and Cu (3.1980 mg/kg, 1.4896 mg/kg, 1.5208 mg/kg and 1.1990 mg/kg) also was found to be higher in station – 4 (Fig.2 b, f, e and c), these metals normal concentrations are 5-150 mg/kg (Cr), 2- 300 mg/kg (Pb), 2- 750 mg/kg (Ni) and 2 – 250 mg/kg (Cu) as per the report of Alloway [13] (Table 2). The study shows that station – 4 is highly polluted than other stations in Kuruchi Lake, which might be due to the discharge of effluent from various industries and municipal wastes. The present values of six heavy metals in all the studied stations were higher than the previous results reported by Mathew et al. [8] in six Coimbatore wetland sediments and Shathi et al. [11] in Singanallur wetland sediments.

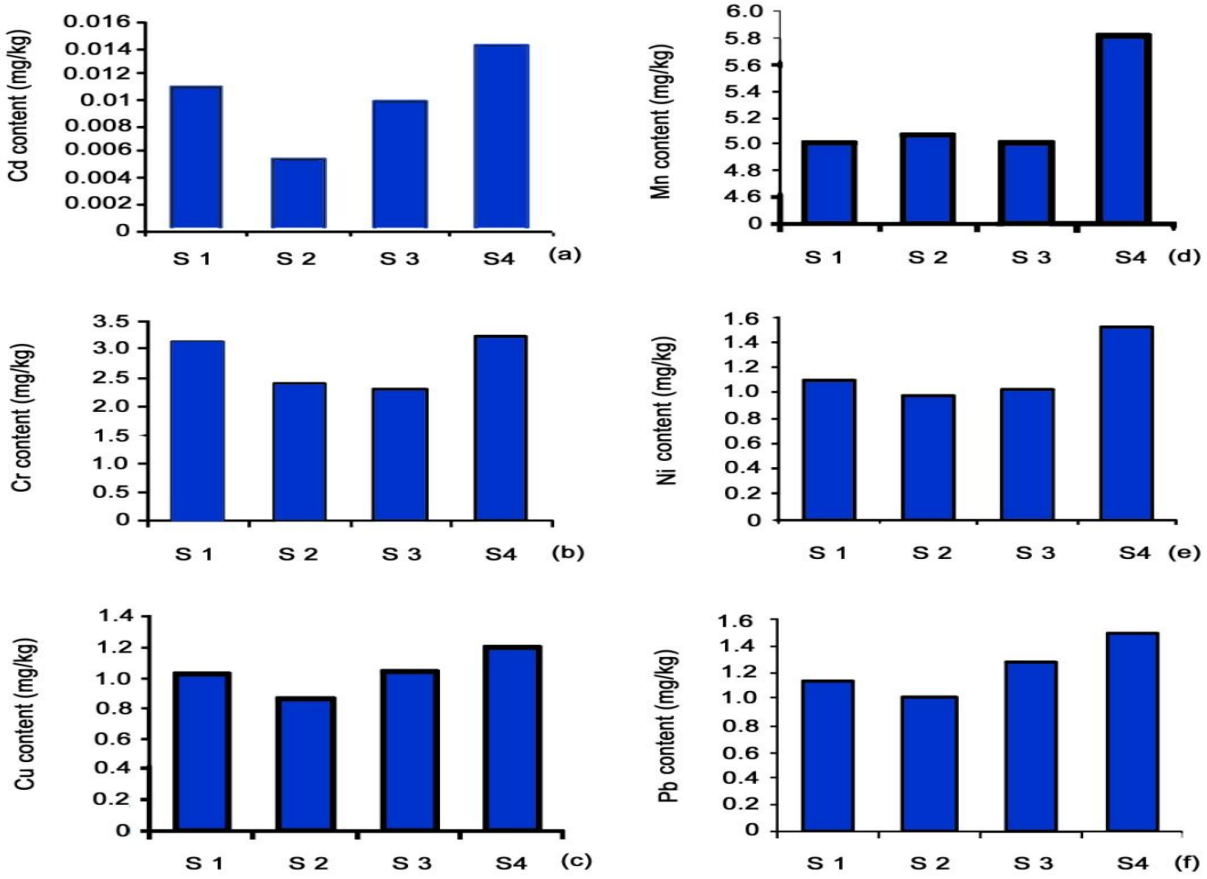

Figure 2: Total heavy metal concentrations in surface sediments of Kuruchi Lake

In all the study stations, these heavy metals (Cr, Cu, Ni and Pb) concentration were obtained much higher than the normal range, which may be attributed to the discharged effluents from some electro planting and textile industries around this lake. The cluster analysis was also used to determine whether the heavy metal concentrations differed from one station to another (Fig. 3). Accordingly, during cluster analysis it has been revealed that the highest heavy metal contamination was found in station 4 followed station 3 which also highly polluted by heavy metals.

Table 2: Normal and critical concentrations of heavy metals in soil (Alloway, 1990)

Heavy metals	Normal range	Critical range in soil (mg/Kg)
Cd	0.01-2.0	3-8
Cr	5-150	75-100
Cu	2-250	60-125
Mn	20-10000	1500-3000
Ni	2-750	100
Pb	2-300	100-400

a. Cadmium (Cd), b. Chromium (Cr), c. Copper (Cu), d. Nickel (Ni), e. Manganese (Mn) and f. Lead (Pb)

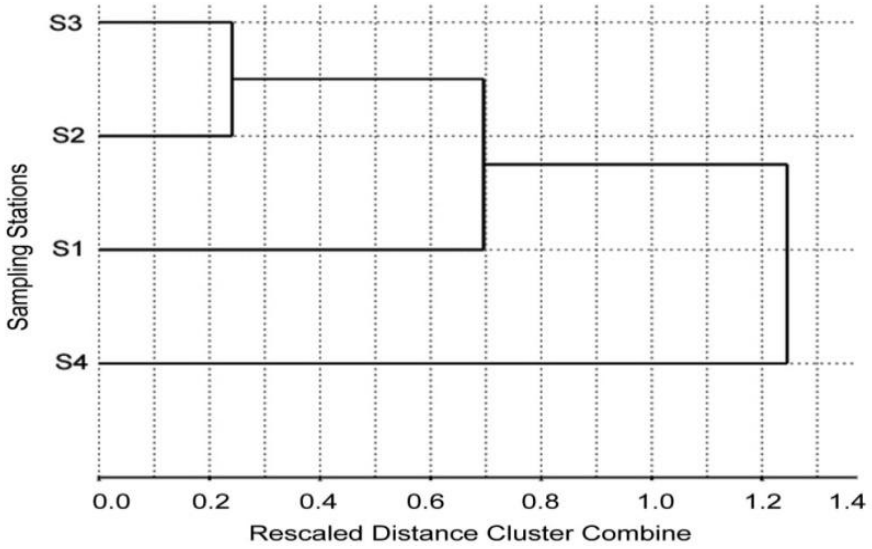

Figure 3: Dendrogram analysis obtained by cluster method which is applied using ward connection method and euclidian distance criteria

Conclusion

This study provides the first comprehensive analysis of physicochemical properties and heavy metals status in surface sediments of Kuruchi Lake. From this investigation, it was showed that the physicochemical parameters and heavy metal levels were much higher in sediment samples, which indicated that this lake was heavily polluted by human activities and discharging of effluents from textile, electroplating industries. We conclude that the Kuruchi Lake sediment quality was deteriorating and potentially hazardous to public health. This needs proper maintenance by the authorities by continuous monitoring of the lake by controlling the discharge of waste and effluents in this study lake.

References

1. Pennington W., *Hydrobiology* 79 (1982) 197-219.
2. Charkhabi A.H, Sakizadeh, M., Rafiee, G., *Environmental Science and Pollution Research* 12(2005) 264–270.
3. Kumar M., Sridevi K., Tamilarasan R.., *Journal of Materials and Environmental Science*, 3 (5) (2012) 947-954

4. Benel harkati F., Elkharrim K.H., Sadek S., Elmarkhi M., Belghyti D., *Journal of Materials and Environmental Science*, 4 (2) (2013) 315-318.
5. Yu B., Zhang, Y., Shukla, A., Shukla, S.S., Dorris, K.L., *Journal of Hazards Materials* 84 (2001) 83-94.
6. Weisz M., Polyák, K., Hlavay, J., *Microchemical Journal*, 67(2000) 207–217.
7. Liu J., Goyer, R.A.,Waalker, M.P., *The Basic of Science of Poisons. McGraw-Hill, New York,* (2008) pp.931-979.
8. Mathew M., Mohanraj, R., Azeez, P. A., Pattabhi, S., India. *Bulletin of Environmental Contamination and Toxicology* 70 (2003) 800-808.
9. Gauoette H., Flight, E., Toruen, W. R L., Folger, D., W., *Joumal of Sedimentary Petrology* 44 (1974)249 - 253.
10. Shanthi K., Ramasamy, K., Lakshmanaperumalsamy, P., *Bulletin of Environmental Contamination and Toxicology* 70 (2003) 372-378.
11. Senthilnathan S., Azeez, P. A., *Journal of Industrial Pollution Control 15* (1999) 77–86.
12. Swarnalatha K., Letha, J., Ayoob S., *Environmental Earth Science* 68 (2013) 795-806.
13. Alloway B.J., *John Wiley and Sons, Inc. New York,* (1990) ISBN 0470215984.