Bull. Environ. Contam. Toxicol. (2003) 70:372–378

DOI: 10.1007/s00128-002-0201-8

Bulletin of Environmental Contamination and Toxicology

Sediment Quality of Singanalluar Wetland in Coimbatore, Tamil Nadu, India

K. Shanthi,[1] K. Ramasamy,[2] P. Lakshmanaperumalsamy[3]

[1] Department of Environmental Science, PSG College of Arts and Science, Coimbatore-14, Tamil Nadu, India
[2] Adhi Parasakthi Agricultural College, Kalavai, Vellore District, Tamil Nadu, India
[3] Department of Environmental Sciences, Bharathiar University, Coimbatore-46, Tamil Nadu, India

Received: 17 April 2002/Accepted: 27 November 2002

Sediments and suspended particulate matter play an important role in dynamics of inorganic and organic compounds in the aquatic environment. Contaminants in sediment have a wide range of availability, depending on lotic, lentic, estuarine or marine conditions, physical properties of the sediments, nature and form of contaminants and the chemical and biological parameters of the water involved. Sediments act as a platform for chemical transformations of heavy metals and also as a secondary contamination source through exchange processes. Freshwater sediments act as an important reservoir of metals of anthropogenic origin and the contamination thus caused is of potential ecological importance (Campbell and Tessier 1991). Most of the limnological works are based on different aspects of physico-chemical factors operating in water (Mohanraj et al. 2000). Investigations on sediments as indicators of pollution are on record (Shanthi et al. 1999; Choudri and Chavadi 2000; Anand and Sharma 2000).

The Singanallur Lake is heavily polluted due to the mixing of raw sewage and silts carried by the drains entering in the lake. This lake is used for fishing and also for recreational activities like boating. At present the northern part of the lake is submerged under a thick sheet of water hyacinth. Littoral regions of the lake are where exchange of various minerals and nutrients are highly pronounced due to the active growth of biota. Considering the minimal work done on physico-chemical characteristics of the sediments of the Indian Lakes (Ahmad et al. 1996; Mathew et al. 2002), the littoral regions of Singanallur wetland have been investigated, as no such attempt has been made in the past. The purpose of the study was to examine physico-chemical characteristics in the sediment of the lake and for the presence of metals.

MATERIALS AND METHODS

Singanallur Lake is situated Southwest of the Coimbatore district of south India between 10°56'46" latitude and 77° 01'11" longitude. The lake, with an area of 835m^2, is divided into two equal halves, but connected by a railway line running through it. The south half of the lake receives freshwater only during the rainy season from the Noyyal River through a channel and the water is clear. The north

Correspondence to: K. Shanthi

half receives urban, domestic and industrial wastes. Storm water and road runoff during the rainy season enters the northern side of the lake through Sanganoor pallam from its catchment area of 41 km^2 comprising part of Coimbatore urban and suburban areas. The north half of the lake was selected for the study because this area seems to be highly polluted by various constituents from urban and domestic sewage.

Sediment samples were collected monthly from six different points along the littoral regions of the lake from January 2000 to December 2000 using a pre-cleaned, acid washed PVC corer. Samples were placed in pre-cleaned polythene bags and transferred to the laboratory (Mathew et al. 2002). Composite samples were prepared by mixing the six samples from the different sites, to provide an overall contamination level of the sediment. This composite sample was ground, sieved with a 200-mesh sieve and kept in airtight containers. pH, nitrogen and phosphate in the sediments were analysed immediately. pH and electrical conductivity were tested using the respective meters. Total organic carbon was estimated following Walkley and Black method (1934). Exchangeable Ca^{2+} and Mg^{2+} were estimated separately after leaching with acetate solution by EDTA titrimetric method (Piper 1966). Available nitrogen was determined using alkaline $KMnO_4$ and available phosphorus by the stannous chloride method. Sulphate was estimated turbidometrically using $BaCl_2$. Total alkalinity was determined by titration using phenolphthalein and methyl orange indicators. Chloride was estimated argentometrically using $AgNO_3$. Sodium and potassium were estimated using flame-photometry, after extracting with neutral ammonium acetate. For accurate metal analysis, 1 gram of dried sediment was weighed and digested using a mixture of concentrated KNO_3 and HCl (3:1 by volume). Finally, the solution was filtered, double distilled water was added to the required volume and the samples were analyzed for metals using atomic absorption spectrophotometry (Perkin -Elmer model 3300).

RESULTS AND DISCUSSION

The data obtained on sediment characteristics were divided into four seasons, representing the winter season (January to February), summer season (March to May), Southwest monsoon (SWM, June to September) and Northeast monsoon (NEM, October to December). The monthly variation of physico-chemical parameters of sediments is summarized in Table 1. The average seasonal concentration of the parameters is shown in Table 2. The pH of the sediment of the lake ranged from 7.7 (March 2000) to 8.3 (July 2000). The average pH value was lower during summer than the winter, Southwest monsoon and Northeast monsoon values. A seasonal fluctuation in conductivity was observed and the data revealed that the monsoons showed higher values followed by the winter and the summer seasons. The monthly concentration of chloride was found to be high during September and low during the January. Seasonally, the monsoon and the winter periods showed high amount of chloride. In the lake, the total alkalinity of sediment ranged between 1.5 % and 3.0 %. The average southwest monsoon

Table 1. Monthly concentration of physico-chemical parameters of Singanallur lake sediments

Parameters	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Average	SD
pH	7.9	7.9	7.7	7.9	7.8	8.1	8.3	8.2	8.1	8.0	7.9	7.8	7.97	0.17
EC mmhos/cm	1.2	1.3	1.1	1.0	1.0	1.2	1.3	1.4	1.2	1.3	1.2	1.2	1.2	0.12
Alkalinity (CaCO3,mg/g)	2.0	1.7	1.7	1.5	1.5	2.0	3.0	2.0	2.0	1.5	1.5	2.0	1.87	0.42
Chloride (mg/ g)	11.4	14.5	13. 0	13. 3	12. 3	13.4	14.7	15. 0	15.1	14. 5	12. 6	13. 2	12.58	3.74
Calcium (mg/ g)	0.85	0.95	0.834	0.855	0.842	0.874	0.92 3	0.946	0.957	0.983	0.994	0.999	91.77	0.623
Magnesium (mg/ g)	0.176	0.18	0.202	0.185	0.174	0.199	0.205	0.239	0.256	0.244	0.269	0.241	21.44	0.335
Organic carbon (%)	0.80	0.84	0.85	0.89	0.79	0.65	0.78	0.83	0.75	0.41	0.67	0.79	0.76	0.13
Organic matter (%)	1.4	1.46	1.47	1.54	1.37	1.13	1.35	1.43	1.29	1.06	1.15	1.37	1.34	0.15
Total nitrogen, (%)	0.03	0.03	0.029	0.027	0.025	0.03	0.032	0.03	0.029	0.03	0.035	0.03	0.029	0.003
Phosphate (mg/g)	1.30	1.0	0.80	0.67	0.50	1.15	1.35	1.35	1.34	1.35	1.40	1.53	1.14	0.33
Potassium (mg/g)	0.18	0.19	0.192	0.201	0.24	0.22	0.182	0.174	0.172	0.181	0.180	0.184	0.191	0.02
Sodium (mg/g)	0.31	0.61	0.72	0.43	0.30	0.15	0.10	0.20	0.13	0.16	0.20	0.25	0.30	0.19

Table 2. Average seasonal concentrations of physico-chemical and heavymetals parameters of Singanallur lake sediment

Parameters	Seasons			
	Winter	Summer	SWM	NEM
pH	7.9	7.8	8.18	7.9
EC (mmhos /cm)	1.25	1.0	1.27	1.23
Chloride (mg /g)	12.93	12.75	14.55	13.45
Alkalinity ($CaCO_3$, mg/g)	1.85	1.57	2.25	1.67
Calcium($CaCO_3$,mg /g)	0.90	0.84	0.92	0.99
Magnesium (mg/ g)	0.17	0.18	0.22	0.25
Organic carbon (%)	0.821	0.846	0.754	0.624
Organic matter (%)	1.441	1.458	1.299	1.191
Total nitrogen (%)	0.028	0.027	0.03	0.033
Phosphate (mg/g)	1.15	0.657	1.339	1.343
Potassium (mg/g)	0.183	0.211	0.186	0.182
Sodium (mg/g)	0.46	0.48	0.145	0.203
Copper (µg/g)	27.0	45.0	29.98	28.0
Zinc (µg/g)	127.5	173	163.75	120
Nickel (µg/g)	30.85	36.3	31.25	31.67
Iron (µg/g)	55.5	60.2	59.75	57.67
Chromium (µg/g)	30	32.3	21.28	19.3
Cadmium (µg/g)	0.015	0.02	0.015	0.01
Lead (µg/g)	4.25	6.1	4.75	4.1

value of total alkalinity was found to be highest. The calcium carbonate content was found to be high during the Southwest monsoon. Monthly and seasonal variation of calcium and magnesium were also observed. The results showed that higher levels of calcium and magnesium were found during November. Whereas, the level of calcium was high during the monsoons and the winter period and magnesium was high during the monsoons and the summer period. The organic carbon and the organic matter of sediment in the lake ranged between 0.414 % to 0.890 %, and 1.059 % to 1.535 % respectively. The organic carbon and organic matter values were found to be higher during the summer season than the monsoon seasons. The total nitrogen of sediment was high in May and less in November. The average total nitrogen was found to be highest during the summer and winter seasons. The monthly concentration of the total phosphate was high during December. The highest average value was found during the monsoon season and lowest average value during the summer and the winter seasons. The potassium and sodium content were high during May and March, respectively. The average seasonal value for potassium and sodium were highest during the summer. Table 3 gives the average metal concentration of the lake sediment. The concentration of all the metals was found to be within the normal range (Alloway 1991). The metal concentration showed the order of Zn > Ni > Cr > Cu > Pb >Cd in the sediment.

Table 3. Range of metal concentrations in sediment sample

Metals	Range in sediment (μg/g)	Normal range	Critical concentration in the soil (mg/kg)
Cu	25 –55	2 – 250	60 – 125
Zn	110 - 90	1 – 900	70 – 400
Cd	0.01- 0.03	0.01 –2.0	3 – 8
Cr	18 - 35	5 – 150	75 – 100
Ni	28.7 – 38	2 – 750	100
Pb	4.0 – 6.8	2 - 300	100 - 400

Adsorption of biogenic deposition means that sediments may act as a temporary or long-term sink for many such compounds. Furthermore, chemical compounds in sediments may undergo a wide variety of biological and geo-chemical transformation processes, which may significantly alter molecular structures and distributions. A decreasing trend in pH from summer, winter, and monsoon periods was observed. This may be explained by the increase in CO_2 during summer when the decomposition of organic matter was at its peak, with CO_2 release lowering the pH. A significant inverse relationship was noted between pH and organic carbon of the sediment in Singanallur Lake (Ahmed et al. 1996). Total alkalinity exhibited slight fluctuation throughout the study period. This may be due to seasonal changes in water quality due to factors such as evapo-transpiration and contamination of wastewater. An increase in calcium carbonate in the lake during a monsoon period was probably due to the decomposition of decaying plant materials, and may be due to the suspended decomposition of bottom deposits by microorganisms as a result of a change in temperature. The release of CO_2 and carbonic acid formation may be due to the increased rate of decomposition of organic matter. Carbonic acid converts insoluble carbonates into soluble carbonates, subsequently depleting calcium carbonate. The fluctuation in the calcium carbonate, total organic carbon and organic matter may be due to the addition of organic matter brought in by surface runoff from its vast catchment area. The high amount of organic matter in the sediments is attributed to higher rate of decomposition and mineralization of organic matter deposited at the sediment (Sharma, 1994). The high organic content can lead to high productivity of flora and fauna in the system. Total nitrogen and phosphate were higher during the monsoon period. Higher values of these parameters may be due to runoff water and sewage from catchment areas. Monsoon periods showed the lowest potassium and sodium content. The decrease in potassium may be due to lattice fixation (Ahmed et al. 1996). The metal content of the sediment was found to be within the normal range (Mathew et al. 2002)

Acknowledgements. The authors are thankful to the Head of the Department of Environmental Sciences, Bharathiar University, Dr. B. SampathKumar, principal and Dr. S. Pattabhi, Head, Department of Environmental Science, PSG College of Arts and Science, Coimbatore for providing facilities. One of the authors, K. Shanthi is thankful to the University Grant Commission, New Delhi for the award of Teacher Fellowship.

REFERENCES

Ahmad S, Siddiqui EN, Khalid S (1996) Studies on certain physico-chemical properties of soil of two freshwater ponds of Darbhanga. J Environ Pollution 3 (1): 31-39

Alloway BJ (1991) Heavy Metals in Soils. John Wiley and Sons, New York.

Anand VK , Sharma S (2000) Physico-chemical characteristics of bottom sediments of Lacustrine habitats of Jammu I. Lake Surinsar. Ecol Env Cons 6 (4): 409-418

Campbell PGC , Tessier A (1991) Biological availability of metals in sediments: Analytical approaches. In: Vernet JP (ed) Heavy Metals in the Environment, Elsevier, New York

Choudri BS, Chavadi VC (2000) Anthropogenic deposition of trace elements in the sediments of Navalur pond around Lakamanahalli area, near Dharwad City, Karnataka, India. Ecol Env Cons 6 (3): 351-353

Mathew M, Satishkumar M, Azeez PA, Sivakumar R, Pattabhi S (2002) Sediment quality of wetlands in Coimbatore, Tamilnadu, India. Bull Environ Contam Toxicol 68: 389-393

Mohanraj R, Sathishkumar M, Azeez PA, Sivakumar R (2000) Pollution status of wetlands in urban Coimbatore, Tamilnadu, India. Bull Environ Contam Toxicol 64: 638-643

Piper CS (1966) Soil and Plant analysis. Hans Publishers, Bombay

Sharma S (1994) Productivity of some submerged macrophytes in relations to the physico-chemical characteristics of water and bottom sediment of lakes Mansar ans Surinsar, Jammu. Ph.D. thesis, University of Jammu, Jammu (J & K)

Shanthi K, Mathew M, Pattabi S (1999) Heavy metal concentration in wetland Sediments of Coimbatore city. Proceedings of the 2nd International conference on Contaminants in Soil Environment in the Australasia-Pacific Region. New Delhi, India, pp 307-308

Walkley A, Black IA (1934) An estimation of the Degtjareff method for determining soil organic matter and proposed modification of the chromic titration method. Soil Sci 37:29-38