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ASSESSMENT OF SEDIMENT TRACE ELEMENT CONCENTRATIONS IN ARUVIKKARA RESERVOIR USING GEO- ACCUMULATION INDEX, ENRICHMENT FACTOR AND CONTAMINATION FACTOR

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The present attempt is to analyze the degree of trace element concentrations (Fe, Mn, Pb, Cd, Zn) in the sediments of the Aruvikkara reservoir. The heavy metal concentration has been evaluated using geochemical index, enrichment factor, contamination factor and degree of contamination. The study revealed that the sediments have been free from the heavy metal contamination except iron because of the lack of industrial establishments in the study area. Iron contamination is seen in the sediments in most of the sites.

Keywords: Contamination Factor, Enrichment Factor, Geo Accumulation Index, Sediment, Trace Metal.

Trace metals commonly occur as pollutants in water bodies, which are widely distributed in the environment from sources mainly the weathering of minerals and soils. However, the level of these metals in the environment has increased tremendously during the past decades as a result of human inputs and activities. Metals are reported to be well concentrated in the water and sediments. Heavy metals can reach the water bodies by natural ways and also by anthropogenic interactions, their presence in aquatic ecosystems, mainly due to anthropogenic influences has far-reaching implications directly to the biota and indirectly to man.Analysis of sediment chemistry using geo accumulation index, enrichment factor and contamination factor of water bodies was carried out by Fatma *et al.* (2009); Chakravarthy *et al.* (2009); Habes *et al.* (2011);Venkatesha *et al.* (2012); Nur *et al* (2013);Azmat *et al.* (2014). The proposed study area is of great significance as the water in the Aruvikkaradam is the source of drinking water to the whole metropolis of Thiruvananthapuram. The present attempt was to determine the level of sediment pollution by heavy metals in Aruvikkara reservoir by calculating enrichment factor, contamination factor and geochemical indexes.

MATERIALS AND METHODS

Study area: The study was carried out in Aruvikkara reservoir (8.5677800°N 77.018890°E), which falls in Thiruvananthapuram district in the state of Kerala, India. It is located on the banks of the Karamana River 15 km from Thiruvananthapuram. Aruvikkara dam is one of the main sources of water for distribution in the entire Thiruvananathapuram. The water supply system for Thiruvananathapuram city was designed in 1928 and commissioned in 1933. The source of supply is the Karamana River. The project, named Wellington Water Works, had a distribution capacity of 20 million liters.

Sediment samples have been collected from the eight selected sites viz Koovakkudy, Mundela, Mullilavinmoodu, Kanchikkavila, Mailammodu, Kaliankuzhi, Vembanni and Temple side of the reservoir from March 2013 to February 2014. Sediment samples were collected using Van Veen grab and were transferred to pre-cleaned polythene bags. The samples were brought to the laboratory and were dried in an oven, powdered and filtered. The filtered samples were digested with nitric acid and perchloric acid in the ratio 4:1and the digest was filtered using Whatman 40 filter paper according to the standard protocol (APHA 1992). The filtered digest was used for the analysis of heavy metals using Atomic Absorption Spectroscopy.

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RESULTS AND DISCUSSION

Metal concentrations in the sediments from eight sites varied between 22.7µg/g to 116.2µg/g for iron, 0.119µg/g to 0.855µg/g for zinc, 1.8µg/g to 8.3µg/g for manganese, 0.48µg/g to 1.26µg/g for lead and 0.024µg/g to 0.037µg/g for cadmium. The heavy metal concentration is presented in the Table 1. The heavy metals like iron, manganese, lead and cadmium has the highest concentration at site 4 (Kaliankuzhi) due to the anthropogenic interactions.

Table 1. Metal concentrations (µg/g) in sediments of Aruvikkara reservoir with average shale values used in the present study.

Sites	Iron	Zinc	Manganese	Lead	Cadmium
Koovakkudy	54.3	0.451	1.8	0.65	0.026
Mundela	69.7	0.731	5.7	1.26	0.034
Mullilavinmoodu	87.4	0.514	4.8	1.13	0.033
Kanchikkavila	72.7	0.308	2.1	0.85	0.027
Mailammodu	53.2	0.359	2.6	0.73	0.024
Kaliankuzhi	116.2	0.336	8.3	1.72	0.037
Vembanni	43.5	0.855	7.7	0.48	0.025
Temple side	22.7	0.119	5.9	0.55	0.028

Table 2. Metal Enrichment Factor (EF) values in sediments of Aruvikkara reservoir

Sites	Zinc	Manganese	Lead	Cadmium
Koovakkudy	0.00041	0.00018	0.0028	0.0075
Mundela	0.00051	0.0017	0.0043	0.0076
Mullilavinmoodu	0.00029	0.00030	0.0031	0.0058
Kanchikkavila	0.00020	0.00015	0.0027	0.0057
Mailammodu	0.00033	0.00026	0.0032	0.0070
Kaliankuzhi	0.00014	0.00039	0.0035	0.0050
Vembanni	0.00097	0.00097	0.0026	0.0089
Temple side	0.00025	0.0014	0.0057	0.019

Table 3. EF values interpreted as described by Chen *et al.* (2007)

EF<1	no enrichment
EF<3	minor enrichment
EF=3-5	moderate enrichment
EF=5-10	moderately severe enrichment
EF=10-25	severe enrichment
EF=25-50	very severe enrichment
EF>50	extremely severe enrichment

Enrichment Factor (EF)

Weiguo *et al.*(2009) and Amin *et al.*(2009) used enrichment factor as a tool in their studies to differentiate the metal sources between lithogenic and naturally occurring. In the present study, enrichment factor is calculated using Iron as it has been used by several

Table 4. Muller's seven classes in relation to contamination levels

Class 0	Igeo<0	Unpolluted
Class 1	Igeo<1	unpolluted to moderately polluted
Class2	1<Igeo<2	moderately to strongly polluted
Class3	2<Igeo<3	strongly polluted
Class4	3<Igeo<4	strongly to very strongly polluted
Class5	4<Igeo<5	very strongly polluted
Class6	Igeo>5	Highest grade reflecting a 100 -fold enrichment above baseline values.

Table 5. Geoaccumulation Index (Igeo) values in sediments of Aruvikkara reservoir

Sites	Iron	Zinc	Manganese	Lead	Cadmium
Koovakkudy	2.8	-8.3	-9.4	-8.8	-10.7
Mundela	3.2	-7.6	-7.7	-4.5	-10.3
Mullilavinmoodu	3.6	-8.1	-8.0	-7.7	-10.4
Kanchikkavila	3.3	-8.8	-9.2	-8.4	-10.7
Mailammodu	2.9	-8.6	-8.9	-8.7	-10.8
Kaliankuzhi	4.0	-8.7	-7.2	-4.1	-10.2
Vembanni	2.6	-7.3	-7.3	-9.2	-10.8
Temple side	1.6	-10.2	-7.4	-9.1	-10.6

Table 6. Contamination Factor (CF) values in sediments of Aruvikkara reservoir

Sites	Iron	Zinc	Manganese	Lead	Cadmium	Degree of contamination
Koovakkudy	11.5	0.0047	0.0021	0.032	0.08	11.6
Mundela	14.8	0.0076	0.0067	0.063	0.11	14.9
Mullilavinmoodu	18.5	0.0054	0.0056	0.056	0.11	18.6
Kanchikkavila	15.4	0.0032	0.0024	0.042	0.09	15.5
Mailammodu	11.3	0.0037	0.0030	0.036	0.08	11.4
Kaliankuzhi	24.7	0.0035	0.0097	0.086	0.12	24.9
Vembanni	9.2	0.009	0.0090	0.024	0.08	9.3
Temple side	4.8	0.0012	0.0069	0.027	0.09	4.9

researchers to normalize metal contamination in river and coastal sediments (Fatma *et al.* 2009).

$$EFmetal = \frac{(Mx/Fex)\ Sample}{(Mc/Fec)\ Shale}$$

Where, Mx stands for concentration of metal in the examined sample. Fex stands for concentration of Fe in the examined sample. Mc is the concentration of metal in the average shale and Fec is the concentration of Fe in the average shale.

In the present study, average shale (Turekian and Wedepohl, 1961) was used as background value for the examined metals because no such data was available for the study area. The average shale values were 0.30µg/g for cadmium, 95µg/g for zinc, 20µg/g for lead, 850µg/g for manganese and 4.7µg/g for iron.

None of the heavy metals in the Aruvikkara reservoir shows enrichment. The enrichment factor of all the heavy metals were found to be less than 1 (EF<1) which indicated that the heavy metals in the reservoir has no enrichment. The absence of industries and other anthropogenic interactions leads the reservoir to a status of no enrichment. Of all the heavy metals, highest enrichment factor has showed by cadmium (0.019).The enrichment factor for different metals obtained in the present study is presented in the Table 2. The increase in enrichment factor may be due to the influence of anthropogenic interactions and the absence or decrease in enrichment factor is due to natural processes (Naji and Ismail,2011).

Geoaccumulation Index (Igeo)

Geoaccumulation index proposed by Mullar (1979) was used to calculate the metal contamination in the Aruvikkara reservoir. Geoaccumulation index was calculated by comparing the metal concentrations with the undisturbed sediment values.

$$Igeo = \log2\ (Cn/1.5Bn)$$

Where Cn is the measured concentration of element and Bn is the geochemical background for the element, which is the average shale value (Turekian andWedepohl 1961). The factor 1.5 is introduced to include possible variation of the background values that are due to lithogenic variations.

Lijuan *et al.*(2010) calculated geo-accumulation index for the heavy metals in Jinjiang river in China and cadmium has the highest geo accumulation index. The geoaccumulation index studies in the present study revealed that all the heavy metals except iron has an geoaccumulation index less than 1(Igeo<0) i.e. in the unpolluted state (Class 0). The heavy metal iron presented in the polluted status having varying geoaccumulation index of 1.6 to 4.0 i.e., moderately polluted to strongly polluted. The heavy metal iron has the maximum geoaccumulation index at the site 4 because of the anthropogenic interactions. The different geoaccumulation index values for the heavy metals are presented in the Table 5.

Contamination Factor (CF) and Degree of contamination

Contamination factor and degree of contamination are used to determine the contamination status of sediments. The contamination factor was calculated by

$$CF = \frac{\text{Measured concentration}}{\text{Background concentration}}$$

The degree of contamination was defined as the sum of all contamination factors. In the present study, maximum contamination factor was found in the site 4 (Kaliankuzhi) where the degree of contamination is 24.7. The different contamination factors and the degree of contamination are presented in the Table 6.

CONCLUSION

The analysis of enrichment factor and geoaccumulation indexes in the Aruvikkara reservoir revealed that the sediment in the reservoir is free from the contamination by the heavy metals. The geoaaccumulation studies showed that all the heavy metals were in the unpolluted state. The heavy metal iron is in moderately polluted to strongly polluted state.

The levels of the heavy metals in the sediments of reservoir did not show enrichment and did not cause any threat to the flora and fauna of the reservoir and the heavy metals in the reservoir did not affect the water quality of the reservoir.In the present study, maximum contamination factor was found at the site 4 where the degree of contamination is 24.7. Of all the studied heavy metals, iron is the heavy metal showing pollution in the reservoir and of the eight sites studied, site 4 (Kaliankuzhi due to probably the terrestrial input including the fertilizers used in the nearby agricultural fields and also by the domestic waste released out due to the human interactions) showed maximum contamination.

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