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DISTRIBUTION OF STRONTIUM IN THE SEDIMENTS OF RIVER KORTALAIYAR, TAMILNADU, INDIA

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ABSTRACT

Strontium (Sr) is one of the uncommon heavy metals found in the sediments of river. It has drawn an attraction towards its distribution in the Kortalaiyar river basin in the present study. Hence, an attempt has been made to analyze the concentration of the metal in the 30 sampling locations in the stretch of the river. The extent of pollution by this metal is assessed using various pollution indices like Geo-accumulation index, Contamination Factor and Enrichment Factor. A complete study has been done on the existence of Sr in the Kortalaiyar river. The outcome of the study gives valuable information regarding the moderate pollution of the river by Sr metal.

Key words: Kortalaiyar river, Geo-accumulation index, Contamination Factor, Enrichment Factor, Strontium.

INTRODUCTION

Rivers are the sources of fresh water. A wide study has been done to conserve the river sources in India. It is well evident that the rivers of India are polluted due to rapid industrialization. The pollution of the rivers is mainly due to the input by human beings. One of the major pollutants harmful to the environment is heavy metals. Enrichment of aqueous environment with heavy metals, first of all results from sewage disposal[1,2], industrial gases and dust emission[3] or vehicles exhausting gases[4-6], accumulation of municipal and industrial wastes as well as applying the artificial fertilizers and plant protection means in agriculture[7-9].

Strontium (Sr) is a notable heavy metal present in the sediments of the river. It is essential to determine the presence of heavy metals like Sr in the sediments of the river as

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they act as a source of pollution indicator. This study aims at evaluating, assessing, and predicting the concentration of strontium in the sediments of Kortalaiyar river.

EXPERIMENTAL

Study area

The study area for the present investigation is the stretch of river Kortalaiyar from Poondi Lake to the Ennore creek. Kortalaiyar river is also known as Kosasthalaiyar. The river has a length of 136 Km and it originates near Kaveripakkam in Vellore district and finally drains into the Bay of Bengal. It has a catchment area in North Arcot District with a branch near Kesavaram anicut and flows into the city as Cooum River. The main Kortalaiyar river flows into Poondi reservoir. The water flows through Thiruvallur district from the Poondi reservoir, enters into the Chennai metropolitan area, and joins the sea at Ennore creek. The total catchment area of the river is 3,757 Km^2 and has a bed width range from 150 to 250 m. The discharge capacity of the river is 110,000 m^3/s and the expected flood discharge capacity is about 125,000 m^3/s. The map of the study area is shown in Fig. 1.

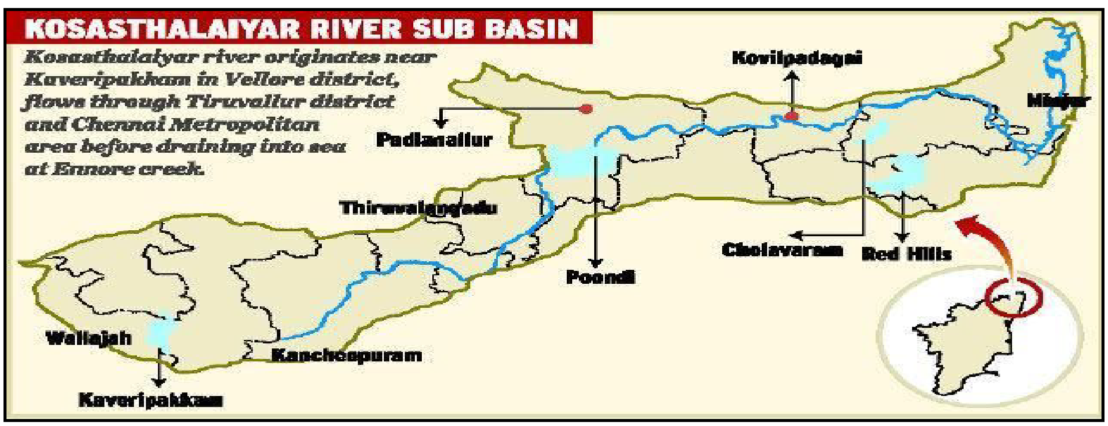

Fig. 1

Materials and methods

A set of thirty sediment samples were collected from the surface of the river in an air tight polythene cover. The sediments were air dried and finely powdered. The fine powder was acid digested and analyzed for Sr using atomic absorption spectrophotometer. This methodology was carried out for two seasons namely Pre-Monsoon (PRM) and Post-Monsoon (POM) annually for two consequent years, 2013-2014.

RESULTS AND DISCUSSION

In the present study, the presence of Sr in the sediments of the Kortalaiyar river is depicted from the analysis using atomic absorption spectrophotometer. The graphical representation of the concentration of Sr in the thirty sampling locations during PRM and POM is shown in Fig. 2. The minimum concentration of Sr was 22 ppm at sampling location -2 in the second POM and the maximum concentration was 521 ppm at the sampling location -5 in the second PRM. The upper continental crust value of Sr is 316 ppm[10], which is much higher than the minimum concentration and much lower than the maximum concentration depicting the depletion of Sr at select locations and also the enrichment of the metal at certain locations.

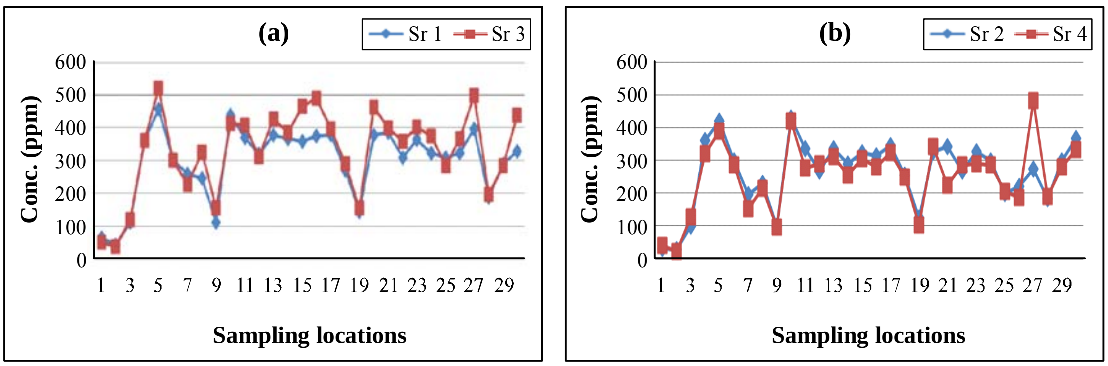

Fig. 2: Variation of Sr in (a) Pre-monsoon seasons (b) Post-monsoon seasons

Strontium is present in group 2 of the periodic table, along with Be, Mg, Ca and Ba. It has an atomic number of 38 and an atomic mass of 88. Sr has only one oxidation state (+2). There are four naturally occurring isotopes (^{84}Sr, ^{86}Sr, ^{87}Sr and ^{88}Sr), of which ^{88}Sr is the most abundant with 82.6% of the total mass. Strontium resembles the heavier alkali earth elements, Ca and Ba in its chemical behavior. Strontium is a lithophile based metal. The size of the Sr^{2+} ion (118 pm) is intermediate between those of Ca^{2+} (100 pm) and K^+ (138 pm), and it may substitute in a variety of rock-forming minerals including K-feldspar, gypsum, plagioclase and, especially, calcite and dolomite, which are the main sources of Sr in river water.

Minerals of Sr are relatively rare. They include strontianite $SrCO_3$ and celestite $SrSO_4$, which are mainly linked with hydrothermal deposits or pegmatites. During magmatic processes, Sr is partitioned into mid-stage fractionates and, hence, it is found to be rich in intermediate rocks (*ca.* 500 mg Kg^{-1}) relative to evolved granite (< 300 mg Kg^{-1}) or mafic igneous rocks (< 450 mg Kg^{-1}). High concentrations (*ca.* 1000 mg Kg^{-1}) have been particularly recorded in anorthosite[10]. Levels of Sr in ultramafic, basaltic and granitic rocks are noted as 1, 465 and 100-440 mg Kg^{-1}. respectively, and a crustal average of 384 mg Kg^{-1}[11].

The enrichment of the metal may lead to pollution. The pollution by the metal is best assessed using various pollution indices like Geo-accumulation index (Igeo), Enrichment factor (EF) and Contamination factor (CF).

The geo-accumulation index (Igeo) is a common criterion used for quantifying the intensity of heavy metal contamination in terrestrial, aquatic and marine environments[12-14]. This index is a single metal approach to evaluate the sediment contamination with heavy metals. Geo-accumulation index is expressed as the metal concentrations relative to reference sites or pre-industrial sediments from the study area. It is calculated using the following relation[15].

$$Igeo = \log_2 (Cn/1.5 \times Bn)$$

Where, Cn - Measured concentration of heavy metal in the sediment,

Bn - Geochemical background value in average shale (Wedepohl, 1995)[16] of element n, and

1.5 - Background matrix correction in factor due to lithogenic effects.

The Igeo value of Sr in the sampling location is shown in Fig. 3.

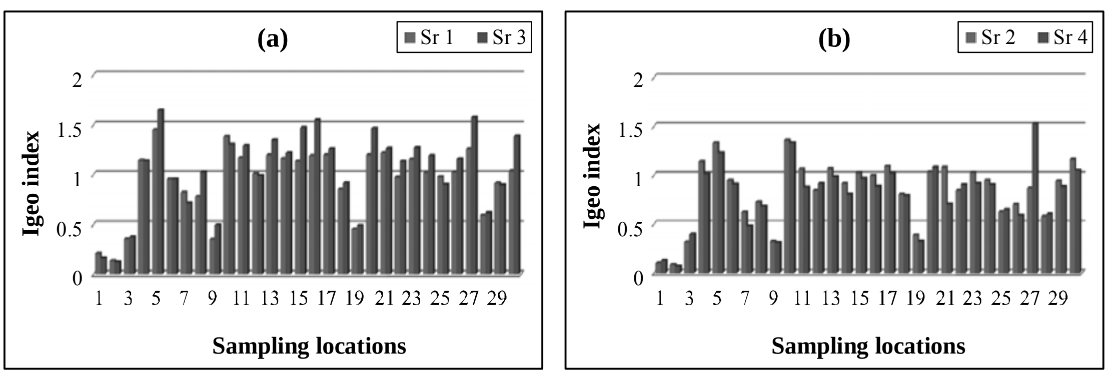

Fig. 3: Igeo of (a) Sr-PRM (b) Sr-POM

The Igeo value shows moderately polluted to unpolluted state of strontium in both the seasons as the values lie in the range of 0 to 2.

The contamination factor, CF, is an indicator that has been used widely to assess the contamination status of sediments in aquatic ecosystems[17-19]. The CF index is used to express the contamination degree with a single metal. Fig. 4 shows the CF of Sr in the various sampling locations.

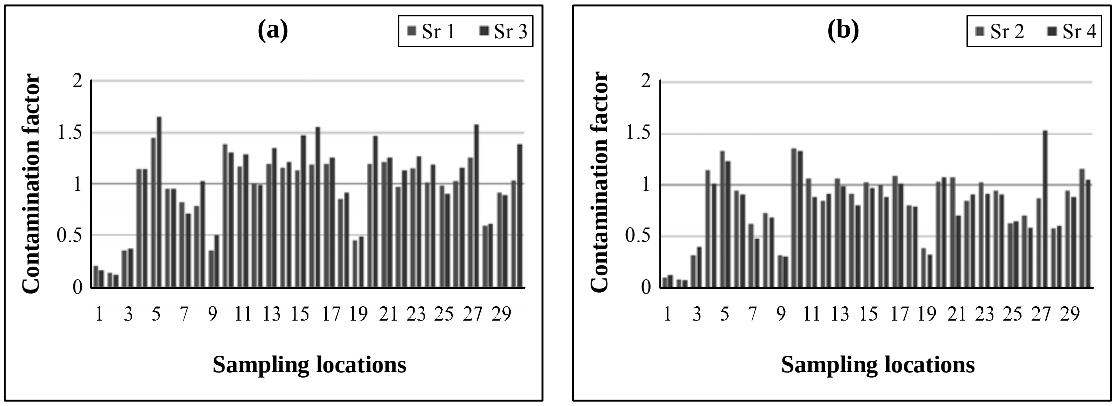

Fig. 4: CF of (a) Sr-PRM (b) CF of Sr-POM

Since the CF index for Sr is below 2 in all the sampling locations, the low level of contamination is assertained.

EF was calculated to determine, if levels of metals in sediments were of anthropogenic origins (e.g., contamination). To identify anomalous metal concentration, geochemical normalization of the heavy metals data to a conservative element, such as Al, Fe, and Si was employed. Several authors have successfully used Al to normalize heavy metals contaminants. In this study also, Al was used as a conservative tracer to differentiate natural from anthropogenic components.

The metal EF is defined as follows[20]:

$$EF = \frac{(M/A1)_{Sample}}{(M/A1)_{Background}} \quad \ldots(1)$$

Where, M- Concentration of the metal.

The graphical representation of the EF of Sr in the PRM and POM is given in Fig. 5.

In PRM, the EF index of Sr is less than 3 and in POM, all the sampling locations except 24 and 25 shows the EF index below 2. The EF index in these locations are 11 and 8, respectively. The enrichment in this particular location is due to the proximity of these locations to the thermal power station and other industries located in Ennore.

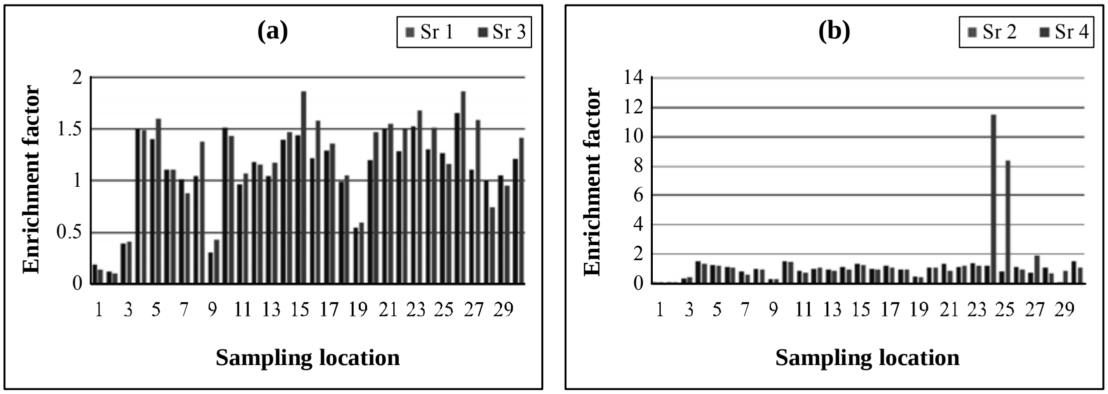

Fig. 5: EF of (a) Sr-PRM (b) Sr-POM

The pollution due to Sr may affect the bone growth in children. It may also cause change in the dental structure. In adults, Sr may increase the bone density. The isotope Sr-90 is carcinogenic, leading to bone cancer and leukamia. It is evident from the pollution indices that Kortalaiyar river is at the verge of pollution by Sr. The present study reveals that the concentration of Sr in the river is slightly enriched and the enrichment may progress, if not monitored.

CONCLUSION

The present study reveals the presence of Sr in river Kortalaiyar. Though the concentration of Sr is not very significant, yet warns us of the condition in the near future. The data also signifies the need for a regular approach towards monitoring the enrichment of Sr and the present study is part of a larger regular monitoring program in the aquatic environments of south India. The development plans and remedial measures can serve as an example and will help to reduce the level of enrichment in the aquatic environment especially in major populated industrialized cities. Kortalaiyar river is one of the important aquatic regions within city limits and special contaminant monitoring programs can be implemented as long term measures. The pollution of the river should be checked in a determined manner especially near the industrial point source.

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