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Research Article

HEAVY METAL POLLUTION IN THE WATER BODIES AND WATER SEDIMENTS OF THE TAMIRABARANI RIVER AT ERAL, TAMILNADU, SOUTH INDIA

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ABSTRACT

Rapid urbanization and industrial development during last decade have provoked some serious concerns in the environment. The Thamirabarani river is located between latitude 8.63˚N and longitude 78.20˚E. The trace metals analysis of water and sediment has been determined by Atomic Absorption Spectrophotometer. In the month of March copper is moderately polluted emphasized as 1.094 geo accumulation index in the water bodies and in the water sediments as 1.346.There are no significant differences between the months and metals in the water bodies and water sediments. In General, the sediment quality in terms of the heavy metals was unacceptable and could pose a serious risk to the aquatic life in future if nothing is done to check metal accumulation in the river.

INTRODUCTION

Water is one of the most precious natural resources and a key element in the socio-economic development of a country. Contamination of aquatic ecosystems with heavy metals has received much attention due to their toxicity, abundance and persistence in the environment and subsequent accumulation in aquatic habitats (Arnason and Fletcher, 2003). Heavy metal undergoes a global ecological cycle in which natural water are the main pathways (Saha and Hossain, 2011). Heavy metal accumulate in the sediments matrix and the properties of adsorbed compounds (Rabee *et al.,* 2011). In the aquatic environment, sediment has a high storage capacity for contaminations (Gibbs, R.J. 1977; Luoma, S.N., Bryan,G. W., 1981; Bettinetti, R., *et al.,* 2003; Hollert, H., *et al.,* 2003). At present, heavy metal pollution has become a great environmental concern with their toxicity, persistence, bioaccumulation and biomagnifications in the food chain (Li S. Y, Xu Z. F *et al.,* 2008; Y uan H. Z, Shen J, *et al.,* 2011). In the present investigation an attempt is made to study the heavy metals in the water bodies and water sediments in Eral River. Therefore, the objectives of this study are given below.

- To determine the geo accumulation index.
- To calculate two way analysis of variance.

Study Area

The Thamirabarani river is located between latitude 8.63˚N and longitude 78.20˚E.

Figure 1 Study area and sampling site in Eral

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The main drains of the river, believed to originate from Manimutharu and Papanasam, passes through many residential communities including Kallidaikuruchi, Seranmahadevi, Tirunelveli, Vallanadu, Konkarayakurichi, Srivaikundam, Eral and Punnaikayal. Further the water flows through the pipelines to the Dharangadhara Chemical Industry. The rain fall range of January was 8Mm. The total length of the study area is 1.80m and the total area is covered as 50× 36 × 9.6 cm. In the Eral town there are about 9478 populations are dwelling. The bridge is surrounded on two sides by major roads with high vehicular emission (Figure-1). In addition; the water is used for washing of vehicles, washing clothes, bathing, sewage and dumping of domestic wastes. The Thamirabarani River is a habitat to many species of plants and animals serves as the major sources of water for fishing, vegetable crops irrigation in Eral town.

Sample Collection

Water and sediment samples were collected from the sampling location during three months (January, February and March 2017).Water samples were collected are 10-15 cm depth in pre conditioned and acid rinsed clean polypropylene bottles.

Statistical Analysis

Data collected are presented as standard deviation and were subjected to Two way analysis of variance (ANOVA) ($P < 0.5$) was used to assess whether heavy metals varied significantly between water bodies and water sediments .All statistical analysis was performed in the Microsoft Excel 2008.

METHODOLOGY

The trace metals analysis of water and sediment has been determined by Atomic Absorption Spectrophotometer. Flame spectrophotometry is an analytical technique used for qualitative and quantitative determination of the metal in a sample. In this method, the sample in the form of a homogeneous liquid was introduced into a flame where thermal and chemical reactions created “free” atoms capable of absorbing, emitting or fluorescing at characteristic wavelengths. The decrease in energy (absorption) was then measured.

The absorption is proportional to the concentration of free atoms in the flame given by Lambert Beer Law:

Absorbance = $Log^{10}\ I^0/I^t = KCl$

Where

I^O = Intensity of incident radiation emitted by the light source.

I^t = Intensity of transmitted radiation (amount not absorbed).

C = Concentration of sample (free atoms).

K = Constant (can be determined experimentally).

L = Path length.

This is the most common method where interference effects are known to be absent. Using the blank solution as zero in the instrument performs the calibration. The standards were then analysed with the lowest concentration first and the blank run between the standards, to ensure the base line (zero point).

Heavy Metal Analysis in Water

Water sample were collected for every three months from January 2017 to March 2017using pre-cleaned and acid – washed polyethylene bottles Care was taken to minimize the exposure of samples to the atmosphere. The sample was acidified with Supra-pure grade nitric acid (5ml of 1m acid per litre of sample) and stored in refrigerator at constant low temperature to avoid evaporation.

Calibration and Determination of Blank

Eight aliquots (400ml) of metal-free water were taken in a pre-cleaned separating funnel. The pH of the solution was adjusted between 2-3by adding1m HCl (2ml). APDC (Ammonium Pyrolidine Dithicarbomate) solution 10ml was added and shaken well. After 30 seconds 15ml of MIBK (Methyl Isobutyl Ketone) was added and shaken vigorously for 2 minutes. The MIBK layer was discarded and it was extracted again with APDC solution (5ml) and MIBK solvent (10ml).The MIBK layer was discarded and the metal- free water was retained for blank determination and calibration.

The metal stock solution of Cu, Pb and Zn were diluted (1ml each) to 100 ml with water containing 1ml of concentrated HNO3.This working standard solution contained 1mg metal Cu/Pb/Zn/ml.

Eight aliquots (400ml) of metal free water were taken in pre-cleaned separating funnels and spiked (in duplicate) with 0.0 (blank) 0.5, 1.0and2.0ml of mixed working standard. To each funnel was shaken for 30 seconds.15ml of MIBK was added and shaken vigorously for 2 minutes. The solution was allowed to stand for 20 minutes for phases to separate. The aqueous layer was collected in a clean polythene bottle of 500ml capacity. The aqueous layer was discarded and the MIBK solvent was added to the separating funnel containing the first extract. The combined extract was washed with Milli-QR water and the aqueous layer was discarded carefully.

For each extraction 0.2ml of concentrated nitric acid was added to the combined MIBK extract and it was shaken vigorously. Then it was allowed to stand for 20 minutes. 19.8ml of water was added with the help of an Eppendorf pipette. The aqueous layer was collected and stored in 50ml polythene bottle for analysis.

The absorbance of the aqueous solutions of blanks and standards was measured in Hitachi Flame Atomic Absorption Spectrophotometer (Z-700).

Sample Analysis

Duplicate aliquots of the sample (400ml) were measured and the pH was adjusted between 2-3with 1m HCL in separating funnels and the extraction procedure was followed as mentioned for standards.

Heavy Metal Analysis In Sediment

Sediments sample were collected and kept in a pre-cleaned and acid-washed polythene container. Collection was made every three months for 2017.The metal such as Cu/Pb/Zn were analysed using the method of Peerzada and Dickinson (1988)by using Hitachi (Z-7000) Flame Atomic Absorption Spectrophotometer.

Determination of Geo-Accumulation Index I_{geo}

The I_{geo} values for different metals were determined following Muller (1979).

$$I_{geo} = \log_2 \frac{C_n}{1.5 \times B_n}$$

Where, C_n is the observed concentration of the metal (n) in the sediment, B_n is the geochemical background of the metal (n), 1.5 is the correction factor for the background matrix due to lithogenic effects.

RESULTS

Geo accumulation index

Water bodies

The geo accumulation index is a quantitative measure of the degree of the pollution in aquatic sediments (Singh *et al.,* 2005).It consists of seven grades ranging from Unpolluted to very extremely pollute. (Table 1).

Table 1 Index Classification of Geoaccumulation Value and Pollution

Igeo Values Muller(1981)	Class	Sediment quality
≤ 0	0	Unpolluted
0-1	1	Unpolluted to moderately polluted
1-2	2	Moderately polluted
2-3	3	Moderately to strongly polluted
3-4	4	Strongly polluted
4-5	5	Strongly to extremely polluted
5-6	6	Extremely polluted

The I-geo grade for the study area varies from water bodies metal to metal in the month of January. Copper, Lead and Zinc remain in grade 0 (Unpolluted) suggesting that the study area sediments are in background value with respect to this metal (Fig 2).

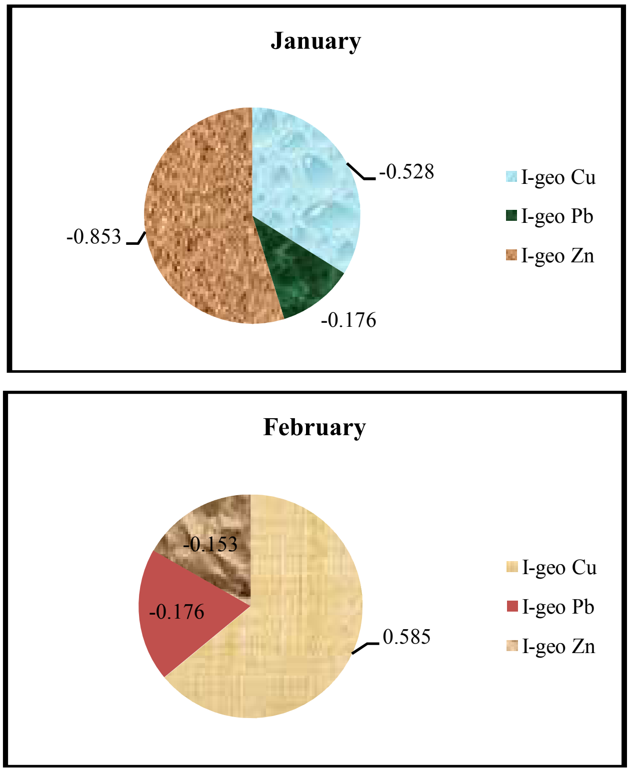

Figure 2 Geo Accumulation Index for Studied Heavy Metals In Water Bodies At Eral Tamirabarani River

The I-geo grades for the study area water bodies varies from metal to metal in the month of February Copper remain in grade 1 (Un polluted to moderately polluted) and the Lead and Zinc remain in grade 0 (Un polluted) indicates that water bodies were slightly polluted by Lead and Zinc (Fig 2).

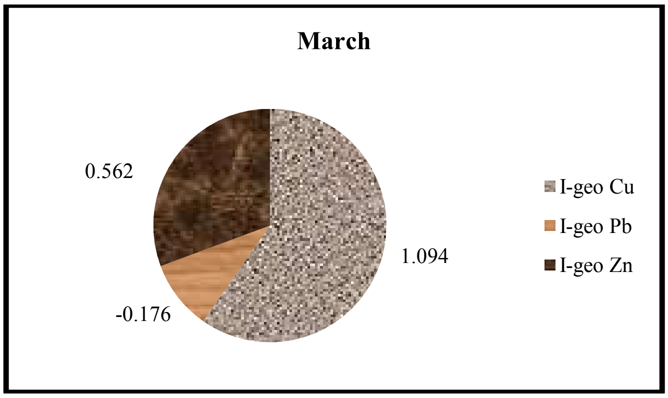

Figure 3 Geo Accumulation Index For Studied Heavy Metals In Water Bodies At Eral Tamirabarani River

The I-geo grade for the study area water bodies varies from metal to metal in the month March. Copper remain in grade 1(Un polluted to moderately polluted) the Lead remain in the grade 0 (Un polluted) and the Zinc remain in grade 1 (Un polluted to moderately), whereas the copper and zinc were slightly polluted (Fig 3).

Water Sediments

The I-geo grade for the study area water sediments varies from metal to metal in the month of January. Copper remain in grade 1 (Unpolluted to moderately polluted) and Lead and Zinc remain in grade 0 (Un polluted) indicates the water sediments were slightly polluted by Copper.

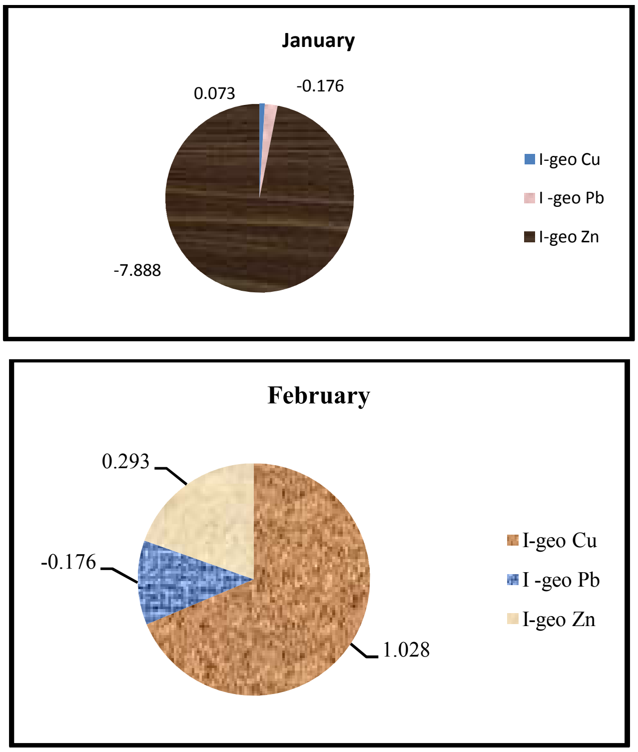

Figure 4 Geo Accumulation Index For Studied Heavymetals In Water Sediments At Eral Tamirabarani River

In the month of February Copper remain in grade 1(Unpolluted to moderately polluted) the Lead remain in grade 0 (Unpolluted) and the Zinc remain in grade 1(Unpolluted to moderately polluted) indicates the water sediments were slightly polluted by Copper and Zinc (Fig 4).

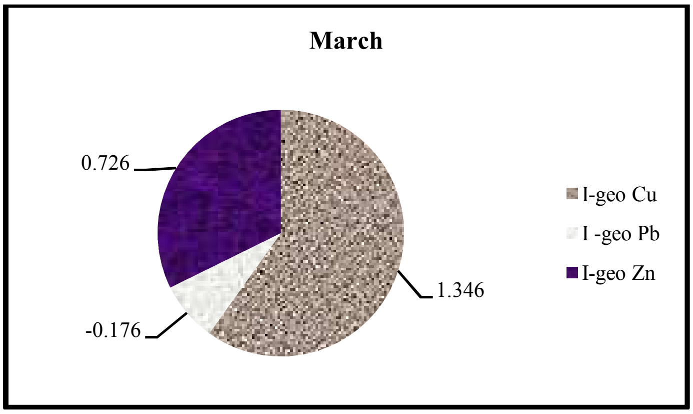

Figure 5 Geo Accumulation Index For Studied Heavymetals In Water Sediments At Eral Tamirabarani River

In the month of March copper remain in grade 2 (Moderately polluted) the Lead remain in grade 0(Unpolluted) and the Zinc remain in the grade 1(Unpolluted to moderately polluted) indicates the water sediments were slightly polluted by Zinc (Fig 5).

Table 2 Two Way Anova Showing Difference between Months and Metals in Water Bodies in January 2017(Zinc And Copper)

Sources of variance	SS	df	Ms	F	P Value		
Between the months	2	118533.3	59266.67	18.52083	0.051227	P=0.05	Significant
Between the metals	1	9600	9600	3	0.225403	P>0.05	No significant

*P > 0.05- No Significant, P ≤ 0.05-Significant

Table 3 Two Way Anova Showing Difference between Months And Metals In Water Bodies In February 21017 (Zinc And Lead)

Sources of variance	SS	df	Ms	F	P Value		
Between the months	118533.3	2	59266.67	18.52083	0.051227	P=0.05	Significant
Between the metals	9600	1	9600	3	0.225403	P>0.05	No significant

*P > 0.05- No Significant, P ≤0.05-Significant

Table 4 Two Way Anova Showing Difference between Months And Metals In Water Bodies In March 2017(Copper And Lead)

Sources of variance	SS	df	Ms	F	P Value		
Between the months	44433.33	2	22216.67	1	0.5	P>0.05	No Significant
Between the metals	46816.67	1	46816.67	2.107277	0.283	P>0.05	No Significant

*P > 0.05- No Significant, P ≤ 0.05 - Significant

Table 5 Two Way Anova Showing Difference between Months and Metals in Water Sediments in January 2017 (Zinc and Copper)

Sources of variance	SS	df	Ms	F	P Value		
Between the months	264900	2	132450	6.4873470	0.133559	P>0.05	No Significant
Between the metals	52266.67	1	52266.67	2.56	0.250731	P>0.05	No Significant

*P > 0.05- No Significant, P ≤ - 0.05 Significant

Table 6 Two Way Anova Showing Difference between Months and Metals In Water Sediments In February 2017 (Zinc And Lead)

Sources of variance	SS	df	Ms	F	P Value		
Between the months	26433.33	2	13216.67	1	0.5	P>0.05	No Significant
Between the metals	52266.67	1	52266.67	3.954603	0.185061	P>0.05	No Significant

*P > 0.05- No Significant, P ≤0.05-Significant

Table 7 Two Way Anova Showing Difference between Months and Metals in Water Sediments in March 2107(Copper And Lead)

Sources of variance	SS	df	Ms	F	P Value		
Between the months	26433.33	2	13216.67	1	0.5	P>0.05	No Significant
Between the metals	52266.67	1	52266.67	3.954603	0.185061	P>0.05	No Significant

*P > 0.05- No Significant, P ≤ 0.05-Significant

The Table 2 showed the concentration of zinc and copper in the water bodies. Analysis of Variance revealed that there was no significant variation (P < 0.05) (F 18.52; P = 0.05) in months between (P < 0.05) (F = 3; P= 0.22) the metals. Table 3 showed the concentration of zinc and lead in the water bodies. Analysis of Variance revealed that there was no significant variation (P < 0.05) (F 18.52; P = 0.05) in months between (P < 0.05) (F = 3; P= 0.22) the metals. Table 4 showed the concentration of copper and lead in the water bodies. Analysis of Variance revealed that there was no significant variation (P < 0.05) (F = 1; P = 0.05) in months between (P < 0.05) (F = 2.10; P= 0.28) the metals.

Table 5 showed the concentration of zinc and copper in the water sediments. Analysis of Variance revealed that there was no significant variation (P < 0.05) (F = 6.48; P = 0.13) in months between (P < 0.05) (F = 2.56; P= 0.25) the metals. Table 6 showed the concentration of zinc and lead in the water sediments. Analysis of Variance revealed that there was no significant variation (P < 0.05) (F = 1; P = 0.5) in months between (P < 0.05) (F = 3.95; P= 0.18) the metals. Table 7 showed the concentration of copper and lead in the water sediments. Analysis of Variance revealed that there was no significant variation (P < 0.05) (F = 1; P = 0.05) in months between (P < 0.05) (F = 3.95; P= 0.18) the metals.

DISCUSSION

The highest concentration during the study period of copper may be due to water supply systems through distribution of pipelines to the DCW chemical industry. Copper is an essential substance to human life, however, in high concentrations, it can cause anaemia, liver and kidney damage stomach and intestinal irritation. During the study period the minimum concentration of lead might be due to less vehicular emissions, less corrosive deposition level of pipe lines to the DCW industry and minimum usage of pesticides the agricultural field by the farmers.

The very high concentration of zinc observed during the study could be as a result of human activities around the river banks include washing of household wares, washing of automobiles, dumping of domestic discharges and agricultural use of pesticides and insecticides. The chronic health effect of zinc includes cancer, birth effect, organ damage, disorders of the nervous system and damage to the immune system.

CONCLUSION

The application of the three metal indicated notably geo accumulation index, contamination factor and pollution load index confirms the enrichment of the metals in the bottom sediments could pose a serious risk to the aquatic life in future if nothing is done to check metal accumulation in the river.

Recommendations

- Consideration of schemes to construct artificial recharge structure.
- Proper sanitation should be strictly observed around the river.
- To create public awareness about non –bio degrade able materials like plastic covers, bottles, metal glass pieces, garbage etc., are thrown into soil.
- Public awareness programmes need to be developed for sustainable management of river water.

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