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STUDY OF HEAVY METAL POLLUTION IN GROUND WATER NEAR PROXIMITY OF THAMIRABHARANI RIVER, TAMIL NADU, INDIA

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ABSTRACT

In this study was carried out on heavy metal contamination of groundwater with respect to chromium, cadmium, manganese, zinc, copper and lead in and around thamirabharani river, Tirunelveli district, Tamil Nadu, India. Heavy metals in groundwater are estimated by using Atomic Absorption Spectrometer, Perkin Elmer AA 200. Univariate statistics along with Skewness, kurtosis and 't' test have been employed to test the distribution normality for each metal. The study reveals that the groundwater of the area is highly contaminated with cadmium. A good number of samples are also found to contain manganese at an alert level. The concentrations of copper and zinc in the groundwater of the area are within the guideline values of WHO. Statistical results show that all the metals under study exhibit an asymmetric distribution in the area with a long asymmetric tail on the right of the median. Keeping in view of the high concentrations of cadmium and manganese, it is suggested to test the potability of groundwater of the area before using it for drinking.

Keywords: Chromium, Manganese, Lead, Skewness, Kurtosis, t-Test

INTRODUCTION

Water is an important role of human life. Although statistics, the WHO reports that

approximately 30% of urban and 70% of rural Indian were without access to safe

drinking water. Fresh water is one of the most important resources crucial for the survival of all the living beings. It is even more important for the human being as they depend upon it for food production, industrial and waste disposal, as well as cultural requirement. Human and ecological use of ground water depends upon ambient water quality. Human alteration of the landscape has an extensive influence on watershed hydrology [1]. Heavy metal contamination of groundwater more often not goes unnoticed and remains hidden from the public view. Presently, it has raised wide spread concerns in different parts of the world and results reported by various agencies have been alarming [2, 3]. There is also evidence of prevailing heavy metal contamination of groundwater in many areas of India [4-6]. Trace amounts of heavy metals are always present in fresh waters from terrigenous sources such as weathering of rocks resulting into geo-chemical recycling of heavy metal elements in these ecosystems [7]. Contaminants such as bacteria, viruses, heavy metals, nitrates and salt have found their way into water supplies as a result of inadequate treatment and disposal of waste (human and livestock), industrial discharges, and over-use of limited water resources [8]. In this work, concentrations of chromium,

cadmium, manganese, zinc, copper and lead ions in drinking water samples from water sources in these communities were determined by using standard analytical methods. Correlations between the metal concentrations were investigated. The monitoring of groundwater quality has been universally recognized as the quality of ground water cannot be restored once it is contaminated, by stopping the flow of pollutants from the source [9]. Toxic metals have adverse effect on the health of human, when they are penetrated through the human organ and tissue as well as the entire systems. Lead in any concentrated can caused kidney damage and toxicity symptoms include impaired kidney function, poor reproductive capacity, hypertension, tumors, etc. chromium (VI) penetrates cell membranes and causes genotoxic, effect and cancer [10].

Statistical analysis

Using SPSS/16 statistical software; SPSS Inc., USA, a t- test analysis was performed and differences were considered significant at values of $P < 0.05$. For the statistical analysis, values below the detection limit were set to half that level.

Sampling information

For the present study, 40 water samples were collected left side as well as right side

ten different stations of thamirabharani river in Tirunelveli district during June to November, 2017 (Table 1).

Experimental Methodology

Separate water samples were selected by random selection and compiled together in clean and sterile one liter polythene cans rinsed with dilute HCl to set a representative sample and stored in an ice box. Samples were protected from direct sun light during transportation to the laboratory and metals were analyzed as per the standard procedures [11]. All the metals were estimated by using Atomic Absorption Spectrometer (Perkin Elmer AA 200). The instrument was used in the limit of précised accuracy and chemicals used were of analytical grade. Doubly-distilled water was used for all purposes.

Data analysis:

Univariate statistics were used to test distribution normality for each metal. The confidence interval was calculated at 0.05 levels. *t*- Test is done under null hypothesis (H_0) by taking the assumption that the experimental data are consistent with the mean rating given by (WHO-2004). Simple correlation analysis was used to relate the metal concentrations among themselves. Moment coefficients of skewness and kurtosis were calculated to

express how the shapes of sample frequency distribution curves differ from ideal Gaussian (normal). Skewness was calculated as third moment of the population mean. In asymmetrical distributions, skewness can be positive or negative. Kurtosis was calculated as fourth moment of the population to describe the heaviness of the tails for a distribution. Some more statistical estimates derived from the normal distribution in the form of sample variance, 1st, 2nd, 3rd Quartile, Inter Quartile Range (IQR) were also made in the present study to find out the distribution pattern of the data and other related information. Details of these may be found in standard books on statistics and software packages [12].

Experimental Findings and Analysis

The results of analysis of various metals in groundwater samples of thamirabharani river in Tirunelveli district, Tamil Nadu are given in Table 2. To get an idea about the distribution pattern of the metal contents in groundwater left side and right side of the river is separately, data are graphically represented in Figure 1 respectively. To look into the trend and distribution patterns of chromium, cadmium, manganese, zinc, copper and lead in groundwater of the study area, data obtained from 40 sampling stations were exposed to

several statistical treatments as discussed briefly in the methodology section. A conventional descriptive statistics based on normal distribution has been shown in **Table 3**.

In most of the samples under investigation, the cadmium contents were much above the guideline value of 0.003 ppm as set by WHO [13]. Cadmium above the permissible limit can potentially cause nausea, vomiting, diarrhea, muscle cramps, salivation, sensory disturbances, liver injury, convulsions, shock and renal failure along

with kidney, liver, bone and blood damage from a lifetime exposure. Differences between mean and median, significant positive skewness and negative kurtosis value indicate that the distribution of cadmium in the study area is highly asymmetric. This is also evident from the width of the third quartile, which is much greater than the first and second quartile. The cadmium contamination of ground water in the area should be accorded maximum attention.

Table 1: Sampling stations

Stations	Sample No	Stations	Sample No
Profile A (towards right side of the river)	A1	Profile B (towards left side of the river)	B1
Karayar	A2	Sivanthipuram	B2
	A3		B3
	A4		B4
	A5		B5
Papanasam	A6	Mukkudal	B6
	A7		B7
	A8		B8
	A9		B9
Settimedu	A10	Ambasamuthiram	B10
	A11		B11
	A12		B12
	A13		B13
Harikesavanallur	A14	Bazhavor	B14
	A15		B15
	A16		B16
	A17		B17
Pathamadai	A18	Suthamalli vilakku	B18
	A19		B19
	A20		B20

Table 2: metal concentration of ground water in the left and right side of the river

Stations	Samples No	Heavy metals					
		Mn	Zn	Cu	Cd	Cr	Pb
Profile A	A1	0.06	0.07	0.04	0.05	0.04	0.04
Karayar	A2	0.05	0.05	0.02	0.06	0.03	0.05
	A3	0.05	0.03	0.04	0.04	0.06	0.04
	A4	0.02	0.02	0.02	0.05	0.01	0.04
Papanasam	A5	0.03	0.03	0.01	0.04	0.01	0.04
	A6	0.02	0.02	0.01	0.08	0.01	0.02
	A7	0.05	0.04	0.03	0.07	0.04	0.02
	A8	0.04	0.04	0.03	0.06	0.01	0.02
Settmedu	A9	0.04	0.01	0.01	0.02	0.04	0.02
	A10	0.04	0.03	0.01	0.04	0.04	0.04
	A11	0.02	0.01	0.01	0.02	0.02	0.02
	A12	0.08	0.05	0.01	0.03	0.02	0.05
Harikesavanallur	A13	0.04	0.04	0.04	0.02	0.05	0.08
	A14	0.03	0.04	0.01	0.02	0.03	0.03
	A15	0.05	0.05	0.01	0.02	0.02	0.02
	A16	0.04	0.04	0.01	0.02	0.01	0.03
Pathamadai	A17	0.07	0.07	0.05	0.05	0.03	0.03
	A18	0.02	0.04	0.01	0.02	0.02	0.02
	A19	0.04	0.04	0.01	0.06	0.02	0.02
	A20	0.03	0.02	0.01	0.02	0.02	0.01

Table 3: Descriptive statistics of the metal contents of ground water in the study area

Statistics	Mn	Zn	Cu	Cd	Cr	Pb
Mean	0.044	0.037	0.024	0.054	0.026	0.036
Standard Error	0.003	0.002	0.002	0.005	0.002	0.002
Median	0.04	0.04	0.02	0.05	0.02	0.04
Mode	0.04	0.04	0.01	0.02	0.02	0.04
Standard Deviation	0.02088	0.01575	0.01411	0.03235	0.01507	0.01456
Variance	0.00	0.0002	0.0001	0.001	0.0002	0.0002
Kurtosis	0.127	0.243	0.953	-0.630	2.994	0.706
Skewness	0.751	-0.442	0.585	0.715	1.481	0.619
Range	0.09	0.07	0.04	0.11	0.07	0.07
Minimum	0.01	0.01	0.01	0.02	0.01	0.01
Maximum	0.1	0.08	0.05	0.13	0.08	0.08
Sum	1.74	1.48	0.96	2.14	1.05	1.43
Count	39	39	39	39	39	39
Confidence Level (95%)	0.00676	0.00510	0.00457	0.01048	0.00488	0.00472
1 st Quartile	0.03	0.03	0.01	0.03	0.02	0.0275
2 nd Quartile	0.04	0.04	0.02	0.05	0.02	0.04
3 rd Quartile	0.05	0.05	0.04	0.0825	0.0325	0.04
WHO Rating, in ppm	0.05	3.0	2.0	0.003	0.05	0.01
t-test value	0.029616	0.001003	0.00296336	0.00008334	0.0007266	0.00008987
Comment, 0.05 level 95% CL	significant	significant	Non-significant	Non-significant	Non-significant	Significant
No of Samples	40	40	40	40	40	40

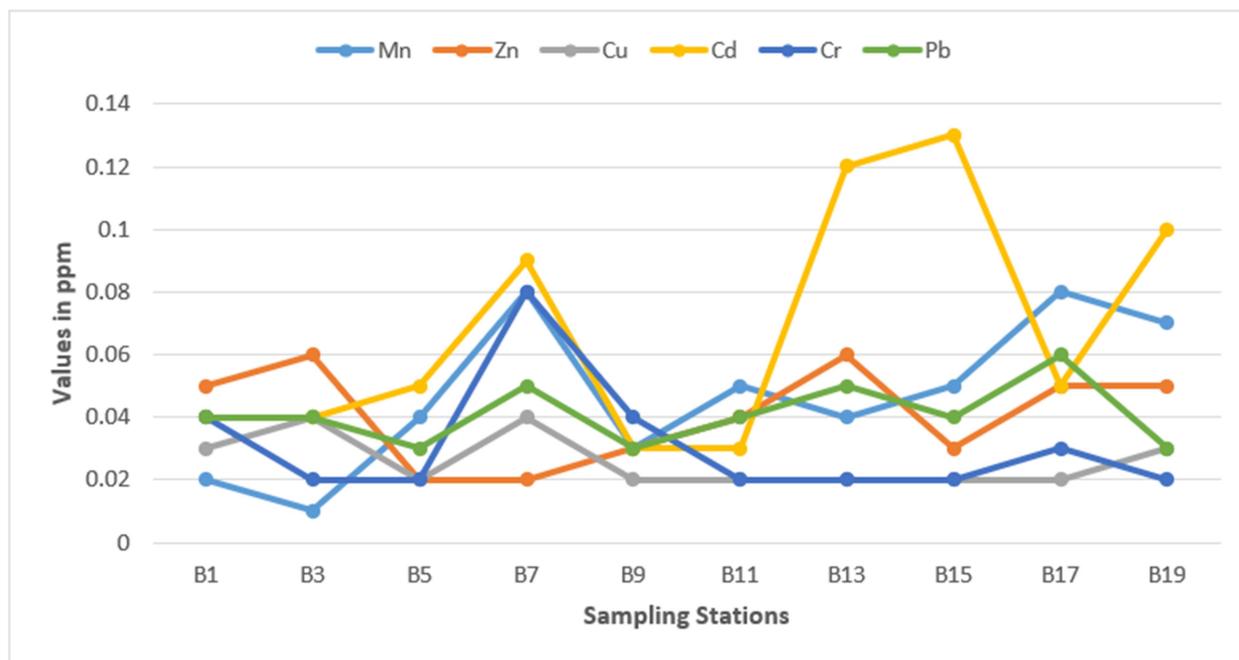


Figure 1: Variations of metal contents of ground water left side of the river

Manganese at concentrations above 0.07 ppm stains plumbing fixtures and laundry and produces undesirable taste in drinks. The WHO limit for manganese in drinking water is 0.05 ppm. It is observed that as many as maximum samples. Under observation contain manganese either at toxic or alert level. Thus, manganese contamination of groundwater in the area needs proper attention. A broad third quartile and negative kurtosis in case of manganese represents a long asymmetric tail on the right of the median. Heaviness of the tail for manganese distribution in the area is evident from very high positive kurtosis value Pearson's correlation coefficient matrix is presented in **Table 3** to measure the linear association

among different metals under study. Since the directions of association of the measured variables are unknown in advance, two-tailed test of significance was carried out.

The ground waters of the study area are by and large safe with regard to zinc as may be seen from **Table 1**, its distribution is still not uniform in the area. Wide data range and high standard deviation in case of zinc is likely to bias the normal distribution statistic. This observation is supported by positive kurtosis and negative skewness value, which point towards sharp zinc distribution with a long right tail in the study area.

The permissible limit for copper in drinking water is 2.0 mg/L. This was set to

ensure the water tastes good and to minimize staining of laundry and plumbing fixtures. The distribution of copper in groundwater of the study area is found to be within the permissible limit of WHO with an average of 0.02 ppm. Asymmetric nature of copper distribution is also apparent from the normal distribution statistics with positive skewness and kurtosis values.

The permissible limit for lead in drinking water is 0.01 mg/L. The distribution of lead in groundwater of the study area is found to be nearly 30 samples above the permissible limit of WHO with an average of 0.036 ppm. Asymmetric nature of lead distribution is also apparent from the normal distribution statistics with positive skewness and kurtosis values.

The permissible limit for chromium in drinking water is 0.05 mg/L. The distribution of chromium in groundwater of the study area is found to be nearly 10 samples above the permissible limit of WHO with an average of 0.026 ppm. Asymmetric nature of lead distribution is also apparent from the normal distribution statistics with positive skewness and kurtosis values.

From the correlation of the studied metals as shown in Table 2, significant correlation was found among chromium, cadmium, copper, Zinc, Lead and manganese

all are positive correlation. Over all significant correlation was found among zinc shares a clear high positive correlation with copper and low positive correlation with lead content at the 0.05 level in the area.

CONCLUSION

Statistical observations on Cr, Cd, Mn, Cu, Zn and Pb in groundwater of near thamirabharani river, Tirunelveli district, Tamil Nadu show that all these metals exhibit an asymmetric distribution with a long asymmetric tail on the right of the median. It is observed that the groundwater of the area is contaminated with cadmium. A sizeable number of groundwater samples contain manganese and lead at an alert level. The concentrations of copper and zinc in the groundwater of the area are either low or moderate and within the guideline values of WHO. Keeping in view of the unusually high concentrations of the harmful metals, *viz.* cadmium and manganese and lead, it is advisable to test the potability of groundwater of the area before using it for drinking.

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