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Assessment of heavy metal enrichment and degree of contamination of ground water quality in sembattu, tiruchirappalli

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ABSTRACT

Tiruchirappalli is growing as an industrial district in Tamilnadu. The people belongs to these area mainly depends on groundwater for both domestic and irrigation purpose. This study is carried out to find the quality of groundwater by analyzing the heavy metals concentration at five places in Sembattu, Trichy district, Tamilnadu. The concentration of heavy metals such as Cr, Cd, Co, Mn, Fe, Pb in the groundwater samples collected from five different places in the study area were determined using “Atomic adsorption spectrometer”. Then the groundwater quality was evaluated by the various index values like “Enrichment factor”, “metal pollution index”, Geo-accumulation index”, by calculating the above three indices we have concluded that our study area comes under the category of low degree of heavy metal pollution. This study finally shows that the groundwater is not affected majorly by the heavy metal.

KEYWORDS: Enrichment factor, metal pollution index, Geo-accumulation index.

1. INTRODUCTION

Due to rapid development of industrial activities, the amount of heavy metals released into the environment causes serious problems. In the environment heavy metal pollution can originate from natural as well as from manmade sources. Geological weathering and volcanic eruption comes under natural sources of heavy metal pollution. Tannery industries, electroplating industries comes under manmade sources of heavy metal pollution. Among this pollution they are both harm to human beings and to the environment (e.g. cadmium, lead, chromium), many of them may cause corrosion (e.g. zinc and lead). In smaller quantity they are required for humans (cobalt, chromium and nickel) while others are toxic, affecting the central nervous system (arsenic) or teeth (nickel, cadmium, chromium).

The groundwater in our study area (Sembattu) was affected due to discharge of untreated effluents from tanneries. This study is an attempt to evaluate heavy metal pollution from untreated tannery effluent. It is necessary that industries must consider the acceptable levels of heavy metals before releasing the effluents into the environment. The main objective of this study is to analyze the concentration of heavy metals (released from tannery industry) in groundwater, to examine the heavy metal concentration level using various indices, and to suggest the suitable remedial measures.

Study area: Tiruchirappalli is the fourth largest city in Tamilnadu and it is located in centre of the state. This city is located on the southern bank of river Kaveri. However, population in these areas depends on groundwater for drinking and other activities like agriculture and industries, etc. For the present study the quality of groundwater was checked in and around the cluster of tanning industries situated at Sembattu. In present, there are 11 tanneries functioning around in Sembattu. Samples were collected from five different points. Three samples from keelasembattu and two samples near the tannery industry at a approximate distance of 5m, 10m, 15m, 20m and 25m from the tanning industries. There are six open wells, two hand pumps and four bore wells in Sembattu. Sample were collected from all the five sampling points.

Figure.1.Study area map for sembattu

2. MATERIALS AND METHODS

Water sample were collected as per the standard procedure from five locations selected randomly in the study area and also by considering the domestic, agricultural, and industrial areas. Using atomic adsorption spectrometer the groundwater sample were analyzed for heavy metal such as iron(Fe), chromium(Cr), lead(Pb), manganese(Mn), copper(Cu), and nickel(Ni). The results were compared with the drinking guidelines of world health organization (who). The results were presented in table 1.

The assessment of heavy metal enrichment can be carried out in many ways. The most common form of index are enrichment factor calculated with reference to iron concentration (EF), geo-accumulation index (I-geo) and pollution load index (PLI). The I-geo has been used to measure of pollution in freshwater with respect to world shale concentration of respective metal, while the pollution load index (PLI) represents the overall level of heavy metal toxicity in a particular sample. In these study contamination factor, contamination degree are also calculated to represent heavy metal enrichment.

Different methods for calculatingpollutant impact: There are number of calculation methods (e.g. Ridgway and Shimmield 2002) have been adopted for quantifying the degree of metal enrichment. Some of the methods are discussed in the following section with proposed modification.

Enrichment factor (EF): A common approach to estimating the anthropogenic impact on sediments is to calculate a enrichment factor (EF) for metal. The measured heavy metal content were normalized with respect to sample reference metal such as Fe or Al (Ravichandran, 1995). In the present study Fe is considered as a reference material.Because Fe has a high natural concentration when comparing with other metals. Five contaminant categories based on EF values are presented at table 1.The EF is calculated according to the following equation:

Enrichment factor (EF) = $(M_x.Fe_b)/(M_b.\ Fe_x)$

M_x = Sediment sample concentration

M_b = Back ground sample concentration

Fe_x = Iron concentration

Fe_b = Back ground concentration of iron

Table.1.Five contaminant categories based on EF value

Enrichment factor value	Contaminant degree
<2	Deficiency to low enrichment
2-5	Moderate enrichment
5-20	Significant enrichment
20-40	Very high enrichment
>40	Extremely enrichment

Metal pollution index: This method has been used for the evaluation of composite influence of individual parameters on the overall quality of water. The MPI represents the summation of ratio between the analyzed parameters and their equivalent national standard values. If metal pollution index is higher than 1 study area is considered as polluted (Ahmed EI Nemr, 2003).

Metal pollution index (MPI) = $\log \sum_{i=1}^{K} (X/\ \mathrm{Refi})$

R_{efi} = normalizer; X= mean value

Geo accumulation index (I_{geo}): It is one of the common method to estimate the enrichment of metal concentration above back ground or baseline concentration.Geo- accumulation index were determined by the following equation according to Muller (1969) which was described by Boszke (2004).

$I_{geo} = \log 2\ (C_n/1.5B_n)$

C_n= measured concentration of heavy metal

B_n= geochemical background value in average shale.

The factor 1.5 is used for the possible variations of the background data due to lithological variations.

Table.2.Seven contamination level based on the geo accumulation index

Geo accumulation index	Pollution level
<0	Un polluted
0-1	Un polluted to moderate polluted
1-2	Moderately polluted
2-3	Moderate to strongly polluted
3-4	Strongly polluted
4-5	Strongly to very strong polluted
>5	Very strong polluted

Contamination factor: Introduced by Hakanson (1980) represents that calculating contamination factor (c_f) for each pollutant. The purpose for calculating contamination factor is to measure the degree of overall contamination in a sampled site. However, the cf requires that at least five samples concentration are averaged to produce a mean pollutant concentration. The formula is given as follows:

$C_f = \frac{c}{c^0}$

The c_f is the ratio obtained by dividing the mean concentration of each metal in the sample Cvalue by the baseline or background (concentration in unpolluted sample, (c^o).

Table.3.Contamination factor (c_f)

Contamination factor	classification
<1	Low contamination
1-3	Moderate contamination
3-6	Considerable contamination
>6	High contamination

Degree of contamination (C_d): The degree of contamination is a common approach used to measure the degree of overall contamination in a particular sampling site. It was developed by Hakanson's, calculated by the formula, Degree of contamination (c_d) = $\sum_{i=1}^{k} C_f$

Table.4.Degree of contamination based on hakanson's classification

Degree of contamination	classification
<6	Low contamination
6-24	Considerable contamination
>24	High contamination

Pollution load index: Pollution load index is used for indicate the input of anthropogenic source. Low level of PLI indicates that source of pollution will be long from the sampling site. PLI can be calculated by the following equation

$PLI = (CF_1 \times CF_2 \times CF_3 \ldots\ldots CF_n)^{1/n}$

n = number of metals

CF = contamination factor

Table.5.Pollution load index

Pollution load index	Classification
<1	No pollution level
>1	High pollution level

3. RESULTS AND DISCUSSION

By considering Fe as a reference element the enrichment factor for heavy metal such as (Cr, Pb, Mn, Cu, Ni) were calculated. It is a common procedure for estimating the anthropogenic impact on water and soil to calculate a normalized factor for heavy metal concentration (SaralaThambavani, 2013). Table 8 represents the enrichment factor values of Cr, Pb, Mn, Cu, Ni. From the fig.2 Enrichment results shows that EF of all the sampling sites were found as less than 2. So this study falls under low enrichment.

Table.6.Average concentration of heavy metals

Heavy metal	Sample details				
	1	**2**	**3**	**4**	**5**
Chromium (ppm)	0.12	0.15	0.08	0.13	0.10
Copper (ppm)	0.08	0.09	0.05	0.06	0.03
Nickel (ppm)	0.01	0.05	0.03	0.04	0.03
Lead (ppm)	0.002	0.002	0.003	0.001	0.004
Manganese (ppm)	0.08	0.09	0.12	0.08	0.06
Iron (ppm)	0.13	0.08	0.09	0.11	0.08

Table.7.World average rock shale value in ppm

Fe	Pb	Cr	Mn	Cu
4.72	20	100	850	45

Table.8.Enrichment factor of heavy metals

Distance	Cr	Pb	Mn	Cu	Ni
5	0.043	0.0036	0.0034	0.0645	0.0053
10	0.088	0.0059	0.0062	0.118	0.043
15	0.041	0.0078	0.0074	0.0582	0.023
20	0.055	0.0021	0.004	0.0572	0.001
25	0.059	0.0118	0.0041	0.0393	0.026

Table.9.Metal pollution index

Distance	Fe (X/ref)	Cr (X/ref)	Pb (X/ref)	Mn (X/ref)	Cu (X/ref)	Ni (X/ref)	Σ (X/ref)	Log Σ
5	2.6	2.4	0.04	0.8	1.6	0.5	7.94	0.89
10	1.6	3	0.04	0.9	1.8	2.5	9.84	0.99
15	1.8	1.6	0.06	1.20	1	1.5	7.16	0.85
20	2.2	2.6	0.02	0.8	1.2	2	8.82	0.94
25	1.6	2	0.08	0.6	0.6	1.5	6.38	0.80

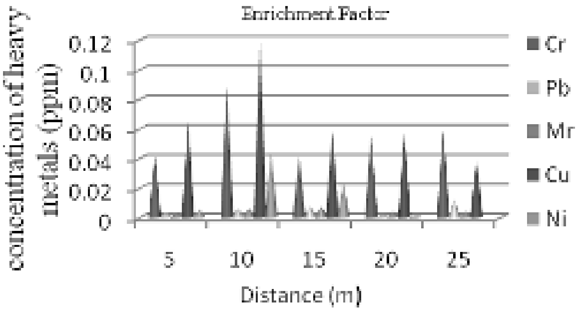

Figure.2.Enrichment Factor

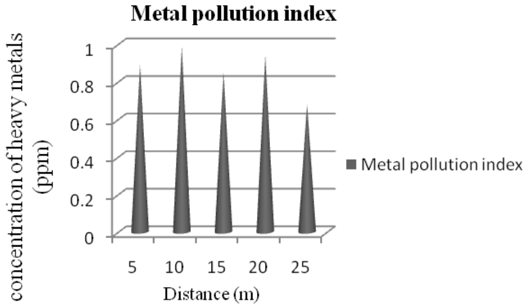

Figure.3.Metal pollution index

Concentration of metal such as Fe, Cr, Pb, Mn, Ni, Cu are taken to find out the metal pollution index. From table.6 average concentration of Fe, Cr, Pb, Mn, Ni, Cu are find out. From theses metal concentration, metal pollution index is calculated with respect to reference values. Table 9 shows that calculated values (MPI) of heavy metal. Fig.3 shows that maximum of metal pollution were at sampling points 2 and 4 at a distance of 10 and 20m (near to 1 i.e 0.99and 0.94). If metal pollution index is higher than 1, study area is considered as polluted (Ahmed EI Nemr, 2003). In our study area MPI is lower than 1. So our area is considered as not polluted by heavy metals. But there is also a chance of near to pollution.

Table.10.Geo Accumulation Index of sampling sites

Distance	Fe	Cr	Pb	Mn	Cu	Ni
5	-5.767	-10.28	-13.87	-13.96	-9.72	-13.31
10	-6.467	-9.965	-13.87	-13.79	-10.13	-10.99
15	-6.297	-10.87	-13.28	-13.37	-7.07	-11.73
20	-6.008	-10.17	-14.87	-13.96	-10.13	-11.31
25	-6.467	-10.55	-12.87	-14.37	-11.13	-11.73

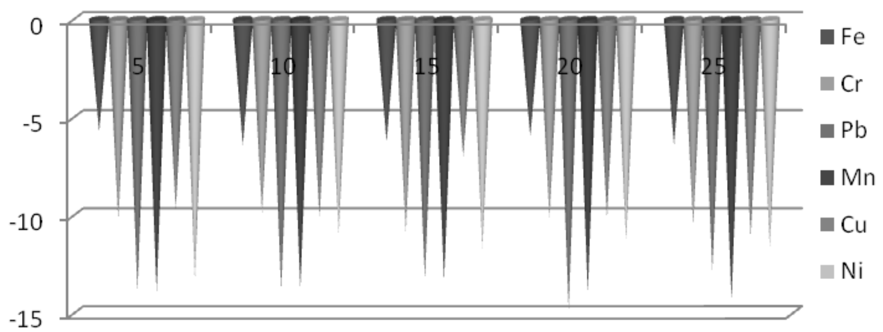

Figure.4.Geo accumulation index

Geo accumulation index is considered to find out contamination level. The results of geo accumulation index for water are in table 10 and it is presented in figure.4. There are seven contamination level between 0-5 (Fagbote Emmanuel Olubunmiet, 2010) our average contamination level is below 0 and some of them is very near to limiting value and it indicates that our study area is unpolluted but near to pollution level.

Table 11 shows the contamination factor of each element. On the basis of Hakanson classification, the contamination factor for all the sampling sites falls under low contamination level. The values of contamination degree indicates that low degree of contamination. All PLI values are below to 1.

Table.11.Contamination factor, Contamination degree, Pollution load index.

	Contamination Factor						Contamination Degree	Pollution Load Index
	Fe	Cr	Pb	Mn	Ni	Cu		
5	0.027	0.0012	0.0001	0.000094	0.00014	0.0017	0.030234	0.00064
10	0.016	0.0015	0.0001	0.0001	0.00073	0.002	0.02043	0.00043
15	0.019	0.0008	0.00015	0.00014	0.00044	0.0011	0.02163	0.00073
20	0.023	0.0013	0.00005	0.000094	0.00058	0.0013	0.026324	0.00068
25	0.016	0.001	0.0002	0.00007	0.00044	0.00066	0.01837	0.00063

4. CONCLUSION

The present study has led to conclude that the quality of water sample were studied and it was not heavily polluted by heavy metal such as iron, chromium, lead copper, nickel, manganese. In this study, the impact of anthropogenic heavy metal pollution in the sampling site was evaluated using Enrichment factor (EF), metal pollution index (MPI), Geo accumulation index (I_{geo}). The result shows that EF of all sampling site was found as less than 2. So the study falls under low enrichment. The results of metal pollution index (MPI) was lower then1 and in sampling point 2 and 4 the values are near to 1, so study falls under low pollution, but in some areas there is a chance of near to pollution . Geo accumulation index (I_{geo}) shows that the study area is regarded as non-polluted but near to pollution level.

But in Sembattu water is highly polluted by heavy metal due to mixing of tannery wastes into the ground water. This leads to affecting the quality of water making it unsuitable for agriculture, water as a non-potable and air filled with bad odor. This highly polluted water deposits the heavy metals on the ground water surface. Addition of alkaline salts, increasing level of hardness and increasing level of heavy metals leads to chronic effects. The present study shows that ground water in Sembattu should be treated, then some of the remedial measures are required to prevent the heavy metal pollution into the ground water, proper discharge and treatment method should be adopted for preventing the quality of ground water.

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