IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG)
e-ISSN: 2321–0990, p-ISSN: 2321–0982.Volume 6, Issue 2 Ver. II (Mar. – Apr. 2018), PP 29-35
www.iosrjournals.org

Concentration of Heavy Metal in Surface Water and Groundwater Adyar River Basin, Chennai, Tamilnadu, India

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Abstract: *A study was investigates the concentration of trace elements in the surface water and groundwater of Adyar River Basin. For this study 50 water samples were collected from in and around of the lake and along the river. These samples were subjected for elements like Fe, Mn, Ni, Cu, Co, Cr, Pb, and Zn by using AAS. The water parameters reach as pH (6.8 - 7.9), EC (932 - 2909), TDS (496 - 1761). The result reveals that the concentration of these metals in the study area was compared with (WHO 2011). The order of dominance is as follows: Fe>Mn>Co for Groundwater and Mn>Cu>Zn for Surface water. The abundance of the metals in order of Cu>Cr>Pb>Zn and Co>Pb>Ni>Fe post-monsoon seasons. Cluster analysis identified four clusters among the studied heavy metals. Cluster 1 consisted of Pb, Cu, and cluster 3 included Cr, Fe; also each of the elements Zn, Co and Ni was located in groups with single member. The same results were obtained by factor analysis. Statistical investigations revealed that anthropogenic factors and notably lead and zinc are the major problems due geochemical pollution sources are influencing water quality in the studied area.*

Keywords: *Heavy metal, Chennai, Adyar River, Factor, Cluster analysis*

Date of Submission: 25-03-2018 Date of acceptance: 14-04-2018

I. Introduction

Trace elements are required for functioning of human system high quantities causes serious health effects due to its persistence, toxicity, and accumulation in nature. Surface water and groundwater abstracted for the supply of drinking water must be capable for environmental region. Surface water has been and is still being used for many purposes, which include drinking, Irrigation, animal farming, recreation and serves as habitat to numerous organisms. In most countries of the world, groundwater and surface water in agricultural areas are at a serious risk of metal pollution, due to unplanned urbanization, population and intensification of agriculture (Klavinš et al., 2000; Li and Zhang, 2010). Trace elements occur in groundwater are derived from the weathering of rocks. High concentration of these metals can be released in to the aquatic environment as a result of leaching from bedrock, atmospheric deposition, water drainage, runoff from riverbanks, and discharge of urban and industrial wastewaters (H.Yang and N. Rose 2005). The behavior of the trace metals is complicated and is related to source of group water and the biological process in elemental conditions WHO (1993). Metals from industrial wastes, agricultural sources, urban runoff, atmospheric deposition, and automobile emissions could also disperse to the surface water via surface runoff or rain water (Smail et al., 2012). They could penetrate to deeper soil layers, and eventually reach groundwater (Bichet et al., 2013). Among the most notorious water pollutants are, which are a group of contaminations long detected as a treat to aquatic organisms and humans their toxicity in the environment (Ahmad, J.U.; Goni, M.A. 2010). Heavy metal under certain condition high concentration they may have a negative impact on the receiving environment. The geologic agents are vital role for evaluate in water depends on natural factors such as aquifer, quality of infiltrating water, The determination of health risk levels posed by various contaminants can be assessed by evaluating the human health factors. The main source of livelihood in the study area relies on agricultural activities and hence application of fertilizer and dumping industrial effluents makes the groundwater resources more vulnerable toward pollution. Increasing of industrial activities has intensified metals in biota and flora although trace elements at low concentration are essential to life, at high concentration, may become hazardous. The toxic substances accumulated in to water bodies are through the unpracticed common by confinement initiates the growth of river pollution. To this end the study was designed to access the surface water and groundwater quality with respect to trace elements at Adyar River Basin.

II. Study area and Geology

The area selected for this study is Adyar River Bank (ARB) in the Kanchipuram District of the state of Tamilnadu. Chembarampakkam Lake is located about 40 km from Chennai. The Adyar River originates from this rainwater-fed lake and flows through Kanchipuram, Tiruvallur and Chennai districts for a distance of about 50 km and debouches into the Bay of Bengal. The Chembarampakkam Lake is one of the major sources of drinking water for Chennai (**Fig. 1**). Major part of the district has flat topography with a very gentle slope towards east. (**Fig 2, 3**). Fluvial, marine and erosional landforms are noticed in the district while the other parts are completely disturbed by built-up areas with large-scale human interference and pollution. The major part Geological Succession of the river basin of Adyar is covered by (**Table 1**). alluvium soil with Tertiary and Gondwana rocks at depth. In the downstream area of the river basin, coastal sand predominates, whereas the middle part and upper parts are dominated by sand and silt. Charnockites are also found in parts of the basin.

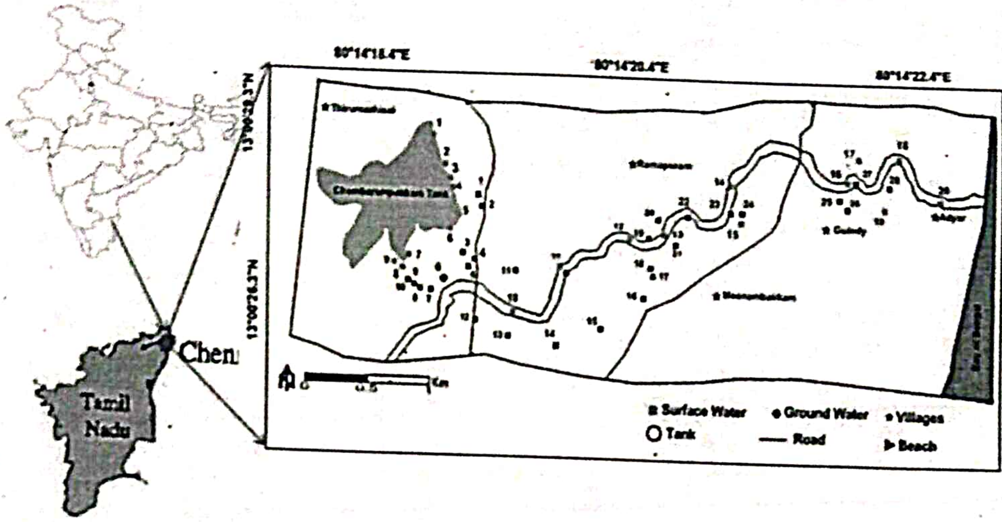


Fig1.Location map of the study area

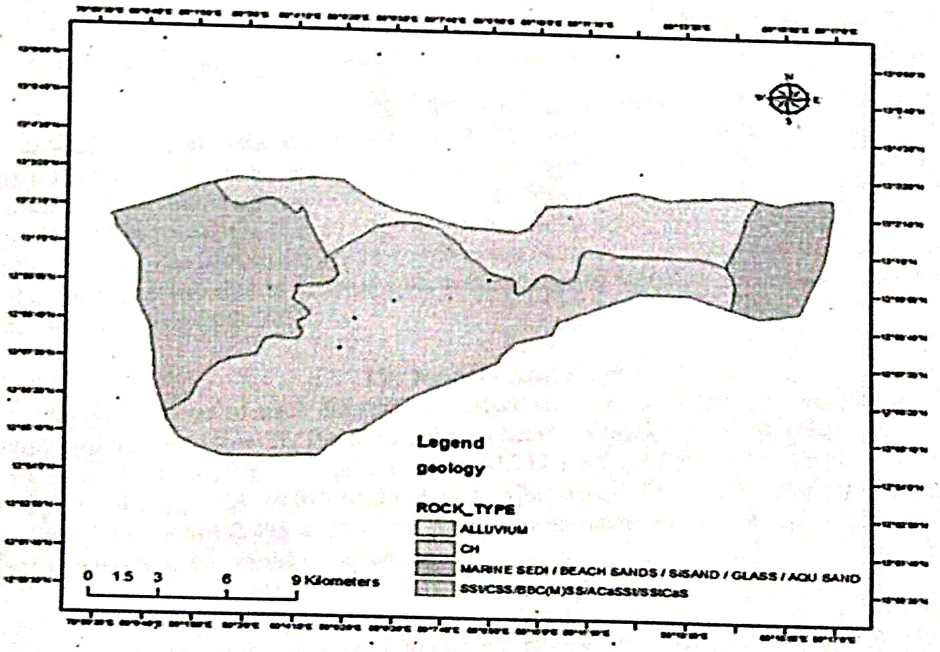


Fig 2. Geology map of the study area

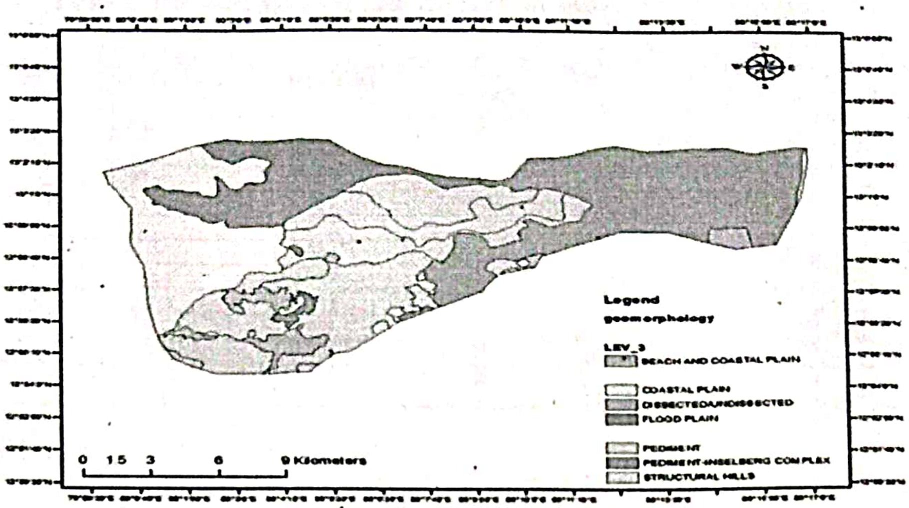


Fig 3. Geomorphology map of the study area

Table1. Geological succession of the Adyar River basin

Group	Age	Lithology
Quaternary	Recent	Soil, alluvium (sand and silt)
Tertiary	Pleistocene Eocene to Pliocene	Black clay Sandstone and shale fossil ferrous
Mesozoic	Lower Cretaceous to Lower Jurassic	Brown sandstone Silt, gray stone, and black shale
Azoic	Precambrian	Charnockite, granite, gneiss

III. Methodology adopted

In total, 50 water samples were collected from surface water as well as bore well and dug well and it's covering during 2016. All water samples were taken in plastic bottles and then brought to the laboratory. The concentration of the following trace elements such as (Iron) Fe, (Manganese) Mn, (Nickel) Ni, (Cobalt) Co, (Copper) Cu, (Chromium) Cr, (Lead) Pb, and (Zinc) Zn by using Atomic Absorption Spectrometry (AAS). During the analysis, the instrument draws a calibration curve of absorbency against concentration of prepared standards. The curve was used to determine the concentration of the elements in the test sample. The results are compared with BIS Standards 2012.

IV. Results And Discussion

The distributions of trace elements in surface water and groundwater samples in Adyar River Basin have been depicted in (Table 2). The absorption of heavy metals in water samples Is systematically given as, (Iron) Fe **(0.01- 6.703 mg/L)**, (Manganese) Mn **(0-3.212 mg/L)**, (Nickel) Ni **(0-0.030 mg/L)**, (Cobalt) Co **(0-0.019 mg/L)**, (Copper) Cu **(0.018-0.088 mg/L)**, (Chromium) Cr **(0-0.091 mg/L)**, (Lead) Pb **(0.172-0.486 mg/L)**, (Zinc) Zn **(0.008-2.455 mg/L)**.This metal concentration leads to recognize the nature and pattern of distribution of these metals in the environment.

Iron (Fe)

During the post-monsoon period the concentration of iron was ranged from 0.01 - 6.703 mg/L with the average value of 0.626 mg/L. WHO (2004) the permissible limits 0.3 mg/l. the source of iron is due to rock-water interaction with Fe bearing rocks and corrosion of house hold pipes in low pH. During the post-monsoon period the Surface water concentration was ranged from 0.01 - 1.55 mg/L, with the average value of 0.48 mg/L

Table 2. Minimum and maximum values of Groundwater and Surface water

	Groundwater			Surface water		
Parameters	Min (mg/L)	Max (mg/L)	Average	Min (mg/L)	Max (mg/L)	Average
pH	6.8	7.9	7.471	7.2	7.6	8.27
TDS	496	1761	1150	313	1523	747
EC	932	2909	1953	645	2537	1324
Fe	0.01	6.703	0.626	0.01	1.55	0.48
Mn	0	3.212	0.316	0.00	0.70	0.24
Ni	0	0.03	0.007	0.00	0.00	0.00
Co	0	0.019	0.002	0.00	0.01	0.00
Cu	0.018	0.088	0.032	0.01	0.03	0.02
Cr	0	0.091	0.006	0.00	0.00	0.00
Pb	0.172	0.486	0.293	0.16	0.22	0.19
Zn	0.008	2.455	0.309	0.01	0.70	0.08

Manganese (Mn)

During the post-monsoon period the concentration of iron was ranged from 0-3.212 mg/L with the average value of 0.316 mg/L. WHO (2004) and BIS (2102), the permissible limits of manganese are 0.05 mg/l and 0.3 mg/l, respectively. Due to industrial waste water containing discharge its effluents being found in the study area.

Lead (Pb)

Lead is the most abundant of the natural heavy metals. The primary form of lead in nature is the sulphide ore Galena (Pbs), a relatively insoluble ore. The main uses of lead are acid storage batteries and antiknock gasoline additives. During the post-monsoon period of the groundwater concentration of lead was ranged from 0.172 - 0.486 mg/L, with the average value of. 0.293 mg/L BIS (2012) and WHO (2004) recommended 0.01 mg/L as the permissible limit for Pb in drinking water, During the post-monsoon period the Surface water concentration of Lead was ranged from 0.16 - 0.22 mg/L, with the average value of 0.293 mg/L the exceeding the maximum allowed limit indicating that these wells are affected with respect to this metal ion. Most wells are located nearby waste disposal site and very close to highways indicating leaching from atmospheric deposition. Pb is toxic element which accumulates in the skeletal structure of man and animal. The presence of lead in groundwater of the study area which indicates that the urbanization has increased has a result in severe contamination of groundwater.

Zinc (Zn)

During the post-monsoon period the concentration of iron was ranged from 0.008 - 2.455 mg/L with the average value of 0.309 mg/L. BIS (2012) and WHO (2004) recommend 3.0 mg/l and 15.0 mg/l as the permissible limit for drinking water. Zinc mostly enters the environment due to the deterioration of galvanized iron, brass and industrial pollutions (Langmuir, 1997; Eisler, 2000). Zn is an essential plant and animal nutrient. During the post-monsoon period the Surface water concentration of Lead was ranged from 0.01 – 0.70 mg/L with the average value of 0.08.

Box whisker Plot

In the present study in surface water and groundwater were graphically represents by Box plots can be used to compare ground water quality data between both water samples. Fig4. A, B shows that the constructed using the median value and the inter-quartile range (25 and 75 cumulative frequencies, diagram reveals that the abundance of the Trace elements is in the order of dominance is as follows: Fe>Mn>Co for Groundwater and Mn>Cu>Zn for Surface water. The abundance of major anions is in the order of Cu>Cr>Pb>Zn during Post-monsoon and Co>Pb>Ni>Fe in the Pre monsoon seasons.

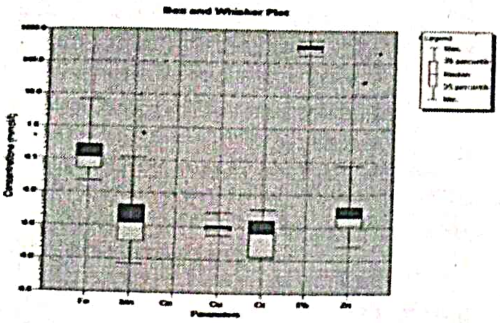
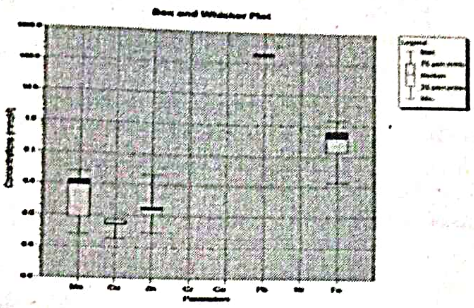


Fig.4.A. Groundwater



B. Surface water

V. Statistical Analysis

The correlation coefficient is commonly used to measure the relationship between two variables. It is a measure to exhibit how well one variable predicts the behavior of the other (Lee et al. 2003). In the study area, Correlation matrixes shows in (Table 3 and 3.1) were carried out using Pearson's correlation. There was a high correlation between EC and TDS was also positively correlated with Fe and Cu in groundwater; Where in Fe correlate with Zn also strong correlative during the study period in the post-monsoon. Where in surface water correlation with EC, TDS and Mn.

Table 3. Correlation matrix of Trace elements Groundwater Post-monsoon

Parameters	pH	EC	TDS	Fe	Mn	Ni	Co	Cu	Cr	Pb	Zn
pH	1										
EC	-0.31	1									
TDS	-0.31	1.00	1								
Fe	-0.31	0.02	0.02	1							
Mn	0.33	0.15	0.15	0.13	1						
Ni	-0.34	0.41	0.41	0.00	-0.22	1					
Co	-0.43	0.17	0.17	0.21	-0.09	0.20	1				
Cu	-0.19	0.03	0.03	0.69	0.06	-0.08	0.35	1			
Cr	0.12	-0.39	0.39	-0.07	-0.10	0.52	-0.15	0.13	1		
Pb	-0.39	0.36	0.36	0.16	-0.08	0.62	0.21	0.20	0.22	1	
Zn	-0.24	0.29	0.29	0.71	-0.03	0.41	0.09	0.52	0.49	0.26	1

Table 3.1. Correlation matrix of Trace elements Surface water

Parameters	pH	EC	TDS	Fe	Mn	Ni	Co	Cu	Cr	Pb	Zn
pH	1										
EC	-0.65	1									
TDS	-0.65	1	1								
Fe	0.05	0.19	0.19	1							
Mn	-0.59	0.58	0.58	0.56	1						
Ni	0	0	0	0	0	1					
Co	-0.27	0.53	0.53	-0.19	-0.03	0	1				
Cu	0.34	-0.18	-0.18	-0.02	-0.54	0	-0.01	1			
Cr	0	0	0	0	0	0	0	0	1		
Pb	-0.09	0.48	0.48	0.25	0.17	0	0.11	0.12	0	1	
Zn	-0.61	0.21	0.21	0.02	0.56	0	-0.04	-0.52	0	-0.08	1

Table 4. Factor Loadings of Trace elements in Groundwater

Parameters	Factor 1	Factor 2	Factor 3	Factor 4
EC	0.96	0.02	0.11	0.11
TDS	0.95	0.02	0.11	0.11
Fe	-0.03	0.91	-0.08	0.21
Cu	-0.02	0.85	-0.06	0.19
Zn	0.24	0.82	0.36	-0.13
Ni	0.42	0.04	0.78	0.06
Mn	0.39	0.15	-0.71	-0.22
Pb	0.38	0.16	0.51	0.30
pH	-0.17	-0.16	-0.35	-0.75
Co	0.12	0.18	0.04	0.75

Cr	0.41	0.21	0.55	-0.56
Total	2.57	2.37	1.97	1.70
% of Variance	23.34	21.54	17.95	15.49
Cumulative %	23.34	44.88	62.83	78.32

Based on these four factors explain about 78.32% of variance in the dataset given below. Factor1: EC, TDS, Factor2: Fe, Cu, Zn, Factor3: Ni, Pb, Cr, Factor4: Co (Table 4). Four factors with different factor loadings indicate that four different contributions are involved in determine the chemical components. Factor 1 (23.34%) is associated with the variables of EC, TDS. Factor 2 explain (21.54%) of the variance and is related to Fe, Cu, Zn. Factor 3 explain (17.95%) of the variance. Factor 4 (78.32%) of the variance. Were factor loading not detected in the surface water samples.

VI. Cluster Analysis

Cluster analysis grouped the studied heavy metals into clusters (called groups in this study) on the basis of similarities within a group and dissimilarities between different groups. CA was performed on the data using Ward method and squared Euclidean distance. A dendrogram was produced by cluster analysis, shown in Figure 5. Cluster 1 indicates high anthropogenic influence; Cluster 2 indicates moderate anthropogenic influence, Cluster 3 as a powerful exploratory data analysis technique which can be applied on large scale for spatial categorized of natural resources.

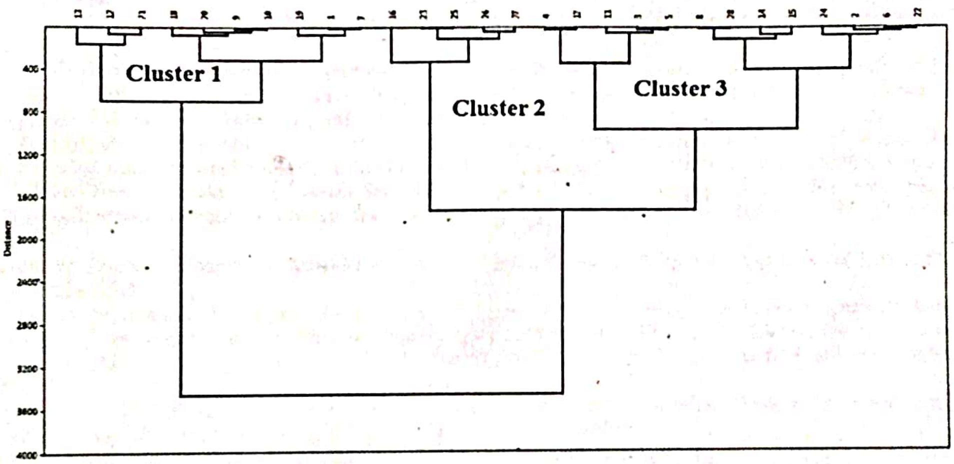


Fig.5 Dendrogram of Groundwater trace elements

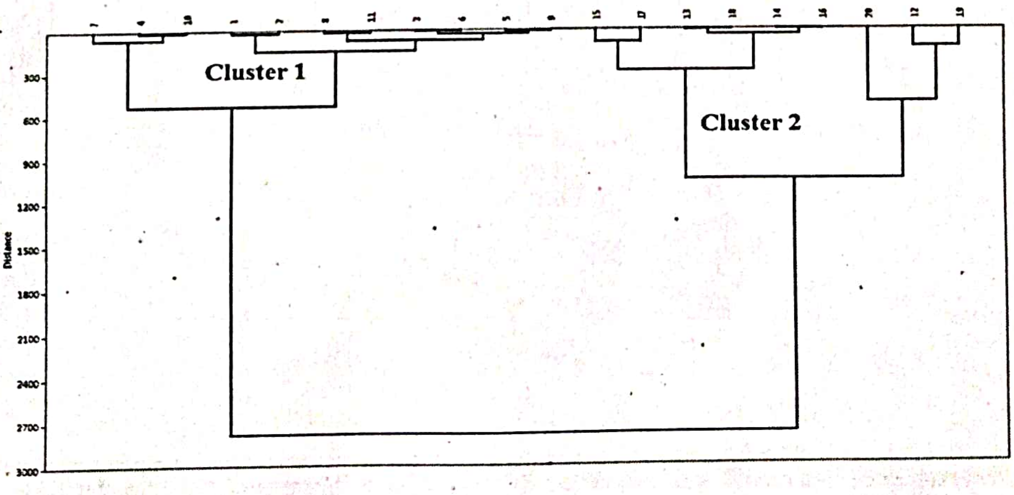


Fig.5.1 Dendrogram of Surface water trace elements

VII. Conclusion

Overall, the present study has shown that the ground water source is contaminated by Iron, Lead, and Zinc, Chromium, copper elements which are present at higher levels. In dry season Cu concentration were not detected in most of the surface samples from boreholes while hand and dug wells were detected with Cu concentrations in both dry and rainy seasons. Multivariate statistical techniques have shown correlations associations of Fe and Cu strong correlate with Zn. The statistical investigation reveal the pollution sources influencing water quality in the study area as anthropogenic (with a very high contribution of industrial pollution) and pedo geochemical for Fe, Cu, Cr and Mn are from fertilizer and industrial waste. Cluster analysis has identified four clusters among the heavy metals. The results suggest that the significant risk to given the toxicity of the studied metals and the fact that this aquifer by far is the main source of their drinking water and irrigation.

Acknowledgement

The authors are thankful to Prof. R.R. Krishnamurthy, HOD, Department of Applied Geology, University of Madras, especially to for the support and infrastructures provided for the study.

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A. Ramachandran "Concentration of Heavy Metal in Surface Water and Groundwater Adyar River Basin, Chennai, Tamilnadu, India." IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG) 6.2 (2018): 29-35.