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Seasonable Variation of Trace Metals, Statistical Values of Groundwater in and around Tannery Areas of Vellore District

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ABSTRACT

Authors investigates the determination of seasonable variation of trace metals named Copper, Zinc, Iron, Cadmium, Chromium and Lead set down in the groundwater in and around area of tannery areas of Vellore district. The tanneries discharge untreated tannery effluents, which get mixed with the soil, water of the Palar River, and underground in this area. The determination of metals was performed for the groundwater samples which are collected from adjacent to tannery localities, which bears untreated tannery effluents at pre-monsoon and post-monsoon seasons. The metals might be deposited into the plants and vegetables grown on that agricultural soil, which disturb human health. Somewhat risky amount of trace metals were found in some groundwater samples, especially in the case of in pre-monsoon. All these trace metals were analysed by the Atomic adsorption spectroscopy technique (AAS). These metals contamination in the groundwater is answerable for the support of harmfulness in farming crops and underground water.

INTRODUCTION

Over two third of earth's surface is covered by water less than a third is taken up by land. On earth 96.5% of water is found in seas and oceans and the remaining is groundwater. Water plays an important role in the world economy because water is an excellent solvent for a wide variety of applications such as household, industries, and agriculture sectors. In earth, water moves continually through the water cycle of evaporation, transpiration, condensation and precipitation[1]. Safe drinking water is essential to humans and other life form even through it does not provide calories or organic nutrients. The lakes, streams and rivers water level will be change with respect to weather but the level of groundwater will not be changed but it decreases due to use of irrigation, domestic and industrial purpose and recharge after several years or months due to rains subsequently.

The groundwater chemistry is mainly controlled by the reactions of geochemical along the direction of flow. It is important to identify these geochemical reactions in the water in order to assess the distribution of major ions of the region[2].

In all living organism including human being to live in earth the basic need is water[3]. In rural areas most of the people are using groundwater for drinking purpose but groundwater is unfit for drinking purpose because it carries total dissolved solids this is due to various factors such as industrial waste, disposal of sewage etc.

In many cities of India usage of groundwater is increased including vellore district due to over population, increased in industrial sector and agriculture, which decrease the groundwater level.

At present, pollution of groundwater is a global environmental problem, due to over exploration and demand of groundwater resources and their recharging is reduced[1-3]. The trace metal contaminates in aquifers of groundwater as constitution of natural due to interaction of soil-water and chemical constituents movement[4]. An ecosystem of aquatic and groundwater contaminations in trace metals. Many researchers have been studied[5-9] by the contaminations of trace metal in groundwater. The natural process of leaching and precipitation is also susceptibly polluted in groundwater results erosion of soil and reduction of quality of water. At present study investigation of copper zinc iron lead chromium and cadmium content in groundwater in Vellore district.

MATERIALS AND METHODS

The groundwater samples were collected in 2L pre cleaned polythene bottles. Add 1mL of con.HNO_3 in each groundwater samples and filtered immediately using 0.45 μm membrane filter of millipore[10] and stored at 4^{O}C in laboratory. The hot plate used to digest the samples and volume reduces less than 50 mL. It is poured in volumetric flash and made up 50 mL used in double distilled water[11]. These samples are kept in dark room and analyses the trace metal by atomic absorption spectrophotometer method[12].

RESULTS AND DISCUSSION

Heavy metals are one of the toxic pollutants in groundwater. It was extracted from earth's crust. Copper is one of the common trace metals, which enter into groundwater due to wastage of industries, copper pipes corrosion and pesticides used in agriculture. The human health need trace amount of copper but, but it concentration is high in drinking water cause damage of liver and kidney[13]. The study area copper concentration varies from 0 to 2.25ppm with average of 0.71ppm, 0 to 1.33ppm with average of 0.477ppm and 0.04 to 1,94ppm with average of 0.767ppm and 0.19 to 2.82ppm with average of 1.104ppm in north, south, central and west parts of vellore district respectively. The maximum copper concentration recorded is (N1, W4, W6, W8, W10) According to World health organization 15 samples exceeds in permissible limit (1ppm). The zinc concentration varies between 0.36 to 2.84ppm with average 1.39ppm in north, 0.48 to 3.83ppm with average 1.841ppm in south, 0 to 3.28ppm with average 1.39ppm in central and 0.1 to 2.27ppm with average 1.224ppm in west part in Vellore district, which enters into groundwater from galvanic industries, productions of battery, zinc pipes and paints. The concentration of zinc is increased may cause stomach ache, fever, diarrhea and vomiting[14]. In our study area all the samples were not exceed in BSI standards and worlds health organization. Iron is one of the essential trace metals in our body. It enters into water from ore, pipes corrosion, etc. The iron concentration ranges from 0 to 1.5ppm with average 0.481ppm in north, 0.04 to 2.17ppm with average 0.579ppm in south, 0 to 0.76ppm with average 0.205ppm in central and 0.02 to 2.17ppm with average 0.608ppm in west part of Vellore district. 44% of the samples are exceeds the permissible limit (0.3ppm) the maximum ion concentration was recorded in (S7). Lead is one of the toxic trace naturally occurring metals. The lead concentration may increase in environmental due to many human activities. Lead concentration varies between 0 to 0.38ppm with average of 0.008ppm, 0 to 0.0038ppm with average of 0.006ppm and 0. to 0.019ppm with average of 0.004ppm and 0.002 to 0.076ppm with average of 0.018ppm in north, south, central and west parts of Vellore district respectively. The drinking water contains small content of lead it cause[15] blood pressure, damage of kidney etc. The present study areas most of samples within the desirable limit except W9 and W10 based on standards of ISI and WHO. The groundwater contains cadmium may naturally or contaminated from mining, sewage water, fertilizers and effluents of industries[16]. It may be change in groundwater pH level. The cadmium concentration varies between 0-0.05ppm in north, 0-0.005ppm in south, 0-0.004ppm in central and 0-0.006ppm in west part of Vellore district. Based on WHO and BIS all the samples within the desirable limit (<0.01ppm). The presence of chromium in groundwater naturally but it exists in combined state. It causes cancer and respiration system damage[17]. All the samples are within desirable limit based on WHO and BIS.

Table 1: Trace metals statistical values of groundwater in north part of Vellore district

Sample Code	Copper	Zinc	Iron	Lead	Cadmium	Chromium
N1	2.25	2.84	0.99	0.003	0.002	0.038
N2	0.67	1.03	0.48	0.01	0.003	0.004
N3	0.57	1.35	0.08	0.038	0.004	0.003
N4	0.48	0.99	0.38	0.019	0.005	0.004
N5	0.04	0.99	0.57	0.003	0.002	0.002
N6	0.97	1.12	0.09	0.003	0.002	0.003
N7	1.52	1.79	0.05	0.009	0.001	0.001
N8	0.48	0.88	0.29	0.004	0.002	0.002
N9	1.18	0.88	1.26	0.004	0.002	0.001
N10	0.06	1.94	0.57	0	0.001	0.001
N11	0	0.36	0.02	0.002	0	0.002
N12	0.57	2.50	1.50	0.004	0.001	0.010
N13	1.33	1.94	0	0.005	0.002	0.002
N14	0.19	0.99	0.38	0	0.004	0.002
N15	0.04	1.39	0.48	0.001	0	0.001
N16	0.08	0.87	0.02	0.004	0.002	0.001
Minimum	0	0.36	0	0	0	0.001
Maximum	2.25	2.84	1.5	0.038	0.005	0.038
Mean	0.704	1.39	0.481	0.008	0.002	0.006

Units = mgL^{-1} (ppm)

Table 2: Trace metals statistical values of groundwater in south part of Vellore district

Sample Code	Copper	Zinc	Iron	Lead	Cadmium	Chromium
S1	1.33	2.02	0.57	0.005	0.005	0.019
S2	1.33	1.89	0.04	0.038	0.003	0
S3	0.76	2.17	0.38	0.001	0.001	0.001
S4	0.47	1.12	0.19	0	0.004	0.002
S5	0.04	1.45	0.09	0.002	0.004	0.001
S6	0.38	2.34	1.2	0.002	0	0.010
S7	0.38	2.55	2.17	0.003	0	0.010
S8	0.02	0.48	0.08	0	0.001	0.001
S9	0	0.97	0.08	0.001	0.001	0.001
S10	0.97	1.73	0.76	0.004	0.001	0.002
S11	0.04	1.89	0.57	0.002	0.004	0.004
S12	0.76	3.83	0.51	0.004	0.002	0.002
S13	0.29	1.50	0.19	0.002	0.001	0.002
S14	0.19	1.39	0.06	0.001	0.002	0.002
S15	0.01	1.89	0.76	0.001	0.002	0.002
S16	0.29	1.6	0.57	0.002	0.004	0.002
Minimum	0	0.48	0.04	0	0	0
Maximum	1.33	3.83	2.17	0.038	0.005	0.019
Mean	0.477	1.841	0.579	0.0059	0.002	0.004

Units = mgL^{-1} (ppm)

Table 3: Trace metals statistical values of groundwater in central part of Vellore district

Sample Code	Copper	Zinc	Iron	Lead	Cadmium	Chromium
C1	0.67	0.48	0.38	0.002	0.002	0.004
C2	1.07	1.33	0.01	0.001	0.002	0.001
C3	1.94	0.76	0.01	0.002	0.002	0.001
C4	0.76	1.07	0.76	0.004	0.001	0.001
C5	0.48	0.97	0.19	0.019	0.001	0.003
C6	0.38	0	0.01	0	0.002	0
C7	0.19	0.88	0.01	0.001	0	0.001
C8	0.19	0.02	0	0	0.001	0.001
C9	0.38	1.38	0.57	0.001	0.001	0.002
C10	1.18	0.34	0.04	0.002	0.002	0.001
C11	1.28	2.78	0	0.005	0.003	0.002
C12	1.14	2.23	0.76	0.004	0.002	0.002
C13	0.97	1.73	0	0.002	0.002	0.001
C14	0.04	2.55	0	0.004	0	0.002
C15	0.67	1.89	0.19	0.004	0.003	0.004
C16	0.48	3.28	0	0.006	0.004	0.006
Minimum	0.04	0	0	0	0	0
Maximum	1.94	3.28	0.76	0.019	0.004	0.006
Mean	0.7667	1.387	0.205	0.004	0.0018	0.002

Units = mgL^{-1} (ppm)

Table 5,6,7: Trace metals statistical values of groundwater in west part of Vellore district

Sample Code	Copper	Zinc	Iron	Lead	Cadmium	Chromium
W1	0.19	1.01	0.38	0.004	0.001	0.002
W2	0.38	0.57	1.07	0.002	0	0.01
W3	0.48	1.18	0.05	0.004	0.002	0.002
W4	2.82	1.83	2.17	0.002	0	0.01
W5	0.38	0.97	0.1	0.002	0.002	0.01
W6	2.13	1.89	0.97	0.019	0.004	0.002
W7	0.93	1.18	0.76	0.019	0.006	0.001
W8	2.36	1.41	0.06	0.01	0.004	0.002
W9	0.69	1.18	1.09	0.076	0.004	0.004
W10	2.3	2.27	0.57	0.057	0.002	0.005
W11	0.57	1.6	0.06	0.002	0	0.002
W12	0.48	0.72	0.02	0.002	0.004	0
W13	0.57	1.3	0.04	0.002	0	0
W14	0.38	0.1	0.19	0.002	0.001	0.019
Minimum	0.19	0.1	0.02	0.002	0	0
Maximum	2.82	2.27	2.17	0.076	0.006	0.019
Mean	1.104	1.224	0.608	0.0176	0.002	0.006

Units = mgL^{-1} (ppm)

Seasonal Analysis

The Table 5,6,7 shows physic-chemical characteristic of groundwater in various seasons. The copper concentration increases from pre-monsoon to monsoon and further increase post monsoon. The maximum copper value were recorded in VEL47 (2.48ppm) in pre-monsoon, VEL46 (2.72ppm) in monsoon and post monsoon (2.84ppm). According to World health organization 31% of the samples exceeds in permissible limit in pre-monsoon and monsoon, 21% of the samples exceeds in post monsoon (>1ppm).

The concentration of zinc ranging from 0.1-4.02ppm with average 1.58ppm in pre-monsoon, 0.2 to 3.62ppm with average 1.65ppm in monsoon and 0.24-3.12ppm with average 1.41ppm in post monsoon. The zinc values decreases from pre-monsoon to monsoon and further decrease in post-monsoon. According to WHO all the groundwater samples are within the desirable limit (5ppm). The maximum values recorded in (VEL24) in pre-monsoon, the minimum values recorded in VEL52 in pre-monsoon, VEL9 in monsoon and post-monsoon.

The observer values of iron ranging from 0.001-2.28ppm with average 0.42 in pre-monsoon, 0.002-3.62ppm with average 0.435ppm in monsoon and 0.001-2.18ppm with average 0.352ppm in post-monsoon. The iron concentration gradually increases from pre-monsoon to monsoon and decreases in post-monsoon. The iron permissible limit in drinking water is 0.1ppm prescribed by IS, but 8 samples exceed the permissible limit in pre monsoon, monsoon and post post-monsoon period. Hence this type of groundwater drawn from bore well is clean but after sometimes the cloudy and brown colour, due to $Fe(OH)_2$ is precipitated[18]. The sampling site of VEL19 is recorded with maximum concentration in pre monsoon and monsoon periods.

The lead concentration is varies from 0.001 to 0.08ppm with average 0.08ppm, 0.01 to 0.08ppm with average 0.008 and 0.001 to 0.04ppm with average 0.005ppm in pre monsoon, monsoon and post monsoon respectively. The lead concentration may constant in pre monsoon and monsoon but it decrease in post monsoon. All samples in three seasons within the desirable limit (<0.05ppm). Cadmium is one of the hazardous metal in environment, because greater accumulation and high toxicity. The range of cadmium is 0.001-0.005ppm with average 0.002ppm in pre monsoon and monsoon, 0.001- 0.004ppm with average 0.002ppm in post monsoon. Almost all the groundwater samples within the desirable limit (<0.005ppm) based on World health organization. The chromium concentration varies from 0.001 to 0.04ppm with average 0.004ppm in pre-monsoon, 0.001-0.002ppm with average 0.005ppm in monsoon and 0.001 to 0.01ppm with average 0.004ppm in post-monsoon, the chromium concentration gradually decrease from pre-monsoon to post-monsoon.

Table 5: Trace metals statistical values of groundwater in Vellore district at pre-monsoon

Sample Code	Copper	Zinc	Iron	Lead	Cadmium	Chromium
VEL1	2.36	2.98	1.04	0.004	0.002	0.04
VEL2	0.7	1.08	0.5	0.01	0.003	0.004
VEL3	0.6	1.42	0.08	0.04	0.004	0.003
VEL4	0.5	1.04	0.4	0.02	0.005	0.004
VEL5	1.02	1.18	0.1	0.003	0.002	0.003
VEL6	0.5	0.92	0.3	0.004	0.002	0.002
VEL7	1.24	0.92	1.32	0.004	0.002	0.001
VEL8	0.06	2.04	0.6	Nil	0.001	0.001
VEL9	0	0.38	0.02	0.002	Nil	0.002
VEL10	0.6	2.62	1.58	0.004	0.001	0.01
VEL11	1.4	2.04	0.005	0.005	0.002	0.002
VEL12	0.2	1.04	0.4	Nil	0.004	0.002
VEL13	0.08	0.92	0.02	0.004	0.002	0.001
VEL14	1.4	2.12	0.6	0.005	0.005	0.02
VEL15	1.4	1.98	0.04	0.04	0.003	Nil
VEL16	0.8	2.28	0.4	0.001	0.001	0.001
VEL17	0.04	1.52	0.09	0.002	0.004	0.001
VEL18	0.4	2.46	1.26	0.002	Nil	0.01
VEL19	0.4	2.68	2.28	0.004	Nil	0.01
VEL20	0.02	0.5	0.08	Nil	0.001	0.001
VEL21	0	1.02	0.08	0.001	0.001	0.001
VEL22	1.02	1.82	0.8	0.004	0.001	0.002
VEL23	0.04	1.98	0.6	0.002	0.004	0.004
VEL24	0.8	4.02	0.54	0..004	0.002	0.002
VEL25	0.3	1.58	0.2	0..002	0.001	0.002
VEL26	0.2	1.46	0.06	0.001	0.002	0.002
VEL27	0.3	1.68	0.6	0.002	0.004	0.002
VEL28	0.7	0.5	0.4	0.002	0.002	0.004
VEL29	1.12	1.4	0.01	0.001	0.002	0.001
VEL30	2.04	0.8	0.01	0.002	0.002	0.001
VEL31	0.8	1.12	0.8	0.004	0.001	0.001
VEL32	0.5	1.02	0.2	0.02	0.001	0.003
VEL33	0.2	0.92	0.01	0.001	Nil	0.001
VEL34	0.4	1.45	0.6	0.001	0.001	0.002
VEL35	1.24	0.36	0.04	0.002	0.002	0.001
VEL36	1.34	2.92	0.003	0.005	0.003	0.002
VEL37	1.2	2.34	0.8	0.004	0.002	0.002
VEL38	1.02	1.82	0.002	0.002	0.002	0.001
VEL39	0.04	2.68	0.004	0.004	Nil	0.002
VEL40	0.7	1.98	0.2	0.004	0.003	0.004
VEL41	0.5	3.44	0.001	0.006	0.004	0.006
VEL42	0.2	1.06	0.4	0.004	0.001	0.002
VEL43	0.4	0.6	1.12	0.002	Nil	0.01
VEL44	0.5	1.24	0.05	0.004	0.002	0.002
VEL45	0.4	1.02	0.1	0.002	0.002	0.009
VEL46	2.24	1.98	1.02	0.02	0.004	0.002
VEL47	2.48	1.48	0.06	0.01	0.004	0.002
VEL48	0.72	1.24	1.14	0.08	0.004	0.004
VEL49	2.42	2.38	0.6	0.06	0.002	0.005
VEL50	0.6	1.68	0.06	0.002	Nil	0.002
VEL51	0.5	0.76	0.02	0.002	0.004	Nil
VEL52	0.4	0.1	0.2	0.002	0.001	0.02
Minimum	0.001	0.1	0.001	0.001	0.001	0.001
Maximum	2.48	4.02	2.28	0.08	0.005	0.04
Mean	0.7509	1.5763	0.42	0.0084	0.0024	0.0044

Units = mgL^{-1} (ppm)

Table 6: Trace metals statistical values of groundwater in Vellore district at monsoon

Sample Code	Copper	Zinc	Iron	Lead	Cadmium	Chromium
VEL1	2.48	3.32	1.12	0.005	0.001	0.02
VEL2	0.8	1.84	0.6	0.01	0.005	0.008
VEL3	0.7	1.62	0.08	0.02	0.003	0.006
VEL4	0.8	1.28	0.2	0.02	0.005	0.009
VEL5	1.04	1.26	0.1	0.008	0.003	0.004
VEL6	0.6	1.12	0.9	0.002	Nil	0.001
VEL7	1.18	0.88	1.24	0.004	0.001	0.002
VEL8	0.04	1.88	0.4	0.001	Nil	0.001
VEL9	0.01	0.2	0.02	Nil	Nil	Nil
VEL10	0.5	2.38	1.56	0.003	0.001	0.01
VEL11	1.4	2.68	0.008	0.008	0.004	0.002
VEL12	0.3	1.44	0.5	0.001	0.002	0.004
VEL13	0.05	1.02	0.04	0.002	0.002	0.001
VEL14	1.8	2.2	0.7	0.006	0.005	0.01
VEL15	1.2	1.86	0.08	Nil	0.002	Nil
VEL16	0.8	2.14	0.4	0.002	0.002	0.001
VEL17	0.04	1.82	0.09	0.001	Nil	0.001
VEL18	0.5	2.28	1.26	0.004	0.001	0.01
VEL19	0.5	2.32	1.88	0.004	0.001	0.02
VEL20	0.01	0.9	0.08	Nil	Nil	Nil
VEL21	0.09	1.02	0.09	0.001	0.001	0.001
VEL22	1.08	1.24	0.4	0.002	0.001	0.001
VEL23	0.09	1.88	0.6	0.001	0.001	0.001
VEL24	0.8	2.16	0.4	0.002	0.003	0.003
VEL25	0.6	1.48	0.2	0.001	0.002	0.001
VEL26	0.2	1.12	0.09	Nil	0.001	Nil
VEL27	0.4	1.54	0.6	0.001	0.001	Nil
VEL28	0.8	0.62	0.9	0.001	0.004	0.004
VEL29	1.18	1.2	0.01	Nil	0.002	Nil
VEL30	1.4	0.86	0.07	Nil	0.004	Nil
VEL31	0.8	1.24	0.4	Nil	0.002	Nil
VEL32	0.6	1.14	0.5	0.001	0.001	0.005
VEL33	0.2	1.02	0.04	Nil	Nil	Nil
VEL34	0.6	1.44	0.8	0.001	0.001	0.001
VEL35	Nil	0.8	0.06	Nil	Nil	Nil
VEL36	1.6	2.86	0.005	0.005	0.002	0.002
VEL37	1.08	2.88	0.8	0.005	0.001	0.002
VEL38	1.2	1.98	0.002	0.002	0.002	0.001
VEL39	0.04	2.24	0.004	0.004	0.001	Nil
VEL40	0.8	2.26	0.2	0.002	0.005	0.004
VEL41	0.2	3.62	0.008	0.002	0.004	0.002
VEL42	0.3	1.04	0.4	0.001	0.002	0.001
VEL43	0.4	1.12	1.18	0.002	0.002	0.01
VEL44	0.6	1.42	0.06	0.004	0.002	0.004
VEL45	0.4	1.28	0.1	0.01	0.002	0.01
VEL46	2.72	2.46	1.26	0.03	0.002	0.02
VEL47	2.4	1.72	0.06	0.01	0.003	0.002
VEL48	1.8	1.42	1.04	0.06	0.005	0.004
VEL49	2.24	2.68	0.6	0.08	0.003	0.006
VEL50	0.7	1.62	0.08	0.004	Nil	0.002
VEL51	0.92	0.92	0.02	0.02	0.004	Nil
VEL52	0.2	1.24	0.4	0.001	0.001	Nil
Minimum	0.01	0.2	0.002	0.001	0.001	0.001
Maximum	2.72	3.62	1.88	0.08	0.005	0.02
Mean	0.8076	0.2	0.4353	0.0082	0.0023	0.005

Units = mgL^{-1} (ppm)

Table 7: Trace metals statistical values of groundwater in Vellore district at post-monsoon

Sample Code	Copper	Zinc	Iron	Lead	Cadmium	Chromium
VEL1	2.28	2.82	1.02	0.002	0.001	0.01
VEL2	0.6	1.05	0.4	0.009	0.002	0.002
VEL3	0.5	1.12	0.05	0.01	0.002	0.002
VEL4	0.5	1.02	0.1	0.01	0.002	0.003
VEL5	0.9	1.16	0.09	0.002	0.001	0.002
VEL6	0.4	0.82	0.2	0.002	Nil	0.001
VEL7	1.08	0.82	1.02	0.002	Nil	0.001
VEL8	0.042	1.82	0.5	Nil	Nil	Nil
VEL9	0.001	0.24	0.01	0.001	Nil	Nil
VEL10	0.4	2.14	1.55	0.003	Nil	0.009
VEL11	1.2	1.88	0.004	0.001	0.001	0.001
VEL12	0.1	1.02	0.2	Nil	0.001	0.001
VEL13	0.04	0.86	0.01	0.002	0.002	Nil
VEL14	1.2	2.04	0.5	0.004	0.004	0.01
VEL15	0.9	1.76	0.02	Nil	0.001	Nil
VEL16	0.6	2.04	0.2	Nil	0.002	Nil
VEL17	0.03	1.22	0.08	0.001	Nil	Nil
VEL18	0.3	2.18	1.06	0.001	Nil	0.008
VEL19	0.2	2.04	1.68	0.002	Nil	0.009
VEL20	Nil	0.4	0.03	Nil	Nil	Nil
VEL21	Nil	0.98	0.07	Nil	Nil	Nil
VEL22	0.09	1.22	0.3	0.001	Nil	Nil
VEL23	0.03	1.86	0.4	Nil	0.001	0.001
VEL24	0.5	2.06	0.3	0.002	0.001	0.001
VEL25	0.2	1.38	0.1	Nil	0.002	Nil
VEL26	0.1	1.02	0.04	Nil	Nil	Nil
VEL27	0.2	1.52	0.5	Nil	Nil	Nil
VEL28	0.6	0.4	0.2	Nil	0.001	0.003
VEL29	1.02	0.9	0.009	Nil	0.001	Nil
VEL30	1.28	0.6	0.009	Nil	0.001	Nil
VEL31	0.6	0.98	0.1	Nil	Nil	Nil
VEL32	0.4	0.82	0.1	Nil	Nil	0.002
VEL33	0.1	0.82	0.02	Nil	Nil	Nil
VEL34	0.4	1.34	0.6	Nil	Nil	Nil
VEL35	Nil	0.3	0.03	Nil	Nil	Nil
VEL36	1.24	2.82	0.002	0.004	0.002	0.001
VEL37	0.9	1.92	0.6	0.002	0.001	0.001
VEL38	0.98	1.78	0.001	0.001	0.001	Nil
VEL39	0.02	2.04	0.002	0.002	Nil	Nil
VEL40	0.7	1.98	0.1	0.001	0.002	0.002
VEL41	0.1	3.12	0.002	0.001	0.001	0.001
VEL42	0.1	1.04	0.2	0.001	Nil	0.001
VEL43	0.3	0.92	1.08	0.001	Nil	0.009
VEL44	0.4	1.22	0.04	0.002	0.001	0.001
VEL45	2.84	1.84	2.18	0.001	Nil	0.009
VEL46	2.02	1.98	0.98	0.01	0.002	0.009
VEL47	2.2	1.42	0.04	0.009	0.001	0.001
VEL48	0.68	1.12	1.02	0.04	0.002	0.002
VEL49	1.98	2.24	0.4	0.04	0.001	0.004
VEL50	0.5	1.62	0.05	0.002	Nil	0.001
VEL51	0.5	0.72	0.01	0.001	0.002	Nil
VEL52	0.1	0.98	0.1	Nil	Nil	Nil
Minimum	1.412	0.001	0.352	0.001	0.001	0.001
Maximum	3.12	2.18	2.18	0.04	0.004	0.01
Mean	0.24	0.001	0.001	0.0052	0.0015	0.0036

Units = mgL^{-1} (ppm)

Table 8: Heavy metal Pollution Index (HPI) and Metal Index (MI) estimation for groundwater samples from Vellore district

Sample Code	Pre-monsoon		Monsoon		Post-monsoon	
	HPI	MI	HPI	MI	HPI	MI
VEL1	104.0	0.780	108.19	0.737	108.71	0.607
VEL2	99.43	0.309	90.30	0.397	101.25	0.248
VEL3	91.59	0.339	98.96	0.285	104.87	0.177
VEL4	89.22	0.325	89.75	0.361	104.73	0.188
VEL5	105.88	0.253	100.70	0.294	110.49	0.208
VEL6	105.16	0.197	113.09	0.272	114.60	0.119
VEL7	103.06	0.487	107.70	0.450	112.90	0.369
VEL8	109.40	0.153	114.23	0.101	114.15	0.111
VEL9	114.89	0.021	115.18	0.007	115.06	0.008
VEL10	106.84	0.456	107.00	0.430	111.47	0.389
VEL11	105.92	0.314	96.55	0.364	110.92	0.245
VEL12	96.49	0.185	105.11	0.199	110.34	0.081
VEL13	105.69	0.077	105.92	0.070	105.98	0.058
VEL14	91.16	0.524	90.89	0.578	95.96	0.190
VEL15	96.37	0.445	106.41	0.267	110.95	0.190
VEL16	109.95	0.249	105.33	0.267	106.01	0.189
VEL17	96.87	0.115	114.93	0.049	144.93	0.035
VEL18	112.27	0.344	107.53	0.382	112.83	0.281
VEL19	109.71	0.523	106.14	0.519	111.27	0.373
VEL20	110.58	0.042	115.06	0.025	115.16	0.009
VEL21	110.44	0.048	110.44	0.065	115.08	0.023
VEL22	168.60	0.360	109.85	0.287	114.45	0.082
VEL23	95.74	0.215	109.32	0.159	109.90	0.112
VEL24	104.77	0.321	100.85	0.291	109.95	0.183
VEL25	110.11	0.131	105.85	0.190	106.12	0.099
VEL26	106.07	0.103	110.61	0.077	115.17	0.035
VEL27	95.79	0.249	109.39	0.204	114.18	0.134
VEL28	105.26	0.242	95.36	0.374	110.44	0.164
VEL29	106.40	0.244	106.55	0.245	110.98	0.198
VEL30	106.46	0.394	97.51	0.321	111.04	0.238
VEL31	108.60	0.312	105.59	0.247	115.16	0.128
VEL32	107.58	0.221	109.65	0.233	115.11	0.099
VEL33	115.12	0.052	115.20	0.051	115.21	0.029
VEL34	109.38	0.209	108.99	0.273	114.00	0.182
VEL35	106.19	0.261	115.10	0.019	115.15	0.008
VEL36	101.46	0.330	105.99	0.356	106.05	0.288
VEL37	104.25	0.413	108.56	0.385	109.37	0.298
VEL38	106.26	0.234	106.31	0.266	110.87	0.203
VEL39	114.71	0.057	110.2	0.062	114.98	0.033
VEL40	100.98	0.249	92.35	0.295	106.11	0.199
VEL41	96.65	0.228	97.14	0.155	110.69	0.075
VEL42	109.35	0.148	105.32	0.168	114.67	0.068
VEL43	112.54	0.300	103.46	0.349	112.75	0.274
VEL44	105.73	0.159	105.73	0.186	110.49	0.114
VEL45	105.87	0.165	104.74	0.198	110.92	0.890
VEL46	92.75	0.705	99.87	0.891	103.17	0.617
VEL47	96.37	0.546	100.84	0.519	109.92	0.439
VEL48	83.54	0.670	82.41	0.786	98.46	0.469
VEL49	96.99	0.780	89.63	0.840	104.66	0.585
VEL50	114.98	0.142	114.67	0.168	114.98	0.120
VEL51	97.115	0.168	94.65	0.300	106.23	0.130
VEL52	110.10	0.1911	109.78	0.138	115.04	0.044

Table 9: Correlation co-efficient matrices of trace metals with seasons Pre-monsoon

Trace Metal	Cu	Zn	Fe	Pb	VEL	Cr
Cu	1.000					
Zn	0.257	1.000				
Fe	0.053	0.314	1.000			
Pb	0.311	0.076	-0.07	1.000		
VEL	0.261	0.081	-0.115	0.299	1.000	
Cr	-0.071	-0.243	-0.066	-0.078	-0.19	1.000
			Monsoon			
Trace Metal	Cu	Zn	Fe	Pb	VEL	Cr
Cu	1.000					
Zn	0.402	1.000				
Fe	0.224	0.224	1.000			
Pb	0.528	0.199	0.169	1.000		
VEL	0.433	0.179	-0.077	0.39	1.000	
Cr	0.421	0.41	0.667	0.256	0.159	1.000
			Post-monsoon			
Trace Metal	Cu	Zn	Fe	Pb	VEL	Cr
Cu	1.000					
Zn	0.37	1.000				
Fe	0.168	0.318	1.000			
Pb	0.393	0.129	0.224	1.000		
VEL	0.406	0.245	-0.102	0.303	1.000	
Cr	0.335	0.35	0.711	0.163	0.198	1.000

Correlation Studies

Table 5,6,7, shows correlation analysis of heavy metals in pre-monsoon, monsoon and post-monsoon seasons. During pre-monsoon the correlation between heavy metals didn't considerable because the value is very low but in monsoon season a moderately correlated between the metals Cu-Pb (r=0.528) and strongly correlated between the metals Fe-Cr (r=0.667) and also strongly correlated in post-monsoon season Fe-Cr (r=0.711). This is due to heavy metals may be dissoluted.

Heavy Metal Pollution Index and Metal Index

The total water quality of groundwater is represented by heavy metal pollution index[19] (HPI). The metal index value used to determine suitable for drinking purpose in groundwater. Table 5,6,7 shows HPI and MI values in all urban areas of Vellore district. In the study area 71%, 75% and 90% of groundwater samples exceeds the critical index values 100 in pre-monsoon, monsoon and post-monsoon respectively. This is due to trace metals leaching from pigments, fertilizers, etc. Based on MI classification 40% of samples are pure and 60% of samples are very pure in pre-monsoon, 35% of samples are pure and 65% of the samples are very pure in monsoon and 17% of samples are pure and 83% of the samples are very pure in post-monsoon.

Table 10: Correlation between variables and factor in Vellore district

Heavy Metals	Pre-monsoon		Monsoon		Post-monsoon	
	F1	F2	F1	F2	F1	F2
Cu	0.362	0.154	0.07	0.363	0.018	0.406
Zn	0.033	0.54	0.221	0.118	0.207	0.163
Fe	-0.228	0.535	0.509	-0.2	0.526	-0.179
Pb	0.45	-0.076	-0.031	0.386	-0.016	0.344
VEL	0.458	-0.076	-0.202	0.473	-0.185	0.493
Cr	-0.134	-0.276	0.451	-0.033	0.45	-0.025
Eigen value	1.775	1.351	2.584	1.368	2.44	1.365
Variability (%)	29.589	22.52	43.073	22.807	40.673	22.742
Cumulative %	29.589	52.109	43.073	65.88	40.673	63.415

Eigen values and two principal components values were extracted greater than 1 in all seasons. During pre-monsoon season, factor 2 moderately loaded with Zn and Fe, In monsoon season, factor 1 moderately loaded with Fe and post monsoon season also moderately loaded with Fe in factor 1 (Table 5,6,7), which explain 30%, 52% and 40% of the variability in pre-monsoon, monsoon and post-monsoon seasons respectively of the data set.

During pre-monsoon season factor 2 moderately loaded with Fe and Zn. In monsoon and post monsoon seasons factor 1 moderately loaded with Fe. The groundwater contains trace amount of lead, cadmium and chromium this is due to metal dissolution during recharge of aquifer by rainfall.

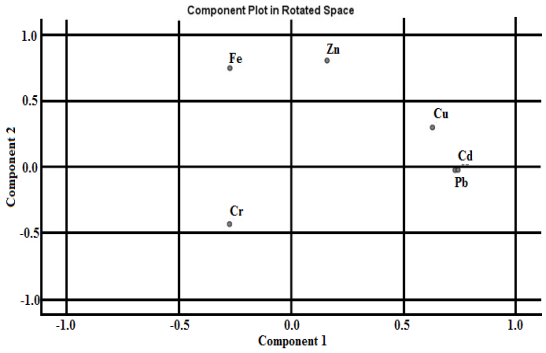

Fig.1. First two principle components in pre-monsoon

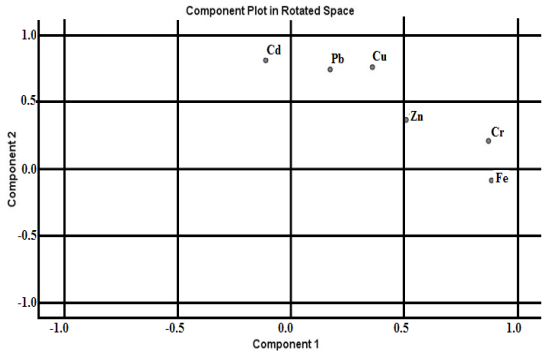

Fig. 2. First two principle components in monsoon

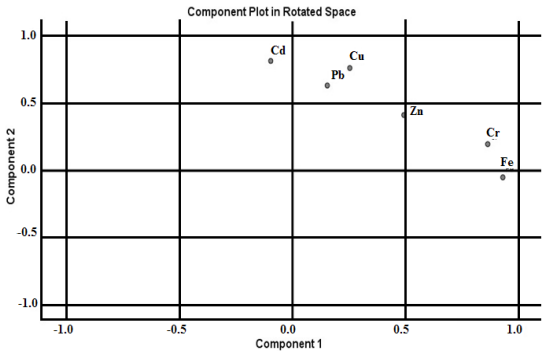

Fig.3. First two principle components in post-monsoon

CONCLUSION

The overall analysis of trace heavy metals in groundwater in and around Vellore district, they suggest following conclusions. The copper concentration of study areas, 33% of the samples exceeds in permissible limits. Iron concentration, 8 samples exceed permissible limits based on BIS. Lead concentration within the desirable limit in all three seasons.

In correlation analysis, monsoon and post-monsoon periods were moderately correlated between Cu-Pb and Fe-Cr. The study of principle component analysis shows moderately loaded in pre-monsoon, monsoon and post-monsoon seasons. This is due to dissolution of heavy metals, the effect of recharge in rain water and degradation of microbial by organic matter presence from wastewater.

Heavy Metal Pollution Index (HPI) and Metal Index (MI) values in most of the samples were pure and very pure.

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REFERENCES

1. Claxton. L.D.; Houk.V.S.; and Hughes, *Mutat. Res.,* **1998,** *410*(3), 237–43.
2. White. P.A.; Rasmussen. J. B.; *Mutat. Res.,* **1998**, *410*(3), 223–36.
3. White. P.A.; Rasmussen. J. B. Bass, C, *Environ. Mol. Mutag.*, **1996**, *27*(2),140-151.
4. Solomons. W.; Forstner. U, Metals in thehydrocycle Berlin, Springer., **1984**, 653.
5. Turekian. K.K, The oceans, streams and atmosphere, Berlin Springer., **1969**, 468.
6. Lenvik. K.; Steinnes. E.; Pappas AC, *Nord Hydrol.,* **1978**, *9*,197-206.
7. Borg. H.; Johansson. K.; *Water, Air Soil, Pollut.*, **1989**, *47*, 427-40.
8. Runnels. D.C.; Shepherd. T.A.; and Angino. E.A, *Env. Sci.Tech.,* **1992**, *26*, 2316-23.

9. Gadh. R.; Tandon. S.N.; Mathur. R.P.; Singh. O.V., *Sci. Total Env.*, **1993**, *136*, 229-42.
10. Vanmathi. G, and Gobalakrishnan. S, Indian *J. Environ.Protect.,* **1999**, *20*(6), 447-451.
11. Prasad. B, and Bose. JM, *Environ. Geol.*, **2001**, *41*, 183-88, (2001).
12. APHA, 'Metals by flame atomic absorption spectrometry', Clesceri, L.S.; Greenberg, A.E.; Eaton., A.D. (Eds.), Standard Methods forthe Examination of Water and Wastewater, twentieth ed. American Public Health Association, Washington, DC., **1998**, *3111*, 3-13e 3-22.
13. Kavitha. R and Elangovan. K, Review article on groundwater quality characteristics at Erode district, *India of Indian J. Environ. Sci.,* **2010**, *1*(2).
14. Wang.J.S.; Huang.P.M.; Liaw.W.K, and Hammer.U.T, Kinetics of the desorption of mercury from selected freshwater sediments as influenced by chloride, Water, *Air and Soil Pollution.,* **1991**, *5*(6), 533-542.
15. Lantzy. R. J and Mackenzie. F. T, Atmospheric trace metals global cycles and assessment of man,s impact, Geochim. *Cosmochim.Acta,* **1979**, *4*(3), 511-525.
16. Houng. K. H and Lee. D. Y, Compar is one of linear and nonlinear Langmuir and Freundlich curve it in the study of Cu,VEL, and Pb adsorption on Taiwan soils, *J .Soil Sci.,* **1998**, *163*(2), 115-121.
17. Ayotte.J.D.; Nielsen.M,G., Jr., G.R., and Moore. R.B., Relation of Arsenic, Iron and Manganese in groundwater to Aquifer Type, Bedrock Lithogeochemistry, and Land use in the New England Coastal Basins, Water Resources Investigations Report., **1999**, 99-4162.
18. EPA Report, Healthy Drinking Waters for Rhode Islanders, EPA-39- 69.U.S.Environmental protection agency, U.S.A., **2003**.
19. Mohan. S.V.; Nithila. P.;and Reddy.S.J.,*J. Environ. Sci. Health.*, **1996**, *A31*(2), 283.