Available online at www.worldscientificnews.com

World Scientific News

WSN 36 (2016) 47-60 EISSN 2392-2192

Seasonal variation of heavy metal contamination of groundwater in and around Udaiyarpalyam taluk, Ariyalur district, Tamil Nadu

K. G. Sekar[a], K. Suriyakala[b]

Department of Chemistry, National College, Tiruchirappalli - 620 001, India

[a,b]E-mail address: drkgsekar@yahoo.co.in , ckmschem@gmail.com

ABSTRACT

The study was carried out to determine the concentration of heavy metal ions in and around this area. Thirty two ground water samples were collected from in and around Udaiyarpalyam taluk during pre-monsoon and post monsoon season during the year of 2014. The concentration of trace metals such as iron, lead, cadmium, and chromium were determined using atomic absorption spectrophotometer and the results were compared with the World Health Organization (WHO) and Bureau Indian standard (BIS) values. It reveals revealed the presence of some heavy metals in few ground water samples and hence refers heavy metal contamination of water sources. The result shows that most of the groundwater is deteriorated less than the permissible limit of WHO.

***Keywords*:** Groundwater; Heavy metals; Irrigation; WHO

1. INTRODUCTION

Agricultural activity is a key of food security in the world as well as an economic activity supporting country development and livelihood of many families. Unreliable rainfalls resulted from climate change cause the agricultural activities to depend on irrigation instead of rain-fed (Hong Aliyu Haliru et al., 2006). However, fresh water scarcity arises from increasing demand of water resources, pollution of water sources overexploitation of

groundwater and periodic droughts due to climate change affects the irrigation practices and threatens the development and sustainability of agriculture (Isabela Thomas Mkude, 2015).

Nowadays water pollution is the biggest problem for human beings characterization by deterioration of the water quality as a result of various human activities which makes water unfit for drinking and domestic purposes. Many toxic heavy metals have been discharged into the environment as industrial waste, causing serious soil and water pollution (Gaur, Joshi, Saxena and Dutt, 2011). Water scarcity is increasing worldwide and pressure on the existing water resources is increasing due to growing demand of different sectors such as domestic, agriculture and industrial, hydropower etc.

Water is a valuable natural resource that is essential to human survival and the ecosystems health. Water comprises of coastal water bodies and fresh water bodies (lakes, river and groundwater). Groundwater resources is one of the most important resource available to humanity, therefore it is more than necessary to provide a tool that can assess its quality over space (Venkata Subba Raju et al., 2014). The principal goal of groundwater management in developing countries is to assess and manage the water resources that are available.

Adequate water resources for future generation are not only a regional issue but also a global concern. In our country fresh water wealth is under threat due to the influence of naturals & human activities. By the term "heavy metals" we usually refer to any metallic element that contain a relative high density and applies to the group of metals and metalloids with atomic density greater than 4 g/cm^3. Heavy metals are environmentally stable, non-biodegradable and tend to accumulate in plants and animals causing chronic adverse effects on human health (Oyeku and Eludoyin, 2010).

Anthropogenic activities such as urbanization, industrialisation, transportation, indiscriminate use of fertilizer, insecticide, pesticide, Improper disposals of sewage and solid wastes material containing toxic chemicals as well as natural process such as precipitation inputs erosion and weathering of crustal materials increases the contents of these elements in soil and water (Bhavana et al., 2009). However some of the metals like Fe, Pb, Cd and Cr are essential as micronutrients for plants and microorganism.

Heavy metal pollution represents an important environmental problem due to its toxic effects and accumulation throughout the food chain. The main sources of heavy metal pollution include electroplating, painting and surface treatment industries. The main sources of water pollution are chemical fertilizers and pesticides getting in an untreated sewage, dumping of waste and industrial effluents into rivers and streams running close in to the cities and to the low lands. Precipitation is accompanied by flocculation or coagulation and one major problem is the formation of large amounts of sediments containing heavy metal ions (Shrivastava and Mishra, 2011). The discharge of large quantities of toxic metals into the air, water and soils inevitable results in the transfer of pollutant metals to the human food chain. Heavy metals are also known to be toxic to both humans and other living forms, with their accumulation over time causing damage to the kidney, liver and reproductive system in addition to cancer. Heavy metal pollution derives from a number of sources, including lead in petrol, industrial effluents and leaching of metal ions from the soil into lakes and rivers by rain. Heavy metals are basically present in groundwater but these play an important role in determining the quality of water for drinking purposes. Metals are considered toxics and when they enter the body more than the prescribed limit they start causing harm. In the same way many physicochemical parameters play an important role in determining the quality of water.

High concentrations of trace elements are dangerous because they tend to bio-accumulate resulting in heavy metal poisoning. However, at higher concentrations they can lead to poisoning (Oyeku and Eludoyin, 2010). Heavy metal poisoning could result, for instance, from drinking-water contamination, high ambient air concentrations near emission sources, or intake via the food chain. Many trace metals are regarded as serious pollutants of aquatic ecosystems because of their environmental persistence, toxicity and ability to be incorporated into food chains. Various metals from industrial, agricultural, domestic and urban wastes may enter river and lake waters through leaching, runoff, effluents and dry deposition (Muthulakshmi, Ramu and Kannan, 2010).

Heavy metals pollution represents a serious problem as these metals leach into ground water or soil, which is detrimental to human health. Ground water pollution is a consequence of several activities like chemical manufacturing, painting and coating and mining (Vijaya Bhaskar, Kiran Kumar and Nagendrappa, 2010). Metals exert a deleterious effect on fauna and flora of lakes and streams. Heavy metals are sometimes called "trace elements", they become of particular interest in recent decades within the framework of environmental investigation (Thilagavathi, et al., 2012). This has without doubt been due to the fact that highly sensitive analytical procedures are available for determining and detecting metal content with high precision.

2. DRINKING WATER IN UDAYARPALYAM TALUK

In Udayarpalyam Taluk, a major share of drinking water supply is met by ground water. In many villages, the ground water is the one and only source of water for drinking, irrigation, domestic and industrial uses. In these villages, the ground water is pumped and stored in common over-head tanks for supply. As, the quality of the drinking water greatly determines the health of the people, it is imperative to protect the water from contamination

3. BJECTIVES OF THIS RESEARCH

The aim of the present study is to understand the hydrogeology and hydro geochemistry of the groundwater of a part of Udayarpalyam taluk in Ariyalur district, Tamil Nadu, India. The major objectives of this study are to

1. To characterize the groundwater quality of the study area,
2. To assess the suitability of groundwater for drinking and irrigation purposes,
3. To suggest suitable recharge method to improve the groundwater quality,
4. Assessment of the anthropogenic pollution in the identified study region with particular reference to heavy metals.

4. EXPERIMENTAL METHODS

4. 1. Research area

Geographically Udaiyarpalyam taluk lies between 10º54′ and 11º30′ of North latitude and 78º40′ and 10º30′ of east longitude (Fig. 1). Ariyalur is almost a coastal district.

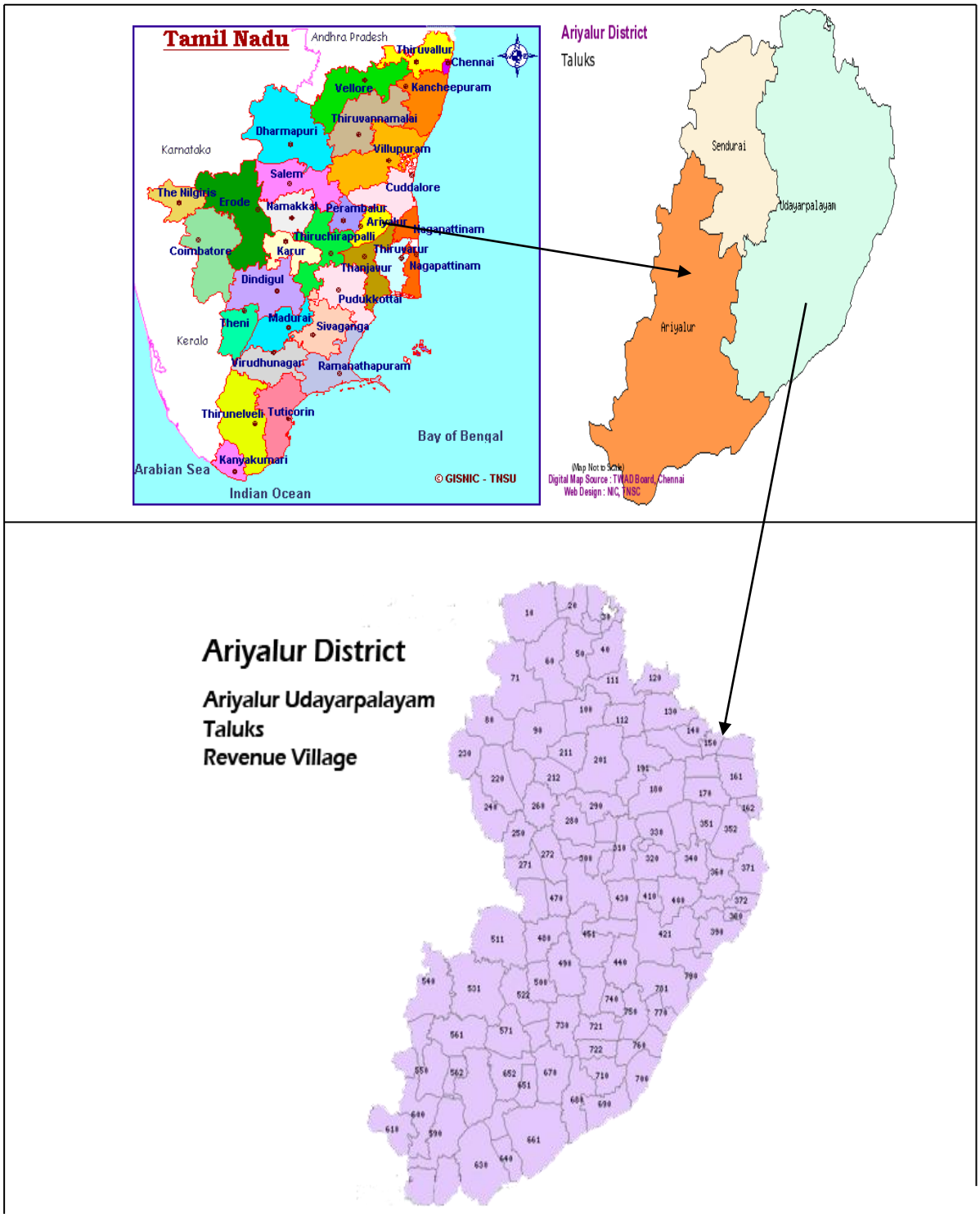

Fig. 1. Map of the study area.

The total geographical area of Udayarpalayam 943.30 km^2, the average annual rainfalls 949.6 mm. The net area under irrigation is 92,432 ha. The area experiences tropical climate. The soil is predominantly red loam, clay loam and black soil. Jayamkondam in Udaiyarpalyam taluk is rich in lignite, oil and gas reserves. According to the 2011 census, the taluk of udayarpalayam had a population of 384,800 (Males 190,974 and Female 193,826). The major crops growth in the study area are Paddy, Millet, Pulses Oilseed, Sugar cane, Black gram, Sunflower, Cotton, Raise, Ground nut, Cashew nut, Vegetables and some other common crops. The annual rainfall during the northeast monsoon accounts for 52, 34 % during the southwest monsoon and 14 % in winter and hot weather periods. The ground water source is through bore well and open well. Ground water is generally using for drinking and irrigation purpose in this study area. (http://www.Ariyalur.tn.nic.in/district profile.htm).

4. 2. Sample collection and analysis

The ground water samples were collected from different location including open well and bore wells, to evaluate the heavy metal contamination during pre monsoon and post monsoon seasons. The depth of the bore wells varies from 190 to340 ft. Samples were collected in one litre capacity high density polyethylene (HDPE) bottles. Prior to collection, the bottles were thoroughly washed with dilute HNO_3 acid, and then with distilled water in the laboratory before sample filling. Each bottle was rinsed to avoid any possible Contamination in bottling and every other precautionary measure was taken. Groundwater samples were analyzed in the laboratory for heavy metal ion. pH and electrical conductivity (EC) were measured within a few hours by using Elico pH and conductivity meter, respectively (APHA, 2005).

4. 3. Determination of Heavy Metals

The analysis/measurements of heavy metal concentration were carried out with an Atomic Absorption Spectrophotometer (AAS) and the results were compared with WHO standard values. All concentrations were determined using the absorbance made with air-acetylene flame. Eight working solutions were prepared from the stock solutions for each of the metals by successive serial dilution and each of the standard solutions was then aspirated into the flame of AAS and the absorbance recorded in each case. A plot of the concentration against the corresponding absorbance gives the calibration curve of each metal. The samples, after aspirated into the flame and the absorbance obtained were then extrapolated from the calibration plot to obtain the corresponding concentration.

4. 4. Availability of minerals

4. 4. 1. Major / minor minerals in Ariyalur district

Limestone of sedimentary origin has been found in Ariyalur and Sendurai Taluks. The Limestone is cementing grade to plus cement grade in quality and is used in the cement plants. Fire Clay is used for the manufacture of floor tiles, stoneware pipes, fire bricks and Chemical industry. Jayamkondam in UdayarpalayamTaluk is rich in Lignite, Oil and Gas reserves. Apart from the above major minerals the common use minor minerals viz Red Gravel, Brick Clay, filling earth and Kankar are also available in this District.

Table 1. Details of sampling locations.

Sampling Place	Sampling point. No
Vallam	S1
Vettiyar Vettu	S2
Kattagaram	S3
Anaikudam	S4
Solankurichi	S5
Naduvalur	S6
Idaikurichi	S7
Koovathur	S8
Ulliyakudi	S9
Kattathur	S10
Kodankudi	S11
Managethi	S12
Karaikurichi	S13
Thevanur	S14
Thaluthalaimedu	S15
Devamangalam	S16
Suthamalli	S17
Suriyamanal	S18
Utkottai	S19
Periyakrishnapuram	S20
Kallathur	S21
Thathanoor	S22
Variyankaval	S23
Marudur	S24
Eravangudi	S25
Elayaperumalnallur	S26
Kuvagam	S27
Edaiyar	S28
Eravangudi	S29
Melur	S30
Vankudi	S31
Valaikurichy	S32

5. RESULTS AND DISCUSSION

The obtained results of heavy metals are tabulated in Table 2. The results are discussed and compared with standard values.

Table 2. Concentrations of heavy metal ions in groundwater samples.

Pre monsoon							Post monsoon					
S. No	**pH**	**EC (µs/cm)**	**Fe**	**Pb**	**Cd**	**Cr**	**pH**	**EC (µs/cm)**	**Fe**	**Pb**	**Cd**	**Cr**
S1	7.12	857	0.43	0.005	0.003	0.02	8.25	1245	0.38	0.04	0.003	0.04
S2	8.22	2789	0.63	0.007	0.04	0.03	7.54	889	0.31	0.003	0.005	0.03
S3	7.56	1805	0.53	ND	0.004	0.04	7.70	990	0.48	ND	0.002	0.02
S4	8.13	1120	0.05	0.005	0.003	ND	7.60	1123	0.34	0.03	0.001	ND
S5	7.30	1230	0.03	0.02	0.04	0.05	7.50	1117	0.77	0.02	0.003	0.03
S6	7.54	1256	ND	0.004	ND	0.03	8.34	1567	ND	0.05	ND	0.05
S7	7.87	1400	0.36	ND	0.02	0.05	7.60	1347	0.12	ND	0.004	0.06
S8	7.50	2245	0.54	0.04	0.003	0.01	7.54	987	0.04	0.03	0.002	0.03
S9	7.23	1345	0.31	0.05	0.005	0.02	7.50	1052	0.45	0.03	0.001	0.01
S10	8.52	956	0.05	0.06	0.04	0.03	8.32	1346	0.11	0.02	0.003	0.05
S11	7.67	679	0.56	ND	0.002	0.01	8.36	1467	0.02	ND	0.001	0.06
S12	8.21	1469	0.12	0.002	ND	0.01	7.30	789	0.65	0.001	ND	0.04
S13	7.73	876	0.06	0.04	0.005	0.02	7.45	1657	0.06	0.04	0.002	0.04
S14	7.94	1775	0.04	0.03	0.01	0.03	8.40	1678	0.02	0.03	0.003	0.02
S15	8.22	1554	ND	0.005	0.03	ND	7.82	834	ND	0.06	0.004	ND
S16	8.32	1255	0.12	0.01	0.003	0.03	8.46	1234	0.04	0.003	0.001	0.01
S17	7.52	976	0.7	0.006	0.001	0.02	7.73	856	0.52	0.004	0.004	0.03
S18	7.95	2856	0.04	0.004	0.002	0.02	7.20	1190	0.44	0.002	0.003	0.04
S19	8.11	1445	0.06	0.002	0.03	0.01	8.50	2345	0.23	0.001	0.002	0.02

S20	7.91	1765	0.63	ND	0.005	0.03	7.64	855	0.02	ND	0.003	0.01
S21	7.12	998	0.12	0.005	0.04	0.02	8.30	1456	0.01	0.004	0.004	0.03
S22	8.21	870	0.03	0.003	0.005	0.01	7.83	887	0.67	0.03	0.005	0.04
S23	7.63	1245	0.02	0.002	0.001	0.02	7.44	1180	0.07	0.02	0.002	0.04
S24	7.65	978	0.05	0.01	0.03	0.04	8.30	1358	0.04	0.03	0.011	0.05
S25	8.24	2131	ND	0.002	0.005	ND	7.32	980	ND	0.03	0.002	ND
S26	7.40	1234	0.02	0	0.011	0.01	8.46	1342	0.52	ND	0.004	0.05
S27	7.30	977	0.45	0.08	0.004	0.03	7.45	1034	0.06	0.03	0.001	0.07
S28	7.70	1320	0.05	0.05	0.003	ND	8.32	1456	0.03	0.02	0.004	ND
S29	7.30	990	0.67	ND	0.04	0.01	7.86	1120	0.63	ND	0.004	0.03
S30	8.30	1445	0.43	0.011	0.003	0.03	8.32	1356	0.43	0.02	0.005	0.01
S31	8.20	1178	0.03	0.05	0.05	0.04	7.93	2134	0.13	0.004	0.011	0.03
S32	7.50	975	0.74	0.06	0.004	0.02	7.64	1243	0.21	0.06	0.003	0.02
Max	8.52	2856	0.74	0.08	0.05	0.05	8.50	2345	0.77	0.06	0.011	0.07
Mini	7.12	679	0.02	0.002	0.001	0.01	7.20	789	0.01	0.001	0.001	0.01
Average	7.79	1398	0.25	0.02	0.01	0.02	7.87	1223	0.25	0.02	0.003	0.03

- All the parameters were given in unit (ppm)
- ND- Not Detectable

Table 3. Results of Heavy Metals in Ground Waters used for Drinking and Irrigation.

S. No	Heavy metals	BIS Guideline for drinking (ppm)	WHO Guideline for irrigation (ppm)
1.	Fe	1.0	5.0
2.	Pb	0.01	5.0
3.	Cd	0.003	0.01
4.	Cr	0.05	0.1

5. 1. Hydrogen ion concentration (pH)

pH is a measure of the balance between the concentration of hydrogen ions and hydroxyl ions in water. The pH of an aqueous solution is controlled by interrelated chemical reactions that procedure or consume hydrogen ions. The pH of groundwater samples in the study area ranges from 7.12 to 8.52 and 7.20 to 8.50 with an average value 7.79 to7.87 in pre- and post-monsoon season respectively. It shows that the groundwater in the study area is slightly alkaline in nature and found within the maximum permissible limits of WHO standards.

5. 2. Electrical conductivity (EC)

Electrical conductivity is the capacity of water to convey current and this may be due to the presence of soluble salts and ionic species which act as conducting medium. Conductivity of the samples ranged between 679 µS/cm to 2856 µS/cm and 789 µS/cm to 2345 µS/cm with an average value 1398 to1223 in pre- and post-monsoon season respectively (Table 2). The most desirable limit of EC in drinking water is prescribed as 1,500 µS/cm. Electrical conductivity in pre and post monsoon seasons exceeds the permissible limit most of the sample in pre monsoon (BIS, 2000).

5. 3. Iron (Fe)

The groundwater sample values (Table 2) of iron in the ranges from 0.02-0.74 ppm and 0.01-0.77 ppm in both the seasons (WHO, 2004). All the values are less than the permissible limit of 1.0 ppm. The content of Fe is within the permissible limit of BIS standards for drinking water. It can be attributed to the dissolution of iron bearing rock and/or soils. The iron concentration obtained in the irrigation water used along the ground water were found to be higher than the value obtained for the control irrigation water which exhibits a concentration of 1.0 ppm.

5. 4. Lead (Pb)

In the present investigation the lead concentration ranges from 0.002-0.08 ppm in pre monsoon and 0.001-0.06 ppm in post monsoon. Some values of lead are showed higher than the permissible set by WHO (0.01 ppm). The maximum permissible concentration of lead in drinking water is 0.05 ppm. This may be due to the various anthropogenic activities. Lead contamination of the ground water may be the result of entry from industrial effluents, household sewages containing phosphate fertilizers and human and animal excreta (Mahmood and Malik, 2014). In this case, high concentrations of lead in the body can cause death or permanent damage to the central nervous system and brain which the effects can be in memory (Musa, Vakasai and Musa, 2004). Other effects are high blood pressure, hearing problems, headaches, slowed growth, reproductive problems in men and women, digestive problems, muscle and joint pain.

5. 5. Cadmium (Cd)

The groundwater samples values (Table 2) of Iron in the ranges from 0.001-0.05 ppm and 0.001-0.011 ppm in both the seasons.

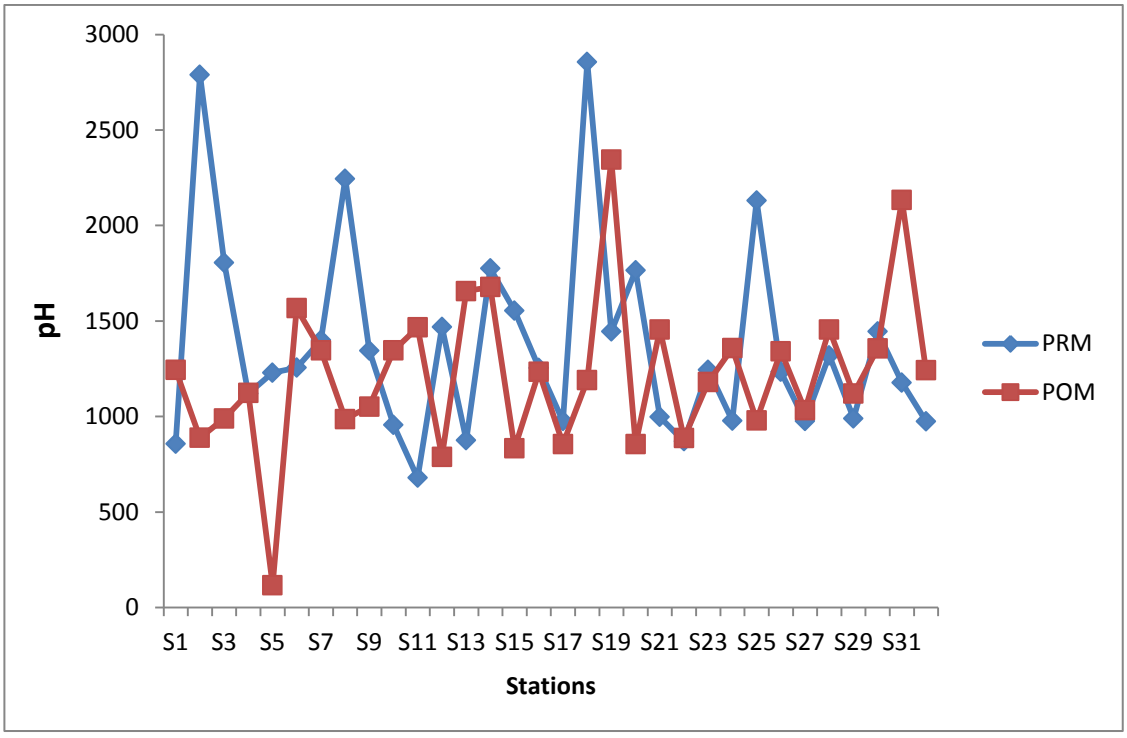

Fig. 1. pH variation of the study area.

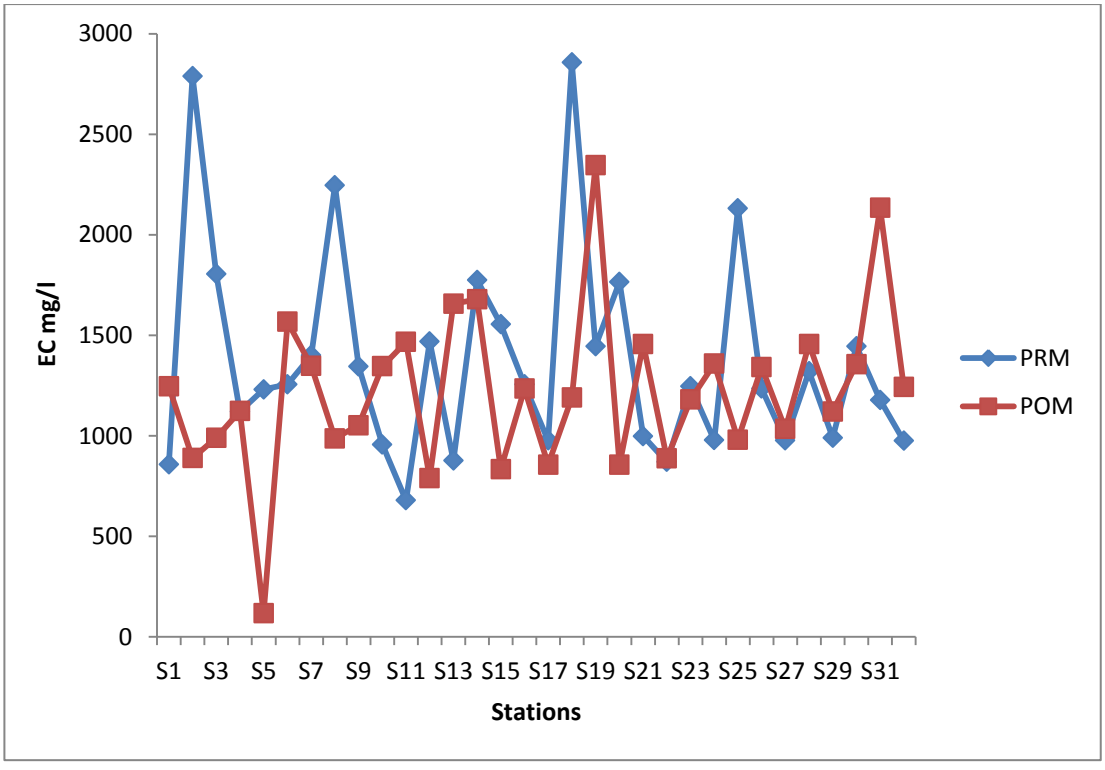

Fig. 2. EC variation of the study area.

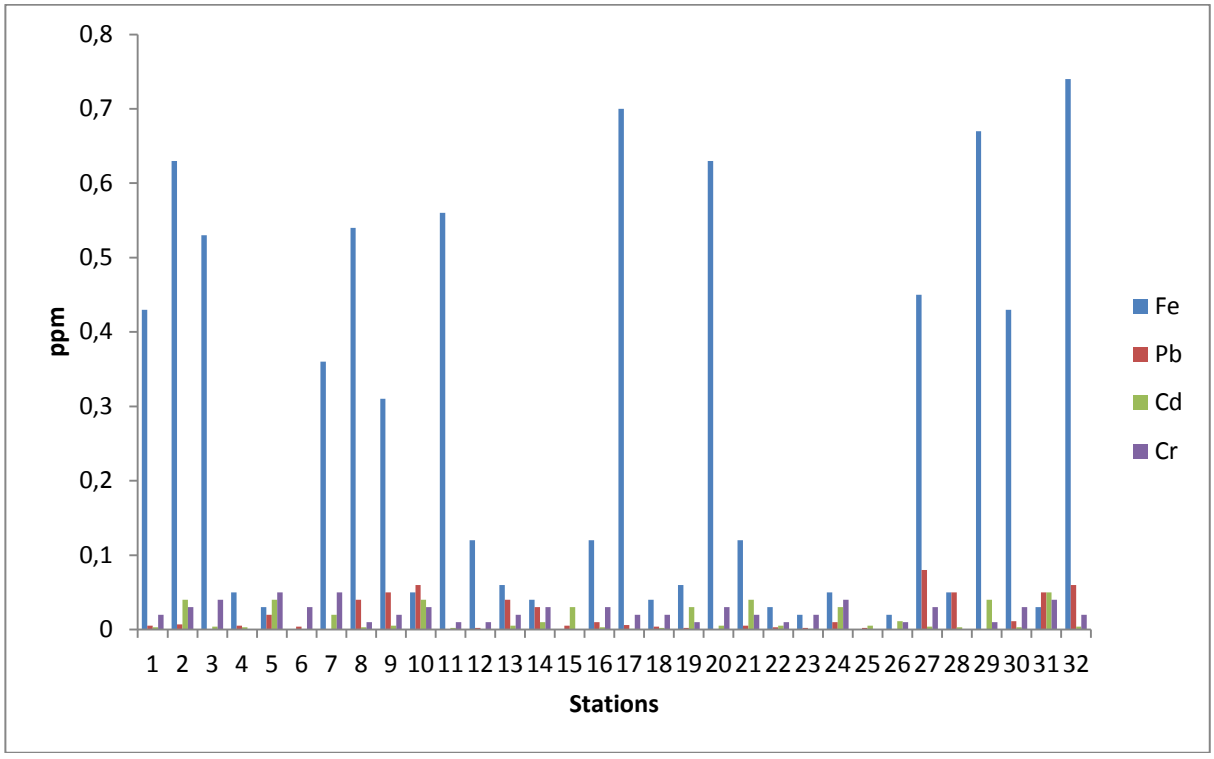

Fig. 3. Variation of heavy metals in pre monsoon seasons.

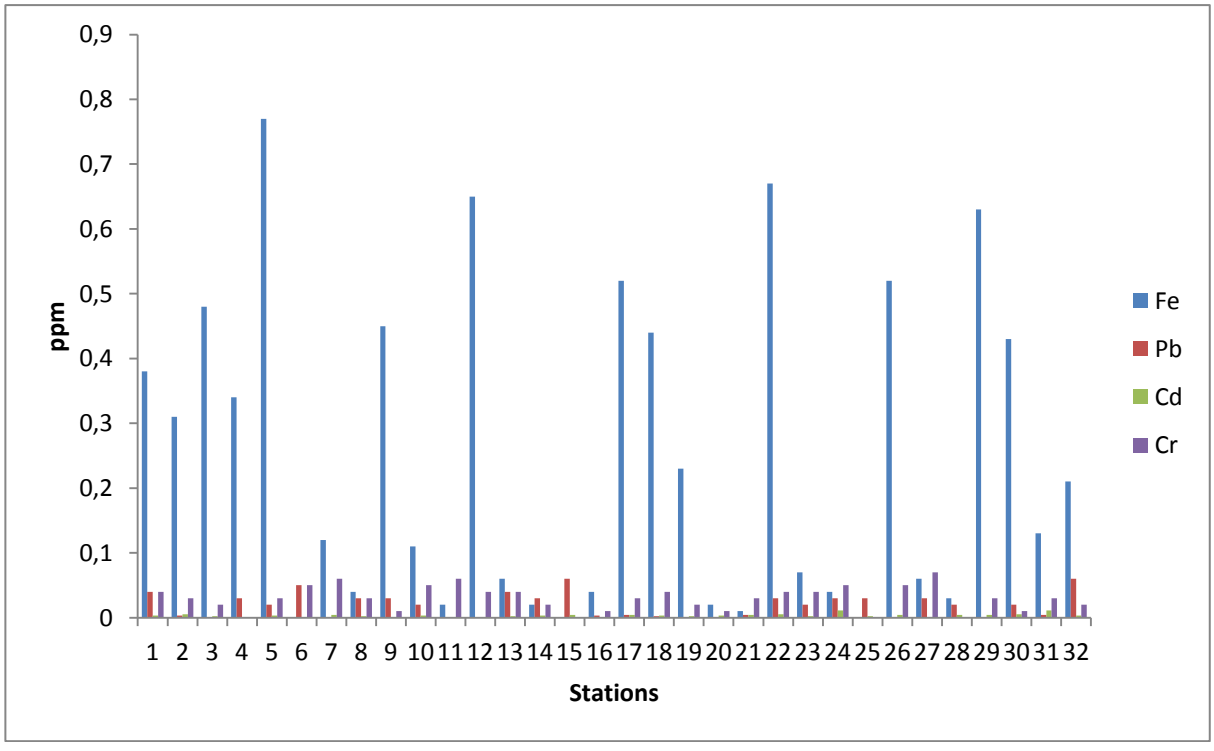

Fig. 4. Variation of heavy metals in post monsoon seasons.

All the values are within the permissible limit. Cadmium in humans on long-term exposure is highly toxic; causes 'itai-itai' disease-painful rheumatic condition; cardio vascular system affected; gastro intestinal upsets and hyper tension (Bichi and Bello, 2013).

5. 6. Chromium (Cr)

Chromium is an essential micronutrient for animals and plants, and is considered as a biological and pollution significant element (Lokeshwari and Chandrappa, 2006). Generally the natural content of chromium in drinking water is very low ranging from 0.01 to 0.05 ppm. The values of chromium in the groundwater sample are recorded within the range of 0.01-0.05 ppm and 0.01-0.07 ppm in both the seasons. The concentration levels of chromium in all the samples are shown in (Table 2). All the values are less than the permissible limit of 0.05 ppm, but one samples are exceed in post monsoon seasons. High content of chromium may be due to various anthropogenic activities, industrial effluents, tanneries, old plumbing and household sewages (Aggarwal, Singh and Gupta, 2000).

6. CONCLUSIONS

Water is one of the abundantly available substances in nature and also called an elixir of life. The study assessed the evolution of water quality in groundwater and open well water of Udayarpalyam Taluk, Ariyalur district. High concentration of EC at a number of areas clearly indicates the unsuitability of groundwater for drinking purpose. Groundwater samples are slightly alkaline nature.

The water samples were subjected to the concentrations of heavy metal ions. Such as Iron, Lead, Cadmium and Chromium were found to be within the limits. Chromium content exceeded the standard in one sample in post monsoon season. Analysis of dissolved heavy metals in these water samples was done for Fe Pb, Cd and Cr. Concentrations of Pb and Cd were found to be in permissible range of WHO standards of drinking water. The result shows that the most of the heavy metal ions are less than the permissible limit of WHO and BIS. Most of the water from these wells is suitable for domestic use and it’s unlikely to pose a major health risk to consumers. Some of the ground water samples can safely be used for drinking and irrigation purposes as their parameters are within the stipulated standards. This information must be shared with people of the area and suggested to improve the water quality. The data may also be shared with the public health.

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(Received 29 December 2015; accepted 13 January 2016)