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RESEARCH ARTICLE

Atomic Absorption Spectrophotometric Studies on Heavy Metal Contamination in Groundwater in and around Tiruchendur, Tamilnadu, India

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Abstract: In the present investigation, groundwater samples were collected from 12 places in Tiruchendur coastal area, Tamilnadu, India. Physicochemical parameters such as pH, alkalinity, electrical conductivity, hardness, total dissolved solids, dissolved oxygen, COD, BOD, sulphate, fluoride, nitrate and trace metals like chromium, zinc, copper, iron, lead, manganese and cadmium were analyzed. Standard methods were followed for the analysis of physicochemical parameters. The trace metals were analyzed in Atomic Absorption Spectrophotometer (AAS). The results were compared with WHO, ICMR, IS. The physicochemical parameters for some samples showed that the values are deviating from the set limits for the domestic purposes. The trace metal analyses are not on the exceeding side of the permissible limit in all the samples. So the trace metal values arouse no concern at present. The water quality in all the areas surveyed was found to be unfit for human consumption. Because of lack of water quality, different diseases frequently affect local people. Hence, suitable water quality management is essential to avoid contamination.

Keywords: Atomic absorption spectrophotometer, Physicochemical studies, Groundwater, Trace metals, Public Health.

Introduction

Water is the most important natural resources on our planet. It is considered absolutely essential to sustain life since the protoplasm of many living cells contains about 80% water and any substantial reduction in this level is disastrous. Groundwater is one of the prime natural resources upon which depend the survival of mankind as well as the social and economic development of the nation[1]. It is an important source of water supply throughout the world. It has been used for drinking for a long time and its purity has made it a well-known source of potable water. Advancement of human civilization has put serious questions to the safe use of groundwater for drinking.

Groundwater was once considered to be free from pollution. But the rapid industrialization made a paradigm shift to this concept. The contaminants are added to groundwater at an alarming rate. Pollutants are being added to the groundwater system through human and natural processes[2]. Solid waste from industrial units is being dumped near the factories, which is subjected to reaction with percolating rain water and reaches the groundwater level.

The quality of groundwater is more important as the case of quantity. The quality varies due to a change in chemical composition of formations. The quality of water should be wholesome, safe and free from pollution of any kind. The health of the public should in no way be endangered due to epidemics associated with water borne diseases[3]. Absolutely pure water is never found in nature. The water found in nature contains a number of impurities in varying amounts. The present investigation was undertaken to study the groundwater quality in Tiruchendur town. Tiruchendur is one of the most important pilgrim and tourist places in Tamil Nadu. Regular monitoring of the quality of groundwater should be undertaken temporarily and spatially, to identify the sources of toxic contaminants and other inhibitory compounds that affect the potability of water. Since development, environment and public health are interlinked, it is necessary for all concerned to adopt sustainable utilization of the available water resources.

Experimental

The study area of Tiruchendur lies between latitudes 8.4902^o N and longitudes 78.1269^o E. The study is situated in Gulf of Mannar **(**Bay of Bengal**)** and it is surrounded by Tirunelveli and Thoothukudi (India).

In the present investigation 12 groundwater samples were collected from bore wells and open wells in and around Tiruchendur are listed in Table 1. Polythene cans of 2 L capacity were made use for collection of water samples. These polythene cans were first washed with tap water, soaked in chromic acid solution for about 10-15 minutes to remove any impurities, again washed with tap water. Finally, they were rinsed with deionised distilled water. Then the polythene cans were taken for sample collection. Acids, alkalis, indicator, buffer reagents, mineral salts *etc*. used in the analysis were of analytical grade of high purity. Hence they were directly used without any purification.

Table 1. Groundwater sampling location in and around Tiruchendur

S. No.	Site / Location of Sampling	S. No.	Site / Location of Sampling
GW – 1	Nalikinar	GW – 7	Amali Nagar
GW – 2	Sannathi Street	GW – 8	Kurunji Nagar
GW – 3	Thoppur	GW – 9	Alanthalai
GW – 4	Jeeva Nagar	GW – 10	Kandasamypuram
GW – 5	Kumarapuram	GW – 11	Tiruchendur
GW – 6	Veerapandiapatanam	GW – 12	Ramasamypuram

Appropriate physical and chemical methods were applied for the determination of various parameters. So, the samples under test were subjected to physicochemical and trace metal analysis. The pH was measured using digital pH meter of Elico make model L1-120. The electrical conductivity was measured using digital conductivity meter type CM82T. Standard methods were followed for the analysis of physico-chemical parameters such as TDS, alkalinity, hardness, BOD, COD, dissolved oxygen, sulphate, fluoride, nitrate and chloride. The trace metals zinc, cadmium, copper, lead, chromium and manganese were analyzed in Atomic Absorption Spectrophotometer model GBC 932.

Results and Discussion

The results of physicochemical analysis of different groundwater samples are presented in Table 2 and 3. Alkalinity in all the water samples lies within the range 249 mg/L to 790 mg/L. The alkalinity is mainly attributable to bicarbonate ions, which is evident from absence of phenolphthalein alkalinity. All the analyzed samples are exceeding WHO permissible limit of 120 mg/L. The high alkalinity values in the study area are due to the action of carbonates upon the basic materials in the soil[4].

Table 2. Physicochemical characteristics of the groundwater samples

Sample	Alkalinity mg/L	Electrical Conductivity µmho/cm	Total Hardness mg/L	Permanent Hardness mg/L	Temporary Hardness mg/L	Calcium mg/L	Magnesium mg/L	pH	TDS mg/L	Dissolved Oxygen mg/L	BOD mg/L	COD mg/L
GW -1	366	626	850	705	145	120	252	7.81	>2000	7.6	2	4
GW - 2	468	537	720	453	267	220	252	7.37	>2000	8.8	2	4
GW - 3	483	842	1113	858	255	180	364	7.91	>2000	8.6	1	3
GW - 4	373	925	716	449	267	100	252	8.09	>2000	8.5	4	6
GW - 5	249	99	160	103	57	80	84	7.55	520	7.5	4	7
GW - 6	578	190	457	256	201	140	112	7.50	1029	10.1	2	5
GW - 7	263	363	662	515	147	180	196	7.52	1740	8.4	2	4
GW - 8	585	299	368	267	101	80	140	7.95	1575	8.1	1	3
GW - 9	307	191	310	177	133	100	140	7.95	1250	9.3	4	7
GW 10	592	246	288	190	98	60	112	7.61	1475	9.4	2	5
GW 11	570	827	1030	667	363	200	308	7.80	>2000	7.9	3	5
GW 12	790	371	274	128	146	60	84	7.57	1773	8.3	1	4

Table 3. Concentrations of inorganic nutrients and trace metals

Sample	Sulphate mg/L	Chloride mg/L	Fluoride mg/L	Nitrate mg/L	Zn mg/L	Cu mg/L	Fe mg/L	Pb mg/L	Cr mg/L	Mn mg/L	Cd mg/L
GW - 1	121	312	1	25	0.0080	0.017	0.015	0.021	1.316	0.011	0.004
GW - 2	210	361	1.1	30	0.0065	0.014	0.0001	0.0002	0.935	0.006	0.002
GW - 3	262	288	0.8	27	0.0100	0.025	0.021	0.011	0.778	0.007	0.005
GW - 4	189	428	0.8	76	0.0496	0.023	0.0003	0.0004	1.121	0.002	0.006
GW - 5	244	391	0.9	81	0.0165	0.013	0.003	0.006	0.0001	0.003	0.002
GW - 6	198	378	1.1	45	0.1035	0.015	0.035	0.004	0.089	0.001	0.006
GW - 7	316	269	0.7	57	0.0102	0.027	0.009	0.012	1.083	0.011	0.003
GW - 8	258	312	0.8	43	0.3850	0.010	0.006	0.019	1.782	0.007	0.004
GW - 9	260	354	1.4	65	0.0346	0.007	0.018	0.059	1.355	0.009	0.004
GW 10	193	398	0.7	64	0.2823	0.011	0.045	0.039	1.150	0.0001	0.001
GW 11	223	372	0.8	37	0.0312	0.024	0.005	0.016	1.954	0.008	0.002
GW 12	248	442	0.8	25	0.0178	0.014	0.027	0.025	0.879	0.007	0.003

It was observed that the conductivity values of the water samples constitute the range 99 to 925 µmho/cm. In most of the samples the electrical conductivity exceeded the domestic water standards of 300 µmho/cm. These high values of electrical conductivity are due to the high concentrations of ionic constituents present in the water bodies under study and reflect the contributions from salinity intrusion as well as pollution by domestic wastes[5].

The prominent hardness causing ions are calcium and magnesium. In the study area, total hardness varies from 160-1113 mg/L. The desirable limit according to IS standard is 300 mg/L.

The water samples of the study area may be termed as hard except the samples GW-5, GW-9, GW-10 and GW-12. Although hardness has no adverse effect on health, there is evidence that hard water plays a role in heart disease[6]. While bathing with hard water, the residues of hardness, that is soap precipitate may remain in the pores of skin causing roughness and discomfort[8]. Calcium concentration varies from 60 to 220 mg/L. WHO permissible limit is 100 mg/L. Most of the samples exceed the permissible limit. Magnesium concentration was observed in the samples range from 84 to 364 mg/L. WHO standard is 50 mg/L. In all the samples magnesium exceeds the permissible limit. Magnesium rich water may cause the gastrointestinal irritation in the presence of sulphate and act as laxative to human beings[7].

In the present study, pH value ranges from 7.37 to 8.09. The limit of pH value for drinking water is 6.5 to 8.5 (ICMR, 1975). This clearly indicates that all the samples were found to be alkaline.

Total dissolved solids (TDS) in the study area varied from 520 to above 2000 mg/L water containing more than 500 mg/L of TDS is not desirable for drinking water purpose. The observed TDS values are higher than the maximum permissible limit value of TDS is found in most of the study area. So people of these areas have laxative and sometimes the reverse effect due to the high solid content[8].

Dissolved oxygen (DO) is one of the important pollution parameters, which measures the extent of organic as well as biological pollution load to a water body. The DO content of water is an index of its sanitary condition[9]. The recommended DO limit for all the domestic purposes is 4-6 ppm. The observed values for all the samples are slightly above the limit set by WHO and these high values may be probably due to the recharge of the groundwater by the surface water.

The BOD and COD parameters pointing out the measure of oxidative decomposable organic components in water, are another two parameters stating the level of pollution like DO. BOD value ranges from 1 to 4 mg/L and COD value ranges from 3 to 7 mg/L. All COD level is below the WHO permissible level of 10 mg/L for domestic water whereas in few samples GW-4, GW-5 and GW-9 BOD exceeds the IS limit of 3 mg/L. This finding indicates contribution of biodegradable pollutants, presumably from sanitary waste in pilgrimage area[8].

Sulphate concentration in the study area varies from 121 to 316 mg/L. WHO permissible limit is 200 mg/L. A few samples (GW - 3, 5, 7, 8, 9, 11, 12) exceed the permissible limit. Excess sulphate content induces diahorrea and cathartic effect on human health[7].

Chloride imparts salty taste to water, depending on the presence of cation constituents. In the present investigation chloride content varies from 269 to 442 mg/L. WHO permissible limit is 200 mg/L. In all the samples, chloride concentration exceeded the WHO permissible limit. Adverse health effects on humans have been reported from intake of waters containing even higher content of chloride.

Fluoride is important in human nutrition for the normal development of bones. It should not exceed 1.5 mg/L. The fluoride content is less than 1 mg/L in most of the samples except GW-2, GW-6 and GW-9. Use of phosphate fertilizers may also contribute to high fluoride content in groundwater. These chemical pollutants affect man’s health not only directly but also indirectly by accumulating aquatic life (*e.g*. fish) used as human food[10].

Nitrate is effective plant nutrient and moderately toxic. Nitrate content in the study area varies from 25 to 81 mg/L. WHO permissible limit is 45 mg/L. A few samples GW-4, GW-5, GW-7, GW-9 and GW-10 exceed the nitrate in drinking water has also be found to cause methemoglobinaemia (blue babies syndrome) in infants. Repeated heavy doses of nitrates on ingestion may cause carcinogenic diseases[11].

Zinc is an essential element for both animals and man. It is necessary for the functioning of various enzyme systems, deficiency of which leads to growth retardation. Low intake of Zinc results in retardation of growth, immaturity and anemia condition known as zinc deficiency syndrome[12]. The concentration of zinc in the study area ranges from 0.0065 to 0.3850 mg/L. Since the recommendations for the domestic water supplies are 5 mg/L the levels of zinc in the groundwater are safe enough for drinking and other domestic purposes.

Copper is an essential element for human body. But excessive large doses may lead to mucosal irritation and corrosion, hepatic and renal damage and central nervous system. The copper concentration in the groundwater samples varies from 0.007 to 0.027 mg/L. All the values are well within the WHO permissible limit of 1 mg/L. The groundwater of these areas can be safely used as a source of drinking water supplies.

The maximum permissible limit of iron content in drinking water is set as 0.3 mg/L (IS 1991). The concentration of iron in groundwater of the study area ranges from 0.0001 to 0.045 mg/L. Studies on the iron content of the groundwater in Tiruchendur have shown that all the values are within the permissible limit.

Lead poisoning has been recognized as an occupational illness for centuries and it is linked with both severe and subtle health damages. Higher concentration of lead in drinking water has adverse effect on central nervous system, blood cell and may cause brain damage. The permissible limit for lead in drinking water is 0.05 mg/L. The lead content in the study area ranged from 0.0002 to 0.059 mg/L (Table 4 and 5). The groundwater of the study area can be safely used as a source of drinking water supplies (Figure 1).

Table 4. Estimation of Pb by AAS Studies-Preparation of Calibration curve with Standard Lead Solution (*Element : Pb (lead) Calibration mode*: *Concentration*)

Sample Label	Conc. μg/mL	%RSD	Mean Abs.	Replicates		
Cal Blank	-	High	0.0012	0.0001	0.0021	0.0015
Standard 1	2.51	1.48	0.1605	0.1591	0.1632	0.1591
Standard 2	5.02	0.12	0.3242	0.3239	0.3246	0.324
Standard 3	10.04	0.48	0.6483	0.6514	0.6451	0.6484
Standard 4	15.056	0.33	0.9575	0.9601	0.9585	0.954

Note: Standard 1, 2, 3 and 4 are different concentrations of lead solution for preparation of calibration curve

Table 5. Estimation of Pb from groundwater sample station by AAS studies

Sample Label	Conc. μg /mL	%RSD	Mean Abs.	Replicates		
Sample blank	-	High	0.0015	0.0051	0.0012	-0.0017
GW1	0.021	High	0.0013	0.0023	0.0004	0.0013
GW2	0.037	High	0.0024	0.0031	0.0039	0.0003
GW3	0.011	High	0.0007	0.0016	0.0011	-0.0005
GW4	ND	High	-0.0056	-0.0095	-0.0046	-0.0027
GW5	0.016	High	0.001	0.0011	0.0006	0.0014
GW6	0.004	High	0.0002	0.0023	0.0006	-0.0023
GW7	0.012	High	0.0008	-0.0025	0.0031	0.0016
GW8	0.019	High	0.0012	0.0013	0.0026	-0.0003
GW9	0.059	High	0.0038	0.0009	0.0049	0.0055
GW10	0.039	High	0.0025	0.0045	0.0023	0.0007
GW11	0.016	High	0.0011	0.0046	-0.0024	0.0011
GW12	0.014	HIGH	0.0010	0.0044	0.0042	0.0010

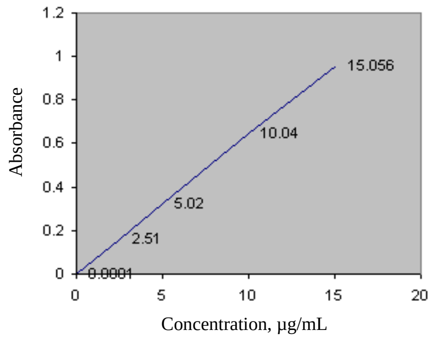

Figure 1. Estimation of lead by AAS studies

Chromium is an essential nutrient for plant and animal metabolism. The 0.05 mg/L is the permissible limit of chromium in drinking water as recommended by WHO. The chromium content in the study area ranged from 0.0001 to 1.954 mg/L. It was found that all samples are above permissible limit. Excess of chromium present in human body causes bronchial cancer in humans.

Manganese content in the study area ranged from 0.0001 to 0.011 mg/L. The permissible limit of manganese is 0.1 mg/L. All the samples in the study area are well within the permissible limit. Water in these areas is safe for domestic purpose.

Concentration of cadmium in the study area ranged from 0.001 to 0.006 mg/L. The permissible limit of cadmium in drinking water is 0.01 mg/L. The levels of cadmium in public water supplies are normally very low. Therefore, the groundwater of the study area does not present any cadmium hazards to humans.

Conclusion

In general, the water quality in all the areas surveyed was found to be unfit for human consumption for one reason or another. Hence, it is recommended that suitable water quality management is essential to avoid any further contamination. From the generated data and the foregoing discussion, it can be concluded that most of the groundwater samples in Tiruchendur area are not suitable for drinking use. Hence the groundwater samples require treatment before being used.

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