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Assessment of Underground Water Contamination and Effect of Textile Effluents on Noyyal River Basin In and Around Tiruppur Town, Tamilnadu

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Abstract: A systematic study has been carried out to assess the underground water contamination and the effect of textile effluents on Noyyal River basin in and around Tiruppur Town. Twenty six sampling locations were selected at random and the ground water samples were collected mostly from tube wells at Noyyal River basin in and around Tiruppur area. The samples were analyzed for major physical and chemical water quality parameters like pH, alkalinity, electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), Ca, Mg, Na, K, Cl^- & SO_4^{2-}. It was found that the underground water quality was contaminated at few sampling sites due to the industrial discharge of the effluents on to the river or land from the Tiruppur town. The sampling sites namely Orathupalayam, Karuvapalayam, Kulathupalayam, Uttukuli and Kodumanalpudur showed high deviations in total alkalinity, total hardness, Ca, Mg and chloride concentrations. Hence our study concludes that the underground water quality study in this region shows a constant variation in different parameters in different periods (before and after monsoon). So it is highly important to take periodical monitoring of the underground water quality in this region for our future sustainability.

Keywords: Physico-Chemical Characteristics, Ground Water, WHO standard, Tiruppur, Noyyal River.

Introduction

Tiruppur is a fast growing industrial city in Coimbatore district of Tamilnadu, also known as the 'Banian City' of India. It is located on the bank of the Noyyal River, a tributary of the River Cauvery. The hosiery industry in Tiruppur provides substantial contribution to the economy in the form of income, employment and foreign exchange generation. However,

the rapid growth of the industry has resulted in serious environmental problems, especially from the bleaching and dyeing units. Hence there is evidence to suggest that these units extract considerable quantity of ground water from the peripheral areas and discharge the effluent without adequate treatment. The discharge of effluents has caused severe pollution of both the surface and ground water in the region and has also contaminated agricultural land. The disposal of untreated wastewater on land and the Noyyal River has affected the quality of surface water, ground water and the soil not only in Tiruppur but in downstream. Available studies clearly prove the accumulation effect of pollution in and around Tiruppur and the downstream stretch of Noyyal exhibit high level of TDS and various salts due to industrial pollution.

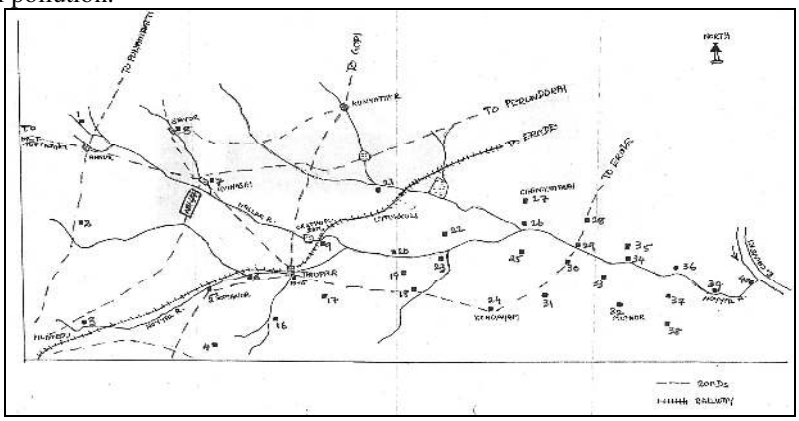

Figure 1. Noyyal River Basin

Ground water contamination is the result of polluted water infiltrating through the soil and rock and eventually reaching the ground water. This process might take many years and might take place at a distance from the well where the contamination is found. Once the ground water is contaminated, it is very difficult to remediate. No doubt that the new technologies will always reduce the pollution level. But the underground water quality in this basin based on various factors, influx of industrial effluent, influx of water through rainfall, soil, agriculture pattern *etc*., so we can say that by these factors, the underground water quality can be varied qualitatively and quantitatively. It is useful to examine the above highlighted problems in an environmental economic framework in which the quantity and quality of water resources is a major concern. So our objective is to assess the underground water quality in the Noyyal River Basin with special emphasis on Tiruppur town.

Experimental

During January-February 2007, ground water samples were collected mostly from tube wells at Noyyal River basin in and around Tiruppur area. In some locations where tube wells are not available, water samples were collected from the dug wells. Twenty six sampling locations were selected at random as indicated in the map. (Figure 1). The water samples were collected during the daytime between 9 a.m to 4 p.m. They were collected in one liter plastic bottles. Before sampling, the plastic bottles were cleaned thoroughly to remove all surface contamination, rinsed with double distilled water and dried. The collected samples were properly brought to the laboratory without adding any preservative. Suspended matters if any, in the samples, were removed by filtering through Whatmann filter No.41. Then it is stored in the refrigerator at 40°C till the analysis was over.

S.No.	Sampling places	S.No	Sampling places	S.No	Sampling places
1	Peelamedu	10	Tirupur-RS**	19	Maravanpalayam
2	Somanur	11	Tirupur-New BS**	20	Kodumanal
3	Mangalam*	12	Kovilur	21	Palayakottai*
4	Avinashi	13	Padiur	22	Kuppichipalayam
5	Otathupalayam	14	Sivagiripudur	23	Chinnamudthur
6	Karuvapalayam**	15	Marur*	24	Valayuthampalayam*
7	Rayapuram**	16	Uttukkuli	25	Pudur*
8	Vallipalayam**	17	Pallarpalayam	26	Attupalayam
9	Kulatthupalayam**	18	Kodumanalpudur*		

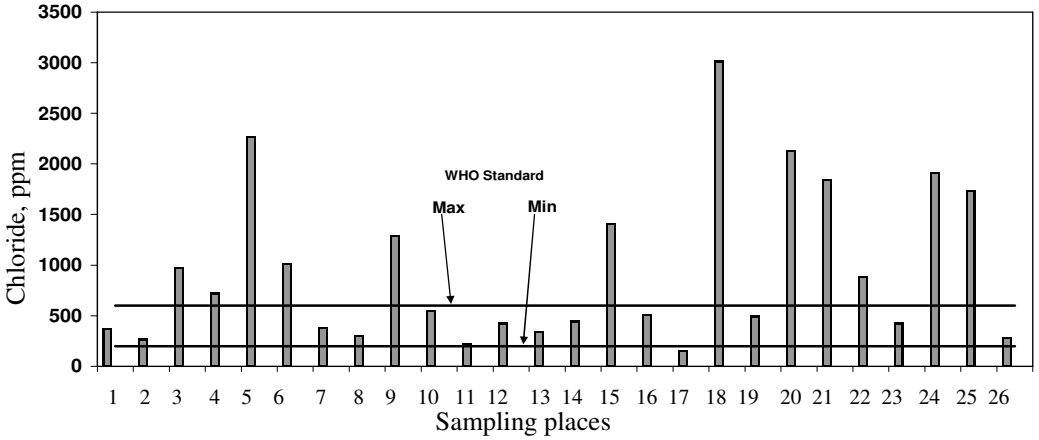

Figure 1. Chloride values of various water samples collected in and around Tiruppur

The samples were analyzed for major physical and chemical water quality parameters like pH, alkalinity, electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), Ca, Mg, Na, K, Cl^- & SO_4^{2-}. The analyses were carried out systematically both volumetrically and by instrumental techniques. The procedures were followed from standard books and manual[1, 2]The pH of the samples was determined using digital pH meter (Model MK VI).Before measuring the pH of the sample water, pH meter standardized using pH buffer of 4.0 and 9.2. Electrical conductivity was measured using an Elico CM-180 conductivity meter and sulphate by turbidimetric method using a spectronic-20 (Bosch and Lamb,USA).

Results and Discussion

Various physico chemical parameters were studied and are given in Table 1. Different physical parameters studied are appearance, colour, odour, taste, turbidity, Electrical Conductivity and Total Dissolved Solids. Different chemical parameters studied are pH, alkalinity, total hardness, calcium, magnesium, sodium, potassium, chloride and sulphate. The values were compared with the WHO standard values which are given in the same Table. The results indicate that the quality of water considerably varies from location to location. This wide variation is mainly due to salinity and other dissolved materials from the near by dyeing, bleaching and textile industries in the study area.

Of the physical parameters studied, variations were observed for the parameters –electrical conductivity and total dissolved solids. The standard value for Electrical Conductivity is 1500 µS/cm according to WHO[3] Electrical conductivity (EC) of water is a direct function of its total dissolved salts[4]. Hence it is an index to represent the total concentration of soluble salts in water[5] In our study area, the electrical conductivity varied between 2.7 to 551.6 µS/cm. The highest conductivity of 551.6 µS/cm was recorded in the sampling site of Attupalayam was found to exceed the WHO standard. Though the variation is less, it is notable. The reason behind this may be continuous discharge of the chemicals and salts used along with dyes from the industries.

Table 1. Major physical and chemical water quality parameters of various water samples collected in and around Tiruppur

Sampling Places	WHO Standard	Peelamedu	Somanur	Mangalam*	Avinashi	Orathupalayam	Karuvapalayam**	Rayapuram**	Vallipalayam**	Kulatthupalayam**	Tiruppur-RS**	Tiruppur-New BS**	Kovilur	Padiur
Water parameters/sample		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
pH	6.5-8.5	7.19	7.16	8.4	7.74	7.73	7.71	7.09	7.3	7.26	7.47	6.96	7.41	7.53
EC, mV	-	44.7	10	66.7	44	43.7	41.2	5.7	17.5	16.2	27	2.7	25	31.1
TDS, ppm	500-1500	1250	735	1798	820	3800	2500	1350	1000	2580	1588	69	390	820
DO, mg/lit	5.0-6.0	7.8	8.2	5.8	7.1	2	5	7.3	7.3	8.5	6.5	9.8	6.1	7.2
Sulphate, ppm	400	94.9	46.8	211.9	166.6	200	223.6	117	190.5	320.2	198.9	Nil	195	63
Cyanide, ppm	-	Nil	Nil	Nil	Nil	0.0015	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Chloride, ppm	1000	368	265	971	720	2265	1013	380	298	1290	545	226	423	339
Hydroxide, ppm	-	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Carbonate, ppm	-	Nil	Nil	37	Nil	30	Nil	Nil	Nil	Nil	Nil	Nil	32	Nil
Bicarbonate, ppm	-	205	210	288	362	595	375	385	360	437	435	322	260	231
Totalalkalinity, ppm	-	205	210	325	362	625	375	385	360	437	435	322	292	231
Ca in $CaCO_3$, ppm	200	225	325	460	206	350	350	330	235	385	370	360	205	260
Ca in Calcium Equivalent, ppm	200	90	130	184	81	140	140	132	94	160	148	144	82	104
Mg in $CaCO_3$, ppm	200	235	325	490	304	500	750	280	215	1006	180	65	325	154
Mg in Magnesium equivalent, ppm	200	56	78	117	72	120	180	67	51	241	43	15	78	109
Totalhardness, ppm	600	460	650	950	510	850	1000	610	450	1391	550	425	520	714
Sodium, ppm	-	102	50	90	93	230	100	230	275	600	126	101	126	73
Potassium, ppm	-	5	-	5	-	5	-	5	-	34	13	7	19	14

* Samples are taken very close to the banks of the river ** Samples are taken in and around Tiruppur

Contd….

Sampling Places	WHO Standard	Sivagiripudur	Marur*	Uttukkuli	Pallarpalayam	Kodumanalpudur*	Maravanpalayam	Kodumanal	Palayakottai*	Kuppichipalayam	Chinnamuthur	Valayuthampalayam*	Pudur*	Attupalayam
Water parameters/sample		**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
pH	6.5-8.5	7.35	7.65	7.2	7.35	7.66	7.51	7.73	7.73	7.61	8.5	7.63	7.69	7.94
EC mV	-	21.4	36.4	12.5	19.5	39.5	30.3	42.1	44.1	36.9	63.2	63.4	39.2	551.6
TDS, ppm	500-1500	1220	1593	915	475	6080	796	3810	3480	823	1231	2970	3114	1745
DO mg/lit	5.0-6.0	6.9	Nil	8.9	7.1	Nil	6.3	4.2	3	6.2	6.4	4.2	2.6	8.1
Sulphate, ppm	400	43	208	Nil	26	337	123	270	291	56	49	154	236	156
Cyanide, ppm	-	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Chloride, ppm	1000	442	1410	510	153	3012	493	2127	1843	886	423	1914	1737	283
Hydroxide, ppm	-	Nil	Nil	Nil	NIL	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Carbonate, ppm	-	Nil	Nil	Nil	19	73	Nil	72	70	63	Nil	45	27	40
Bicarbonate, ppm	-	236	273	165	174	602	524	565	515	446	441	367	440	438
Total alkalinity, ppm	-	236	273	165	193	675	524	637	585	509	441	412	467	478
Ca in $CaCO_3$, ppm	200	338	325	540	229	725	280	345	350	261	175	260	250	50
Ca in Calcium Equivalent, ppm	200	132	130	216	91	290	113	138	140	104	70	104	100	20
Mg in $CaCO_3$, ppm	200	482	450	435	491	1175	535	480	455	423	41	451	475	175
Mg in Magnesium equivalent, ppm	200	116	108	104	117	282	126	115	109	103	57	108	114	42
Total hardness, ppm	600	820	775	975	720	1900	915	825	805	693	416	710	725	225
Sodium, ppm	-	93	1250	160	121	1310	126	1170	1115	141	290	985	970	550
Potassium, ppm	-	9	55	20	24	311	22	55	55	21	36	50	50	7

** Samples are taken very close to the banks of the river ** Samples are taken in and around Tiruppur*

The salinity can also be measured in terms of electrical conductivity. Occurance of saline water is more frequent in maximum sampling points. Saline water is generally associated with alluvial aquifers which in general, yield water of higher salinity. Moreover, the bicarbonates contamination from the salt which is mixed with the dyes from the textile industries found to increase the electrical conductivity of the water.

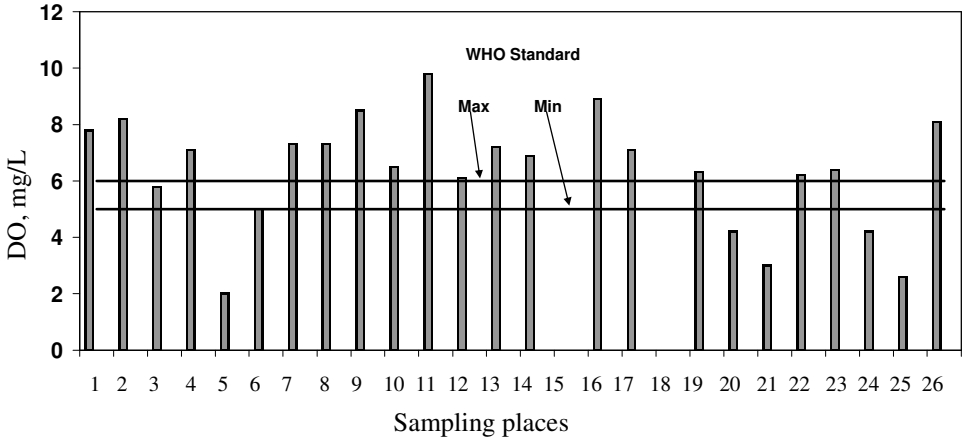

Figure 2. DO values of various water samples collected in and around Tiruppur

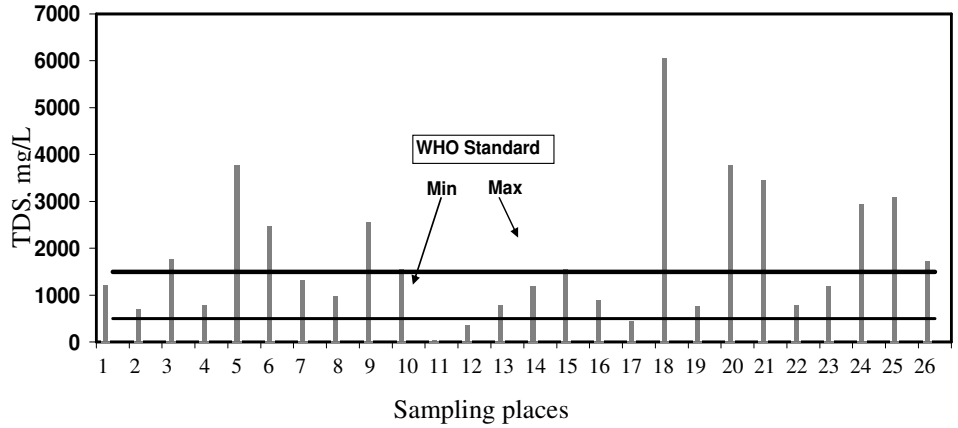

Figure 3. TDS values of various water samples collected in and around Tiruppur.

Out of 26 samples collected in our study area, 12 samples were found to have the highest value of total dissolved solids (TDS) above the permissible limit of 500 to 1500 mg/L. It is worth mentioning here that generally the rocky nature of the earth containing several minerals might be responsible for the high levels of total solids in the groundwater of this region. Moreover the excess TDS values could be due to the dissolved solid waste originated from the discharge of the effluent from the dyeing industries. Particularly the water sample which is collected at Kodumanalpudur showed high TDS value in the range of 6080 mg/L and it is responsible for ground water pollution. High values of TDS in ground water are generally not harmful to human beings but high concentration of these may affect persons, who are suffering from kidney and heart diseases[6]. Water containing high solid may cause laxative or constipation effects[7].

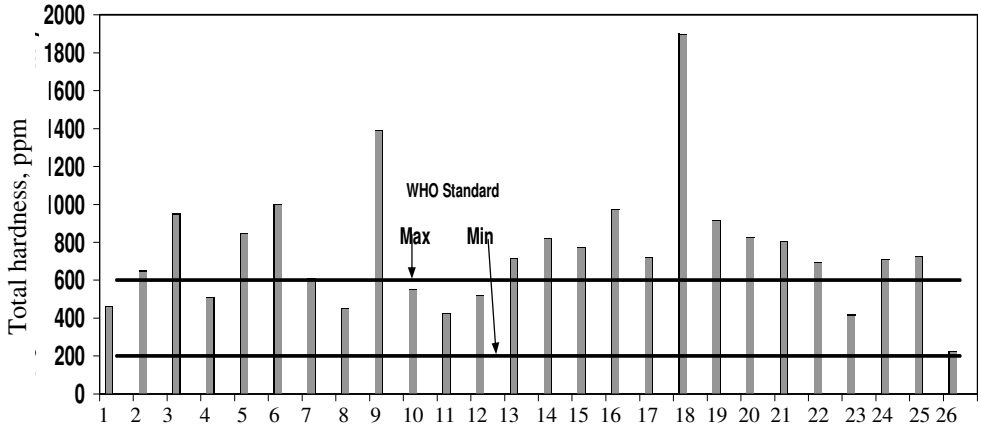

Figure 4. Hardness of various water samples collected in and around Tiruppur.

Among the different chemical parameters analyzed, variations were observed comparing with the standard values for the parameters-sulphate, chloride, Ca, Mg, and Total Hardness *etc*.,

The pH values in the study area vary from 6.96 to 8.5 with the mean value of 7.59 suggesting the alkaline nature of the ground water in the study area. Thus a slight variation was recorded due to the alkalinity of effluent. However the pH value of all the samples falls within the permissible limit[8,9].

Alkalinity of water is the capacity to neutralize acidic nature and the presence of carbonates, bicarbonates and hydroxides are the main cause of alkalinity in natural waters. The alkalinity values in the study area found to vary from 165 to 675 mg/L. The alkalinity of ground water samples in Kodumanalpudur, Kodumanal & Orathupalayam found to be greater than 600 mg/L. Alkalinity around 150 mg/L has been found conductive to higher productivity of water bodies[10].

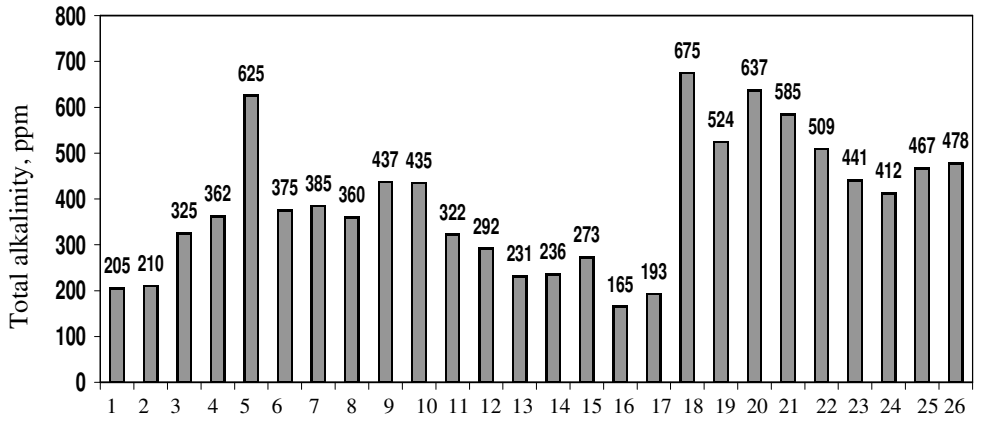

Figure 5. Alkalinity of various water samples collected in and around Tiruppur

Of the physical parameters studied, variations were observed for the parameters – electrical conductivity and total dissolved solids. The standard value for Electrical Conductivity is 1500 µS/cm according to WHO.[3] Electrical conductivity (EC) of water is a direct function of its total dissolved salts[4]. Hence it is an index to represent the total

concentration of soluble salts in water[5]. In our study area, the electrical conductivity varied between 2.7 to 551.6 µS/cm. The highest conductivity of 551.6 µS/cm was recorded in the sampling site of Attupalayam was found to exceed the WHO standard. Though the variation is less, it is notable. The reason behind this may be continuous discharge of the chemicals and salts used along with dyes from the industries.

Based on the EC values, the ground water quality can be classified as poor, medium and good. The water samples collected in the sampling sites of Peelamedu, Mangalam, Avinashi, Orathupalayam, Karuvapalayam, Tiruppur-RS, Padiyur, Marur, Kodumanalpudur, Maravan-palayam, Kodumanal, Palayakottai, Kuppichipalayam, Chinnamuthur, Velayutahmpalayam, Pudur and Attupalayam showed a very high value of electrical conductivity in the range of 27 to 66.7µS/cm and hence they are said to be of poor quality. Water samples collected in the sampling sites namely Vallipalayam, Kulatthupalayam, Kovilur, Sivagiripudur, Uttukkuli and Pallarpalayam showed value of electrical conductivity in the range of 10 to 25µS/cm and they are said to be of medium quality. Water samples collected in the sampling sites of Somanur, Rayapuram and Tiruppur New BS are found to have very low electrical conductivity in the range of 1 to 10 µS/cm and they are said to be of good quality.

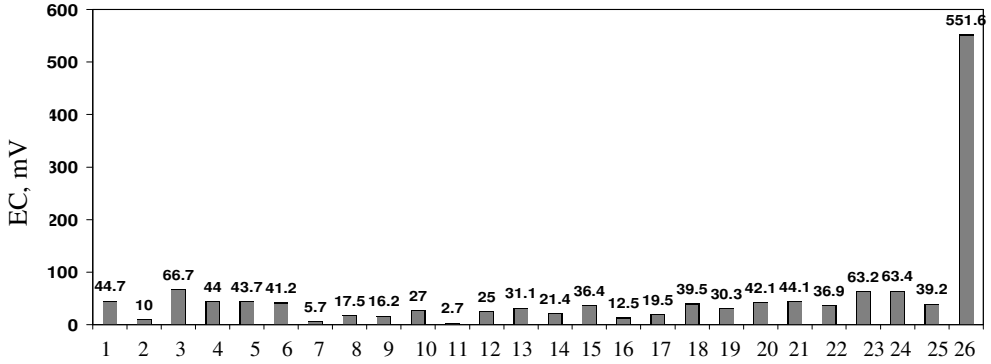

Figure 6. EC values of various water samples collected in and around Tiruppur.

The total hardness (TH) in the study area found to vary from 225 to 1900 mg/L with mean value of 753. Only one sample were found within desirable limit of 300 mg/L, 40% samples were found within maximum permissible limit of 600mg/L and about 60% samples crossed the maximum permissible limit. Among this the water samples collected at Kulathupalayam and Kodumanalpudur was found to be very higher than the permissible limit. It clearly indicates that the effluent has affected the ground water. Though it affects the ground water, it has no adverse effect on human health. In most of the samples, total hardness value exceeds the tolerance limit; this may be due to industrial discharge of the effluents on to the land.

Chloride is a widely distributed element in all types of rocks in one or the other form. Its affinity towards sodium is high. Therefore, its concentration is high in ground waters, where the temperature is high and rainfall is less. Soil porosity and permeability also has a key role in building up the chlorides concentration[11]. The chloride concentration varied from 153 to 3012 mg/L in the study area. The samples collected at Kodumanalpudur & Orathupalayam was found to have high chloride concentration of 3012 & 2265 mg/L. It may be due to the continuous usage of chloride salts in the industries preferably in dyeing and bleaching. Most of the other samples were found to possess excess chloride concentration due to the presence of soluble chlorides from rocks[12].

Calcium, magnesium and total hardness in the water are inter-related. An important source of calcium is the dissolution of small quantities of carbonate compounds from industries. Calcium concentrations varied from 20 to 290 mg/L in the study area. However, the calcium in Ca equivalent value falls within the permissible limit except the two samples collected at Kodumanalpudur & Uttukuli. The value was found to be 290 and 216 mg/L respectively.

Magnesium usually occurs in lesser concentration than calcium due to the fact that the dissolution of magnesium rich minerals is slow process and that of calcium is more abundant in the earth's crust.[13] Magnesium concentrations varied from 15 to 282 mg/L in the study area. All values lies within the desirable limit except few samples. The desirable magnesium value for drinking water prescribed by WHO is 150 mg/L. The water samples collected from Karuvapalayam, Kalatthupalayam and Kodumanalpudur was found to have 180, 241 & 282 mg/L of Mg concentration respectively which beyond the limit of WHO value.

Sodium occurs as a major cation in water samples. The concentration of sodium in the study area ranged from 50 to 1310 mg/L with the mean value of 403 mg/L. The sodium concentration more than 50 mg/L makes the water unsuitable for domestic use. The sodium concentration was observed to be higher at few sampling sites namely Marur, Kodumanalpudur, Kodumanal and Palayakottai.

Potassium is though a minor element in ground water, the concentration of potassium in ground water varied from 5 to 311 mg/L with the mean value of 38 mg/L. Its abnormal concentration is found in the sampling site of Vallipalayam.

No cyanide was identified even in trace amounts. This may be due to the absence of major cyanide based chemical industries in our focus area. The sulphate concentration varied from 26 to 337 mg/L in the study area did not show any remarkable deviation and were very much within the tolerance limit.

17 samples out of 26 samples tested found to have DO value greater than the permissible limits. This may be attributed to the seepage of effluents from the industries in to the ground water. But this value does not have any impact since it is not directly consumed by aquatic animals[14].

On the basis of the obtained values for various physico-chemical parameters, the sampling sites namely Orathupalayam, Karuvapalayam, Kulathupalayam, Uttukuli and Kodumanalpudur showed high deviations in total alkalinity, total hardness, Ca, Mg and chloride concentrations. Only slight variations were recorded in alkalinity, total hardness and total dissolved solids for other samples. High concentrations of sodium, potassium and chlorides were observed at few sampling places but they were not at any risk conditions. Sulphate and Cyanide values for all the water samples did not show any remarkable deviation and were very much within the tolerance limit. Few samples were reported with higher DO values than the permissible limits, but this value does not have any impact for the underground water.

Conclusions

Among 26 water samples analyzed, except few samples, all other samples were found to have the values according to the standard values prescribed by WHO for all the parameters. It was also found that the underground water quality was contaminated at few sampling sites due to the industrial discharge of the effluents on to the river or land from the Tiruppur town. It is because of soil porosity, permeability and also the rocks nature of those particular sampling places. From the analyses, it will be logical to say that the textile effluent from the

industrial area of Tiruppur town has its impact on the quality of underground water in some sampling sites of our study area. Hence the results suggest that the underground water may be altered in future due to excess population, urbanization and rapid industrialization of this catchment area. Therefore, there should be proper disposal of solid slurry after treatment as well as recycling of wastewater along with periodical monitoring of the underground water. It is some of relevant ingredients of management strategies for Tiruppur area.

Hence our study concludes that the underground water quality study in this region shows a constant variation in different parameters in different periods (before and after monsoon). So it is highly important to take periodical monitoring of the underground water quality in this region for our future sustainability.

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