Asian Journal of Water, Environment and Pollution, Vol. 10, No. 4 (2013), pp. 33–42.

Water Quality Assessment in Tiruchirappalli, India

G. Venkatesan*, B. Balaji, S. Dhivyabharathi, K.S.S. Lidhuveniya and F. Sylvester Martin

Department of Civil Engineering, University College of Engineering Tiruchirappalli
Anna University, Tiruchirappalli – 620024, India
✉ gvenkat1972@gmail.com

Received September 3, 2012; revised and accepted September 9, 2013

Abstract: The water quality assessment was conducted in Tiruchirappalli in southern India. The study region under consideration is located in the Indian southern state Tamilnadu, intersecting in the geological co-ordinates 10°48′9″N 78°42′43″E. It was doubted that the water resources in that location might be polluted due to the impact of distillery industry effluents located in the mentioned region thus causing stinky environment. So there was a necessity to test the ground and surface water pollutants. Clean plastic bottles were used to collect samples in various locations around the distillery unit. These samples were taken in three trials with fortnightly frequency. The collected samples were analyzed for their chemical parameters like hardness, pH, chlorides, sulphates, alkalinity, total dissolved solids, nickel, chromium, dissolved oxygen, biological oxygen demand and chemical oxygen demand. Surface water samples are analyzed for parameters like BOD, COD, TDS, copper, zinc, lead, cadmium, nickel and manganese. These parameters are helping to indicate the level of quality of ground and surface water for drinking and other domestic purposes. The parameters then were checked in par with the World Health Organization standards. As a result it is observed that some parameters such as hardness of ground water were 10 times as that of the pure drinking water with desirable limits.

Key words: Water quality assessment, distillery effluent, ground water, surface water, Tiruchirappalli.

Introduction

Water quality assessment is a process of determining the true nature of water by estimating the presence of parameters and its limits by various experiments available. Water quality assessment is considered to be one of the important projects that a civil engineer may undergo thereby evaluating the presence of parameters and ways to get rid of their effects (Andreadakis et al., 2003).

Ground water is usually a dependable source of water for household and it is observed to be the easiest and purest form of water source available to a large group of people. But recently this purest source of water is also contaminated due to changes in ecosystem and impacts of urbanization. This also gets worse due to the industrialization process. The effluent from many industries which is untreated and directly dumped into the land infiltrates into the ground and pollutes the groundwater source beneath. Another reason may be dumping of household waste and inadequate drainage facilities. Thus the groundwater source which is believed to be pure over years is contaminated now a days and a water quality assessment is in need to estimate the limits of parameters present and to provide any solutions available (Subramanian, 2011; Senthil Kumar, 2011). Ground water is getting polluted due to various human activities such as solid-waste landfill sites arising out of municipal and industrial activities (Ikem et al., 2002; Venkatesan and Swaminathan, 2009).

*Corresponding Author

Water quality characteristics of aquatic environment arise from a multitude of physical, chemical and biological interactions (Jain, 2009; Bibi Saima Zeb et al., 2011) .The surface water quality analyses by various researchers (Dasgupta et al., 2001; Godwin Billy Mensah, 2008; Bharti and Katyal, 2011) show some of the parameters exceeding the limits of WHO.

Senthanneerpuram is a sub-urban area located in Tiruchirappalli, Tamil Nadu. This place is surrounded by industries like Trichy Distillery, Trichy Steel, etc. and is a vast area on the side of National Highway. This place is less populated with people living at a distant location from that of industries. Recently, the groundwater quality of this place is getting polluted which may be due to any one of the reasons like effluent discharge from many industries present and also due to environmental variations and changes in lifestyle of people present. The air surrounding is filled with a smell which confirms the presence of chemical pollutants in atmosphere over there. But this cannot be said as a reason of changes in parameters of ground water. Thus a water quality assessment was planned to be conducted to find out the reasons for ground water becoming unusable for drinking.

Uyyakondan Canal flows through Senthanneerpuram and it functioned as one of the drinking water source for people there. But recently, this water is polluted to the extent that it can only be used for domestic purposes. The visual appearance of canal itself confirms the presence of pollutants. But due to flow of water most of the pollutants gets diluted and some gets deposited as sediments. Water from this is used for domestic purposes like washing, bathing, etc. The industries nearby dump their wastes and effluents into this canal so as to make the disposal easier. Households nearby too dump their waste into this canal thereby increasing the cause to get polluted. With the usage of this water even for domestic purposes many people living nearby are affected. Thus a water quality assessment had been planned thereby to estimate the parameters present above limits and to find a solution to make this source of water usable for drinking purposes without any risk.

Methods

Study Area

Water quality assessment was planned on Senthanneerpuram region in Tiruchirappalli shown in Figure 1. The samples were taken around the distillery unit located in Senthanneerpuram. Two locations are far beyond the canal bridge and four locations are located nearer to the distillery unit and west side of the National Highway 45 as shown in Figure 2. In Figure 3, distances of six locations from where the water samples were collected vary from 710 m to 1210 m from the spot where the distillery effluents are released into the Uyyakondan Canal. The two sampling locations in the east region are located at distances of 820 m to 1.21 km. The effect of the effluent discharge to this extent of distance could not accurately be justified yet these locations are taken for sampling to ascertain the vicinity of habitats and their reach for the groundwater resources. This method of subdivision consists of the protocols that were followed for collecting water samples for analysis, procedures for experiments to test the parameters for ground water and also for surface water.

Sampling Procedure

Six locations were chosen for sampling groundwater sources. Samples were collected in the time period of 30 days, on 15.02.12, 01.03.12 and 15.03.12 as three trials, periodically once in a fortnight. The samples were collected in clean plastic bottles and few tests like pH and dissolved oxygen are done within half an hour from the time of the samples being taken. After the completion of these tests, the samples are preserved and other tests were also conducted.

Results and Discussions

Hardness is one of the most important parameters which has to be analysed for water quality assessment done in the laboratory using EDTA method. All samples except location 3 (Open well) were taken from bore wells (Hand Pumps) which is found to be of a lesser value than others because it is free of mineral corrosion and deposition of bore and pipe systems. Its average value after three systems of trial was found to be 3.68 times that of the value that can be used for drinking purposes as per the WHO Standards. The values of test results for the parameter hardness vary from the minimum value of 245 ppm at location 3 and to the maximum of 628 ppm at location 6 shown in Figure 4. The average value of the hardness of water samples collected from all the six locations is 450 ppm. It is 4.5 times higher than the desirable limit of WHO Guidelines. The water samples had total hardness greater than permissible limits which lead to heart and kidney problems (Satya Narayana and Guru Prasad, 2006) and is not suitable for drinking purpose (Senthil Kumar et al., 2011).

pH is yet another parameter that is analyzed in laboratory using electronic pH meter. Location 6 is

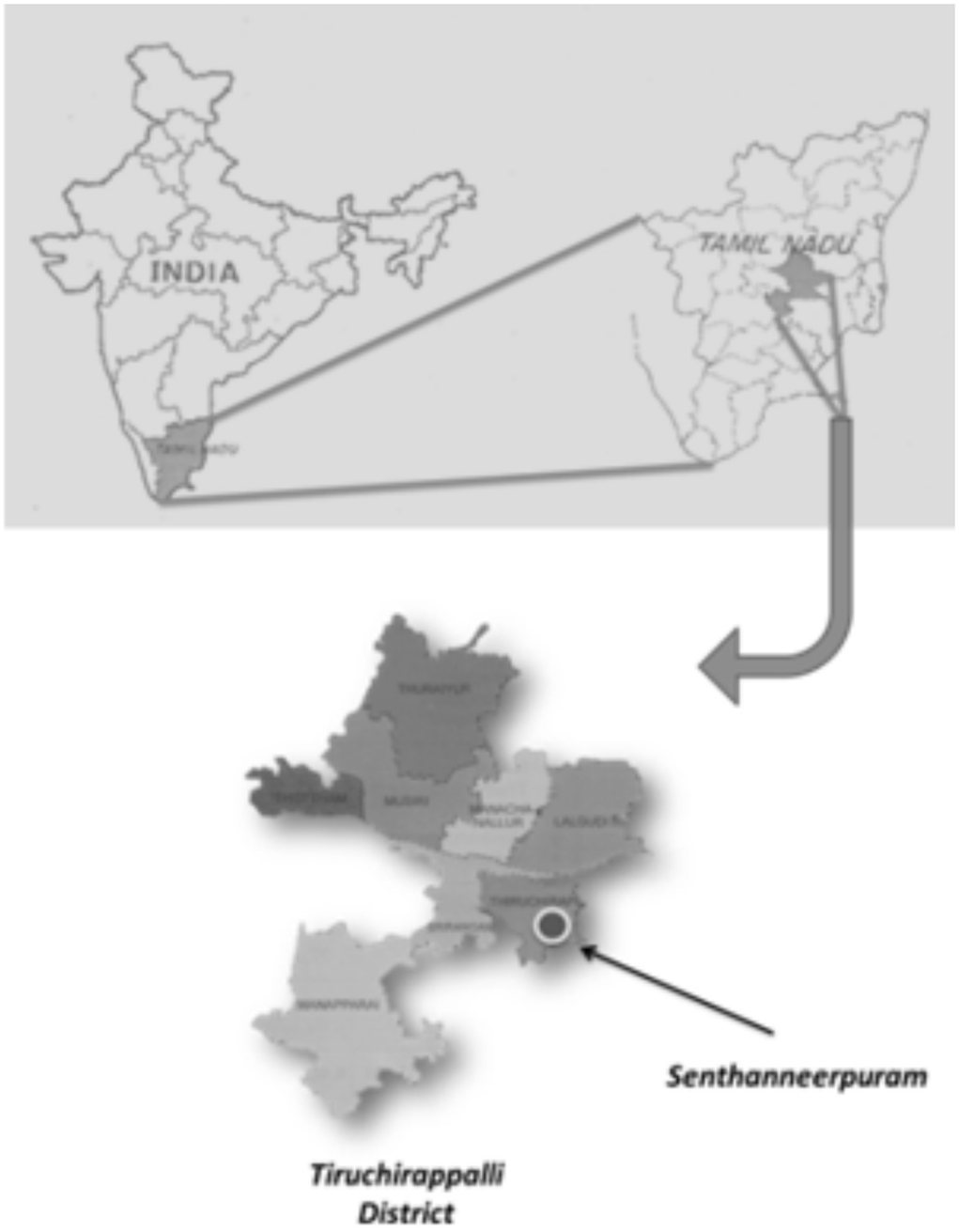


Figure 1: Location of study area.

situated near waste drainage system installed near graveyard which is found to be polluted by the infiltrations of local drainage systems; thus it seems to be of a higher pH than all other locations. In Figure 5, location 1 which is a bore well system and used as a source of drinking water is found to be of the least value and within the limits of WHO Standards (Subramanian, 2011). The values of test results for the parameter pH vary from the minimum value of 6.74 at location 1 and to the maximum of 6.98 at location 3. The average value of the pH of water samples collected from all the six locations is 6.84. So it is observed that this range does not violate the desirable limit (6.5–8.5) of WHO Guidelines. It is concluded that the water quality in this locality is slightly acidic and never basic.

Chlorides content is analysed using Argentometric Titrations in laboratory by titrating against silver nitrate solution which is found to be uneconomical to use. So the sample water is diluted to 50% using distilled water and titrated again to find out the results. As observed

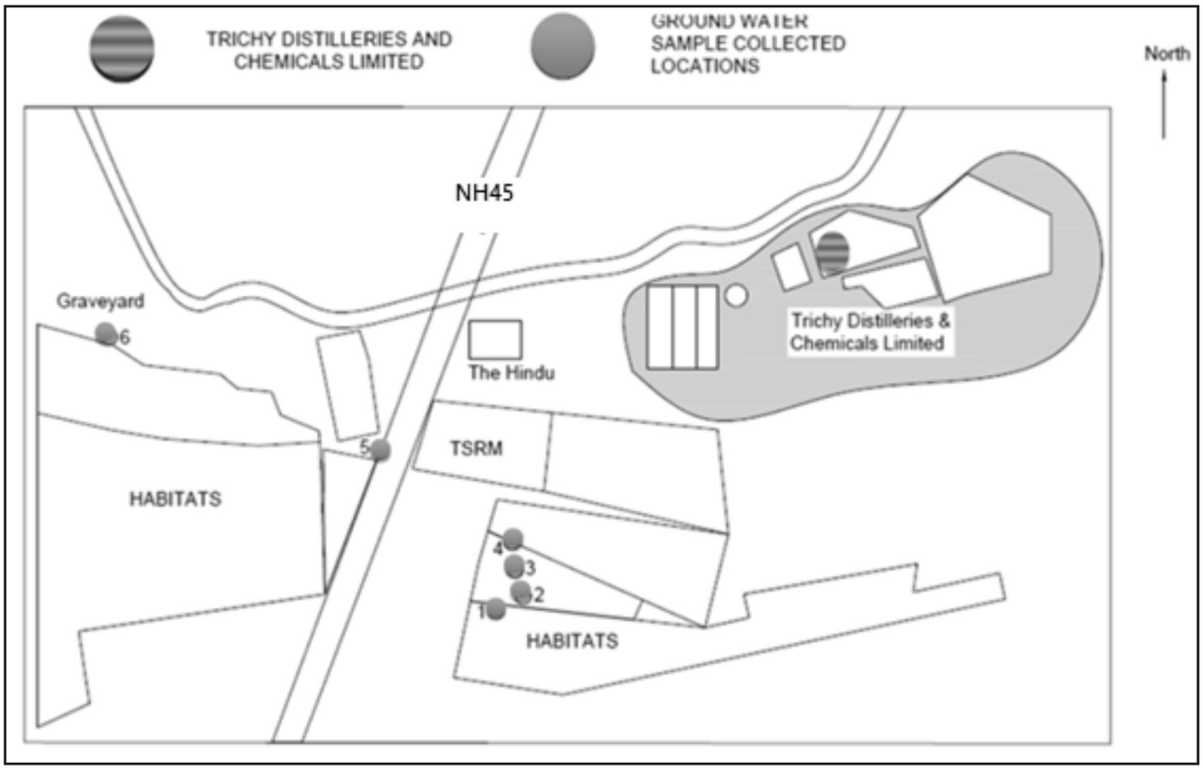


Figure 2: Ground water sample location points.

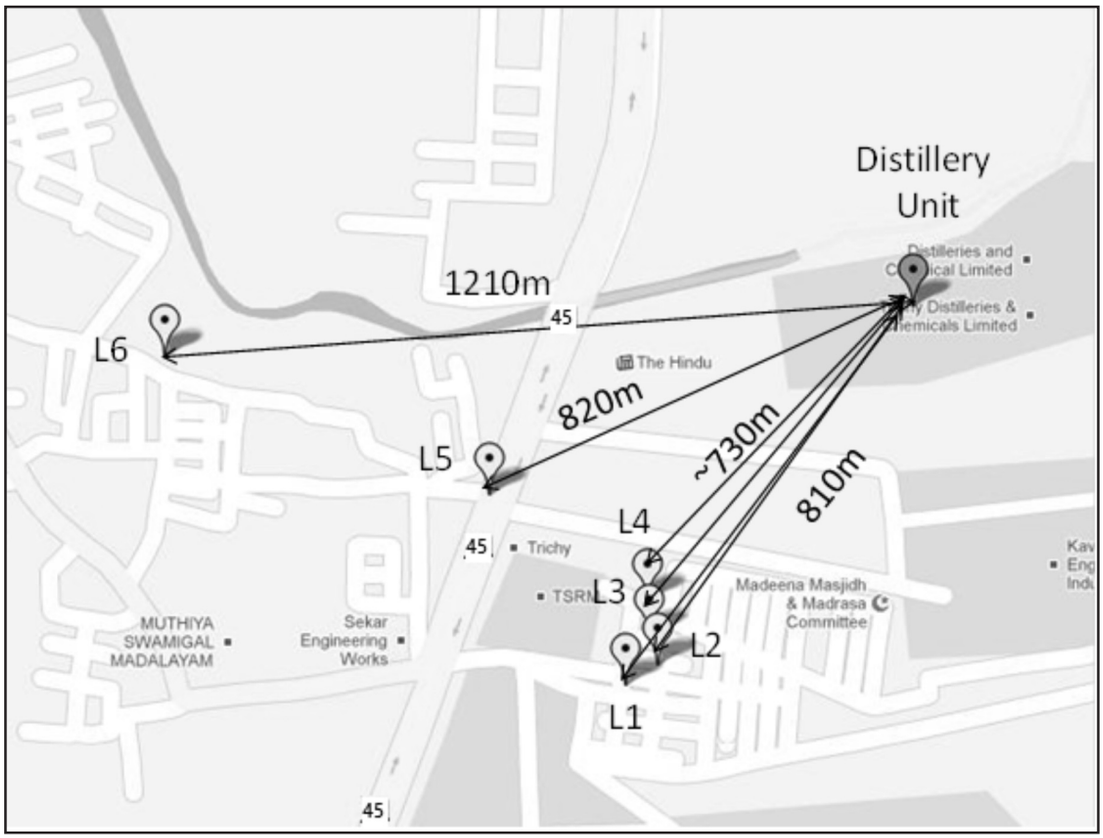
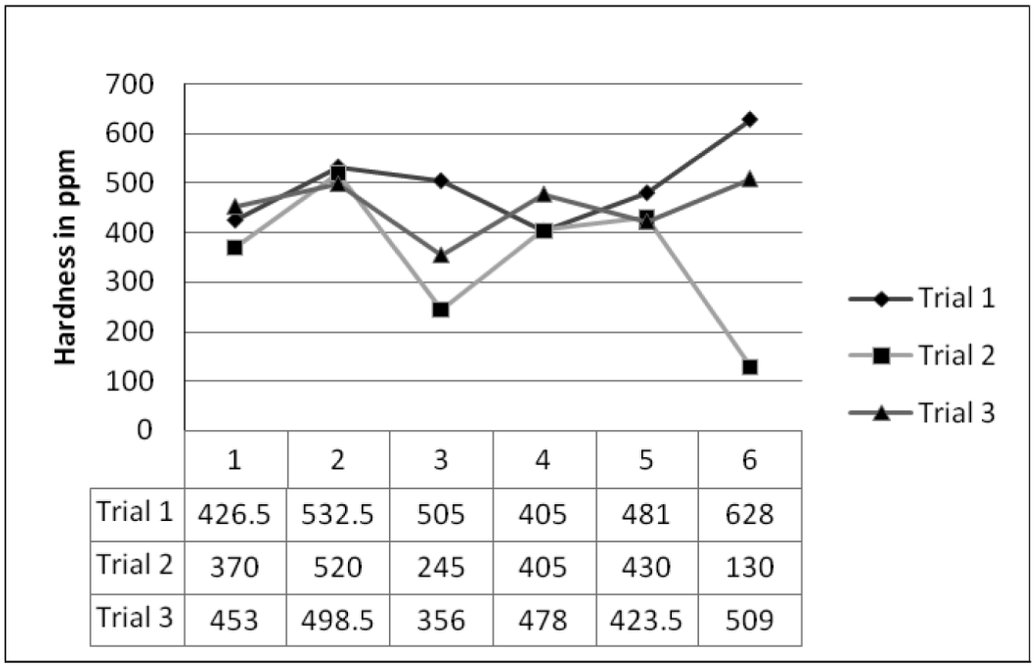
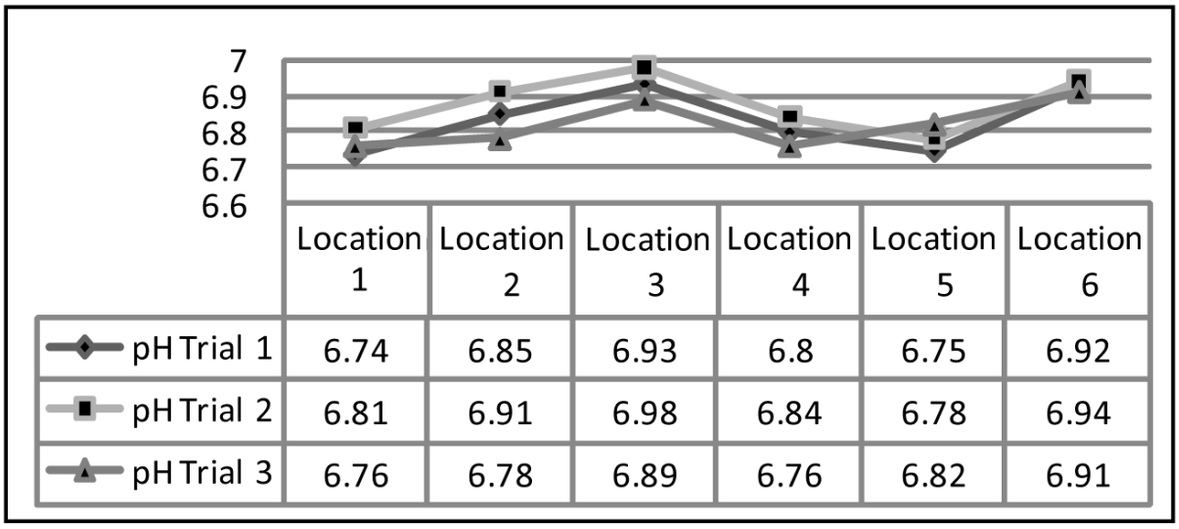


Figure 3: Map showing the locations of sampling points and their distance from distillery unit.



	1	2	3	4	5	6
Trial 1	426.5	532.5	505	405	481	628
Trial 2	370	520	245	405	430	130
Trial 3	453	498.5	356	478	423.5	509

Figure 4: Variation of hardness.



	Location 1	Location 2	Location 3	Location 4	Location 5	Location 6
pH Trial 1	6.74	6.85	6.93	6.8	6.75	6.92
pH Trial 2	6.81	6.91	6.98	6.84	6.78	6.94
pH Trial 3	6.76	6.78	6.89	6.76	6.82	6.91

Figure 5: Variation of pH.

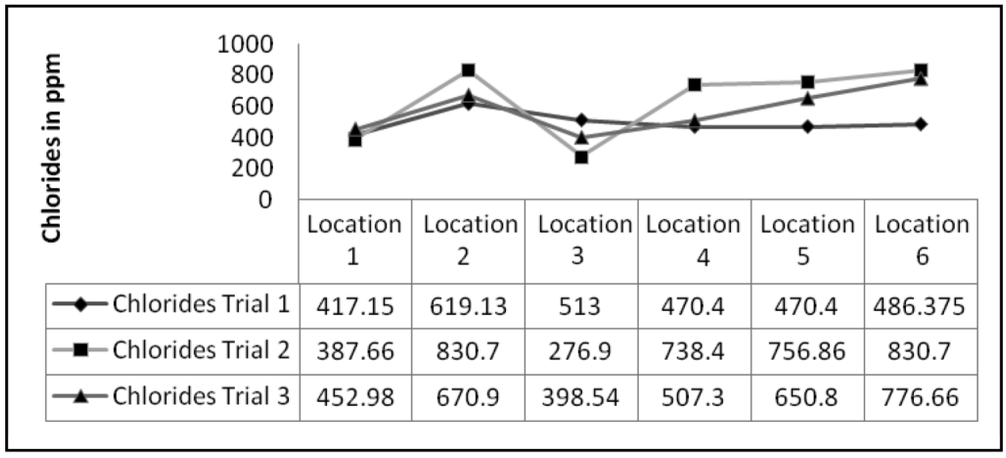
earlier, location 3 which is taken from open well is found to be of low concentration of chloride ions as that of hardness value which is also found to be minimal in that area. The values of test results for the amount of chlorides vary from the minimum value of 276.9 ppm at location 3 and to the maximum of 830.7 ppm at location 6 shown in Figure 6. The average value of the chlorides of water samples collected from all the six locations is 570 ppm. So it is observed that average value is twice as much as the desirable limit (250 ppm) of WHO Guidelines. This will affect corrosion and palability of colour. If the water is used for bathing purposes, it can severely damage the hair follicles and result in moderate hair loss.

Sulphate ion concentration is analysed in laboratory using Turbidmeter checking the amount of turbidity created using reaction of sulphate ion with barium chloride forming turbid nature equalizing with that of the su1phate ion present. Sulphate ion concentration is found to be low value in location 1 whereas other

factors seem to be of not lesser concentrations out there. Thus we can come to a conclusion that all the mineral concentration is less in location 3 than that of location 1. In Figure 7, the values of test results for the amount of sulphates varies from the minimum value of 136 ppm at location 3 and to the maximum of 393 ppm at location 5. The average value of the sulphates of water samples collected from all the six locations is 280 ppm. It is observed that maximum value is nearly two times higher than the least desirable value (200 ppm) of WHO Guidelines. So there is a possibility for occurrence of gastro-intestinal problems for people who use the water for drinking and cooking purposes.

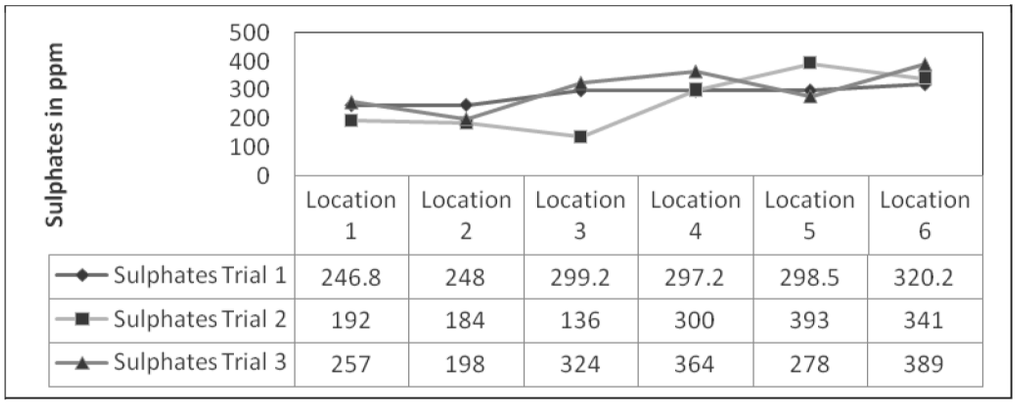
Alkalinity is analysed in laboratory using volumetric titrations following a sequential of titrating the sample against standard HCl using methyl orange and phenolphthalein as indicators. Alkalinity may be of carbonate, bicarbonate and hydroxide ions and the average of all three alkaline values is averaged and tabulated below. Location 1 is found to be of lesser alkalinity value which also denotes the lesser pH value in that location. The highest value of alkalinity goes to location 6 which also has pH as its higher value due to environmental conditions there shown in Figure 8. The values of test results for the amount of sulphates vary from the minimum value of 200 ppm at location 4 and to the maximum of 450 ppm at location 2. The average value of the alkalinity of water samples collected from all the six locations is 320 ppm. So it is observed that maximum value is nearly 60% higher than the least desirable value (200 ppm) of WHO Guidelines. This may cause minor effects like sour taste of water due to the alkaline nature (Dhillon and Dhillon, 2003; Venkatesan et al., 2013).

Amount of total dissolved solids is the concentration of solids that is in suspended condition with that of water sample. This can be found out by heating the water sample at its boiling point evaporating all of water molecules leaving just the solid content behind thereby; difference in values provided with the amount of total dissolved solids present. Figure 9 shows the TDS values found to be lesser in location 1 which is one of the



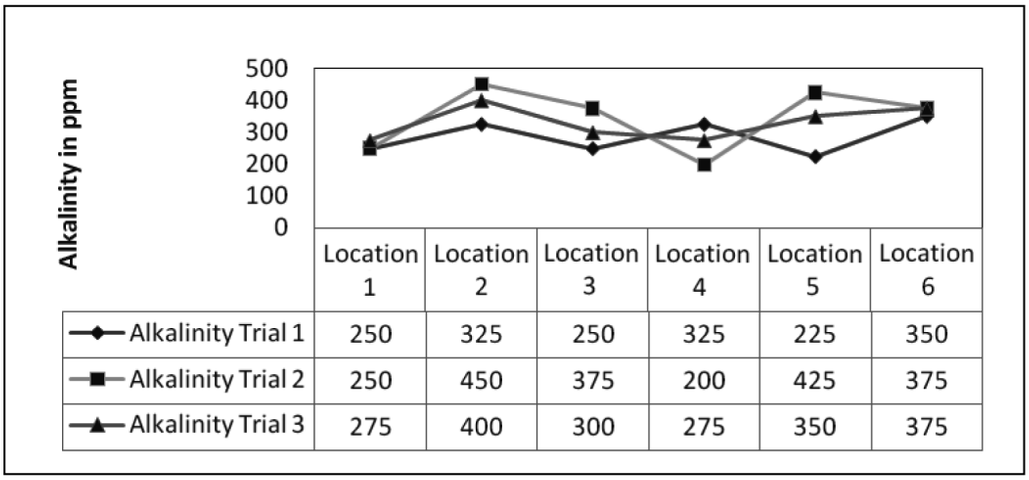
	Location 1	Location 2	Location 3	Location 4	Location 5	Location 6
Chlorides Trial 1	417.15	619.13	513	470.4	470.4	486.375
Chlorides Trial 2	387.66	830.7	276.9	738.4	756.86	830.7
Chlorides Trial 3	452.98	670.9	398.54	507.3	650.8	776.66

Figure 6: Variation of chlorides.



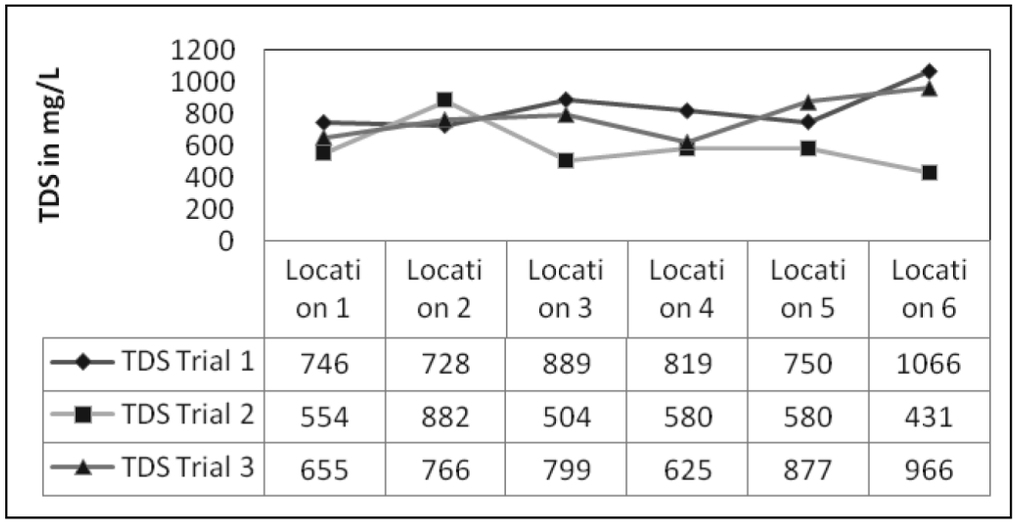
	Location 1	Location 2	Location 3	Location 4	Location 5	Location 6
Sulphates Trial 1	246.8	248	299.2	297.2	298.5	320.2
Sulphates Trial 2	192	184	136	300	393	341
Sulphates Trial 3	257	198	324	364	278	389

Figure 7: Variation of sulphates.



	Location 1	Location 2	Location 3	Location 4	Location 5	Location 6
Alkalinity Trial 1	250	325	250	325	225	350
Alkalinity Trial 2	250	450	375	200	425	375
Alkalinity Trial 3	275	400	300	275	350	375

Figure 8: Variation of alkalinity.



	Locati on 1	Locati on 2	Locati on 3	Locati on 4	Locati on 5	Locati on 6
TDS Trial 1	746	728	889	819	750	1066
TDS Trial 2	554	882	504	580	580	431
TDS Trial 3	655	766	799	625	877	966

Figure 9: Variation of total dissolved solids.

drinking water sources and that source is still used for domestic purposes. Location 6 due to the environmental condition there is found to be of higher concentration of TDS value. The values of test results for the amount of TDS varies from the minimum value of 430 mg/L at location 6 to a maximum of 1065 mg/L. The average value of the TDS of water samples collected from all the six locations is 735 mg/L. It is observed that maximum value is nearly two times higher than the least desirable value (500 mg/L) of WHO Guidelines. So the water can be used for drinking purposes without any objection. The solids present in ground water, besides affecting the growth of the plants directly, also affect the soil structure, permeability and aeration, indirectly affecting the plant growth (Senthilnathan and Azeez, 1999).

The dissolved oxygen amount in water should be in the range 5-8 ppm. The average value of test results for DO is 5.8 ppm. So this is acceptable for domestic purposes. Comparison of various quality parameters for ground water are tabulated in Table 1.

The COD and BOD values in the groundwater samples are very less so that they could not be measured. They are identified to be less than 2 ppm. These characteristics are mainly related with effluent discharge and sewage waters. So the ground water is unaffected and can be utilized without any hazardous behaviour regarding COD and BOD.

Turbidity was measured using turbidity meter. The least desirable and maximum permissible values of turbidity in terms of NTU are 5 and 10 units

Table 1: Comparison of various quality parameters for ground water

Parameters			*Hardness*	*pH*	*Chlorides*	*Sulphates*	*Alkalinity*	*TDS*
Units			*ppm*	*No.*	*ppm*	*ppm*	*ppm*	*mg/L*
WHO (1984)	Highest desirable		100	6.5-8.5	250	200	200	500
	Max permissible		500	7.0-8.5	1000	400	600	2000
Concentration in the study area	Location 1	Max	426.5	6.81	452.98	257	275	745
		Min	370	6.74	387.66	192	250	553
	Location 2	Max	532.5	6.91	830.7	248	450	882
		Min	520	6.78	619.13	184	325	728
	Location 3	Max	505	6.98	513	324	375	889
		Min	245	6.89	276.9	136	250	504
	Location 4	Max	478	6.84	738.4	364	325	819
		Min	405	6.76	470.4	297.2	200	580
	Location 5	Max	481	6.82	756.86	393	425	876.54
		Min	430	6.75	470.4	278	225	580
	Location 6	Max	628	6.94	830.7	389	375	1066
		Min	130	6.91	486.38	320.2	350	431
Undesirable effect produced beyond max allow limit			Encrustation in water supply and adverse effect on domestic use	Taste effects mucus membrane and water supply system	Corrosion and palatability occurs	Causes gastro-intestinal irritation In case of Mg or Na sulphates	Unpleasant taste	Causes gastro-intestinal irritation

respectively. The groundwater samples are having an average value of 2.3 NTU. So it is observed that the water is suitable for consumption without any hesitation for the people. The presence of nickel was affirmed using UV Spectroscopic method. That is found to be 30 ppm approximately. This is certainly under the desirable limits as per WHO Guidelines. No trace for chromium using analytical methods was identified through colourimetric experiments.

Variation of surface water quality parameters are shown in Figure 10. There is no vulnerable finding regarding physical characteristics of water samples

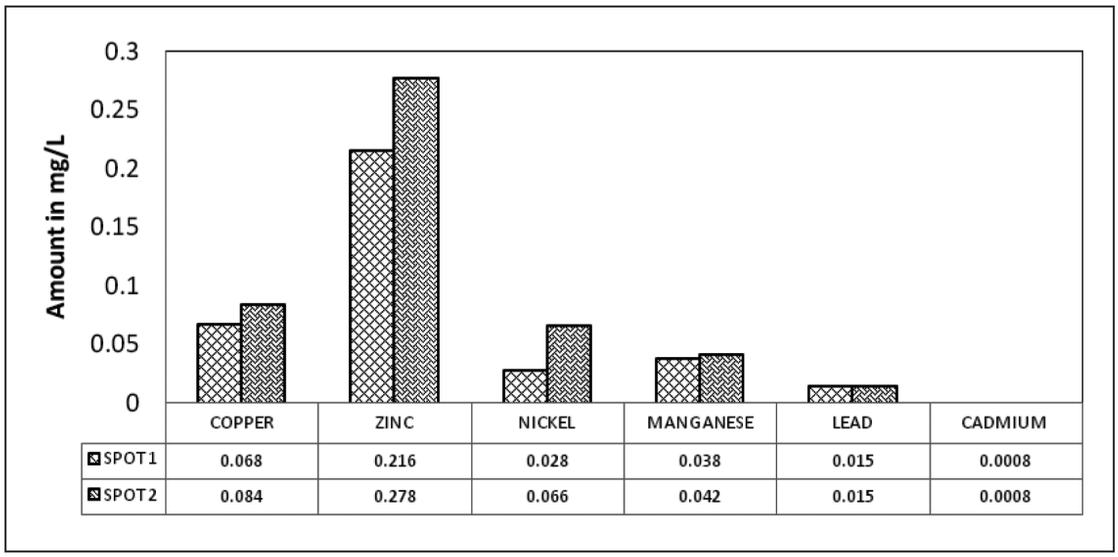


Figure 10: Variation of surface water quality parameters.

like colour, odour and taste. These are judged visibly and manually. The taste of the water is slightly saline to moderately sour. Results of surface water quality parameters are tabulated in Table 2. People who usually consume fresh and pure water would find the condition of the water in this locality objectionable. The inhabitants in the locality are used to it due to the scarce sources of fresh ground water. The fresh water hand pumps have become polluted over years and only few useful pumps are in operation presently.

Table 2: Results of surface water quality parameters

Parameter	*Spot 1*	*Spot 2*	*Average*
	All units in ppm		
BOD	< 2*	< 2*	< 2*
COD	24	24	24
Copper	0.084	0.068	0.076
Zinc	0.278	0.216	0.247
Lead	<0.015*	<0.015*	<0.015*
Cadmium	<0.0008*	<0.0008*	<0.0008*
Nickel	0.066	0.028	0.047
Manganese	0.042	0.038	0.04

*Denotes minimum detectable values by the instruments.

Conclusion

The average value of hardness is 3.68 times higher than WHO standards and the hardness value of sample 6 collected in location 6 alone is 5.28 times higher than desirable value. pH values are found to be in limits of 6.5–7.5 for all the six locations of ground water; thus the ground water sample is not affected. Chlorides also seem to be of 5.8 times greater than normal hardness limit in the location 6. Location 2 has high amount of chlorides contamination due to soil wastages dumped into the place and water drawn from that location is not utilized for drinking. Whereas the lowest level of chlorides values exceeds the highly desirable value by 0.269 times. Sulphates seems to be at lower values in all the six locations, the highest of all occurs in location 5 which exceeds the highly desirable value by 1.93 times which seems to be in the range of maximum permissible. Alkalinity is found to be greater in location 2 which is 2.5 times greater than the highly desirable value and it is also within range of maximum permissible. TDS values are also found to be greater in location 6 exceeding the desirable value by 5.66 times and also exceeding the maximum permissible value. Dissolved oxygen is found to be in the range of 5.6–5.8 for all samples when tested with a DO meter. Chromium is found to be within the limits which cannot be detected by normal laboratory methods whereas nickel is found to be in the range 30–32 ppm which is also within standard limits thus not affecting the sample's characteristics. COD and BOD for groundwater samples are found to be within limits that is undetectable in nature, thus bringing up the fact that ground water may not be polluted by the effluent discharge.

The correlation charts that depict the variation of the average values of parameters with respect to distance confirm that no significant impact of distillery effluents are reflected in the decline of groundwater quality in Senthanneerpuram location. Being hardness as the greater concern there we can conclude that after treating with processes like reverse osmosis or desalination of water this groundwater source can be better suited for drinking purposes as per the standards of the World Health Organisation.

The surface water quality is also found not to be vulnerable. The water seems turbid with simple observation in the canal. Yet, when samples are collected in clean plastic bottles, they are found to be nearly transparent as the ground water in the location has very little opacity. Parameters like BOD, lead and cadmium are below least detectable value. COD was 24 mg/L and copper, zinc, nickel and manganese were in the average values of 0.076 mg/L, 0.246 mg/L, 0.047 mg/L and 0.040 mg/L respectively for the two locations where samples were collected before and after the effluents were released from the distillery unit into the Uyyakondan Canal. It is advisable that this water is not suitable for drinking and other domestic purposes, since it is physically highly polluted and stinky. Further investigation may be carried out to find the causes for high levels of hardness and chlorides in the ground water. Also, studies may be continued to analyze the surface water pollutants in many locations along the sides of the Uyyakondan Canal.

References

APHA (2011). Standard methods for the examination of water and wastewater analysis (22nd ed.). American Public Health Association, American Water Works Association.

Andreadakis, A., Noutsopoulos, C. and E. Gavalaki (2003). Assessment of the water quality of lake plastira through mathematical modeling for alternative management scenarios. *Global Nest: The International Journal*, **5(2):** 99-105.

Bharti, N. and D. Katyal (2011). Water quality indices used for surface water vulnerability assessment. *International Journal of Environmental Sciences*, **2(1):** 154-173.

Bibi Saima Zeb, Amir Haider Malik, Amir Waseem and Qaisar Mahmood (2011). Water quality assessment of Siran river, Pakistan. *International Journal of the Physical Sciences*, **6(34):** 7789-7798.

Dasgupta, A.M. and K.M. Purohit (2001). Status of surface and groundwater quality of Mandiakadar - Part II: Agricultural Utilities. *Pollution Res*., **20(2):** 219-225.

Deborah Chapman (1996). Water Quality Assessments: A Guide to Use of Biota Sediments and Water in Environmental Monitoring. Second Edition. United Nations Educational Scientific and Cultural Organization; World Health Organization and United Nations Environment Programme.

Dhillon, K.S. and S.K. Dhillon (2003). Quality of underground water and its contribution towards selenium enrichment of the soil-plant system for a seleniferous region of northwest India. *Journal of Hydrology*, **272(1-4):** 120-130.

Godwin Billy Mensah (2008). Effect of some biological and physico-chemical factors on the water quality of river ankobra and its major tributaries. Master of Science Thesis, Kwame Nkrumah University of Science and Technology.

Ikem, A., Osibanjo, O., Sridhar, M.K.C. and A. Sobande (2002). Evaluation of groundwater quality characteristics near two waste sites in Ibadan and Lagos, Nigeria. *Water, Air and Soil Pollution***, 140:** 307-333.

Jain, A.K. (2009). River pollution. APH Publishing, New Delhi.

Satya Narayana, T. and B. Guru Prasad (2006). Hydrogeological Study of Sub-surface Waters. *Nature, Environment and Pollution Technology*, **5(3):** 459-461.

Senthilnathan, S. and P.A. Azeez (1999). Influence of Dyeing and Bleaching Industries on Ground Water of Tirupur, Tamilnadu, India. *Bull. Environ. Contam. Toxicol*, **62:** 330-335.

Senthil Kumar, D., Satheeshkumar, P. and P. Gopalakrishnan (2011). Ground water quality assessment in paper mill effluent irrigated area—Using multivariate statistical analysis. *World Allied Sciences Journal*, **13(4):** 829-836.

Shaji, C., Nimi, H. and L. Bindu (2009). Water quality assessment of open wells in and around Chavara industrial area, Quilon, Kerala. *Journal of Environmental Biology*, **5(30):** 701-704.

Subramanian, A. (2011). In ground water quality assessment of Nagercoil town (hand pumps). *Journal of Environment and Earth Science*, **1(1):** 1-5.

Venkatesan, G. and G. Swaminathan (2009). Review of chloride and sulphate attenuation in ground water nearby solid-waste landfill sites. *Journal of Environmental Engineering and landscape management*, **17(1):** Ia-Ig, doi: 10.3846/1648-6897.2009.17.Ia-Ig

Venkatesan, G., Swaminathan, G. and R. Nagarajan (2013). Study on the groundwater quality in and around solid waste landfill site at Tiruchirappalli, Tamil Nadu, India. *International Journal of Environmental Engineering*, **5(2):** 179-196.