International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 03 | Mar -2017 www.irjet.net p-ISSN: 2395-0072

Hydro-chemical Assessment of Ground water in and Around Kariapatti Region

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Abstract - *Water is the most valuable natural resource for the human survival and ecosystem. The quality of water is usually described according to its physical, chemical and biological characters. Rapid industrialization and indiscriminate use of chemical fertilizers and pesticides in agriculture causes heavy and varied pollution leading to deterioration of water quality. The present study was carried out at 18 different localities in and around Kariapatti region, Virudhunagar district, Tamilnadu. The ground water samples were collected from the selected locations and analyzed for different physico-chemical parameters such as pH, turbidity, alkalinity, hardness, electrical conductivity, calcium, magnesium, iron, manganese, ammonia, nitrate, nitrite, phosphate, BOD, DO, chloride, fluoride, sulphate. Water quality index was calculated to classify suitability for drinking purpose. The results were compared with the Bureau of Indian Standards. The results shows that the water from the most of the study area has higher physio-chemical characteristics. The water quality index shows that most of the sampled area falls on the poor and very poor category. Out of 18 sampled sites 3 sites (Pappanam coloney, Kizhavaneri, Thoppur) ground water is unfit for drinking. Therefore, these areas need some attention on purification of water.*

Key Words: Hydro-chemical, Water Quality index, Ground water, BIS, BOD, DO.

1. INTRODUCTION

Water plays an important role in the life of all living organism. Chemical formula of water is H_2O. It exists in three states namely solid, liquid and gas. Water is universal solvent used as media for bio-chemical as well as chemical reaction. Water is essential for all living organism. Life cannot run without water. On earth 97.2% of water is salty and 2.8% is fresh water from which about 20% constitutes ground water. Rapid growth of industrialization, population urbanization spoils the ground water. Once ground water gets polluted, it cannot be restored by stopping the pollutants from their source. According to WHO, about 80% diseases in human being are caused by water. Certain properties which are not possessed by surface water are possessed by ground water, so ground water is highly valued. The main objective of the hydro-chemical analysis of ground water is to check the suitability of the ground water for drinking, agriculture and industrial purpose.

2. STUDY AREA

Kariapatti is a town panchayat in district of virudhunagar. It is located at 9°42' north latitude and 78°06' east longitude. The city is located at the height of 85m from the sea level. The samples were collected from the 18 villages around this city.

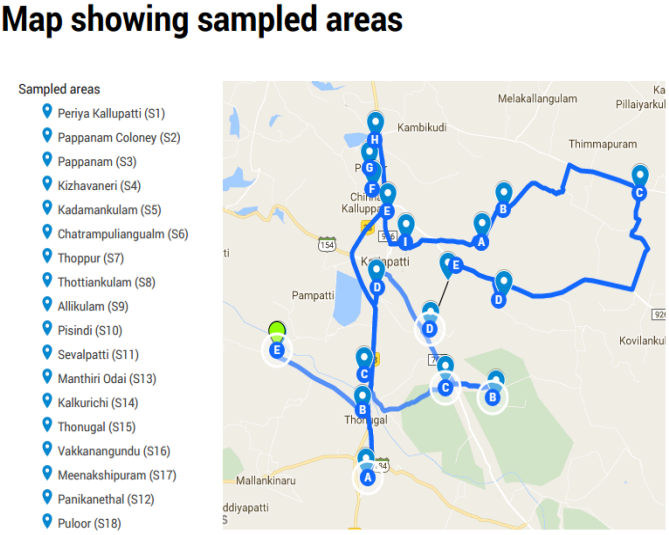

Fig-1 Map showing sampled area

3. MATERIAL AND METHODOLOGY

The ground water samples were collected from selected area. Samples were collected from the Hand pump and Power pump. Clean 1liter water bottle was rinsed several times with distilled water which was being sampled. At every point 3liters of water samples were collected. Samples were transported to the laboratory for further testing.

At each sampling point, users of the waters were interviewed. Interviewees were asked about the uses they make with the water. They were asked about their perception on the quality of the water, as well as their experience that they could link to the use of the water in their various activities.

The pH of the water was determined by the pH meter. The samples were analyzed chemically and physically by standard procedures. Physical parameters like electrical conductivity was find out by Hatch conductivity meter and turbidity with Nephlometric meter. The chemical parameters like nitrates, ammonia, chloride, total alkalinity, total hardness, sulphate, iron estimation were done with spectrophotometrically. Fluoride was estimated by colorimetric SPADNS method. Calcium and magnesium were determined by EDTA titration method. Dissolved oxygen (DO) and Biochemical oxygen demand (BOD) were estimated by Wrinkler method with Azide modification.

4. RESULT AND DISCUSSION

The results of the samples are listed in table 1 and 2

Table 1 Physio-chemical characteristics of ground water in and around Kariapatti region

Parameter	S1	S2	S3	S4	S5	S6	S7	S8	S9
Colour	NO	Brown	NO	Brown	NO	NO	NO	NO	NO
Turbidity	2.3	10.6	3.2	8.1	2	1.6	8.6	2.3	2.1
TDS	455	942	621	3867	1176	923	2453	489	14.09
EC	659	1365	900	5604	1704	1338	3555	709	2042
pH	7.4	7.9	7.9	8.5	8.4	7.9	7.5	7.7	8.5
pH Alkalinity	0	0	0	24	`12	0	0	0	20
Total Alkalinity	105	295	264	1067	416	259	452	129	723
Total Hardness	182	307	154	1212	202	267	667	162	182
Ca	50	85	42	335	56	74	184	45	50
Mg	14	23	11	90	15	20	50	12	14
Fe	0.17	0.93	0.24	0.71	0.17	0.12	0.79	0.19	0.17
Free Ammonia	0.17	0.07	0.15	0.17	0.07	0.14	0.09	0.12	0.24
NO_2	0.02	0.04	0.03	0.02	0.01	0.01	0.01	0.02	0.03
NO_3	2	2	1	5	2	2	3	2	6
Cl	77	166	73	1045	232	232	808	106	113
F	0.8	0.6	0.8	1.5	1	1.2	1.6	0.4	1.2
So_4	86	83	43	516	111	132	219	75	49
Po_4	0.04	0.06	0.02	0.2	0.07	0.08	0.13	0.05	0.09
DO	5	7	28	26.7	7.2	6	6.4	2	10
BOD	4.3	5.4	25.4	23.5	5	5.4	5.8	1.2	8
WQI	54.28	151.58	64.91	218.15	69.74	71.55	174.98	56.32	47.24

Table 2 Physio-chemical characteristics of ground water in and around Kariapatti region

Parameter	S10	S11	S122	S13	S14	S15	S16	S17	S18
Colour	NO	Brown	NO	NO	NO	NO	NO	NO	NO
Turbidity	2.8	1.2	0.8	0.4	0.7	2	0,8	0.6	0
TDS	1472	1380	3552	3772	1248	684	1920	3576	1068
EC	2133	1900	6100	3100	3900	1000	5200	1500	1900

pH	8.1	7.5	8	7	7.08	7.4	7.59	7	7.36
pH Alkalinity	0	12	24	14	12	0	25	11	13
Total Alkalinity	796	450	990	470	180	290	230	2330	250
Total Hardness	273	510	710	970	500	180	570	400	350
Ca	75	142	198	271	139	49	159	111	97
Mg	20	61	83	112	60	24	68	49	43
Fe	0.23	0.28	0.36	0.4	0.15	0.25	0.34	0.3	0.4
Free Ammonia	0.15	0.4	0.5	0.5	0.7	0.3	0.5	0.4	0.4
NO_2	0.03	0.4	0.8	1	0.8	0.7	0.7	0.6	0.9
NO_3	2	120	100	96	45	120	80	90	125
Cl	83	190	1260	870	360	100	800	250	290
F	1.4	1	3	1.5	1	2	1.5	2	1.5
So_4	42	89	500	360	154	54	323	112	127
Po_4	0.05	0.08	0.06	0.04	0	0	0.05	0	0.07
DO	18.3	14.3	8.5	9.7	4.4	5.9	5.4	3.7	4.6
BOD	15.8	12.7	7,3	8.7	2.5	2.9	2.3	3.1	3.3
WQI	76.42	89.62	94.48	76.76	39.5	49.35	76.59	45.75	84.78

pH

pH values range from the 7-8.5 for the collected samples, as per Bureau of Indian Standards, it can be 6.5-8.5. So there is no problem in accordance with pH of the water. Although no health based guidelines are proposed for pH but sometimes, eye irritation and other skin disorders are associated with values of pH greater than 11 (Sajid *et al.,* 2012). The water having pH range 10 to 12.5 can cause hair to swell and in sensitive individuals gastrointestinal irritation may occur. The lower values will also lead to similar effect (Khan and Ahmad, 2001).

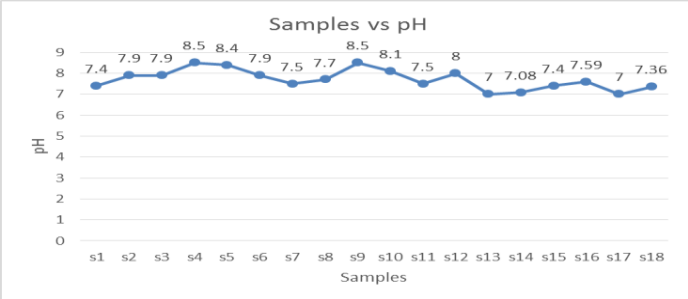

Chart-1: pH of samples

Total dissolved solids

Total dissolved solids (TDS) comprise mainly of inorganic salts (bicarbonates, chlorides and sulphates of calcium, magnesium, potassium and sodium) and some small amounts of organic matter that are soluble in water. In other words, the total dissolved solids concentration is the sum of the cations and anions in the water. Therefore the total dissolved solids test provides a measure of the amount of dissolved ions but does not tell us about the nature of ions. Total dissolved salts in drinking-water originate from natural sources, sewage, urban runoff, industrial wastewater and chemicals used in the water treatment process and the nature of the piping or hardware used to convey the water, that is, plumbing. TDS values ranges between 455 & 3867 mg/L. Most of the water samples have TDS level above the permissible limits recommended by BIS (500 mg/L). High level of TDS indicates high concentration of dissolved ions, which render water non-potable, corrosive and of salty or brackish taste (Sajid *et al.,* 2012).

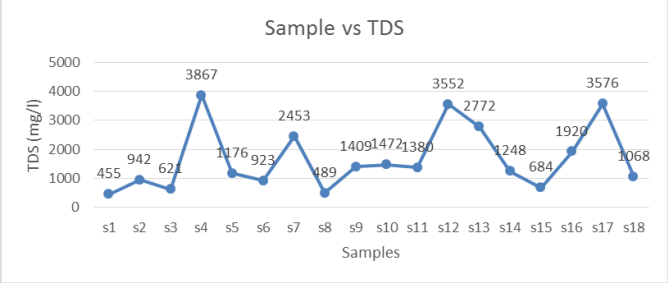

Chart-2: TDS of samples

Turbidity

Turbidity is not a much a health concern as an indicator of health risk. Science has proven that turbidity increases the health problem particularly for at risk population such as newborns, the elderly and people with compromised immune system. The samples have the turbidity ranges from 0-10.6(NTU). As per BIS turbidity should be 1NTU, most of the samples exceed the limit and may lead to health problem in that study area.

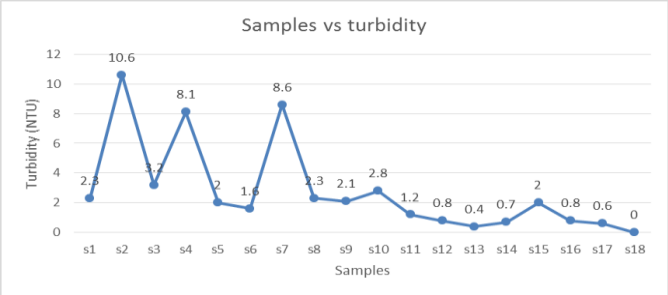

Chart-3: Turbidity of samples

Hardness

Hardness values ranges from 154-1212 mg/L in the collected samples. The maximum limit of the hardness as per BIS is 200 mg/L. Mostly the values ranges above the permisible limits. Hardness is due to carbonates, bicarbonates, sulphates and chlorides of Ca and Mg (Sajid *et al.,* 2012). Hardness in water leads to the over consumption of soap and forms clogging in pipe line by deposition of salts.

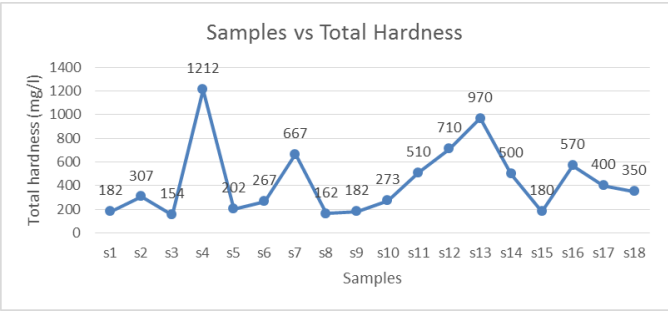

Chart-4: Hardness of samples

Alkalinity

Alkalinity is a measure of the amount of acid (H^+ ion), water can absorb to get a designated pH. Alkalinity of the samples range between 105-2330 mg/L, where as BIS has suggested the permissible limit of 200 mg/L. Beyond the permissible limit, alkalinity causes problems like hardness of kidney stone, gas trouble, severe irritation of the eye, skin and mucus membrane (Sajid *et al.,* 2012).

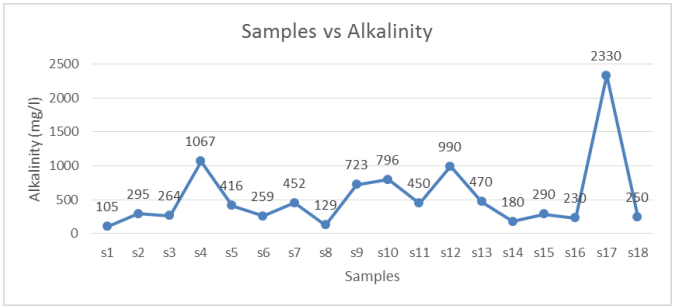

Chart-5: Alkalinity of samples

Sulphate

Sulphate is one of the least toxic anions. However, catharsis, dehydration and gastrointestinal irritation have been observed at high concentration (Sajid *et al.,* 2012). The permissible level recommended by BIS is 200 mg/L for sulphate. The Sulphate content of water varies from sample to sample and ranged from 42 to 516 mg/L. In 5 samples areas sulphate level is above the critical level and may cause above-mentioned diseases.

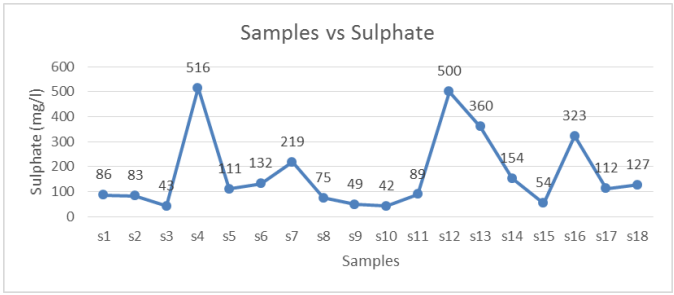

Chart-6: Sulphate of samples

Chloride

Chloride is normally associated hardness as it readily reacts with Ca, Mg and forms salts. The results show that the chloride level of water samples is in the range of 73 to 1260 mg/L. Certain areas have chloride level above the BIS limit that is, 250 mg/L. High level of chloride may cause gastrointestinal problems, irritation, diarrhoea and dehydration (Sajid *et al.,* 2012). Excessive level of chloride imparts taste problem.

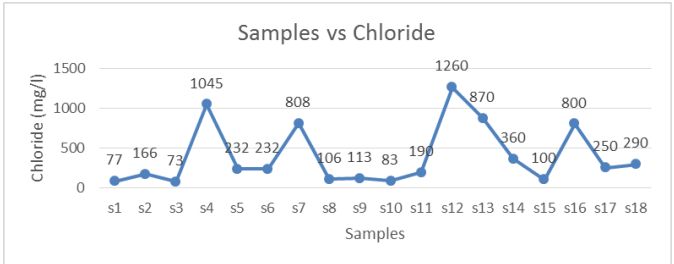

Chart-7: Chloride of samples

Iron

The concentration of iron in samples varies from 0.12 to 0.93 ppm. The permissible limit of iron is 0.30 ppm in drinking water defined by BIS. Iron limits for drinking water are based on aesthetic parameters rather than on toxicity. The major disadvantage of the presence of iron in water is that it increases the hazard of pathogenic organism because most of these organisms need iron to grow (Khan *et al.,* 2001). Concentration above permissible limits leads to metallic taste and also causes anemia. Most of the samples in our study are have Fe concentration above critical level.

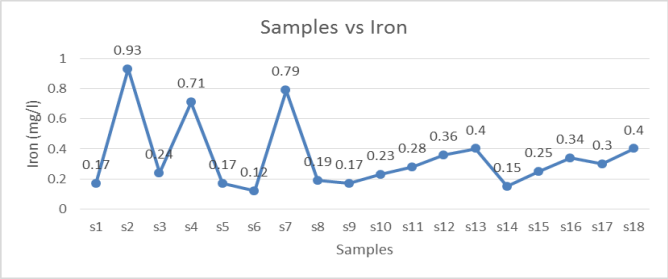

Chart-8: Iron of samples

Electrical conductivity

Electrical conductivity of the sample areas ranges from 659 to 6100 mho/cm. The limited of samples electrical conductivity suggested by BIS is 750-2250 mho/cm (Muthulakshmi *et al.,* 2009). Mostly the samples have higher values than the permissible limits.

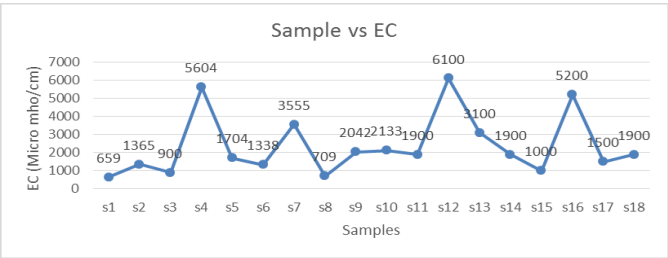

Chart-9: Electrical conductivity of samples

Nitrate

Nitrate in drinking water causes problems for infants, especially those under the age of 6 months. This can cause a condition known as " Blue baby syndrome". Excess nitrates decreases the ability of blood to carry vital oxygen through the body. The nitrate values ranges 2-125 mg/L, as per BIS the permissible limit of the nitrate is 45 mg/L.

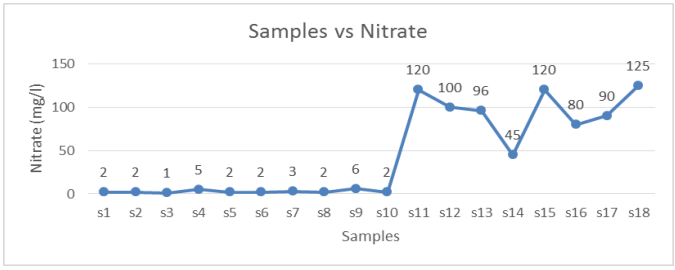

Chart-10: Nitrate of samples

Calcium and Magnesium

Calcium and magnesium ions are the major component of the hardness of water, if their concentration are high, the water is said to be hard water and it has salty taste. It may lead to the kidney stone problems and in some cases fatal occurs. According to BIS the range of calcium and mangnesium is 75 mg/L and 30 mg/L respectively and from our results it ranges 42-335 mg/L and 11-112 mg/L respectively.

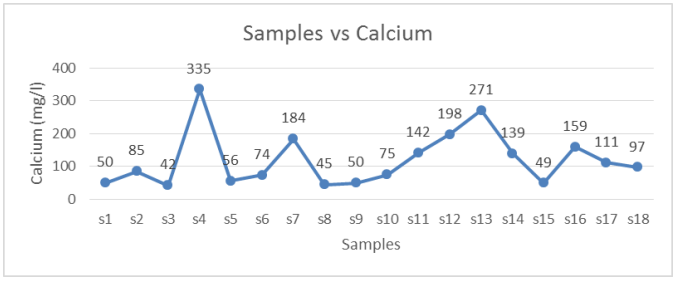

Chart-11: Calcium of samples

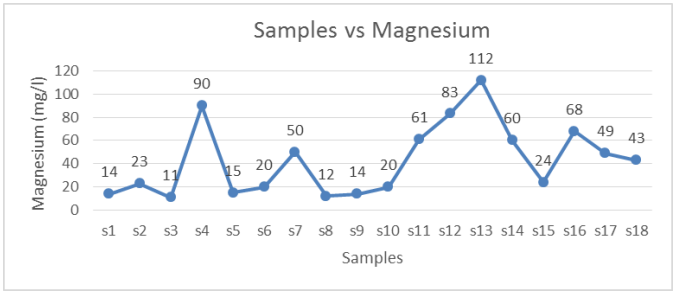

Chart-12: Magnesium of samples

Nitrite

Nitrite in water causes similar problem related to the excess amount of nitrate in water. WHO sugessted that the maximum amount of nitrite in drinking water is 1 mg/L. The sample renges the value from 0.02 to 1.0 mg/L. All the values of nitrite with in the limit.

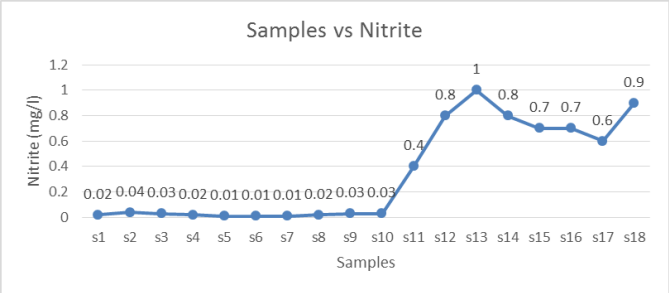

Chart-13: Nitrite of samples

Fluoride

Maximum permisible limit of flouride content in drinking water is 1 mg/L. In the sampled area it valued from 0.4 to 3 mg/L. Fluoride is essential for the animals and humans upto 1 mg/L suggested by BIS. Low concentration provides protecion against dental carries, especially in children. Elevated fluoride intakes can also have more serious effect on skeletal tissues.

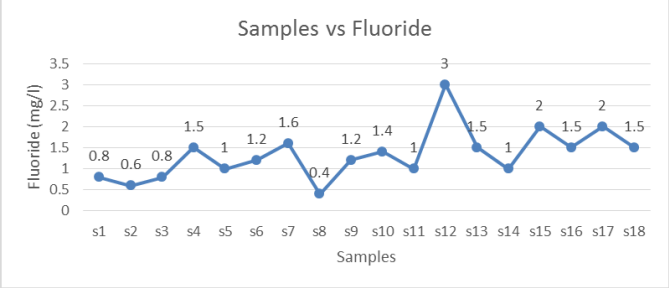

Chart-14: Fluoride of samples

Phosphate

Phosphate level in water leads to the digestive problem in humans. The level of phosphate in drinking water is 0.1 mg/L as per WHO. The of samples phosphate ranges from 0 to 0.2 mg/L.

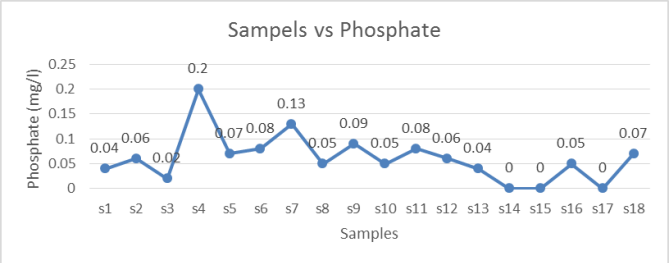

Chart-15: Phosphate of samples

Free ammonia

Ammonia is administered in the form of ammonium salts, the effects of the anion must also be taken into account. With ammonium chloride, the acidotic effects of the chloride ion are greater importance than those of the ammonium ion. At a dose of more than 100 mg/kg of body weight per day (33.7 mg of ammonium ion per kg of body weight per day), ammonium chloride influences metabolism by shifting the acid–base equilibrium, disturbing the glucose tolerance, and reducing the tissue sensitivity to insulin. As per BIS the permissible limit of ammonia is 0.5 mg/L. In the study area it ranges from 0.07 to 0.7 mg/L.

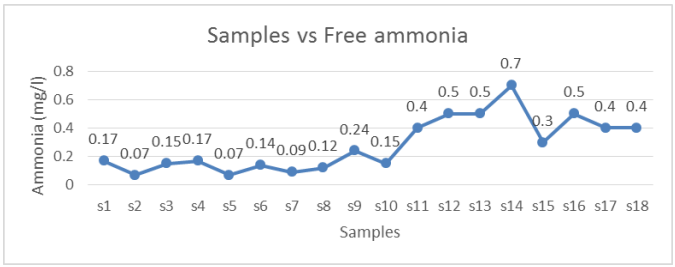

Chart-16: Free ammonia of samples

Dissolved oxygen

Dissolved oxygen in water must be with in 4 ppm as per BIS. The DO in the sampled area ranges from 2 to 28 ppm. Higher level of DO in drinking water makes taste better but it leads to corrosion of pipe lines, if it exceeds 5 ppm.

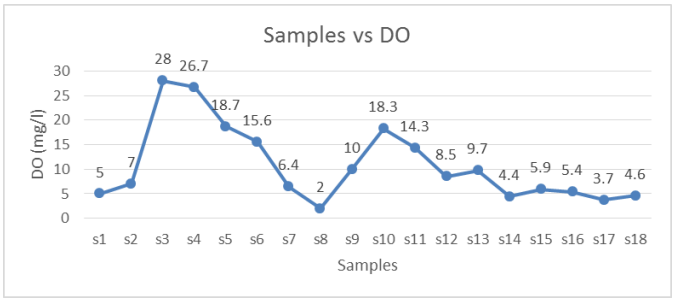

Chart-17: Dissolved oxygen of samples

Bio-chemical oxygen demand

BOD is the amount of oxygen necessary to decompose the organic matter by micro-organism and chemical process. High range of BOD means the high range of microbial content in the water. As per BIS the maximum permissible range of BOD is 5 ppm. The of samples BOD in study area is 1.2-25.4 ppm.

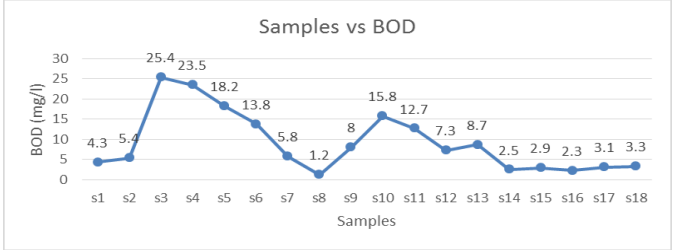

Chart-18: Bio-chemical oxygen demand of samples

3.1 Water Quality Index

WQI is a dimensionless number that combines multiple water-quality factors into a single number by normalizing values to subjective rating curves. Factors to be included in WQI model could vary depending upon the designated water use and local preferences. Some of these factors include DO, pH, BOD, COD, total coliform bacteria, temperature, and nutrients (nitrogen and phosphorus), etc. These parameters occur in different ranges and expressed in different units. The WQI takes the complex scientific information of these variables and synthesizes into a single number.

Calculation procedure (Gorde *et al.,* 2013)

Water Quality Index =Σ (Qi) Wi/Σ Wi

Quality rating, Qi = 100 [(Vn -Vi) / (Vs -Vi)]

- Where, Vn : actual amount of nth parameter, Vi : the ideal of samples this parameter, Vi = 0 except for pH and D.O.; Vi = 7.0 for pH; Vi = 14.6 mg/L for D.O., Vs : recommended WHO standard of corresponding parameter

Relative weight (Wi) = 1/Si

Water Quality Standard

Table-3: Water quality standard

Sl. No	Parameter	BIS specification
1	Appearance	Clear
2	Colour	5 Hazen max
3	Turbidity	1 NTU max
4	pH	6.5-8.5
5	EC	750-2250
6	Alkalinity	200 mg/L max
7	Fluoride	1 mg/L max
8	Chloride	250 mg/L max
9	Phosphate	0.1mg/L (WHO)
10	Sulphate	200 mg/L max
11	Total hardness	200 mg/L max
12	Calcium	75 mg/L max
13	Magnesium	30 mg/L
14	TDS	500 mg/L max
15	Free Ammonia	0.5 mg/L
16	Manganese	0.1 mg/L
17	Iron	0.3 mg/L
18	BOD	5ppm
19	DO	4ppm
20	Nitrite	1 mg/L (WHO)
21	Nitrate	45mg/L

Water quality index categories

The water quality index is categorized by their range as follows(Arjun verma *et al.,* International journal of water resources and environmental engineering feb 2013)

Table-4: Water quality index categories

Water Quality Index	Category
0-25	Excellent
25-50	Good
50-75	Poor
75-100	Very poor
Above 100	Unfit for drinking (UFD)

Calculation of water quality index

We created a spread sheet for the calculation of water quality index, using this WQI for any samples having "n" number of parameters can be calculated easily.

Parameters	values	standarc	Qi	Wi	Qi*Wi			
turbidity	0	1	0	1	0			
TDS	1068	500	213.6	0.002	0.4272			
EC	1900	1500	126.67	0.0007	0.0844			
pH	7.36	7.5	72	0.1333	9.6			
pH Alkalinity	13	0			0			
Total Alkalinity	250	200	125	0.005	0.625			
Total Hardness	350	200	175	0.005	0.875			
Ca	97	75	129.33	0.0133	1.7244			
Mg	43	30	143.33	0.0333	4.7778			
Fe	0.4	0.3	133.33	3.3333	444.44			
Free ammonia	0.4	0.5	80	2	160			
NO2	0.9	1	90	1	90			
NO3	125	45	277.78	0.0222	6.1728			
Cl	290	250	116	0.004	0.464			
F	1.5	1	150	1	150			
So4	127	200	63.5	0.005	0.3175			
Po4	0.07	0.1	70	10	700			
DO	4.6	4	115	0.25	28.75			
BOD	3.3	5	66	0.2	13.2			
				19.007	1611.5	Water Quality Inde	84.782	

Fig-2: Spread sheet for water quality index calculation

Using the spread sheet the WQI for the samples were calculated by substituting the values of the parameters find out from test results. The results were shown in the table 5

Table-5: WQI of samples

Study area	WQI	Category
Periya Kallupatti (S1)	**54.28**	**Poor**
Papanam Coloney (S2)	**151.58**	**UFD**
Papanam (S3)	**64.91**	**Poor**
Kizhavaneri (S4)	**218.15**	**UFD**
Kadamakulam (S5)	**69.74**	**Poor**
Chathirapuliangulam (S6)	**71.52**	**Poor**
Thoppur (S7)	**174.78**	**UFD**
Thotiyankulam (S8)	**56.32**	**Poor**
Allikulam (S9)	**47.24**	**Good**
Pisindi (S10)	**76.42**	**Very poor**
Sevalpatti (S11)	**89.62**	**Very poor**
Panikanethal (S12)	**94.48**	**Very poor**
Manthiriodai (S13)	**76.76**	**Very poor**
Kalkurichi (S14)	**39.5**	**Good**
Thonukal (S15)	**49.35**	**Good**
Vakanagundu (S16)	**76.59**	**Very poor**
Meenakshipuram (S17)	**45.75**	**Good**
Pullor (S18)	**84.78**	**Very poor**

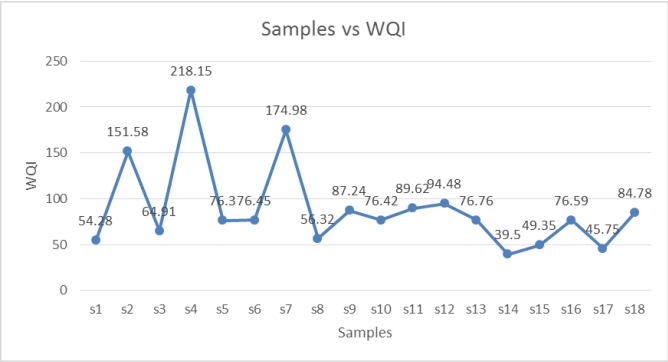

Chart-19: WQI of samples

5. RECOMMENDATION

We met and interact with the people in the sampled area and explained the necessity and importance of water. They were informed about the quality of ground water. A brief explanation about the poor quality and its effects were given. Based on discussion and sample parameters, certain suggestions were recommended.

5.1 Supply from nearby region

From the result it is observed that Pappanam coloney, Kizhavaneri, Thoppur regoins ground water is unfit for drinking.

Areas like Allikulam and Papanam has the most of the parameters with in the permissible values. Hence, supply can be taken from these areas.

5.2 Other recommendations

1. Cleaning the overhead tank regularly.
2. Recharge the ground water with rain water by rain water harvesting.
3. Maintain the ponds to its full capacity by clearing the trees in that for the collection of rain water.
4. More surveys of water quality analysis should be carried out in other communities in this region.
5. Storing and using water in clean containers.
6. Consuming the water after performing boiling process to remove excess hardness.
7. Avoiding excess usage of water to minimize the waste water generation.
8. Developing onsite treatment method to provide quality water for consumers.

6. CONCLUSIONS

The results demonstrate that the water quality obtained from the sampled areas is contaminated and 3 sites (Pappanam coloney, Kizhavaneri, Thoppur) ground water is Unfit for drinking. Relying on the natural filtration characteristics of the local soil, to filter the water as it percolates through the surrounding ground, is clearly insufficient to provide safe potable water for the majority of sampled areas. Therefore the use of hand pump and bore water is discouraged. People depend on this water are often prone to health hazards due to polluted water. There is an urgent need to develop some form of local treatment to purify ground waters for people in the region.

ACKNOWLEDGEMENT

We thank our Head of department, all the teaching and non-teaching faculties for their help and support for our work. We also thank our parents, friends and our colleagues for their encouragement in the successful completion of our project work.

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