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Study of Groundwater Quality at Dindigul Town, Tamilnadu, India

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Abstract

Contamination of drinking water by human and industrial activities is a serious concern now-a-days. Thus the analysis of the water quality is very important to preserve and protect the natural eco system. An assessment of the groundwater quality was carried out in and around Dindigul town, Tamilnadu, India. Dindigul is an interior region of Tamilnadu having landscape of 6058 sqkm. A total number of twenty three groundwater samples were taken from the bore well in and around Dindigul town with necessary precaution. All the groundwater samples were subjected to analysis of physico-chemical parameters such as pH, electrical conductivity, total dissolved solids, carbonate, bicarbonate, chloride, sodium, potassium, calcium, magnesium, nitrate, sulphate, phosphate and fluoride and biological analysis such as dissolved oxygen, biochemical oxygen demand and chemical oxygen demand. The obtained results are compared with WHO standard values. The results revealed that most of the physicochemical parameters such as fluoride, dissolved oxygen, biochemical oxygen demand and chemical oxygen demand were in high concentration at most of the groundwater sampling stations. The study of physico-chemical and biological characteristics of these groundwater samples suggest that the evaluation of water quality parameters as well as water quality management practices should be carried out periodically to protect the water resources.

Keywords: Dindigul, groundwater, physico-chemical, total dissolved solids, water quality.

Introduction

Two- thirds of the earth surface is covered by water. Water is very important to life, without water our life cannot move. Availability of quality freshwater is one of the most critical environmental issues of the twenty first century[1]. Groundwater is an important water resource for domestic and agriculture in both rural and urban parts of India.

The chemical composition of groundwater is very important criteria that determine the quality of water. Water quality is very important and often degraded due to agricultural, industrial and human activities. Even though the natural environmental processes provide by means of removing pollutants from water, there are definite limits. It is up to the people to provide security to protect and maintain quality of water[2]. Drinking water with good quality is very important to improve the life of people and to prevent diseases[3].

Pollution of groundwater comes from many sources. Discharge of waste disposal from agriculture, industries and municipalities are main source of groundwater pollution. Sometimes surface run-off also brings mud, leaves, and human and animal wastes into surface water bodies. These pollutants may enter directly into the groundwater and contaminate it.

Dindigul is the headquarters of Dindigul district and is an important growing city in the Tamilnadu state. Dindigul area is a hard rock, drought prone region and is situated in the Dindigul district of Tamilnadu, India. It lies in between $10^0 13^/$ - $10^0 26^/$ north latitudes and $77^0 53^/$ - $78^0 01^/$ east longitudes. It covers an area of about 240 km^2. The highest elevation in the hilly area (Sirumalai hill) is of order of 1350 m. But it varies from 360 m in Southern portions to 240 m in the Northern parts of the area. Runoff from precipitation within the basin ends in small streams flowing towards main river Kodaganar. The average annual rainfall is in the order of 915.5 mm during the year of 2010–2011.

Dindigul is one of the important places for its tannery units. It has more than 80 tannery units in and around the city and nearly 50 units are under processing of leather. It is the fact that the processing of leather requires large amount of freshwater along with various chemicals. Groundwater is the main source of drinking water in Dindigul. The leather industry in and around the Dindigul city pollute both surface and groundwater by discharging their wastes.

Hence the present study has been undertaken to determine the physico-chemical characteristics of groundwater in some parts of Dindigul town.

Material and Methods

The sampling places are referred as stations (S1 – S23). The stations are represented as Dindigul central bus stand (S1), Dudley school (S2), Dindigul government hospital (S3), St. Mary's school (S4), East govindapuram (S5), Dindigul taluk office (S6), Mariamman kovil (S7), Begambur mosque (S8),

District treasury office (S9), Annamalai mills girls HSS (S10), Government industrial estate (S11), Railway station (S12), SP Camp office (S13), MSP School (S14), St. Joseph Hospital (S15), Cauvery water tank (S16), Chatra kulam (S17), West Ashok Nagar (S18), K.K Nagar (S19), Rockfort (S20), Paraipatti (S21), Poochinaickan Patti (S22), Bharathipuram (S23). Water samples were collected from various bore well located in and around Dindigul town (Fig.1). The samples were collected in 1000 ml plastic bottles with necessary precaution. They were then carefully sealed, labeled and taken for analysis of physico-chemical parameters such as pH, EC, TDS, CO_3, HCO_3, Cl, Na, K, Ca, Mg, NO_3, SO_4, PO_4, F, DO, BOD and COD. The groundwater samples were subjected to physico-chemical analysis using standard procedure by APHA[4].

Results and Discussion

The groundwater samples were collected in and around the Dindigul town. The obtained results are tabulated in table-1. The experimental results are compared with the limits recommended by WHO[5] and discussed.

pH: pH is used to determine whether a solution is acidic or alkaline. The pH values of all groundwater samples are found to be in the range of 7.02 - 7.65 (table 1). The highest value of 7.65 is observed at station S3 whereas the lowest value of 7.02 is observed at station S7. The permissible limit of pH for drinking water is 7.0 - 8.5 (WHO). The groundwater sample is found to be within the acceptable limit of WHO. There is no abnormal change of pH in the groundwater samples. If the pH is found beyond the permissible limit, it affects the mucous membrane of cells[6].

Electrical conductivity (EC): The electrical conductivity values for all the groundwater samples are recorded within the range of 0.69 - 1.56 dsm^{-1}. The electrical conductance is a good indication of total dissolved solids which is a measure of salinity that affects the taste of potable water[7]. Several factors like temperature, ionic mobility and ionic valences also influence the conductivity. The electrical conductivity value for all the groundwater samples are found within the permissible limit (1.8 dsm^{-1}).

Total dissolved solids (TDS): The total dissolved solids in water are due to the presence of sodium, potassium, calcium, magnesium, manganese, carbonates, bicarbonates, chlorides, phosphate, organic matter, and other particles[8]. The values of the total dissolved solids for all the groundwater samples vary between 442 and 998 mg/l. The maximum allowable limit of total dissolved solids in groundwater for domestic purpose is 1500 mg/l (WHO). The maximum value (998 mg/l) is recorded at station S21 and minimum value (442 mg/l) is recorded at station S11. According to classification of drinking water on the basis of TDS values, all the groundwater samples are found to be non-saline. In this study, the TDS value for all the groundwater samples are well within the permissible limit of 1500 mg/l.

Carbonate and bicarbonate (CO_3 and HCO_3): Carbonate values are not found in the groundwater sample, this may be due to the low pH value. The same result was observed by Zahir and Abdul Jameel[9]. The bicarbonate values are recorded between 123 and 186 mg/l (table 1). The maximum value (186 mg/l) is observed at station S3 and minimum value (123 mg/l) is observed at station S7. The bicarbonate values for most of the groundwater samples are well within the permissible limit (150 mg/l) as per the WHO guidelines. There is slight variation of bicarbonate is observed at S1, S2 and S3. High amount of alkalinity in water is harmful for irrigation which leads to soil damage and reduce crop yields [10].

Chloride (Cl): The value of chloride for all the groundwater samples is ranged from 103 - 258 mg/l. Most of the groundwater samples show chloride values within the acceptable limit (250 mg/l) of WHO. The groundwater sample at station S2 has slightly excess chloride (258 mg/l). Excess chloride (>250 mg/l) imparts a salty taste to water. Excessive chloride in potable water is particularly not harmful but the criteria set for chloride value is based on its potentially high corrosiveness. Soil porosity and permeability also play an important role in building up the chloride value[11]. Increase of chlorine level in water is injurious to people suffering due to heart and kidney diseases.

Sodium (Na): Sodium and potassium are naturally occurring elements in groundwater. These two elements are directly added into groundwater from industrial and domestic wastes and contribute salinity of water[12]. The value of sodium for the groundwater samples is recorded in the range of 20 - 96 mg/l. The highest value of sodium is recorded at station S2 and lowest value of sodium is recorded at station S10. From this study, it is confirmed that the value of sodium for the groundwater sample is well within the permissible limit (200 mg/l) suggested by WHO. High concentration of sodium ion in drinking water may cause heart problems and High sodium ion in irrigation water may cause salinity problems[13].

Potassium (K): Sodium and potassium are the most important minerals occurring naturally. The potassium values for the groundwater samples are observed between 0.12 and 0.25 mg/l. High amount of potassium in the groundwater sample is due to the presence of silicate minerals from igneous and metamorphic rocks[9]. The maximum value (0.25 mg/l) of potassium is observed at station S4 and minimum value (0.12 mg/l) is observed at five stations (S1, S7, S10, S12 and S19) (Table 1). On comparison with the WHO standard value, it is found that the potassium values for all the groundwater samples are well within the maximum permissible limit (12 ppm).

Calcium (Ca): Calcium may dissolve readily from carbonate rocks and lime stones or be leached from soils. But calcium is an essential nutritional element for human being and aids in the maintaining the structure of plant cells and soils[12]. In this investigation, the estimated calcium values are recorded between 74 and 220 mg/l. For most of the groundwater samples,

the calcium values are found within the maximum permissible limit (200 mg/l). The calcium value is slightly higher than permissible limit at station S1, this may be due to the cationic ion exchanges with sodium.

Magnesium (Mg): The magnesium values are recorded between 48 and 95 mg/l for the groundwater samples. The highest value of magnesium is observed at station S4 and the lowest value of magnesium is observed at station S3. On comparison with the WHO standard value of magnesium, in this study it is confirmed that the magnesium value for all the groundwater sample is within the maximum permissible limit (150 mg/l). Magnesium generally occurs in lesser concentration than calcium because of dissolution of magnesium rich minerals is slow process and calcium is more abundant in earth crust[14].

Fluoride (F): The value of fluoride for the groundwater samples is recorded between 2.47 and 5.26 mg/l. The maximum allowed limit of fluoride according to WHO is 1.0 mg/l. The fluoride values for all the groundwater samples are well exceeding the permissible limit. High concentration of fluoride in groundwater may be due to breakdown of rocks and soils or infiltration of chemical fertilizers from agricultural land. The high concentration of fluoride in the study area poses a sign of water quality problem. Skeletal fluorosis is an important disease due to presence of high fluoride content in groundwater[15].

Nitrate (NO_3): The value of nitrate in all the groundwater sampling stations is found between 0.02 and 0.09 mg/l (table 1). The acceptable limit of nitrate is 45 mg/l according to WHO. The presence of nitrate in groundwater may be due to leaching of nitrate with the percolating water. The contamination of groundwater may be due to sewage and other wastes rich in nitrates[16]. Toxicity of nitrates in infants causes methaemoglobiaemia[17].

Sulphate (SO_4): The sulphate values for the groundwater samples are exhibited between 42 and 97 mg/l. The maximum value (97 mg/l) is noted at station S2 and minimum value sulphate (42 mg/l) is noted at S13. The sulphate values for all the groundwater samples are well within the permissible limit (200 mg/l) of WHO. High concentration of sulphate may cause gastro – intestinal irritation particularly when magnesium and sodium ions are also present in drinking water resources[18].

Phosphate (PO_4): The value of phosphate in the groundwater samples lie between 0.01 to 0.06 mg/l. Highest value (0.06 mg/l) is recorded at station S4 and minimum value (0.01 mg/l) is recorded at station S11. In this present study, the phosphate values are found within the permissible limit (0.1 mg/l) of WHO. Normally groundwater contains only a minimum phosphorus level because of the low solubility of native phosphate minerals and the ability of soils to retain phosphate[19]. The phosphate values of all the groundwater samples do not pose any water quality problem.

Dissolved oxygen (DO): The DO values in the groundwater samples have observed from 0.2 to 0.6 mg/l. The highest value (0.6 mg/l) of DO is recorded at station S6 whereas the lowest value (0.2 mg/l) is recorded at S1, S3, S10, S12, S13 and S23. The concentration of dissolved oxygen in clean water is 8 – 10 mg/l. In this investigation, the DO is very low in all the groundwater samples. It indicates that the deoxygenation is due to biological decomposition of organic matter. The same result was supported by Muhammad Barzani Gasim[20]. The dissolved oxygen is a regulator of metabolic activities of organisms. Oxygen is generally reduced in the water due to respiration of biota, decomposition of organic matter, rise in temperature, oxygen demanding wastes and inorganic reluctant[21].

Biochemical oxygen demand (BOD): Biochemical oxygen demand is used as an experimental measure of the amount of biochemically degradable organic matter present in a water sample. The BOD value of the groundwater samples are recorded in the range of 48 to 150 mg/l. All the groundwater samples are exceeded the permissible limit (5 mg/l) of WHO. This indicates that the groundwater at all stations has suffered degradation due to continuous discharge of domestic, industrial and municipal sewage. The same results were observed by Zahir and Abdul Jameel[6]. The high value of BOD at all sampling stations indicates the pollution by biochemically degradable organic wastes from various sources.

Chemical oxygen demand (COD): COD is a measure of the oxygen required for the chemical oxidation of organic matter. The values of COD in the groundwater samples are found to be in the range of 25 - 95 mg/l. the maximum value (95 mg/l) is recorded at station S4 and minimum value (25 mg/l) is recorded at station S7. The COD values at all sampling stations are exceeded the permissible limit (10 mg/l) according to WHO. High COD may cause oxygen depletion on account of decomposition of microbes to a level detrimental to aquatic life[22].

Conclusion

Physico-chemical characterization of groundwater samples are taken from Dindigul town. 23 groundwater samples were collected from different parts of Dindigul town and analyzed for pH, EC, TDS, CO_3, HCO_3, Cl, Na, K, Ca, Mg, NO_3, SO_4, PO4, F, DO, BOD and COD using standard procedures. The values of all the groundwater samples are compared with the standard permissible value. Fluoride, dissolved oxygen, biochemical oxygen demand and chemical oxygen demand are exceeding the permissible limit in most of the groundwater samples. From the obtained results, it is suggested to monitor the groundwater quality and assess periodically in this study area to prevent the further contamination.

Table-1
Physico-chemical characteristics of groundwater of Dindigul town

	pH	EC	TDS	CO_3^{2-}	HCO_3^-	Cl^-	Na^+	K^+	Ca^{2+}	Mg^{2+}	NO_3^-	SO_4^{2-}	PO_4^{3-}	F^-	DO	BOD	COD
S1	7.26	1.12	717	-	185	216	78	0.12	220	89	0.08	96	0.02	2.87	0.20	150	85
S2	7.19	1.03	660	-	179	258	96	0.13	186	75	0.02	97	0.03	2.96	0.40	148	74
S3	7.65	1.54	986	-	186	246	85	0.15	179	48	0.06	85	0.04	2.84	0.20	123	86
S4	7.48	1.29	826	-	159	231	81	0.25	169	95	0.02	94	0.06	2.95	0.40	145	95
S5	7.50	1.16	795	-	153	131	26	0.11	118	85	0.05	59	0.03	3.63	0.23	94	38
S6	7.63	1.12	717	-	146	196	83	0.18	184	86	0.05	83	0.02	2.64	0.60	126	72
S7	7.02	0.98	627	-	123	148	26	0.12	80	56	0.05	65	0.02	2.59	0.30	56	25
S8	7.16	0.74	474	-	145	156	25	0.14	75	51	0.06	68	0.03	2.65	0.60	48	29
S9	7.23	0.89	570	-	126	147	23	0.16	74	54	0.04	57	0.05	2.48	0.40	74	32
S10	7.19	0.75	480	-	143	159	20	0.12	86	59	0.08	49	0.02	2.47	0.20	59	35
S11	7.15	0.69	442	-	129	165	21	0.16	79	53	0.03	58	0.01	2.65	0.40	56	28
S12	7.26	1.06	678	-	126	103	29	0.12	120	89	0.08	45	0.03	3.69	0.20	96	36
S13	7.25	1.12	717	-	158	125	37	0.15	136	87	0.06	42	0.05	3.48	0.20	89	35
S14	7.16	1.03	659	-	142	115	35	0.14	142	82	0.05	48	0.04	5.26	0.40	87	39
S15	7.05	1.05	672	-	126	119	31	0.13	120	86	0.03	47	0.02	4.36	0.30	84	34
S16	7.09	1.09	698	-	125	124	36	0.15	130	84	0.04	43	0.03	4.12	0.40	72	38
S17	7.45	1.15	654	-	119	121	32	0.13	125	83	0.04	52	0.04	4.52	0.40	76	34
S18	7.21	0.89	570	-	156	126	29	0.12	120	89	0.05	58	0.02	3.69	0.20	96	36
S19	7.22	1.22	781	-	129	123	37	0.15	136	87	0.08	59	0.03	3.48	0.20	89	35
S20	7.30	1.02	828	-	121	144	24	0.15	77	59	0.07	63	0.03	2.52	0.30	54	27
S21	7.06	1.56	998	-	148	136	35	0.14	142	82	0.09	62	0.02	5.26	0.4	87	39
S22	7.14	1.03	659	-	126	120	31	0.13	120	86	0.07	63	0.03	4.36	0.3	84	34
S23	7.16	1.09	698	-	136	126	36	0.15	130	84	0.02	67	0.05	4.12	0.4	72	38

All parameters are expressed in mg/l except pH and EC. EC in dsm^{-1}.

Table-2
Classification of Groundwater based on TDS

TDS mg/l	Description	No of samples
≤ 1000	Non – saline	23
1000-3000	Slightly saline	0
3000-10000	Moderately saline	0
>10000	Very saline	0

Table-3
Statistical evaluations of groundwater samples collected in and around Dindigul town.

Parameters	Minimum	Maximum	Mean	Median	SD	WHO (1992)	
						Acceptable	Allowable
pH	7.02	7.65	7.25	7.21	0.17	7.0 – 8.5	6.5 – 9.2
EC	0.69	1.56	1.07	1.06	0.21	-	-
TDS	442	998	691.56	678	140	500	1500
CO_3	-	-	-	-	-	-	-
HCO_3	119	186	142.87	142	20.31	30	150
Cl	103	258	153.6	136	44.65	250	1000
Na	20	96	41.56	32	23.90	175	200
K	0.11	0.25	0.14	0.14	0.02	-	12
Ca	74	220	128.1	125	39.84	75	200
Mg	48	95	76.04	84	15.28	50	150
NO_3	0.02	0.09	0.05	0.05	0.02	45	100
SO_4	42	97	63.47	59	16.80	200	400
PO_4	0.01	0.06	0.03	0.03	0.01	0.1	1
F	2.47	5.26	3.46	3.48	0.88	-	1.0
DO	0.2	0.6	0.33	0.3	0.12	5.0	-
BOD	48	150	89.78	87	30.14	3.0	5.0
COD	25	95	44.52	36	21.13	10.0	20.0

All parameters are expressed in mg/l except pH and EC. EC in dsm^{-1}

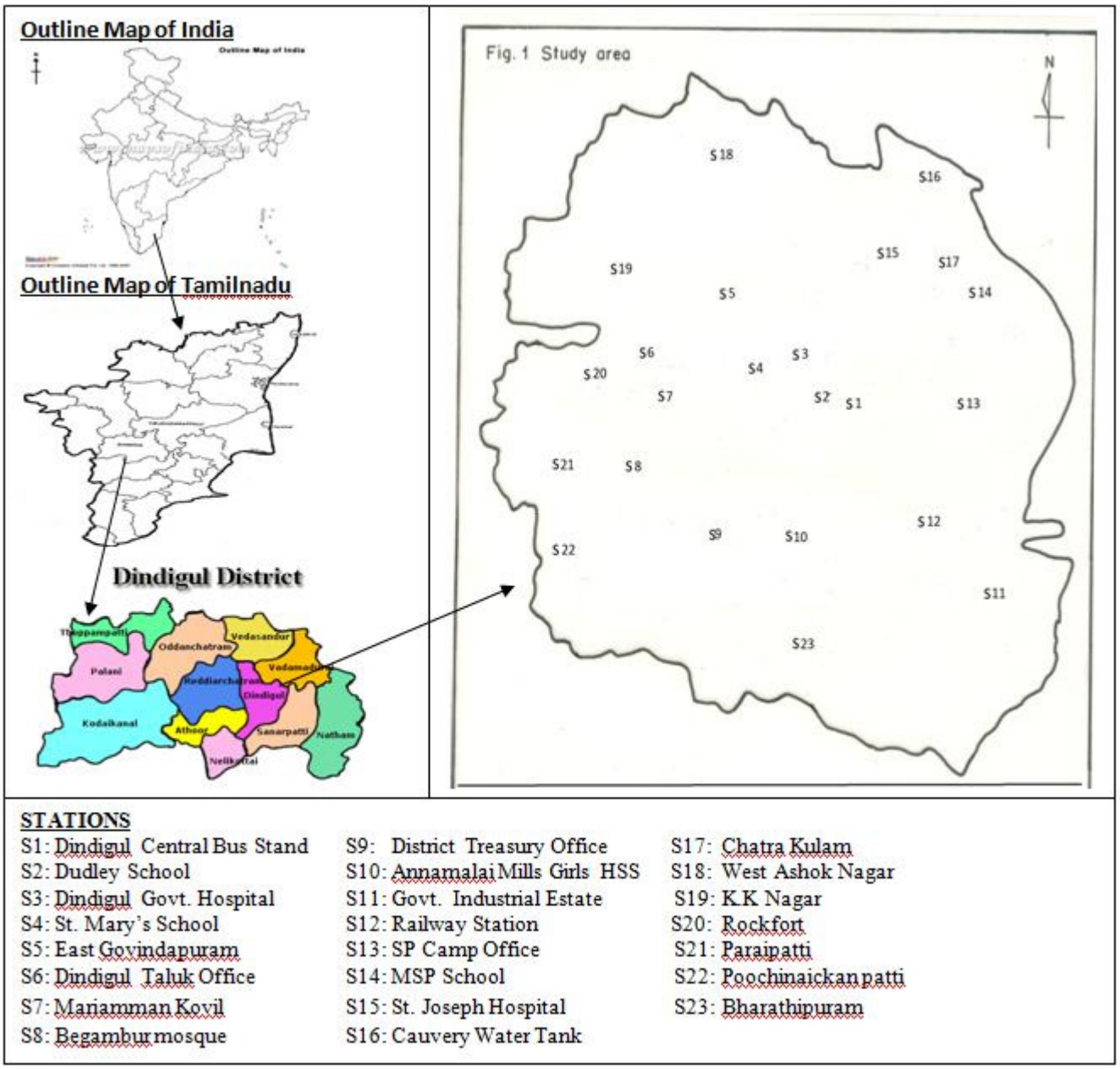

Figure-1
Location map of the Study Area

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