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Seasonal Variations of Groundwater Quality in and around Dindigul Town, Tamilnadu, India

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ABSTRACT

Dindigul is situated southwest of the state capital, Chennai. The town does not have underground drainage system. The study area is facing the problem of water pollution because of various industries. Tanneries are thickly situated in and around Dindigul town. The pollution is affecting large numbers of people and causing a detrimental effect upon their health. The aim of the present study is to assess the physicochemical parameters for the groundwater samples in summer and rainy seasons. Twenty groundwater samples collected from borewells in and around Dindigul town and subjected to physicochemical analysis. The results were compared with WHO standard. The obtained result revealed that the parameters such as EC, TDS, HCO3, Cl, K, PO4, BOD, COD, and DO exceed the permissible limit of WHO in most of the groundwater sampling stations in summer and rainy seasons. The groundwater samples were more polluted beside industrial area.

Keywords: Dindigul, Groundwater, Seasonal variation, Physico-chemical, Water quality

INTRODUCTION

Water is the precious gift of nature to all the living beings for sustenance. The suitability of water for domestic, agricultural and industrial purposes mainly depends on the chemical composition of surface and subsurface. Groundwater is the largest source of fresh water on the planet excluding the polar icecaps and glaciers. In India, 90% population depends on groundwater for drinking, domestic, agricultural and industrial purposes in several states. Several factors like discharge of agricultural, domestic and industrial wastes, land use patterns, geological formation, rainfall pattern and infiltration rate affect the quality of groundwater.

When the waste water of an industry is dumped into streams, it gets into natural sources and causes change in physicochemical composition of ground water which ultimately becomes unsuitable for human use. For a long time, Dindigul town has been a centre of the tobacco trade and a manufacturer of cigars. The study area is having sidco industrial park, paper, textile, tanning, plastic and steel industries. Tanneries are thickly situated in and around Dindigul town. At present more than 80 tannery units are well established. Processing of leather requires a large amount of fresh water along with various chemicals. Every 10 kg of raw skin tanned requires about 350 L of fresh water. Leather production involves the use of excessive water and so it generates large quantities of effluents and other wastes.

The pollution is affecting large numbers of people and causing a detrimental effect upon their health. During the past few decades, the groundwater is being contaminated and it’s giving rise to health problems and epidemics. Usage of the chemical fertilizers for agriculture and small scale industries falls heavily on the quality of the drinking water in the study area. Hence the present study has been attempted to determine the physicochemical characteristics of groundwater in and around Dindigul town in summer and rainy seasons.

MATERIALS AND METHODS

Study Area

Dindigul town is located in the southern state of Tamilnadu between 10°18' to 10°25' N latitude and 77°56' to 78°01' E longitude. It is the administrative headquarters of the Dindigul district. Dindigul is situated 420 km southwest of the state capital, Chennai covering an area of 14.01 km^2 and has an average elevation of 265 m (869 ft). Dindigul is located in the foothills of Sirumalai hills. The topography is plain and hilly with the variation resulting in climatic changes. The map of the study area is shown in **Figure 1.**

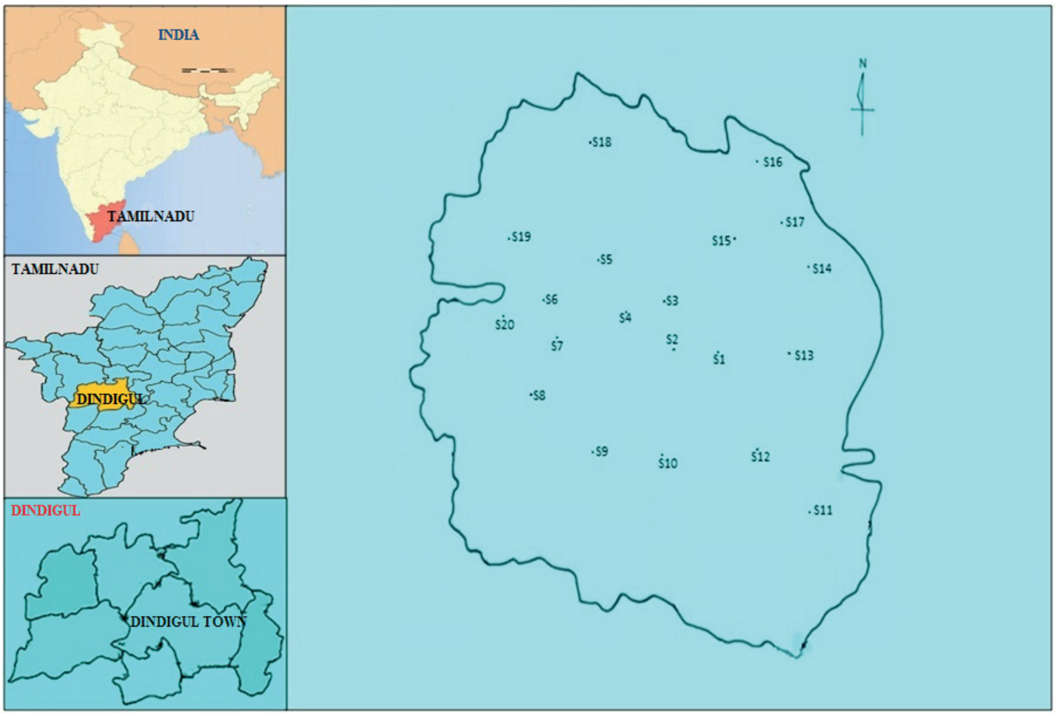

Figure 1: Map of the study area..

Sampling Stations

S1. Central Bus Stand, S2. Dudley School, S3. Dindigul Government Hospital, S4. St. Mary's School, S5. East Govindapuram, S6. Dindigul Taluk Office, S7. Mariamman Kovil, S8. Begambur Mosque, S9. District Treasury Office, S10. Annamalai Mills Girls HSS, S11. Government Industrial Estate, S12. Railway Station, S13. SP Camp Office, S14. MSP School, S15. St. Joseph Hospital, S16. Cauvery Water Tank, S17. Chatra Kulam, S18. West Ashok Nagar, S19. K.K Nagar and S20. Rockfort.

Sampling collection and analysis

Twenty groundwater samples were collected in and around Dindigul town, Tamilnadu, India for the present study. The sampling was done in summer and rainy seasons for three successive years (2012, 2013 and 2014). Groundwater samples were collected from bore well after discarding water for the first two minutes in 2 litre plastic container. Before collecting the sample, the containers were rinsed with distilled water and finally rinsed with the water sample to be collected. After that, the groundwater samples from different locations were sealed, labelled and then brought into the laboratory for detailed physicochemical parameters. All necessary precautions were taken during sampling and analysis. Preservatives such as conc. HCl and conc. H_2SO_4 were added to the samples. The collected groundwater samples were subjected to physicochemical analysis. The parameters such as pH, electrical conductivity, total dissolved solids, total hardness, carbonate, bicarbonate, chloride, sodium, potassium, calcium, magnesium, nitrate, sulfate, phosphate, fluoride, biochemical oxygen demand, chemical oxygen demand and dissolved oxygen were analysed. The standard methods of APHA [1] adopted for each parametric analysis of groundwater samples. The obtained results are compared with WHO (2011) standard of water quality parameters.

RESULTS AND DISCUSSION

The groundwater samples were collected in and around Dindigul town. The obtained results are tabulated in **Tables 1 and 2**. The experimental results are compared with the limits recommended by WHO (2011) [2] and discussed as follows.

Table 1: The mean values of physicochemical parameters of groundwater samples during summer seasons (April 2012, 2013 and 2014).

Stations	pH	EC	TDS	TH	CO_3^{2-}	HCO_3^-	Cl^-	Na^+	K^+	Ca^{2+}	Mg^{2+}	NO_3^-	SO_4^{2-}	PO_4^{3-}	F^-	BOD	COD	DO
S1	6.7	1402	703	657	36	395	235	109	17	123	85	29	85	0.29	1.33	45	48	2.8
S2	7.2	1089	679	608	36	379	333	166	16	116	77	21	139	0.39	1.21	31	42	2.9
S3	7.4	1519	1122	601	30	433	416	195	14	177	39	26	146	0.43	0.94	20	43	4.8
S4	7.3	1223	815	505	33	427	167	118	70	90	69	25	167	0.61	1.47	43	45	4.0
S5	7.4	1290	877	451	48	162	137	67	94	85	59	19	164	0.39	0.76	50	26	4.2
S6	7.7	1048	782	569	30	511	148	126	22	99	78	19	51	0.23	0.78	68	45	3.1
S7	7.1	976	770	369	28	505	125	87	111	53	59	23	83	0.31	1.66	45	27	3.4
S8	7.5	2920	1720	481	24	290	328	183	26	78	70	21	53	0.79	1.43	46	34	4.0
S9	7.2	920	630	440	28	302	423	213	13	81	57	32	109	0.52	0.65	26	28	4.1
S10	7.4	761	497	793	21	324	541	123	21	143	104	24	39	0.25	0.84	23	31	4.1
S11	7.4	708	507	624	23	332	339	72	26	110	86	18	59	0.23	0.46	45	29	3.9
S12	7.5	945	661	510	28	266	218	99	10	92	69	24	94	0.29	0.29	29	29	5.2
S13	7.7	1043	744	483	29	288	215	104	13	94	62	23	94	0.54	0.89	24	27	5.5
S14	7.7	1084	729	525	18	305	289	135	20	113	59	38	105	0.39	0.15	50	33	3.5
S15	7.5	991	567	465	27	277	209	98	13	94	56	22	88	0.26	1.07	16	28	5.3
S16	7.4	1155	747	468	25	204	372	142	16	122	60	33	135	0.27	0.24	37	27	4.9
S17	7.6	1658	1041	573	36	202	381	146	14	121	64	38	87	0.50	0.28	34	39	3.2
S18	7.5	748	528	414	29	242	167	84	9	84	50	19	92	0.26	0.42	24	35	5.0
S19	7.5	1176	968	294	30	292	233	77	14	96	64	27	78	0.34	1.15	23	36	4.4
S20	7.7	1077	848	423	28	477	122	102	10	60	67	22	49	0.37	1.70	23	49	3.2

Table 2: The mean values of physicochemical parameters of groundwater samples during rainy seasons (December 2012, 2013 and 2014).

Stations	pH	EC	TDS	TH	CO_3^{2-}	HCO_3^-	Cl^-	Na^+	K^+	Ca^{2+}	Mg^{2+}	NO_3^-	SO_4^{2-}	PO_4^{3-}	F^-	BOD	COD	DO
S1	6.8	767	629	310	29	266	256	124	22	44	49	18	51	0.25	1.26	79	31	2.9
S2	7.2	1138	778	444	43	385	500	200	28	68	62	21	137	0.27	1.16	86	30	4.4
S3	7.1	1696	1115	352	34	281	358	212	7	36	55	30	158	0.36	0.52	64	19	5.3
S4	7.1	1612	1021	1070	52	335	711	175	29	164	158	28	131	0.58	1.37	68	34	3.9
S5	7.1	645	389	391	67	275	240	143	36	85	64	20	134	0.30	0.68	49	37	3.1
S6	7.6	547	361	193	28	317	85	59	78	26	33	18	36	0.22	0.58	70	39	2.6
S7	7.3	945	579	243	22	554	144	137	53	47	31	24	70	0.25	1.40	44	40	2.9
S8	7.5	1729	1129	676	15	552	580	354	89	84	112	26	90	0.69	1.61	45	35	3.2
S9	6.9	1820	1205	787	17	529	502	321	18	63	112	48	157	0.65	0.43	52	21	4.7
S10	7.3	1907	1210	965	30	365	659	251	26	127	129	41	128	0.48	0.68	41	19	5.3
S11	7.5	1406	902	898	20	302	434	138	23	124	94	35	104	0.21	0.36	46	45	3.2
S12	7.3	1000	665	602	14	355	272	139	43	65	45	29	76	0.38	0.21	45	27	4.7
S13	7.8	862	594	386	19	262	202	140	13	35	41	18	92	0.49	0.69	44	28	5.3
S14	7.8	1213	834	451	19	362	360	185	48	75	63	39	104	0.45	0.18	74	25	5.2
S15	7.2	952	585	416	17	342	240	152	20	48	59	27	106	0.21	0.67	46	26	5.5
S16	7.4	5472	3472	2070	15	391	2472	525	83	287	207	123	242	0.63	0.21	37	35	4.6
S17	7.4	603	366	352	57	238	295	318	28	72	38	34	77	0.26	0.24	53	43	3.2
S18	7.2	815	488	647	16	383	247	168	11	55	44	19	86	0.33	0.25	55	24	5.3
S19	7.2	1158	765	455	16	417	353	156	100	94	44	26	65	0.35	0.92	55	20	5.1
S20	7.3	674	517	301	21	422	163	142	76	20	31	19	45	0.26	1.52	65	25	4.6

pH

The mean pH values are recorded in the range of 6.7-7.7 and 6.8-7.8 for the groundwater samples during the summer and rainy seasons respectively (**Tables 1 and 2**). The pH values are within the permissible limit of 6.5-8.5 (WHO 2011) in all the sampling stations. There is no abnormal change in the pH in most of the ground water sampling stations in both summer and rainy seasons. The low pH does not cause any harmful effect [3]. The reaction of minerals in rocks with water, carbon dioxide and possibly organic matter such as Humic acid and Fulvic acid changes the pH of water [4].

Electrical Conductivity

The mean electrical conductivity values are observed in the range of 708-2920 µmhocm^{-1} and 547-5472 µmhocm^{-1} for the groundwater samples in summer and rainy seasons respectively (**Tables 1 and 2**). The EC values exceed the permissible limit of 600 µmhocm^{-1} (WHO 2011) in most of the groundwater sampling stations except at station S6 in rainy seasons. Electric conductivity of water relates to the total concentration of dissolved ions in the water. The high value of EC may be due to high concentration of ionic constituents present in the water bodies. EC is directly proportional to the total dissolved solids. Percolation of industrial wastes and intrusion of sewage may also enhance the high EC values in most of the sampling stations. The high value of EC may also be due to the due to the high dissolved solids [5].

Total dissolved solids

In the present investigation, the mean TDS values are found in the range of 630-1720 mg/l and 361-3672 mg/l for the groundwater samples in summer and rainy seasons respectively (**Tables 1 and 2**). The TDS values exceed the permissible limit of 500 mg/l (WHO 2011) in most of the groundwater sampling stations in summer and rainy seasons. The higher concentrations are due to leaching of solid wastes from ground surface as well as enhanced seepage from domestic sewages. Maximum value of TDS is found at station S16 in rainy season. High level of TDS in this station may be due to the discharge from industries and untreated waste water [6]. The high level of dissolved solids may aesthetically unsatisfactory for bathing and living. Water containing high TDS concentration may cause laxative or constipation effects [7].

Total hardness

The mean total hardness values are found to be in the range of 369-793 mg/l and 193-2070 mg/l for the groundwater samples in summer and rainy seasons respectively (**Tables 1 and 2**). The total hardness values exceed the permissible limit of 500 mg/l at sampling stations S1-S4, S6, S10-S12, S14 and S17 in summer and S4, S8-S12, S16 and S18 in rainy seasons. The high value of TH is observed at station S16 in rainy season. Percolation of industrial wastes and domestic wastes enhance the TH value in this station. The total hardness values are lesser concentrations in the rainy season than in summer. High rate of evaporation increase the concentration of total hardness in the groundwater samples [8].

Carbonate and bicarbonate

The mean values of carbonate are found in the range of 18-48 mg/l and 14-57 mg/l for the groundwater samples in summer and rainy seasons respectively. The mean values of bicarbonates are found to be in the range of 162-511 mg/l and 238-554 mg/l for the groundwater samples in summer and rainy seasons respectively (**Tables 1 and 2**). The carbonate values are well within the permissible limit of 200 mg/l (WHO 2011) in all the sampling stations. The bicarbonate values exceed the permissible limit of 150 mg/l (WHO 2011) in all sampling stations in summer and rainy seasons. This may be due to the action of atmospheric CO_2 and CO_2 released from organic decomposition [9].

Chloride

The mean values of chloride are found in the range of 122-541 mg/l and 85-2472 mg/l for the groundwater samples in summer and rainy seasons respectively (**Tables 1 and 2**). The chloride values exceed the permissible limit of 250 mg/l (WHO 2011) at sampling stations S3, S8-S11, S14, S16 and S17 in summer and S1-S4, S8-S12, S14, S16, S17 and S19. High content of chloride in ground water may result from both natural and anthropogenic sources such as run-off containing salts, the use of inorganic fertilizers, landfill leachates, septic tank wastes, animal feeds, industrial effluents, irrigation drainage [10]. Soil porosity and permeability also has a key role in building up the chloride concentration in these stations [11].

Sodium

The mean values of sodium are observed in the range of 67-213 mg/l and 59-525 mg/l for the groundwater samples in summer and rainy seasons respectively (**Tables 1 and 2**). The sodium values are within the permissible limit of

250 mg/l (WHO 2011) in most of the sampling stations except at stations S8-S10, S16 and S17 in rainy seasons. High content of sodium in groundwater may be from the release of the soluble products during the weathering of rocks and minerals [12].

Potassium

The mean values of potassium are found in the range of 9-111 mg/l and 7-100 mg/l for the groundwater samples in summer and rainy season respectively (**Tables 1 and 2**). The values of potassium exceed the permissible limit of 12 mg/l (WHO 2011) in most of the sampling stations except at stations S12, S18 and S20 in summer and S3 and S18 in rainy season. The high value of potassium may be due to the presence of geochemical strata in these stations [13]. Potassium concentration also influenced by the cation exchange mechanism [14].

Calcium and Magnesium

The mean values of calcium and magnesium are found to be in the range of 53-122 mg/l and 20-287 mg/l in summer and rainy seasons and 39-104 mg/l and 31-207 mg/l in summer and rainy seasons respectively (**Tables 1 and 2**). In the present investigation, the calcium and magnesium values are within the permissible limit of 200 mg/l and 150 mg/l (WHO 2011) in most of the groundwater sampling stations in summer and rainy seasons respectively. High content of calcium and magnesium is recorded in few sampling stations in both summer and rainy seasons. The high calcium content in the ground water can be related to oxidation of organic matter, releasing free calcium in the solution in the acidic pH [15]. The concentration of magnesium also depends upon exchange equilibria and the presence of the ions like sodium.

Nitrate

The mean values of nitrate are found in the range of 18-38 mg/l and 18-123 mg/l for the groundwater samples in summer and rainy season respectively (**Tables 1 and 2**). The nitrate values exceed the permissible limit of 45 mg/l (WHO 2011) at the sampling stations S9 and S16 in rainy season. The percolation of domestic sewage, industrial wastes, dumping of garbage and leakage of septic tanks enhance the nitrate value [16].

Sulphate

The mean sulphate values are recorded in the range of 39-167 mg/l and 36-242 mg/l for the groundwater samples in summer and rainy season respectively (**Tables 1 and 2**). The sulphate values are well within the permissible limit of 250 mg/l (WHO 2011) in all sampling stations. The sulphate values are lower in rainy than summer season. This may be due to dilution effect. High level of sulphate imparts a bitter taste to water [17].

Phosphate

The mean values of phosphate are found in the range of 0.23-0.79 mg/l and 0.21-0.69 mg/l for the groundwater samples in summer and rainy season respectively (**Tables 1 and 2**). The phosphate values exceed the permissible limit of 0.1 mg/l (WHO 2011) in all the sampling stations in summer and rainy seasons. The excess concentration of phosphate may be due to percolation of domestic sewage and agricultural inputs in the study area. During the natural process of weathering, the rocks gradually release the phosphorus as a phosphate ion which are soluble in water and mineralize phosphate compounds breakdown.

Fluoride

The mean values of fluoride are found to be in the range of 0.15-1.70 mg/l and 0.18-1.61 mg/l for the groundwater samples in summer and rainy seasons respectively (**Tables 1 and 2**). The fluoride values are slightly higher than the permissible of 1.5 mg/l (WHO 2011) in most of the sampling stations. The dissolution of fluoride bearing minerals may be contributing to the high percentage of fluoride in the groundwater samples [18].

Biochemical oxygen demand

The mean values of BOD are found in the range of 20-68 mg/l and 37-86 mg/l for the groundwater samples in summer and rainy season respectively (**Tables 1 and 2**). The BOD values exceed the permissible limit of 5 mg/l (WHO 2011) in all the groundwater sampling stations in summer and rainy seasons. The high value of BOD may be due to percolation of dumping of domestic wastes, organic wastes, sewage, and industrial wastes [19].

Chemical oxygen demand

The mean COD values are found to be in the range of 26-41 mg/l and 19-45 mg/l for the groundwater samples in summer and rainy season respectively (**Tables 1 and 2**). The COD values exceed the permissible limit of 10 mg/l (WHO 2011) in all the groundwater sampling stations in summer and rainy seasons. This indicates the pollution by biodegradable and chemically degradable organic matter in the study area [20]. The high value of COD indicates high strength of organic as well as inorganic pollution in the groundwater [21].

Dissolved oxygen

The mean values of DO are found in the range of 2.8-5.3 mg/l and 2.6-5.5 mg/l for the groundwater samples in summer and rainy season respectively (**Tables 1 and 2**). The DO values are below the permissible limit of 6.0 mg/l (WHO 2011) in most of the sampling stations. The dumping of garbage and the seepage of the landfill may cause the depletion of dissolved oxygen in the groundwater. The DO values are lower in summer than rainy seasons in most of the sampling stations. This may be due to high temperature, percolation of sewage and other wastes might be responsible for low values of DO.

CONCLUSION

The present study provides significant information on the quality of groundwater in and around Dindigul town. The groundwater is most important for water supply in urban as well as rural areas in developing countries. The results of physicochemical analysis reveal that the parameters such as EC, TDS, HCO_3, Cl, K, PO_4, BOD, COD and DO exceed the permissible limit of WHO in most of the sampling stations in summer and rainy seasons. The high value of these parameters can be attributed by anthropogenic activities, effective ion leaching and discharge of effluents from agricultural and domestic wastes in summer and rainy seasons. The groundwater in this region can be used for domestic use only after pre-treatment. It is also suggested to monitor the groundwater quality and assess periodically to prevent further contamination.

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