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RESEARCH ARTICLE

Assessment of physicochemical characteristics of groundwater collected from different taluks, Dindigul district, Tamilnadu, India

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ABSTRACT

To evaluate the physicochemical characteristics, water samples were collected from thirty-three villages at Dindigul district. From the analysis, pH of the all samples were varying from 6.64 to 8.17. The pH values are within the permissible limit. In Natham taluk, bore wells samples showed extreme (991, 963 and 951 mg L^{-1}) total dissolved solids (TDS) values when compared to maximum permissible TDS is 600 mg L^{-1}. The taste of water comes under poor TDS rating. The highest total hardness (TH) 725 mg L^{-1} was tested at Silukuvarpatti bore well in Nilakottai taluk. Residual free Chlorine and Iron were not detected in any of the samples. All samples showed Nitrate (NO_3^-) concentrations were ranged from 0 to 25 mg L^{-1}. The values are less than NO_3^- desirable limit, that is 45 mg L^{-1} respectively. Maximum number of samples showed chloride (Cl^-) values were higher than Cl^- permissible limit (1000 mg L^{-1}) as referenced by BIS. The highest Cl^- values were obtained at 2950 and 2000 mg L^{-1} in Pudukkottai well and Sengulam bore well taken from Reddiyarchatiram and Natham taluks. In regards to fluoride (F^-) contamination, thirty-four samples showed < 0.5 ppm F^- and rest of fourteen samples viewed <1ppm F^-. According to BIS and WHO standard, low concentration of F- below 0.5 ppm may increase the risk of tooth decay.

Keywords: Groundwater, fluoride, physicochemical parameters

1. INTRODUCTION

Water is a necessary component for everyday life [1]. Underground water is the main source of drinking water, used for agricultural and industrial activities [2]. All over 0.2 billion people from 25 nations have health risks because high fluoride concentration in underground water [3]. Approximately 80% of the diseases in the world are due to poor quality of drinking water [4]. Contamination of groundwater can result in poor drinking water quality, loss of water supply, high clean-up costs, high expenses for alternate water supplies, and feasible health issues [5]. There is a rising worldwide consumption of anionic pollutants from industries have been concerned due to their potential risk for environment and human health [6-10]. Fluoride is a toxic element present in the groundwater due to natural and or anthropogenic sources [11]. In small amounts, F^- is a necessary component for normal mineralization of bones and formation of dental enamel [12]. It is harmful when it exceeds the permissible limit 1.5 mg L^{-1} of F^- in water [13, 14]. A very small amount of F^- can cause several biochemical alterations [15] and excessive F^- intake causes fluorosis and severe skeletal problems [16-19]. The major sources of F^- in groundwater are due to dissolution of F- bearing minerals such as fluorspar, cryolite, fluorapatite, and hydroxyapatite in rocks [20]. Some anthropogenic activities due to agricultural usage of fertilizers, pesticides and discharge of sewage and sludge have also been indicated as a cause for the increase in F^- concentration in groundwater [21]. In this work to assess the physicochemical characteristics of groundwater samples were collected in and around Dindigul district, Tamil Nadu, South India.

2. DESCRIPTION OF STUDY AREA AND SAMPLING SITES

Dindigul district is situated between latitude 10.4747°N longitude 77.8367°E. It divided into six

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different taluks. The water samples were collected from Nilakottai (latitude 10.165497, longitude 77.852451), Athoor (latitude 10.288646, longitude 77.853165), Reddiyarchatiram (latitude 10.474745, longitude 77.836728) and Natham (latitude 10.222202, longitude 78.233374) in Dindigul district. Nilakottai taluk is located in the southern part of the Dindigul district and covers about 261.12 square km and is distributed in 23 panchayat villages. Athoor is located 16 KM towards west from Dindigul district. Reddiyarchatiram taluk is a revenue block consists of 24 panchayat villages. It is bounded by Athoor taluk towards South, Dindigul block towards East, and Oddanchatram block towards west. Natham taluk is located 37 KM towards East from Dindigul district (Fig 1).

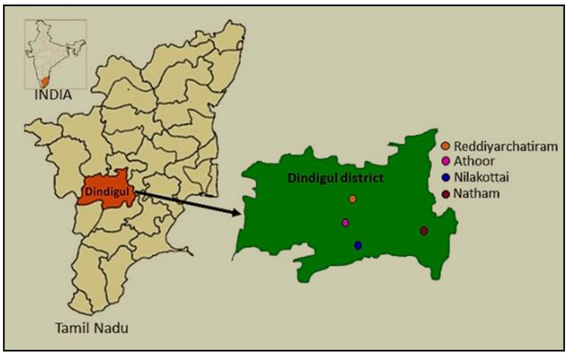

Fig 1. Samples collected in and around four taluks of Dindigul district

3. METHODOLOGY AND ANALYSIS

A total of forty-eight groundwater samples were taken from thirty-three villages of Dindigul district (Table 1). It includes 43 bore wells, 2 wells and 3 hand pumps samples were collected in sterile plastic bottles and then carefully sealed, labelled and transferred to laboratory for the analysis. The physicochemical parameters like pH, electrical conductivity (EC), total dissolved solid (TDS), and salinity was tested by multiparameter tester (PCSTestr 35, EUTECH instrument, ThermoScientific). Other characteristics, total hardness (TH), residual (free) chlorine, chloride, iron and nitrate were analysed by using multiparameter water analysis kit (Hi-media). The concentration of fluoride was estimated by LABMAN ion meter (lumion-40) with fluoride electrode combination.

4. RESULTS AND DISCUSSION

The observed pH values of all sampling sites ranged from 6.64 to 8.17 with an average value of 7.52, exhibiting the marginally alkaline condition of groundwater (Table 2). Similarly, groundwater pH (7.3-8.4) slightly basic, was collected from Dindigul district [22]. The safe limit of pH for drinking water is specified as 6.6-8.5 [23, 24] and tested water samples showed pH values were within the safe limits. The study area, EC values are in the range of 2.06 to 1890 μS cm^{-1} with an average value 826.59 μS cm^{-1} respectively (Table 2). In another finding, EC of the groundwater ranged from 150 to 5,020 μS cm^{-1} [22]. The EC of the water is one of the important parameter used to determine the suitability of water for irrigation. It is also suitable indicator for salinity or total salt content of waste water [25]. Salinity in the groundwater occurs due to the high concentration of TDS [26]. The salinity index or hazard which is correlated by EC values are the most important groundwater quality criteria for crop production [27]. The EC values of less than 750 μS cm^{-1} in the groundwater are categorized as excellent to good quality for the agricultural needs (Table 3). In this study, 20 groundwater samples are classified as class I and low to medium salinity levels suitable for high salt tolerant crops [27]. The remaining 28 samples are grouping under Class II with high salt level and permissible water quality. According to Handa [28], the samples classification are mentioned in Table 3. Based on Bureau of Indian Standards (BIS) guidelines, the ideal TDS for drinking water is below 300 mg L^{-1} and the maximum permissible limit is 600 mg L^{-1}. According to the taste of drinking water, TDS ratings can be classified as excellent (300 mg L^{-1}), good (300-600 mg L^{-1}), fair (600-900 mg L^{-1}) and poor (900-1200 mg L^{-1}) categories. The highest value of TDS 991 mg L^{-1} was observed at Karakundu bore well, Natham taluk. High level of TDS in the groundwater is due to leaching of salts from soil and also domestic sewage may penetrate into the groundwater, which may lead to increase in TDS values [29]. Consumption of water with high concentrations of TDS has been reported to cause disorders of alimentary canal, respiratory and nervous system, coronary system besides, causing miscarriage and cancer [30]. Total hardness (TH) of water samples are varying from 125 to 725 mg L^{-1}. However, TH permissible value is 600 mg L^{-1} as referenced by BIS [31]. Hardness is expressed in mg L^{-1} as $CaCO_3$, used to characterize the types of water (Table 4). In this work, few samples exhibited high TH values such as 625, 650, 675, and 725 mg L^{-1} respectively (Table 2). The highest value of 725 mg L^{-1} TH was estimated from Silukuvarpatti at Nilakottai. The increase in the maximum level of TH is due to presence of carbonate and non-carbonate compounds [32]. Iron and residual free Chlorine values were not found in any of the samples. In general nitrate and nitrite are the forms of nitrogen most commonly associated with groundwater contamination [33]. In this study, nitrate concentration of all samples ranged from 0 to 25 mg L^{-1} nitrate (NO_3^-) and also below the admissible limit. According to the WHO and BIS, the acceptable limit of NO_3^- is 45 mg L^{-1} respectively.

The origin of chloride ions (Cl^-) in groundwater may be from different sources such as weathering, intrusion of saltwater, leaching of sedimentary rocks and soils, domestic and industrial waste discharges and municipal effluents [34]. In Reddiyarchatiram and Natham taluks, maximum number of samples exhibited higher than Cl^- permissible limits (1000 mg L^{-1}, BIS; 600 mg L^{-1}, WHO). Among the samples, the highest Cl^- concentration was obtained at 2950 and 2000 mg L^{-1} from Pudukkottai and Sengulam bore wells (Table 2). The higher consumption of Cl^- which lead to high blood pressure, risk for stroke and left ventricular hypertension, osteoporosis, renal stones and asthma and heart and kidney diseases [35-37]. Besides, the excess of Cl^- in water is usually taken as an index of pollution and considered as tracer from groundwater contamination [38]. In other side only nine samples showed under Cl^- desirable values 50-150 mg L^{-1} tested in Athoor and Nilakottai taluks when compared to BIS specified Cl^- desirable limit is 250 mg L^{-1} respectively.

The F^- content in water was estimated by ion selective electrode method. From the analysis, thirty-four samples showed < 0.5 ppm F^- and rest of fourteen samples viewed <1ppm F^- values. Fluoride when consumed at < 0.5 mg L^{-1} produces adverse health effects including dental caries, lack of formation of dental enamel, and deficiency of mineralization of bones, especially in children [39]. The previous studies also concluded that the development of dental fluorosis even if the people consume drinking water with fluoride less than 1.0 mg L^{-1} [40-44; 2; 45-48]. In addition, WHO [49] evidenced that fluoride as one of the very few chemicals that have been shown to cause significant effects on people's health through drinking water.

Table 1. The latitude and longitudes of sampling sites in Dindigul district

S.no	Sampling sites	Samples type	Latitude	Longitude
1A	Pallapatti near A	Bore water	10.775355	77.908899
1B	Pallapatti near B	Bore water	10.775355	77.908899
2A	Pallapatti entrance	Bore water	10.775355	77.908899
2B	Gopalapuram	Bore water	10.465829	77.656895
2C	Pallapatti A	Bore water	10.775355	77.908899
2D	Pallapatti B	Bore water	10.775355	77.908899
2E	Pallapatti C	Bore water	10.775355	77.908899
3A	Goundanpatty	Bore water	10.112552	77.868582
4A	Velayuthapuram	Bore water	10.136868	77.906681
5A	Chokkanchettipatti	Bore water	10.149698	77.910763
6A	Malayakoundapatti A	Bore water	10.361782	77.984819
6B	Malayakoundapatti B	Bore water	10.361782	77.984819
7A	Silukuvarpatti	Bore water	10.153256	77.885264
7B	Silukuvarpatti Outer	Bore water	10.153256	77.885264
7C	Silukuvarpatti (Nilakkottai road)	Bore water	10.153256	77.885264
7D	Vellathathanpatty	Bore water	10.200874	77.870219
9A	Kamupillaichatiram	Bore water	10.274134	77.877210
10A	Vakkampatti	Bore water	10.3205137	77.907378
11A	Mutakusalai near	Bore water	10.3205137	77.907378
12A	Thathankottai	Bore water	10.441592	77.848782
13A	K. Pudukkottai	Well water	10.361782	77.984819
13B	K. Pudukkottai A	Well water	10.361782	77.984819
13C	K. Pudukkottai B	Bore water	10.361782	77.984819
14A	Alagupatti	Bore water	10.444765	77.871901
14B	Alagupatti A	Bore water	10.444765	77.871901
14C	Alagupatti extension	Bore water	10.444765	77.871901
15A	Teppakulathupatti	Bore water	10.46225	77.97535
16A	Ketchanaipatti	Hand Pump	10.391912	77.918352
17A	Silvarpatti	Hand Pump	10.367330	77.908103
18A	Kannimanuthu	Bore water	10.433159	77.909283
18B	Kannimanuthu	Bore water	10.433159	77.909283
19A	Muthanampatty pudur	Bore water	10.407465	77.910601
20A	Nochi Odaipatti	Bore water	9.832280	77.439090
21A	Gopalpatti	Bore water	10.257303	78.148081
22A	Kanavaipatti	Hand pump	10.246503	78.147480
22B	Kanavaikaruppu kovil	Bore water	10.247685	78.196340
23A	Karagundu	Bore water	10.251152	78.196340
23B	Karagundu A	Bore water	10.251152	78.196340
24A	Uluppagudi	Bore water	10.243148	78.196707
25A	RMTC nagar	Bore water	10.314977	78.018352
26A	Narasimmapuram	Bore water	10.316870	77.960692
26B	NarasimmapuramA	Bore water	10.316870	77.960692
27A	Sengulam	Bore water	10.238285	78.253094
28A	N. Pudupatti	Bore water	10.361782	77.984819
29A	Kuttupatti Pudur	Bore water	10.270504	78.261442
30A	Kuttupatti Thottam	Bore water	10.272441	78.261366
30B	Kuttupatti Thottam A	Bore water	10.272441	78.261366
31A	Kuttupatti	Bore water	10.272441	78.261366

Table 2. Physiochemical characteristics of groundwater samples

Sample No.	pH	EC (µS cm^{-1})	TDS (mg L^{-1})	Salinity (ppt)	TH (mg L^{-1})	Nitrate (mg L^{-1})	Chloride (mg L^{-1})	Fluoride (ppm)
1A	7.68	1245	885	621	250	25	100	0.819
1B	7.56	1225	870	612	250	25	100	0.785
2A	8.16	2.19	1.56	1.12	250	25	300	0.864
2B	7.47	1469	1.04	737	175	25	150	0.815
2C	7.78	2.53	1.78	1.29	425	25	300	0.429
2D	7.3	2.53	1.8	1.3	450	25	450	0.431
2E	7.89	2.40	1.7	1.23	375	25	250	0.578
3A	7.85	863	612	424	225	0	100	0.535
4A	7.15	3.26	2.3	1.7	575	25	300	0.435
5A	7.7	3.39	2.38	1.75	575	0	450	0.267
6A	7.6	2.74	1.93	1.41	325	25	400	0.124
6B	7.43	3.71	3.62	1.93	650	25	700	0.149
7A	7.52	2.06	1.46	1.05	375	25	350	0.265
7B	7.43	3.72	2.63	7.95	**<u>725</u>**	0	450	0.131
7C	7.17	688	486	333	150	25	50	0.144
7D	8.02	1848	1.31	935	450	0	350	0.184
9A	**<u>8.17</u>**	762	540	72	250	25	100	0.375
10A	7.32	220	157	108	125	0	50	0.078
11A	6.84	2.21	1.56	1.13	500	25	550	0.377
12A	7.58	1373	976	688	275	25	350	0.078
13A	7.46	1159	824	577	275	25	2500	0.148
13B	7.47	2.19	1.55	1.12	675	25	2600	0.08
13C	7.49	1531	1.09	770	375	25	**2950**	0.06
14A	7.76	1711	1.22	865	325	0	2650	0.287
14B	8.16	1612	1.15	813	250	0	2000	0.221
14C	7.6	1681	1.19	846	375	25	2700	0.226
15A	7.64	2.24	1.59	1.14	625	25	2550	0.165
16A	6.92	**<u>1890</u>**	1.34	**<u>954</u>**	500	0	2000	0.143
17A	7.64	1594	1.13	806	375	25	2200	0.3
18A	8.01	1664	1.18	839	300	25	2750	0.999
18B	8.08	1582	1.12	794	300	25	2500	**<u>1.1</u>**
19A	7.55	3.03	2.15	1.58	500	0	2800	0.393
20A	8.05	770	547	377	175	0	550	0.161
21A	7.98	918	652	452	175	0	2150	0.204
22A	6.93	1539	1.09	773	425	0	2400	0.344
22B	8.08	744	529	364	125	0	2750	0.188
23A	7.75	1355	963	678	300	0	2750	0.63
23B	7.80	1397	**<u>991</u>**	699	300	0	2750	0.704
24A	6.85	1652	1.17	832	550	25	2100	0.206
25A	7.65	1341	952	670	425	0	1850	0.37
26A	7.31	901	640	447	250	0	2100	0.736
26B	7.21	928	659	456	175	0	2000	0.667
27A	7.27	1022	726	505	250	0	2900	0.435
28A	7.20	2.18	1.55	1.11	625	25	2150	0.204
29A	6.64	423	301	205	125	0	2450	0.112
30A	7.11	475	337	230	200	0	2100	0.109
30B	7.22	1079	767	535	375	25	2250	0.188
31A	7.39	1184	840	586	325	25	1700	0.17

Note: High values denoted in bold and underlined

Table 3. Classification of water based on Electrical Condctivity [28]

EC (µS/cm)	Salinity level	Water quality	No. of samples	Category
0-250	Low	Excellent	**16** (2A, 2C, 2D, 2E, 4A, 5A, 6A, 6B, 7A, 7B, 10A, 11A, 13B, 15A, 19A, 28A)	Class I
251-750	Medium	Good	**4** (7C, 22B, 29A, 30A)	Class I
751-2500	High	Permissible	**28** (1A, 1B, 2B, 3A, 7D, 9A, 12A, 13A, 13C, 14A, 14B, 14C, 16A, 17A, 18A, 18B, 20A, 21A, 22A, 23A, 23B, 24A, 25A, 26A, 26B, 27A, 30B, 31A)	Class II

Table 4. Total hardness (TH)

Total hardness (mg/l of CaCo3)	Types of water	No. of present study samples showed values	Samples No.
0-50	Soft water	-	-
50-100	Moderately soft	-	-
100-150	Neither hard or soft	4	7C, 10A, 22B, 29A.
150-200	Moderately hard	5	2B, 20A, 21A, 26B, 30A.
200-300	Hard	15	1A, 1B, 2A, 3A, 9A, 12A, 13A, 14B, 18A, 18B, 19A, 23A, 23B, 26A,27A.
>300	Very hard	24	2C, 2D, 2E, 4A, 5A, 6A, 6B, 7A, 7B, 7D, 11A, 13B, 13C, 14A, 14C, 15A, 16A, 17A, 22A, 24A, 25A, 28A, 30B, 31A

5. CONCLUSIONS

The study results concluded that pH values are within the safe limits. In addition 66% of the samples showed greater than 300 µS cm^{-1} EC values as suggested by WHO. Water samples are hard and vary hard types incontrast excellent and good TDS rating. Alomost maximum number of samples showed chloride values are higher than permissible limit. Predominant samples found less than 0.5 ppm fluoride and rest of them viewed <1ppm fluoirde values, its were beyond the daily fluoride desirable limit (1mg L^{-1}). It may prone to dental caries in childran. According to the results, water is only suitable for household non drinking purposes.

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