International Journal of Applied Research 2017; 3(4): 118-122

ISSN Print: 2394-7500
ISSN Online: 2394-5869
Impact Factor: 5.2
IJAR 2017; 3(4): 118-122
www.allresearchjournal.com
Received: 20-02-2017
Accepted: 21-03-2017

Mohamed Hanipha M
PG and Research Department of Chemistry, Jamal Mohamed College (Autonomous), Tiruchirappalli, Tamil Nadu, India

Zahir Hussain A
PG and Research Department of Chemistry, Jamal Mohamed College (Autonomous), Tiruchirappalli, Tamil Nadu, India

Correspondence
Mohamed Hanipha M
PG and Research Department of Chemistry, Jamal Mohamed College (Autonomous), Tiruchirappalli, Tamil Nadu, India

Physicochemical analysis of selected groundwater samples in and around Dindigul town, Tamilnadu, India

Mohamed Hanipha M and Zahir Hussain A

Abstract
Physicochemical characteristics of groundwater samples of Dindigul town were studied by taking 20 groundwater samples at different stations. The aim of the present study is to analyse the physicochemical parameters for groundwater samples in summer and rainy seasons for three successive years. The results were compared with WHO standard. The obtained result revealed 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 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 elixir of life. Adequate supply of potable safe water is absolutely essential and is the basic need for all human beings on the earth. Groundwater is a globally important, valuable and renewable resource of drinking water because of its storage capacity in the aquifers and purification property of soil. It is a precious and the most widely distributed resource of the earth and unlike any other mineral resource, it gets annual replenishment from the meteoritic precipitation.

Over past few decades, the shortage of freshwater is gradually increasing due to parallel demanding of clean water in agriculture, domestic and industrial units. Availability of quality freshwater is one of the most critical environmental issues of the twenty first century. Water conservation and water quality management have nowadays assumed a very complex one due to rapid industrialization, urbanization and subsequent contamination of surface and groundwater sources.

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.

The degradation of water quality is mainly due to increasing population, urbanization, industrialization and over-utilization of water resources. Pollutants are being added to the groundwater system through human activities and natural processes. Solid wastes from industrial units are being dumped near the factories and are subjected to react with percolating rainwater and eventually reach the groundwater level. The percolating water pick up a large amount of dissolved constituents reach the aquifer system and contaminate the groundwater. The conventional septic tanks, low cost sanitation and improper maintenance of septic tanks are also a major source of groundwater pollution in urban areas.

Hence the present study has been attempted to determine the physicochemical characteristics of groundwater in and around Dindigul town in summer and rainy seasons.

Study Area
Dindigul town is located in the south 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 Fig.1.

Sampling Stations

S1. Paraipatti, S2. Poochinaickan Patti, S3. Bharathipuram, S4. Nehruji Nagar, S5. Anumand Nagar, S6. RR Pudur, S7. Koil Street, 8. Don Bosco Nagar, S9. Burma Colony, S10. Ganapathy Colony, S11. Santhai Road, S1. Guru Nagar, S13. Kuttiapatti Koil, S14. Malai Kovil, S15. Krishna Paper Mill, S16. Pillayarnatham, S17. Vatlagundu Bye Pass, S18. Harini Nagar, S19. Pudur and S20. Ponmandurai Road.

Sampling collection and analysis

Twenty groundwater samples were collected from bore well 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). All necessary precautions were taken during sampling and analysis. 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 analyzed. The standard methods of APHA [2] 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 results are tabulated in Table 1 and 2 and compared with the limits recommended by WHO (2011) [18] and discussed as follows.

Temperature

The mean value of temperature is found to be in the range of 29.5 – 31.6 °C and 27.3 – 29.4 °C for groundwater samples in summer and rainy seasons respectively (Table 1 and 2). The values of temperature are within the permissible limit of 40 ^{0}C (WHO 2011). Maximum value of temperature is recorded at station S4 and S5 in summer season. The slightly elevated values of temperature during summer season may be due to thermal storage of solar energy (Yusufu, Murtala and David, 2014) [19].

pH

The mean pH values are recorded in the range of 7.3 – 8.2 and 7.1 – 8.4 during summer and rainy seasons respectively (Table 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 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 (Raj and Jayashekhar, 2007) [14].

Electrical Conductivity

The mean electrical conductivity values are observed in the range of 382 – 18915 µmhocm^{-1} and 524 – 16883 µmhocm^{-1} for the groundwater samples in summer and rainy seasons respectively (Table 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 S16 in summer and rainy seasons. High value of EC may be due to the dissolution of minerals (Ballukraya and Ravi, 1999) [4].

Total dissolved solids

In the present investigation, the mean TDS values are found in the range of 273 – 11986 mg/l and 354 – 10580 mg/l for the groundwater samples in summer and rainy seasons respectively (Table 1 and 2). The TDS values exceed the permissible limit of 500 mg/l (WHO 2011) in most of the groundwater sampling stations except at station S16 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. Water containing high TDS concentration may cause laxative or constipation effects (Kumarasamy, 1991) [9].

Total hardness

The mean total hardness values are found to be in the range of 248 – 13941 mg/l and 172 – 5213 mg/l for the groundwater samples in summer and rainy seasons respectively (Table 1 and 2). The total hardness values exceed the permissible limit of 500 mg/l in most of the sampling stations in summer and in rainy seasons. High value of TH is observed at station S13 in summer season. Percolation of industrial wastes and domestic wastes may enhance the TH value in this station.

Carbonate and bicarbonate

The mean values of carbonate and bicarbonates are found in the range of 0 – 35 mg/l and 0 – 37 mg/l and 131 – 962 mg/l and 125 – 806 mg/l in summer and rainy seasons respectively (Table 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 most of the 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 (Umapathy, 2011) [17].

Chloride

The mean values of chloride are found in the range of 61–2877 mg/l and 113 – 2508 mg/l for the groundwater samples in summer and rainy seasons respectively (Table 1 and 2). The chloride values exceed the permissible limit of 250 mg/l (WHO 2011) in most of the sampling stations in summer and rainy seasons. High value of chloride 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 (Pushpendra Singh Bundela, Anjana Sharma, Akhilesh Kumar Pandey, Priyanka Pandey and Abhishek Kumar Awasthi, 2012) [13].

Sodium

The mean values of sodium are observed in the range of 35 – 795 mg/l and 80 – 680 mg/l for the groundwater samples in summer and rainy seasons respectively (Table 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 S10, S12, S13, S15 and S18 in summer and S2, S5,

S10, S13, and S15 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 (Udayalaxmi, Himabindu and Ramadass, 2010) [16].

Potassium

The mean values of potassium are found in the range of 8 – 41 mg/l and 12 – 55 mg/l for the groundwater samples in summer and rainy season respectively (Table 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 S11 and S17 in summer season. The high value of potassium may be due to the presence of geochemical strata in these stations (Mahananda, Mohanty and Behera, 2010) [10]. Potassium concentration also influenced by the cation exchange mechanism (Narain and Chauhan, 2000) [12].

Calcium and Magnesium

The mean values of calcium and magnesium are found to be in the range of 40 – 697 mg/l and 51 – 609 mg/l and 23 – 596 mg/l and 20 – 378 mg/l in summer and rainy seasons respectively (Table 1 and 2). In the present investigation, the calcium values exceed the permissible limit of 200 mg/l at stations S2, S3, S5, S6, S8 – S10 S12, S13, S15, S18 and S19 in summer S2, S5, S8, S10, S13 and S15 in rainy seasons. The value of magnesium is within the permissible limit of 150 mg/l (WHO 2011) in most of the groundwater sampling stations in summer and rainy seasons. 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 (Goel and Jadhav, 1983) [7].

Nitrate

The mean values of nitrate are found in the range of 17 – 273 mg/l and 15 – 323 mg/l for the groundwater samples in summer and rainy season respectively (Table 1 and 2). The nitrate values exceed the permissible limit of 45 mg/l (WHO 2011) at the sampling stations S10, S13, S15 and S17 – S19 in summer and S2, S5, S9, S10, S13, S15 and S17 – S19 rainy season. The percolation of domestic sewage, industrial wastes, dumping of garbage and leakage of septic tanks may enhance the nitrate value at these stations (Abdul Jameel and Zahir Hussain, 2011) [1].

Sulphate

The mean sulphate values are recorded in the range of 56 – 1938 mg/l and 79 – 1543 mg/l for the groundwater samples in summer and rainy season respectively (Table 1 and 2). The sulphate values are well within the permissible limit of 250mg/l (WHO 2011) in most of the sampling stations except at stations S10, S13 and S15 in summer and S10 and S13 in rainy seasons. This may be due to the accumulation of soluble salts in soil, anthropogenic activity and addition of excessive sulphate fertilizer in soil (Jain, Bhatia and Kumar, 2003) [8]. The sulphate values are lower in rainy than summer season. This may be due to dilution effect. High level of sulphate imparts bitter taste to water (Bhalerao and Khan, 2000) [3].

Phosphate

The mean values of phosphate are found in the range of 0.20 – 2.41 mg/l and 0.11 – 2.07 mg/l for the groundwater samples in summer and rainy season respectively (Table 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 0.53 – 2.47 mg/l and 0.57 – 2.10 mg/l for the groundwater samples in summer and rainy seasons respectively (Table 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 the high percentage of fluoride in the groundwater samples (Ramachandramoorthy, Sivasankar and Gomathi, 2009) [15].

Biochemical oxygen demand

The mean values of BOD are found in the range of 14 – 79 mg/l and 17 – 122 mg/l for the groundwater samples in summer and rainy season respectively (Table 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 (Mishra, Pradhan, and Patel, 2003) [11].

Chemical oxygen demand

The mean COD values are found to be in the range of 23 – 126 mg/l and 19 – 48 mg/l for the groundwater samples in summer and rainy season respectively (Table 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 (Elangovan, Dharmendirakumar, 2013) [6]. The high value of COD indicates high strength of organic as well as inorganic pollution in the groundwater (Bhanja, Mohanta, Ajoy and Patra, 2000) [5].

Dissolved oxygen

The mean values of DO are found in the range of 0.9 – 5.6 mg/l and 2.1 – 6 mg/l for the groundwater samples in summer and rainy season respectively (Table 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 seepage of landfill may cause the depletion of dissolved oxygen in the groundwater.

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

Stations	Temp	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	29.5	7.5	2518	1459	471	ND	292	366	161	13	92	59	28	143	0.28	1.44	14	36	4.4
S2	30.2	7.7	1082	696	654	ND	278	263	132	15	244	68	28	66	0.35	1.12	44	32	3.9
S3	30.7	7.4	1139	740	902	26	330	746	182	17	248	121	20	86	0.64	1.53	46	35	3.1
S4	31.6	7.5	2145	1304	386	21	260	288	41	12	72	41	17	125	0.25	0.54	58	35	3.0
S5	31.6	7.7	2359	1150	802	32	463	995	165	25	318	163	77	193	0.36	1.33	31	56	2.2
S6	30.4	7.5	1705	1201	958	35	549	609	163	22	218	105	27	137	0.27	1.13	33	23	5.6
S7	29.7	7.9	1406	1048	733	ND	764	363	175	16	141	93	23	124	0.44	0.53	40	38	3.1
S8	30.2	7.4	2222	1342	1264	23	359	1134	227	15	226	166	27	173	0.53	0.64	27	32	4.2
S9	30.8	8.2	2872	1719	1768	20	571	1312	242	14	494	133	45	231	0.51	0.94	58	52	1.8
S10	31.4	8.0	4720	2931	2444	23	962	1997	258	15	426	480	78	528	0.36	0.85	66	49	2.2
S11	30.7	7.7	1333	928	776	24	439	482	146	11	124	117	36	142	0.20	1.40	30	45	3.2
S12	30.6	7.6	2337	1371	925	27	608	589	277	08	228	164	39	180	0.40	0.90	79	55	2.0
S13	31.2	7.7	18915	11986	13941	25	851	2877	795	13	697	596	273	1938	1.65	1.55	71	114	0.9
S14	30.4	7.3	1253	850	706	ND	284	315	91	16	129	87	21	109	1.28	1.41	42	29	3.0
S15	30.7	8.0	5190	3417	2100	22	424	1337	487	35	451	256	182	578	2.04	1.37	36	45	2.6
S16	31.0	8.1	382	273	248	25	131	61	35	13	40	23	37	56	1.50	0.73	49	51	2.4
S17	31.5	8.1	2126	1154	791	31	419	363	189	10	117	65	85	140	0.64	0.91	62	56	2.3
S18	29.8	8.1	3227	1157	1744	28	703	1035	252	19	278	147	73	231	0.37	0.59	68	126	1.3
S19	30.4	8.1	2648	1638	1062	19	229	359	118	22	204	116	61	116	2.41	1.73	38	36	3.1
S20	30.7	7.8	815	505	471	ND	198	166	51	41	132	60	45	126	0.68	2.47	38	37	3.5

All the values are expressed in mg/l except pH and EC.
EC in micromhocm^{-1}
Temperature in ^{0}C
ND – Not Detectable

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

Stations	Temp	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	28.2	7.5	1112	751	297	ND	406	307	202	40	55	57	26	84	0.27	1.34	53	21	6.0
S2	28.0	7.7	4001	2605	2028	21	438	2006	568	55	250	223	58	147	0.44	0.77	56	31	4.3
S3	28.9	7.1	1997	1297	966	15	327	756	227	46	146	127	28	90	0.59	1.23	49	36	3.9
S4	29.3	7.3	1880	1134	370	10	244	183	30	13	51	40	15	114	0.17	0.72	42	23	2.3
S5	29.3	7.4	2051	1373	1526	15	313	336	254	15	246	149	49	157	0.29	1.23	53	38	3.2
S6	28.5	7.7	1545	1005	922	29	252	473	147	18	160	113	37	149	0.21	1.25	17	19	4.6
S7	27.8	7.8	1473	1005	782	33	254	470	170	20	143	109	29	103	0.41	1.42	46	39	3.6
S8	28.1	7.1	2270	1490	1170	23	246	776	225	23	215	133	27	138	0.41	1.63	27	26	4.6
S9	29.2	7.7	2282	1523	1052	23	296	690	203	21	185	137	48	173	0.37	0.57	41	41	2.2
S10	28.5	7.7	3871	2474	1891	19	472	1284	298	23	299	210	57	318	0.33	1.57	39	36	2.4
S11	29.0	7.6	1679	1096	847	26	196	450	197	15	98	125	44	155	0.25	1.47	33	39	3.9
S12	28.9	7.4	2455	1618	1035	31	452	352	171	14	153	63	39	194	0.36	1.03	46	42	2.6
S13	29.4	7.5	16883	10580	5213	22	806	2508	680	42	609	378	323	1543	1.22	1.17	122	37	2.4
S14	28.4	7.4	1297	999	746	06	196	444	129	15	67	111	36	144	0.11	2.10	41	33	3.9
S15	29.2	7.6	4015	2562	1355	15	462	1288	492	15	320	136	153	236	2.00	1.43	76	39	3.3
S16	28.8	7.7	524	354	172	26	125	113	111	12	62	20	30	79	1.24	1.63	81	33	3.0
S17	28.9	7.9	2017	1253	749	37	414	306	212	30	135	78	61	136	0.50	1.30	44	39	2.7
S18	27.3	7.7	2439	1004	833	29	336	398	164	26	108	86	62	134	0.49	0.77	98	45	2.1
S19	28.7	8.4	2339	1062	1025	24	475	436	164	16	159	92	52	222	2.07	1.77	44	38	3.2
S20	29.4	7.8	1200	798	580	16	149	380	162	17	97	88	41	116	0.49	2.07	51	42	4.0

All the values are expressed in mg/l except pH and EC.
EC in micromhocm^{-1}
Temperature in ^{0}C
ND – Not Detectable

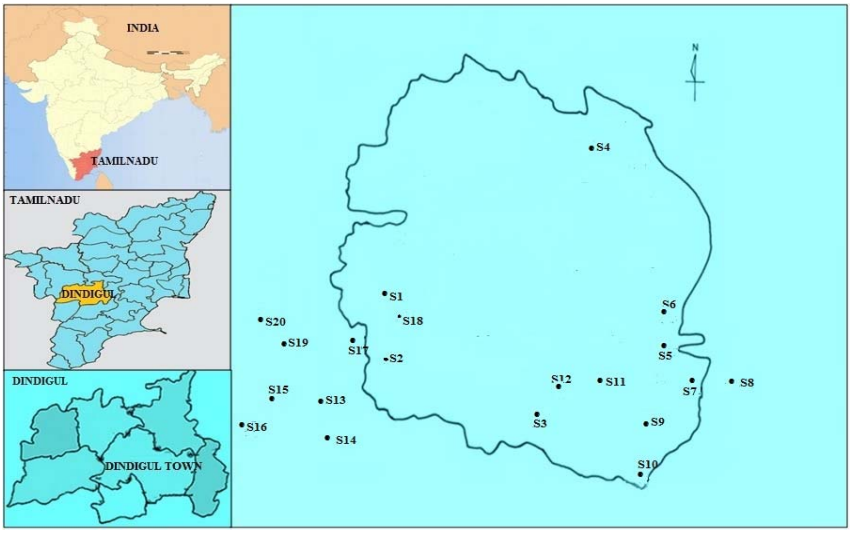

Fig 1: Map of the study area

Conclusion

Twenty groundwater samples were taken in and around Dindigul town, Tamilnadu in summer and rainy seasons for three successive years. The groundwater samples were subjected to physicochemical analysis. The results show that the physicochemical parameters such as EC, TDS, TH, HCO_3, Cl, Na, K, Ca, SO_4, 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 pretreatment. It is also suggested to monitor the groundwater quality and assess periodically to prevent further contamination.

References

1. Abdul Jameel M, Zahir Hussain A. Monitoring the quality of groundwater on the bank of Uyyakondan channel of river Cauvery at Tiruchirappalli, Tamil Nadu, India, Environmental Monitoring and Assessment. 2011; 10.10007/s 10661:011:1910-14.
2. APHA. American Public Health Association, Standard Methods for Estimation of water and Wastewater, AWWA, Water Pollution Control Federation, New York, 1995, 19.
3. Bhalerao AP, Khan AM. Fluorine and sulpher contents in the lake in triable area of Marathwada, Maharashtra, J. Aqua. Biol. 2000; 15(1-2):59-61.
4. Ballukraya PN, Ravi R. Characterization of groundwater in the unconfined aquifers of Chennai city, J Geol Soc. 1999; 54:1-11.
5. Bhanja Mohanta K, Ajoy Patra KU. Studies on the water quality index of river Sanamachhakandana at Keonjhar Garh, Orissa. India, Poll Res. 2000; 19:377-385.
6. Elangovan NS, Dharmendirakumar M. Assessment of groundwater quality along the cooum river, Chennai, Tamil Nadu, India, Journal of Chemistry. 2013; ID 672372:1-10.
7. Goel PK, Jadhav SG. Studies on the treatment process of waste water from sugar factory 33rd DSTA Annual Convention, 1983; I:M3-9.
8. Jain CK, Bhatia KKS, Kumar SR. Groundwater quality in Mala Prabha sub-basin, Karnataka, Indian J. Envl. Prot. 2003; 23(3):321-329.
9. Kumarasamy N. Ascending pollution potential from basic panactric ratio- A case study, Env. Prot. 1991; 9:178-181.
10. Mahananda MR, Mohanty BP, Behera NR. Physicochemical analysis of ground and surface water, IJRRAS. 2010; 2:272-283.
11. Mishra PC, Pradhan KC, Patel RK. Quality of water for drinking and agriculture in and around mines in Keonjhar district, Orissa, Indian J. Env. Hlth. 2003; 45(3):213-220.
12. Narain S, Chauhan R. Water quality status of river complex Yamuna at Panchnada (Etawah, U.P., India): An integrated management approach, Poll. Res. 2000; 19(3):357-364.
13. Pushpendra Singh Bundela, Anjana Sharma, Akhilesh Kumar Pandey, Priyanka Pandey, Abhishek Kumar Awasthi. Physicochemical analysis of groundwater near municipal solid waste dumping sites In Jabalpur, IJPAES. 2012; 2(1):2231-4490.
14. Raj ADS, Jayashekhar T. Hydrogeochemistry of the river basin of Kanyakumari district, Indian J. Env. Prot. 2007; 27(2):145-152.
15. Ramachandramoorthy T, Sivasankar V, Gomathi R. Fluoride and otherparametric status of ground water samples at various locations of the Kolli hills, Tamil Nadu, JIPHE. 2009; 3:431-438.
16. Udayalaxmi G, Himabindu D, Ramadass G. Geochemical evaluation of ground water quality in selected areas of Hyderabad, A.P., India, Indian J. of Sci. and Tech. 2010; 3(5):546-553.
17. Umapathy S. A study on ground water quality of Neyveli area, Cuddalore district. Tamilnadu, Int. J. of Geomatics and Geosciences. 2011; 2(1):49-56.
18. WHO. Guidelines for drinking-water quality, 4th ed. Geneva, World Health Organization, 2011.
19. Yusufu A, Murtala MI, David G. Physicochemical and microbiological quality of water used in Ajaka Igalamela/Odolu local government area of Kogi state, Nigeria. J Applied Sci and Envir. 2014; 4:37-43.