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Ground Water-quality of Coastal Kanyakumari District, South India

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Groundwater quality in coastal region became a matter of concern due to continuously changing environment and increasing industrial and social activities that influence the water quality directly or indirectly. This survey is an attempt to assess the ground water quality along the western coast of the Kanyakumari district, Tamil Nadu, South India. Groundwater samples from sixteen representative open and bore wells from six coastal villages along the coast were collected and preserved separately as per the standard methods. Parameters such as temperature, pH, conductivity and salinity were measured at the site. Quality of groundwater at many of the stations showed near normalcy and physico-chemically safe for drinking purpose. The central region of the station Manakkudy showed normalcy, whereas the results obtained from south (S2) and north (S3) regions of Manakkudy showed higher levels of sulphate 278 mg/L (S2), 242.8 mg/L (S3) and chloride 1810 mg/L (S2), 2710 mg/L (S3). This may be due to the seawater intrusion and mixing of leachate from the coir retting zones. Also magnesium levels in these stations are beyond the permissive limit, which again confirms the contamination and unsuitability for drinking purpose.

Key Words: Ground water quality, Heavy metal, Physico-chemical assessment.

INTRODUCTION

Kanyakumari is one of the smallest districts in Tamil Nadu. It is predominantly an agricultural region with vast natural resources and variety of geological features. It is a coastal district of Tamil Nadu bordering three oceans, Bay of Bengal on the east, Indian Ocean on the south and the Arabian Sea on the west. It lies between 77°05′ and 77°36′ of the eastern longitude and 8°03′ and 8°35′ of the northern latitude. Its coastal belt runs to a length of 67 km, which is studded with forty-four coastal hamlets, a municipality and a township. The main part of the coast faces the Arabian Sea. The coast has dense population. Most of the villages depend for fresh water upon open wells. The monsoons are normally punctual, but at times fail, causing water scarcity. The coastal areas mark the low lying areas of the district where all running waters and monsoonal drainages

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ultimately reach short stretches of beaches and sand dunes are found along the coast line. Coastal villages have congested neighbourhood with virtually no drainage facility. The Kanyakumari coast is facing environmental problems

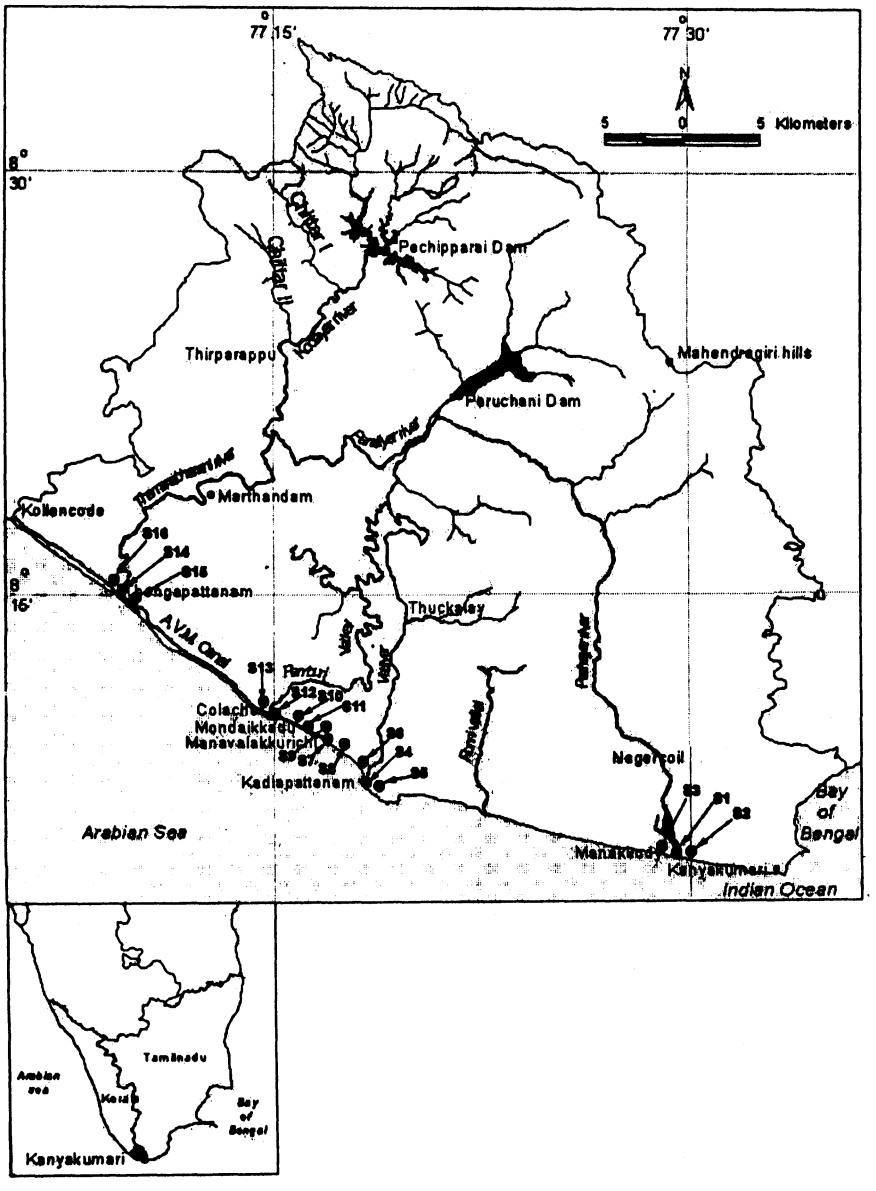

Fig. 1 Map of study area (Kanyakumari district)

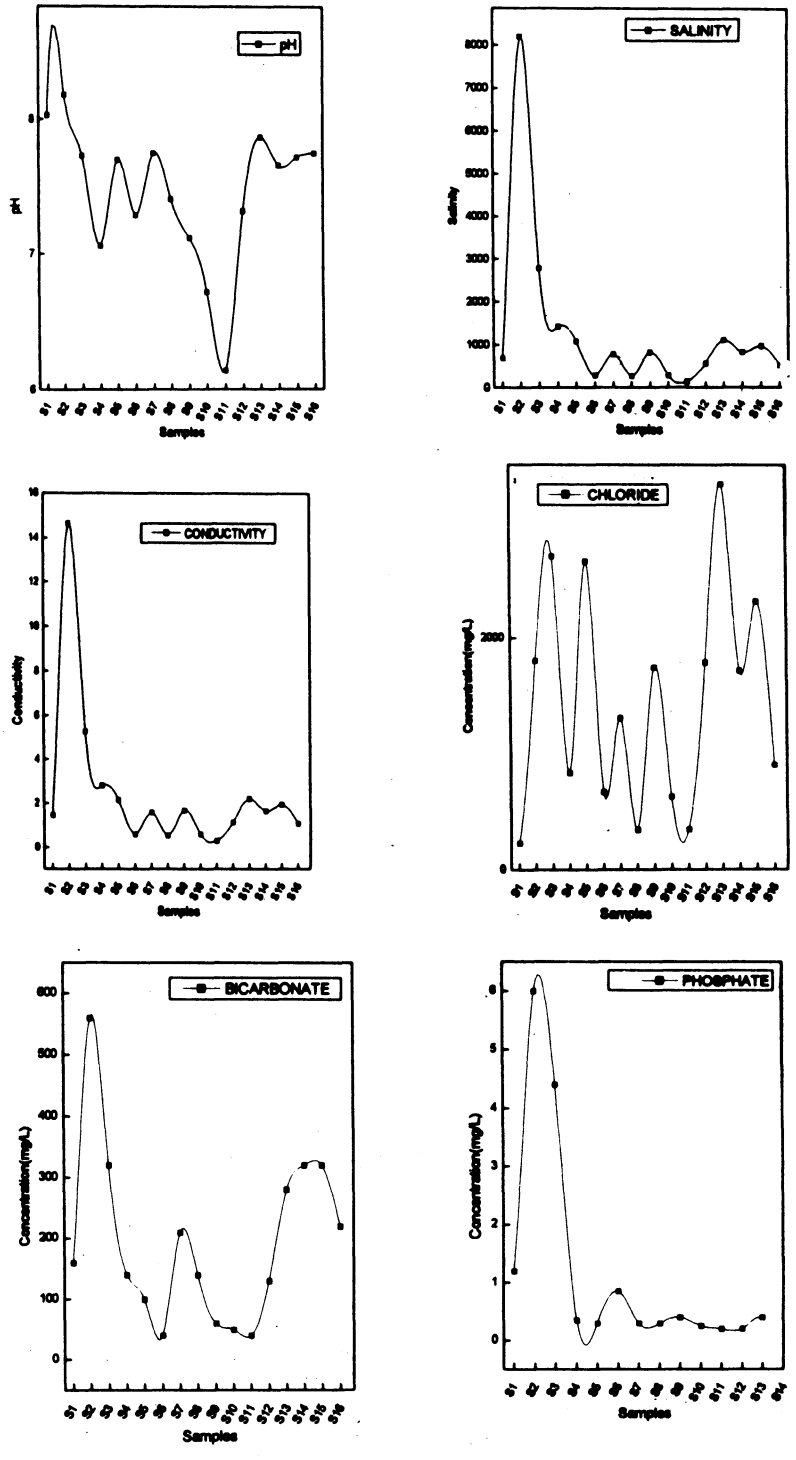

Fig. 2 Ground water quality monitored (Jan 2002)

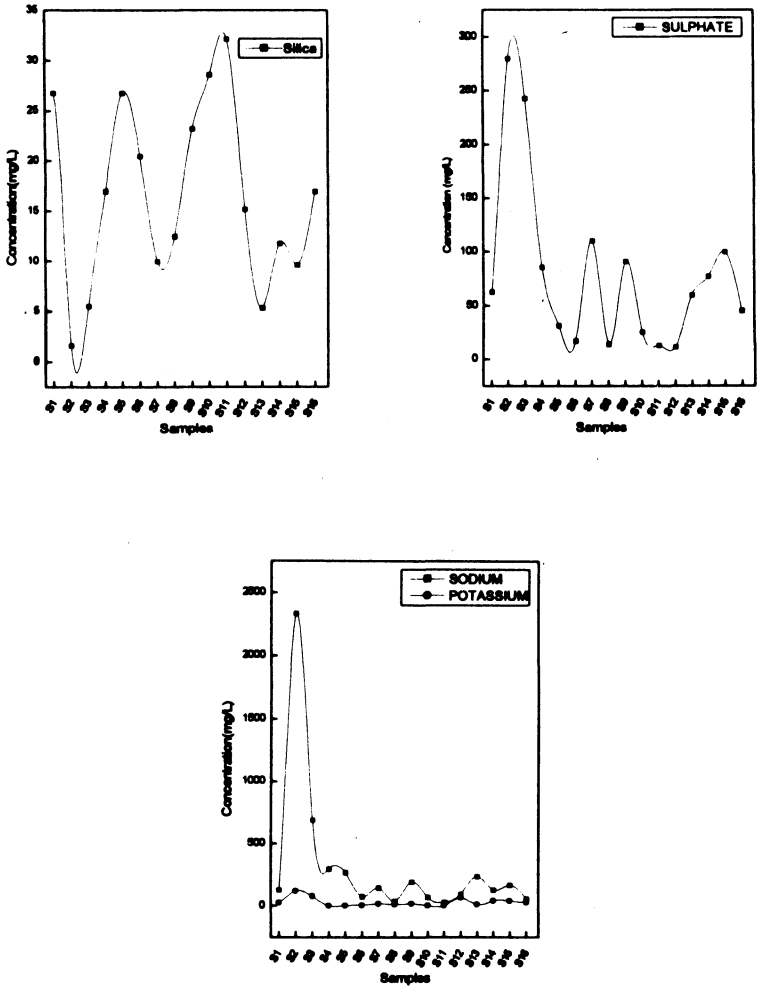

Fig. 2 (Contd.)

especially with regard to fresh water availability and the worst affected are the fisher folks. The present study is aimed to explain the effects of natural as well as anthropogenic pollution sources of ground water quality in six selected stations.

EXPERIMENTAL

Ground water samples were collected at sixteen points (three samples each from four stations Manakkudy, Kadiapattanam, Manavalakkurichi and Thengapattanam and two samples each from Mondaikkadu and Colachel) during the month of January 2002 (Fig. 1). Open wells located in residential areas were selected for sampling. From each station three samples were collected with a gap of 0.5 km in between sampling sites. Ground water samples from open wells and bore wells were collected in properly washed polythene bottles as per standard methods. The pH and electrical conductivity were estimated at sampling sites.

Total alkalinity, fluoride, chloride, calcium, magnesium, sodium, potassium, phosphate, silicate, salinity, and sulphate were analysed in the laboratory as per standard methods[1, 2]. The samples were brought to the laboratory and analysed as per the standard procedures[3-5]. Trace metals were analysed using voltammetric trace analyzer (Metrohm VA 746, Switzerland) using hanging mercury drop electrode (HMDE) and against Ag/AgCl as reference and platinum as auxilliary electrodes. Estimation of alkalinity was done titrimetrically. Sodium and potassium were estimated using flame photometer while calcium and magnesium were estimated by EDTA method. Using Orion ion analyzer, estimation of chloride and fluoride was carried out. Sulphate, phosphate and silicate were analysed by spectrophotometry. The present paper reports the concentration of heavy metals in the ground water of six stations along the Kanyakumari coast analyzed during the month of January 2002.

RESULTS AND DISCUSSION

The fluctuations occurred in various parameters depending upon the geochemistry of the study area and also the quantity of wastewater released from the different sources. The water quality parameters depend on the climatic conditions. Results of chemical parameters and heavy metals are tabulated in Tables 1 and 2 respectively.

pH : The pH of the water body indicates the degree of deterioration of water quality[6]. The pH of ground water samples of Kanyakumari coast ranged from 6.14 to 8.18. The variations were not only in the samples collected from different localities, but in samples collected from the same locality. This might be due to irregular distribution of the rocks or due to the difference in the depth of bore wells. pH below 6.2 may cause corrosion[7]. Only at stations **S10** and **S11**, pH was found to be less, *i.e.*, 6.72 and 6.14 respectively. An increase in acidity may give rise to undesirable increase in dissolved metals[8, 9]. Coconut husk retting ponds situated on either side are responsible for lowering the pH. At **S2**, high pH value 8.18 was observed and a low pH value was recorded at **S11** (6.14). The reduction of pH values may be related to low alkalinity of the ground water.

Electrical Conductivity: Electrical conductivity ranged from 0.30 to 14.65 mS/cm. Lower the pH the lower will be the conductivity, salinity, chloride, sulphate, phosphate, bicarbonate, sodium, potassium, calcium, magnesium[10] etc. The lower the electrical conductivity, higher will be the level of silicate. Maximum electrical conductivity was observed at Manakkudy during the study period. Therefore it is concluded that the electrical conductivity value is the indication of dissolved ionizable solids[11].

Alkalinity: The alkalinity of water showed wide fluctuations. An increase in alkalinity may be due to increased salinity conditions[12], or may be due to the biological precipitation of calcium carbonate. When high salinity prevailed, the alkalinity was high[13]. Bicarbonate values in the study regions were found to be of different magnitudes. The alkalinity was greater at Manakkudy and Thengapattanam due to the presence of basic salts of sodium and potassium in addition to calcium and magnesium[14]. Alkalinity also may be due to the

TABLE-1
GROUND WATER QUALITY MONITORED IN THE MONTH OF JANUARY 2002

Location	S. No.	pH	Salinity	Conductivity	Chlorides	Fluoride	Bicarbonate	Phosphate	Silica	Sulphate	Sodium	Potassium	Calcium	Magnesium
	S1	8.03	695.4	1.47	232	0.175	160	1.20	26.79	62.86	130	24	92	24
Manakkudy	S2	8.18	8209.0	14.65	1810	0.854	560	6.00	1.61	279.99	2334	120	196	321.6
	S3	7.73	2778.0	5.27	2710	0.376	320	4.40	5.54	242.80	690	80	192	96
	S4	7.06	1429.0	2.80	840	0.434	140	0.35	16.97	85.70	296	4	120	57.6
Kadiapattanam	S5	7.70	1085.0	2.16	665	0.731	100	0.30	26.79	31.40	268.5	4	76	38.4
	S6	7.29	283.6	0.59	675	0.193	40	0.85	20.50	17.10	77	6	20	12
	S7	7.75	786.4	1.58	1315	0.146	210	0.30	10.00	110.40	147	18.5	124	16.8
Manavalakkurichi	S8	7.41	259.6	0.54	347.5	0.173	140	0.30	12.50	14.00	39	13.5	40	12
	S9	7.12	828.7	1.66	1750	0.074	60	0.40	23.20	91.40	193	18.5	80	31.2
Mondaikkadu	S10	6.72	285.6	0.59	635	0.063	50	0.25	28.58	25.70	68.5	4	20	12
	S11	6.14	144.8	0.30	351.5	0.033	40	0.20	32.15	12.86	31	2	16	4.8
Colachel	S12	7.32	556.3	1.13	1790	0.107	130	0.20	15.18	11.40	96	67	56	14.4
	S13	7.87	1110.0	2.20	3335	0.147	280	0.40	5.36	59.99	237.5	13	144	28.8
	S14	7.66	827.1	1.65	1720	0.035	320	ND	11.79	77.10	130.5	40	164	12
Thengapattanam	S15	7.72	966.5	1.93	2320	0.034	320	ND	9.64	100.00	167	41	160	28.8
	S16	7.75	520.1	1.06	910	0.026	220	ND	16.97	45.70	58.5	29.5	120	12

• All values are given in mg/L except pH and conductivity (mS/cm). ND = Not detected.

contamination by leaching process during the rainy season[15]. Since phenolphthalein alkalinity was zero, the alkalinity was only bicarbonate alkalinity. OH^- and carbonate alkalinity were zero.

TABLE-2
HEAVY METALS IN GROUND WATER (JANUARY 2002)

Stations	Sample No.	Zn (μg/L)	Cd (μg/L)	Pb (μg/L)	Cu (μg/L)
	S1	91.78	ND	154.50	33.94
Manakkudy	S2	58.74	0.264	86.66	22.44
	S3	195.30	108.300	181.20	157.30
	S4	ND	ND	ND	ND
Kadiapattanam	S5	214.60	ND	46.81	54.82
	S6	148.30	0.142	53.66	26.35
	S7	69.20	ND	47.56	28.85
Manavalakkurichi	S8	181.40	ND	61.60	34.50
	S9	78.03	0.259	53.04	25.32
Mondaikkadu	S10	97.78	ND	48.07	21.73
	S11	85.65	ND	57.97	24.70
Colachel	S12	80.70	ND	44.14	23.43
	S13	64.41	0.104	55.62	33.34
	S14	62.60	ND	44.65	20.57
Thengapattanam	S15	62.79	0.378	55.32	23.80
	S16	67.73	ND	40.63	24.52

ND = Not detected

Chloride: The minimum chloride (232 mg/L) content was observed at **S1** and the maximum value (3335 mg/L) was obtained at **S13.** Generally **S2, S3, S7, S9, S12, S14** and **S15** samples of ground water exhibited high chloride content. The chloride content was found beyond the WHO[16, 17] acceptable limit (< 500 ppm) except at three locations **S1, S8** and **S11.**

Salinity: Salinity varied from a minimum of 144.8 mg/L to a maximum of 8209 mg/L at all stations. The highest salinity value recorded was 8209 mg/L at **S2,** and a minimum 144.8 mg/L at **S11.** According to the salinity classification of ground water, ground water was nonsaline at **S11** site and slightly saline at **S6, S8** and **S10** sites and moderately saline at other sites. Salinity is a measure of the salt content present in natural water and it is considered as a parameter in studying the mixing process and the intrusion of saline water into the water stream[18, 19] During summer the ground water in the coastal zone became more saline[20]

Sulphate: Sulphate content more than 200 ppm is objectionable for domestic purposes, as water having more than 500 ppm tastes bitter and beyond 1000 ppm has purgative effect[21-23]. At one location in Manakkudy, **S2,** the sulphate concentration was exceptionally high, *i.e.*, 279.99 mg/L.

Fluoride: Fluoride ions inhibit a variety of enzymes often by forming

complexes with Mg^{2+} ions or by forming fluorophosphato complexes with magnesium or other metal ions[24]. The concentration of fluoride in the well water samples of the study area was found to be in the range of 0.026 to 0.854 mg/L. If the fluoride concentration is very high it may affect the cement construction strength[7].

Silicate: The silicate values ranged between 1.61 to 32.15 mg/L. Silicate concentration was comparatively higher at Mondaikkadu and Kadiapattanam. 30 mg/L is the permissible limit of silicate in drinking water[17]. In the present study it was observed that the concentration of silicate was inversly related to salinity.

Phosphate: High phosphate content was recorded at **S2** and **S3** (Manakkudy). The major sources of inorganic phosphorus are domestic sewage, detergents and agricultural effluents[25]. According to Desai[26], phosphate concentration above 2 mg/L can be considered as an indication of high pollution. The phosphate content in ground water samples of the study area varied from 0.2 to 6.00 mg/L.

Sodium and Potassium: Sodium and potassium ranged from 31 to 2334 mg/L and 2 to 120 mg/L respectivey. Sodium content more than 50 ppm makes the water unsuitable for drinking purposes[21, 22, 27]. Sodium content at all the studied locations was higher than 50 ppm except at **S8** and **S11.** Sodium content was very high at Manakkudy due to the seawater intrusion. The wells had no cemented platform above the ground level. Utensil washing with ash on the well was a year-round practice. This ash might be the reason for higher potassium content in well water[23]. The ground water of Manakkudy was affected by sodium, showing higher concentration at **S2** (2334 mg/L).

Calcium: In the upper reaches of Manakkudy estuary dredging of dead lime shells for lime leads to high turbidity and high calcium concentration. In the present investigation calcium content ranged from 16 to 196 mg/L. Calcium content was very low at Mondaikkadu and high at all sites in Thengapattanam. WHO permissible limit of calcium in the ground water is 100 ppm[17]. Maximum calcium content was recorded at **S2** (at Manakkudy). Calcium content in all the samples was found to be higher than that of magnesium.

Magnesium: Magnesium values varied between 4.8 and 321.6 mg/L. Magnesium was directly proportional to chloride concentration in the present investigation. Magnesium content was higher at all sites of Manakkudy. This higher concentration of magnesium in wells was due to the domestic discharges[28]. The ions percolate through the soil and contaminate the well water[29]. The drinking water containing high magnesium contents may be cathartic and diuretic[30, 31]. At Manakkudy the magnesium level was found to be 321.6 mg/L. At **S3, S4, S5** and **S9** the ground water samples exceeded 30 mg/L which is maximum permissible USPH standard.

Heavy Metals: The presence of non-essential heavy metals at high concentrations is indicative of heavy metal pollution[31]. The distribution pattern of copper, zinc, cadmium, and lead in the ground water from the coastal belt of Kanyakumari District were shown in Table-2. Heavy metals such as copper, zinc, lead, cadmium and iron occur in the ground water in different forms at different concentrations. The concentrations of heavy metals in ground water varied spatially as zinc, cadmium, lead and copper were high at **S3** (at Manakkudy). Such a high

concentration was perhaps due to the presence of major sources of metal pollution, intensive human activities, workshops located along the banks of the river system, discharge of domestic wastes, fall-outs from the automobile and land run off reaching the bar mouth area at Manakkudy and also discharge of small scale (cottage) industrial effluents, sewage outlets and municipal wastes at Manakkudy bar mouth area.

Zinc and Copper: Zinc and copper concentrations were high at S3 of Manakkudy and at S5 of Kadiapattanam. This may be due to the higher levels of these metals in the discharges from agricultural area containing fertilizer, pesticide and rodenticide residues. Elevated zinc and copper levels at S3 and S5 were attributed to galvanization and electroplating. Zinc concentration in ground water along the Kanyakumari coast varied from 58.74 μg/L to 214.6 μg/L. Comparatively less amount of zinc was observed at Thengapattanam samples. Zinc salts are relatively non-toxic but heavy doses for long period cause vomiting, renal damage and cramps[32]. The maximum permissible limit of zinc is 5.5 mg/L. Copper content in the ground water fluctuated between 20.57 μg/L and 157.3 μg/L. The maximum copper observed in the ground water was far below the toxic level of copper. Copper, zinc and iron are derived from pigments and dyes as well as from corrosion of metals. Zinc is used in furniture factory and metal plating process. Batteries, domestic utensils, wires, alloy contain copper[33].

Cadmium: Cadmium is widely used as a pigment and stabilizer in paints[34]. Cadmium is used in nickel-cadmium batteries, plastics and as a protective coating for metal parts. Ground water samples collected under the study programme had cadmium in the range of 0.104 to 108.3 μg/L. The concentration of cadmium was low as the source for this metal is found lacking in the vicinity of the study area except at S3. Cadmium could not be detected in most of the samples.

Lead: Lead, another important toxic metal, was found to be maximum at S3, 181.2 μg/L, and minimum at S16. In nine samples the lead content was beyond the permissible limit (0.01 ppm)[17,35].

Conclusion

This study provides an informative data and helps to understand the contamination of ground water of Kanyakumari coast and also serves in predicting the possible health risk. These investigations are greatly needed for future planning of general and drinking water quality. In the present study it was found that physico-chemical characteristics of a few of the drinking water samples crossed the maximum permissible limit. This may be attributed to improper sanitation around the source or having no parapet lining, no platform or leak-proof casing. The chemical parameters indicate that total alkalinity, calcium hardness and magnesium hardness have higher value, which make it very harmful as drinking water for human beings. Comparatively low heavy metal concentration might be due to low industrial pollution or point source. Among the study areas Manakkudy was found to be relatively more polluted. Though, at present, values of all metals are low, their values may cross the tolerance limit if prevention measures are not taken. Therefore, it is concluded from the present study that the Kanyakumari coast of India is rapidly subjected to environment loading of high levels of cations

and anions. Thus it is concluded that in general the ground water quality was not satisfactory and unsuitable for human consumption and other domestic uses.

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