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Physico Chemical Study On The Sea Water Intrusion In Tuticorin Coastal Area

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Abstract: The post effects of Tsunami are damage to the lives of human being as well as animals, damage to buildings and other properties, damage to agricultural lands and crops, soil erosion, loss of ecological habitats. In addition with one of the most predominant effect is the sea water intrusion in water resources. This paper deals with the study on the post Tsunami impact on sea water intrusion in Tuticorin coastal area. In the present investigation, more than 12 ground water samples were collected from the various parts of Tuticorin coastal area (i.e.) 1 km and 5 km away from the sea shore. Physico-chemical parameters such as pH, Alkalinity, Electrical conductivity, Total Dissolved Solids, Total Hardness, Calcium, Magnesium, Dissolved Oxygen, Biological Oxygen Demand, Chemical Oxygen Demand, Fluoride, Chlorides, Nitrites, Ammonia, Phosphate, Trace metals like Iron and Manganese were analyzed. Bacteriological examinations for the enumeration of *coliform bacteria* were carried out. Standard methods were followed for the analysis of physico-chemical and bacteriological examinations. The results were observed in each sample and compared with standards WHO, ICMR and IS. The water quality in all the areas surveyed was found to be unfit for human consumption. Because of lack of poor water quality due to the effect of Tsunami and sea water intrusion, the residents of Tuticorin coastal area were affected by water born diseases. Hence suitable water quality management is essential to avoid contamination.
Key words: Tuticorin coastal area, water quality parameters, sea water intrusion and Tsunami impact.

Introduction

Water is considered absolutely essential to sustain life. It is estimated that two-thirds of the human body is constituted of water. Water is the dominant environment of these ecosystems. Water gets contaminated with microbe through intestinal discharge of human and animals [1]. The term “saline” is applicable to waters containing sodium chloride present in more than usual quantities. The rapid growth of population and technological and industrial boom has brought enormous problems and degradation of environment [2] chemical and toxic elements are being let into the drain streams and even open spaces adjoining the industrial areas without any check. It is to be noted that more than 2000 chemical contaminants of all kinds have been found in water, about 750 of which have been identified in drinking water. The intrusion of salty seawater into wells is a ground water pollution problem in many coastal cities and towns. India is fortunate enough to be bestowed with a long coastline of bout 5000km and a fairly bright sunshine for about 6-9 months. Major constituents of the seawater are sodium chloride. Besides there, other salts such as $CaCO_3$, $CaSO_4$, $MgSO_4$, $MgCl_2$ and KCl are also present. Minor constituents are iron oxide and magnesium carbonates. Off shore waters [3] of the oceans have a salt concentration of 30,000 to 36,000mg/lit of dissolved solids including 19,000mg/lit of chloride, 10,500mg/lit of sodium and 1270 mg/lit of magnesium. Due to their close proximity to the sea, intrusion of

chlorides and sulphates are expected in the ground water. In coastal areas [4], there is an interface or boundary between the fresh ground water flowing from upland areas and the saline water from sea. Because seawater is about 2.5 percent denser than fresh water, a pressure head of 40ft of seawater is equivalent to a pressure head of 41ft of fresh water [5, 6].

The quality of ground water is more important as the case of quantity. Since ground water contains a number of unwanted constituents such as dissolved solids, suspended impurities, biological matters, collides etc., it has to be treated to remove their constituents before consumption [7]. About 90 percent of the population in the coastal area [2] utilizes a shallow ground water for drinking and other needs. Regular monitoring of the quality of ground water should be undertaken, temporarily and spatially to identify the sources of toxic contaminants and other inhibitory compounds that affect the potability of water [8].

Materials and Methods

Twelve ground water samples were collected from twelve bore wells and open wells around Tuticorin coastal area namely Chinnamani Nagar (S_1), Kamaraj College (S_2), Sathya Nagar (S_3), Harbour(S_4), Muthaiyapuram (S_5), Thendral Nagar (S_6), Kakanji Nagar (S_7), Palayakayal (S_8), Attoor (S_9), Arumuganeri (S_{10}), Koyalpattinam (S_{11}) and Tiruchendur (S_{12}). All water samples were collected from the various parts of Tuticorin coastal area ie 1km and 5km away from the seashore to monitoring the after effect of Tsunami. The pH of the samples was measured with digital pH meter. The electrical conductivity of the water samples was determined from the digital conductivity meter. The Total Hardness and Alkalinity were determined using titration method. The presence of calcium was determined by EDTA-Titrimetric method. The method for the determination of dissolved Oxygen, COD and BOD were based on the Winkler method. The presence of nitrate is determined [9] by Visible Spectrophotometer. The chloride was determined by titration method using standard silver nitrate solution. The method used [10] for the determination of fluoride was Zirconyl-Alizarin method. The gravimetric method was used to determine the presence of Sulphate. The method used for the determination of total phosphates was stannous chloride method. The determination of Ammonia was done using Nesslerization method. The presence of Fe was analyzed by colorimetric method using thiocyanate solution and for Bacteriological Examinations [4], the Standard plate counts method was used for the enumeration of coliform bacteria.

Table I. Parameters of water quality characterization and standards.

Parameters	WHO	ICMR	USPH	ISI
PH	6.5 – 9.2	7.0 – 8.5	6.0 – 8.5	6.5 – 8.5
Electrical conductivity Mho/cm	300	300	300	-
TDS	500	500	500	500
Alkalinity	120	120	-	200
Total Hardness	300	300	500	300
Calcium	75 – 200	75	100	-
Magnesium	30 – 150	50	30	30
Chloride	200 – 600	250	250	250
Sulphate	200 – 400	200	250	200
Fluoride	1.0 – 1.5	1.0	1.5	0.6
Nitrate	45	20	45	45
Phosphate	-	-	-	-
Dissolved O_2	4 – 6	-	4.6	3.0
BOD	6.0	-	5	-
COD	10	-	4	-
Iron	0.1 – 1.0	0.3	-	0.3
Ammonia	-	0.1	-	-
Coliform **bacteria**	10	10	-	10

All units except pH and Electrical Conductivity are in mg/l

WHO - World Health Organization
ICMR - Indian Council of Medical Research
USPH - United States public drinking water standard
ISI - Indian Standard Institution

Result and Discussion

The aim of the present study is to determine the extent of ground water contamination and seawater intrusion around Tuticorin coastal area by taking water samples from 1km and 5km away from the seashore. For this study, physico-chemical analysis and bacteriological examination were done with the ground water samples collected from twelve places around Tuticorin coastal area. The results of both physico-chemical and bacteriological analysis[6,8] of different ground water samples are presented in Tables (II& III). These results were compared with values of prescribed standard quality parameters presented in Tables (I).

The results reveal that pH values of all the samples vary from 7.3 to 7.9. These values are within the permissible limit of 6.5 to 9.2 (ICMR, 1975). TDS in all the water samples exceed the permissible limit. TDS in the water samples S_1, S_5, S_6, S_7, S_8, S_9 & S_{11} are slightly higher than the permissible limit. So these water samples are suitable for domestic purposes and not for drinking purposes. Total hardness of water samples that are collected 1km away from the sea water is S_2, S_3, S_4, S_{10} & S_{12} are beyond the permissible limits according to ICMR i.e. 300 µmho/l. So these water samples are very hard. But the water samples that are collected 5km away from the sea water i.e. S_1, S_5, S_6, S_9 & S_{11} have total hardness values within the permissible limits.

The electrical conductivity of all the water samples exceeded the domestic water standards of 300µmho/cm. Theses high values of electrical conductivity may be due to the high concentration of ionic constituents present in the water bodies and sea water intrusion. So these water samples cannot be used[8] for drinking purposes. The water samples S_2, S_3, S_4, S_{10} & S_{12} are unsuitable even for irrigation purposes as the values are beyond the permissible limit of 2000 µmho/cm.

In samples S_2, S_3, S_4, S_7 & S_{10} as the alkalinity values are much less than the values of total hardness, neutral salts of calcium or magnesium such as sulphates and chlorides may be present because of the intrusion of sea water. But in samples S_1, S_5, S_6, S_8 S_9 & S_{11} the alkalinity values are not much less than that of total hardness. So the water samples can be used for the domestic purposes.

The DO permissible limit for all the domestic purposes is 4-6 ppms. The observed values for the water samples S_2, S_3, S_4, S_7, S_{10} & S_{12} lie above the permissible limit i.e.7.5 to 8.8 and S_1, S_5, S_6, S_7, S_8, S_9 & S_{11} have DO values within the permissible limit. The higher the values of DO mean the rate of oxygen replenishment in water is greater than the oxygen utilization. This is healthy for almost all aqueous lives. The WHO permissible limit for BOD values range from 4.1 mg/l and 8.0 mg/l. The water samples S_2, S_3, S_4, S_{10} & S_{12} exceed the permissible limit of 6mg/l and especially in S_3 & S_4, the values are very high. The WHO permissible limit for COD is 10 mg/l for domestic water. COD values in the water samples S_2, S_3, S_4, & S_{12} slightly exceed the permissible limit and especially in S_{10}, the value is high. This may be due to the discharge of the chemicals from the industry situated in Arumuganeri [2].

Most of the water samples have high calcium concentration and magnesium concentration of most of the samples lie within the permissible limits i.e. 75mg/l for calcium and 50 mg/l for magnesium. The chloride concentration of most of the water samples except S_1, S_5, S_6, S_8 & S_9 exceed the ICMR limit of 250 mg/l. These higher concentrations of chloride may be due to the intrusion of sea water, brines, sewages or industrial effluents such as those from paper works, galvanizing plants, water softening plants and petroleum refineries. Hence the water samples S_1, S_5, S_6, S_7, S_8, S_9 & S_{11} can be used for domestic purposes and S_2, S_3, S_4, S_7, S_9, S_{12} & S_{14} cannot be used for the same purpose. Sulphate concentration in the study area is found to vary from 55 to 330 mg/l. All the water samples except S_4 lie within WHO permissible limit of 200 mg/l. A high amount of sulphate imparts a bitter taste to the water and it also causes gastric intestinal irritation. The permissible limit for fluoride concentration [6] is 1 to 1.5 mg/l. This indicates that desirability of fluoridation of water supply to prevent the dental decay in children. All the water samples have the fluoride content less than 1 mg/l. So all the water samples cause dental fluorosis and skeletal fluorosis.

Nitrates are the end products of the aerobic stabilization of organic nitrogen and occur generally in high levels in some ground waters. Even though there are many chemical fertilizer-manufacturing plants are near the study area, all the water samples lay within the permissible limit ranges from 1 to 14 mg/l. This may be due to the recycling of effluents discharged from the industries. The ammonia content present in water samples should not exceed 0.05 mg/l. Some of the water samples S_2, S_3, S_4, S_7, S_8, S_{10} & S_{11} have no ammonia content and some of the water samples S_1, S_5, S_6, S_9 & S_{12} have ammonia content beyond the limit ranging from 0.42 to 0.84 mg/l. This may be due to the pollution of water with sewage because sewage is rich in ammonia. The phosphorous content in all the water samples range from 0.08 to 0.24 mg/l. These presences are widely employed to prevent scale formation and to inhibit corrosion particularly in boiler feed waters and cooling waters. Due to rapid

industrialization and over exploitation of the ground water resources, there is a distribution of major and trace elements in the environment. Depending upon the environmental parameters, each element moves at a different rate and due to the changing environment, the trace metals and associated elements may form complex and precipitate is become concentrated at several places. The concentration of iron in water exceeding 1 mg/l causes poor or bitter taste, colour and turbidity. It also causes staining of materials and iron bacteria causing slime. All the water samples except S_6 and S_{10} do not contain the iron concentration. Even S_6 and S_{10} contain iron concentration 0.2 and 0.1 mg/l, which lie within the WHO permissible limit of 0.3 mg/l. All the water samples do not contain the concentration of manganese.

The 10^{-3} and 10^{-4} dilution of all the sterile water samples S_1, S_5, S_6, S_7, S_8, S_9 & S_{11} have colonies that are too numerous to count. But in 10^{-5} dilution, they are countable within the limit of 30 to 3000 colonies. Specific pathogens are isolated in all the water samples S_1, S_5, S_6, S_7, S_8, S_9 & S_{11} using selective media such as TCBS agar, XLD agar and EMB agar. When the colony in the TCBS media is yellow in colour, the pathogen vibrio cholerae is identified and when the colony is green colour, the pathogen vibrio parahaemolyticus is identified. When the colony is yellow colour XLD in agar media, the pathogen present is E.Coli & when the colony is black in colour, the pathogen present is salmonella sp. When the colony is pink in colour, in EMB agar media, the pathogen present is Enterobacter aerogen and when the colony is metallic sheen colour, the pathogen E.Coli is present. So in all water samples except S_{10} the pathogens vibrio cholerae and Enterobacter aerogen[6] are present. In S_1, S_5, & S_{10} E.Coli are present and in all the samples except S_1 & S_{11} salmonella sp., are present.

Table II. Physico-Chemical Characteristics Of Ground Water In The Study Area.

Parameters	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}
PH	7.3	7.7	7.3	7.4	7.3	7.9	7.6	7.3	7.3	7.9	7.5	7.4
Electrical conductivity mho/cm	1350	10190	6590	4520	765	1435	2200	1940	970	7030	2230	4500
TDS	945	7133	4613	3164	536	1005	1596	1358	679	4921	1561	3150
Alkalinity	254	373	564	572	284	318	212	522	204	644	437	522
Total Hardness	275	626	909	1010	246	202	434	576	271	808	444	465
Calcium	71	178	234	275	69	58	117	145	71	226	109	113
Magnesium	23	44	78	78	17	14	34	51	22	58	41	44
Dissolved O_2	5.6	7.6	8.8	8.5	5.0	4.3	5.7	4.9	5.4	7.9	4.8	8.3
BOD	5	6.3	7.5	7.8	5.7	4.1	5.2	4.4	5.9	6.4	6.5	6.2
COD	9.8	10.1	10.5	10.3	9.8	8.4	9.1	8.0	8.2	12.5	9.0	10.7
Chloride	223	3127	1675	1049	53	180	514	212	184	1696	413	1230
Sulphate	84	140	66	330	55	99	116	136	55	178	128	116
Fluoride	0.4	0.8	0.8	0.6	0.4	0.6	0.4	0.6	0.6	0.2	0.2	0.8
Nitrate	14	13	2	3	2	12	1	4	1	2	6	5
Ammonia	0.42	0.00	0.00	0.00	0.32	0.42	0.00	0.00	0.84	0.00	0.00	0.56
Phosphate	0.20	0.24	0.08	0.24	0.08	0.16	0.16	0.20	0.12	0.20	0.16	0.24

Table – III Pathogens identified in different samples

Sample	Vibrio Cholerae	Vibrio Parahaemolyticus	E.Coli	Salmonella Sp.	Enterobacter Aerogen
S_1	√	√	√	-	√
S_5	√	-	√	√	√
S_6	√	√	-	√	√
S_7	√	-	-	√	√
S_8	-	√	√	√	-
S_9	√	-	-	√	√
S_{11}	√	-	-	-	√

Conclusion

In the present study, the analysis shows that according to the physico-chemical and bacteriological examinations, all the water samples are unfit for drinking purposes.The reason may be due to sea water intrusion and the presence of pathogens like *Vibrio Cholerae, Salmonella Sp., and E.Coli*. The water samples that are collected 1 km away from the sea water are more contaminated than that are collected 5 km away from the sea water. The non potability of the ground water may be due to high values of TDS, Total Hardness, Chloride, Sulphate & Pathogens present in the samples. Because the ground water was contaminated more by micro organism, disposal of sewage and the intrusion of sea water. They cause many water born diseases such as cholera, typhoid, dysentery, diarrhea, tuberculosis, jaundice, infectious hepatitis etc.They also cause water washed diseases such as skin diseases, leprosy scabies etc. and water related diseases such as malaria, sleeping sickness, filarial etc. So the water samples that are collected near the coastal area cannot be used not even for domestic purposes.

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