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ASSESSMENT OF GROUNDWATER POLLUTION A CASE STUDY FROM BANDAR TOWN, KRISHNA DISTRICT ANDHRA PARADESH, INDIA

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ABSTRACT:
Rising demand of water for irrigation, agricultural, domestic consumption and industry is forcing stiff competition over all the allocation of scarce water resources among both, areas and type of use. The small portion of available fresh water for human consumption is being contaminated by various natural as well as anthropogenic sources at very alarming rate. With this view, the present study was under taken to ascertain groundwater pollution of Bandar Town, in view of the sever contamination from various sources. Groundwater samples were collected from various locations and analyzed for physical and chemical parameters like pH, Specific conductance, total dissolved solids, chloride, alkalinity, total hardness, calcium, sulphate and nitrate. High levels of these chemical characteristics are attributable to salt water intrusion, urbanization and sewage drains. The data and the results of the investigation area are presented and discussed.

KEY WORDS: Bandar town, physico - chemical characteristics, sea water intrusion

INTRODUCTION:

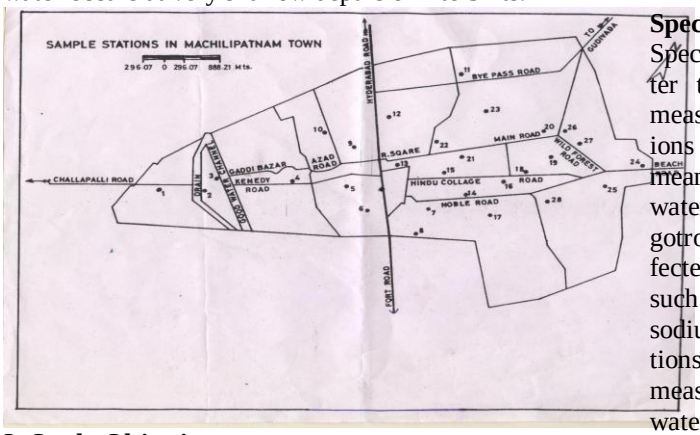
Water is one of the most abundantly available substances in the nature and forms about 75 % of the earth's crust. It is an essential constituent of all animal and plant matter, but all water is not useful for human activities. Physical and chemical parameters of water sources are influenced seasonally and environmentally. Some changes in water sources can cause unhealthiness to humans Pollution problem in the cities of developing countries are due to disposal of large quantities of urban wastes and industrial effluents on to the land surface, that consequently get infiltrated with these pollutants with water. About 80% of the diseases in the world are due to polluted water (WHO, 1970). Due to increased human population and man- made conditions, the ground water quality is deteriorating everywhere. Bandar town is probably no exception. With this intention, 28 water sampling stations were kept under observation and monitored regularly at Bandar town of Andhra Pradesh.

STUDY AREA:

Bandar Town is popularly is known as Machilipatnam and headquarter of Krishna District, A.P. it is an old town and now growing rapidly due to Bandar port, urbanization and industrialization. Machilipatnam (Lat. $16^0 12^1$ North and long. $81^0 09^1$ East) situated on the southern part of the East coast of India. Its area is about 40sq.km. with a population of 5 lakh, experiencing with tropical climatic conditions. April to June are the hottest months with maximum temperature of 47^0 C and humidity varies from 70 to 80 %. The mean annual rainfall is 835 mm. Most of the rain fall is received during South-West monsoon.

Bandar Town is located at 3.25m above MSL on fine sand and silts with clay of marine origin. Near the coast, surface is fringed with dunes of sand deposited by air and tidal wave action. The salinity of the top soil indicates tidal action of the sea, probably since geological past, particularly in the years 1977 and 1991. Salt water intrusion in which saline water the displaces or mines with fresh groundwater is another source of groundwa-

ter contamination. Bandar canal from the Krishna river is the source for Machilipatnam Municipal water supply. The groundwater aquifer in the study area is principally composed of gravel, sand and silt. Groundwater occurs at very shallow depths of 1 to 3mts.



3. Study Objectives:

1. Collection of collateral Ground water samples from different locations and creation of attribute data.
2. Study of Physical and chemical characteristics.
3. Identification of Ground water pollution sensitivity areas.

MATERIALS AND METHODS:

A total of 28 ground water samples collected from different sampling locations in and around Machilipatnam town (Fig.1). These samples were analyzed for physical and chemical characteristics such as pH, specific Conductance, total dissolved solids, chloride, alkalinity, total hardness, nitrate, calcium and sulphate, as per the standard procesures described in APHA(1989), and Trivedy et.al.(1986).

RESULTS AND DISCUSSIONS:

pH: pH is a method of expressing hydrogen ion concentration, which determines whether the water is acidic or alkaline. The pH of most natural waters ranges from 6.5 to 8.5. Deviation from the neutral pH 7.0 is largely the result of interaction between acids and bases. Industrial and community wastes, acid rain, nature of rock type and biological processess influence the pH level. As rain falls, it dissolves carbon dioxide from the atmosphere, thus forming a weak carbonic acid and lowering the pH of the precipitation. Low pH levels can have a harmful impact on aquatic communities. The lower pH value tends to make water corrosive and higher pH results in the taste complaint and can have negative impact on skin and eyes (Murugesan et. al, 2006). The pH values that exceed 9.0 cause excessive algal growth, a sign of nutrient enrichment. In the study area pH ranged from 7.02 to 8.5 showing alkaline nature of groundwater. Generally, lower pH value (7.02) is found at Circlepet in the study area.

Specific conductance:
Specific conductance is a measure of the ability of water to conduct electrical conductance. Conductivity measures the amount of ions in a solution. The more the ions in the solution, the higher is the conductivity. This means that sea water has higher conductivity than fresh water and eutrophic water higher conductivity than oligotrophic water. Thus, the conductivity in water is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulphate and phosphate ions or sodium, magnesium, calcium, iron, and aluminum cations. The specific conductance of water is an indirect measure of the total dissolved solids(TDS) content of water, and there is usually approximately linear relationship between TDS and conductivity. Conductivity decreases as the point of source is farther from the sea. This observation indicates that salt water intrusion is more predominant near the sea and the probability of salinization phenomenon of groundwater decreases with increasing distance between the coast and point of source in the study area. The conductivity values of groundwater varied widely from 772 to 13390 µ mhos/cm. water with electrical conductance more than 2000 µ mhos/cm is unsatisfactory for drinking and for irrigation, when it exceeds 3000 µ mhos/cm (Gangal et.al.,1990). Maximum electrical conductivity (13390 µ mhos/cm) was noticed at Circlepet and minimum value (772 µ mhos/cm) at Balaramunipet.

The total dissolved solids:
Drinking water quality is affected by the presence of soluble salts. The total dissolved solids (TDS) in groundwater originate from natural sources, sewage, urban run-off and industrial wastes. In the present study, the TDS of groundwater samples varies from 502 to 8704 mg/l. Minimum concentration of TDS is recorded at Balaramunipet, indicating no/less pollution, where as maximum values of TDS are observed at Circlepet and Batchupet indicating that infiltration of pollutant solutes from effluents. The TDS concentration is increased by the contaminated water from surface drains and cesspools in the study area. Safety levels of TDS for drinking water are less than 1000 mg/l (WHO,1971), where as the range of 3000 to 7000 mg/l is classified as normal to moderately saline (Robinove et.al.,1958). Groundwaters with less than 1000 mg/l of TDS are observed at Chinaguntapalem, Inakudurupet, Buttaipet, Robertsonpet, Machavaram and Frenchpet. Moderately saline waters with TDS above 3000 mg/l are observed at very nearer to the sewage drains, cess-

pools and thickly populated areas (sampling stations 5,6,14,15,26,27). The TDS affects the strength and durability of concrete, and palatability of food cooked.

Chlorides:
Chloride ion is one of the major inorganic anions in water and waste water. In potable water, the salt taste produced by chloride concentrations is variable and dependent on the chemical composition of water. The chloride concentration is higher in waste water than in rain water because sodium chloride is a common article of diet and passes unchanged through the digestive system to contaminate groundwater. Along sea coast, chloride may be present in high concentrations in groundwater, because of leakage of salt water into sewage system. The chloride content is found to be large in the samples near sea, due to salt water intrusion. As per Indian Standard Institution (1983), the desirable and maximum permissible levels of chloride for potable water are 200 mg/l and 600 mg/l respectively. The chloride values in various locations of Bandar Town varies from 280 to 6590 mg/l. High concentrations of chloride may be due to sewage wastes, salt application to coconut trees and leaching of saline residues in the soil. High concentration of calcium, chloride and sulphate, in groundwater of the study area is through the subsurface intrusion of sea water. After sea regression , the study area was subjected to denudation. However, shallow layers of coastal sediments (Dune sand) are found to contain portable waters at Frenchpet, Balaramunipet, Chintaguntapalem and Inakudurupet. 28.68 % of the collected samples were within the desirable limits.

Alkalinity:
Alkalinity is a measure of the capacity of water to neutralize acids. It is primarily determine by the presence of bicarbonates, carbonates and hydroxides in water. These alkaline compounds in the water remove H^+ ions and lower the acidity of water (increased pH). They usually do this by combining with H^+ ions to make new compounds. Alkalinity of natural waters is primarily the result of bicarbonates, but is expressed in terms of calcium carbonate. Carbonates and bicarbonates are common to most waters, since they are abundant in nature. However, if the bed rock of watersheds is lacking in carbonates and other buffering minerals, as in granite rock, the alkalinity values will be low. The alkalinity of fresh water is between 20 and 200 mg/l. carbon dioxide and bicarbonate are in a balance in the pH range 4.4 and 8.2. At pH of 4.4 or lower, all alkalinity is in the form of carbon dioxide. At pH of 8.2, there is no carbon dioxide and all alkalinity is bicarbonate. Bicarbonate and carbonate are in a balance in the pH range of 8.2 and 9.6. At pH of 9.6, there is no carbon dioxide or carbonate and all alkalinity is due to carbonate. Most naturally occurring water sources have a pH between 6 and 8.4, so the presence of hydroxides is the result of man maid activity. During the present study the alkalinity range is 98 to 593 mg/l. High alkalinity waters usually unpalatable, which are noticed at Kalekhanpet (593mg/l), Javvarpet (517gm/l), Rajupet (544 mg/l), Narasimhanagar (491 mg/l) and Chilakalapudi (468 mg/l). Excess alkalinity gives bitter tastes to water and reacts with cations, forming precipitates, which can damage pipes and other appurtenances like valves , pumps, etc. Alkalinity in itself is not harmful to human beings, still the water samples with less than 600 mg/l are desirable for domestic use. 21 % of the collected samples were within the desirable limit (Table-3). None of the samples was above the maximum permissible limit.

Hardness:
Hardness is the chemical property of water, which prevents the formation of lather with soap, which is mainly caused by the multivalent metallic cations like calcium, magnesium, iron, and strontium. Therefore, hardness of water reflect the nature of geological formations, with which it has been in contact. In the present study, hardness varied between 150 to 1175 mg/l. Hardness of water crosses permissible limits 120 mg/l (Hem, 1986) at all the sampling locations in the present study. Moderately hard waters with values of 150 to 200 mg/l (Twort et.al., 1974) are noticed at Inakudurupet and Frenchpet, and rest of the study area has groundwater hardness beyond permissible limits. It is mainly due to calcium, magnesium and chloride in sewage and subsurface clayey soils. Total hardness exceeding 300mg/l generally not recommended for drinking as it may cause cardiac and kidney problems. Only 7 % of the collected samples are within the desirable limit.

Nitrates:
Naturally high nitrate concentrations may occur in groundwater in semi - arid and arid regions, where there is widespread termite activity, or natural vegetation is determined by leguminous species such as acacias. Nitrates and nitrites are the most forms of dissolved nitrogen in groundwater and surface water due to agricultural and domestic activities (Zutshi & Khan,1988). Nitrate levels in surface waters can change quite quickly, but levels in groundwater usually change very slowly, unless the groundwater is heavily influenced by surface water. Elevated levels are primarily associated with human contamination from fertilizers and sewage.High nitrate concentrations of water are deterious to human

health (Feth,1966). Unpolluted waters contain less than 5 mg/l of nitrate, but polluted waters contain up to 100 mg/l or more (Karanth,1987). In the study area, the nitrate concentrations in groundwater varies from 5 to 89mg/l. High nitrate content in groundwaters is due to improper maintenance of septic tanks and sewage drains. The rainfall and return flow from surface drains in the study area are the main carriers of nitrate to groundwater from soil enriched with organic matter. It may also due to pollution from surface sources such as domestic waste waters and industrial effluents. Widespread use of faulty septic tanks, unlined open drains and cesspools are the sources for excessive nitrate concentrations at Circlepet (89 mg/l), Javarpet (80 mg/l), Kalekhanpet (79 mg/l) and Valandapalem (76 mg/l). Drinking water with nitrate concentrations greater than maximum permissible value of 45 mg/l (Maxcy, 1950) is obtained from 20 sampling stations in the study area. This has caused Mathemoglobinemia in infants a disease, where the skin becomes blue, owing to decreased efficiency of haemoglobin to carry the oxygen.

Calcium:

The Presence of calcium in water supplies results from passage through or over the deposits of limestone, dolomite and gypsum. Calcium contributes to the total hardness of water. Small concentrations of calcium combat corrosion of metal pipes by laying down a protective coating. Appreciable calcium salts, on the other hand precipitate on treating to form harmful scale in boilers, pipes and cooking utensils. In the present study, calcium values varied from 30 to 216 mg/l. However, except sampling location at Ramanaidupet (216 mg/l), the calcium values are well within the maximum permissible limit of 200mg/l prescribed by the ISI (1991). It has been observed that 96 % of the collected samples are within the maximum permissible limit in the present study.Concentrations of Sulphate values in the area of investigation ranged from 22 to 827 mg/l reported at Frenchpet and Circlepet respectively. 28.68% of the collected samples were within the desirable limit.

STATISTICAL ANALYSIS:

Correlation coefficient (r) among selected water quality parameters are presented in Table-2. Highest positive correlation (r = 1.0) was obtained between specific conductivity and total dissolved solids. It reflects that specific conductivity is mainly due to dissolved solids. Sulphates showed highest correlation with chlorides (r = 0.847), total dissolved solids (r = 0.79) and specific conductivity (r = 0.789). Total hardness showed significant correlation with specific conductivity (r= 0.624), total dissolved solids (r= 0.624)and alkalinity (r= 0.523). It was responsible for temporary type of hardness. It also showed highest correlation with calcium (r= 0.912) that seems to be important contributor for hardness of water. Significant correlation was obtained between alkalinity with total hardness (r= 0.523), nitrates (r= 0.456) and total dissolved solids (r= 0.410).

CONCLUSION AND CONTROL MEASURES:

In the present study area, groundwater is the source for drinking and other domestic purposes, which is exploited by people, through number of shallow dug wells and tube wells. The investigation revealed that the quality of potable groundwater occurs in shallow zones of coastal sediments (dune sand) in certain locations of Bandar urban area, where the shallow open or bore wells are located away from the sources of contamination. High groundwater quality variations are due to from various sources such as sea water intrusion, surface effluents, decomposed garbage, faulty septic tanks, unlined sewage drains, cesspools and other surface effluents entering the open wells.

High concentration of chloride, calcium, alkalinity and sulphate may be due to intrusion of sea water and other sources of contamination, since the observed sampling locations are nearer to the sea coast. Prevention of sea water intrusion is the only way, since there is no technology so far for treating saline water below the ground itself. The salinity of groundwater is also increased as a result of over exploitation of groundwater from thin sandy aquifers and shallow occurrence of water table below the ground level. Hence, it requires to enact a legislation to regulate the use of groundwater in the observed locations of the study area. Providing adequate drainage system with proper treatment before disposal and removal of faulty constructed septic tanks and cesspools may restrict the determination of water quality.

1. Proper sewage systems (preferably an open drainage system) should be employed in Bandar town for collecting the waste water and to avoid the stagnation of domestic sewage as well as storm water.

2. Eucaliptus (Nilagiri) tress can be grown at the sides of roads and streets. So that they consume more water and hence water logging problems can be avoided.

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Table-1: Average physico-chemical values of groundwater samples at different locations in the BandarTown (All values are in mg/l except pH and EC in µ mhos/cm)

S.No	Location	pH	Specific Con-ductivity	TDS	Chlorides	Sulphates	Alkalinity	Total Hardness	Ca2+	Nitrates
1	Sarada Nagar	8.15	2683	1720	1085	32	164	400	30	9
2	Kalekhan pet	7.60	4135	2646	1205	31	593	500	78	79
3	Chintagunta palem	7.27	1041	666	279	28	244	465	124	35
4	Inakudurupet	7.42	1044	679	325	30	119	150	36	19
5	Javvarpet	7.26	5218	3390	1914	135	517	785	120	80
6	Circlepet	7.02	13390	8704	6593	827	350	1100	146	89
7	Buttaipet	7.94	1051	676	425	104	255	300	52	40
8	Malkapatnam	7.73	2147	1392	625	28	225	450	90	24
9	Godugupet	7.84	3212	2068	1205	76	330	585	94	49
10	Rajupet	7.48	3696	2403	1063	36	544	650	92	40
11	APHB Colony	7.44	3180	2067	1243	301	389	500	64	13
12	Balaramunipet	7.92	772	502	325	117	185	275	54	17
13	Robertsonpet	7.84	960	624	354	83	316	300	48	22
14	Ramanaidupet	7.21	5455	3546	2197	427	283	1175	216	27
15	Batchupet	7.64	10560	6865	850	271	405	450	72	32
16	S.P.Off.center	7.41	2393	1556	652	151	294	625	110	11
17	Bhaskarpuram	7.45	2224	1446	709	124	216	500	88	5
18	Parasupet	7.62	4010	2607	1276	355	358	945	140	12
19	Narasimhanagar	7.6	4146	2695	1347	177	491	800	166	38
20	Machavaram	7.81	1001	651	354	26	369	350	60	40
21	Englishpalem	7.23	2955	1921	921	61	351	620	108	36
22	Revati Theatre junction	7.5	2666	1733	638	224	289	370	72	38
23	Edepalli	7.62	2546	1655	530	230	275	395	70	35

24	FCI Godowns	7.22	2863	1861	709	132	175	300	54	55
25	Panduranga Temple	7.77	1456	947	496	85	198	400	74	50
26	Valandapalem	7.21	6026	3917	2127	225	285	575	66	76
27	Chilakalapudi	7.46	4609	2996	1772	228	468	1010	152	66
28	Frenchpet	7.92	949	617	312	22	98	175	38	32

Table:2 Correlation coefficients between physico-chemical values of groundwater samples:

		Correlation Coefficient								
S.No	Location	pH	Specific Conduc-tivity	TDS	Chlorides	Sulphates	Alkalini-ty	Total Hardness	Ca2+	Nitrates
1	pH	-	-0.491	-0.492	-0.528	-0.503	-0.246	-0.526	-0.532	-0.411
2	Specific Conductivity	-0.491	-	1.000	0.830	0.789	0.411	0.624	0.433	0.507
3	TDS	-0.492	1.000	-	0.830	0.790	0.410	0.624	0.433	0.506
4	Chlorides	-0.528	0.830	0.830	-	0.847	0.286	0.704	0.493	0.568
5	Sulphates	-0.503	0.789	0.790	0.847	-	0.156	0.672	0.521	0.282
6	Alkalinity	-0.246	0.411	0.410	0.286	0.156	-	0.523	0.435	0.456
7	Total Hardness	-0.526	0.624	0.624	0.704	0.672	0.523	-	0.912	0.323
8	Ca^{2+}	-0.532	0.433	0.433	0.493	0.521	0.435	0.912	-	0.204
9	Nitrates	-0.411	0.507	0.506	0.568	0.282	0.456	0.323	0.204	-

		WHO* Standard Vlaues		% of sample within	
S.No	Location	Desirable lim-it	Max permissible limit	Desirable limit	Max permissible limit

1	pH	7.0-8.5	6.5-9.2	100	-
2	Specific Conductivity	N.A**	N.A	-	-
3	TDS	500	3000	-	82
4	Chlorides	250	1000	-	57
5	Sulphates	200	400	68	93
6	Alkalinity	200	600	21	100
7	Total Hardness	200	600	7	68
8	Ca^{2+}	75	200	50	96
9	Nitrates	45	100	45	100

Table:3 Percentage of collected water samples above and below the limits