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Original Research Article

Chemical and microbial characterization of surface and ground waters near estuaries of East Godavari region for evaluation of their potential for application

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A B S T R A C T

Surface and Ground water are systems linked with each other. In Coastal region salanization problem is significant for ground water contamination. The transition of ground water in to the surface waters contributes a noticeable change in the ground water environment besides heavy metal cycling. Due to natural and anthropogenic activities the surface waters become contaminated which in turn depletes the ground water quality in the nearby areas of estuaries. The present research is focussed on the characterization of surface and ground waters for physicochemical parameters viz., pH, EC, TDS, TH, TA, F^-, Cl^-, So_4^{-2}, No_3-, Po_4^{-3}, Na, K, Ca, Mg and heavy metals. Further the Irrigation parameters like %Na, SAR, RSC, Kelly's Ratio (KR) and MH are determined. The waters are further characterized for identification of *Bacterial spp.* The research results revealed that the waters are chemically and bacteriologically contaminated and confirms their unsuitability for drinking and domestic application. Higher levels of Magnesium hazardness indicates that the waters are with Magnesium hazardness and the waters can deplete the soil quality which results in the reduction of crop yields in the study area. Hence the waters are to be treated properly and suitably even for considering them for irrigation purposes.

Introduction

It has long been known that ground water and surface waters are intrinsically linked systems. The areas around coastal environments, like estuaries, represent zones of interaction and transition between groundwater and the estuary where dissolved constituents such as pollutants, nutrients etc can be diluted, exchanged, transformed and destroyed. Increasing urbanization along coastlines and estuaries increased use of ground water that will have a large impact on the quality and quantity of aquifers (Campbell, 1992). Problems like as the discharge of untreated or inadequately treated waste water, agricultural runoff from farms and discharge of untreated sewage can

also contaminate ground water in costal aquifer (Campbell, 1992).

Salinization is the most widespread form of ground water contamination in coastal aquifers, and is represented by the increase of total dissolved solids (TDS) and some specific chemical constituents such as Cl^-, Na^+, Mg^{+2} and SO_4-$^{-2}$ (Nadler et al., 1981; Magaritz and Luzier, 1985; Dixon and Chiwell, 1992; Morell et al., 1996; Sukhija et al., 1996; Gime'nez and Morell, 1997). Many of the coastal aquifers in the world already experience salt water intrusion caused by both natural and anthropogenic activities. It is necessary to understand the movement and mixing between freshwater and salt water and the factors which can effect these processes (Ranjan et al., 2005). As a result of their marine nature, the sediments have a high calcareous content and hence alkalinity. The dissolution of these components into ground water leads to high salt content.

Ground water reaches coastal environments either by direct discharge or as base flow in the streams and rivers that drain coastal areas. It has been shown that ground water input into coastal waters accounts for as much as 65% of the total freshwater in flows. Ground water/Surface water interactions in estuarine environments result in forming complex spatially and temporally variable systems. Tidal activity often induces a fluctuating water table and an infiltration of surface water into the coastal sediments to form a "mixing" zone with ground water discharging from the adjacent aquifer for such a zone and term ground water/surface water interface is used. The transition of ground water into the sediments and surface waters of an estuary can represent a significant environmental change from the relatively stable ground water environment. Heavy metal Cycling is also a problem in mangrove environment[i]. The high levels of heavy metals are from anthropogenic activities from industries around estuary. The study by Kehrig et al, (2003) suggests that metal concentrations in sediments of Jequia mangrove forest Brazil significantly exceeded the natural concentration. The study area is presented in figure-1.

Materials and Methods

Materials ad Methods

The present research study area Matlapalem is located in East Godavari region of Andhra Pradesh around the latitude $16^0$51'18.05N and longitude $81^0$13'56.01E, the surface of subsurface waters are collected in the mangrove region of East Godavari Eastuaries located at Matlapalem. The details of sampling code, source and location are presented in Table-1

Physicochemical Characterization:

Polythene containers were employed for sampling and preserved for characterization by following the standard procedures. The samples are characterized for physicochemical parameters viz., pH, Electrical conductivity (EC), Total Dissolved solids (TDS), Total Alkalinity (TA), Total hardness(TH), Calcium and Magnesium, Na, K, Chloride, Sulphate and Phosphate. pH determined by pH meter (Global-DPH 505,India-Model) and Conductivity measured by the digital conductivity meter (Global-DCM-900-Model). TDS is determined from the relation TDS=Electrical conductivity (EC) X 0.64. Chloride, Total hardness, Total Alkalinity and Chloride are estimated by titrimetry. Sulphate and Phosphate by spectrophotometer (Model-167, Systronics), Na and K by Flame photometer (Model-125, Systronics). The analytical data is presented in tables-2 and 3 respectively.

Irrigation parameters

The irrigation parameters % Na, SAR, RSC, KR and MH are detailed by using the relationship.

$$\%Na = \frac{Na \times 100}{Na+K+Ca+Mg}$$

$$SAR = \frac{Na}{\sqrt{Ca+Mg/2}}$$

$$RSC = (CO_3^{-2}+HCO_3^{-}) - (Ca^{+2}+Mg^{+2})$$

$$KR = \frac{Na}{(Ca+Mg)}$$

$$MH = \frac{Mg \times 100}{Ca+Mg}$$

The data related to Irrigation parameters are presented in Table-4

Microbial (Bacterial Analysis)

The most probable Number (MPN) technique has been employed for the enumeration for the Coliform count which involves the presumptive test using lactose broth and Nutrient agar confimatory test using Eosin Methylene Blue (EBM) agar, pure colonies of the isolated were subjected to Grams stain, motility, Indole, Methyl red, Voges Proskue test, Citrate utilization test, Urease test, Catalse and Oxidase test.

The bacteria is characterized by various characteristic which include the shape, staining, color and the biochemical (IMViC) tests such as Indole formation test, Methylred test, Voges proskauer tes The cultural characteristics and the details of Biochemical characterization for identification of bacteria are presented in table-5.

Results and Discussion

pH: Water with pH ranging from 6.5 to 8.4 can be considered for irrigation without any problem and between 5.1 to 6.4 and 8.5 to 9.5 moderate class. The pH of surface water of Pre monsoon season is 7.87 while the average pH of ground water is 8.42. The pH of surface water of Post monsoon season is 7.73 while the pH of ground water is 7.43. All waters are within the no problem range of pH for considering the water for irrigation.

Electrical Conductivity: Waters with EC greater than 4000 µmhos/cm are saline in nature and are not suitable for irrigation. Water with EC from 0-750 µmhos/cm is classified as class-I waters and are excellent for irrigation. EC from 750-2250 µmhos/cm are classified as Class-II waters and are good; however harmful to sensitive crops. Waters with EC greater than 2250 µmhos/cm are classified as Class-III Waters and are unfit for irrigation. EC of surface water of Pre monsoon season is 2333.3µmhos/cm^3 and for the ground water is 4141.67 µmhos/cm and the waters are classified as Class-III waters and are unfit for irrigation. EC of surface waters of Post Monsoon season is 3713.33µmhos/cm and EC of ground waters post monsoon season is 1840µmhos/cm. The ground waters are classified as class-II waters and can be considered for irrigation; however they are harmful to sensitive crops. The high values of EC may be due to the increased rate of percolative of domestic and agricultural wasters containing high dissolved solids.

Total Dissolved Solids (TDS): Waters with TDS greater than 500mg/l are not suitable for drinking purpose. Water with TDS ranging from 0-192mg/l are classified as class-I waters and excellent for irrigation and in between 192-480mg/l are classified

as class-II waters and good for irrigation; however harmful to sensitive crops. Water with TDS greater than 480mg/l are unfit for irrigation. TDS of surface waters of pre monsoon season is 1463.33 while TDS of ground water is 2650.67mg/l while TDS of ground water is 2376.53mg/l. TDS of ground water is 1177.60mg/l. All values are above the permissible limit of drinking and irrigation standards making post monsoon season waters unsuitable for drinking or domestic utilization.

Total Hardness (TH): It is an important parameter of water quality and is used to evaluate the water quality for considering the waters for domestic, industrial land agricultural purposes. Waters with TH less than 300mg/l are suitable for drinking purposes. TH of surface waters of pre monsoon season is 2300mg/l while TH of ground water is 800mg/l.TH of surface of post monsoon season is 37000mg/l while TH of ground water is 8516.67mg/l. All the levels exceed the permissible limit and are at high order indicating the very hard nature of waters which can cause encrustation on water supply system and are unsuitable for domestic utility. High hardness is due to the contamination by the presence of Ca, So_4, Cl in the study area.

Chloride (Cl^-): Chloride concentration up to 250mg/l in waters is a permissible limit of drinking water standards. Waters with chloride in the range from 0-142mg/l are classified as Class-I waters and excellent for irrigation and between 142-355mg/l are classified as Class-II waters and are good for irrigation; however harmful to sensitive crops. Waters with chloride greater than 355mg/l are unfit for irrigation.

Chloride in surface waters of Pre monsoon period is 8118.05mg/l while in ground water it is 1051.68mg/l. Chloride in surface waters of post monsoon season is 15326.22mg/l while it is 135.89mg/l in ground water of post monsoon season. The values of chloride in ground waters exceeded permissible limit indicating the signatures of saline water intrusion to brackish waters. In post monsoon season the chloride concentration in ground waters is within the permissible limit and it indicates the non association of salt water with ground water in the study area. High level of chloride may be due to the discharge of sewage waters and unprotected drainage waters in to the ground waters. Increased rate of percolative of Agricultural wastes and domestic wastes also enhance the chloride level in ground waters.

Calcium (Ca^{+2}): Calcium up to 75mg/l in water is suitable for drinking purposes[19]. Calcium in surface waters of pre monsoon season is 220mg/l while it is 140mg/l in ground waters. Calcium in surface waters of post monsoon season is 266mg/l While Calcium in ground water is 233.33mg/l. Calcium ion concentration exceeded the permissible limit and can cause encrustation on water supply structure and make the waters unsuitable for domestic applications. High values of Calcium may be due to the seepage of domestic works of due to the cationic exchange who sodium.

Magnesium (Mg^{+2}): The permissible limit of Magnesium in drinking water is 30mg/l. The Magnesium concentration in surface waters of pre monsoon season is 427mg/l while it is 109.80mg/l in ground waters. The Mg^{+2} ion concentration in surface waters of post monsoon season is 8962.93 mg/l while it is 2021.13mg/l in ground waters of post monsoon season and crossed the permissible limit. High levels of Mg are due to the interaction of sea water with sediment in the study area and also due to the seepage of domestic wastes or due to the cationic exchange with sodium.

Total Alkalinity (TA): The permissible limit of Total Alkalinity in drinking water is 300mg/l. TA of surface waters of pre monsoon season is 966.67mg/l while TA of ground water is 2133. 33 mg/l. TA of surface waters of post monsoon season is 433.33mg/l while TA of ground waters is 852.25mg/l. All TA values crossed the permissible limit of drinking water standards and hence are unsuitable for drinking purposes. High values of TA indicate the over exploitation of ground waters for various agricultural applications in the study area.

Fluoride (F^-): The permissible limit of Fluoride in drinking water is 1mg/l. The average Fluoride concentration in surface water of pre monsoon sample is 0.83mg/l. While its concentration in ground waters is 0.77mg/l. The fluoride in surface waters of post monsoon is 0.83mg/l while it is 0.75mg/l in ground waters. All the values are within the permissible limit of drinking water and fluoride less no effect on the quality of waters.

Sodium and Potassium: Sodium ion concentration in surface waters of pre monsoon season is 107.13 mg/l while its concentration in ground water is 51.10mg/l. In case of Post monsoon surface water samples sodium ion concentration is 100.96mg/l while its concentration in ground water sample is 53.06 mg/l. All the values are within the permissible limit (250mg/l) of WHO standards. Potassium ion concentration in surface waters of pre monsoon season is 27.23mg/l. While its concentration in ground waters is 21.15mg/l in surface water samples of post monsoon. Potassium level is 6.1 mg/l while its concentration in ground water is 12.58 mg/l. Potassium concentration crossed the permissible limit of WHO standards (12ppm) in case of surface and ground water samples. But in case of waters of Post monsoon potassium levels are within the permissible limit.

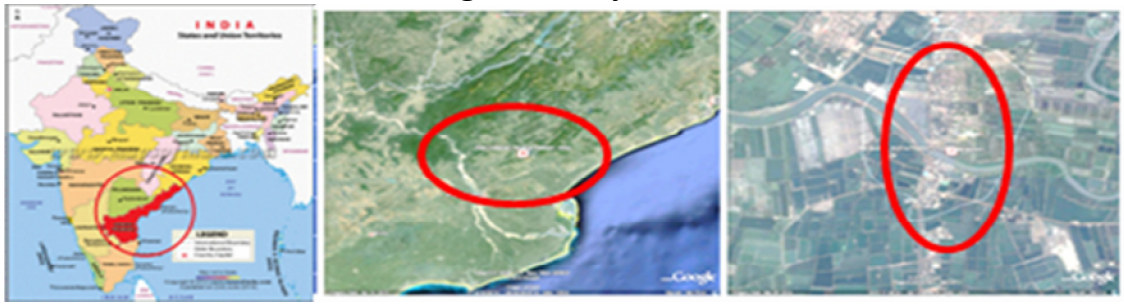
Sulphate (SO_4^{-2}): Sulphate ion concentration in surface waters of pre monsoon season is 237.90mg/l. While its concentration in ground waters is 149.83mg/l. The concentrations are within the permissible limit. In case of Post monsoon surface waters sulphate ion concentration is 107.90mg/l and in ground water samples the concentration is 35-70mg/l. All the levels are within the permissible limit indicating the non discharge of industrial effluents into the water bodies.

Nitrate: Nitrate concentration in surface waters of pre monsoon season is 49.16 mg/l. While Nitrate concentration in ground water is 54.6 mg/l. The nitrate in surface waters of post monsoon season is 54.45 mg/l and in ground waters the nitrate concentration is 56.9mg/l. The higher values of nitrate indicate discharge of Agricultural runoff into the water bodies.

Phosphate: The Phosphate iron concentration in surface waters of pre monsoon season is 5.83mg/l while its concentration in ground waters is 2.16mg/l. In waters of post monsoon season phosphate ion concentration in surface waters is 5.66 mg/l and its concentration in ground water is 1.63mg/l. The concentrations indicate some occasional discharges of Agricultural runoffs into water bodies.

Bacterial Species: The water samples though are not containing MPN Count and are observed with *bacterial species* like *Proteus*, *Bacillus* and *Staphylococcus spps*. The presence of *Proteus species* can cause health problems while the *Staphylococcus spps* can cause skin infections and respiratory related problems.

Figure.1 Study Area



India - Andhra Pradesh **East Godavari District** **Matlapalem (Estaury)**

Table.1 Sample code and Sampling locations

Sampling Code	Type of Source	Sampling Location
S-1	SW	Near Bridge (L Side)
S-2	SW	Near Bridge (R Side)
S-3	SW	Near Temple
G-1	OW	Beside Temple
G-2	OW	Near Main Road
G-3	BW	Matlapalem Area – 1
G-4	BW	Matlapalem Area – 2
G-5	OW	Matlapalem Area – 3
G-6	OW	Matlapalem Area – 4

** S – Surface water, G – Ground Water,*
SW – Stream Water, OW – Open Well, BW – Bore Well

Table.2 Physicochemical Characteristics of Surface and Ground Waters

Sample code	pH		EC (µmhos/cm)		TDS (mg/l)		TH		TA		F^-		Cl^-	
	Monsoon		Monsoon		Monsoon									
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
S-1	7.5	7.9	2100	3610	1344.0	2310.4	1800	37000	820	500	0.76	0.81	28	40
S-2	8.1	7.6	2410	3580	1542.4	2291.2	2600	40000	920	400	0.82	0.83	19	50
S-3	8.0	7.7	2490	3950	1593.6	2528.0	2500	34000	920	400	0.85	0.86	22	40
G-1	8.7	7.2	1480	1280	947.2	819.2	600	9000	1130	400	0.75	0.79	0.7	0.3
G-2	8.8	7.5	2180	1080	1395.2	691.2	600	9500	1340	400	0.68	0.71	1.1	0.4
G-3	8.7	7.4	3060	2460	1958.4	1574.4	500	7500	2240	1000	0.76	0.79	1.5	0.5
G-4	8.0	7.5	5120	1580	3276.8	1011.2	900	11300	2080	1000	0.79	0.82	2.5	0.3
G-5	8.0	7.5	7920	1960	5068.8	1254.4	1300	7500	2840	1100	0.86	0.71	10	0.7
G-6	8.3	7.5	5090	2680	3257.6	1715.2	900	6300	2110	1250	0.78	0.68	2.6	0.7

Table.3 Physicochemical Characteristics of Surface and Ground Waters

Sample Code	So_4^{-2}		No_3^-		Po_4^{-3}		Na		K		Ca		Mg	
	Monsoon		Monsoon		Monsoon		Monsoon		Monsoon		Monsoon		Monsoon	
	Pre	Post	Pre	Post	Pre	Post	Pre	Pre	Pre	Post	Pre	Post	Pre	Post
S-1	239.4	104.4	48.4	51.4	2.4	1.60	125.5	9.2	4.6	0.5	240	120	292.8	8954.8
S-2	236.4	107.4	49.5	56.4	8.9	9.10	81.7	9.5	33.7	0.6	200	80	512.4	9711.2
S-3	104.4	111.9	48.6	55.6	6.2	4.50	114.2	11.6	43.4	0.7	220	120	475.8	8222.8
G-1	21.8	22.6	45.1	48.4	4.3	2.00	17.8	3.8	11.1	1.5	120	80	73.2	2147.2
G-2	73.6	21.8	47.9	52.5	2.4	1.80	28.7	4.0	13.9	0.5	160	120	48.8	2244.8
G-3	42.6	62.5	54.3	56.4	1.5	BDL	37.3	7.8	24.4	1.4	120	120	48.8	1756.8
G-4	175.1	77.7	59.5	61.3	1.7	BDL	67.0	3.8	24.8	0.8	100	80	158.6	2708.4
G-5	22.6	14.5	63.4	64.5	1.9	1.10	95.1	5.9	28.3	1.2	220	80	183.0	1781.2
G-6	200.8	15.1	57.4	58.6	1.2	BDL	62.4	6.7	24.4	2.2	120	80	146.4	1488.4

Table.4 Irrigation parameters of Surface and Ground waters

Sample Code	RSC (me/l)		%Na (me/l)		SAR (me/l)		Kelly's Ratio(KR)		MH	
	Monsoon		Monsoon		Monsoon		Monsoon		Monsoon	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
S-1	BDL	BDL	13.31	0.06	1.30	0.02	0.15	BDL	66.12	99.17
S-2	BDL	BDL	6.41	0.05	0.70	0.02	0.07	BDL	80.39	99.49
S-3	BDL	BDL	9.00	0.08	1.00	0.03	0.10	BDL	77.58	99.10
G-1	10.44	BDL	5.99	0.09	0.32	0.02	0.07	BDL	49.39	97.72
G-2	14.50	BDL	9.22	0.09	0.51	0.02	0.10	BDL	32.80	96.77
G-3	34.50	BDL	13.34	0.23	0.73	0.04	0.16	BDL	39.42	95.91
G-4	23.11	BDL	13.71	0.07	0.98	0.02	0.16	BDL	71.73	98.19
G-5	30.76	BDL	13.56	0.18	1.16	0.03	0.16	BDL	57.10	97.27
G-6	24.39	BDL	12.88	0.23	0.91	0.04	0.15	BDL	66.12	96.75

Table.5 Cultural and Biochemical characterization Bacterial Species:

Sample No.	MPN Count/100ml	No. of Biochemical Colonies	Gram Staining	Motility	Biochemical Tests				Catalase	Bacterial spp identified
					IMVic Tests					
					Indol	MR	VP	Citrate		
1	0	1	-ve	Motile	-ve	+ve	-ve	-ve	+ve	*Proteus spps*
2	0	1	+ve	Motile	-ve	-ve	-ve	-ve	+ve	*Bacillus spps*
3	0	1	+ve	Non-Motile	-ve	+ve	-ve	-ve	-ve	*Staphylococcus spps.*

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