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PHYSICO AND BIOCHEMICAL ANALYSIS OF SUBSURFACE WATERS NEAR POLLUTED SURFACE WATER SOURCE FOR QUALITY EVALUATION

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ABSTRACT

The focus of the present research study is to characterize the subsurface waters from 12 rural and urban locations of Peddapuram and Kakinada of East Godavari Districts. The sub surface sample drawn during pre monsoon and post monsoon seasons in the habitations of the nearby polluted surface water sources in the revenue divisions are for the purpose of physicochemical and biochemical parameters towards assessing their suitability for drinking and domestic utility. The physicochemical parameters studied include pH, EC, TDS, TH, TA, Ca, Mg, Na, K, Cl^-, SO_4^{-2} and PO_4^{-3}. In terms of IS: 10500-1992 standards, the results of the studied parameters do not recommend the suitability of these waters either for drinking purpose or for other domestic purposes. Further bacterial species (spp) viz., *E.Coli, Pseudomonas, Enterobactor, Klebsiella and Proteus* were also observed in these ground water samples confirming their unsuitability for drinking purposes and have concern for human health.

KEYWORDS: **Sub surface waters, Parameter, Bacteria, Human health.**

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INTRODUCTION

Water is essential for all living beings[1]. The quality of surface and subsurface waters is important not only for human health but also for agriculture, recreational activities and industrial purposes. But in the present scenario the surface waters are also contaminated by point sources like industrial and municipal waste disposals, hazardous product spills etc., Application of fertilizers can also be considered as a prime source for contamination in farming areas[2]. In urban locations, unlimited disposal of industrial effluents along with other domestic wastes may greatly contribute to the contamination of water sources resulting in the depletion of the water quality [3-6]. Previous research studies[7] also confirmed the higher parametric values of pH, EC, Ca, Mg and Na in ground waters indicating the discharge of industrial effluents into the surface water sources which may in turn enhance the degree of contamination due to the seepage of surface waters into ground water table. The natural composition of ground water can be altered by manmade activities by utilization of chemicals in huge quantities and due to the development of Microbial species[8]. Ground water pollution happens on a different time scale compared to the surface water pollution. Pollution from Non point sources like agriculture, forestry, urban runoffs, constructional activity and habitat degradation has become an eternal problem in any nation and cause concern on land or water quality. Enrichment in water pollution causes deterioration of water quality and becomes a threat to human health. Hence it is proposed to carry out the analysis of the subsurface waters collected in the nearby polluted surface water source in between Tamarada of Peddapuram revenue division and Yetimoga of Kakinada revenue division for physicochemical parameters and bacteria for quality evaluation of subsurface waters for utilization for drinking and domestic purposes. The study area is represented in Diagram -1.

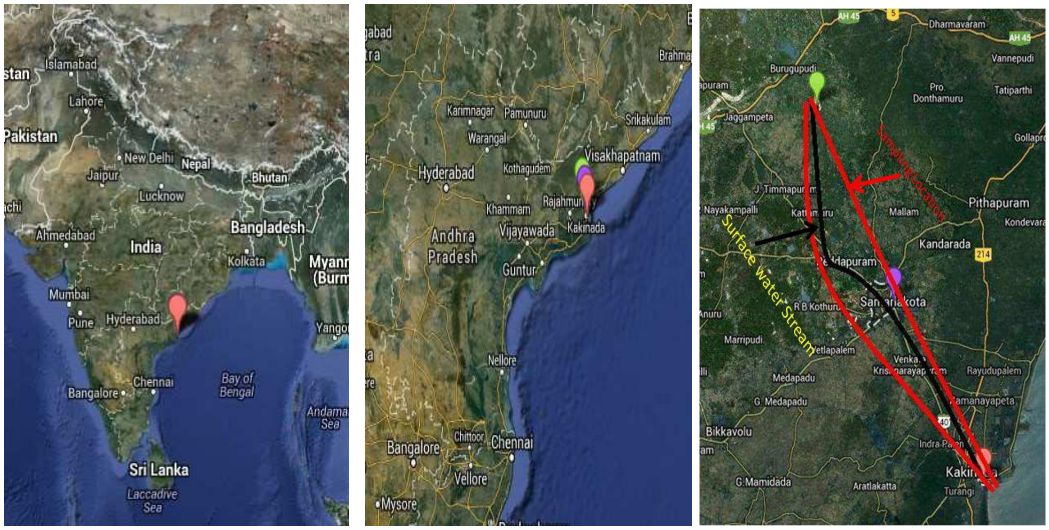


Diagram 1
Study area map and polluted surface water source

MATERIALS AND METHODS

The sampling locations of the study area selected for the present research study in East Godavari region which is situated along the northern coast of Andhra Pradesh between the latitudes $16^0.433^1$ to $17^0.354^1$ N and longitude $80^0.993^1$ to $82^0.222^1$ E. The subsurface water sampling locations were identified near polluted surface water source which is a combination of domestic sewage, industrial effluents and agricultural runoffs in Peddapuram and Kakinada revenue divisions. The details are presented in Table-1.

Table 1
Details of sample code and Sampling location

Sample code	Location
GW-1	Tamarada
GW-2	Maralava
GW-3	Kandrakota
GW-4	Sirivada
GW-5	Gudivada
GW-6	Peddapuram
GW-7	Samalkota
GW-8	V.K.Rayapuram
GW-9	Madhavapatnam
GW-10	Pratapnagar
GW-11	Warf road
GW-12	Yetimoga

Polythene containers were employed for sampling and preserved for analysis by following the standard procedures[9]. The samples were analyzed for physicochemical parameters which include 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) ×0.64. Chloride, Total hardness, Total Alkalinity and Chloride were estimated by titrimetry. Sulphate and Phosphate by Spectrophotometer (Model-167, Systronics), Na and K by Flame photometer (Model- 125, Systronics).

Bacterial Analysis

The samples were collected in sterilized containers [10] and immediately transported to the laboratory for the bacterial analysis. The Most Probable Number (MPN) technique was employed for the enumeration for the *Coliform* count in water samples[11, 12]. It involved the presumptive test using lactose broth and Nutrient agar, confirmatory test using Eosin Methylene Blue (EMB) agar, pure colonies of the isolated were subjected to Grams stain, motility, Indole, Methyl red, Voges-Proskuer test, Citrate utilization test, Urease test, Catalse and Oxidase test[13].The analytical data related to physicochemical parameters and bacterial spps is presented in Table 2, 3 and 4 respectively. The *bacterial spps* identified in subsurface water samples are presented in photographs 2(a), 2(b) and 2(c) respectively

Table-2 Physicochemical characteristics of sub surface waters

Sample Code	PH		EC(µmhos/cm)		TDS(mg/l)		TH(mg/l)		Ca^{+2}(mg/l)		Mg^{+2}(mg/l)		TA(mg/l)		$CO3^{-2}$(mg/l)	
	Monsoon		Monsoon		Monsoon		Monsoon		Monsoon		Monsoon		Monsoon		Monsoon	
	Pre	post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
GW-1	8.2	7.63	530	830	339	531	600	400	40	120	122	24.4	300	400	BDL	BDL
GW-2	8.2	7.18	986	1120	631	717	600	500	40	240	122	BDL	300	400	BDL	BDL
GW-3	8.7	7.51	1390	600	889.6	384	500	500	80	40	73.2	97.6	300	400	BDL	BDL
GW-4	8.3	7.77	950	860	608	550	400	400	40	120	73.2	24.4	400	500	BDL	BDL
GW-5	8.4	7.93	853	1280	545.9	819	400	300	40	80	73.2	24.4	400	500	BDL	BDL
GW-6	8.6	8.06	415	790	265.6	506	300	400	80	80	24.4	48.8	300	400	BDL	BDL
GW-7	7.9	7.81	489	900	313	576	400	300	40	120	73.2	BDL	300	400	BDL	BDL
GW-8	8.0	7.7	1150	1660	736	1062	300	500	80	240	24.4	BDL	500	600	BDL	BDL
GW-9	8.4	7.65	437	3300	279.7	2112	400	500	80	BDL	48.8	122	300	400	BDL	400
GW-10	7.6	7.94	1020	500	700	684.8	500	700	80	BDL	73.2	170.8	400	700	BDL	BDL
GW-11	8.8	8.01	1240	1280	793.6	819	400	400	40	BDL	73.2	97.6	100	200	BDL	200
GW-12	7.8	7.89	2700	910	1728	582	900	300	200	120	97.6	BDL	300	200	BDL	200

Table-3 Physicochemical characteristics of sub surface waters

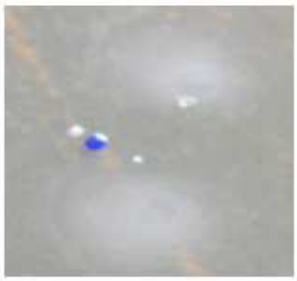
Sample Code	HCO_3^-(mg/l)		OH^-(mg/l)		Na(mg/l)		K (mg/l)		Cl^-(mg/l)		SO_4^{-2}(mg/l)		PO_4^{-3}(mg/l)	
	Monsoon		Monsoon		Monsoon		Monsoon		Monsoon		Monsoon		Monsoon	
	Pre	post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
GW-1	300	400	BDL	BDL	25.59	12.8	3.49	9.41	71	142	21.7	6.3	4.1	BDL
GW-2	300	400	BDL	BDL	76.7	6.16	9.36	0.73	142	1312	62.3	45	3.1	BDL
GW-3	300	400	BDL	BDL	81.7	10.27	88.7	0.86	106	35	24.1	20.9	3.4	0.6
GW-4	400	500	BDL	BDL	71.93	5.2	7.37	2.28	497	177	26.8	19.3	1.7	0.4
GW-5	400	500	BDL	BDL	75.2	9.59	33.82	0.99	106	177	42.1	28.9	2.8	BDL
GW-6	300	400	BDL	BDL	19.72	12.92	4.49	0.83	36	355	19.7	12.2	1.3	1.9
GW-7	300	400	BDL	BDL	34.53	10.58	1.63	0.37	71	213	25.4	18.3	11.2	0.9
GW-8	500	600	BDL	BDL	103.3	15.28	7.36	1.21	106	319	36.7	30.1	14.7	0.1
GW-9	300	BDL	BDL	BDL	29.01	25.28	3.98	7.97	36	496	238	216.6	3.2	0.3
GW-10	400	700	BDL	BDL	57.76	9.39	4.42	1.88	106	213	42.4	39.3	3.1	BDL
GW-11	100	BDL	BDL	100	112.1	7.51	5.2	7.02	248	35	64.3	51.5	3.2	BDL
GW-12	300	BDL	BDL	BDL	180.2	48.72	10.22	5.3	284	106	27.5	18.2	3.5	BDL

Table 4
Details of microbial analytical data

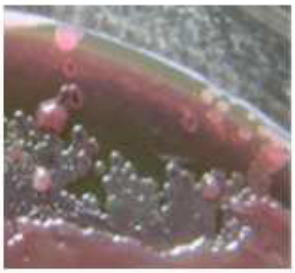
Sl.No	Sample Location	MPN Count		Bacteria identified	
		Pre Monsoon	Post Monsoon	Pre Monsoon	Post Monsoon
1	GW-1	2	<2	*Pseudomonas*	*Pseudomonas, Proteus*
2	GW-2	2	<2	*E.coli Pseudomonas*	*Pseudomonas*
3	GW-3	13	2	*E.coli*	*E.coli , Proteus*
4	GW-4	<2	<2	*Pseudomonas Proteus*	*Pseudomonas, Proteus*
5	GW-5	<2	2	*Pseudomonas Proteus*	*E.coli, Pseudomonas*
6	GW-6	<2	6	*Pseudomonas*	*E.coli, Klebsiella*
7	GW-7	<2	4	*Pseudomonas*	*E.coli*
8	GW-8	95	6	*Enterobacter*	*Proteus, Enterobacter*
9	GW-9	33	<2	*E.coli Pseudomonas*	*Pseudomonas*
10	GW-10	22	<2	*E.coli Pseudomonas*	*Pseudomonas*
11	GW-11	<2	<2	*Pseudomonas*	*Pseudomonas*
12	GW-12	2	<2	*Enterobacter*	*Pseudomonas*

Diagram –2 : Photographs of Bacterial Species Identified

2(a) E.coli , klebsiella



2(b) E.coli, pseudomonas



2(c) Enterobacter

RESULTS AND DISCUSSION

pH: pH of pre monsoon water samples range from 7.6 to 8.7 while the pH of post monsoon samples range from 7.18 to 8.06.Though the levels of pH are within the permissible limits (6.5-8.5) of IS:10500-1992 of drinking water standards. pH levels indicate that the waters possess slightly to moderate alkaline nature.

Electrical conductivity (EC)

EC is considered to be an indicator of Total Dissolved Solids (TDS) and a useful tool to evaluate the purity of water. EC levels of water samples during pre monsoon season range from 415-2700 µ mhos/cm while EC levels of post monsoon samples range from 500-3300 µ mhos/cm.

Total Dissolved Solids (TDS)

TDS level in water samples during pre monsoon season range from 265.6 mg/l - 1728 mg/l. In case of only 3 samples the TDS levels are within the permissible limits of 500 mg/l. While in case of post monsoon samples TDS levels range from 384 mg/l - 1062 mg/l. Out of these only in one sample TDS level is within the permissible limit and in other water samples TDS exceeded the permissible limit as such the waters may lose palatability and may cause gastro intestinal irritation.

Total Hardness (TH)

The total hardness of ground water samples during pre monsoon season range from 300-600 mg/l and in case of post monsoon samples TH range from 300-700 mg/l indicating that the levels of TH already reached the threshold limit of 300 mg/l and exceeded the permissible of IS : 10500-1992 in water samples of both pre and post monsoon water samples. The TH levels indicate that these water samples are to be considered as very hard [15].

Total Alkalinity (TA)

TA levels of pre monsoon water samples range from 100- 500 mg/l. In case of 7 samples the levels reached the threshold limit of 300 mg/l of IS:10500-1992 while in 4 samples the values exceeded the permissible limits and in case of only one sample (GW-11) and the TA level (100 mg/l) is within the permissible limit. During the post monsoon samples the levels were observed to be in the range of 200-700 mg/l. In two samples the level is 200 mg/l and within the permissible limit while in other samples the levels exceeded the limit.

Carbonate Alkalinity(CO_3^{-2})

Except in GW- 9, GW-11 & GW-12, carbonate alkalinity was absent due to the presence of bicarbonate in water samples collected in post monsoon season and in case of pre monsoon samples CO_3^{-2} alkalinity was observed at Below Detectable Limit (BDL).

Bicarbonate Alkalinity (HCO_3^-)

Bicarbonate levels in water samples collected during pre monsoon season range from 100-500 mg/l. In case of GW-8 the level reached the threshold limit (500 mg/l) while in other samples bicarbonate level exceeded the permissible limit of IS: 10500-1992. In case of water samples collected during post monsoon season bicarbonate levels range from 400-700 mg/l. Out of 12 samples collected, bicarbonate level was observed at BDL. In case of three samples (GW-9, GW-11 & GW-12) and in case of two samples (GW-8& GW-10) the bicarbonate level exceeded the permissible limit while in other samples the levels are within the permissible limit. The higher values of bicarbonate during post monsoon season may be due to the percolation of sewage and industrial wastes from the nearby polluted sources into the ground water in the study area.

Hydroxyl Alkalinity(OH^-)

In case of one water sample (GW-11) collected during post monsoon period, hydroxyl alkalinity was identified; hence the alkalinity of water may be attributed to CO_3^{-2}, HCO_3^- and also OH^- ions in the respective ground water collected in that particular location of the study area.

Chloride (Cl^-)

Chloride occurs naturally in all kinds of waters and may be due to agricultural or industrial activities. High concentrations of Chloride are due to the invasion of domestic wastes and disposals by human activities. The Chloride level in ground water samples collected during pre monsoon samples range from 36-497 mg/l. Except in samples GW-4 and GW-12, Chloride levels are within the permissible limit (250 mg/l) of IS : 10500-1992. In the post monsoon water samples Chloride level ranges from 35 mg/l to 1312 mg/l. In 8 samples the levels are within the permissible limit while in samples GW-2, GW-6, GW-8 and GW-9 the levels crossed the permissible limits. Increase in chloride levels during post monsoon period samples may be

due to lack of effective leaching process during the monsoon season.

Sulphate (SO_4^{-2})

Presence of higher levels of sulphate in ground water may be due to industrial and anthropogenic additions. Sulphate concentration in subsurface waters collected during pre monsoon period ranges from 19.7-64.3 mg/l while the sulphate levels in post monsoon period range from 12-217 mg/l and the levels are within the permissible limit (250 mg/l) of IS: 10500-1992.

Phophate (PO_4^{-3})

Phosphate levels range from 1.3 to 14.7 mg/l in water samples collected during pre monsoon season. Only in two samples GW-7 and GW-8 the levels exceeded the permissible limits 5 mg/l of IS: 10500-1992 and the higher levels of PO_4^{-3} may be due to the discharge of agricultural runoff from the polluted source of surface waters in to the subsurface waters while in other samples the PO_4^{-3} levels are within the permissible limits. The subsurface waters samples collected during post monsoon season were observed with PO_4^{-3} levels ranging from 1.1 to 1.9 mg/l.

Sodium and Potassium (Na & K)

Sodium level in pre monsoon water samples range from 25.59 - 112.1 mg/l while the level in post monsoon samples range from 5.20 – 48.72 mg/l. During pre monsoon period majority of ground water samples were observed with higher levels of sodium while the concentrations of sodium in post monsoon water samples are comparatively lower than the levels of sodium in pre monsoon samples. Potassium levels in pre monsoon water samples range from 1.63- 88.7 mg/l. In only two sample (GW-3 & GW-5) the levels were higher compared to the potassium levels in remaining water samples while in post monsoon water samples K levels range from 0.37- 9.41 mg/l. Higher levels of sodium and potassium during pre monsoon season may be due to excess ground water exploitation in the study area locations and further the higher levels of sodium and potassium may also indicate the leaching and dissolution of secondary salts in the pore spaces.

Calcium and Magnesium (Ca^{+2}& Mg^{+2})

In case of water samples collected in pre monsoon season Calcium levels range from 40 - 200 mg/l. In six samples Ca^{+2} in levels exceeded the permissible limit (75 mg/l) of IS: 10500-1992 and the remaining water samples the levels are within the permissible limits. The Calcium level in 9 water samples collected in post monsoon season range from 40 – 240 mg/l. In three samples Calcium levels were observed at BDL and in one sample Calcium level is within the permissible limit and in the remaining water samples Calcium levels exceeded the permissible limit (75 mg/l) of IS:10500-1992. Magnesium concentrations range from 24.4 to 122 mg/l in ground water samples collected in pre monsoon period. In only two samples (GW-6 & GW-8) Magnesium levels are within the permissible limit while in other samples Mg levels exceeded the permissible limit (30 mg/l) of IS:10500-1992. The levels of Magnesium in water samples of post monsoon period range from 24.4 to 170.8 mg/l in 8 samples but in 4 samples magnesium levels were observed at BDL. The Magnesium levels in samples GW-1, GW-4, & GW-5 were observed to be at below the permissible limit while in other samples Magnesium levels were found to be on the higher side of the permissible limit. The higher levels of Calcium and Magnesium are due to the discharge of domestic as well as industrial effluents or otherwise due to the cationic exchange with Sodium.

Bacterial Species

The ground waters were found to contain MPN count and several other bacterial species. During pre monsoon season three ground water samples (GW-2, GW-9&GW-10) *E.Coli, pseudomonas spp* were identified. In two samples (GW-8 & GW-12) *Enterobacter spp* was identified. In four samples (GW-1, GW-7, GW-8 &GW-11) *pseudomonas* was identified. In two samples (GW-4&GW-5) *pseudomonas spp along with proteus spp* were identified. In post monsoon season in 5 ground water samples (GW-2, GW-9, GW-10, GW-11 & GW-12) *pseudomonas spp* was identified. In two samples (GW-1 &GW-4) *pseudomonas spp* with *proteus spp* were identified. In one sample GW-8 *proteus spp* with *enterobacter spp* GW-7

E.Coli spp, GW-6 *E.Coli spp* with *Klebsiella spp* , GW-5 *E.Coli spp*, *pseudomonas spp* and in GW-3 *E.Coli spp* with *proteus spp* were identified.

CONCLUSION

pH, EC and TDS levels in majority of samples in both pre monsoon and post monsoon season were found to be on higher side of the permissible limit indicating the slight alkaline nature and the presence of soluble solids in waters and hence are unsuitable for human consumption. The Total Hardness and Calcium values confirmed that the waters are within hard to very hard nature and hence may cause encrustation in water supply structure and adversely affect on domestic use. Higher levels of alkalinity impart bad taste to waters and make them unpleasant for drinking and domestic use. Higher levels of Chloride impart corrosion nature to the waters and the palatability of water will be affected and becomes unsuitable for human consumption. The ground water samples which are associated with higher levels of Sulphate along with Na and Mg can cause gastro intentional irritation and hence the waters will become unsuitable for utility. Presence of bacteria like E.*Coli, pseudomonas , Enterobacter, Proteus* and *Klebsiella* can also cause severe health hazards like stomach cramps, diarrhea, vomiting, fever, Urinary tract infection, pneumonia, hepatic infections and opportunistic infections on burns, wounds and also blood related infections. Hence the ground waters in the study area were found to be chemically as well as bacteriologically contaminated and can cause health hazards if consumed for drinking purposes.

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