An Investigative Study on Hydro Geochemistry of Waters in Coringa Mangrove Region of East Godavari District

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Abstract

In this present research Investigation, it is proposed to characterise surface and ground waters collected from the Estuaries-Mangroves of Coringa Mangrove region to evaluate the quality of waters for considering them for various applications. The waters were characterized for physicochemical parameters viz., pH, EC, TDS, TH, Na, K, Ca, Mg, CO_3, HCO_3, Cl, F, SO_4 and NO_3. Irrigation parameters like Percent Sodium (% Na), Sodium Adsorption Ratio (SAR)', Kelly's Ratio (KR) and Magnesium Hazard (MH) were also determined. Metal ion concentrations of Li, Be, Al, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, As, Ar, Se, Rb, Sr, Ag, Cd, Cs, Ba, Ti, Pb and U were analysed for bacterial species for estimating the level of waters were chemically contaminated due to the higher parametric levels of EC, TDS, TH, TA, Ca^{2+} and Mg^{2+} indicating the ground waters suitability for drinking and domestic purposes. Lower levels of metal ion concentrations in surface and ground waters indicate the non-toxicity of waters with respect to metals. In addition, Ground Waters were found with *bacterial species., Proteus, Bacillus, Staphylococcus* indicating the bacterial contamination of waters and hence can cause water borne diseases like diarrhoea, vomiting, fever, Urinary tract infection, hepatic infections, Pneumonia, skin and soft tissue infections. The research findings revealed that the waters were chemically contaminated and also contaminated with bacteria and hence the ground waters are unsuitable for drinking and domestic utilization.

Keywords: Mangrove, Surface Water, Ground Water, Irrigation, Metal, Bacterial

I. INTRODUCTION

Water is essential for all living beings[i]. Ground water contamination is nearly always the result of human activity. The quality of surface and ground waters is important not only for human health but also for agriculture, recreational activities and industrial purpose. Contamination of ground water can result in poor drinking water quality, loss of water supply, degraded surface water systems, high clean up costs, high costs for alternative water supplies, and potential health problems. The consequence of contaminated ground water or degraded surface water is often serious.

Mangrove ecosystem acts as a buffer between near shore and lagoonal or estuarine environments with regard to the influence of freshwater discharge and salinity regime[ii]. The study of mangrove regions is necessary as they are highly productive and play an important role as breeding and nursery grounds for many commercially important fishes especially shrimps[iii] . Mangroves represent a rich and diverse living resource and are available to both the economy and protection of mangrove environment. Mangroves have been variously described as "Coastal woodland" and "inter tidal forest". Mangroves are the plant communities occurring near inter-tidal zones along the coasts of tropical and subtropical countries. They are one of the most productive ecosystems[iv]. Mangroves are a valuable ecological and economic resource, and offer protection against coastal erosion[v]. The total mangrove area in India has been estimated at 6, 81,000 hectare[vi] to 5,00,000 hectare[vii]. Of this, Andhra Pradesh has about 9 per cent, an area of 58,263 hectare of mangrove region and 33,263.32 hectare under Godavari[viii] region. The Corenga Wildlife Sanctuary in East Godavari District was established in 1978 with 4242 hectares.

Several authors have studied the physical and chemical characteristics of some Indian estuaries and mangroves[ix–xiv] . The chemical composition of groundwater samples collected from 67 administrative units of the Coastal Maharashtra district were analysed for pH, EC, TDS, TH, Na, K, Ca, Mg, CO_3, HCO_3, Cl, F, SO_4 and NO_3 to assess the suitability of groundwater in the area for drinking as well as irrigation purposes. The subsurface water chemistry of the area is dominated by sodium, calcium and bicarbonate. High values of Fluoride and nitrate at some locations have made it unsafe for drinking and demands detailed ground water investigation in the area. High values of SAR, %Na, and RSC in the ground water at many sites restrict its suitability for

irrigation. The water quality of the Sundarbans mangrove is alkaline in nature. The TDS and EC are very high in the area near the coast. The water chemistry indicates that there is around 30% dilution effect during the monsoon period[xv]. The concentration of dissolved ions determines the quality and utility of water. Hydro geochemical studies carried out in the study area in pre monsoon and post monsoon season reveals the dominance of the ions in the following order $Cl<SO_4<HCO_3$ and Na< Mg<Ca<K.

In recent decades, the Mangroves forests have been affected mainly due to human activities resulting into the impact of climate on ecosystem[xvi]. Trace elements like Fe, Mn, Cu and Zn occur in the mangrove environment as a result of natural process[xvii]. A study on[xviii] Trace elements viz., Fe, Mn, Cu, Co, Ni, Pb, Cd and Cr were analysed in particulate matter and sediments were carried out at 16 different locations in the Godavari Mangrove Ecosystems was carried out and the studies revealed that the estuarine ecosystem was not a pollution concern.

A number of microorganisms and thousands of synthetic chemicals have the potential to contaminate ground water. Drinking water containing bacteria can result in illness such hepatitis, cholera, diarrea, typhoid etc.

II. EXPERIMENTAL

A. Study Area:

The present study area Corangi is located in East Godavari District of Andhra Pradesh around the latitude $82^0$19'E and longitude $16^0$52'N, ground waters were collected in the mangrove region Corangi (figure-1). The details of sampling code, source and location are presented in Table – 1.

B. Characterisation of Surface and Ground Water:

The waters were 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 as per standard procedures[xix]. 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 the tables – 2(1) – 2(3) and shown graphically in figure – 2(1) to 2(14).

C. Irrigation Parameters:

The irrigation parameters like Percent Sodium (% Na)[xx], Sodium Adsorption Ratio (SAR)[xxi,xxii], Kelly's Ratio (KR)[xxiii] and Magnesium Hazard (MH)[xxiv] were determined by using the relationship. The analytical is presented in table – 3 and they are shown graphically in figure – 2(14) – 2(17)

$$\%Na(me/l) = \frac{Na^+ x100}{Na^+ + K^+ + Ca^{2+} + Mg^{2+}}$$

$$SAR(me/l) = \frac{Na^+}{\sqrt{Ca^{2+} + Mg^{2+}/2}}$$

$$KR = \frac{Na^+}{(Ca^{2+} + Mg^{2+})}$$

$$MH = \frac{Mg^{2+} X\ 100}{Ca^{2+} + Mg^{2+}}$$

D. Metal Ions:

The water samples collected during pre and post monsoon periods were characterised for metal ions by ICP-MS technique and the analytical data is presented in ppm and is presented in tables from 4(a) – 4(f)

E. Bacterial Analysis of Waters:

Bacterial analysis has been carried out to identify the type of bacteria present in three representative ground water samples collected as per the procedure and the cultural and biochemical characteristics of detected organisms are identified according to Bergeys Manual of systematic Bacteriology, Vol. 1 (Sec.1 to 11) and Vol. 2 (Sec.12 to 17) are summarised in the section. The most probable Number (MPN) technique has been employed for the enumeration for the Coliform count. The microscopic examination of the bacteria on stains found in water sample revealed the details of viz., Cultural, Morphological and Biochemical Characterization by IMViC tests for identification of *bacterial species* in waters and the details are presented in table – 5 and the *bacterial spps* is presented in figures 3(1) – 3(3).

III. RESULTS & DISCUSSION

1) *Physico Chemical Characteristics:*

A. pH:

The average pH of surface water in both pre and post monsoon seasons are observed at 7.7. The pH of ground waters in pre and post monsoon seasons is 8.2 and 7.5 respectively. The values are within the permissible range of drinking water standards[xxv]. However the waters may be with slight to moderate alkaline nature.

B. Electrical Conductivity (EC):

Electrical Conductivity of surface water of pre and post monsoon seasons are 1640 and 1086µmhos/cm, while EC of ground water of pre and post monsoon seasons are 4103 and 2666µmhos/cm. The values exceeded the permissible limits of irrigation standards indicating the saline nature of waters.

C. Total Dissolved Solids (TDS):

Total Dissolved Solids of surface waters of both pre and post monsoon seasons are 1049mg/l and 695mg/l, while TDS of ground waters of both pre and post monsoon seasons are 2626mg/l and 1706mg/l respectively. The levels are on the higher side of drinking water standards[25] and indicate the higher quantity of dissolved solids in waters.

D. Total Hardness (TH):

Total Hardness of surface waters of pre and post monsoon seasons are 1700mg/l and 33333mg/l. TH of ground waters of pre and post monsoon season are 1150mg/l and 6000mg/l. The values exceeded the permissible limit of drinking water standards[25]. Higher values of TH can cause encrustation on water supply system and make the waters unsuitable for domestic purposes.

E. Total Alkalinity (TA):

Total Alkalinity of surface waters of pre and post monsoon seasons are observed as 773mg/l and 400mg/l, while TA of ground waters of pre and post monsoon seasons are 1706mg/l and 565mg/l respectively. The values exceeded the permissible limit of drinking water standards [25]. Higher values of TA of waters can cause unpleasant smell and make the waters unsuitable for drinking[25].

F. Fluoride (F^-):

Fluoride ion concentration of surface waters of both pre and post monsoon seasons are 0.8mg/l and 0.7mg/l, while its concentration in ground waters in pre and post monsoons are 0.8mg/l and 0.8mg/l. The values are within the permissible limit of drinking water standards[25].

G. Chloride (Cl^-):

Chloride ion concentration in surface waters of pre and post monsoon season are 6581.9mg/l and 673.6mg/l and in case of pre and post monsoon seasons ground waters, the concentration is 1288mg/l and 304.3 mg/l. The values exceeded the permissible limits of drinking water standards[25] indicating the saline nature of waters.

H. Sulphate (SO_4^{2-}):

Sulphate ion concentration of surface waters of pre and post monsoons period is 103.5mg/l and 38.6mg/l, while the Sulphate concentration in ground waters of pre and post monsoon periods are 103.7mg/l and 38.8mg/l respectively. The levels are within the permissible limits of drinking water standards[25].

I. Nitrate (NO_3^-):

Nitrate in surface waters during pre and post monsoon seasons is 45.4mg/l and 47.9mg/l. While the nitrate ion concentration in ground water of pre and post monsoon season are 53.4mg/l and 55.6mg/l respectively. The values are slightly higher than the permissible limits of drinking water standards[25] and make the water unsuitable for drinking purposes. Higher values of Nitrate indicate the discharge of agricultural runoff into the water sources in the study area.

J. Phosphate (PO_4^{3-}):

The average Phosphate ion concentration in surface waters of pre and post monsoon seasons is 5.9mg/l and 6.0mg/l respectively. The average Phosphate ion concentration in ground waters of both pre and post monsoon season is 3.0mg/l and 2.8mg/l. The Phosphate levels in surface waters indicate the discharge of agricultural runoff into the surface waters, while the concentrations of Phosphate ion in ground waters are within the permissible limit[xxvi] indicating the non discharge of agricultural runoff into the ground water sources in the study area.

K. Sodium (Na^+) and Potassium (K^+):

Sodium ion concentration in surface waters of pre and post monsoon season is 352.6mg/l and 3.2mg/l, while its concentration in ground waters of pre and post monsoon season is 61.8mg/l and 7.2mg/l, except in pre monsoon surface waters, the Sodium ion concentration is within the permissible limit of WHO standards. Potassium ion concentration in surface waters of both pre and post monsoon season is 25.6mg/l and 0.4mg/l while its concentration in ground waters during pre and post monsoon period is 34.3mg/l and 0.8mg/l respectively. The values are within the permissible limits of WHO standards[xxvii].

L. Calcium (Ca^{2+}):

Calcium ion concentration in surface waters of pre and post monsoon seasons is 146.7mg/l and 80mg/l, while its concentration in ground waters of pre and post monsoon seasons is 193.3mg/l and 80mg/l. The values are on the higher side of permissible limits of drinking water standards. Waters with higher Ca^{2+} ion concentrations can cause encrustation on the water supply systems[25] and hence the waters unsuitable for purposes.

M. Magnesium (Mg^{2+}):

Magnesium ion concentrations in surface water of pre and post monsoon season are 325.3mg/l and 884.5mg/l respectively, while the Magnesium ion concentration of ground waters in pre and post monsoon seasons are 162.7mg/l and 1415.2mg/l respectively. The concentrations of Magnesium ion exceeded the permissible limit of drinking water standards and the waters unsuitable for drinking purposes[25]. In addition, the waters with higher Magnesium ion concentrations indicate the Magnesium Hazard of waters which can deplete the quality of soil.

IV. IRRIGATION PARAMETERS

A. Percent Sodium (%Na):

Percent Sodium in waters of pre and post monsoon season is 31.1me/l and 0.02me/l and the Percent Sodium values of ground waters of pre and post monsoon seasons is 12.8me/l and 0.3me/l. The values are within the permissible limit of irrigation standards[xxviii].

B. Sodium Adsorption Ratio (SAR):

Sodium Adsorption Ratio of surface waters of both pre and post monsoon seasons is 3.8me/l and 0.01me/l respectively, while SAR of ground water of both pre and post monsoon season is 0.8me/l and 0.4me/l. The values are within the permissible limit of irrigation standards[25].

C. Kelly's Ratio (KR):

Kelly's Ratio of surface waters of both pre and post monsoon seasons is 0.5 and at BDL, while KR of water of pre and post monsoon season is 0.2 and BDL. The values are within the irrigation standards indicating the suitability of waters for irrigation[25].

D. Magnesium Hazard (MH):

Magnesium Hazard of surface water of both pre and post monsoon seasons 82.0 and 99.24, while MH of ground water of both pre and post monsoon seasons is 56.9 and 96.4. The values exceeded the permissible limits of irrigation standards[25] indicating the Magnesium Hazard of waters which can deplete the quality of soil in the study area.

E. Metal Analysis

The concentration of metal ions viz., Li, Be, Al, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, As, Ar, Se, Rb, Sr, Ag, Cd, Cs, Ba, Ti, Pb and U in representative samples of surface and ground waters collected during pre and post monsoon seasons are found to be within the permissible limit of drinking water standards.[25]

F. Micro Biological (Bacterial) Analysis

The waters are observed with bacterial spps like *Proteus, Staphylococcus and Bacillus.* The presence of these pathogenic bacteria indicates the bacterial contamination of waters making the waters unsuitable for drinking and domestic purposes.

V. CONCLUSION

pH of both pre and post monsoon surface and ground waters revealed the slight alkaline nature of waters. Higher values of EC indicates the saline nature of waters, while higher TDS indicate the presence of soluble solid contents in waters making the waters unsuitable for drinking purposes. Excessive Total Hardness indicate that the waters can cause encrustation of water supply systems and hence unsuitable for domestic purposes. Total alkalinity which crossed the permissible limit of drinking water standards can cause unpleasant taste to waters and make them unfit for drinking and domestic purposes. Fluoride levels are within the permissible limits indicating the non Fluoride contamination status of the waters. Higher levels of Chloride indicate

the saline nature of waters and lower Sulphate concentrations indicate the non discharge of industrial effluents into the water bodies. Higher Nitrate levels are an indication for the discharge of agricultural runoff into the waters and the levels of Phosphate at some locations indicate the occasional discharge of agricultural runoff into the waters. Sodium levels are within the permissible limit in majority samples while Potassium levels crossed WHO limits in majority samples. Excessive Calcium levels indicate that the waters can cause encrustation of waters supply systems making the waters unsuitable for domestic purposes. Magnesium ion concentration values are on the higher side of the permissible limit indicating the Magnesium Hazard of waters. Available and possible treatment methodologies are to be employed to control the chemical contamination of waters for considering them for suitable applications. Percent Sodium, Sodium Adsorption Ratio (SAR) and Kelly's Ratio (KR) of waters indicates the suitability of these waters for irrigation purposes. Higher values of Magnesium Hazard of majority waters indicate the Magnesium Hazard of waters which can become a serious cause for depletion in soil quality and consequently the crop yields will be reduced in the study area. Hence the soils are to be reclaimed properly.

Lower Metal ion concentration indicate non metal toxicity of waters. The presence of pathogenic *bacterial spps.* like *Proteus, Bacillus, Staphylococcus* indicate the bacterial contamination of waters and hence the waters can cause diseases like diarrhoea, vomiting, fever, Urinary tract infection, hepatic infections, Pneumonia, skin and soft tissue infections. The waters are to be treated suitably by disinfection and sterilization to remove bacteria contamination.

Table – 1
Sample Code, Location, Source Type, Longitude and Latitude

Sampling Code	*Sampling Location (Coringa)*	*Type of Source*	*Longitude*	*Latitude*
S-W-1	*Near Bridge (left)*	*SW*	*$82^0 19'E$*	*$16^0 52'N$*
S-W-2	*Near Bridge (Right)*	*SW*		
S-W-3	*Near Sub Stream*	*SW*		
G-W-1	*Coringa Area-1*	*OW*		
G-W-2	*Coringa Area -2*	*OW*		
G-W-3	*Coringa Area -3*	*OW*		
G-W-4	*Coringa Area -4*	*BW*		
G-W-5	*Coringa Area -5*	*BW*		
G-W-6	*Coringa Area -6*	*OW*		

SW – Surface Water, GW – Ground Water, OW – Open Well, BW – Bore Well

Table – 2
(A): Ph, EC, TDS, TH, TA of Waters

Sample code	*pH*		*EC (µmhos/cm)*		*TDS (mg/l)*		*TH (mg/l)*		*TA (mg/l)*	
	Monsoon		*Monsoon*		*Monsoon*		*Monsoon*		*Monsoon*	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*
S-W-1	*8.0*	*7.7*	*1680*	*1090*	*1075*	*698*	*1800*	*43000*	*710*	*400*
S-W-2	*7.8*	*7.7*	*1690*	*1100*	*1082*	*704*	*1600*	*30000*	*610*	*450*
S-W-3	*7.3*	*7.6*	*1550*	*1070*	*992*	*685*	*1700*	*27000*	*1000*	*350*
Average	*7.7*	*7.7*	*1640*	*1086*	*1049*	*695*	*1700*	*33333*	*773*	*400*
G-W-1	*8.6*	*7.4*	*3600*	*3420*	*2304*	*2189*	*400*	*8000*	*1340*	*120*
G-W-2	*8.4*	*7.6*	*5510*	*1120*	*3526*	*717*	*1100*	*6500*	*1700*	*800*
G-W-3	*7.7*	*7.6*	*8360*	*3160*	*5350*	*2022*	*1000*	*4300*	*2100*	*100*
G-W-4	*8.5*	*7.5*	*2670*	*1160*	*1709*	*742*	*800*	*6700*	*2040*	*750*
G-W-5	*8.3*	*7.6*	*2990*	*1680*	*1914*	*1075*	*400*	*6000*	*1420*	*120*
G-W-6	*7.4*	*7.3*	*1490*	*5460*	*954*	*3494*	*3200*	*4500*	*1640*	*1500*

Average	*8.2*	*7.5*	*4103*	*2666*	*2626*	*1706*	*1150*	*6000*	*1706*	*565*

Table - 2
(B): F-, Cl-, SO42-, NO3- And PO43- Ion Concentrations In Waters

Sample code	*F^- (mg/l)*		*Cl^- (mg/l)*		*SO_4^{2-} (mg/l)*		*NO_3^- (mg/l)*		*PO_4^{3-} (mg/l)*	
	Monsoon		*Monsoon*		*Monsoon*		*Monsoon*		*Monsoon*	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*
S-W-1	*0.75*	*0.73*	*5991.1*	*673.6*	*62.0*	*24.6*	*45.6*	*47.8*	*14.5*	*16.7*
S-W-2	*0.78*	*0.72*	*7054.6*	*673.6*	*233.6*	*77.8*	*46.2*	*49.2*	*1.2*	*0.8*
S-W-3	*0.76*	*0.71*	*6700.1*	*673.6*	*15.0*	*13.3*	*44.5*	*46.8*	*2.1*	*0.6*
Average	*0.8*	*0.7*	*6581.9*	*673.6*	*103.5*	*38.6*	*45.4*	*47.9*	*5.9*	*6.0*
G-W-1	*0.81*	*0.82*	*957.2*	*425.4*	*62.0*	*21.9*	*56.4*	*57.4*	*9.4*	*10.0*
G-W-2	*0.86*	*0.87*	*1240.8*	*70.9*	*184.0*	*25.0*	*59.2*	*58.7*	*1.7*	*1.2*
G-W-3	*0.84*	*0.86*	*3722.3*	*460.9*	*77.0*	*29.2*	*63.2*	*63.6*	*1.8*	*2.4*
G-W-4	*0.79*	*0.81*	*496.3*	*70.9*	*38.0*	*91.9*	*49.4*	*52.4*	*1.2*	*BDL*
G-W-5	*0.78*	*0.82*	*460.9*	*53.2*	*21.0*	*22.4*	*47.4*	*51.6*	*1.8*	*1.0*
G-W-6	*0.81*	*0.83*	*850.8*	*744.5*	*239.4*	*42.3*	*44.5*	*49.8*	*2.3*	*2.0*
Average	*0.8*	*0.8*	*1288.0*	*304.3*	*103.7*	*38.8*	*53.4*	*55.6*	*3.0*	*2.8*

Table – 2
(C): Na^+, K^+, Ca^{2+}, Mg^{2+}Ion Concentrations In Waters

Sample code	*Na^+(mg/l)*		*K^+(mg/l)*		*Ca^{2+}(mg/l)*		*Mg^{2+}(mg/l)*	
	Monsoon		*Monsoon*		*Monsoon*		*Monsoon*	
	Pre	*Pre*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*
S-W-1	*375.5*	*2.8*	*28.20*	*0.39*	*160*	*80*	*341.6*	*10443.2*
S-W-2	*344.1*	*3.5*	*24.70*	*0.43*	*160*	*80*	*292.8*	*7271.2*
S-W-3	*338.2*	*3.2*	*24.00*	*0.40*	*120*	*80*	*341.6*	*6539.2*
Average	*352.6*	*3.2*	*25.6*	*0.4*	*146.7*	*80.0*	*325.3*	*8084.5*
G-W-1	*57.3*	*10.3*	*12.09*	*1.09*	*60*	*80*	*61.0*	*1903.2*
G-W-2	*75.0*	*2.4*	*19.72*	*0.33*	*80*	*80*	*219.6*	*1537.2*
G-W-3	*116.6*	*8.9*	*29.65*	*0.67*	*160*	*80*	*146.4*	*1000.4*
G-W-4	*29.3*	*2.6*	*18.23*	*0.42*	*160*	*80*	*97.6*	*1586.0*
G-W-5	*30.7*	*5.0*	*22.97*	*0.57*	*100*	*80*	*36.6*	*1415.2*
G-W-6	*BDL*	*14.0*	*102.90*	*1.79*	*600*	*80*	*414.8*	*1049.2*
Average	*61.8*	*7.2*	*34.3*	*0.8*	*193.3*	*80.0*	*162.7*	*1415.2*

Table – 3
% Na, SAR, KR & MH of Waters

Sample Code	%Na (me/l)		SAR (me/l)		Kelly's Ratio(KR)		MH	
	Monsoon		Monsoon		Monsoon		Monsoon	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
S-W-1	31.17	0.01	3.88	0.01	0.46	BDL	77.36	99.52
S-W-2	31.82	0.03	3.77	0.01	0.48	BDL	74.54	99.32
S-W-3	30.23	0.03	3.60	0.01	0.44	BDL	82.00	99.24
Average	31.1	0.02	3.8	0.01	0.5	BDL	78.0	99.4
G-W-1	23.33	0.28	1.26	0.05	0.32	BDL	61.93	97.44
G-W-2	12.86	0.08	0.99	0.01	0.15	BDL	81.45	96.85
G-W-3	19.84	0.46	1.61	0.06	0.26	BDL	59.42	95.24
G-W-4	7.27	0.09	0.45	0.01	0.08	BDL	49.39	96.94
G-W-5	13.54	0.18	0.67	0.03	0.17	BDL	36.93	96.59
G-W-6	BDL	0.69	BDL	0.09	BDL	BDL	52.52	95.45
Average	12.8	0.3	0.8	0.04	0.2	BDL	56.9	96.4

Table – 4
(A) Concentration Of Li, Be, Al, V In Surface And Ground Waters

Table –4(a) Concentration of Li, Be, Al, V in surface and ground waters

Sample code		Metal ion Concentration (ppm)							
		Li		Be		Al		V	
Monsoon		Monsoon		Monsoon		Monsoon		Monsoon	
Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
BVK-13	BVK-14	0.0758	0.0013	BDL	BDL	0.0124	0.2088	0.0089	0.0057
BVK-15	BVK-16	0.0383	0.0052	BDL	0.0001	0.0111	0.0128	0.0336	0.0097
BVK-17	BVK-18	0.0031	0.0186	0.0001	BDL	0.0187	0.0091	0.0088	0.0476

Table – 4(b): Concentrations of Cr, Mn, Fe, Co in surface and ground waters

Sample code		Metal ion Concentration (ppm)							
		Cr		Mn		Fe		Co	
Monsoon		Monsoon		Monsoon		Monsoon		Monsoon	
Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
BVK-13	BVK-14	0.0015	0.0013	0.0005	0.0003	0.0304	0.2068	BDL	BDL
BVK-15	BVK-16	0.0007	0.0005	BDL	0.0001	BDL	0.0054	0.0001	BDL
BVK-17	BVK-18	0.0005	0.0001	BDL	0.0007	0.0117	BDL	BDL	0.0001

Table – 4(c): Concentrations of Ni, Cu, Zn, Ga in surface and ground waters

Sample code		Metal ion Concentration (ppm)							
		Ni		Cu		Zn		Ga	
Monsoon		Monsoon		Monsoon		Monsoon		Monsoon	
Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
BVK-13	BVK-14	0.0003	BDL	0.0031	0.0012	0.0041	0.0122	0.0232	0.0031
BVK-15	BVK-16	0.0009	0.0011	0.0011	0.0025	0.0039	0.0032	0.0019	0.0123
BVK-17	BVK-18	0.0004	0.0003	0.0015	0.0011	0.0029	0.0041	0.0087	0.0001

Fig. 1: Satellite Picture of Study Area

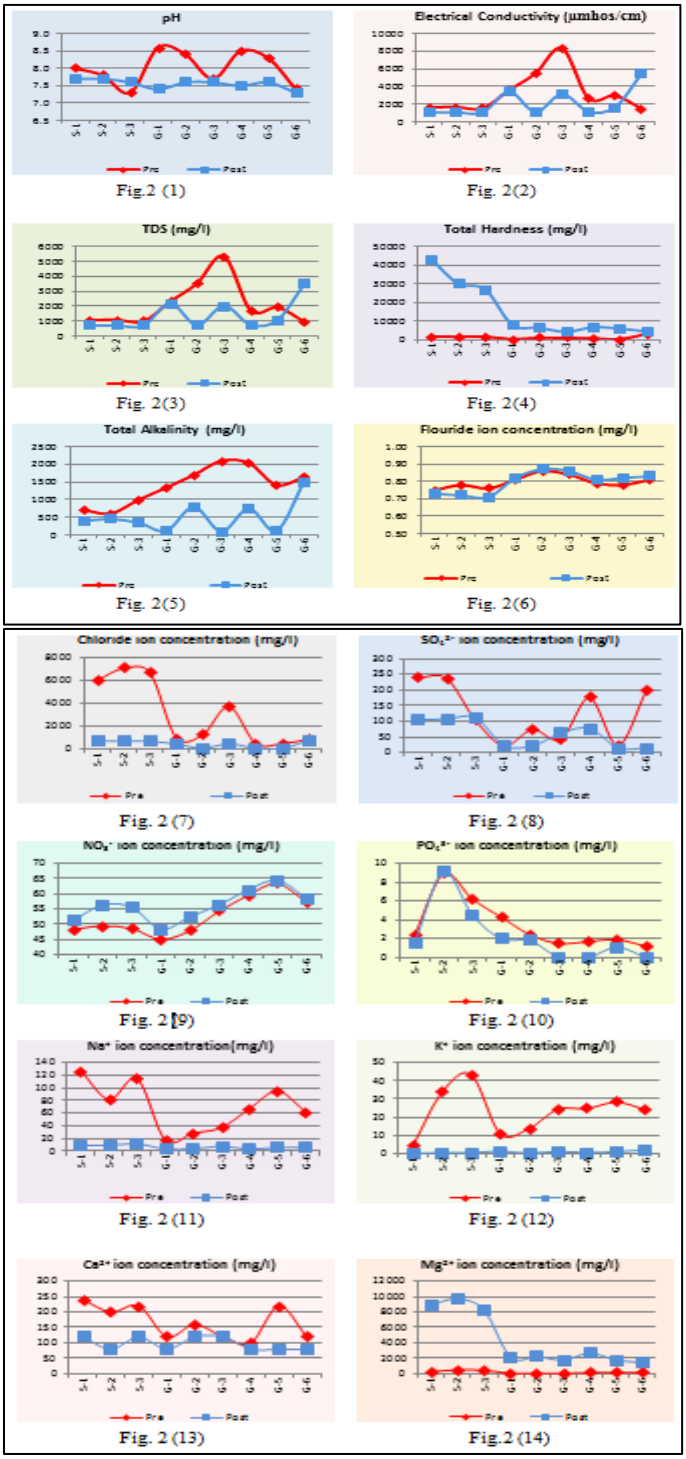

Fig. 2: (1)-2(14): Physico Chemical Parameters

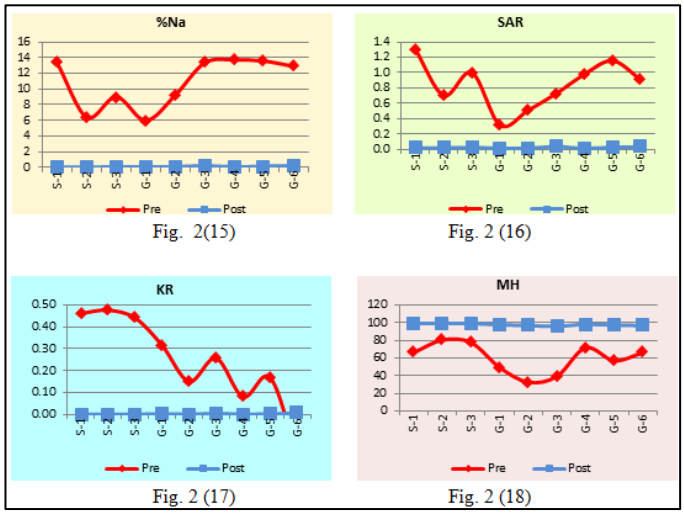

Fig. 2(15) Fig. 2 (16)

Fig. 2 (17) Fig. 2 (18)

Fig. 2: (15)-2(18): Irrigation Parameters

Figure – 3(1) – 3(3): Photographs of bacterial spps identified in waters of Coringa Mangrove region.

A. List of Figures:

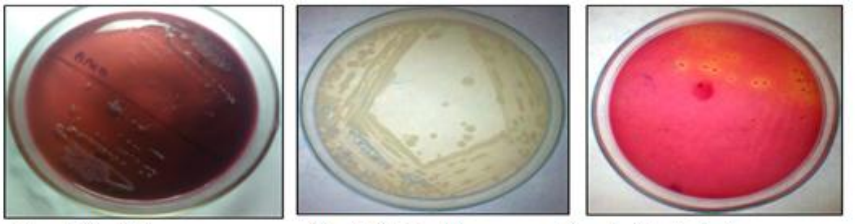

Fig. 3 (1): Proteus spps Fig. 3 (2): Bacillus spps Fig. 3: (3): Staphylococcus spps

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