Quality Evaluation of Ground Waters nearby an Urban Sewage by Physicochemical Characterization and Microbial Assessment

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Abstract

The present research study is focused on the characterization of ground waters collected nearby an urban sewage source for physicochemical characterization and microbial assessment for quality evaluation. Twelve ground water samples were collected at distances of 0.5, 1.0, 2.0, 3.0, 4.0 and 5.0 km on both sides of the sewage source and were characterized for physicochemical parameters viz., pH, Electrical Conductivity (EC),Total Dissolved Solids (TDS), Total Alkalinity (TA), Total Hardness (TH), Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Chloride, Sulphate, Nitrate and Phosphate. Higher levels of parameters EC, TDS, TH, TA, Mg^{2+}, Chloride, Nitrate and Phosphate indicate the chemical contamination of waters and hence the waters are unsuitable for drinking and domestic purposes, The ground waters were further analyzed for bacterial species and in majority samples MPN count was observed. In addition, the presence of pathogenic bacterial spps like E. Coli, klebsiella, Proteus, Enterobacter and pseudomonas in ground waters indicate the bacterial contamination of the ground waters. These waters can cause waterborne diseases and hence are highly unsuitable for drinking purposes. The waters are to be treated properly by the available treatment methodologies for the protection of their quality.

Keywords: Ground water, Parameter, Characterization, Bacteria

I. INTRODUCTION

Water quality now is the concern of all countries in the world. In India more than 90% population depend on ground water for drinking and other purposes (Ramachandraiah C., 2004). Survey of literature (Khan, L.R., and Basak, B.C., 1986) revealed that nearly one fifth of all water used in the world is obtained from ground water resources. Ground water is the major source of drinking water in both urban and rural areas (Gupta, D.P., et al., 2009). It is estimated that approximately one third of the world's population use ground water for drinking (Nickson, R.T., et al. 2005). Fresh water quality and its availability is one of the most critical environmental and sustainability issues of the twenty first century (UNEP-2002,). Out of all sources of fresh water on the Earth, ground water constitutes over 90% of the world's readily available fresh water resources (Boswinkel-2000) with remaining 10 percent in lakes, reservoirs, rivers and wet lands. Several scientific investigations revealed that ground water as an important source of water and solute input to coastal waters (Lewis, J.B., 1987, Moore, W.S., 1996, Kim, G., et al., 2003). Literature Survey (Church, T.M.,-1996) revealed that scientific findings challenge on present understanding of coastal and oceanic chemical mass balance and ecosystem findings. Pollutants which can seep down can also affect the ground water resources. Contaminated water spread disease causing microbes through agricultural run-off or the irrigation back waters which drain into river. In fact, attention has been paid for monitoring and assessing the microbial quality of water resources all over the world (Lindskog, R.U., and Lindskog, P.A.,1988; Fernandez- Alvars et al., 1991; Khalafalla, G.M et al., 1993). In the present scenario, powerful monitoring programme is highly necessary to provide reliable information about the current water quality. Hence the present study was conducted to assess the physicochemical and the microbial quality of waters to establish a baseline for initiating the preventive measures for safe guarding the quality of ground waters which are really a source for consumption by the public in the nearby habitats of the study area.

II. MATERIALS AND METHODS

East Godavari is situated along the northern coast of Andhra Pradesh and the study area from Sarpavaram to Atchampeta is located in between the latitudes 82^0 03' N and longitude 17^0 04'E. Ground water samples were collected nearby the sewage source on both sides at a distance of 0.5,1,2,3,4 and 5 km on the both sides. Sampling was done in Pre and Post Monsoon seasons and the details of sampling code, locations and type of source are presented in Table-1 and the study area Map is presented in figure-1.

Containers made of polythene were employed for ground water sampling and preserved for analysis as per the standard procedures (D.S.Ramteke, C.A.Moghe-1998). Twelve ground water samples were collected and analyzed for physicochemical parameters viz., pH, EC, TDS, TA, TH, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Chloride, Sulphate , Nitrate and Phosphate. pH was determined by

pH meter (Global-DPH 505, India – Model), Conductivity measured by the digital conductivity meter (Global-DCM-900-Model), TDS calibrated from the relation TDS= Electrical conductivity(EC) x0.64. Total Hardness, Total Alkalinity and Chloride ion concentrations were estimated by Titrimetry. Sulphate, Nitrate and Phosphate measured by Spectrophotometer (Vissican167, Systronics), Na and K by Flame photometry (Systronics).

A. Bacterial Analysis

The ground water samples were collected in sterilized containers (APHA-1992) and immediately transported to the facility for bacterial analysis. The Most Probable Number (MPN) technique was employed for the enumeration for the C*oli form* count in water samples (K.Obiri. Danso and Jones K-1999). The bacterial analysis include 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, Indole, Methyl red, Voges-Proskuer test, Citrate utilization (IMVIC)tests, Urease, Catalse and Oxidase tests (Sohani Smruti and Iqbal Sanjeeda-2012)

B. Characterization of Physicochemical Parameters:

The representative Ground Water samples collected were characterized for physicochemical parameters and the analytical data is presented in Tables 2 & 3.The parametric levels are also represented graphically in figure-2
The ground waters were analyzed for bacterial species and the details are presented in tables-4&5. The *bacterial species* identified are presented in fig-3.

III. RESULTS & DISCUSSION

A. pH:

pH of Ground water in pre monsoon ranges from 7.1-8.2 while it ranges from 7.5-8.8 in post monsoon season. pH of pre monsoon are within the permissible limit of drinking water while the pH level of post monsoon season in water samples W-3,5 exceeded the permissible limits and in other samples pH is within the permissible limits (IS : 10500-1992).

B. Electrical Conductivity (EC):

EC of ground waters in pre monsoon season ranges from 992-3220 while it ranges from 1110-3980 in post monsoon season. Higher values of EC indicate saline nature of waters.

C. Total Dissolved Solids (TDS):

TDS of ground waters of pre monsoon ranges from 634.88-2060.8 mg/l while it ranges from 710.4-2547 mg/l in post monsoon season. TDS values crossed the permissible limit of drinking water standards **(**IS: 10500-1992)

D. Total Hardness (TH):

TH of ground water in pre monsoon season ranges from 300-700 mg/l while in post monsoon season it ranges from 1900-2900 mg/l. TH exceeded the permissible limits (IS : 10500-1992) indicating the encrustation nature of waters.

E. Ca^{2+}:

Ca^{2+} levels of ground water in pre monsoon season ranges from 40-80mg/lit. In half of the water samples Calcium ion concentration exceeded the limit, while it ranges from 80-320 mg/l in post monsoon season and crossed the permissible limit (IS : 10500-1992).

F. Mg^{2+}:

Mg^{2+} levels of ground water in pre monsoon season ranges from 48.8-122 mg/l and in post monsoon season it ranges from 414.8-585.6 mg/l. All values exceeded the limit (IS: 10500-1992) indicating the magnesium hazard of waters.

G. Total Alkalinity (TA):

Total Alkalinity of Ground Water Samples collected during Pre Monsoon Season ranges from300-800 mg/l and the TA of waters in Post Monsoon Season ranges from 500-1100 mg/l. The levels are on the higher side of the permissible limit (IS: 10500-1992) and can contribute unpleasant taste to the waters.

H. Sodium (Na^+) & Potassium (K^+):

Sodium in pre monsoon season ranges from 46.5-115.2 mg/l while in post monsoon season it ranges from 16.1-46.7 mg/l. Potassium in ground water in pre monsoon season ranges from 3.94-24.55 mg/l while it ranges from 1.59-5.68 mg/l in post monsoon season

I. Fluoride:
Fluoride levels in pre monsoon season ranges from 0.64-0.92 mg/l while it ranges from 0.60-0.88 mg/l in post monsoon and are within the permissible limit of drinking water standards. (IS: 10500-1992)

J. Chloride:
Chloride levels of ground waters in pre monsoon season ranges from 141.8-1701.6 mg/l while in post monsoon season it ranges from 70.9-673.5 mg/l. Except in sample-W-8, chloride concentration is higher in all other samples. In post monsoon samples chloride exceeded the permissible limit (IS:10500-1992) in half of the samples. Higher values of chloride indicate the corrosive nature of waters.

K. Sulphate:
Sulphate level in ground waters collected during Pre Monsoon season are observed in the range from 27.6-117.6 while the water samples collected during Post Monsoon period are observed in the range from 5.2-200.1 mg/l and all are within the permissible limit of drinking water standards (IS : 10500-1992)

L. Nitrate:
Ground Waters of Pre Monsoon Period are with Nitrate levels ranging from 40-58 mg/l. Nitrate in water samples of Post Monsoon Period are in the range from 48-70 mg/l. Nitrate in samples W-7,W-8 of pre monsoon season are within the permissible limit and Nitrate concentration exceeded the permissible limit (IS : 10500-1992 in all other samples.

M. Phosphate:
Phosphate level ranges from 10.8-16.2 mg/l)in ground waters of Pre Monsoon period while it ranges from12.8-18.8 mg/l in Post Monsoon Period. Higher levels of PO_4^{3-} may be due to the discharge of Agricultural runoff from the surroundings into the Ground Waters.

N. Bacterial Species:
The ground waters of pre and post monsoon seasons were observed with bacterial species viz., Klebsiella, Enterobacter, Proteus, E.Coli and Pseudomonas, however majority of water samples were also observed with MPN count indicating the bacterial contamination of waters and water borne disease causing nature.

IV. CONCLUSION

pH levels in majority ground water samples indicate slight to moderate alkaline nature. Higher TDS indicate the presence of soluble salts in waters due to which the palatability decreases and hence the waters can cause gastrointestinal irritation. Higher values of Total Hardness and Calcium concentrations impart encrustation in water supply structure and can cause adverse effects on domestic use. Higher values of Total Alkalinity change the taste of waters and make the waters unpleasant for consumption. Higher Chloride in water can affect the taste, corrosion and palatability of waters and make the waters unsuitable for drinking and domestic utility. Sulphate levels are within the permissible limit indicating the non discharge of industrial waste waters into the ground water sources. Higher Phosphate levels of ground water indicate the discharge of agricultural runoff into the ground waters.

The analytical results revealed that the higher parametric levels of pH, EC, TDS, TH, Ca^{2+}, Mg^{2+}, TA, Cl^-, NO_3^-, PO_4^{-3} indicate the chemical contamination of the ground waters . The presence of bacterial species like Klebsiella, Enterobacter, Proteus, E.Coli and Pseudomonas also indicate the bacterial contamination. The presence of these bacteria can cause waterborne diseases like typhoid, jaundice, and diarrhea etc., Hence the waters are treated by the suitable treatment techniques available for the improvement of the quality of waters for considering them even for domestic purpose. Sterilization and disinfections are to be employed for control of bacterial contamination. Otherwise the waters can cause health hazards among people residing near the study area.

Table 1:
Sampling Code, Location and Type of Source

Sampling Code	*Sampling Location*	*Type of Source*
W-1	*Anjaneya nagar*	*GW*
W-2	*Anjaneya nagar*	*BW*
W-3	*Avanthi Nagar*	*BW*
W-4	*Avanthi Nagar*	*BW*
W-5	*Anjaneya nagar Road No.1*	*BW*
W-6	*Anjaneya nagar*	*BW*

W-7	*Anantha Nagar*	*BW*
W-8	*Anantha Nagar*	*BW*
W-9	*Muralidhar Nagar*	*BW*
W-10	*Muralidhar Nagar*	*BW*
W-11	*Near AP Transco*	*BW*
W-12	*Near AP Transco*	*BW*

BW-Bore well and OW-Open Well

Table 2:
Physicochemical Characteristics of Ground Water

Sample	*pH*		*EC*		*TDS*		*TH*		*TA*		*Ca^{2+}*		*Mg^{2+}*	
Code			*(µmhos/cm)*		*(mg/l)*		*(mg/l)*		*(mg/l)*		*(mg/l)*		*(mg/l)*	
	Monsoon		*Monsoon*		*Monsoon*		*Monsoon*		*Monsoon*		*Monsoon*		*Monsoon*	
	Pre	*Post*	*pre*	*post*	*Pre*	*Post*	*pre*	*Post*	*pre*	*Post*	*Pre*	*Post*	*pre*	*post*
W-1	*7.4*	*7.5*	*1350*	*3980*	*864*	*2547*	*400*	*2500*	*600*	*1000*	*40*	*320*	*73.2*	*414.8*
W-2	*7.4*	*8.2*	*1580*	*3960*	*1011.2*	*2534*	*500*	*2000*	*700*	*800*	*40*	*120*	*97.6*	*414.8*
W-3	*7.9*	*8.7*	*2870*	*2640*	*1836.8*	*1690*	*500*	*2000*	*700*	*900*	*40*	*120*	*97.6*	*414.8*
W-4	*8.2*	*8.8*	*1380*	*1510*	*883.2*	*966.4*	*300*	*2500*	*800*	*800*	*40*	*80*	*48.8*	*536.8*
W-5	*7.8*	*8.8*	*3220*	*3620*	*2060.8*	*2317*	*700*	*2100*	*500*	*1100*	*80*	*120*	*122*	*439.2*
W-6	*8.0*	*8.0*	*2280*	*3280*	*1459.2*	*2099*	*400*	*2500*	*600*	*800*	*40*	*160*	*73.2*	*512.4*
W-7	*7.7*	*8.4*	*1040*	*1160*	*665.6*	*742.4*	*500*	*1900*	*400*	*500*	*40*	*80*	*97.6*	*414.8*
W-8	*8.0*	*8.3*	*992*	*1110*	*634.88*	*710.4*	*400*	*2400*	*400*	*500*	*80*	*120*	*48.8*	*512.4*
W-9	*7.2*	*7.7*	*1520*	*1860*	*972.8*	*1190*	*500*	*2600*	*300*	*800*	*80*	*160*	*73.2*	*536.8*
W-10	*7.5*	*8.0*	*1470*	*1560*	*940.8*	*998.4*	*600*	*2500*	*500*	*700*	*80*	*120*	*97.6*	*536.8*
W-11	*7.1*	*8.2*	*1380*	*1700*	*883.2*	*1088*	*400*	*2400*	*500*	*600*	*80*	*160*	*48.8*	*488*
W-12	*7.5*	*7.8*	*2540*	*2950*	*1625.6*	*1888*	*600*	*2900*	*400*	*600*	*80*	*200*	*97.6*	*585.6*

Table 3:
Physicochemical Characteristics of Ground Water

Sample	*Na^+*		*K^+*		*F^-*		*Cl^-*		*So_4^{2-}*		*NO_3^- (mg/l)*		*Po_4^{3-}*	
Code	*(mg/l)*		*(mg/l)*		*(mg/l)*		*(mg/l)*		*(mg/l)*				*(mg/l)*	
	Monsoon		*Monsoon*		*Monsoon*		*Monsoon*		*Monsoon*		*Monsoon*		*Monsoon*	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*
W-1	*46.5*	*34.4*	*3.94*	*3.61*	*0.84*	*0.88*	*283.6*	*640.5*	*44.6*	*180.1*	*48*	*68*	*12.5*	*14.4*
W-2	*115.2*	*41.2*	*11.03*	*5.53*	*0.85*	*0.78*	*248.15*	*673.5*	*43.5*	*97.8*	*50*	*70*	*14.2*	*16.2*
W-3	*115.2*	*38.1*	*21.9*	*4.11*	*0.78*	*0.68*	*992.6*	*389.9*	*117.6*	*117.1*	*56*	*60*	*16.2*	*18.2*
W-4	*115.2*	*29.9*	*12.04*	*2.71*	*0.64*	*0.6*	*212.7*	*141.8*	*27.6*	*23.1*	*48*	*64*	*12.6*	*14.4*
W-5	*115.2*	*46.7*	*21.63*	*4.1*	*0.84*	*0.8*	*1063.5*	*567.2*	*114.1*	*200.1*	*58*	*62*	*16.2*	*18.8*
W-6	*115.2*	*33.6*	*17.21*	*4.47*	*0.92*	*0.86*	*1701.6*	*673.5*	*95.4*	*134.8*	*46*	*54*	*14.6*	*16.2*
W-7	*81.01*	*19.6*	*8.21*	*1.98*	*0.74*	*0.82*	*212.7*	*70.9*	*49*	*74.7*	*42*	*52*	*12.8*	*14.6*

W-8	*56.63*	*16.1*	*6.4*	*1.59*	*0.64*	*0.6*	*141.8*	*106.3*	*64.8*	*5.2*	*40*	*48*	*10.8*	*12.8*
W-9	*115.25*	*24.5*	*24.55*	*5.68*	*0.72*	*0.7*	*212.7*	*141.8*	*50.3*	*44.3*	*46*	*56*	*12.4*	*16.2*
W-10	*100.5*	*20.5*	*14.35*	*3.05*	*0.86*	*0.84*	*283.6*	*177.2*	*52.5*	*55.1*	*46*	*58*	*13.2*	*16.4*
W-11	*95.71*	*23.3*	*20.12*	*11.3*	*0.78*	*0.72*	*248.15*	*70.9*	*46*	*35*	*50*	*66*	*14.6*	*16.8*
W-12	*115.2*	*31.2*	*13.75*	*2.98*	*0.9*	*0.88*	*815.35*	*638.1*	*48.8*	*52.4*	*54*	*68*	*16.2*	*16.6*

Table 4:
Cultural, Morphological and Biochemical characterization of Pre Monsoon waters

Sample code	*MPN count/ 100ml*	*Grams stain*	*BIOCHEMICAL TESTS*							*Bacterial spp identified*
			(IMViC TESTS)							
			I	*MR*	*VP*	*C*	*CA*	*OX*	*UR*	
W-1	*0*	*-ve*	-	+	-	-	+	-	+	*Proteus*
W-2	*30*	*-ve*	-	-	+	+	+	-	-	*Klebsiella*
W-3	*110*	*-ve*	-	-	+	+	+	-	-	*Klebsiella*
W-4	*90*	*-ve*	+	+	-	-	+	-	-	*E.coli*
		-ve	-	+	-	-	+	-	+	*Proteus*
W-5	*0*	*-ve*	-	+	-	-	+	-	+	*Proteus*
W-6	*21*	*-ve*	-	-	+	+	+	-	-	*Enterobacter*
		-ve	-	+	-	-	+	-	+	*Proteus*
W-7	*0*	*-ve*	-	-	-	-	-	+	-	*Pseudomonas*
		-ve	-	+	-	-	+	-	+	*Proteus*
W-8	*7*	*-ve*	-	-	-	-	-	+	-	*Pseudomonas*
W-9	*17*	*-ve*	-	-	+	+	+	-	-	*Enterobacter*
W-10	*80*	*-ve*	+	+	-	-	+	-	-	*E.coli*
		-ve	-	+	-	-	+	-	+	*Proteus*
W-11	*2*	*-ve*	+	+	-	-	+	-	-	*E.coli*
		-ve	-	+	-	-	+	-	+	*Proteus*
W-12	*0*	*-ve*	-	+	-	-	+	-	+	*Proteus*

Table 5:
Cultural, Morphological and Biochemical characterization of Post Monsoon waters

Sample code	*MPN count/ 100ml*	*Grams stain*	*BIOCHEMICAL TESTS*							*Bacterial spp identified*
			(IMViC TESTS)							
			I	*MR*	*VP*	*C*	*CA*	*OX*	*UR*	
W-1	*7*	*-ve*	-	-	+	+	+	-	-	*Klebsiella*
		-ve	-	-	+	+	+	-	-	*Enterobacter*
W-2	*17*	*-ve*	-	-	+	+	+	-	-	*Klebsiella*
W-3	*14*	*-ve*	-	-	+	+	+	-	-	*Klebsiella*
		-ve	-	+	-	-	+	-	+	*Proteus*
W-4	*10*	*-ve*	+	+	-	-	+	-	-	*E.coli*
		-ve	-	-	+	+	+	-	-	*Klebsiella*
W-5	*11*	*-ve*	+	+	-	-	+	-	-	*E.coli*
		-ve	-	+	-	-	+	-	+	*Proteus*
W-6	*8*	*-ve*	-	-	+	+	+	-	-	*Enterobacter*
		-ve	-	+	-	-	+	-	+	*Proteus*
W-7	*0*	*-ve*	-	+	-	-	+	-	+	*Proteus*
		-ve	-	-	-	-	-	+	-	*Pseudomonas*
W-8	*0*	*-ve*	-	-	-	-	-	+	-	*Pseudomonas*

W-9	*10*	*-ve*	-	-	+	+	+	-	-	*Enterobacter*
W-10	*11*	*-ve*	+	+	-	-	+	-	-	*E.coli*
		-ve	-	-	+	+	+	-	-	*Klebsiella*
W-11	*0*	*-ve*	-	+	-	-	+	-	+	*Proteus*
W-12	*14*	*-ve*	+	+	-	-	+	-	-	*E.coli*
		-ve	-	-	+	+	+	-	-	*Klebsiella*

*: I = Indole, MR=Methyl red, VP=Voges Proskauer, C=Citarte, CA= Catalase, OX= Oxidase, UR= Urease

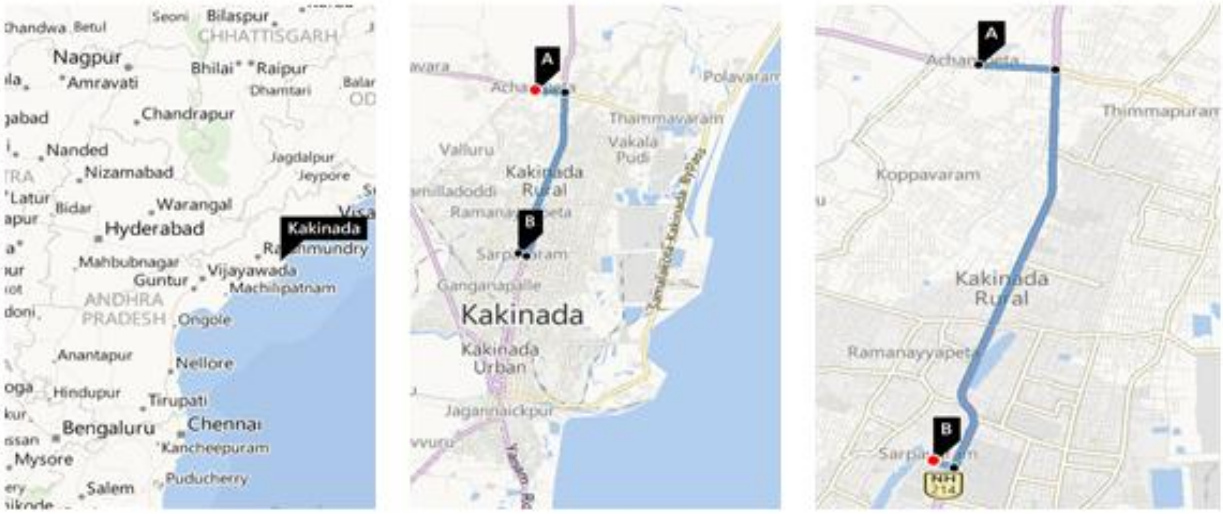
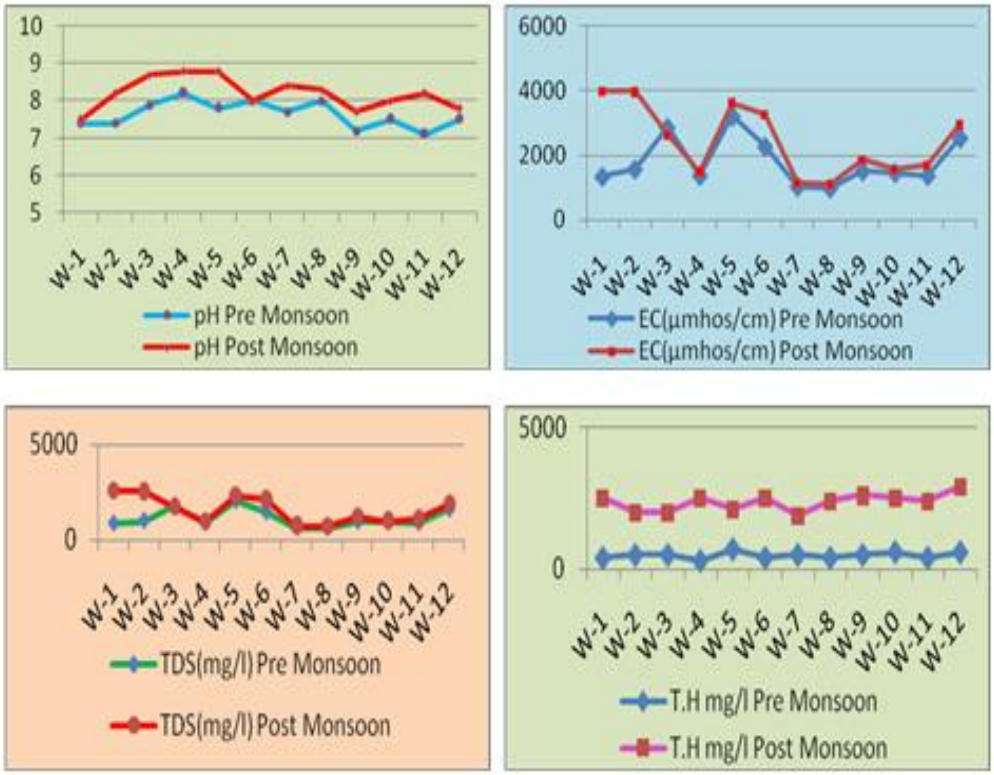


Fig. 1: Study Area Maps



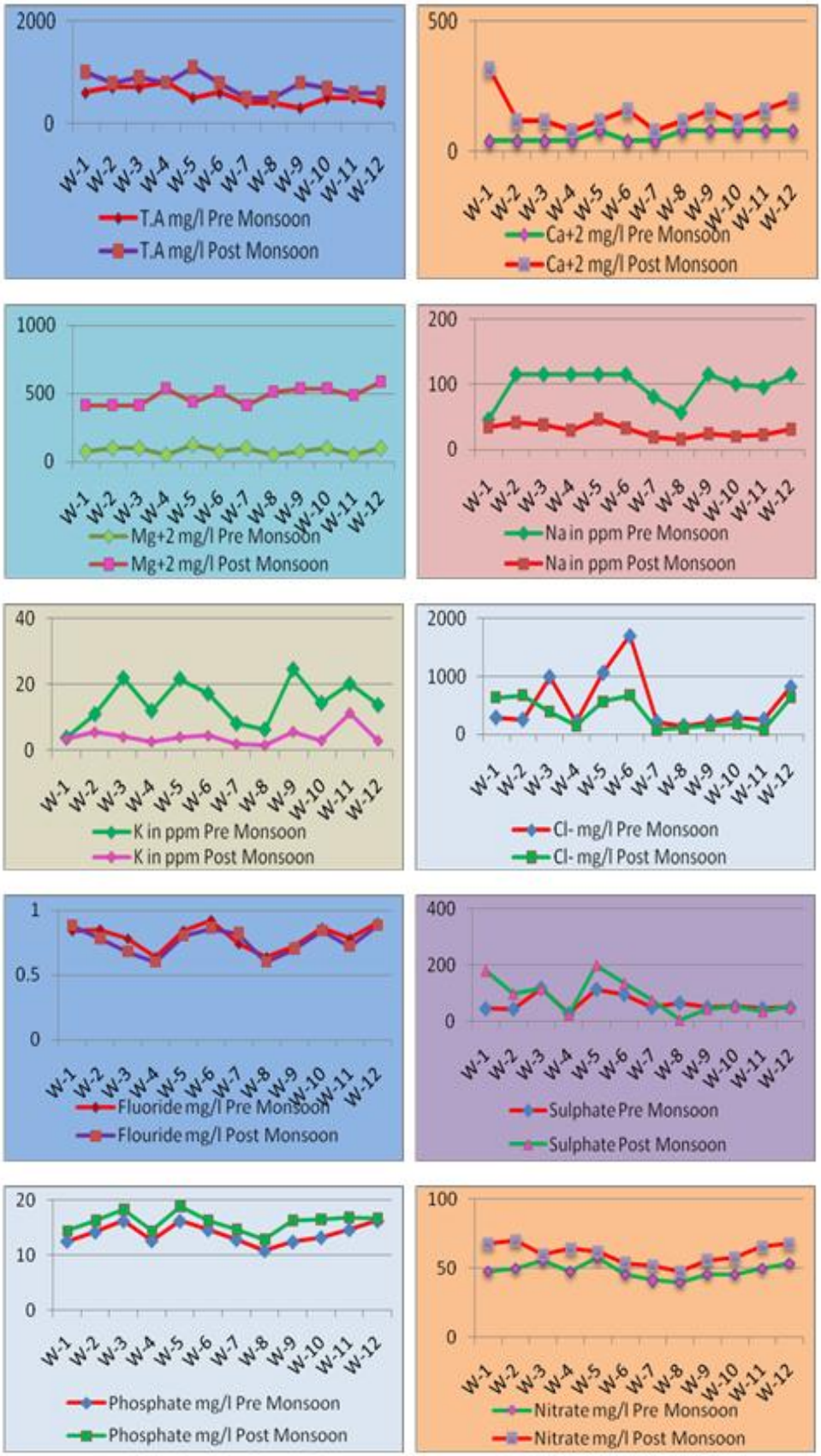


Fig. 2: Graphical representation of physicochemical parameters:

Fig. 3: Bacterial Spps identified water samples

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