Comparison of Qualities of River Water and Groundwater Assessed by Water Quality Index

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Abstract- Water quality index (WQI) values of both river water samples and groundwater samples collected at different locations along Krishna River in Andhra Pradesh, India, are presented. Seven locations are chosen for the purpose and nine water quality parameters are considered for obtaining WQI. During determination of WQI, the standard values of water quality parameters recommended by Indian Council for Medical Research (ICMR) and Bureau of Indian Standards (BIS) are considered. Most of the groundwater samples are found to possess higher concentration of chloride content, alkalinity, hardness, total dissolved solids and electrical conductivity than the corresponding river water samples. Turbidity values are found to be more for river water samples while fluoride content is more for groundwater samples. Dissolved oxygen and pH are obtained in the ranges 5.0-7.5 and 7.00-7.93 respectively for both river and groundwater samples. The groundwater samples are found to be of poor quality as indicated by their WQI values ranging from 46 to 91. The river water samples obtained WQI in the range 39 to 78. It can be concluded from the study that at most of the locations considered, the river water samples are of better quality than the corresponding groundwater samples.

Keywords —Water quality index, Water quality parameters, Krishna river, Ground water, Volumetric analysis, Instrumental analysis.

I. INTRODUCTION

Surface water and groundwater are the basic sources of water. The changes in water resources both qualitatively and quantitatively are resulted due to developments in various areas like human activities in urban areas, industrial activities and agricultural renovations, etc. Hence, the knowledge of better resources of water in a particular area can be obtained by continuous monitoring of water quality. Hence, water resource modeling involves monitoring of surface water and groundwater. Water quality analysis involves determination of different types of parameters – physical, chemical and biological. In order to arrive at a reliable assessment of water quality and to consolidate all these parameters, a simple way of expression of water quality, considering the most significant parameters, was proposed and it has been expressed as water quality index (WQI).

Water quality index involves summarizing numerically the values of various water quality parameters and expressing it as a single numerical value. Thus, a single value denotes the quality of a given sample of water. Some of the water quality parameters considered for obtaining WQI are total alkalinity (TA), dissolved oxygen (DO), electrical conductivity (EC), turbidity (TD), total hardness (TH), total dissolved solids (TDS), pH, fluoride (F^-), chloride (Cl^-), etc. For instance, Pesco and Wunderlin [1] considered WQI based on 20 water quality parameters in order to assess the quality of river water affected by urban discharge. According to this study, the number of parameters for calculation of WQI can be minimized without affecting the accuracy in expression of quality of water. There are several such studies [2-8] involving expression of water quality in terms of WQI.

In this background, the present study was aimed at obtaining the quality of both river water and groundwater at the selected sampling locations along the river and comparing the quality of water samples in the form of water quality index.

II. MATERIALS AND METHODS

For the present study, 7 locations were selected for collection of water samples. The first sample is from Muktyala of Jaggaiahpet mandal and the last one being at Surayapalem of Gollapudi mandal. The distance covered along the Krishna river between first and last sampling site is about 90 km. At each location, the river water sample was collected and a groundwater sample from the village adjacent to the river was

also collected. Thus, the total number of water samples is 14, among which half are river water samples and the other half groundwater samples. For all the 14 samples of water, the water quality index values were calculated after obtaining 9 quality parameters. Depending on WQI values, the status of the water quality at each location is discussed. One of the authors of the present study was involved in the study of water quality in the same region as presented in this work. However, the aim of the reported work [9] was quite different from that of the present study. The map containing the selected locations along the Krishna river is shown in figure 1. The details of mandal-wise locations are listed in Table 1. Following the standard procedures [10,11], various water quality parameters were determined for the samples collected. The methods used for this analysis were same as those presented in the work already reported in literature [4]. In order to compare the results of water samples analysis, the standard values recommended by two organizations namely Indian Council for Medical Research (ICMR) and Bureau of Indian Standards (BIS) [12] are taken as reference and are shown in Table 2. The water quality index values were obtained by following the calculation procedures as described elsewhere [4].

III. RESULTS AND DISCUSSION

The results of the analysis of all the water quality parameters are presented in Table 3 and Table 4. The serial numbers R1 to R7 indicate the river water samples and G1 to G7 indicate groundwater samples. The corresponding subindex values are presented in Table 5 and Table 6 respectively. The results obtained in case of each parameter are systematically discussed below.

Table 1 Names of the sampling locations and the corresponding sample numbers (all locations belong to Andhra Pradesh state)

Sampling site	Sample number	
	River water	Ground water
Muktyala, Jaggaiahpet mandal	R1	G1
Vedadri, Jaggaiahpet mandal	R2	G2
Gudimetla, Chandarlapadu mandal	R3	G3
Pokkunuru, Chandarlapadu mandal	R4	G4
Eturu, Chandarlapadu mandal	R5	G5
Tummalapalem, Ibrahimpatnam mandal	R6	G6
Surayapalem, Gollapudi mandal	R7	G7

Table 2: Drinking water quality parameters and their unit weights

S. no.	Parameter	Standard value	Unit weight
1	Chlorides (Cl^-)	250 mg/L	0.00260
2	Total alkalinity (TA)	120 mg/L	0.00542
3	Total hardness (TH)	300 mg/L	0.00217
4	Total dissolved solids (TDS)	500 mg/L	0.00130
5	Dissolved oxygen	5.0 mg/L	0.12998
6	pH	6.5-8.5	0.07646
7	Electrical conductivity	300 µS/cm	0.00217
8	Turbidity	5.0 NTU	0.12998
9	Fluorides (F^-)	1.0 mg/L	0.64992

A. Chloride content

As per the ICMR and BIS standards, the permissible limit of chloride content is 250 mg/L. From the Table 3, it is clear that all the river water samples contain chloride content in the range 53-71 mg/L, which is much lesser than the permissible limit. However, the groundwater samples are found to contain higher chloride contents. The groundwater sample at Muktyala was found to contain a chloride content of 35 mg/L, which is very low when compared with all other groundwater samples. The remaining groundwater samples are found to have high chloride content in the range 197-345 mg/L. In total, four groundwater samples were found to contain chloride content within the permissible limits. The groundwater samples collected at Vedadri, Pokkunuru and Eturu contain higher chloride content than the permissible value.

Table 3 Quality parameters of the river water and groundwater samples

S. no.	$[Cl^-]$	$[F^-]$	TA	TH	TDS	EC
R1	53	0.56	137	135	433	453
R2	55	0.32	151	142	464	475
R3	61	0.89	164	102	513	465
R4	65	0.52	160	160	479	488
R5	63	0.44	177	178	508	503
R6	71	0.73	156	165	550	498
R7	68	0.56	174	129	538	510
G1	35	1.01	220	354	318	709
G2	315	0.96	201	439	2374	1267
G3	238	0.88	282	446	2285	1870
G4	345	0.86	285	513	3197	2910
G5	320	1.10	225	550	2950	2522
G6	250	0.82	425	220	1628	2090
G7	197	0.46	263	350	1206	1294

Table 4 Quality parameters of the river water and groundwater samples

S. no.	DO	pH	TD
R1	6.7	7.54	1.12
R2	6.5	7.66	0.96
R3	7.1	7.95	1.36
R4	6.8	7.64	0.84
R5	7.5	7.39	0.96
R6	6.9	7.93	1.60
R7	7.2	7.91	1.42
G1	7.0	7.05	0.70
G2	6.2	7.00	0.10
G3	7.5	7.55	0.43
G4	6.8	7.08	0.25
G5	7.0	7.83	0.22
G6	6.5	7.89	0.15
G7	5.8	7.15	0.32

B. Fluoride content

According to the ICMR and BIS standards, the permissible limit of fluoride content is 1.0 mg/L. From the Table 3, it is clear that all the river water samples contain chloride content in the range 0.32-0.89 mg/L, which is lesser than the permissible limit. However, some of the groundwater samples are found to contain higher fluoride contents. The groundwater sample at Surayapalem was found to contain a fluoride content of 0.46 mg/L, which is very low when compared with all other groundwater samples. The remaining groundwater samples are found to have fluoride content in the range 0.82-1.10 mg/L. In total, five groundwater samples were found to contain fluoride content within the permissible limits. The groundwater samples collected at Muktyala and

Eturu contain higher fluoride content than the permissible value.

Table 5 Subindex values to the parameters listed in Table 3

S. no.	[Cl⁻]	[F⁻]	TA	TH	TDS	EC
R1	21.2	56.0	114.1	45.0	86.6	151.0
R2	22.0	32.0	125.8	47.3	92.8	158.3
R3	24.4	89.0	136.6	34.0	102.6	155.0
R4	26.0	52.0	133.3	53.3	95.8	162.6
R5	25.2	44.0	147.5	59.3	101.6	167.6
R6	28.4	73.0	130.0	55.0	110.0	166.0
R7	27.2	56.0	145.0	43.0	107.6	170.0
G1	14.0	101.0	183.3	118.0	63.6	236.3
G2	126.0	96.0	167.5	146.3	474.8	422.3
G3	95.2	88.0	235.0	148.6	457.0	623.3
G4	138.0	86.0	237.5	171.0	639.4	970.0
G5	128.0	110.0	187.5	183.3	590.0	840.6
G6	100.0	82.0	354.1	73.3	325.6	696.6
G7	78.8	46.0	219.1	116.6	241.2	431.3

Table 6 Subindex values to the parameters listed in Table 4

S. no.	DO	pH	TD
R1	82.2	36.0	22.4
R2	84.3	44.0	19.2
R3	78.1	63.3	27.2
R4	81.2	42.6	16.8
R5	73.9	26.0	19.2
R6	80.2	62.0	32.0
R7	77.0	60.6	28.4
G1	79.1	3.3	14.0
G2	87.5	0.0	2.0
G3	73.9	36.6	8.6
G4	81.2	5.3	5.0
G5	79.1	55.3	4.4
G6	84.3	59.3	3.0
G7	91.6	10.0	6.4

C. Total alkalinity

The ICMR and BIS standards indicate that the permissible limit of total alkalinity is 120 mg/L. Table 3 shows that all the samples both river water and groundwater samples possess the total alkalinity greater than this permissible limit. Total alkalinity of river water samples is found to be somewhat closer to the permissible limits. The maximum alkalinity among river water samples is 177 mg/L for Eturu sample. However, the groundwater samples are found to contain very high alkalinity in the range 201-285 mg/L, except for the sample at Tummalapalem, where the alkalinity is 425 mg/L, maximum among all the samples.

D. Total hardness

As per ICMR and BIS standards, the permissible limit of hardness is 300 mg/L. From Table 3, it is clear that all the river water samples contain hardness in the range 102-178 mg/L, which is lesser than the permissible limit. As far as hardness is concerned, these samples possess quality equivalent to potable water. However, the groundwater samples are found to contain higher hardness-causing salts. Except for the groundwater sample of Tummalapalem, which has the hardness of 220 mg/L, all the other groundwater samples have hardness values in the range 350-550 mg/L. The total hardness was found to be extremely high, crossing 500 mg/L for the samples collected at Pokkunuru and Eturu.

E. Total dissolved solids

According to ICMR and BIS standards, the total dissolved solid content can be up to a maximum of 500 mg/L. It includes both ionic and non-ionic matter. The range of TDS for river water samples is 433-550 mg/L, which can be considered as the range close to the higher permissible limit. But, the groundwater samples were found to have extremely high TDS values in the range 1206-3197 mg/L, except for the groundwater sample collected at Muktyala, which has the TDS of 318 mg/L well within the permissible limit. As far as the TDS is concerned, multiple times of the value to the permitted value indicates that these groundwater samples do not fit for domestic purposes.

F. Electrical conductivity

Electrical conductivity is considered as a significant water quality parameter in view of its characteristic of expressing ionic content available in the sample. The permitted value of EC is 300 µS/cm. It is surprising to see from the Table 3 that EC value for none of the water samples, both river water and groundwater, is within the limit. The EC values for river water samples are in the range 453-510 µS/cm, while for the groundwater samples, it is 709-2910 µS/cm. The maximum value of EC was obtained for the sample of Pokkunuru of Chandarlapadu mandal, and this observation is in agreement with the highest value of TDS obtained for the same sample. Among the groundwater samples, the sample of Muktyala was found to have lowest EC value of 709 µS/cm, however, this value is beyond the permissible limit too.

G. Dissolved oxygen

Dissolved oxygen is another significant water quality parameter which is indicative of the extent of pollutants in water samples. The expected value of DO for drinking water is 5.0 mg/L. It is interesting to see from the Table 4 that all the river water and groundwater samples have higher values of DO than expected as per the guidelines of the water quality agencies. Hence, with reference to DO the water quality is in accordance with the guidelines for drinking water.

H. pH

pH is one of the significant water quality parameters and drinking water may have pH in the range 6.5-8.5. It can be observed from Table 4 that all the river water and groundwater samples have pH value in the expected range. No sample was found to exhibit acidic nature.

I. Turbidity

Turbidity for a water sample to be suitable for drinking purpose can be up to 5.0 NTU. From Table 4, it can be observed that turbidity of water samples is in the range 0.10-1.60, which is very less than the maximum permitted value. It indicates that all the quality parameters listed in Table 4 are well within the permissible limits and all the water samples are suitable for domestic purposes as far as the parameters listed in Table 4 are concerned.

J. Water quality index

The water quality index (WQI) values and corresponding water quality status [13] are shown in Table 7. The WQI values obtained for all the water samples in the present study are shown in figure 2. The figure shows that no water sample is of excellent quality and suitable for drinking purpose directly without any treatment. Most of the groundwater samples have WQI values higher than corresponding river water samples. WQI values for river water samples are in the range 38.9-77.7, while for groundwater samples they are in the range 46.3-90.9. In case of river water samples, three are found to be of good quality, three are of poor water quality and one sample is found to be of very poor quality. But, in case of groundwater samples, only one sample is found to be of good quality while the remaining are of poor to very poor quality.

Table 7 Water quality index range and corresponding water quality status [13]

WQI range	Water quality status
0 – 25	Excellent water quality
26 – 50	Good water quality
51 – 75	Poor water quality
76 – 100	Very poor water quality
> 100	Unsuitable for drinking purpose

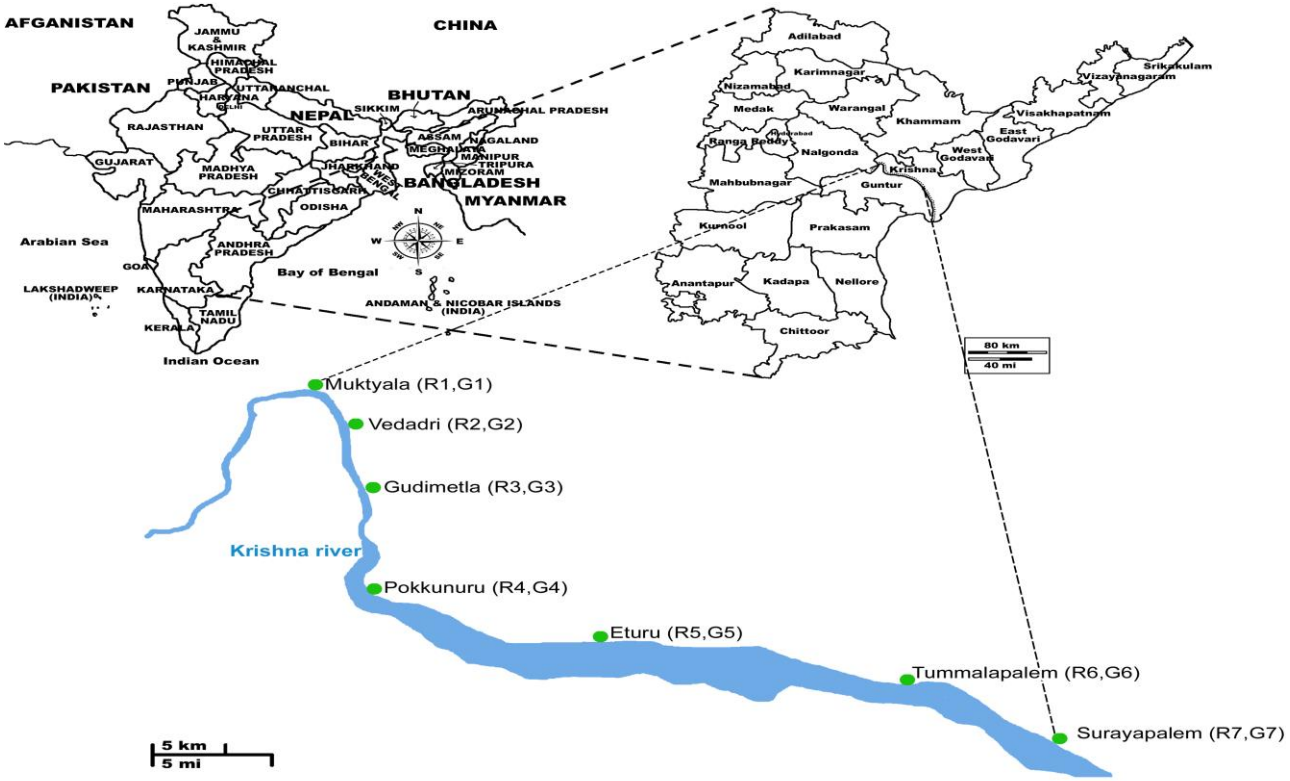

Figure 1: Map showing sampling locations

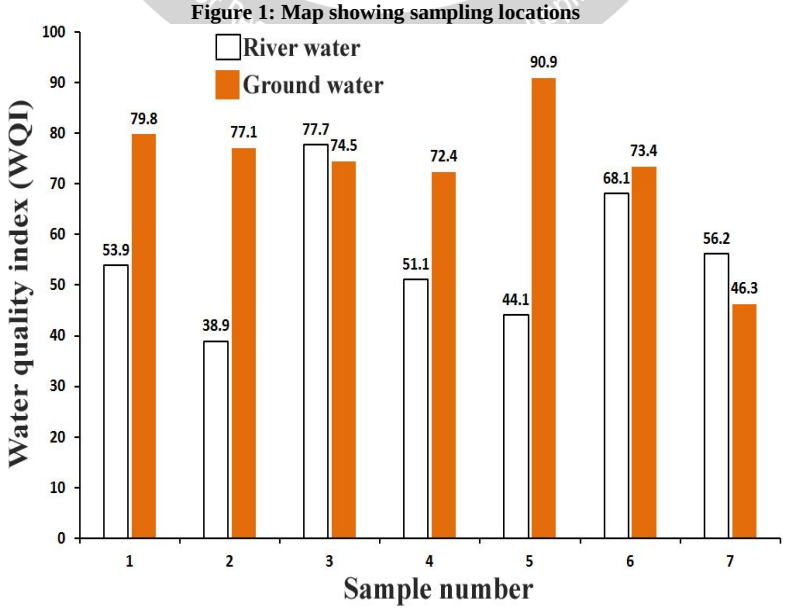

Figure 2: Water quality index values of the river water and groundwater samples at different locations

IV. CONCLUSION

Both the river water and groundwater samples are found to have three water quality parameters pH, dissolved oxygen and turbidity well within the permissible limits. The river water samples possess many quality parameters in the range prescribed by ICMR and BIS. However, groundwater samples are found to have very high values of hardness, total dissolved solids, alkalinity, chlorides and electrical conductivity. Because of this reason, most of the groundwater samples came under the category of either poor quality or very poor quality. High soluble content in groundwater samples yielded higher values of water quality index. By consolidating all the results, it can be concluded that collected river water samples are superior in quality than the groundwater samples. However, both river water and groundwater requires suitable treatment for making them suitable for domestic purposes.

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