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Assessment of Quality of Groundwater in Certain Villages nearby Krishna River, Krishna District, Andhra Pradesh, India

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Abstract— *In the present study, the quality of groundwater samples was evaluated in terms of certain water quality parameters. The 24 groundwater samples were collected from the villages located along the Krishna river in Krishna district of Andhra Pradesh. Nine most significant quality parameters were determined for all the water samples collected. Water quality index values were calculated by incorporating data of quality parameters in to mathematical equations. Based on the water quality index values, the quality of water is assessed. From the results, it is found that all the water samples are of good quality and suitable for drinking/domestic purpose.*

Keywords— Water quality index, Krishna river, Groundwater, Krishna district, Villages.

I. INTRODUCTION

It is believed that groundwater is polluted to a lesser extent when compared with any surface water. This is the reason for usage of groundwater for several applications including domestic, agricultural and industrial purposes. But, groundwater has also been polluted gradually because of natural and anthropogenic activities including continuous dumping of waste water from industries and domestic sewage and it is continuously becoming harmful for human health. Water resource management involves several aspects including study of water quality of groundwater at different intervals of time. However, it is difficult task to study and evaluate for larger number of samples. Further, each sample has several parameters and each parameter is very significant in assessing the suitability of water for a particular purpose [1]. The complexity in water quality assessment is mainly due to complexity of parameters that significantly affect water quality, and the large variability of parameters used to indicate the quality of water resources [2].

In order to minimize the complexity in expressing water quality, a dimensionless number was proposed, by name water quality index (WQI). Using WQI, it is possible to indicate quality of water in a simple form by the aggregation of the measurements of the selected parameters. Considering the easiness of the use of WQI and their scientific basis, WQIs became important and popular tool for the assessment of water quality of water bodies [3]. WQI attempts to provide a mechanism for presenting a cumulatively derived numerical expression defining a certain level of water quality [4]. There are several reports in literature in which WQI was determined in order to assess the quality of water at different places and different sources [5-13]. The present investigation of the quality of groundwater from various villages of Krishna district of Andhra Pradesh state has been carried out, based on the above background. All the 24 groundwater samples were collected from the villages located adjacent to the river. For each sample of groundwater, nine quality parameters were determined from which water quality index was calculated. Based on the WQIs, the water quality status of each location is presented.

II. MATERIALS AND METHODS

In order to determine water quality indices, the groundwater samples were collected from 24 sampling locations, all of them being in villages located adjacent to the Krishna river in Krishna district of Andhra Pradesh, India. The map indicating the selected villages and the sampling locations are shown in Fig. 1. The names of the locations with the corresponding sample numbers are listed in Table 1. The samples were collected in clean brown glass bottles with all the necessary precautions. All the chemicals used belong to AR grade purity.

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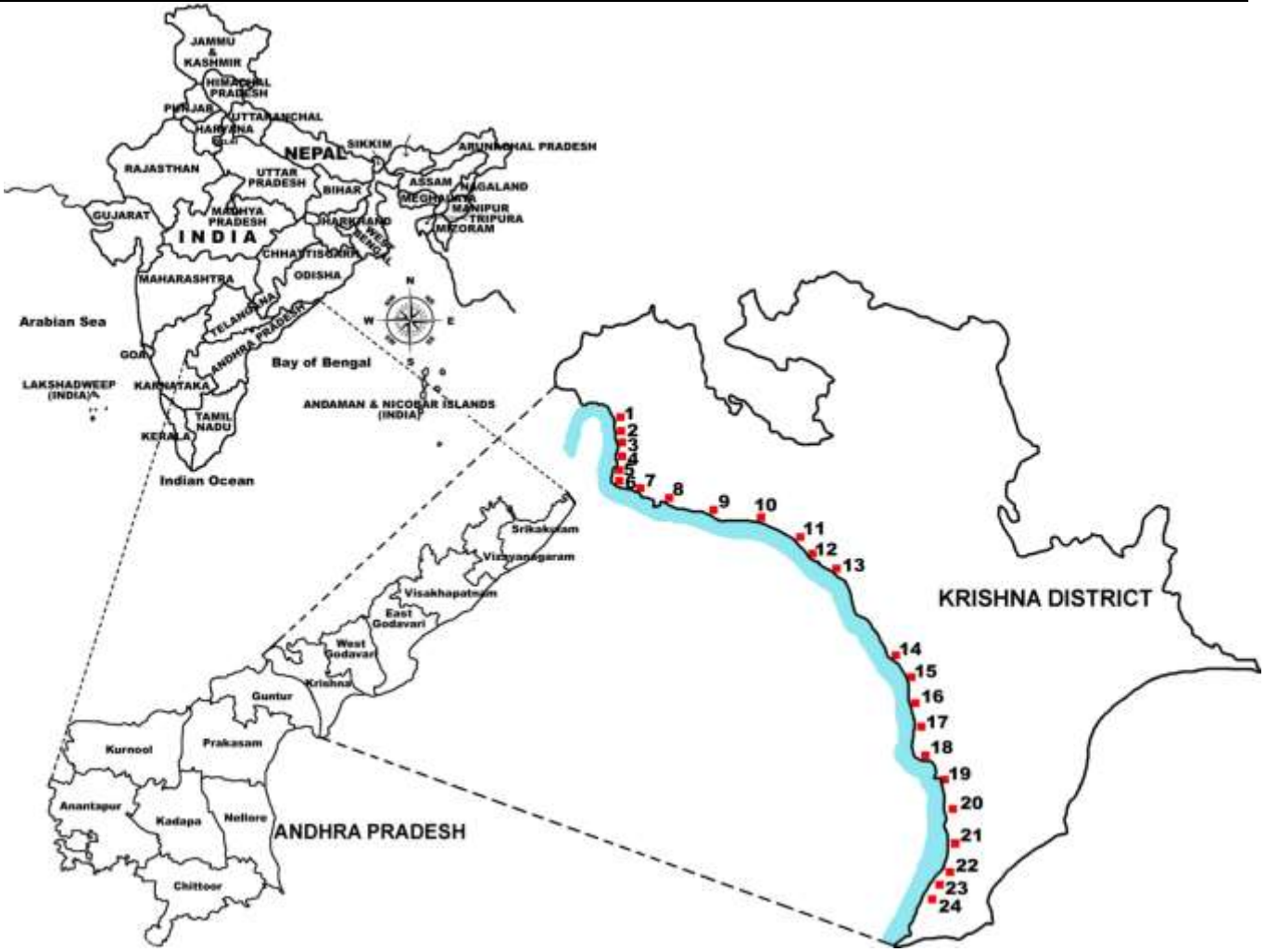

Fig.1: Map indicating the location of sampling sites

Table.1: Names of sampling villages and corresponding sample numbers

Name of village	Sample number	Name of village	Sample number	Name of village	Sample number	Name of village	Sample number
Vedadri	01	Kodavatikallu	07	Surayapalem	13	Bhadrirajupalem	19
Katrenipalle	02	Veladi	08	Kasaranenivaripalem	14	Devarapalli	20
Ramanapeta	03	Chevitikallu	09	Madduru	15	Iluru	21
Ustepalle	04	Damuluru	10	Royyuru	16	Inapuru	22
Kasarabada	05	Ferri	11	Vallurupalem	17	Srikakulam	23
Pokkunuru	06	Tummalapalem	12	Thotlavalluru	18	Nimmagadda	24

Table.2: Water quality parameters, their units and analytical methods/instruments used

Parameter	Analytical method/ Instrument	Parameter	Analytical method/ Instrument
Chlorides (Cl^-) (mg/L)	Volumetric – Argentometry	Electrical conductivity (EC) (µS/cm)	Digital conductivity meter
Total alkalinity (mg/L)	Volumetric – Neutralization	Dissolved oxygen (DO) (mg/L)	Winkler's method
Total hardness (mg/L)	Volumetric – EDTA method	Turbidity (NTU)	Nephelometer
Total dissolved solids (TDS) (mg/L)	Gravimetric method	Fluorides (F^-) (mg/L)	SPADNS method–UV-vis spectrophotometer
pH	Digital pH meter		

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Double distilled water was used for preparation of the solutions and reagents. The water samples were analysed for various water quality parameters as per the standard procedures [14, 15] given in Table 2. The experimental values of water quality parameters were compared with the standard values recommended by the Indian Council for Medical Research (ICMR) and Bureau of Indian Standards (BIS) [16] given in Table 3. In order to calculate water quality index, 9 important parameters such as chlorides, total alkalinity, total hardness, total dissolved solids, dissolved oxygen, pH, electrical conductivity, turbidity and fluoride concentration were selected. The subindex (q_i) corresponding to i^{th} parameter is a number reflecting the relative value of this parameter in water with respect to its standard permissible value. q_i value is obtained from the following expression [13].

$$\mathbf{q_i = 100 \times [V_i - V_o] / [S_i - V_o]}$$

q_i = subindex for the i^{th} water quality parameter
V_i = Estimated value of the i^{th} parameter at a given sampling location
S_i = Standard permissible value of the i^{th} parameter
V_o = Ideal value of the parameter in pure water
(For pH and DO, V_o = 7.0 and 14.6 mg/L respectively, and for all other parameters V_o = 0)
Unit weight was calculated by a value inversely proportional to the recommended standard value Si of the corresponding parameter [13].

$$\mathbf{W_i = k / S_i}$$

W_i = Unit weight for the i^{th} parameter
S_i = Standard value for the i^{th} parameter
k = Proportionality constant
Finally, the overall water quality index was calculated by aggregating the subindex with the unit weight linearly [13].

$$\mathbf{WQI = \sum q_i W_i / \sum W_i}$$

Table.3: Standard values of drinking water quality parameters, recommending agencies and unit weights

Parameter	Standard value	Recommended by	Unit weight
Chlorides	250 mg/L	ICMR/BIS	0.00260
Alkalinity	120 mg/L	ICMR	0.00542
Hardness	300 mg/L	ICMR/BIS	0.00217
TDS	500 mg/L	ICMR/BIS	0.00130
DO	5.0 mg/L	ICMR	0.12998
pH	6.5-8.5	ICMR/BIS	0.07646
EC	300 µS/cm	ICMR	0.00217
Turbidity	5.0 NTU	BIS	0.12998
Fluorides	1.0 mg/L	BIS	0.64992

III. RESULTS AND DISCUSSION

The physicochemical parameters for all the groundwater samples are listed in Table 4. From the Table, it can be stated that the quality parameters namely fluorides, turbidity, pH and DO are within the permissible standard limits described by ICMR and BIS. The other variables namely chlorides, alkalinity, hardness, TDS and electrical conductivity are found to exceed the limits. The presence of very low levels of suspended and colloidal impurities in all the water samples is inferred by the extremely low turbidity values even compared with the maximum permissible limit of 5.0 NTU. Conductivity of water is said to be a direct function of its TDS [17]. Thus, it is an index to the total concentration of soluble salts in water [18]. In the present study, electrical conductivity of groundwater samples varied between 359 µS/cm and 2570 µS/cm. The TDS values are in the range 357-3024 mg/L, while the permissible limit of TDS is 500 mg/L. A few samples are found to contain very high levels of TDS and EC. As far as TDS and EC are concerned, the water is not preferable for drinking purpose. High TDS values in groundwater affect people who are suffering from kidney and heart diseases [19].
Concentration of chloride was observed to be within the permissible limit of 250 mg/L in most of the stations. It was found to exceed the limit at locations 9, 10 and 11. Soil porosity and permeability have important role in increasing the chloride concentration [6]. Fluoride limit as per the ICMR and BIS are 1.0 mg/L, while it is 1.5 mg/L as per the WHO standards [20]. The concentration of fluoride in the study area is found to be less than 1.0 mg/L. Total alkalinity values of all the samples are found to exceed the limit of 120 mg/L. The high alkalinity of groundwater sample is due to release of ions like hydroxide, carbonate and bicarbonate from carbonate-rich soils, limestone, sedimentary rocks as well as domestic solid waste [21]. Hardness is one among the important water quality parameters. Its excess beyond the above limit causes gastrointestinal irritation [22]. The total hardness values were found to be within the limit of 300 mg/L at 17 locations, while the higher values were obtained at remaining 7 locations. Table 4 also infers that the variables like chlorides, alkalinity, TDS and EC are extremely high when compared with the standard values in case of the samples 9, 11 and 19. The water quality index (WQI) values and corresponding water quality status [12] are shown in Table 5. The WQI values obtained for all the water samples in the present study are shown in Fig. 2. The figure shows that three water samples (from Katrenipalle, Kasarabada and Kasaranenivaripalem) exhibited WQI less than 25 indicating that these samples are of excellent quality and suitable for domestic purpose [12]. The water samples

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from Royyuru and Devarapalli have the WQI value of 25.1 and hence they also can be treated suitable for domestic usage. The samples from the villages namely, Ramanapeta, Veladi, Chevitikallu, Ferri, Tummalapalem, Madduru, Inapuru and Srikakulam exhibited WQI values in the range 27-30, which indicates that these groundwater samples are also of good quality. However, the remaining 11 water samples were found to exhibit WQI values from 30 to 40. As per the standards, these samples are also good in quality and can be used for domestic purpose. The highest value of WQI (= 36.8) was exhibited by the groundwater sample of Pokkunuru village. The sample from the station, Mullapadu exhibited the WQI value of 36, which indicates the water as good quality water. The higher value of WQI for the water at this station is due to higher values of many parameters namely EC, TDS, hardness, chlorides, etc.

Table.4: Physicochemical parameters of groundwater samples collected at 24 sampling locations

Sample no.	$[Cl^-]$	Alkalinity	Hardness	TDS	DO	pH	EC	Turbidity	$[F^-]$
1	105	189	226	743	6.9	7.89	450	0.45	0.28
2	88	254	228	588	6.7	7.05	540	0.56	0.11
3	134	298	367	358	7.9	7.55	823	0.49	0.18
4	113	214	245	593	7.3	7.55	928	0.78	0.27
5	117	196	252	584	7.7	7.23	506	0.84	0.14
6	109	281	275	778	7.1	7.89	750	0.37	0.29
7	158	232	317	804	8.0	7.9	954	0.58	0.27
8	122	291	198	829	7.7	8.11	1089	0.64	0.13
9	369	225	503	3024	7.2	7.3	2570	0.17	0.17
10	287	321	355	672	7.5	7.81	556	0.68	0.22
11	295	371	256	1736	7.9	7.59	1425	0.15	0.19
12	186	288	381	955	6.8	7.23	870	0.46	0.21
13	144	267	245	812	7.4	7.58	1046	0.74	0.22
14	98	214	266	692	7.5	7.46	856	0.39	0.15
15	77	295	175	394	7.1	7.49	359	0.25	0.19
16	129	198	371	813	6.9	7.44	888	0.94	0.12
17	95	352	229	357	6.5	7.89	412	0.81	0.25
18	119	331	274	952	6.8	7.29	1566	0.68	0.21
19	138	591	295	1354	5.9	8.33	1197	0.93	0.10
20	128	348	298	542	7.8	7.86	546	0.24	0.13
21	98	268	311	881	8.0	8.23	1222	0.82	0.25
22	110	378	293	555	7.7	8.44	814	0.62	0.12
23	94	597	176	619	7.4	8.59	572	0.97	0.09
24	74	319	238	452	7.3	8.15	511	0.54	0.26

Table.5: Water quality index (WQI) range and corresponding water quality status [12]

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

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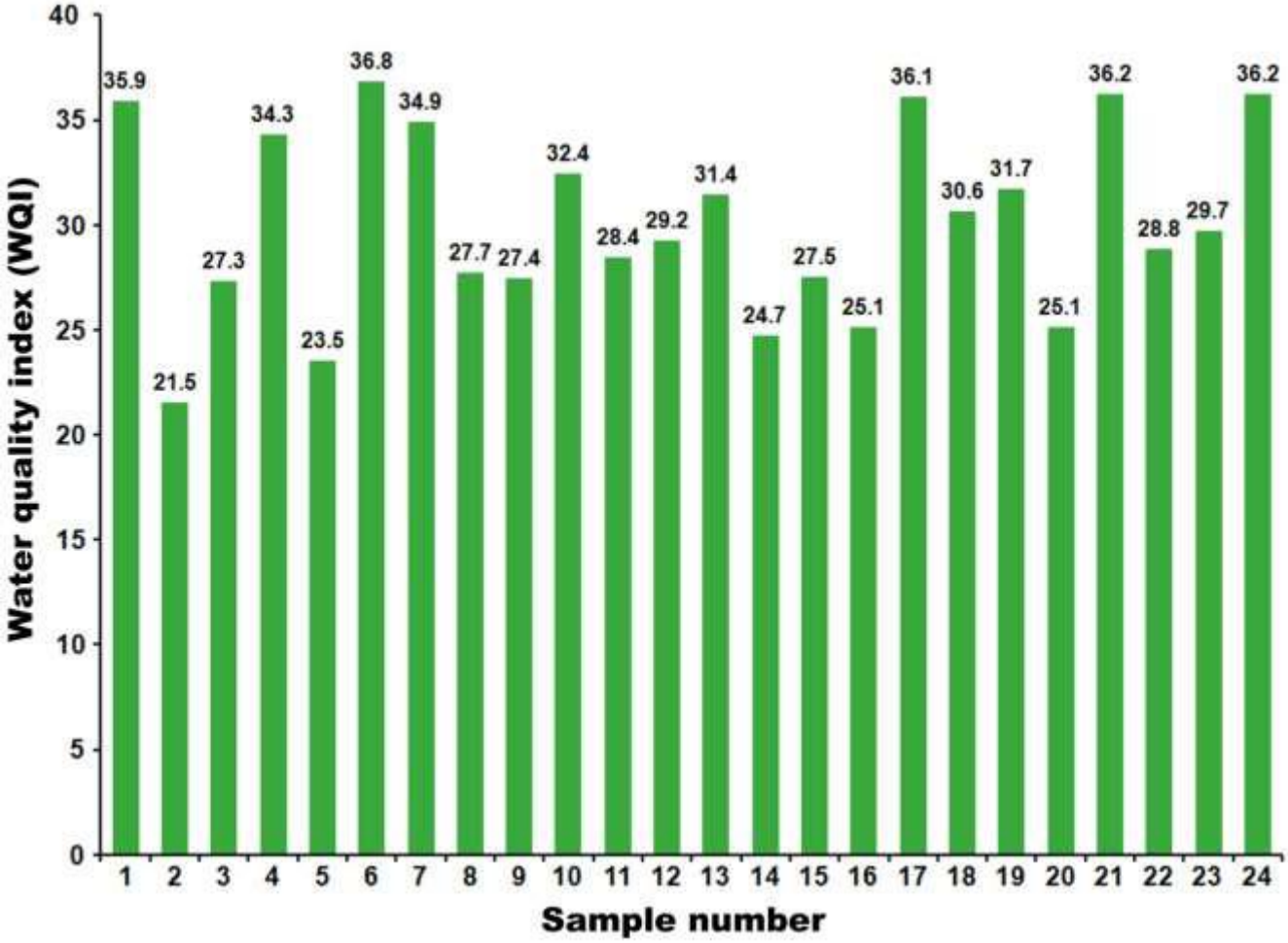

Fig. 2: Water quality index (WQI) values of groundwater samples

IV. CONCLUSIONS

1. The quality parameters viz., fluorides, turbidity, pH and DO are within the permissible standard limits described by ICMR and BIS.
2. The chlorides, alkalinity, hardness, TDS and electrical conductivity are found to exceed the limits.
3. Concentration of chloride was observed to be within the permissible limit of 250 mg/L in most of the stations. Total alkalinity values of all the samples are found to exceed the limit of 120 mg/L.
4. Chlorides, alkalinity, TDS and EC are extremely high when compared with the standard values in case of the samples at Chevitikallu, Ferri and Bhadrirajupalem.
5. The water samples from Katrenipalle, Kasarabada and Kasaranenivaripalem are of excellent quality and suitable for domestic purpose as inferred from very low values of WQI.
6. The groundwater sample from Pollunuru village has the WQI value of 36.8, which is highest value among all the water samples collected in the present study.
7. All the water samples considered in the present study are suitable for domestic/drinking purpose, as per the WQI values. However, it is desirable that the water samples containing very high values of TDS, hardness and EC may be treated before the water is consumed for drinking purpose.

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