International Journal of Lakes and Rivers.
ISSN 0973-4570 Volume 12, Number 1 (2019), pp. 33-42

http://www.ripublication.com

Assessment of groundwater and surface water quality using Water Quality Index in Krishna, West Godavari and East Godavari districts of Andhra Pradesh

V.Vijay Kumar* and Dr.B.Chakradhar

Ramky Enviro Services Private Limited (Subsidiary of Ramky Enviro Engineers Ltd.), Consultancy division, Ramky Grandiose, Ramky Towers, Gachibowli, Hyderabad – 500032, Telangana, India.

**Corresponding author*

Abstract

The present investigation is aimed to calculate Water Quality Index (WQI) of groundwater and surface water in Krishna, West Godavari and East Godavari districts of Andhra Pradesh in order to ascertain the quality of water for public, irrigation and industrial use. There are several ways to assess the quality of water as deemed fit for drinking, irrigation and industrial use. WQI is commonly used for detection and evaluation of water pollution and may be defined as a reflection of composite influence of different quality parameters on the overall quality of water (Horton, 1965). WQI indices is broadly classified into two types, they are physico-chemical and biological indices. The physico-chemical indices are based on the values of various physico-chemical parameters in the water samples, while biological indices are derived from the biological information of the water sample. There are numerous WQI indices formulated by several national and international organizations are in use. In this study Weighted Arithmetic Water Quality Index method is used. WQI is an efficient and simplified way to express the quality of water in a single value by comparing data obtained from the investigation of a number of parameters with existing limits. The limits of these parameters given in Bureau of Indian standards - IS 10500 (2012): Drinking water – specifications were considered. WQI offers a useful representation of overall quality of water for public or for any intended use as well as in the pollution abatement programmes and in water quality management. This number is placed on a relative scale to justify the quality of water in various categories ranging from excellent to unfit for drinking. A number of parameters affect the usability of water for a particular purpose. In this study WQI was determined on the basis of some important physico-chemical parameters of water samples.

Keywords: Water Quality Index, Physico-chemical, Ground waters, Water Pollution and Andhra Pradesh.

INTRODUCTION

The most important fresh water resources in the world are the surface water and groundwater, the fresh water is of vital concern for mankind, since it is directly linked to human welfare. These water resources which are most important sources of water for human activities are unfortunately under severe environmental stress and are being threatened as a consequences of developmental activities. The quality of water resources depends on the composition of recharge water, the interaction between the water and the soil, the rocks with which it comes in contact in the unsaturated zone, and the residence time and reactions that occur within the aquifer (Freeze and Cherry, 1979; Fetter, 1994: Appelo and Postma, 2005). Quality is also affected by various anthropogenic activities. Quality of water is an important concern in rural areas where the population is widely dependent on groundwater and surface water for their domestic needs.

There are several standards to express the water quality based on individual physico-chemical and biological parameters, whereas WQI provides a single number that expresses overall water quality based on several water quality parameters. The objective of WQI is to turn complex water quality data into information that is understandable and usable by the public. A single number cannot tell the whole story of water quality there are many water quality parameters that are not included in the index. However, a water quality index based on some very important parameters can provide a simple indicator of water quality (Yogendra and Puttaiah, 2008). In general WQI incorporate data from multiple water quality parameters into a mathematical equation that rates the health of a water resource with number.

The area under investigation is a rural area where residents depend on groundwater and surface water fort there domestic needs. The objective of this paper is to discuss the suitability of groundwater and surface water for various domestic needs with reference to drinking water standards and computed WQI values.

STUDY AREA

The study was carried out in three coastal districts Krishna, West Godavari and East Godavari of Andhra Pradesh. The study area is bounded with Latitudes 16°18’05” to 16°49’32” and longitudes 81°00’51” to 82°08’27” in the Survey of India (SOI) topographical survey sheets E44V3, E44V6, E44V7, E44V10, E44V11, E44V13, E44V14, E44V15, E44W2, E44W3 and E44W6, the study are map is given as Figure 1. The climate of the study area is moderate and characterized by tropical rainy climate with aggressive summer with a temperature range of 17.4°C in winter and 43.5°C in summer (Climatological normal 1981-2010) and the average annual rainfall in Krishna district is 1011mm; West Godavari district is 1078mm and in East Godavari district is 1100mm (Ground water brochure – Krishna, West Godavari, East Godavari, (2013) CGWB). The significant rainfall occurs during the southeast monsoon from June to October.

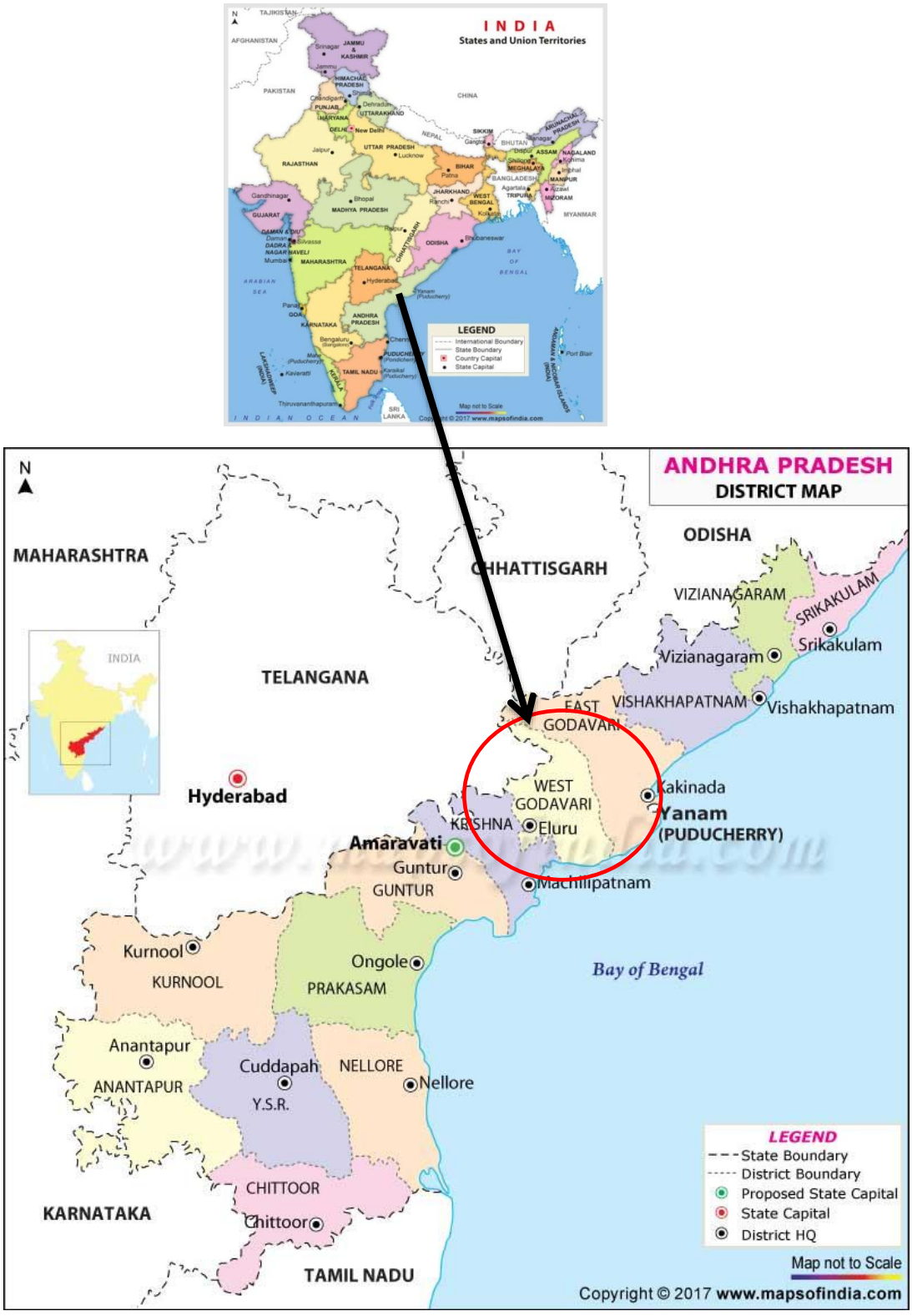

Figure 1 - Location Map

The Krishna river is the major river in the Krishna district, it is perennial in nature and flows alonf the western boundary of the district. Kolleru lake is located between Krishna and Godavari delta and spans into two districts – Krishna and West Godavari, it is the largest fresh water lake in Asia. The Godavari river is the main river in both the districts of West Godavari and East Godavari districts which is perennial river. The general drainage patter in the study area is dendritic to sub-dendritic and having both surface and groundwater irrigation sources. The main occupation of the study area is agriculture and paddy is the main crop, coconut and banana plantation is also very common. Oil and Natural Gas Corporation Limited started exploration activities in 1980 in the Krishna Godavari basin, Reliance and Cairn are making efforts to extract oil and gas. Fishing and aquaculture are the major industrial activity in the coastal part of the study area.

MATERIAL AND METHODS

About 30 groundwater samples from various water sources (open wells and bore wells) and 7 surface water samples from various surface water sources (river, lake, pond) were collected and analysed for 13 physico-chemical parameters by following established procedures during March-April 2017. The samples collected at the site were stored in properly washed polyethylene bottles at 4°C until the analysis were completed. The pH was monitored at the sampling site and other parameters like total dissolved solids (TDS), total hardness (TH), bicarbonate, chloride, sulphate, nitrate, fluoride, calcium, magnesium, iron, manganese and zinc were analysed in the laboratory as per the standard procedures of American Public Health Association (2005). The suitability of the groundwater and surface water in the study area was examined using compliance of the measured data with respect Bureau of Indian Standards IS 10500 (2012): To get a comprehensive picture of overall quality of groundwater and surface waters the WQI was used.

The WQI is defined as a rating reflecting the composite influence of different water quality parameters on the overall quality of water. The Weight Arithmetic Water Quality Index method (Brown et.al 1970, Luliana et al 2016) has been used for the calculation of WQI of the water sources. The calculation of WQI was made by using the following equation.

$$WQI = \Sigma QiWi / \Sigma Wi$$

The quality rating scale (Qi) for each parameter is calculated by using the following equation.

$$Qi = 100 [(Vi-Vo) / (Si-Vo)]$$

Vi is estimated concentration of the ith parameter in the analysed water sample

Vo is the ideal value of the ith parameter in in pure water (for all parameters this value is 0 except for pH it is 7.0)

Si is the standard value of the ith parameter

The unit weight (Wi) for each water quality parameter is calculated by using the formula

$$Wi = k/Si$$

Where k is the proportionality constant and can be calculated using the following equation

$$K = 1 / \Sigma\ (1/Si)$$

The WQI and status of water quality (Chatterji and Raziudding 2002) is given in Table 1.

Table 1. WQI and status of the water quality

Water quality index (WQI)	**Water quality status**	**Possible usages**
0 – 25	Excellent water quality	Drinking, irrigation and industrial
26 – 50	Good water quality	Domestic, irrigation and industrial
51 – 75	Poor water quality	Irrigation and industrial
76 – 100	Very poor water quality	Irrigation
Above 101	Unsuitable for drinking purpose	Restricted use for irrigation

RESULTS

The water quality parameters are selected based on its direct involvement in deteriorating water quality for domestic needs. The standards for the drinking water, recommended by the Bureau of Indian Standards are considered for the computation of quality rating and unit weights. For purpose of calculation of WQI for the study area, thirteen water quality parameters have been considered. The values of these parameters in some of the samples are found to be above the acceptable limits. The higher values of these parameters would increase WQI value. The standard values of water quality parameters and their corresponding ideal values and unit weights, etc., are given in Table 2. The details of the sampling locations and type of source and WQI values are given in Table 3. The WQI of groundwater samples were in the range of 33 to 2768, whereas WQI of surface waters were in the range of 17 to 106.

Table 2. Standard values of water quality parameters and their corresponding ideal values and unit weights, etc.

Parameter[a]	**Sn**	**1/Sn**	**Vid**	**k**	**Qn**	**Wn**
pH	6.5-8.5	0.154	7	0.068	120.0	0.440
Total dissolved solids	500	0.002	0	0.068	117.0	33.842
Total hardness	300	0.003	0	0.068	109.3	20.305
Bicarbonate	244	0.004	0	0.068	89.8	16.515
Chlorides	250	0.004	0	0.068	44.0	16.921
Sulphates	200	0.005	0	0.068	32.5	13.537
Nitrates	45	0.022	0	0.068	7.8	3.046
Fuloride	1	1.000	0	0.068	58.0	0.068
Calcium	75	0.013	0	0.068	100.0	5.076
Magnesium	30	0.033	0	0.068	113.3	2.031
Iron	0.3	3.333	0	0.068	50.0	0.020
Manganese	0.1	10.000	0	0.068	100.0	0.007
Zinc	5	0.200	0	0.068	20.0	0.338

[a] Parameters in mg l^{-1} except pH

Table 3. Details of sampling locations

Code	**Latitude**	**Longitude**	**Source**	**District**	**WQI**
S1	16°49'32.8"	81°56'32.9"	Ground Water	East Godavari	75
S2	16°46'27.6"	81°55'52.4"	Ground Water	East Godavari	57
S3	16°43'58.4"	81°59'18.1"	Ground Water	East Godavari	2768
S4	16°43'03.5"	81°53'38.7"	Ground Water	East Godavari	65
S5	16°38'25.9"	81°59'00.9"	Ground Water	East Godavari	133
S6	16°32'13.4"	81°00'51.5"	Ground Water	East Godavari	749
S7	16°42'00.5"	82°00'01.6"	Ground Water	East Godavari	126
S8	16°30'13.9"	81°57'02.8"	Ground Water	East Godavari	174
S9	16°29'19.9"	81°55'51.4"	Ground Water	East Godavari	110
S10	16°28'16.5"	81°55'16.0"	Ground Water	East Godavari	33

Code	Latitude	Longitude	Source	District	WQI
S11	16°25'06.1"	81°55'16.5"	Ground Water	East Godavari	256
S12	16°24'54.9"	81°56'19.2"	Ground Water	East Godavari	149
S13	16°24'41.4"	81°54'34.1"	Ground Water	East Godavari	91
S14	16°24'32.4"	81°53'29.0"	Ground Water	East Godavari	93
S15	16°31'17.8"	82°01'58.5"	Ground Water	East Godavari	242
S16	16°31'18.4"	82°03'32.2"	Ground Water	East Godavari	388
S17	16°31'04.0"	82°10'19.0"	Ground Water	East Godavari	673
S18	16°35'51.3"	82°10'21.4"	Ground Water	East Godavari	205
S19	16°28'21.5"	81°43'32.0"	Ground Water	West Godavari	94
S20	16°32'10.6"	81°24'37.5"	Ground Water	West Godavari	152
S21	16°32'48.3"	81°24'24.7"	Ground Water	West Godavari	57
S22	16°23'15.8"	81°31'01.6"	Ground Water	West Godavari	203
S23	16°22'08.3"	81°30'47.4"	Ground Water	West Godavari	92
S24	16°26'40.3"	81°12'41.5"	Ground Water	Krishna	609
S25	16°20'12.7"	81°14'18.1"	Ground Water	Krishna	278
S26	16°21'28.8"	81°16'09.9"	Ground Water	Krishna	207
S27	16°22'11.0"	81°16'19.6"	Ground Water	Krishna	302
S28	16°22'31.2"	81°15'43.9"	Ground Water	Krishna	120
S29	16°21'02.4"	81°16'56.9"	Ground Water	Krishna	419
S30	16°21'17.5"	81°17'50.5"	Ground Water	Krishna	315
S31	16°46'36.6"	81°52'32.1"	Surface Water	East Godavari	17
S32	16°46'36.6"	81°52'32.1"	Surface Water	East Godavari	32
S33	16°26'18.8"	81°28'37.0"	Surface Water	West Godavari	59
S34	16°28'14.1"	81°31'31.4"	Surface Water	West Godavari	62
S45	16°25'08.6"	81°30'38.4"	Surface Water	West Godavari	73
S36	16°18'05.5"	81°16'07.8"	Surface Water	Krishna	106
S37	16°23'46.6"	81°11'19.3"	Surface Water	Krishna	86

Table 4. Status of district wise groundwater and surface water samples

Status of water	Krishna		West Godavari		East Godavari		Total in study area	
	GW	SW	GW	SW	GW	SW	GW	SW
0-25	0	0	0	0	0	1	0	1
26-50	0	0	0	0	1	1	1	1
51-75	0	0	1	3	3	0	4	3
76-100	0	1	2	0	2	0	4	1
101-150	1	1	0	0	4	0	5	1
above 150	6	0	2	0	8	0	16	0
Total	**7**	**2**	**5**	**3**	**18**	**2**	**30**	**7**

DISCUSSION

Out of thirty groundwater samples in the study area only one sample is falling under good water quality, four samples in poor water quality, four samples in very poor water quality and twenty one samples are falling in unsuitable for drinking purposed. Whereas from the seven surface water samples one each sample falling in excellent water quality, good water quality, very poor water quality and unsuitable for drinking purposes but three samples are falling under poor water quality.

In the study area when compared to surface waters the groundwater samples are more contaminated. Out of thirty groundwater samples only one sample is falling under good water quality rest all are in poor to unsuitable range. Whereas out of seven surface waters one each falling under excellent and good, rest of the samples are in poor to unstable range. The poor quality of the groundwater in the study area may be due to anthropogenic activities (aqua culture development, oil and gas exploration, over exploitation) and natural geological conditions.

The study area is underlain by different geological formations comprising oldest archaeans to recent alluvium. Groundwater occurs in all most all geological formations and its potential depends upon the nature of geological formations, geographical setup, and incidence of rainfall, recharge and other hydrogeological characters of the aquifer.

As per Ground water brochure – Krishna, West Godavari, East Godavari, (2013) CGWB, in general the quality of groundwater in shallow aquifers of crystalline formations, Rajahmundry & Tirupati sandstones is good and suitable for domestic, industrial and irrigation purposes except at few localities in isolated places, which is due to localised pollution. In alluvial aquifers the deeper aquifers are invariably saline and not suitable for drinking and irrigation purpose under ordinary conditions. In deltaic area and coastal area the brackish / saline groundwater occurs in hydraulic

contact with fresh ground water. The quality of groundwater varies widely from place to place even within short distance and deeper aquifers are invariably saline. The salinity of groundwater is caused due to geomorphic landform, water logging conditions, sluggish nature in ground water movement and excess use of fertilizers and unregulated growth of aquaculture in the coastal area.

CONCLUSION

The WQI of groundwater samples were in the range of 33 to 2768, whereas WQI of surface waters were in the range of 17 to 106. The majority of the groundwater samples and some surface water samples are falling under poor water quality to unsuitable for drinking purposes; these phenomena may be due to various anthropogenic activities such as oil & gas exploration, aqua culture and geological formations of the area.

To improve the quality of waters in the study area measures to be taken are in alluvium areas the fresh water repositories are to be protected from over pumping. Optimum utilisation of surface and ground water may be considered locally after micro level surveys considering quality constraint. Environmental protection measures are to be followed in aqua culture practices and during oil & gas exploration. The Aqua culture development should be restricted to areas close to the coast only. In the limited groundwater potential area, modern irrigation methods like drip and sprinkler irrigation should be adopted. Artificial recharge measures should be adopted in the urban areas, in the deltaic area and areas with considerable exploitation of groundwater for improving the ground water situation.

Acknowledgements

Authors are thankful to the management of Ramky Enviro Services Private Limited, Hyderabad for giving encouragement and support to publish this article.

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