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Water Quality Status of Andra Reservoir in Vizianagaram District of Andhra Pradesh, India

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ABSTRACT

The present study of the author is aimed at the assessment of water quality of Andra reservoir situated in Andra village, Mentada mandal in Vizianagaram district of Andhra Pradesh. The study was carried out for the analysis of physico- chemical characters such as pH, EC, TDS, total hardness, calcium, magnesium, sodium, potassium, iron, chloride, nitrite, phosphate, fluoride, total alkalinity and content of heavy metals such as Mn, Cr, Ba Ti, Hg, As Pb and Cd. Different samples were collected at random in the reservoir and mixed to get a representative sample, which is subjected to analysis. The analysis was performed in the seasons of August 2010, December 2010, April 2011, August 2011, and December 2011. April 2012, August 2012, December 2012 April 2013, August 2013 and December 2013. Quality of the water samples collected from the reservoir was determined by Water Quality Index (WQI) method and found to be excellent in its quality. Irrigation water quality parameter such as SAR, RSC, % Na and Mg-hazard were also determined and found to be well within the prescribed limits. From the water quality index data and irrigation water quality data, the authors conclude that the water is fit for human consumption, irrigation and agriculture purpose.

Keywords: WQI, SAR, RSC, %Na, reservoir water quality.

INTRODUCTION

Water quality of reservoir water content is determined by the physical, chemical parameters and biology of a reservoir and includes all physical chemical and biological factors that influence the fitness for use of water. Djukic et al., have used the physico chemical properties of water to assess the quality of water in a reservoir. The conventional approach of expressing different parameters of water quality in varying units was well accepted by water resource experts. However, it is not readily understood by the general public and policymakers, who have profound impact on water resource policies. Thus, the need for expressing water quality in a fitting format that is simple and easily understood by common people has been recognized for a long time. Experts have worked on international level including in the United States—for the past several years and have proposed the term *Water Quality Index (WQI)*. The WQI [1-8] takes the complex scientific information and synthesizes into a single number between zero and 100, by normalizing the observed values to subjective rating curves. WQI summarizes the relative changes in the underlying group of the water-quality variable.

Factors to be included in WQI model would vary depending upon the designated water uses and local preferences. Some of these factors include DO, pH, BOD, COD, total coli form bacteria, temperature, and nutrients (nitrogen and phosphorus), etc. These parameters occur in different ranges and expressed in different units. The WQI takes the complex scientific information of these variables and synthesizes them into a single number. Several authors have worked on these concepts and presented examples with case scenarios. This method is a statistical approach for normalizing errors.
In the present work the authors used the following methodology to calculate WQI and the procedure is given under here:

$$W_i = k/S_i$$

Where W_i is the unit weight of and S_i is the standard for i^{th} parameter,K is the proportionality constant

$$Q = 100V_i /S_i$$

Where Qi is the sub index of the i^{th} parameter, Vi is the monitored value of i^{th} parameter and WQI is calculated as follows

$$WQI= \sum Q_i W_i / \sum W_i$$

Irrigation water quality can be determined by SAR, RSC, %Na and Mg-hazard values. These can be calculated using the following formula:

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

$$\text{Magnesium hazard} = 100 \text{ x } Mg^{2+}/ (Ca^{2+} Mg^{2+})$$

$$Na \% = 100 \text{ x } Na^+ / (Na^+ + Ca^{2+} + Mg^{2+} + K^+)$$

$$RSC = (CO_3^{2-} + HCO_3^-) - (Ca^{2+} Mg^{2+})$$

For all these calculation of irrigation water quality parameters all the chemical parameters are expressed in m. eq L^{-1}.

In literature [9] it was found that a computer program was developed in C language and used. However, for the calculation of WQI, a computer program in JAVA was developed and used by the authors, which is simple and advanced. In the present study, the authors probe into the assessment of the water quality of Andra reservoir of river Champavati in Vizianagaram district.

MATERIALS AND METHODS

Area under study: Andra (18.3500°N, 83.2000°E) is a village and panchayat in Mentada mandal, Vizianagaram district of Andhra Pradesh, India. It is located at about 7 K.M. from Mentada village and about 34 K.M. from Vizianagaram city. It has an average elevation of 127 M (419'). The reservoir was constructed during 1983-2000. The project utilizes 0.980 TMC of the available water and the reservoir storage capacity is about 0.9 TMC. The total ayacut of 9,426 acres has been located in Bondapalli, Gajapathinagaram and Mentada mandals of Vizianagaram district

Sampling: Integrated sampling procedures were adopted in order to get a true representative sample of water from the reservoir. The samples were collected during different seasons such as August 2010, December 2010, April 2011, August 2011, and December 2011. April 2012, August 2012, December 2012 April 2013, August 2013 and December 2013. The samples were collected in previously cleaned, dry polyethylene bottles of capacity 1000ml and mixed with appropriate preservatives such as dilute nitric acid, for the determination of heavy metals for further analysis. EC, temperature, pH and DO of the collected samples were measured on the spot.

The concentration of chloride ion in water sample was determined by Mohr's method using potassium chromate as indicator. Concentrations of calcium and magnesium were determined using EDTA with EBT and murexide as indicators. DO of the samples was determined on the spot by a DO meter with a gold electrode. An ELICO scanning visible spectrophotometer (SL-177) with 1 cm glass cell was used for the determination of nitrite in the water samples. An ELICO flame photometer (CL-361) was used for the determination of sodium and potassium. For the pH measurements, an ELICO digital pH-meter (LI-127) and for conductance measurements, an ELICO conductivity meter (CM-180) was used. Standard methods of APHA [12] were used for the analysis of water samples. ICP-OES was used for the analysis of heavy metals. All the chemicals and reagents used were of AR grade only and the aqueous solutions were freshly prepared using double distilled water.

RESULTS AND DISCUSSION

The complete analysis report of the physico chemical characteristics of the water samples collected from the Andra reservoir for all the seasons is presented in Table.1.These reported values are compared with IS:10500 standards prescribed and CPCB[10,11]. Heavy metal analysis reports are presented in Table.2. Water quality index data, Irrigation water quality data including SAR, RSC, Na% and magnesium hazard in all the seasons under study is presented in Table.3. From the above collected data the following inferences are presented.

Table.1 Seasonal variation of physico chemical characters of reservoir water

Season / Parameter	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	IS 10500
pH	8.7	9.3	7.1	7.2	8.2	8.4	8.4	8	8	8.2	8.4	**6.5-8.5**
EC	220	180	150	250.8	275	300	300	290	285	300	352	**500**
TDS	300	300	200	255	280	300	300	280	285	290	295	**500**
THW	200.5	201.3	302	215.4	225.5	245	245	230	230	235	230	**300**
Ca	80.5	40.3	80.6	60.2	100.2	110	110	100	110	115	120	**75**
Mg	42.5	24.1	24.1	24.3	36.2	38.5	38.5	36.5	38	40	45	**30**
Na	68.5	42.5	15	50	75	92	92	84	84	90	98	**200**
K	6.5	2.5	2.1	10	20	25	25	20	20	28	25	**10**
Fe	0.1	0.07	0.05	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.08	**0.3**
Cl	98.5	86.2	95	100.3	100	98	98	95.5	98.2	100	150	**250**
PO_4	0.5	0.8	1	0.8	0.9	1.2	1.2	1.1	1.1	1	1.2	**10**
NO_2	0.05	0.03	0.3	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.06	**1.0**
F	0.1	0.4	0.4	0.4	0.5	0.6	0.6	0.7	0.9	0.8	0.8	**1.2**
TA	159.5	159.5	160.5	150.8	165	160	165	168	165	165	170	**200**
CO_3	18.1	18.1	36.1	38.2	40	38.5	38.5	38.5	40	42	45	**-----**
HCO_3	110.7	110.7	221.8	225	228	235	235	228.6	228.6	230.5	230	**----**
DO	6.5	6.8	7.2	7.4	7.8	7.5	7.4	7.5	7.6	7.2	7.5	**4-8**

Table.2. Seasonal variation in WQI of the reservoir water

Season	WQI	SAR	%Na	RSC	Mg hazard
August 2010	24.9	1.537	27.9	-5	46.4
December 2010	23.5	1.308	31.3	-1.5	49.5
April 2011	36.4	0.376	9.71	-1.2	32.9
August 2011	27.1	1.374	29.25	-0.03	39.8
December 2011	32.1	1.632	27.25	-2.9	37.2
April 2012	35.1	1.922	30.1	-3.5	36.4

August 2012	35.1	1.922	30.1	-3.5	36.4
December 2012	35.6	1.827	30	-2.9	37.4
April 2013	38.5	1.759	28.5	-3.5	28.6
August 2013	38.7	1.841	36.1	-3.8	36.3
December 2013	36.6	1.93	29.20	-4.41	38.1

Table.3 Guidelines for evaluation of irrigation water quality

Water class	Sodium (Na) %	Electrical conductivity (µS/cm)	SAR	RSC meq/l
Excellent	< 20	< 250	< 10	< 1.25
Good	20 - 40	250 – 750	10 – 18	1.25 – 2.0
Medium	40 - 60	750 – 2,250	18 – 26	2.0 – 2.5
Bad	60 – 80	2,250 – 4,000	> 26	2.5 – 3.0
Very bad	> 80	> 4,000	> 26	> 3.0

pH of the water samples analyzed were found to be well within in the prescribed standard value , 6.5-8.5. During, December 2010, a maximum pH of 9.3 was observed. A sample of water with a pH that is too high can indicate in nutrient deficiencies, mainly micronutrients such as iron. Keeping the pH of the irrigation water below 7.0 is also important in order to prevent emitter clogging due to sedimentation of salts. From the data it was found that the water of the reservoir is alkaline in nature, except in April and August 2011. As the pH of the water sample is not the highest in pH it is inferred that the water is suitable for irrigation with respect to pH, as higher pH influences the concentration levels of micronutrients in water. Electrical conductivity is an important parameter in assessing the quality of water for both human consumption and irrigation purposes. The primary effect of high EC water on crop productivity is the inability of the plant to compete with ions in the soil solution for water (physiological drought). The higher the EC, the lesser is the water available to plants, even though the soil may appear wet. Because plants can only transpire "pure" water, usable plant water in the soil solution decreases dramatically as EC increases. The EC of the water samples analyzed during all the seasons mentioned was found to ranging from 150-300 µS/cm. According to Indian standards IS: 2296-1992, water with EC of below250µS/cm is rated as “Excellent” for irrigation purpose. In the present study, during December 2011, April 2011, August 2011 and August 2013 water analyzed was rated as “Good” in its quality. Total dissolved solids for the water samples analyzed were found in the range of 200-300mg L^{-1} , which indicates a good quality for the water. Total hardness of water was found in the range of 200-300mg L^{-1}, which is well within the prescribed standard value for drinking as well as irrigation purpose. Calcium in the water samples was found to have a concentration ranging from 40.3-115mg L^{-1}. The high levels of calcium are due to the presence of limestone rocks, as the river basin comprises with such. The concentration of magnesium in the water samples analyzed was found to be in the range of 24.1-42.5mg L^{-1}, well within the prescribed standard value. Sodium and potassium in the water samples analyzed were found to be in the range 15-92mg L^{-1} and 2.1-28mg L^{-1} respectively. This indicates that the concentration of sodium and potassium in the water samples analyzed were well within the prescribed standard values .Iron in the water samples analyzed was found to be in the range of 0.05-0.1mg L^{-1}. It is a well known fact that certain bacteria flourishes in the presence of very low concentrations of iron such as 1.0mg L^{-1} even, causing rust colored sludge blocking the filters and emitters. For the samples of analyzed from the reservoir are found to have the least concentration of iron indicating that the water is free from iron contamination. The concentration of chloride in the water samples was found to be 86.2-100.3mg L^{-1}, this is well within the prescribed standard value. With respect to the chloride ion concentration the water is rated as “good” in its quality for irrigation and drinking purpose. Nutrients such as phosphate and nitrite were found to have concentration ranging from 0.5-1.1mg L^{-1} and 0.03-0.05mg L^{-1}. It was found that in most of the seasons, the concentration of nitrite was 0.03mg L^{-1}. This indicates that the water in the reservoir is free from contamination by industrial sewage or household seepage. It indicates the suitability of water for drinking and irrigation purpose. The concentration of fluoride in the water samples analyzed was found to be in the range 0.1-0.9mg L^{-1}. The concentration of fluoride ion was found to be well within the prescribed standard value and is suitable for drinking purposes. Total alkalinity of the water samples analyzed was found to be in the range of 159.5-165mg L^{-1}. The concentration of carbonates in the water samples analyzed was found to be in the range of 18.1-42mg L^{-1} and that of bicarbonates was 110-235mg L^{-1}. The higher level of bicarbonate is directly related to the pH of the water samples analyzed. High levels of bicarbonate increases the pH of the water samples due to alkalizing effect. This is clearly observed in case of the water samples analyzed from Andra reservoir.

Irrigation water quality data: To assess the water quality for the reservoir irrigation, water quality parameters such as SAR, RSC, %Na and Magnesium hazard were calculated and the results were presented in Table.2. The prescribed standard values for the same are also presented in Table.3 for necessary comparison.

From the data it was found that, in all the seasons, all the irrigation water quality parameters were found to be well within the prescribed standard (IS: 2296-1992) limits, indicating that the water of the reservoir is suitable for irrigation purposes. In all the seasons the value of RSC is found to be less than 1.25 and is negative in sign, indicating the water is “Excellent” in its quality. Higher levels of bicarbonates were found in the water samples, which are responsible for the slight alkaline nature of the water, without affecting the residual carbonate content. From the data of irrigation water quality, it is concluded by the authors that the water analyzed is “Excellent” for irrigation. All this data is graphically represented in Figs 1 to 4.

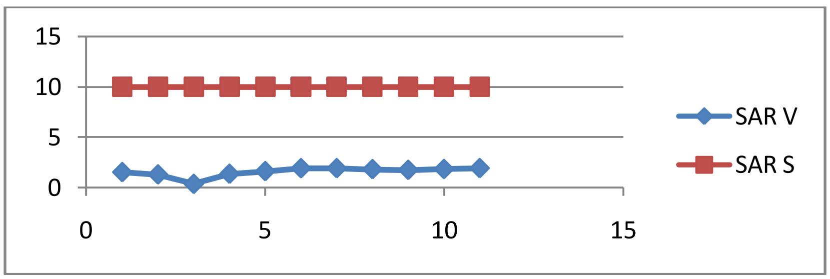

Fig.1.Seasonal variation in SAR

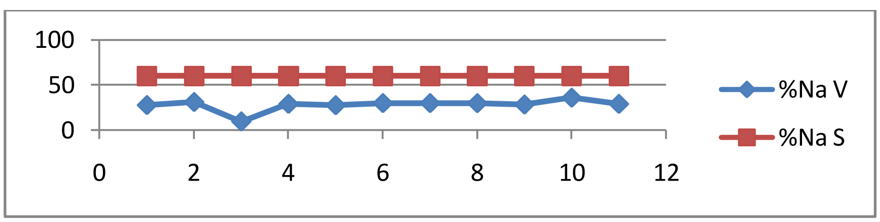

Fig.2 Seasonal variation in %of Na

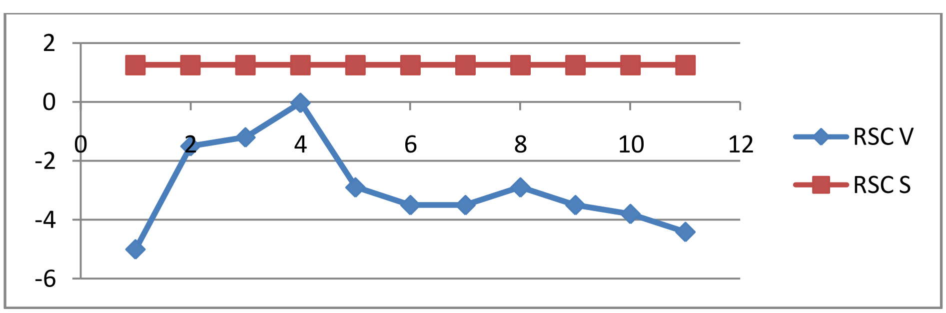

Fig.3.Seasonal variation in RSC

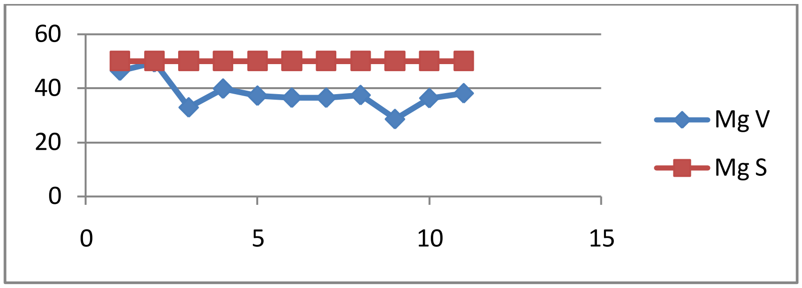

Fig.4 .Seasonal variation in Mg hazard

In all the seasons (100%) the water samples are rated as "Excellent" with respect to SAR, during three seasons (30%) the water quality is rated as "Excellent" and in seven seasons (70%) are rated as "Good" with respect to electrical conductivity. With respect to the parameter % Na, during one season the water quality is rated as "Excellent" in rest of all the seasons (90%) the same is rated as "Good". It is concluded from all this data the water is rated "Good" in its quality for irrigation purpose and for human consumption.

Heavy metal analysis: The reports of analysis are presented in Table.4. From the results it was found that the concentration of the heavy metals under study was not detected by ICP. This indicates that the water of the reservoir is free from hazardous heavy metals under study. Silicon with a concentration of 17.45ppm was found in the water samples hence, the authors conclude that the water is suitable for drinking and irrigation purpose, as it is free from heavy metal contamination.

Water quality index data: Water quality index of the water samples collected from the Andhra reservoir (Fig.6)is calculated using the formula WQI= $\sum Q_i W_i / \sum W_i$. The complete WQI data in all the seasons is presented in Table.2 and Fig.5. The WQI for the water was found to be the least in December 2010 as 23.5; in all the other seasons the WQI value varies in the range 24.9-38.7, hence inferred as good in its quality. The WQI, in all the seasons under study was found to be blow 50, indicating the quality of the water as "Excellent".

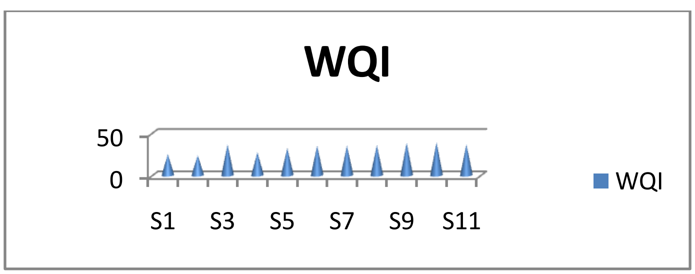

Fig.5 Seasonal variation in WQI

Fig. 6 Andhra reservoir

APPLICATIONS

This study is useful in assessing the quality of the water in the reservoir under study; based on the results obtained and the conclusions the use of the water for drinking as well as for irrigation purpose is ascertained. Various researchers have developed different computer programs to calculate the WQI, whereas the method developed by the authors is found to be simple, accurate and faster in execution.

CONCLUSIONS

From the physico- chemical characteristics, heavy metal analysis, WQI and irrigation water quality data collected on analysis of several samples, the authors conclude that the water is good for irrigation as well as drinking purpose.

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