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Keywords: pH, Turbidity, Chlorides, Hardness, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), BIS, WHO, AMARAVATHI.

A STUDY OF WATER QUALITY IN AMARAVATHI AREA, GUNTUR DIST, ANDHRA PRADESH.

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Abstract Water is the important for everyone for land and regulating the climate. It is one of the most important compounds that profoundly influence life. The quality of water usually described according to its physical and chemical characteristics. The quality of water is studied in the villages of AMARAVATHI, Andhra Pradesh, India. The water samples from ten locations within the area of the Amaravathi region are collected with monthly variations for three month and analysed for their suitability with respect to drinking, irrigation . The results are compared with the respective BIS codes and Indian standards coads analysed using different approaches (a) National Sanitation Foundation Water Quality Index (NSFWQI) (b) Nemerow's pollution index method . However, the overall ground water quality is suitable for irrigation purposes, though a few parameters showed high values at few locations.. Parameters that are tested include temperature ,pH, Hardness ,Acidity, Alkalinity ,turbidity ,chlorides ,DO,BOD and based on the quality treatment plant will also be designed. The water quality is ranked as Excellent Good Poor to Very Poor in the study region based on test results.

INDEX WORDS: pH, Turbidity, Chlorides, Hardness, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), BIS, WHO, AMARAVATHI.

Introduction Water covers 71% of earth surface. In that almost 96.5% is salt water and the remaining 3.5% is fresh water. In that 3.5% also 2.15% is in the form of Glaciers. Only 0.3% is usable by the humans for their survival and for other activities. Water as extra ordinary substance exist in three states as gasses, Liquid proved important for survivability of life [1]. That usable fresh water is existing above and below the Ground, they are surface and sub-surface sources of water. Sub-surface sources are the ground water sources which contain 0.61% of water and the surface sources are rivers, lakes and streams. River water quality is an important for each state holders as it effects human uses as well as plant and human life [2]. Water plays an important role in world's economy. Approximately 70% of the freshwater used by humans goes to agriculture. Fresh water sources are in the form of rivers are very much essential [3]. Fishing in salt water and fresh water bodies is a major source of food for many parts of the world, much of the long distance trade of commodities and manufactured products is transported by boats through seas ,rivers, lakes, and canals .large quantities of water ,ice and stream used for cooling and heating in industry and homes.water is an excellent solvent for wide variety of chemical substances ,as such it is widely used in industrial processes, and in cooking and washing. water is also central to many sports and other forms of entertainments , such as swimming ,pleasure boating ,boat racing,surfing ,sport fishing ,and diving.Water is one of the most important natural resources that is essential for the sustenance of life on our planet earth. To preserve the water resources against pollution the implantation of stringent rules and guide lines are needed to preserve resources for future generations [4]. Apart from human domestic consumption, water is highly used in agriculture, commercial, recreational, navigational, industrial and so on.

It is required to use proper quality of water used for drinking and irrigation purposes. Usage of quality less water for drinking will adversely affect human health. Regular monitoring and effective management strategy to be taken to protect water bodies for further pollution [5].In developing countries like India most of the population use untreated groundwater for various purposes ,as they do not have access to good quality of water. The suitability of water drinking depends on various constituents such as suspended particles and dissolved inorganic ,organic, radiological and biological constituents .the bureau of Indian standards (BIS 2003) and the world health organization (WHO 2006) have prescribed maximum permissible limits for various dissolved ions in water used for human intake.Researchers around the world have studied the quality of water based on these standards .all biological reactions occur in water and it is the integrated system of biological metabolic reactions in an aqueous solution that is essential for the maintenance of life .Most human activities involve the use of water in one way or other .it may

be noted that humans early habitation and civilization sprang up along the banks of rivers. Fresh water is essential for human life and its quality is a matter of global concern [6].

The water pollution control strategies largely depend on the characteristics of water quality. Drinking water sources are under increasing threat for contamination [11]. To obtain precise and appropriate information pertaining to the quality characteristics of water is to assess various quality parameters i.e. physical, chemical and biological through the analysis of the water sample collected from the identified water resource. The assessment of water quality may lead to the development of some useful tools to keep watch on the quality of such priceless water resources and to retain their excellence for various beneficial uses. Hence, water quality assessment is important for strategic management plans.

Water borne pathogens can enter human body through intact or compromised skin, inhalation, ingestion, aspiration, or by direct contact with mucosa of the eye, ear, nose, mouth and genitals, and cause disease. 50% wastes from industries are directly released to rivers and seas [12]. Besides failure of potable water systems, which usually contribute to the greatest number of outbreaks of waterborne diseases common outdoor recreational activities such as swimming, boating, bathing, camping and hiking, all place humans at risk of waterborne diseases from ingestion or direct contact with contaminated water [13]. A risk analysis approach is required for overcoming the problems with water borne diseases and water quality monitoring. While this could be achieved relatively easily with respect to chemical contaminants and standards could be setup.

The problem of the quality of water resources in general, and groundwater resources in particular, is becoming increasingly important in any nation. Although water is the most frequently occurring substance on earth, lack of clean water is more prominent in the developing areas. Groundwater is the main source of water supply throughout the world. Due to increasing demand of world population, and increasing urban needs, ground water is being extracted for irrigation, construction works, and industries, urban and rural households day by day. During dry season the withdrawal of groundwater for irrigation purpose is very difficult. Lowering the water table in the aquifer and also changing the chemical composition of water quality. After the bifurcation of Andhra Pradesh, water demand is increased in the AP Capital Regional Developmental Agency (AP CRDA) area in various forms such as housing, new constructions, population migrations, infrastructural facility creation etc. besides continuing with agricultural practices. The water availability in terms of quantity and quality needs to be studied in this perspective. The water quality, particularly ground water quality, is an important parameter because of severe exploitation of groundwater in the region for the different needs. Several studies are reported for the study of ground water quality for drinking purpose in this region. In the study area groundwater sample and surface water samples were collected in AMARAVATHI region. Ten villages/towns (Yerrabalam, Krishnayapalem, ZPHS Mandadam, Velagapudi, Rayapudi, Thullur, Amaravathi, SRM University, Lingaya palem, Dondapadu.) are identified within the Amaravathi region limits. These samples are assessed on the basis of various qualitative parameters. The considered water quality parameters are pH, Electrical conductivity, Hardness, Chlorides, D.O, BOD, Colour, Taste, Odour, Alkalinity, Turbidity, TDS.

STUDY AREA AMARAVATHI is a town located on the banks of Krishna River, in Guntur district of the Indian state of Andhra Pradesh. It is the headquarters of AMARAVATHI mandal, and forms part of the Andhra Pradesh Capital Region. It is situated at 16.579444°N 80.311111°E. It is spread over an area of 1,524 ha (3,770 acres) it is 18.9 km from Vijayawada and pin code is 522020 and postal head office is AMARAVATHI. Telugu is the local language here. Total population of AMARAVATHI is 13,400 with 3,316 households. The total population constitutes 6,432 males and 6,958 females—a sex ratio of 1,082 females per 1,000 males. 1,321 children are in the age group of 0–6 years, of which 647 are boys and 674 are girls—a ratio of 1,042 per 1,000. The average literacy rate stands at 71.34% with 8,617 literates, higher than the state average of 67.41%. AMARAVATHI'S economy is based on Agriculture.

Figure 1 Map of study area

METHODOLOGY

Raw water sampling(collection) From the study area for analysis of the sampled water to determine physic-chemical parameters such as pH, Electrical conductivity, Hardness, Chlorides, D.O, BOD, Colour, Taste, Odour, Alkalinity, Turbidity, TDS.. The observed results are calculated further for comparison of the results with water quality index and with Nemerow's pollution index method for rating the quality of the water.

Figure 2 map of the location sites

SAMPLE	SAMPLE STATION	LATITUDE	LONDITUDE
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stations			
1	YERRABALAM	16°477160'	80°562526'
2	KRISHANAYAPALEM	16°492250'	80°559687'
3	MANDADAM	16°520820'	80°521301'
4	VELAGAPUDI	16°527110'	80°510661'
5	RAYAPUDI	16°546268'	80°481692'
6	THULLUR	16°529418'	80°466993'
7	AMARAVATHI	16°581778'	80°355939'
8	SRM UNIVERSITY	16°461831'	80°508211'
9	LINGAYA PALEM	16°553559'	80°495817'
10	DONDAPADU	16°272727'	81°022114'

Table1 showing sampling location along with names and latitude and longitude

From table1 the calculation of water quality index was done by **National Sanitation Foundation Water Quality Index (NSFWQI)**.

2.1 National Sanitation Foundation Water Quality Index (NSFWQI)

Water quality index developed by Brown et al. using Delphi method was done by selecting parameters rigorously, developing a common scale and assigning weights to the parameters. National Sanitation Foundation (NSF) supported this index so also called as NSFWQI. It has been mentioned in many papers because it's the most comprehensive work [10][38]. Based on experts opinion rating curves are developed to attribute values for variation in the level of water quality caused by different levels of each of the selected parameters. Computing a water quality index is possible by established rating curves and associated weights, such as Additive index

$$WQI = \sum_{i=1}^n Q_i w_i$$

$$W_i = k/S_i$$

$$K = \sum_{i=1}^n W_i = 1(\text{General})$$

$$Q_i = (V_a - V_i) / (S_i - V_i)$$

Where

$$\sum_{i=1}^n W_i = 1$$

W_i= Weighting factor

Q_i= is the rating value of parameter

I and **n**= Number of sub-indices.

After calculation of water quality index the water catagiry is marked with reference of table2

SI.NO	Water Quality index	Status
1	0-25	Excellent
2	26-50	Good
3	51-75	Fair

4	76100	Poor
5	101-150	Very poor
6	Above 150	Unstable for drinking (U.F.D)

Table 2 Status of Water Quality Based on WQI

Calculation water quality based on Nemerow's Pollution index method

Nemerow's pollution index (NPI) is an easy pollution index that introduced by Neme. Besides models, several water quality indices have been developed and used time to time. Water quality indices are generally used as a tool to convert a large data set into a much reduced and informative form so that underlined facts about the characteristics of the sample may be extracted. Nemerow's pollution index is a water quality index. A very simplified pollution index was introduced by Nemerow, which is generally known as Nemerow's pollution index (NPI). It may be mathematically expressed as

$$NPI = C_i/L_i$$

Where

C_i = observed concentration of i parameter

L_i = permissible limit of i parameter

In above expressions unit of C_i and L_i should be identical. Each value of NPI shows the relative pollution contributed by single parameter. NPI values exceeding 1.0 indicate the presence of impurity in water and hence require some treatment prior to use.

Nemerow's Pollution Index (NPI): (observed value/ standard value)	Status
Less than one	It is not a pollutant
Greater than one	It is a pollutant

Table 3 showing the Water Quality based on NPI

Analysis	Method/ Instrument
pH	Digital pH Meter
Electrical Conductivity	Digital Conductivity Meter
Total Dissolved Solids	Using TDS PEN
Total Hardness	EDTA Titrimetry
Temporary Hardness	EDTA Titrimetry
Permanent Hardness	Indirect method (Total Hardness - Temporary Hardness)

Chlorides	Mohr's – Titrimetry
DO	Winkler method
BOD	Iodometric (Titrimetric)
COD	Titrimetric
Colour	Physical Observation
Taste	Physical Observation
Odour	Physical Observation
Turbidity	Digital Turbidity Meter

Table 3.1 showing Analytical methods adopted for Physico-chemical analysis

PARAMETER STUDIED	REQUIRED SOLUTIONS
Dissolved oxygen, BOD	1. MnSO ₄ 2. Alkaline-iodide-Azide reagent 3. Starch indicator 4. 0.025N Hypo solution (Na ₂ S ₂ O ₃) 5. Conc H ₂ SO ₄
COD	1. 0.025N K ₂ Cr ₂ O ₇ +SULPHURIC 2. ACID(H ₂ SO ₄) 3. H ₂ SO ₄ With AgSO ₄ 4. Ferroin Indicator 5. Mohr's Salt solution
Alkalinity	1. 0.02N Standard Sulphuric Acid 2. Phenolphthalein indicator 3. Methyl Orange indicator 4. CO ₂ Free distilled water 5. Sodium thiosulphate 0.1N
ACIDITY	1. Standard sodium hydroxide 0.02N

	2.Phenolphthalein indicator 3.Methyl Orange indicator 4.Sodium thiosulphate 0.1N 5.Co2 Free distilled water
CHLORIDES	1.Standard NaCl solution 2.Potassium chromate indicator 3.Standard silver nitrate 0.0141N 4.Chlorides free distilled water
HAREDNESS	1.Buffer solution 2.EBT indicator 3.Standard EDTA solution 0.01M 4.Standard Calcium solution 5.Meuroxide Indicator 6.Sodium hydroxide 2N

Table 3.2 showing the chemicals used for the titration process

Results after collection and testing of the water samples and there parameters are shown in the table- 4 was obtained based on the water qulity index calculation following the Indian Standard Drinking water Specifications IS10500:2012 and Bureau of Indian standards recommended input values are taken from the table- 5

S.NO	pH	E.C	TDS ppm	Turbidity Ntu	Colour	Odour	Taste
1	7.8	0.538	269	0.6	Pale green	Earthy	Earthy
2	7.69	0.36	180	0	Nil	No odour	No taste
3	7.74	1.608	804	0	Nil	No odour	No taste
4	7.93	1.46	730	0	Nil	No odour	Salt

5	7.77	0.884	442	1	Nil	No odour	No taste
6	8.02	0.95	475	0	Nil	No odour	No taste
7	8.6	0.384	192	6	Pale green	Fishey	Earthy
8	7.0	0.064	32	1	Nil	No odour	Sour
9	7.40	0.474	237	0	Nil	No odour	No taste
10	7.96	0.44	220	1	Nil	No odour	No taste

Table 4.0 concretion of parameter at the sampling points

S.NO	Acidity Mg/l	Alkalinity Mg/l	DO Mg/l	BOD Mg/l	Chlorides Mg/l	T.H Mg/l	Mg2+ H Mg/l	Ca2+ H Mg/l
1	20	50	1.8	0.7	20.56	260	140	120
2	21	75	2.5	1.4	167.37	1624	542	1082
3	25	75	1.9	0.4	60.99	1544	1079	465
4	29	100	1.6	1.3	41.33	748	528	220
5	20	57.4	2.6	1.5	36.87	356	212	144
6	10	75	1.9	1.6	36.87	352	176	176
7	6	40	1.6	0.8	17.0	180	104	76
8	5	37.5	2.4	1.4	3.4	20	20	0
9	9	37.5	1.7	0.8	17.87	160	100	60
10	5	30	2.8	1.7	21.55	168	64	104

Table 4.1 concretion of parameter at the sampling points

S.NO	PARAMETERS	Maximum values	Minimum values	Units
1	pH	8.8	6.5	-
2	Total alkalinity	600	124	mg/L
3	Total acidity	16	8	mg/L
4	DO	8	4.6	mg/L
5	BOD (3 days @ 27°C)	2.0	0.2	mg/L

6	COD	44.5	11.9	mg/L
7	TDS	2000	500	mg/L
8	TSS	553	1631	mg/L
9	Chloride	1000	250	mg/L
10	Total hardness	600	200	mg/L
11	Turbidity	5	1	NTU

Table-5 standard values with mean values

3.1pH in drinking water it is the indicator which is used to show the condition of the water whether it is soft or hard. By testing it by taking a 5ml of water in a test tube and placing 2 drops of universal indicator it shows the results of the pH with the colour comparison with the table given on the bottle and also we can find by using digital meter. The pH value is fluctuated in between 7.0 to 8.6 which is found satisfactory according to the Indian standards

3.2 Turbidity it is the degree of the clear water and how much the light scatter by the sample. It can create the health issues by creating objectionable taste odour and colour along with interfering during disinfection. The standard value of turbidity according to the Indian standards is 5 NTU, the concentrations of the turbidity is found to be good in all the sample stations except sample station 7.

3.3 Total Dissolved Solids the TDS is measured with the help of the digital meter the total amount of inorganic salts with additional with the small amount organic matter soluble in the water, As this value is high the water becomes objectionable to drink and forms the scaling in the pipes and household appliances the max level considerable is 2000mg/L according to the Indian standards among the 10 samples all are found to be good.

3.4 Biological Oxygen Demand it is measured for determining the organic compounds present in the water. If the sample shows higher level BOD the sample is highly polluted with the presence of oxygen demand the marginal levels of the sample are good and some sample showing high values of BOD

3.5 Hardness in the drinking water the hardness levels are in between 200mg/L -600mg/L according to the Indian standards we found sample station 2,3,4 are showing high values and remaining are in good condition .

Table:6 showing Water Quality Index

SAMPLING STATIONS	WQI	WQI	WQI
1	22.10	16.74	25.79
2	57.36	53.03	76.99
3	60.90	49.68	80.63
4	45.95	38.48	67.87
5	35.38	25.82	53.86
6	33.27	26.62	53.51
7	32.17	27.74	50.88
8	13.72	8.96	29.31
9	18.53	13.00	34.86
10	25.41	16.31	42.21

Fig 3 Graph showing WQI

Table7 showing the NPI results of pH

Item/parameter	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10
Min	7.8	7.21	6.98	7.54	7.2	7.09	7.92	6.99	7.2	7.41
Max	6.87	7.69	7.56	7.93	7.77	8.02	8.6	7	7.4	7.96
Avg	7.335	7.45	7.27	7.735	7.485	7.555	8.26	6.995	7.3	7.685
NPI	0.8837	0.897	0.8759	0.9319	0.9018	0.9102	0.9951	0.8427	0.8795	0.9259

Table 7.1showing the NPI results of Total Dissolved Solids

Item/parameter	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10
Min	265	178	756	659	422	475	167	32	230	210
Max	285	198	804	730	460	520	192	40	273	220
Avg	275	188	780	694.5	441	497.5	179.5	36	251.5	215
NPI	0.2998 91	0.2050 16	0.8506	0.7573 61	0.4809 16	0.5425 3	0.1957 47	0.0392 58	0.2742 64	0.2344 6

Table7.2 showing the NPI results of Total Hardness

Item/parameter	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10
Min	150	1122	565	385	189	204	96	3	60	114
Max	120	1082	465	220	144	176	76	0	50	104
Avg	135	1102	515	302.5	166.5	190	86	1.5	55	109
NPI	0.4909	4.0072	1.8727	1.1	0.6054	0.6909	0.3127	0.0054	0.2	0.3963

Table 7.3 showing the NPI results of Chlorides

Item/parameter	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10
Min	32.56	178.4	89.25	53.22	42.36	39.56	17	5.6	18.9	21.55
Max	20.56	167.4	60.99	39.83	36.87	36.87	15	3.4	17.87	19.55
Avg	26.56	172.9	75.12	46.525	39.615	38.215	16	4.5	18.385	20.55
NPI	0.16	1.0415	0.4525	0.2802	0.2386	0.2302	0.0963	0.0271	0.1107	0.1237

Table 7.4 showing the NPI results of Dissolved Oxygen

Item/parameter	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10
Min	1.8	2.5	2.1	2.9	2.6	2.1	1.6	2.4	1.7	2.9
Max	1.2	2.5	1.9	1.6	2.6	1.9	1.5	2	1.5	2.8
Avg	1.5	2.5	2	2.25	2.6	2	1.55	2.2	1.6	2.85
NPI	0.2559 73	0.4266 21	0.3412 97	0.3839 59	0.4436 86	0.3412 97	0.2645 05	0.3754 27	0.2730 38	0.4863 48

Table 7.5 showing the NPI results of Biological Oxygen Demand

Item/parameter	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10
Min	0.9	1.6	1	1.5	1.7	1.6	1	1.6	1.1	2
Max	0.6	1.2	0.4	1.3	1.4	0.7	0.5	0.7	0.8	1.6

Avg	0.75	1.4	0.7	1.4	1.55	1.15	0.75	1.15	0.95	1.8
NPI	0.1875	0.35	0.175	0.35	0.3875	0.2875	0.1875	0.2875	0.2375	0.45

Table 7.6 showing the NPI results of Turbidity

Item/parameter	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10
Min	0.7	0	0	0	1	0	16	1	0	1
Max	0.6	0	0	0	0.9	0	12	1	0	1
Avg	0.65	0	0	0	0.95	0	14	1	0	1
NPI	0.0755	0	0	0	0.1104	0	1.6279	0.1162	0	0.1162

Table 7.7 showing the NPI results of Acidity

Item/parameter	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10
Min	23	26	32	29	30	13	9	5	19	10
Max	20	21	25	26	20	9	4	3	9	5
Avg	21.5	23.5	28.5	27.5	25	11	6.5	4	14	7.5
NPI	1.9545 45	2.1363 64	2.5909 09	2.5	2.2727 27	1	0.5909 09	0.3636 36	1.2727 27	0.6818 18

Table 7.8 showing the NPI results of Alkalinity

Item/parameter	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10
Min	61	90.2	87.3	111	68.2	79	50	39.5	37.5	45
Max	50	75	75	100	57.4	75	40	37.5	29.5	30
Avg	55.5	82.6	81.15	105.5	62.8	77	45	38.5	33.5	37.5
NPI	0.3801 37	0.5657 53	0.5558 22	0.7226 03	0.4301 37	0.5273 97	0.3082 19	0.2636 99	0.2294 52	0.2568 49

Fig 4 Graph Showing results of NPI

Table 8 showing WQI RESULTS

S.NO	SAMPLE STATION	WATER QUALITY INDEX
1	YERRABALAM	Excellent
2	KRISHANAYAPALEM	FAIR
3	MANDADAM	FAIR
4	VELAGAPUDI	GOOD
5	RAYAPUDI	GOOD
6	THULLUR	GOOD
7	AMARAVATHI	GOOD
8	SRM UNIVERSITY	Excellent
9	LINGAYA PALEM	Excellent
10	DONDAPADU	GOOD

Table9 Showing NPI Results

S.NO	SAMPLE STATION	Nemerow'S Pollution Index (NPI)
1	YERRABALAM	Excellent
2	KRISHANAYAPALEM	Total hardness and chlorides levels are high
3	MANDADAM	Total hardness levels are high
4	VELAGAPUDI	Total hardness levels are high

5	RAYAPUDI	Excellent
6	THULLUR	Excellent
7	AMARAVATHI	Excellent
8	SRM UNIVERSITY	Excellent
9	LINGAYA PALEM	Excellent
10	DONDAPADU	Excellent

CONCLUSION

As per the Nemerow's Pollution Index (NPI) It conclude that the SS2,SS3,SS4 are showing high values of calcium and magnesium hardness. As well as SS2 is also having moderate raise in chlorides concentration. As per the water quality index method (WQI) The SS1,SS8,SS9 are perfect which does not required any further treatment. And the SS4,SS5,SS6,SS10 are proved in the good region slightly treatment is required such as boiling of water is enough to remove the impurities in the water. The remaining sample stations 2 and SS3 are in fair condition this shows the water may need some treatment to remove the impurities such as the hardness in the water.

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