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**APPLICATION OF NEMEROW'S POLLUTION INDEX (NPI) FOR WATER QUALITY**  
**ASSESSMENT OF AMARAVATHI CITY, THE NEW CAPITAL OF ANDHRA**  
**PRADESH, INDIA**

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**ABSTRACT**

Pollution index is a powerful tool for assess the water quality. To remit the problem of lacking of good quality of water in Coastal Andhra Pradesh, India, it is the comprehensive pollution index method, is one of the earliest methods for water should be assessed objectively and reasonably, we collect the water samples from various locations of Amaravathi City in 2017, NPI was calculated for the water samples. The experimental analysis was done for various Physico -chemical parameters such as pH, Electrical Conductivity, Turbidity, Alkalinity, Fe, TH, Cl, Mg, F, Ca, TDS, NO<sub>2</sub>, NO<sub>3</sub> and SO<sub>4</sub>.The results are compared with standards of BIS: 10500:2012. The results show that the improved Nemerow's index method can be more comprehensive and more objective to reflect the status of water, the present study attempts to show the NPI values of all sampling stations showed high NPI value and water samples from to bring an acute awareness among the people about the quality of ground water by taking specific locations for analysis.

**Keywords:** Ground Water, Surface Water, Water Quality, Nemerow's Pollution Index, Physico-Chemical Parameters.

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**I. INTRODUCTION**

Water is one of the basic needs to survival on the earth. The sources of water are surface and ground water. The surface water source is precipitation and melting of glaciers. The formation of water is hydrological cycle process. The water is important for any type of industries. The 50% wastes from industries are directly released to rivers and seas. So, by that the water quality also changes. Hence it is needed to analyze the water quality. Here we used a predefined tool to find the Water Quality status by NPI, is one of the most effective and simplified tool to communicate information on overall quality status of water to the concerned user community and policy makers. Water quality has become an important water resources issue due to rapid increase of population, rapid industrialization, unplanned urbanization, flow of pollution from upland to lowland, and too much use of fertilizers, pesticides in agriculture. In general weathering, dissolution and base-exchange processes control the levels of cationic concentrations in groundwater, and it is the prime resource of raw water under such conditions. One of the most significant environmental problems in coastal Andhra Pradesh is the increase in salinity of the groundwater. The source of salinity and the mechanism of groundwater salinization in the coastal Andhra Pradesh are not known. Nemerow's Pollution index is a powerful tool for processing analyzing, and conveying raw environmental information to decision makers, managers, technicians and the public, the aim of this work is to calculate NPI value for water in study region. Considering this effect, assessment method of Nemerow's pollution index, which combines average value of pollutants with that of maximum value, was used to evaluate the water quality. In order to provide scientific basis for water environment management and river basin water resources development, single-factor evaluation method and integrated Nemerow's pollution index analysis were used to assess the water quality status.

## II. MATERIALS AND METHODS

### Study Area

AMARAVATHI is the capital city of newly formed Indian State of Andhra Pradesh. The planned city is located on the southern banks of Krishna River in Guntur district. As the city is being built in Guntur district, on the bank of the Krishna River it is just 12 and 24 kilometres from Vijayawada and Guntur cities respectively. The city is located at 16.541°N 80.515°E on the south bank of Krishna river. The capital city is spread over an area of 217.23 KM<sup>2</sup> and will comprise into three mandals Mangalagiri, Thullur and Tadepalli by forming 25 villages. As per 2011 census population of the city was 1, 03,000 and the corresponding population of the metropolitan area were 5.8 million as shown in Fig.1.

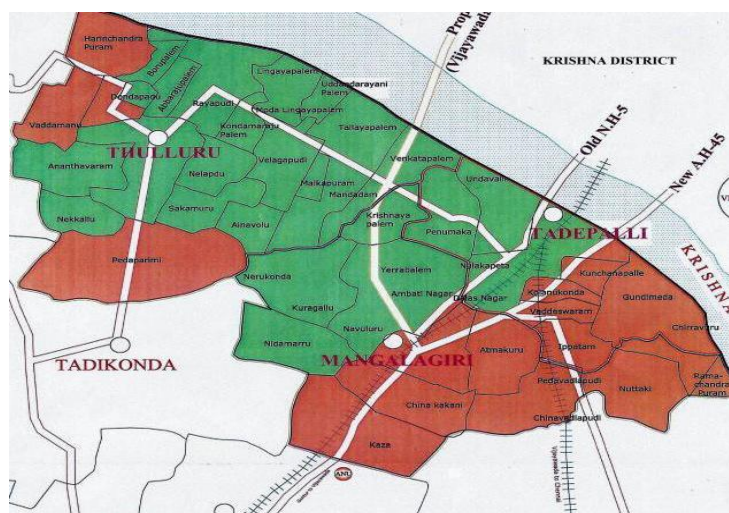


Figure.1. Map of Amaravathi Capital City

### Sample Collection

Surface Water Samples (from Krishna River) and Ground water samples (from Bore wells) were collected in the month of February 2017. A field investigation was done to overview the quality of water in various locations. Before collection of water, the bottles were rinsed with the corresponding water that is being taken into the container, filled completely and closed well. The capacity of each bottle was 5L. A total of 25 numbers of samples were collected from different locations. Ten samples are collected from River. After the completion of sampling, the containers were stored in a cool and dark place. The Groundwater samples were collected from 10 villages which come under capital region.

### Analysis of Samples

The samples are analyzed using standard procedures in the laboratory according to APHA, 1985. To estimate the quality of water we have to analyze various physical and chemical parameters in each collected sample. The parameters analyzed in the laboratory according to lab procedures, and those are Electrical Conductivity, Turbidity, pH, Total Dissolved Solids, Total Hardness, Alkalinity, Calcium Hardness, Magnesium, Iron, Fluorides, Chlorides, Nitrites, Nitrates and Sulphates. The obtained values of various physico-chemical parameters of surface water samples and ground water samples indicated in Table.1 and Table.2 respectively.

Table.1. Analysis Results of Surface Water Samples

Parameter	Sampl e 1	Sampl e 2	Sampl e 3	Sampl e 4	Sampl e 5	Sampl e 6	Sampl e 7	Sampl e 8	Sampl e 9	Sampl e 10
E C	780	812	760	680	764	796	786	720	722	772
Turbidity	4	2	3.2	2.8	4.2	3	2.6	3	3.5	4.1
pH	7.3	7.4	7.3	7.2	7.4	7.35	7.35	7.25	7.3	7035
TDS	507	528	494	442	497	517.5	538	468	469.5	502
TH	176	180	172	164	176	178	176	168	170	176
Alkalinity	96	100	92	80	92	98	96	86	86	94
Calcium	68	68	68	64	68	68	68	66	66	68
Magnesium	26	27	25	24	26	26.5	26	24.5	25	26
Iron	0.06	0.08	0.06	0.08	0.32	0.07	0.07	0.07	0.2	0.19
Fluorides	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Chlorides	112	120	108	84	108	116	114	96	96	110
Nitrites	0	0	0	0	0	0	0	0	0	0
Nitrates	14.6	15.2	15	10.5	13.4	14.9	15.1	12.8	12	14
Sulphates	32	34	31	30	32	33	32.5	30.5	31	32

Table.2. Analysis Results of Ground Water Samples

Parameter	Sampl e 1	Sampl e 2	Sampl e 3	Sampl e 4	Sampl e 5	Sampl e 6	Sampl e 7	Sampl e 8	Sampl e 9	Sampl e 10
E C	3420	1940	2380	2320	2440	1980	3460	4680	2240	1774
Turbidity	2	2	6.8	3.2	12	1.2	12	12	0	10
pH	8.2	7.8	7.9	7.9	7.9	7.7	8.1	8.4	7.9	7.7
TDS	2223	1261	1547	1508	1586	1287	2249	3042	1456	1153
TH	720	448	524	512	536	440	732	880	472	400
Alkalinity	520	276	344	336	352	292	532	760	340	264
Calcium	248	152	184	184	188	148	236	280	176	140
Magnesium	115	72	83	80	85	71	121	146	72	63
Iron	0.22	0.18	0.41	0.2	1.2	1.1	1.2	0.28	0.1	0.14
Fluorides	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.8
Chlorides	540	280	364	352	368	288	568	840	340	240
Nitrites	0	0	0	0	0	0	0.02	0.02	0	0
Nitrates	32.8	10.4	12.5	8.4	16.8	11.4	25.8	62	12.8	11.4
Sulphates	140	84	106	104	108	92	130	204	102	86

**Nemerow's Pollution Index -NPI**

The Nemerow index evaluation method used to analysis the quality of water. The pollution causing parameters are evaluated through Nemerow's pollution index using the obtained values of various physico-chemical parameters indicated in Table.1 and Table.2. NPI is evaluated for all the parameters for each sample analysed, thus identifying the pollution causing parameters.

The equation used in evaluating the NPI is reproduced below:

$$NPI = C_i / L_i$$

Where  $C_i$  = observed concentration of  $i$  parameter

$L_i$  =permissible limit of  $i$  parameter.

In above expressions unit of Ci and Li should be identical. Each value of NPI shows the relative pollution contributed by single parameter. It has no units. Li values for different water quality parameters are indicated in Table 3. NPI value exceeding 1.0 indicate the presence of impurity in water and hence require some treatment prior to use.

Table 3: Permissible Values of water quality parameters

S.No	Parameter	Permissible Value as per IS10500:2012 (Li)	S.No	Parameter	Permissible Value as per IS10500:2012 (Li)
1	EC	300	8	Magnesium	100
2	Turbidity	5	9	Iron	0.3
3	pH	8.5	10	Fluorides	1.5
4	TDS	2000	11	Chlorides	250
5	TH	600	12	Nitrites	0.05
6	Alkalinity	600	13	Nitrates	45
7	Calcium	75	14	Sulphates	400

\*All the values are in mg/lit except EC in mho/lit, Turbidity in NTU

### III. RESULTS AND DISCUSSION

As per Nemerow's Pollution Index (NPI), the pollution parameters of surface water at each station is calculated and presented in Table.4.

Table.4. NPI Values of Surface Water Samples

Parameter	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10
EC	2.6	2.71	2.53	2.27	2.55	2.65	2.62	2.4	2.41	2.57
Turbidity	0.8	0.4	0.64	0.56	0.84	0.6	0.52	0.6	0.7	0.82
pH	0.86	0.87	0.86	0.85	0.87	0.86	0.86	0.85	0.86	0.86
TDS	0.25	0.26	0.25	0.22	0.25	0.26	0.27	0.23	0.23	0.25
TH	0.29	0.3	0.29	0.27	0.29	0.3	0.29	0.28	0.28	0.29
Alkalinity	0.16	0.17	0.15	0.13	0.15	0.16	0.16	0.14	0.14	0.16
Calcium	0.91	0.91	0.91	0.85	0.91	0.91	0.91	0.88	0.88	0.91
Magnesium	0.2	0.27	0.25	0.24	0.26	0.27	0.26	0.25	0.25	0.26
Iron	0.2	0.27	0.2	0.27	1.07	0.23	0.23	0.23	0.67	0.63
Fluorides	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
Chlorides	0.45	0.48	0.43	0.34	0.43	0.46	0.46	0.38	0.38	0.44
Nitrites	0	0	0	0	0	0	0	0	0	0
Nitrates	0.32	0.34	0.33	0.23	0.3	0.33	0.34	0.28	0.27	0.31
Sulphates	0.08	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08

Surface water is one of the earth's widely distributed, renewable and most important resources. It is generally considered as Krishna River water is least polluted compared to other inland water resources, it is proved from this study. The NPI values indicate that surface water is suitable for drinking purpose. From the results of NPI, The parameters except Electrical Conductivity and Iron all the remained parameters are within the limits. Treatment should be carried with respect to Electrical Conductivity, which varies from 2.27 to 2.71 and Iron has high value in sample 5 which is 1.07. The remaining parameters like, Turbidity, pH, Total Dissolved Solids, Total Hardness, Alkalinity, Calcium Hardness, Magnesium, Fluorides, Chlorides, Nitrites, Nitrates and Sulphates are not needed to

treat. Very high NPI Value in dictated that unsuitable for drinking purpose, the graphical representation has been showing sampling stations variation in Figure 2 and Figure.3.

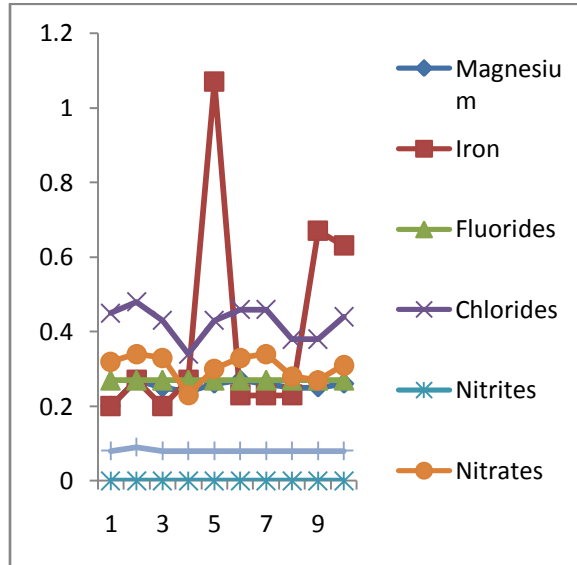


Figure.2. NPI Results of Surface Water Samples

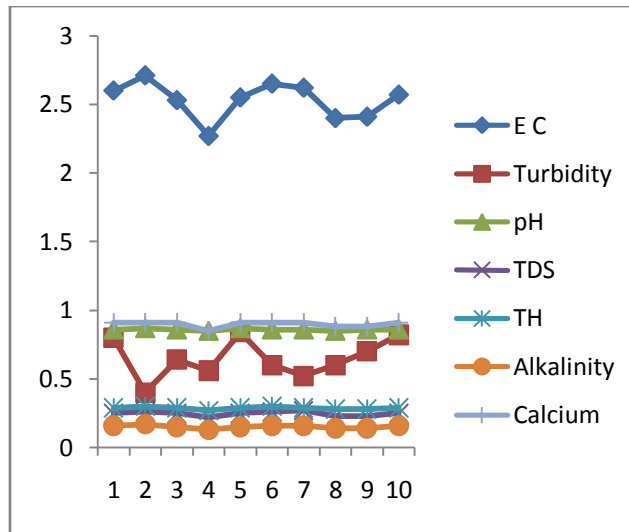


Figure.3. NPI Results of Surface Water Samples

As per Nemerow’s Pollution Index (NPI), the pollution parameters of Ground water at each station is calculated and presented in Table.5.

Table.5. NPI Values of Ground Water Samples

Parameter	Sampl e 1	Sampl e 2	Sampl e 3	Sampl e 4	Sampl e 5	Sampl e 6	Sampl e 7	Sampl e 8	Sampl e 9	Sampl e 10
E C	11.4	6.47	7.93	7.73	8.13	6.6	11.53	15.6	7.47	5.91
Turbidity	0.4	0.4	1.36	0.64	2.4	0.24	2.4	2.4	0	2
pH	0.96	0.92	0.93	0.93	0.93	0.91	0.95	0.99	0.93	0.91
TDS	1.11	0.63	0.77	0.75	0.79	0.64	1.12	1.52	0.73	0.58
TH	1.2	0.75	0.87	0.85	0.89	0.73	1.22	1.47	0.79	0.67
Alkalinity	0.87	0.46	0.57	0.56	0.59	0.49	0.89	1.27	0.57	0.44
Calcium	3.31	2.03	2.45	2.45	2.51	1.97	3.15	3.73	2.35	1.87
Magnesium	1.15	0.72	0.83	0.8	0.85	0.71	1.21	1.46	0.72	0.63
Iron	0.73	0.6	1.37	0.67	4	3.67	4	0.93	0.33	0.47
Fluorides	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.53
Chlorides	2.16	1.12	1.46	1.41	1.47	1.15	2.27	3.36	1.36	0.96
Nitrites	0	0	0	0	0	0	0.4	0.4	0	0
Nitrates	0.73	0.23	0.28	0.19	0.37	0.25	0.57	1.38	0.28	0.25
Sulphates	0.35	0.21	0.27	0.26	0.27	0.23	0.33	0.51	0.26	0.22

Ground water is one of the earth's widely distributed, renewable and most important resources. It is generally considered least polluted compared to other inland water resources, but studies indicate that ground water is not suitable for drinking purpose without proper treatment. From the results of NPI, The pH, Fluorides, Nitrites and Sulphates are within the limits. There is no need to treat the water with respect to these parameters. The remaining parameters like, Electrical Conductivity, Turbidity, TDS, TH, Calcium, Magnesium, Iron, Chlorides and Nitrates are overcome the NPI standard values in some samples. In these locations water should be treated with respect to these parameters only.

The NPI values of Electrical Conductivity is as high as standards and is varies from 6.47 to 15.6 where as the turbidity varies from 0 to 2.4. 0.63 to 1.52 is noted for TDS, 0.73 to 1.47 is noted as TH, and the alkalinity is varied from 0.44 to 1.27. The NPI of calcium is high in all the collected ground water samples it is noted as 1.87 to 3.73 where as magnesium is varied from 0.63 to 1.46. Except in sample 10, all samples contain high NPI value which is in the range of 1.12 to 3.36 and the NPI value of nitrates is noted as 1.38 in sample 8 which has a minimum value of 0.19. Very high NPI Value in dictated that unsuitable for drinking purpose, the graphical representation has been showing sampling stations variation in Figure 4 and Figure.5.

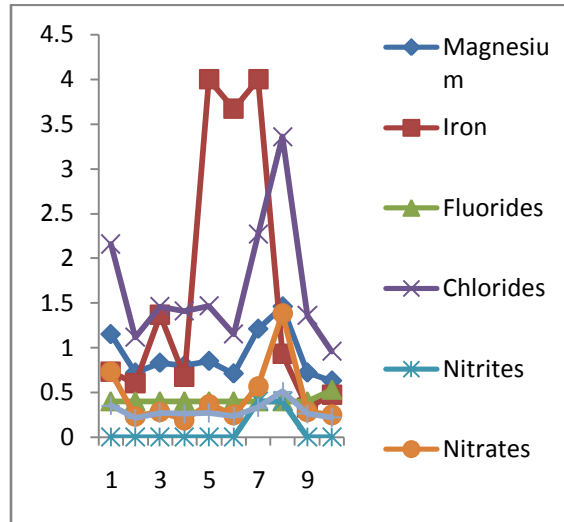


Figure.4. NPI results of Ground Water Samples

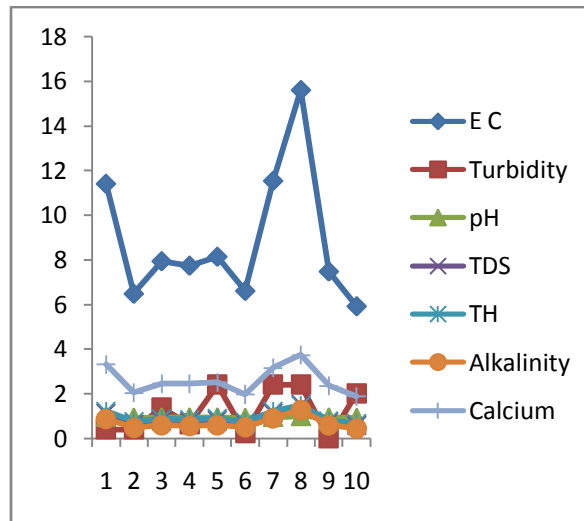


Figure.5. NPI results of Ground Water Samples

The overall comparison of NPI values of all the samples of Surface Water and Ground Water are shown in Table.6.

Table.6. NPI Results-List of Polluted Parameters

Surface Water		Ground Water	
Sample No.	Parameter Polluted	Sample No.	Parameter Polluted
Sample 1	EC	Sample 1	EC, TDS, TH, Calcium, Magnesium, Chloride
Sample 2	EC	Sample 2	EC, Calcium, Chloride
Sample 3	EC	Sample 3	EC, Turbidity, Calcium, Iron, Chloride
Sample 4	EC	Sample 4	EC, Calcium, Chloride
Sample 5	EC, Iron	Sample 5	EC, Calcium, Turbidity, Chloride, Iron
Sample 6	EC	Sample 6	EC, Calcium, Chloride, Iron
Sample 7	EC	Sample 7	EC, TDS, TH, Calcium, Magnesium, Chloride, Iron,



			Turbidity
Sample 8	EC	Sample 8	EC, TDS, TH, Calcium, Magnesium, Chloride, Turbidity, Alkalinity, Nitrates
Sample 9	EC	Sample 9	EC, Calcium, Chloride
Sample 10		Sample 10	EC, Calcium, Turbidity

#### IV. CONCLUSION

The weight and improved Nemerow's index method to evaluate the water quality based on the data of the Amaravathi. The results show that the method is correct and reasonable. In water quality assessment some pollutants' concentration exceeded standard and induce harm to environment, considering this effect assessment method of Nemerow's pollution index. The people directly depend on the groundwater for drinking and domestic purpose from hand pumps and open wells without any treatment, the proper treatment is required for consumption of groundwater for drinking and domestic purpose in the study area, otherwise the people facing more health problems, the people already facing some of the health problems not only in elders but also youngers and children. In the study area the surface water samples are not polluted than that of Ground water. Due to the importance of water quality issues, better management of water systems is required for regional supply of water for irrigation, industrial and domestic uses and water samples from to bring an acute awareness among the people about the quality of ground water by taking specific locations for analysis.

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