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# Ground Water Quality Analysis using Spatial Distribution Technique in Geographical Information System – A Case Study of Kakinada, East Godavari district, Andhra Pradesh, India

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#### Abstract

This paper is about the study of the Ground water quality analysis using Geographical Information System (GIS) techniques of Kakinada mandal of East Godavari District, Andhra Pradesh, India on 1: 50,000 scale. The Godavari district is also known as the rice bowl of Andhra Pradesh. Godavari River is the second longest river in the country with a length of 1,465 km spreads over an area of about 5,100 sq km on the east coast of India bordering the Bay of Bengal and is a densely populated basin. The study area bounded on its North by Kottapalli; Pithapuram; in the West by Samalkota, Pedapudi, Karapa; in the South by Tallarevu and in the East by Bay of Bengal. The area is flourished with lands of fertile soils, good rain fall and balanced climatic conditions and possesses all the natures hand works of perennial rivers, forests. The sea coast covers 144.4 sq km with made up of Gondawana sandstones. The average annual rain fall is between 110 and 115 centimeters. 20 ground water samples collected at different parts of the study area for Physio-chemical analysis. Using the Inverse Distance Weighted (IDW) interpolation method in ArcGIS software, spatial distribution maps of 12 major water quality parameters are prepared. Water Quality Index (WQI) has been calculated to find the suitability of water for potable purposes. Ground water samples analyzed show quality parameters are pH, Electrical Conductivity, TDS, Fluorides, Chlorides, Calcium, Magnesium, Iron, Turbidity, Magnesium, Alkalinity, Hardness and water zoning using spatial data.

Keywords: ArcGIS software, Water quality index

#### Introduction

For the Ground water study of an area, the knowledge of the nature of lithological units, geomorphic set up, their structural disposition, surface water conditions and climate occurring in the area are required<sup>1</sup>. There are many organic constituents and dissolved minerals present in ground water in various concentrations. Among them dissolved mineral substances are Sodium, Magnesium, Potassium, Chloride, Bicarbonate, and Sulphates. These substances are called common constituents<sup>2,3</sup>. The imbalance between sea water and the groundwater in the coastal zones has been leading to sea water intrusion into fresh water aquifers causing irreparable damage and environmental degradation. Andhra Pradesh is fifth largest state in the country which is a riverine state with 40 major, medium and minor rivers. Of these, three are major interstate rivers viz. Godavari, Penna, Krishna which flow through the heart of the state. All the rivers are seasonal with bulk of flow taking place during monsoon. Many researchers studied on ground water quality in various areas using GIS tools such as Subbarao etal.<sup>1</sup>, Singh<sup>4</sup>, and Burrough<sup>5</sup> explained the impact of emerging technologies on hydrologic and water modeling.

Study area: The study area, Kakinada is the headquarters of East Godavari, bounded on North by Kottapalli, Pithapuram, in

the West by Samalkota, Pedapudi, Karapa, in the South by Tallarevu and in the East by Bay of Bengal. The district flourishes with lands of fertile soils, good rain fall and balanced climatic conditions and possesses all the natures hand works of perennial rivers, forests and also sea coast. East Godavari district with lush paddy fields and coconut groves is also known as Rice Bowl of Andhra Pradesh. The average annual rainfall is 1,157.6 mm. Industrial pollution in the eastern region of the study area, Intensive agriculture in the Northern part and Aquaculture in the south of the study area are the major sources affecting the quantity and quality of the ground water. Physiographically the area is plain and made up of the sandstones of Gondawanas (NAC). The study area is mainly covered by agriculture land, grasslands and plantation. Climate is hot and humid for most of the year. The hottest part of the year late May to early June with maximum temp 38°- 48°C. Land use /land cover extremely valuable especially for water quantity, quality and assessing the hydrological effects of land uses. Kakinada has fertile soil, good rainfall, all the natures and perennial rivers. Cyclones in the Bay of Bengal frequently hit the town.

The East Godavari region is classified into three natural divisions - the Plains, the Delta and the Upland or Agency or hill tracts. Konaseema and portions of Kakinada,

Ramachandrapuram and Rajahmundry presents a vast expanse of rice-fields surrounded by innumerable coconut gardens and plantain and betel plantations constitute Delta region. The erstwhile Taluks of Peddapuram, Pithapuram, Tuni, and Portions of Kakinada, Ramachandrapuram and Rajahmundry constitute the Plain areas. The Eastern Ghats mountain range rise by gradations from the level of the coast and spread throughout the erstwhile agency Taluks of Rampachodavaram and Yellavaram.

## Methodology

From the study area, 20 samples were collected for the analysis and application of the methodology for the assessment of Water Quality Index (WQI)<sup>6</sup>. The sample collection points are located using GPS and converted into vector form on 1:50,000 scale. The sample locations are as shown the Figure-2;



Figure-1 Location map of the study area



Location map of the study area

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The analyzed data is added as points into feature class using Inverse Distance Weighted (IDW) Interpolation Method<sup>9</sup>. Actually the method assumes the known value of a point. The general equation for the inverse distance Weighted method is

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$$Z_o = \begin{cases} \sum_{i=1}^{s} \frac{Z_i}{d_i^k} \\ \frac{\sum_{i=1}^{s} \frac{1}{d_i^k}}{\sum_{i=1}^{s} \frac{1}{d_i^k}} \end{cases}$$

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Where:  $Z_o$  is the estimated value at a point 0,  $Z_i$  is the distance between control point I, is the distance between control point and point o, is the number of control points used in estimation, k is the specified power. The methodology implemented in the study is as illustrated in the flowchart presented below;

 Table-1

 Spatial location and Laboratory results of the water samples

Location	LONGTTUD E (°E)	LATITUDE (°N)	Hq	EC	SQL	Turbidity	Alkalinity	Hardness	Fluorides	Chlorides	Calcium	Sulphate	Fe	Mg	IQW	Remarks
GSPC2	82.27017	17.00902	6.91	78	51	0.5	25	30	0.1	12	8	10	0.1	2	54.8646	Poor
APSP	82.25194	17.00846	6.54	550	357	0.5	50	55	0.1	70	18	15	0.1	2	44.3954	Good
Valasapakala	82.25949	16.99777	6.55	260	169	0.5	60	20	0.1	30	4	12	0.2	2	23.2996	Excellent
Gadimoga	82.24740	16.93770	7.1	230	150	0.6	75	45	0.2	30	12	17	0.2	4	19.6096	Excellent
GSPC	82.26961	17.01099	6.94	190	123	0.3	50	50	0.1	20	10	22	0.1	6	39.1082	Good
Pallamrajunagar	82.25259	16.98017	6.9	680	442	0.6	205	225	0.1	50	76	43	0.2	8	32.5051	Good
Vakalapudi	82.26119	17.00361	6.5	100	65	0.2	25	35	0.1	20	8	4	0.1	9	19.6000	Excellent
Fort2	82.27808	16.98657	6.8	280	182	0.5	75	85	0.1	30	18	36	0.2	10	63.9952	Poor
Fort4	82.27171	16.98633	6.67	320	208	0.6	100	100	0.1	25	22	32	0.2	11	55.6228	Poor
Fort	82.27558	16.97766	7.46	580	377	0.3	105	105	0.1	33	24	37	0.2	11	63.7676	Poor
Srinagar	82.23870	16.96868	7.3	280	182	0.2	90	120	0.1	40	28	14	0.1	12	33.0237	Good
Fort3	82.27612	16.98847	7.06	380	247	0.6	90	120	0.1	35	28	55	0.2	12	55.4228	Poor
Bharat Petroleum	82.23144	16.95433	6.52	1200	780	0.2	65	140	0.1	300	32	25	0.2	14	54.3905	Poor
Nagamallithota Junction	82.24128	16.98544	6.8	3000	1950	0.8	370	495	0.2	560	96	220	0.3	61	20.3489	Excellent
Vidhyutnagar	82.23530	16.98697	7.6	1400	910	0.6	400	520	0.2	160	92	224	0.3	69	ERR	Ufd
Chitrada	82.24611	17.08137	7.03	2100	1365	0.6	370	575	0.2	345	98	152	0.3	79	21.0517	Excellent
Subhanikethan	82.23082	16.99841	6.4	4300	2795	1	260	1075	0.2	950	230	174	0.3	120	21.0584	Excellent
Ramanayyapeta	82.24629	16.98967	6.38	3700	2405	0.8	250	1230	0.2	950	244	170	0.3	148	34.3133	Good
Vidhaynagar	82.24790	16.98764	7.38	3200	2080	0.6	425	940	0.2	750	104	103	0.3	163	35.7662	Good
Shipping Corp	82.23852	16.94557	6.83	5600	3640	0.6	295	1305	0.2	1360	194	216	0.3	196	34.2000	Good



Figure-3 Flowchart of the Methodology

**Estimation of Water Quality Index (WQI):** Water Quality Index (WQI) is a very useful and efficient method for assessing the Quality of water <sup>9</sup>. Water Quality Index (WQI) is very useful tool for communicating information on overall quality of water <sup>10,11</sup>. To determine the Suitability of the groundwater for drinking purposes, WQI is computed adopting the following formula<sup>12</sup>.

$$WQI = Antilog \left[ \Sigma W_{n-1}^n log_{10} q_n \right]$$
(1)

Where: W, Weight age factor computed using the following equation

$$Wn = K / Sn \tag{2}$$

and K, Proportionality constant is derived from,  $K = 1/\sum_{n=1}^{n} (1/S_i)$ (3)

 $S_n$  and  $S_i$  are the WHO / BIS10500 standard values of the water quality parameter <sup>12,13</sup>

Quality rating (q) is calculated using the formula,

$$q_{ni} = \left\{ \left[ \left( V_{actual} - V_{ideal} \right) / \left( V_{standard} - V_{ideal} \right) \right] \times 100 \right\}$$
(4)

where,  $q_{ni}$  = Quality rating of  $i^{th}$  parameter for a total of n water quality parameters.  $V_{actual}$  = Value of the water quality parameter obtained from laboratory analysis  $V_{ideal}$  = Value of that water quality parameter can be obtained from the standard tables.  $V_{ideal}$  for pH = 7 and for other parameters it is equal to

zero.  $V_{standard}$  = WHO / ICMR standard of the water quality parameter.

Based on the above WQI values, the ground water quality is rated as excellent, good, poor, very poor and unfit for human consumption (Table 2).

#### **Results and Discussion**

In this study the spatial distribution of 12 parameters are calculated according as per the ISO 10500-1991 (Table-1). The Electrical conductivity is (Figure-5) high at Subhaniketan, Ramanayyapeta shipping corporation and Vidyutnagar.

The spatial distribution of the Total Dissolved Solids (TDS) shown in Figure-6. According to the findings, Gadimoga, Srinagar, Vakalapudi, Fort, Valasapakala, APSP, GSPC have beyond the 500 mg/l. The high Turbity (Figure-7) of water makes the water less acceptable by the public and also interfere with disinfection mechanism and reduce the disinfection efficiency especially of chlorination.

Alkalinity shows moderate at centre part of the study (Figure-8) high at Chitrada, Vidhutnagar, Nagamallithota. The Hardness parameter (Figure-9) is high at Subhaniketan, Shipyard and few places at Ramanayyapeta remaining areas are maintain uniformly throughout the study.

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The spatial distribution of the chlorides is shown in the Figure-11. As per standard, Total Hardness,  $CaCO_3$  is 300 ppm. Ramanayyapeta, Shipping Corporation and Vidyutnagar, Vidhyanagar, Vidyanagar show very hard water.

Water quality index has been calculated based on 12 important water quality Parameters (pH, TDS, EC, Turbidity, Alkalinity, Chlorides, Fluorides, Hardness, Calcium, Magnesium, Sulphate andIron). Vakalapudi, APSP, GSPC, Atchampeta, Timmapuram fall under Excellent category. Only few areas like Gadimoga, Valasapakala, Pallamrajunagar, Nemam, Indrapalem are having good water quality index and fit for drinking.

Table-2								
Water	quality Index categories							

Water Quality Index	Description
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very poor
>100	Unfit for drinking (UFD)

Table-3 Water Quality parameters and assigned unit weights (BIS 10500/WHO standards)

Parameter	Standard (Sn and Si)	Weightage (Wn)			
pH	8.50	0.024939			
Electrical Conductivity	2000.00	0.000106			
Solids(TDS)	500.00	0.000424			
Turbidity	5.00	0.042396			
Alkalinity	200.00	0.001060			
Hardness	300.00	0.000707			
Fluoride	1.00	0.211978			
Chloride	250.00	0.000848			
Calcium	75.00	0.002826			
Sulphates	200.00	0.001060			
Iron	0.30	0.706592			
Magnesium	30.00	0.007066			



Figure-4 Spatial distribution map of pH

Legend 0 - 6 6.1 - 6.5 6.6 - 7.5 7.6 - 8



Spatial distribution map of Electrical Conductivity

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Spatial distribution map of Total Dissolved Solids (TDS)



Spatial distribution map of Turbidity



Figure-8 Spatial distribution map of Alkalinity



Spatial distribution map of Hardness

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Spatial distribution map of Fluorides



Figure-11 Spatial distribution map of Chlorides



Figure-12 Spatial distribution map of Calcium



Spatial distribution map of Sulphate



Figure-16 WQI range in the study area



Spatial distribution of Water Quality Index (WQI) in the study area

## Conclusion

pH value equal to 7 indicates neutral water, greater than 7 the water is basic, less than 7 is acidic. Figure-4 shows the pH in the study area starts from 6 to 7 and increases from town to coast in permissible limit only. The maximum Total Dissolved Solids (TDS) allowed for drinking water is 500mg/l and beyond this palatability decreases and may cause gastrointestinal irritation. Fluoride content in the mandal was observed to be less than 1.0 mg/l (Figure-10). Sulphur content is under permissible limit. The desirable limit for Iron is 0.3 ppm beyond which water exhibit bad, appearance bad taste and effect water supply structures and promotes iron bacteria (Figure-14). Remaining other areas is categorized as poor to very poor and is unfit for drinking. The spatial distribution of the Water Quality Index is shown in the Figure-16 and Figure17.

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