Available Online at http://www.recentscientific.com

ISSN: 0976-3031

International Journal of Recent Scientific Research
Vol. 6, Issue, 4, pp.3602-3608, April, 2015

International Journal of Recent Scientific Research

RESEARCH ARTICLE

GROUNDWATER QUALITY MAPPING OF EAST GODAVARI DISTRICT, ANDHRA PRADESH, INDIA , USING REMOTE SENSING AND GEOSTATISTICS

Surekha Gangavarapu*[1], Udaya Bhaskar Pinnamaneni[2] and Padma Kumari K[3]

[1]Jawaharlal Nehru Technological University Kakinada. Ap, India
[2]Department of Civil Engineering, Jawaharlal Nehru Technological University Kakinada Ap, India

ARTICLE INFO

Article History:

Received 2nd, March, 2015
Received in revised form 10th, March, 2015
Accepted 4th, April, 2015
Published online 28th, April, 2015

Key words:

Groundwater quality, Contamination, GIS Application, Water Quality Index, Spatial Distribution,

ABSTRACT

This paper examines the hydro chemical facies and quality of Groundwater present at different locations in East Godavari district. Groundwater the only major source for domestic, consumption, industries, agriculture and aquaculture etc. In the coastal areas of southern India, where the majority of the population, which is rural or semi-urban, rely on groundwater sources for their domestic agricultural and aqua cultural activities. All these activities together with the various other natural and anthropogenic influences are responsible for invigorating the aquifers vulnerable to contamination. Quality of drinking water supplies has always been a vital concern. An alarming growth rate in the density of the population, urbanization, industrialization and agricultural activities skyrocket the usage and demand for water to such an extent that even the Groundwater quality is being degraded. According to WHO, about 80% of all the diseases in human beings are water borne. Hence 348 samples from the open wells and dug wells distributed all over the district were collected, analyzed and calculated for the quality index. GIS a powerful computational tool not only facilitates data capture but also facilitates spatial map integrations. In this research ground water quality analysis was carried out for 58 mandals of the District, the analysed results were used to calculate the Water Quality Index (WQI) to find the suitability of water for potability and agriculture, and using ARC GIS 10.2 VERSION water quality mapping was done. Groundwater samples analysed show quality exceedance in terms of Electrical conductivity, Total Hardness, Chlorides, and TDS.

INTRODUCTION

Potable water is the primary need of every human being. Fresh water has become a scarce commodity due to over exploitation and pollution of water. Globally one fifth of the water used is obtained from the ground water resources and in many areas groundwater is the only source available hence protection of the ground water quality has gained priority. Groundwater is immensely important to suffice human needs in both the urban and rural areas of developing nations. Estimates for Asia and America alone suggest that more than 1000 million people directly depend upon these sources. Groundwater is also widely used as a source of primary or supplementary irrigation in agricultural development (Foster,1995). The chemical composition of groundwater is controlled by many factors that include the composition of precipitation, mineralogy of the watershed and aquifers climate and topography. These factors can combine to form diverse water types that change in composition spatially and temporally. Water quality and quantity tends to be one of the most critical environmental issue Worldwide, especially in India, where aquifers are experiencing an increasing threat of pollution from urbanization, industrial development, agricultural activities. Ground waters absorb gases of decomposition and degradable organic matter within the pores of the soil mantle through which they percolate. Among gases of decomposition encountered by groundwater's are hydrogen sulphide and methane. Natural filtration of groundwater's remove organic matter and microbes' life, where as salts remain in solution (Fair *et al*. 1967). Once the groundwater is contaminated, its quality cannot be restored by merely arresting the pollutants from the source. Furthermore the Groundwater contamination tend to remain undetected for several years Riberio and Macedo (1995) applied multivariate statistics, classification and trend analysis techniques to describe and classify the groundwater monitoring network for the confined aquifer of the Tejo and Sado system. The principle source of water for East Godavari district is groundwater. Water is withdrawn from both from open wells as well as tube wells. Because of relatively long residence time of groundwater, the impact of Groundwater contamination is often not recognized until large volumes of water are affected. The most useful indicators of aquifer contamination are Cl- and EC/TDS. TDS is a measure of the amount of material dissolved in water and is measure of the "freshness" of water. Increasing levels of TDS in an aquifer are indication that the aquifer is contaminated. Conductivity is

Corresponding author:* **Surekha Gangavarapu
Jawaharlal Nehru Technological University Kakinada . Ap, India

a measure of capacity of a solution to conduct electric current is also an important criterion in determining the suitability of water for irrigation, to assess water contamination and is also useful in controlling water treatment processes. As most of the salts in water are present in the ionic form and capable of conducting electric current, conductivity is a good and rapid measure of concentration of Chloride, Sodium and TDS. Consumption of water with fluoride concentration above 1.5 mg/l results in acute to chronic dental fluorosis where the tooth become coloured from yellow to brown. Skeletal fluorosis which causes weakness and bending of the bones also results due to long term consumption of water containing high fluoride. Presence of low or high concentration of fluoride in groundwater is because of natural or anthropogenic causes or a combination of both. Natural sources are associated to the geological conditions of an area. Several rocks have fluoride bearing minerals like apatite, fluorite etc. The weathering of these rocks and infiltration of rainfall through it increases fluoride concentration in groundwater.

According to WHO organization, about 80% of all the diseases in human beings that are water borne are various gastrointestinal problems, liver infections, tropical diseases and terminal diseases like cancer. Children are often the worst affected, dying in large numbers because of diarrhoea..

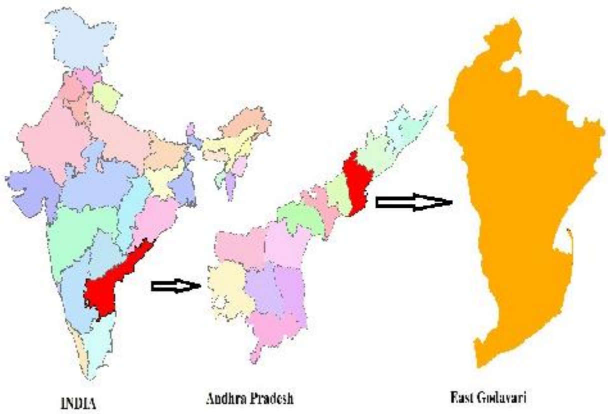
GIS can be used as a powerful tool for developing solutions for water resources problems for assessing water quality, determining water availability, preventing flooding, understanding the natural environment, and managing water resources on a local or regional scale. [1, 2]. The GIS has the power of organizing effective Social Information System (SIS) towards decision-making or resource management. The spatial information system comprises synthesis of spatial formation and non-spatial data within GIS framework. The GIS aims and works at bringing together, the diverse information, which are gathered from various different sources. Hence, this is also known as integrated analysis

Study Area

East Godavari district is situated on the North East of Andhra Pradesh in the Geographical co-ordination of 16° - 30° and 18° - 20° of Northern Latitude and 81° - 30° and 82° - 36° of the Eastern Longitude. The district is bounded on the North by Visakhapatnam District and State of Orissa, on the East by Bay of Bengal and on the South and West by West Godavari and Khammam districts. It is one of the largest Districts of the State of Andhra Pradesh, with Kakinada as its headquarters covers an area of 10,807 sq. Km. and is uniquely distinguished with marine, inland and brackish water pisciculture. It has a coastline of 144 km. The average annual rainfall of the district is 1100 mm. The district is also known as "rice bowl" of Andhra Pradesh as it is one of India's main rice-producing states.

Data Source And Analysis

Data on groundwater quality parameters for both pre monsoon and post monsoon) water samples were obtained from open wells and dug wells of 58 mandals distributed all over the district has been obtained from the Department of Rural Water Supply and Sanitation of East Godavari District. The data comprises water quality of samples collected during the pre-monsoon and post-monsoon months of 2014-15. The analysed results along with the water quality index are represented in the table no.3.



Location Map of the Study Area

Estimation of Water Quality Index (WQI)

Water Quality Index (WQI) is a very useful tool for communicating the information on overall quality of water [7, 8]. It can be defined as a technique of rating that provides the composite influence of individual water quality parameter on the overall quality of water. To determine the suitability of the groundwater for human consumption Quality Index (WQI) can be examined, WQI is computed adopting the following formula [9]

$$WQI = \text{Antilog} [\Sigma Wnn=1\log10qn] \quad (1)$$

Where, W, Weightage factor (W) is computed using the following equation, (Table 1)

$$Wn = K / Sn \quad (2)$$

and K, Proportionality constant is derived from,

$$K = [1 / (\Sigma nn=1\ 1/Si)] \quad (3)$$

Sn and Si are the WHO / BIS10500 standard values of the water quality parameter.[10,11]

Quality rating (q) is calculated using the formula,

$$qni = \{[(Vactual – Videal) / (Vstandard – Videal)] * 100\} \quad (4)$$

where,
qni = Quality rating of ith parameter for a total of n water quality parameters
Vactual = Value of the water quality parameter obtained from laboratory analysis
Videal = Value of that water quality parameter can be obtained from the standard tables.

Videal for pH = 7 and for other parameters it is equal to zero.
Vstandard = 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).

Table 1 Water quality parameters, their BIS 10500/WHO standards, and assigned unit weights

Parameter	Standard (Sn & Si)	Weightage (Wn)
pH	8.5	0.024939
Electrical Conductivity(EC)	2000.00	0.000106
Total.Dissolved Solids(TDS)	500.00	0.000424
Turbidity	5.00	0.042396
Alkalinity	200.00	0.00106
Hardness	300.00	0.000707
Fluoride	1.00	0.211978
Chloride	250.00	0.000848
Calcium	75.00	0.002826
Magnesium	30.00	0.007066
Sulphate	200.00	0.00106
Iron	0.30	0.706592

RESULTS AND DISCUSSION

The Physico-chemical data analysis of the ground water samples collected in both pre monsoon and post monsoon seasons during the months of May-2014-15 and December-2015-16 evaluated for the 58 mandals of the district of East Godavari, Andhra Pradesh, India. are found to be in the range of good ,poor and very poor category. The results of the samples vary with different collecting places because of the different nature of soil contamination [(3)]. Values of WQI of fourteen (14) mandals Amalapuram, Allvaram, Ambajipeta Antharvadi, Ravulapalem, Karapa, Kirlampudi, G.Mamidada Mummdivaram, Rayavaram , Razole , Sampatnagaram, Tallarevu ,Thonddangi ,and U.Kothapalli were found to be very poor making it unfit for human consumption. and agriculture, Gandepalli mandal was categorised as semi critical as the water quality is on the verge of contamination and the remaining 43 forty three samples were of poor quality and very poor quality respectively. These high values of WQI in the 14 areas are an indication of salinity. Salinization is the most widespread form of ground water contamination in coastal aquifers, and is represented by the increase of total dissolved solids (TDS) and some specific chemical constituents such as Cl-, Na+, Mg+2 and SO4-2 (Nadler *et al*., 1981; Magaritz and Luzier, 1985; Dixon and Chiwell, 1992; Morell *et al*., 1996; Sukhija *et al*., 1996; Gime Nez and Morell, 1997). Salinity makes the water unfit for drinking. Salts enter groundwater naturally through dissolution of soil, rock, and organic material. Many of the coastal aquifers in the world already experience salt water intrusion caused by both natural and anthropogenic activities. due to which most of the fertile land has become wasteland and cultivation rate has also decreased. and also due to the vast growth in demand for seafood, and it being a more profitable source of income, has lead many farmers to take up aquaculture . The saline nature of the water used for aquaculture gradually infiltrates and reaches the ground water table, thus triggering the bionetwork naturally ,encompassed by anthropogenic influences that lower groundwater levels thereby reducing fresh groundwater flow to coastal waters. The analysis of the results drawn at various stages of the work revealed that integration of Remote Sensing and GIS are effective tools for the preparation of various digital thematic layers and maps showing spatial distribution of various water quality parameters. The final output has been represented in the form of maps, the legends are prepared on the basis of the minimum and maximum values of the parameters categorising the ground water quality into two types suitable or unsuitable for drinking purposes and saline in the study area.

As the study area is a developing area in all the fields of agriculture, aquaculture, pisciculture and industries and also due to the poor ground water management practices the water quality in the area is more or less poor. The analysis reveals that the ground water of the area needs treatment before consumption. The outcome of this research work can be effectively utilized by the Rural Water Supply and Sanitation Engineering Department, for better management of groundwater resources as well as supplying good quality water to the affected areas.

All metabolic and physiological activities and life processes of the living are generally influenced by the temperature in the water bodies. Temperatures of these samples were in the range of 25.8^{o}C to 28.7^{o}C.

pH is a measure of hydrogen ion concentration. The pH value of water is an expression of how acidic or basic the water is on the scale of 0 to 14. pH values (>7) are indicative of alkaline nature of water. For pH values, general acceptable limit is 6.5 to 8.5. pH lower than 4 will produce sour taste and higher value above 8.5 bitter taste. Higher pH hastens the scale formation in water heating apparatus. pH below 6.5 starts corrosion in pipes, thereby releasing materials such as Zn, Cu, etc. pH values of water samples were found in the Range of 2.15 Minimum 7.12 Maximum 9.287. having a mean value of 8.427 and Standard Deviation of 0.451. 33 percent of the samples distributed in twenty mandals were found to be beyond permissible limits and three mandals were slightly beyond the desirable limit of pH suggested by BIS and WHO. The spatial distribution of pH is shown in the Figure 2.

Total Dissolved Solids (TDS) The Total dissolved solids describes the general quality of water. As water is excellent solvent, it picks up many impurities. Total dissolved solids (TDS) in water originates from various factors like minerals, sewage, natural sources, agricultural runoff, etc. Many dissolved substances are undesirable in water .The TDS value of the groundwater samples. varied from Minimum 203 to Maximum 6664 mg/l. For TDS, BIS suggests 500 mg/l as the desirable limit while 2000 mg/l as the maximum permissible limit in the absence of alternate source. If drinking water contains high TDS, palatability decreases and may cause gastro intentional irritation. The presence of high levels of TDS may also be objectionable to consumers, owing to too much scaling in water pipes, boilers and domestic appliances. Here, 35 mandals samples showcased TDS values exceeding the desirable limit of 500 mg/l . Allvaram (3289.6), Ambajipeta (2084.27) Antharvadi (6664.66) ,and Tuni (2480) 2617.6 Ravulapalem i.e. five samples TDS values exceeded the permissible limit of 2000 mg/l. and remaining mandals range were within the permissible limits, acquiescent for drinking and irrigation. The spatial distribution of the TDS is shown in the in the Figure 3.

Hardness of water is caused is mainly due to calcium and magnesium ions. The higher values of calcium and magnesium were significantly interrelated and indicate the hardness of the water in nature. Calcium is a major constituent of different types of rocks. Similarly, magnesium salts are also important contributors in the hardness of water. Absolute soft water is tasteless. With the raise in hardness of water, its aptness decreases for cooking, cleaning and laundry jobs and if the concentration of magnesium is more than 300 mg/l, it is toxic [4]. Ca2+ and Mg2+ may combine with SO4 2- causing stable hardness which cannot be removed by boiling.

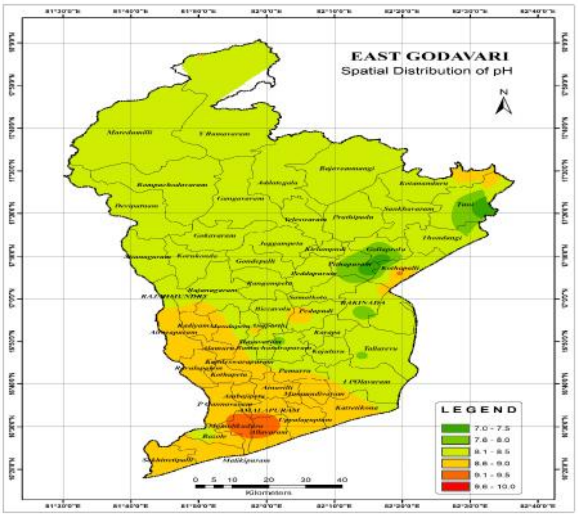


Fig 2 Spatial distribution of pH

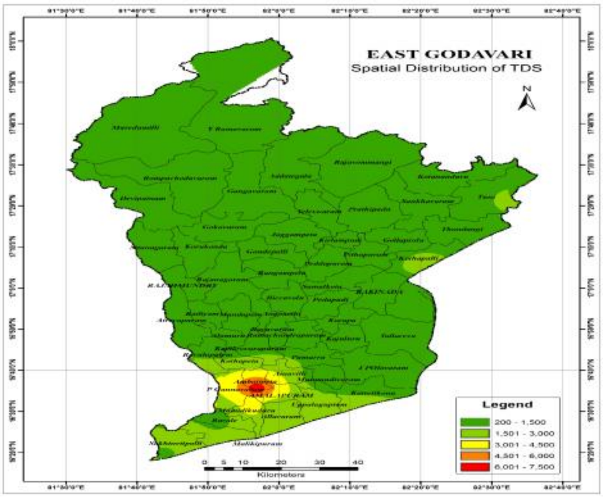


Fig 3 Spatial distribution of TDS

Such water may be softened by ion exchange process that is capable of exchanging Na1+ or H1+ for Ca2+ and Mg2+. In the samples, Ca2+ concentration ranged from 12.02 to 1255.4mg/l, while Mg2+ content was found from 0.14 to 214 mg/l. So, the amount of Ca2+ present in the samples was partially within the desirable limit for very few mandals like indicated for Ca2+ by BIS. Almost all the samples was exceeding the maximum permissible limit indicated by BIS for Mg2+. The spatial distribution of Total Hardness is shown in the Figure:4

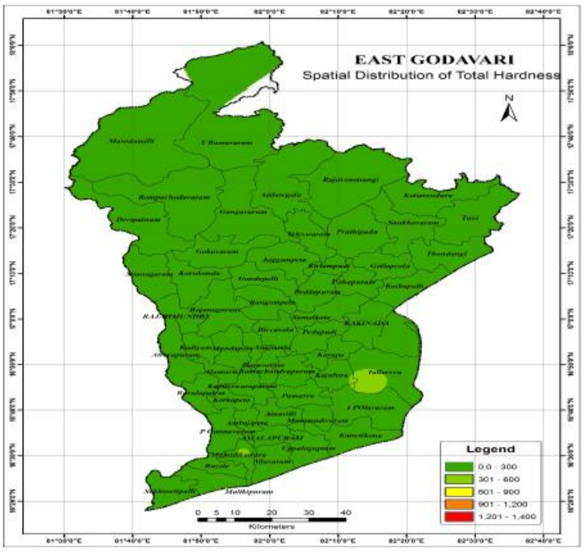


Fig 4 Spatial distribution of TH

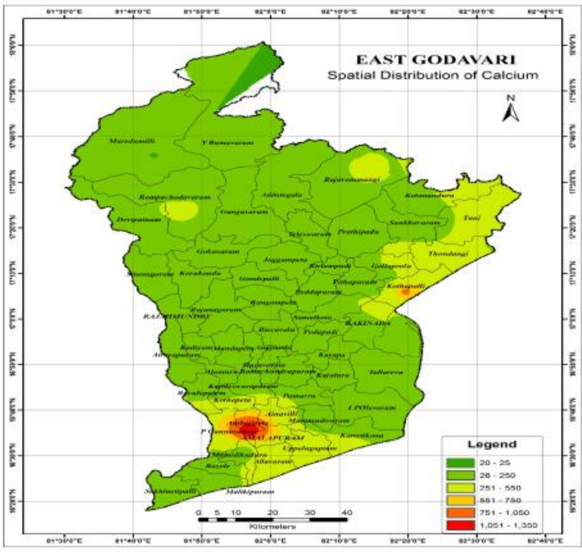


Fig 5 Spatial distribution of Ca

The nitrate rich water is not fit for drinking. Increased presence of nitrate in water is a big threat to the public health. Excess nitrate content in drinking water may become the cause of methemoglobinemia (blue baby syndrome). In groundwater, nitrate may result due to livestock facilities, agrochemicals and sewage disposal. The nitrate values of the samples varied from 0.2967 to 473.33 mg/l having a mean value of 199.7 and standard deviation of 100. Hence, the observed values were too high. Almost all the samples concentration was beyond 45.58 mg/l. Sodium is an essential mineral in our diet. It is generally found in the form of sodium chloride (salt). It dissolves easily in water and gives water a salty taste at levels greater than 180mg/l to 200 mg/l. The district is entirely contaminated with nitrates, The leachate of crop nutrients and nitrate fertilizers from agricultural lands may be the reason, as the district is luscious with paddy fields , and possibility of usage of agrochemicals naturally will be more. The spatial distribution of nitrate (N03) is shown in the Figure:5

Fluoride a major natural contaminant in waters generally should not exceed 10mg/lit 5. The factor responsible for ground water contamination with fluoride are geological factors such as weathering of minerals, rock dissolution and decomposition over a long period of time results in the leaching fluoride into ground water 6. An anthropogenic factor such as industrial process liberates higher concentration of fluoride into atmosphere. The permissible limit of fluoride in drinking water is 1.5mg/L by WHO, 1.0 mg/L by ICMR and 0.6 to 1.2 mg/L by BIS. (BIS1991; WHO 1994).

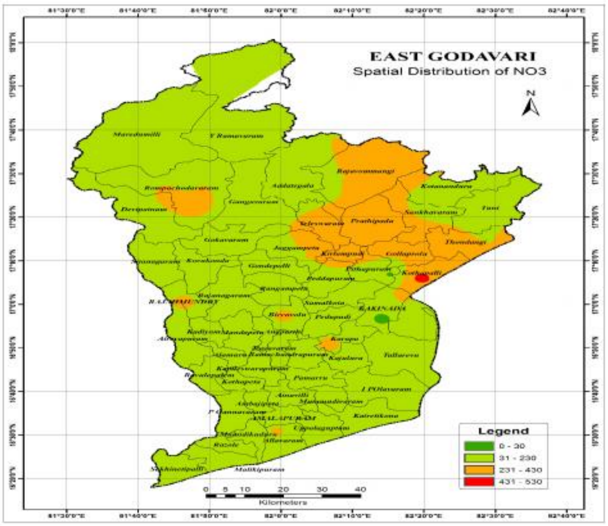


Fig 6 Spatial distribution of NO3

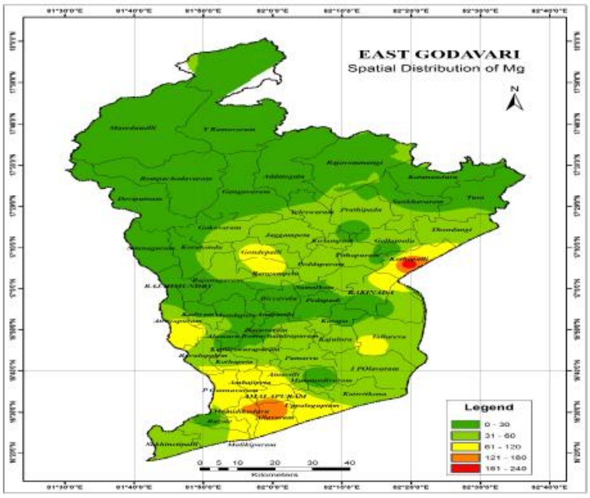


Fig 7 Spatial distribution of Mg

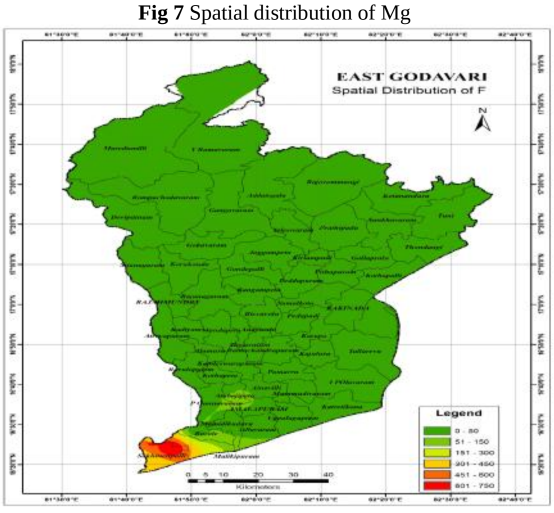


Fig 8 Spatial distribution of F l

The concentration of fluoride in the studied Water samples varies from 0.1 to 741 mg/lt. The analyzed fluoride concentration of the sites shows that around 90% samples have the fluoride levels higher than 1.5 mg/l (as shown in fig2 and fig 3). Taking into account the BIS recommended fluoride concentration (1.5 mg/l) in drinking water, people in these localities should be advised to adopt some defluoridation technique prior to use of groundwater for drinking purposes. High fluoride concentration in drinking water causes dental fluorosis and more skeletal fluorosis 7 whereas the low concentration or its absence results in dental caries in children particularly when the fluoride concentration is less than 0.5 mg/lit 8. spatial distribution of fluoride is shown in the Fig 8.

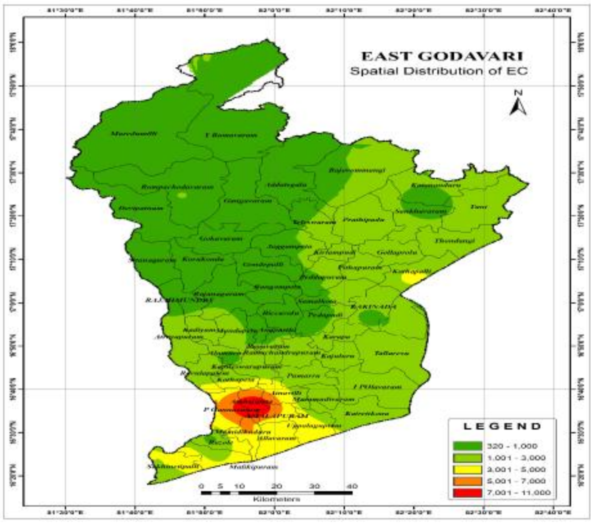


Fig 9 Spatial distribution of SO4

Potassium is vital for the body. Potassium and sodium together maintain the body's water balance. In water, potassium has no smell or colour, but may give water a salty taste. Potassium is also associated with nerve function blood pressure. Concentration of K1+ was in the range of 0.12 to 362 mg/l, having mean value 35.5 and standard deviation 56.0. Spatial distribution of Potassium is shown in the Figure:8

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

Sodium is an essential mineral in our diet. All natural waters contain sodium It is generally found in the form of sodium chloride (salt). It dissolves easily in water and gives water a salty taste at levels greater than 180mg/l to 200 mg/l. High level of Na1+ is associated with excessive salinity and is found in many minerals in water .Concentration of Na1+ was in the range of 22.5 to 507.3 mg/l, having mean value 203.87 and standard deviation 87.2. Spatial distribution of Sodium is shown in the Figure:8 . Sulphate is found in most mineral waters. It can cause a pungent odour and taste in water and may have a laxative effect. For SO4 2- , is indicates 200 mg/l as desirable limit. Beyond this causes gastro intentional irritation when magnesium or sodium is present. Concentration of SO4 2- was in the range of 19.2 to 62.41 mg/l, having mean value 38.74 and standard deviation 17.02. Sulphate levels are in permissible range all over the district except for Amalapuram, Ainavilli, Uppalaguptam, Ambajip*et Al*lavarm Mamidikuduru and P.Gannavaram mandals. Spatial distribution of Sulphate is shown in the Figure:8

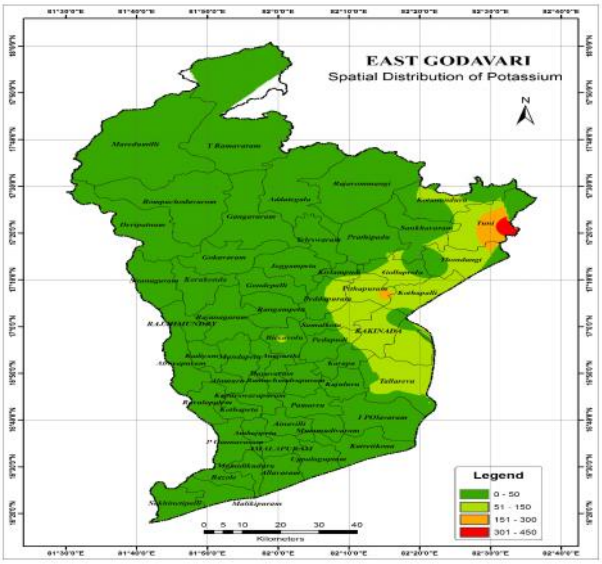


Fig 10 Spatial distribution of Na

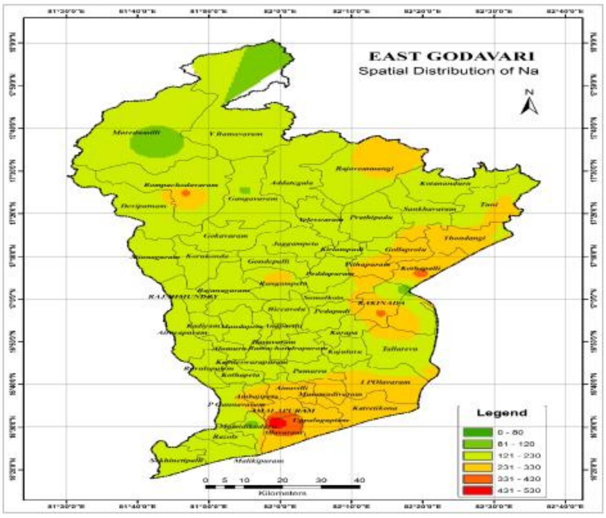


Fig 11 Spatial distribution of K

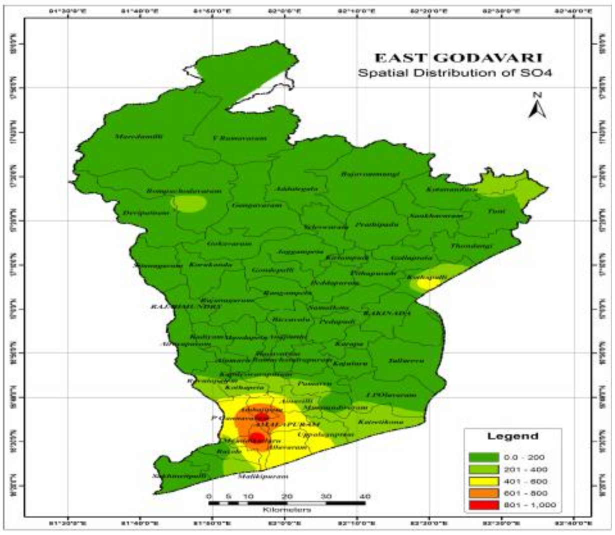


Fig 12 Spatial distribution of EC

MANDALS	TH	EC	TDS	Cl	WQI
Addateegala	40.27	586.33	375.25	32.00	29
Alamuru	26.67	756.67	484.27	18.67	46
Ainavilli	61.00	2100.00	1100.00	350.00	72
amalapuram	327.09	5140.00	3289.60	28.27	*59*
Allvaram	166.67	3256.67	2084.27	35.87	71
Ambajipeta	117.68	10413.54	6664.66	40.77	57
Antharvadi	38.81	2200.44	1408.28	34.71	83
Anaparthi	73.33	945	604.8	29.33	27
Atreyapuram	22.67	1976.67	1265.07	28.23	30
Biccavole	52.00	710.00	810.00	110.00	30
Devipatanam	26.67	584.00	373.76	26.67	29
Katrenikona	173.33	4090.00	2617.60	24.00	27
Ravulapalem	210.00	920.00	740.00	90.00	56
I.polavaram	46.67	767.33	491.09	37.33	29
Gandepalli	34.00	611.67	391.47	29.33	27
Gangavaram	54.33	655.00	419.20	44.67	38
Gollaprolu	193.33	1120.00	728.00	23.33	29
Jaggampet	31.04	1050.04	672.02	46.81	36
Kadiam	70.67	1484.33	949.97	29.33	28
Kakinada	17.33	766.67	498.33	31.00	31
Karapa	46.67	1136.67	727.33	32.00	59
Korukonda	58.67	1310.5	838.65	30.66	56
Kotananduru	55.67	1133.33	725.33	36.00	30
Kirlampudi	58.67	1310.5	838.2	32.67	55
Kajuluru	604	945	604.8	15.7	31
Kothapet	64.5	1039.1	665.06	32.66	29
Maredumilli	13.33	320.00	204.80	29.33	29
Mandapeta	33.33	1521.67	973.87	58.67	28
Mumidivaram	39.33	1091.67	698.67	37.33	62
U.Kothapalli	228.6	1436.6	872.9	180.9	63
Nemam	43.63	1958.75	1253.60	367.50	29
P.Gannavaram	9	347	12	40	51
Peddapudi	46.67	767.33	491.09	37.33	56
Peddapuram	30.67	883.33	565.33	53.33	28
Pithapuram	0.00	1085.00	705.00	26.67	30
Prattipadu	45.33	1303.33	834.13	61.33	29
Rangampeta	68.67	695.00	444.80	21.33	28
Rajanagaram	34.33	890	574.9	24	35
Rajahmundry	36.67	561.67	359.47	56.00	28
Rajaommangi	40.85	1050.42	672.27	40.07	30
Ramachandrapuram	225.67	1090.17	651.23	169.63	29
Rampachodavaram	37.33	524.00	335.36	42.67	29
Rowthulapudi	13.33	462.00	295.68	42.67	38
Rayavaram	0	660	671.8	48	54
Razole	53.33	738.33	472.53	34.67	54
Sampatnagaram	4.24	635	406.4	24.015	61
Sitanagaram	35.00	518.67	331.95	32.00	28
Tallarevu	431.33	1862.00	1098.73	312.60	59
Thonddangi	116.6	2655.80	1676.48	109.54	89
K.Puram	4.65	3875.00	2480.00	38.10	**63**
Tuni	140.00	2737.67	1779.33	89.33	34
Yeleswaram	25.90	1011.23	647.19	49.38	36
Ravulapalem	73.33	945.00	604.80	29.33	30
Uppalaguptam	58.00	881.67	564.27	69.33	27
Samalkot	65.61	1090.00	697.60	24.00	29
Sankavaram	1421	1100.00	1010	910	**69**

References

1. A.I.Vogel, Text Book of Quantitative, Inorganic Analysis,4th Edn, ELBS, London (1978)
2. BIS (Bureau of Indian Standards) 10500, 1991, Indian standard for drinking water specification, First revision, p 1-8.
3. Burrough PA, McDonnell., 1998, Principles of Geographical Information Systems. Oxford University Press, Oxford, 333 pp.
4. Ferry Ledi Tjandra; Akihiko Kondhoh; Mohammed Aslam M.A. A Conceptual Database Design For Hydrology Using GIS. Proceedings of Asia Pacific

Association of Hydrology and Water Resources. March 2003, 13-15, Kyoto, Japan.

5. K. S. Venkateswarlu , Water Chemistry - Industrial and Power Station Water Treatment, New Age International Pvt. Ltd., New Delhi (India), 1999, 7, 11.
6. Nirmala B., Suresh Kumar B.V., Suchetan P.A. and Shetprakash M., seasonal variations of Physico –chemical characteristics of ground water sample of Mysore city, Karnataka, India. *Int. J. Env.sci*.,vol.1(4),43-49, Nov. (2012).6. Jamal A.A., Physico –chemical studies in Uyyakonda channel water of river Cauvery., Poll. Res .,vol.17(2),111(1998).
7. Patil N., Ahmed A., Suresh Babu H., Kottureshwar N.M., Jayashree M. and Nijalingappa J., Study on the physico -chemical characteristics of ground water of Gulbarga city, Karnataka, India. *Intl .J. Appli. Biopharm. Tech*., Vol. 1 (2), 518-523 (2010).
8. Ravindra K. and Garg V.K., Appraisal of ground water quality for drinking purpose in Hisar city (India) with special reference to fluoride. *Int. J. Envt. Hlt. Res*, in press (2005).

How to cite this article:

Surekha Gangavarapu *et al.,* Groundwater Quality Mapping Of East Godavari District, Andhra Pradesh, India , Using Remote Sensing And Geostatistics. *International Journal of Recent Scientific Research Vol. 6, Issue, 4, pp.3602-3608, April, 2015*

****