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Analysis, estimation and mapping of irrigation water quality index of Bapatla Mandal, Guntur district, Andhra pradesh, India by using surfer software

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Abstract
An investigation is carried out to analyze the underground water quality of 26 villages in Bapatla mandal for their quality parameters and comprehensively arriving at a single water quality index. The irrigation water samples were collected manually from the bore wells which are approximately equally distributed all over 26 villages of Bapatla mandal. The samples were analyzed using standard procedures in the laboratory (APHA, 1985). The parameters analyzed during the analysis are pH, EC, Chlorides, Calcium, Magnesium (Mg), Total Dissolved Solids (TDS), Total Hardness (TH). The final output has been given in the thematic representation of irrigation water quality attributes using SURFER 7.0 for individual as well as weighted Water Quality Index. From the investigation, it is clearly evident that the groundwater of the area needs some degree of treatment before consumption. Based on the investigations carried out, it is observed that Asodivaripalem, West Bapatla, Cheruvujamulapalem, Murukondapadu, Muthayapalem, Maruproluvaripalem and Vodarevu villages contain water quality very poor for irrigation purpose due to over salt accumulation. Necessary measures are to be taken to gain safe irrigation and drinking water to the people living in the villages. Total hardness was found to be very high in Murukondapadu, and Muthayapalem villages. Very high concentrations of chloride, calcium and magnesium were found in West Bapatla, Cheruvujamulapalem, Murukondapadu and Muthayapalem villages. The water quality is good in Jillelamudi, Mulapalem, Etheru, Bhartipudi, Tsundurupalli, Gopapuram, Appikatla, East Bapatla, Kondubotlavaripalem and Poondla villages based on Water Quality Index. The water quality was found moderately good in Vedullapalli, Bethapudi, Pinniboinavaripalem, Gudipudi, Stuvartpuram, Kankatapalem, Marripudi, and Narasayapalem villages

Keywords: Water quality index-analyze-mapping by using surfer

Introduction
World's global water resources accounts for 97.5% out of which 2.5% fresh water resources in which India fresh water resources accounts for 7 to 17% which is inclusive of both surface 64% and ground water resources 36% out of which domestic purpose 5%, industries 6% and agricultural 89%. In the increased globalization scenario, a paradigm shift is being foreseen in increasing the industrialization major shift of agricultural land put to non- agricultural use perhaps the reduction in water allocation for crop production sector possess a great threat for agricultural sustainability. Besides even for drinking water for the alarming rate of increased population, it is very critical and important to treat the waste water and re use for some non-important activities. Hence there is a great focus in assessing the water quality at point source.

The remainder of the earth's water constitutes the planet's resource. Typically, fresh water is defined as water with a salinity of less than 1 percent that of the oceans i.e. below around 0.35%. Water with salinity between this level and 1% is typically referred to as marginal water because it is marginal for many uses by humans and animals. The ratio of salt water to fresh water on earth is around 40 to 1.

Ground water is a precious natural gift and an important renewable resource having several inherent advantages over surface water. It is a good source of fresh water available on the earth. The demand for water has increased over the years and this has led to water scarcity in many parts of the world. The situation is aggravated by the problem of water pollution or contamination. India is heading towards a fresh water crisis mainly due to improper

management of water resources and environmental degradation. This leads to lack of access to safe potable water supply to millions of people. It becomes imperative to regularly monitor the quality of ground water and to device ways and means to protect it. Water Quality Index is one of the most effective tools to communicate information on overall quality status of water to the concerned user community and policy makers (Chopra. S.L. and Anwar, J.S, 1999). Thus, it becomes an important parameter for the assessment and management of ground water.

In case of agricultural lands with underground saline water to a widely varying extent, with in a Panchayath level, the underground water quality, soil extract salinity should be documented for better crop planning. However, uncontrolled extraction without commensurate recharge and leaching of pollutants from pesticides and fertilizers into the aquifers has resulted in pollution of groundwater supplies. In addition to leachate from agriculture, ground water is threatened with pollution from various sources viz., domestic wastes, industrial wastes, agricultural wastes, run off from urban areas and soluble effluents.

Though environmentalists have done certain water quality aspects in almost very few patches that to in a randomized way. Under these circumstances, water quality, soil quality parameters needs a closer and thorough investigation for the better utilization of natural resources. Hence the present investigation is proposed to analyze the underground quality in 26 villages in Bapatla mandal for their quality parameters and comprehensively arriving at a single water quality index to fulfill the following specific objectives.

Materials and Methods

Location map of the study area

The irrigation water quality in different villages of Bapatla Mandal was analyzed by collecting the samples of water from each village. Samples are collected from cultivated areas. These samples are analyzed at soil science laboratory agricultural college Bapatla for pH, EC, TDS, Total Hardness, Ca, Mg and chlorides. The lists of villages taken into consideration for this present investigation are enlisted in Table 1.

Table 1: List of villages considered for the present study in Bapatla Mandal

S1.No	Village	S1.No	Village
1	Adivi	14	Poondla
2	West Bapatla	15	Jillellamudi
3	Vedullapalli	16	Mulapalem
4	Asodivaripalem	17	Stuvartupuram
5	Bharthipudi	18	Murukondapadu
6	Gopapuram	19	Kankatapalem
7	Bethapudi	20	Muthayapalem
8	Appikatla	21	Maruprolluvaripalem
9	Cheruvjamullapalem	22	Marripudi
10	East Bapatla	23	Etheru
11	Pinniboinavaripalem	24	Tsundurupalli
12	Gudipudi	25	Narasayapalem
13	Kondubotlavaripalem	26	Vadarevu

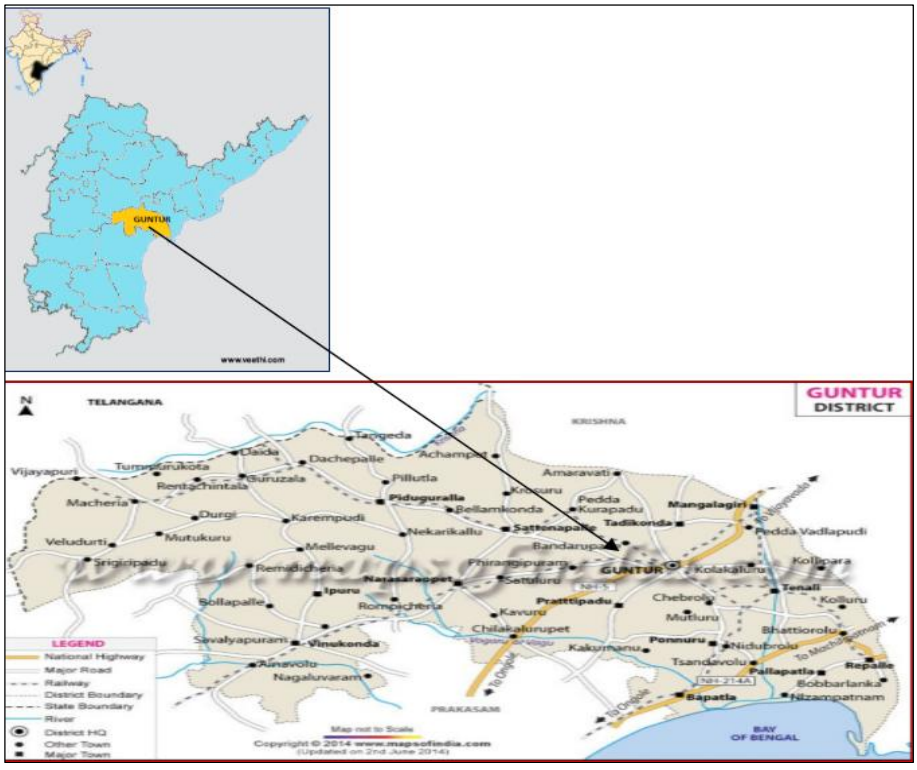

Fig 1: Location map of the study area

Analysis of irrigation water quality

- Determination of Total Salts (EC)
- Determination of pH
- Determination of chlorides
- Determination of Total Hardness (Ca + Mg)
- Determination of calcium and magnesium
- Determination of Total dissolved solids (TDS)

Estimation of water quality index

Water Quality Index (WQI) is a very useful and efficient method for assessing the quality of water. Water Quality Index is very useful tool for communicating the information on overall quality of water. To determine the suitability of the

groundwater for drinking purpose, WQI is computed by adopting the following formula. Table 2 provides the information about water quality parameter, their BIS standards and weight ages and table 3 provides the information of water quality index categories.

Calculation of Water Quality Index

$$WQI = \frac{\sum(q_i w_i)}{\sum w_i}$$

Where, q_i*(Water quality rating)* = $100(V_a - V_i)/(V_s - V_i)$

V_a = Actual value present in the water sample.

V_i = Ideal value (0 for all parameters except PH and DO)

w_i(Unit weight) = $\frac{K}{S_n}$

K (constant) = $\frac{1}{((1/Vs1)+(1/Vs2)+ +.....(1/Vsn))}$

S_n= Standard value

Table 2: Water quality parameter, their BIS standards and Weightages

Sl. No.	Parameter	Standard (Sn and Si)	Weightage (Wi)
1	pH	8.5	0.1363529
2	Calcium (mg/l)	75	0.0154533
3	Chlorides (mg/l)	250	0.0046360
4	Fluorides (mg/l)	1.5	0.7726666
5	Total Hardness (mg/l)	300	0.0038633
6	Mg (mg/l)	30	0.0386333
7	Nitrates (mg/l)	45	0.0257555
8	TDS (mg/l)	500	0.00231800

Table 3: Water quality index categories (Source: Rao *et al.* 2013)

Sl. No.	Water Quality Index (WQI)	Description
1	<50	Excellent
2	50-100	Good
3	100-200	Moderately good
4	200-300	Poor
5	>300	Very poor

Mapping of water quality parameters and index

The study was carried out with the help of two major components; Cadastral maps and field data. The cadastral maps was collected from the MRO office and demarcating all villages, scanned and digitized to generate a digital output forming a spatial database. Field work was conducted and ground water samples were collected from various villages of Bapatla Mandal with the help of the map. These samples were tested using standard procedures in the laboratory and the results were tabulated in an excel worksheet. The Water Quality Index for each village was calculated. The water quality data thus obtained forms the attribute database for the present study. The database table consisting of average values of the parameters determined.

Use of Surfer 7.0 for mapping water quality parameter and index

Free downloadable version of Winsurf (SURFER 7.0) model was downloaded for mapping the various water quality parameters and WQI of various villages of Bapatla Mandal. The equal attribute zones for all the water quality parameters as well as for the WQI were prepared using this model. Kriging option was selected in the model for scattered data interpolation. The methodology followed for making the maps is presented in a simple flow chart as shown in Fig. 2

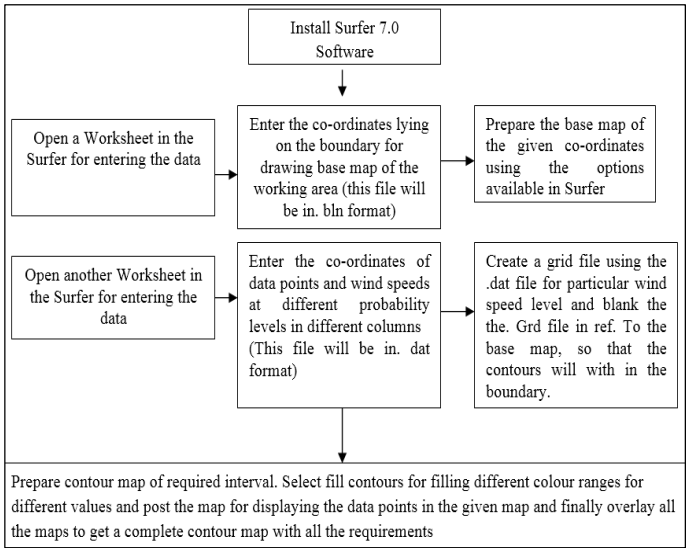

Fig 2: Step by step procedure of using SURFER 7.0 for mapping the water quality parameters

Results and Discussion

Analysis of water samples for its quality in the study area

The quality of irrigation water varies from place to place; even at the same location, from season to season. It also depends upon both the surface and subsurface characteristics. Presence of landfills, open dump, usage of fertilizers, disposal of industrial wastes etc., change the quality of irrigation water. As part of the investigations, the quality parameters like Chlorides, Calcium, Magnesium, TH, pH, EC and TDS were analyzed. The results are reported in the following Table 4.

Table 4: Summary of quality parameters of irrigation water samples of Bapatla Municipality

S. No.	Village	pH	Ca (mg/l)	Cl (mg/l)	TH (mg/l)	Mg (mg/l)	TDS mg/l	EC (mg/l)
1	Adivi	6.53	76	49.7	112	36	400	480
2	West Bapatla	6.56	114	276.9	240	126	0	1773
3	Vedullapalli	6.03	100	113.6	140	40	0	928
4	Asodivaripalem	6.30	62	170.4	128	66	400	1523
5	Bharthipudi	6.91	34	42.6	52	18	0	326
6	Gopapuram	7.43	40	49.7	64	24	0	422
7	Bethapudi	6.07	116	127.8	152	36	0	973
8	Appikatla	6.42	44	49.7	124	80	200	403
9	Cheruvjamullapalem	6.61	134	291.1	200	66	200	1990
10	East Bapatla	6.20	38	56.8	76	38	200	486
11	Pinniboinavaripalem	6.36	74	163.3	124	50	0	966
12	Gudipudi	6.18	64	177.5	136	72	0	986
13	Kondubotlavaripalem	6.25	90	49.7	124	34	0	544
14	Poondla	6.26	38	56.8	96	58	0	390
15	Jillellamudi	6.28	50	49.7	116	66	200	332
16	Mulapalem	6.14	18	56.8	52	34	0	346
17	Stuvartupuram	6.02	94	134.9	144	50	0	780
18	Murukondapadu	6.25	60	291.9	172	112	400	1587
19	Kankatapalem	6.07	64	156.2	128	64	200	915
20	Muthayapalem	6.65	84	553.8	232	148	200	2982
21	Maruprolluvaripalem	6.64	144	163.3	212	68	200	1158
22	Marripudi	6.32	50	56.8	160	110	0	410
23	Etheru	6.33	44	42.6	100	56	0	339
24	Tsundurupalli	6.30	54	71	108	54	0	454
25	Narasayapalem	6.04	56	191.7	116	60	400	928
26	Vodarevu	6.50	85	553.9	233	149	203	2980

Estimation of Water Quality Index

As per the methodology reported in the previous chapter, weighted parameter i.e. Water Quality Index (WQI) was calculated for each village and is presented in Table5. The variations of WQI of the irrigation water ranged between 82.25 to 936.54 in different villages of Bapatla Mandal.

Table 5: Averages of various parameters of all villages along with WQI

Sl. No.	village	WQI	Sl. No.	village	WQI
1	Adivi	129.57	14	Poondla	108.83
2	West Bapatla	547.91	15	Jillellamudi	98.53
3	Vedullapalli	271.54	16	Mulapalem	84.76
4	Asodivaripalem	465.13	17	Stuvartupuram	224.37
5	Bharthipudi	82.25	18	Murukondapadu	488.55
6	Gopapuram	116.98	19	Kankatapalem	269.23
7	Bethapudi	286.28	20	Muthayapalem	936.54
8	Appikatla	127.06	21	Maruprolluvaripalem	346.58
9	Cheruvjamullapalem	615.28	22	Marripudi	153.85
10	East Bapatla	129.89	23	Etheru	94.18
11	Pinniboinavaripalem	284.46	24	Tsundurupalli	125.56
12	Gudipudi	293.14	25	Narasayapalem	272.78
13	Kondubotlavaripalem	148.30	26	Vodarevu	936.19

Mapping of water quality parameters and index

To assess the temporal variability of individual water quality parameter as well as the weighted Water Quality Index equal attributed parameter maps were prepared using SURFER 7.0 software. The contours were prepared using the option Kriging for scattered data interpolation. The maps were presented in Fig.3 to Fig.10 respectively and discussed briefly for all the quality parameters as well as WQI.

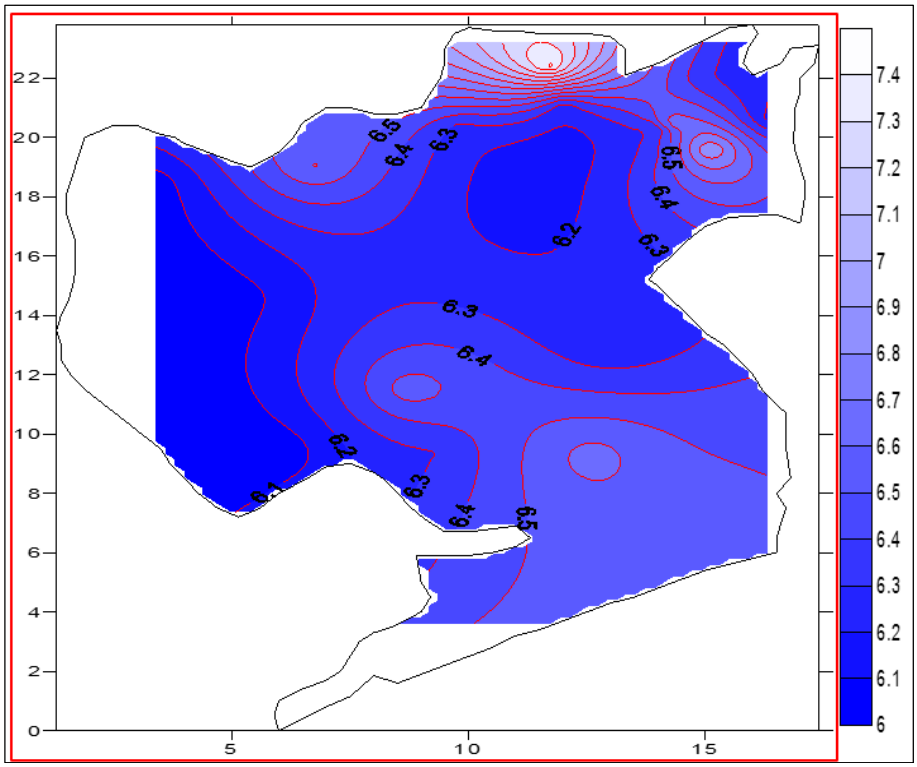

Fig 3: Map showing Equal pH zones of Bapatla Mandal

From the above Figure, It could be observed that the p^H in Bapatla Municipality varied little over the entire area. As we move from coastal area, the p^H is slightly found decreasing towards north in the tune of 6.5. Finally it could be inferred that the irrigation water of Bapatla region has no adverse effects with p^H.

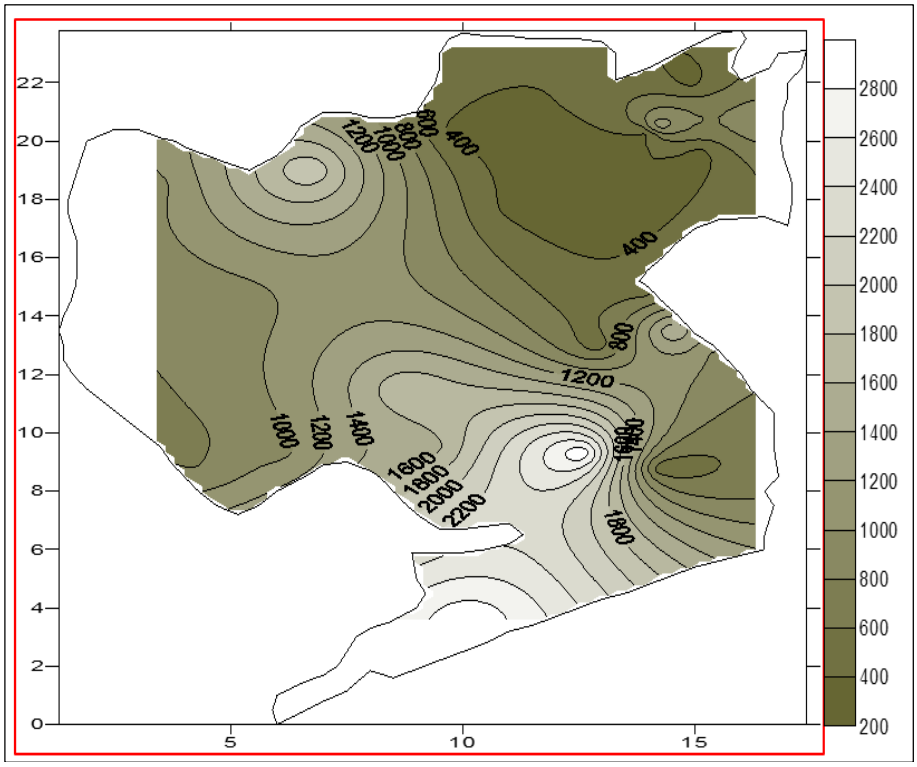

Fig 4: Map showing equal EC zones of Bapatla Mandal

From the above Figure, it is evident that Bapatla villages has high EC i.e salt concentration at the costal side (south) i.e, 2200 mg/l at a point of investigation and found decreasing towards north with and a low EC of 400mg/l.

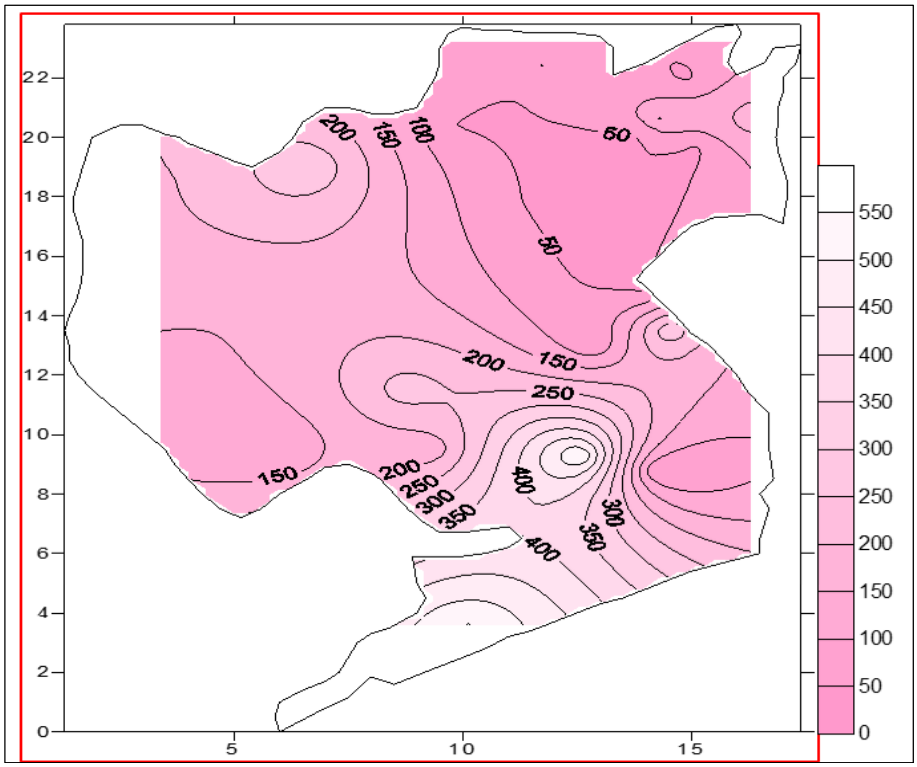

Fig 5: Map showing equal Chloride zones of Bapatla Mandal

From the above Figure, it could be obvious that the chloride is more near to the coastal side and showed a maximum value of 400mg/l m and decreased towards north east. In the eastern side the lowest concentration of chlorides are found i.e. in the tune of 50 mg/lt.

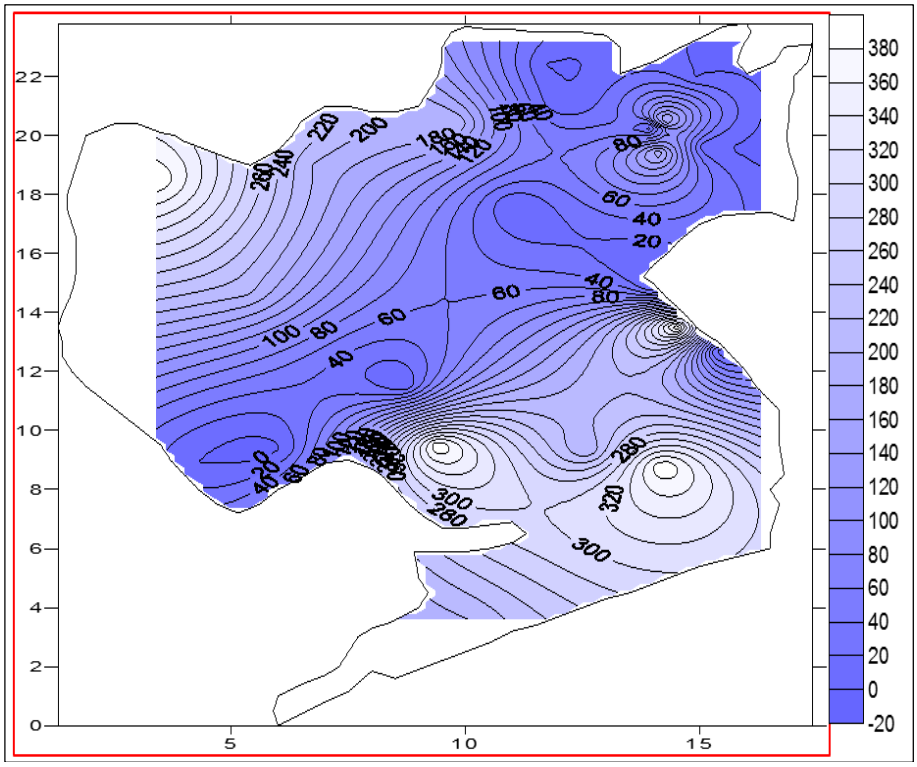

Fig 6: Map showing equal TDS zones of Bapatla Mandal

From the above, it is clear that high TDS are found in the irrigation water near the coast and found decreasing slightly away. Lower values of TDS are observed in the eastern and western parts of the Mandal. Higher values of TDS in the tune of 300mg/l is found near to the coast and in the western side, in some places no TDS readings were observed.

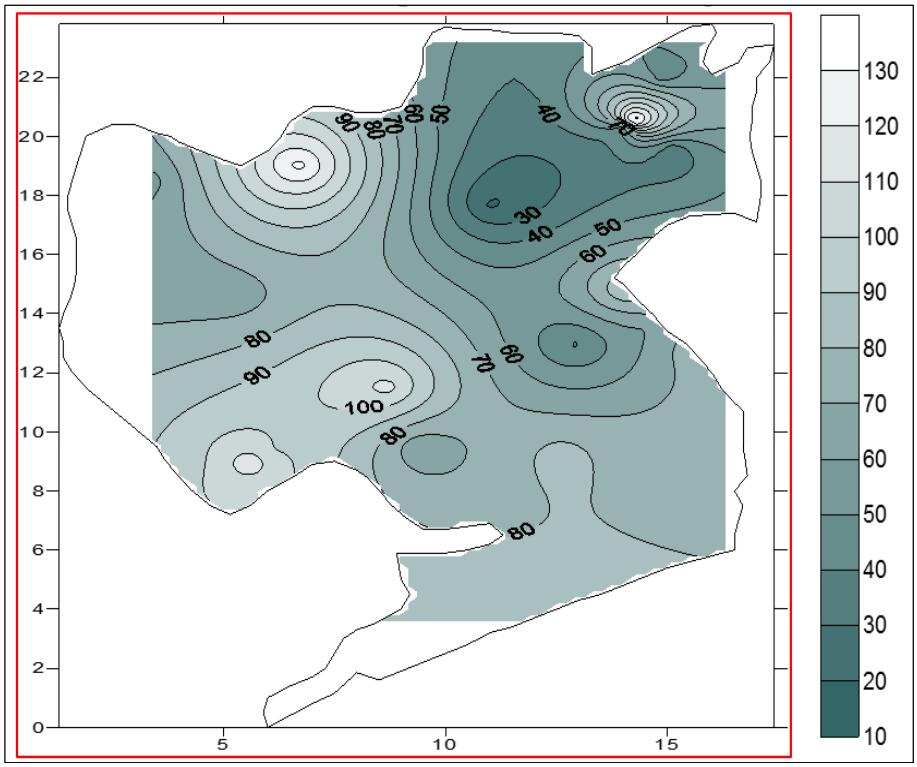

Fig 7: Map showing equal 'Ca' zones of Bapatla Mandal

From the above figure, 'Ca' contamination is found in the northern and southern sides of Bapatla. At some parts of south-west side, higher value of Ca concentration i.e. 110 mg/l and at some parts of North West side, less 'Ca' concentration of 30mg/l are observed.

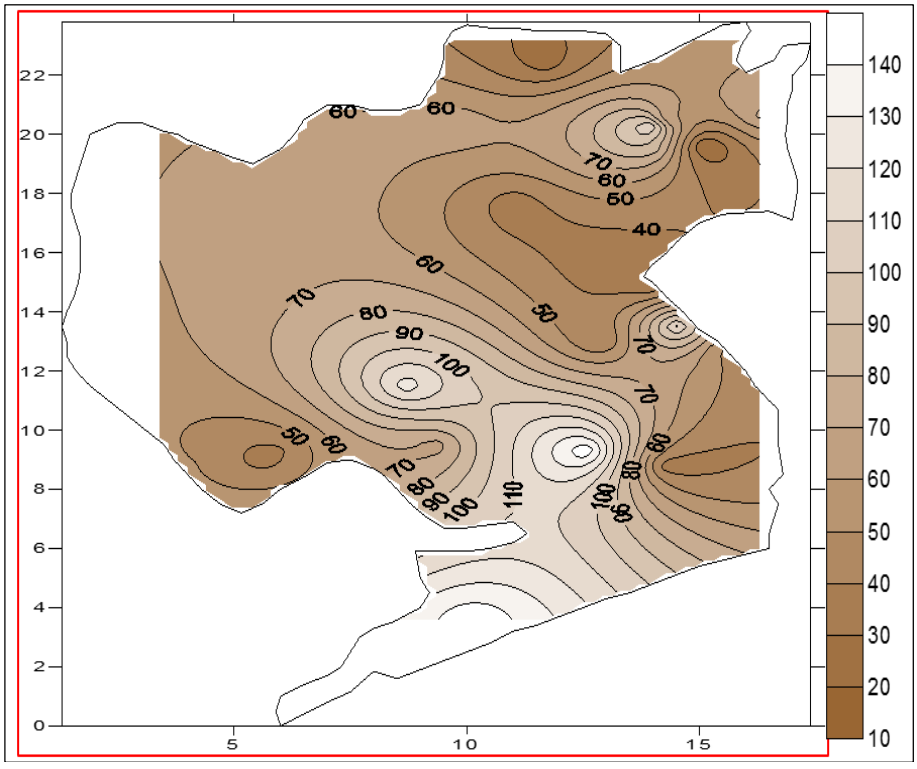

Fig 8: Map showing equal Mg of Bapatla Mandal

From the above Figure, higher traces of Mg concentration are found near the coast with a maximum value of 110mg/l. A minimum value of 40mg/l is found in the northern and eastern sides of Bapatla. Eastern and western sides of Bapatla have almost equal amount of Mg.

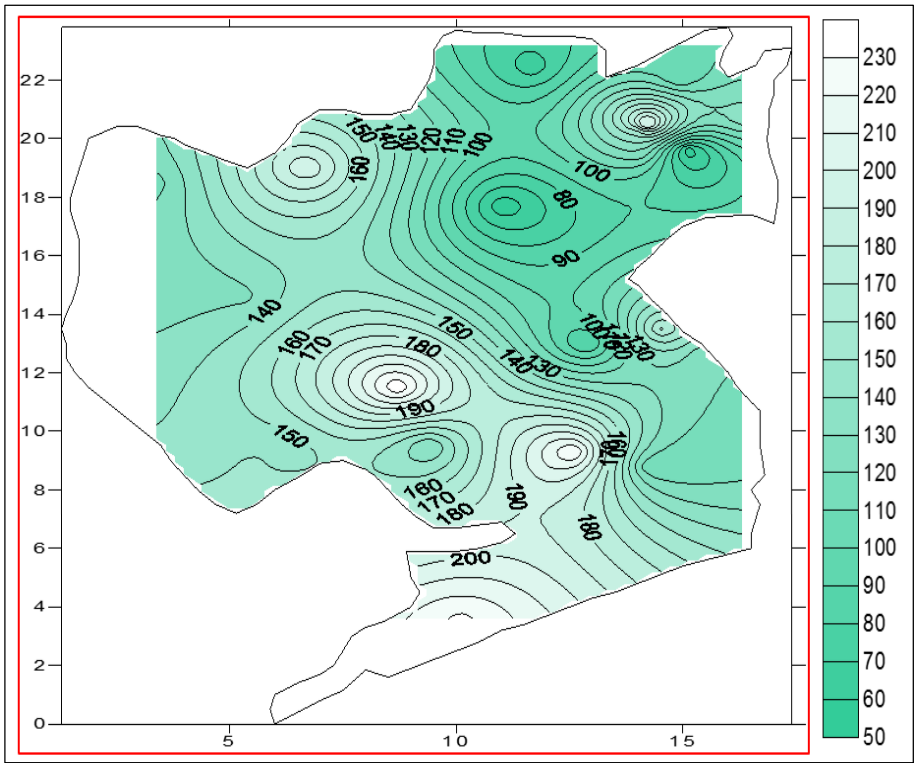

Fig 9: Map showing equal TH zones of Bapatla Mandal

From the above map, high TH is found near the coast and decreased gradually away from the coast. The western and northern sides of Bapatla Mandal showed equal amounts of TH and have lower values of around 80mg/l in the northeastern side.

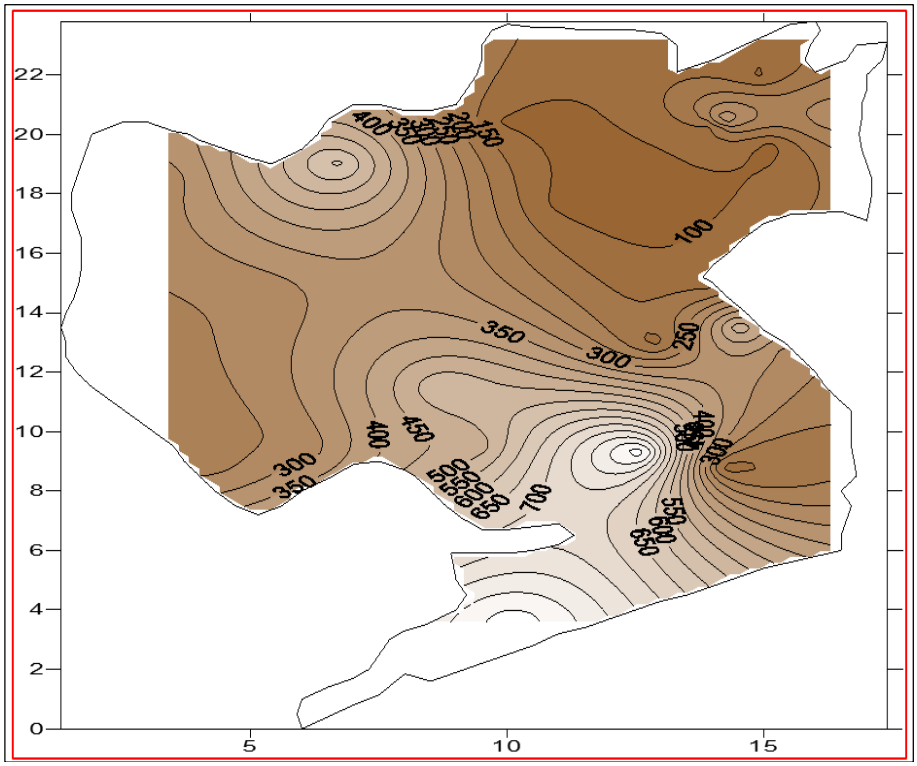

Fig 10: Map showing equal WQI of Bapatla Mandal

From the above figure, overall WQI varied widely within Bapatla Mandal villages. Very poor quality of water for both irrigation and drinking in the coastal side of the region were found. Good quality irrigation water is found in the north-eastern side of Bapatla Mandal. There is moderately good irrigation water in the eastern side and poor irrigation water in the western side of the Bapatla Mandal.

The final output has been given in the thematic representation of irrigation water quality attributes using SURFER 7.0. For individual as well as weighted Water Quality Index. From the investigation, it is clearly evident that the groundwater of the area needs some degree of treatment before consumption. Based on the investigations carried out, the following valid conclusions could be drawn.

- It is observed that Asodivaripalem, West Bapatla, Cheruvujamulapalem, Murukondapadu, Muthayapalem, Maruproluvaripalem and Vodarevu villages contain water quality very poor for irrigation purpose due to over salt accumulation. Necessary measures are to be taken to gain safe irrigation and drinking water to the people living in the villages.
- Total hardness was found to be very high in Murukondapadu, and Muthayapalem villages.
- Very high concentrations of chloride, calcium and magnesium were found in West Bapatla, Cheruvujamulapalem, Murukondapadu and Muthayapalem villages.
- The water quality is good in Jillelamudi, Mulapalem, Etheru, Bhartipudi, Tsundurupalli, Gopapuram, Appikatla, East Bapatla, Kondubotlavaripalem and Poondla villages based on Water Quality Index. The water quality was found moderately good in Vedullapalli, Bethapudi, Pinniboinavaripalem, Gudipudi, Stuvartpuram, Kankatapalem, Marripudi, and Narasayapalem villages.

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