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QUALITY OF GROUNDWATER IN CENTRAL GODAVARI DELTA, ANDHRA PRADESH

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ABSTRACT

Groundwater is one of earth's most vital renewable and widely distributed resources as well as an important source of water supply throughout the world. The quality of water is a vital concern for mankind since it is directly linked with human welfare. Central Godavari Delta is known for its rice cultivation and the Canal irrigation. This area covers 16 mandals of East Godavari District of Andhra Pradesh. To study the chemical quality of ground water, 48 key observation wells were established and samples were collected during pre-monsoon season and post monsoon seasons and locations are identified with GPS. Water quality parameters for drinking water standards determined using standard water quality procedures and prepared spatial distribution maps in Arc GIS environment. Groundwater is a valuable natural resource that is essential for human health, socio-economic development, and functioning of ecosystems. Various chemical constituents of water occur as dissociated particles or ions. In the present area of investigation, the chemistry of groundwater with respect to the major elements and chemically related properties has been determined. The major cations include Calcium (Ca^{+2}), Sodium (Na^{+}), Potassium (K^{+}), Chloride (Cl^{-}), Sulphate (So_4^{-2}) and Nitrate (No_3^{-}). The chemically related properties such as Total Dissolved Solids (TDS) and Total Hardness (TH) were also determined. Integrated overlay technique helped to delineate to prepare spatial distribution of groundwater quality for drinking purposes Potable and Non – potable in the study area. The variation in electric conductivity also has a relation with the proximity to sea. Based on the recommendations of the Bureau of Indian Standards, the quality of ground water from the shallow aquifer in the area is potable except in a small pockets around Katrenikona, Uppalaguptam, Malikipuram where the Electrical conductivity is more than 3000 micro siemens/cm at 25°C.

KEYWORDS: Groundwater, Godavari Delta, Water quality, Cations, Potable and Non – potable.

INTRODUCTION

Water is essential for existence of life on the planet. It mentioned in the Vedas that water is one of the five components of the human body. It has played an important role in the development of ancient civilizations. Human civilization developed near the rivers or source of water. It is also known that some of the ancient civilizations perished due to unexpected droughts representing climate variability (Brown, 2009). A huge amount of untreated waste by products and toxic chemicals enters the lake from the industries, which are located on the banks of inflowing drains, like tanneries, pulp and paper mills, distilleries, dairy industries, chemical and sugar factories.

Groundwater is a valuable natural resource that is essential for human health, socio-economic development, and functioning of ecosystems (Zektser, 2000; Humphreys, 2009; Steube et al., 2009). In India severe water scarcity is becoming common in several parts of the country, especially in arid and semi-arid regions. The overdependence on groundwater to meet ever-increasing demands of domestic, agriculture, and industry sectors has resulted in overexploitation of groundwater resources in several states such as Rajasthan, Punjab, Gujarat, Haryana, Uttar Pradesh, Tamil Nadu, among others (CGWB 2006; Garg and Hassan, 2007; Rodell et al., 2009). Groundwater can be optimally used and sustained only when the quantity and quality is properly assessed (Kharad et al., 1999). GIS has been used in the map classification of groundwater quality, based on correlating total dissolved solids (TDS) values with some aquifer characteristics (Butler et al., 2002) or landuse and landcover (Asadi et al., 2007). Other studies have used GIS as a database system in order to prepare maps of water quality according to concentration values of different chemical constituents (Yammani, 2007). In such studies, GIS is utilized to locate groundwater quality zones suitable for different usages such as irrigation and domestic (Yammani, 2007).

With over 700 million people living in around 1.60 million rural habitations. Provision of safe drinking water to such a huge population is a complex challenge (Anupam Hazra, 2010). Impure water is the root cause for many diseases especially in developing countries. Millions of people become sick each year from drinking contaminated water (Anumakonda Jagadeesh, 2010). The UN recommends that people need a minimum of 50 litres of water per a day for drinking, washing, cooking and sanitation (Paramasivan and Karthravan 2010). Water has become the biggest problem of the 21st century. More than 2.2 million people die each year from diseases related to contaminated drinking water and poor living conditions, faced with water scarcity (Paramasivan and Karthravan 2010). Aladejana and Talabi (2013) were studied groundwater quality in Abeokuta Soutwestern Nigeria. R.S.Negi et al. (2011) were analyzed the geo hydrological studies of springs and stream water of Takoli Gad watershed.

For any area, a ground water quality map is important to evaluate the water safeness for drinking and irrigation purposes and also as a precautionary indication of potential environmental health problems. Considering the above aspects of groundwater contamination and use of GIS in groundwater quality mapping, the present study was undertaken to map the groundwater quality in Krishna District, Andhra Pradesh, India. The main objective of the research work is to make a groundwater quality assessment using GIS, based on the available physico-chemical data from 48 locations in the study area. The purpose of this assessment are (1) to provide an overview of present groundwater quality, (2) to determine spatial distribution of groundwater quality parameters such as total dissolved solids, total hardness, calcium hardness, magnesium hardness, carbonates, bicarbonates, sodium, potassium, nitrates, chlorides and sulphates (3) to generate groundwater quality zone map for the study area.

Study Area

The Central Godavari Delta is part of East Godavari district, Andhra Pradesh and lies in between 81°40' and 82°25' East longitudes and 16°15' and 17°00' North latitudes and is part of the well known Konaseema Region. The study area is bounded by Bay of Bengal in the east and in the south where as in the North it is bounded by the river Gautami Godavari and in the west by the river Vasishta Godavari. The study area is covered by 16 mandals. The administrative Divisions of the study area are shown as Fig.1.

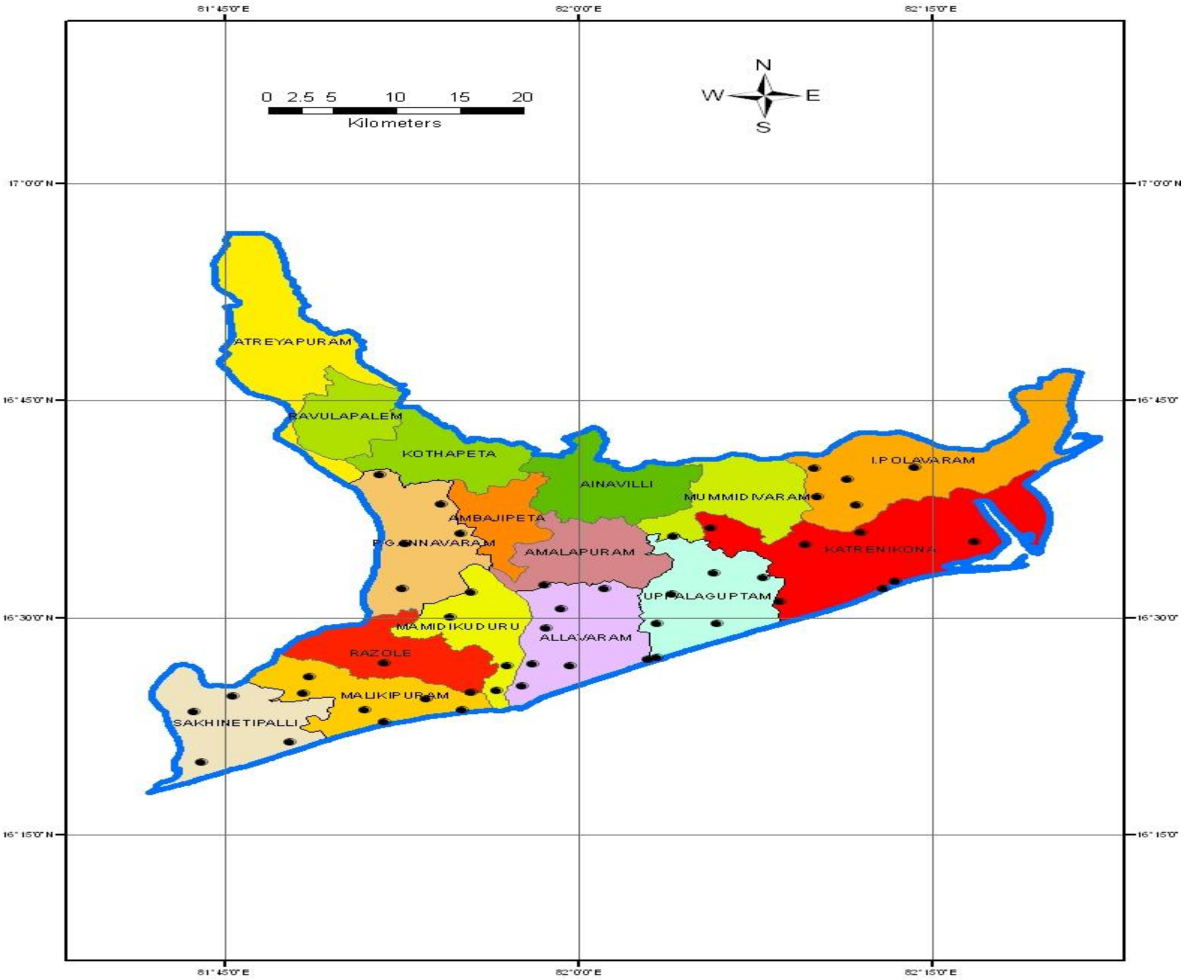

Fig. 1: Administrative Divisions of the Study Area.

This area is crisscrossed by the canal network of Central Godavari Delta Irrigation System. A total area of 84282ha (57.93%) is irrigated during kharif and 61216ha (47.07%) is irrigated during rabbi season by various sources of the irrigation. In these sources of irrigation canal sources account for 51999ha (61.70%) during kharif and 51875ha (84.74%) during rabbi season. Tube wells and Filter points irrigate 32283ha (38.30%) and 9341ha (15.26%) during khariff and rabbi seasons respectively. (CPO, 2011).

Hydrometeorology

Climatologically the area experiences dry, sub-humid, mega thermal climate with oppressive summer and good seasonal rainfall. The south west monsoon sets in the second week of June and lasts till September end. October and November receives rainfall from north east monsoon. The winter starts from December and lasts till mid February followed by summer season upto early June. There are sixteen raingauge stations in the area one each at mandal head quarters maintained by the Revenue Department. The normal annual rainfall in this area varies from a minimum of 1131.0mm at Kothapeta to a maximum of 1582.0mm at Sakhinetipalli and the weighted average of rainfall of the area is 1343.77 mm.

Geology

The geological formations in the area belong to Recent alluvium The geological succession of the area is shown in Table 1.

Table 1: Geological Succession of the Study Area.

Era	Period	Formation	Lithology
Quaternary	Recent to Sub- Recent	Alluvium	Sand, Gravel, Clay and Silt

The recent to sub recent alluvial deposits mainly occupy the study area. Alluvium comprising clay, sand and gravel occur in the entire area. The Alluvium has a maximum spread of 80kms width in this area.

Aquifer Geometry

The aquifer mapping in the area was carried out in this area by Central Ground Water Board, which indicates the disposition of various aquifers in the area. The first aquifer which is present upto a maximum of 34m below MSL is unconfined whereas the other aquifers are confined. The disposition of aquifers is as given below in Table 2.(CGWB,2011)

Table 2: Disposition of aquifers in the Study Area.

S. No	Aquifer No.	Lithology	Type	From	To	Thickness
1	I	Sand	Unconfined	Ground Level	34m below MSL	10-34m
2	II	Sand	Confined	23m below MSL	63m below MSL	5 – 38m
3	III	Sand	Confined	61m below MSL	111m below MSL	6 – 38m

Ground Water Levels

As a part of this study, 48 key observation wells were established in the area during May, 2008 and were monitored regularly. During the Pre monsoon season in the year 2010, water levels in the area is in general in the range of 2-4m bgl except in small pockets where it is more than 4.0 m bgl near Lankala Gannavaram. Water levels during November,2010 are mostly less than 1.0m except in the area near Lankala Gannavaram, where it is more than 2.0 m bgl. Fluctuation between pre and post monsoon water levels during 2010 is in general less than 2.0m. But higher fluctuation of more than 2.0 is observed near Lankala Gannavaram.

Hydrochemistry

The chemical quality of ground water mostly depends on the lithological composition of various rock types through which the ground water passes. Ground water pollution can be caused by artificial sources. During the study, Pre-monsoon samples were collected during May 2008 and post-monsoon samples were collected during January 2011.

Distribution of Electrical Conductivity

The Electrical conductivity is defined as the reciprocal of electrical resistance and it measures the ability of water to conduct electric current. It is an index of mineralization in ground water. BIS prescribes 500 mg/l of Total Dissolved Solids as desirable limit and 2000 mg/l as maximum permissible limit in the absence of any alternate source. These limits correspond to 750 and 3000 μs/cm at 25° of electrical conductivity respectively. The distribution of electric conductivity in the area during Pre-monsoon and Post-monsoon is presented as Fig 2 & Fig 3.

Distribution of Chloride

The distribution of Chloride in the study area during pre monsoon and post monsoon seasons are presented as Fig 4 and Fig 5. The perusal of these maps indicate that more concentration of chloride i.e. more than 1000ppm is observed in some area near the coast in Uppalaguptam, Sakhinetipalli and malikipuram mandals during pre-monsoon season. Similarly some area near to the coast in Katrenikona, Malikipuram, Uppalaguptam and I.Polavaram mandals have recorded chloride more than 1000ppm during post monsoon season also. The distribution of chloride in the area during Pre-monsoon and Post-monsoon is presented as Fig 4 & Fig 5.

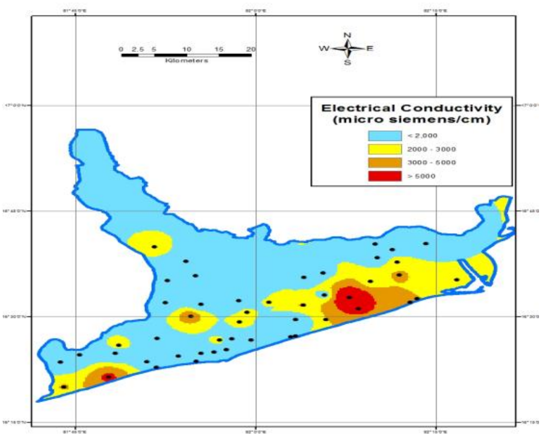

Fig. 2: Distribution of Electric Conductivity During Pre monsoon.

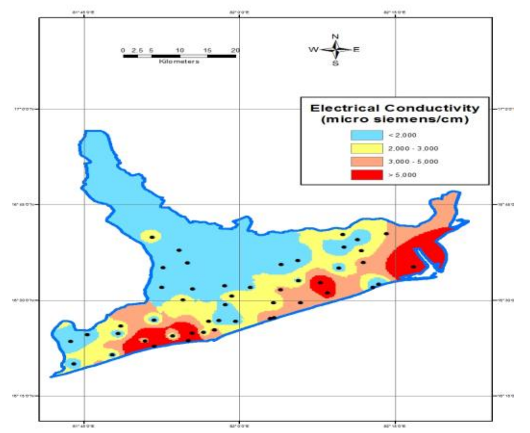

Fig. 3: Distribution of Electric Conductivity During Post monsoon.

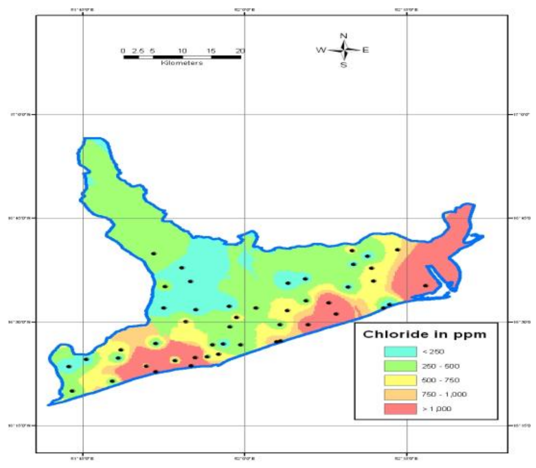

Fig. 4: Distribution of Chloride in the Study Area During Pre-monsoon Season.

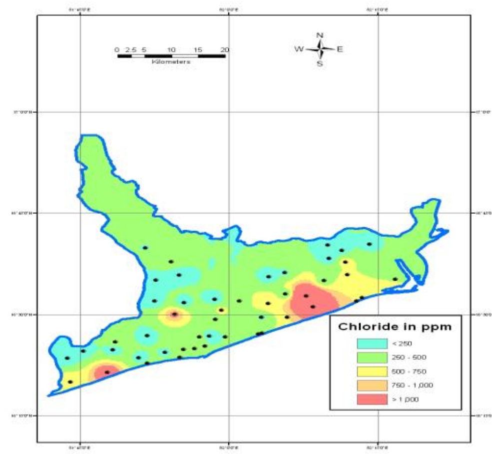

Fig. 5: Distribution of Chloride in the Study Area During Post-monsoon Season.

Distribution of Nitrate

The distribution of Nitrate in the pre monsoon and post monsoon seasons are presented in as Fig 6 and Fig 7. The perusal of these maps indicate that in most of the area the concentration of Nitrate is more than the maximum permissible limit of 45ppm during the pre-monsoon season where as during post monsoon season it is well within the permissible limits in most of the area.

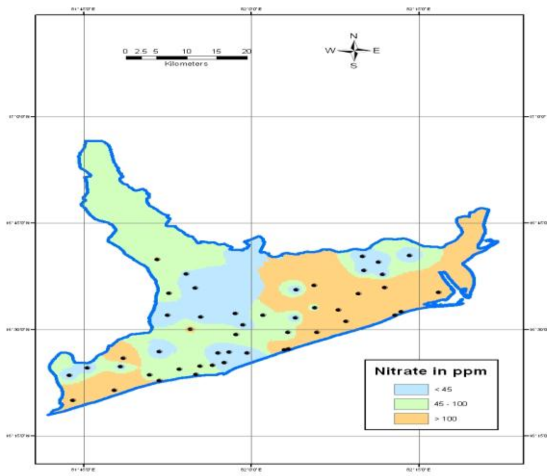

Fig. 6: Distribution of Nitrate in the Study Area During Pre-monsoon Season.

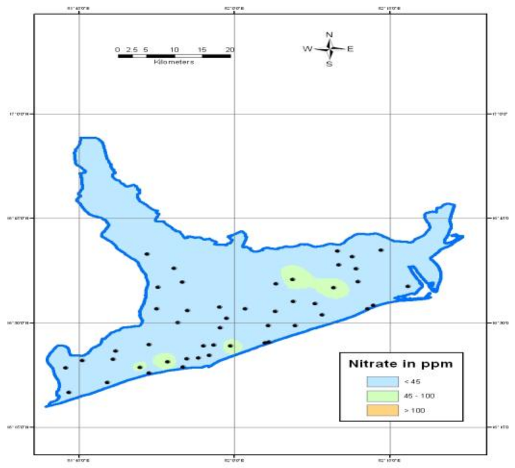

Fig. 7: Distribution of Nitrate in the Study Area During Post-monsoon Season.

Suitability of Shallow Ground Water for Domestic Purposes

In general, the quality of ground water from the shallow aquifer in the area is potable except in a small pockets around Katrenikona, Uppalaguptam, Malikipuram where the Electrical conductivity is more than 3000 micro siemens/cm at 25°C. Limits of this unsuitable area, where the quality of ground water in the phreatic aquifer is not potable, is always varying in shape and size depending on various factors major of which is the ground water abstraction for the purpose of irrigation because of less rainfall or less supply of canal water due to various reasons.

Suitability of Shallow Ground Water for Irrigation Purposes

The suitability of shallow ground water in this area for irrigation purposes is studied based on the sodium hazard based on sodium adsorption ratio and as well as percent sodium. The distribution of sodium adsorption ratio in the area during both pre monsoon and post monsoon seasons are presented as Fig 8 and Fig 9. The perusal of these maps indicate that the sodium adsorption ratio has crossed 15% in Uppalaguptam, Malikipuram, Razole Mandals during the pre monsoon season where as in the post monsoon season it has spread to more area. This type of situation is an indication that the variation is dependent on the agricultural activities which are less in summer than in the other seasons.

The distribution of percent sodium in the area during both the seasons is presented as Fig 10 and Fig 11. Some area in Sakhinetipalli, Malikipuram, Razole, Katrenikona and Uppalaguptam, mandals show percent sodium above 60% during pre monsoon season where as in the post monsoon season this area expands into a bigger area even covering some parts of I.Polavaram mandal.

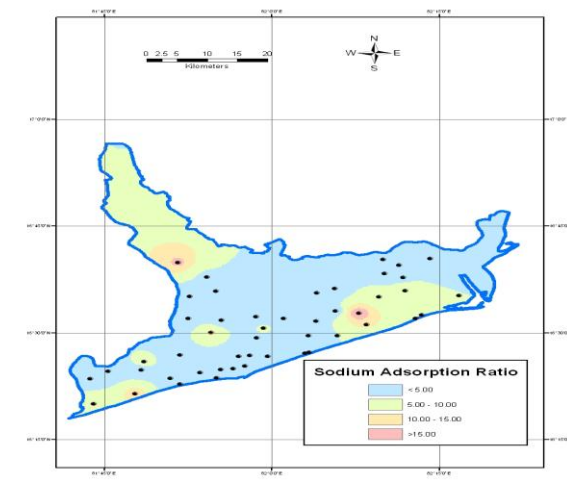

Fig. 8: Distribution of Sodium Adsorption Ratio in the Study Area During Pre-monsoon Season.

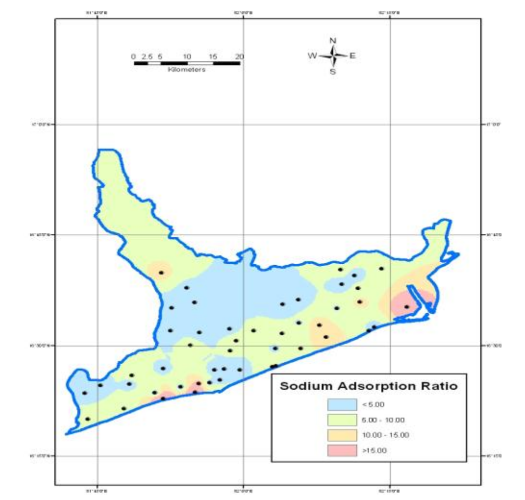

Fig. 9: Distribution of Sodium Adsorption Ratio in the Study Area During Post-monsoon Season.

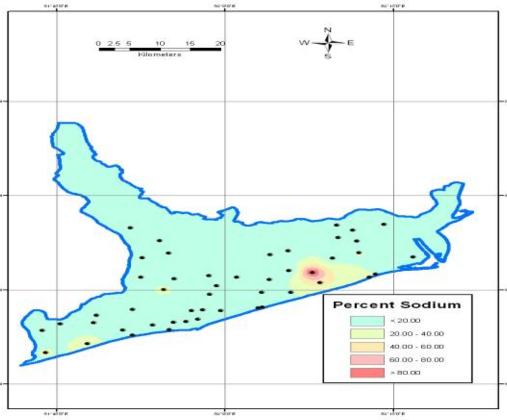

Fig. 10: Distribution of Percent Sodium in the Study Area During Pre-monsoon Season.

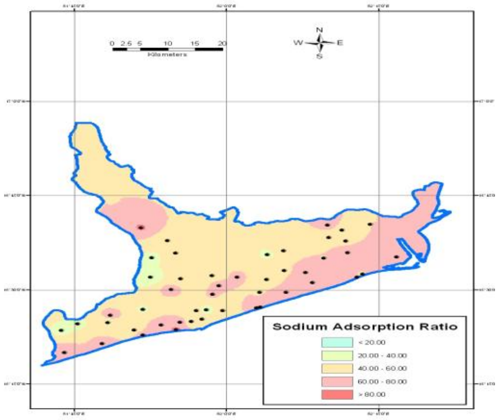

Fig. 11: Distribution of Percent Sodium in the Study Area During Post-monsoon Season.

The water samples analysed were classified using Piper Trilinear Diagram and majority of the samples were classified as NaK-ClSO4 type and the diagrams are presented as Fig 12& 13 and Fig 14 and 15.

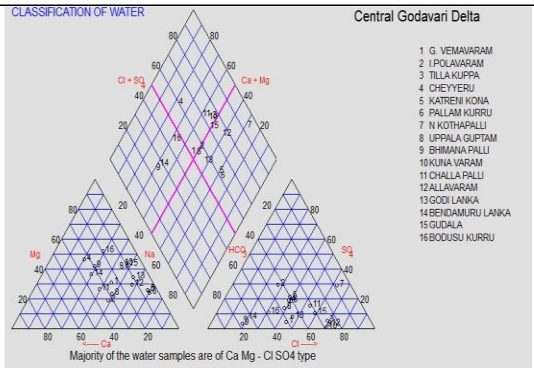

Fig. 12: Classification of Ground Water in the Study Area During Pre-monsoon.

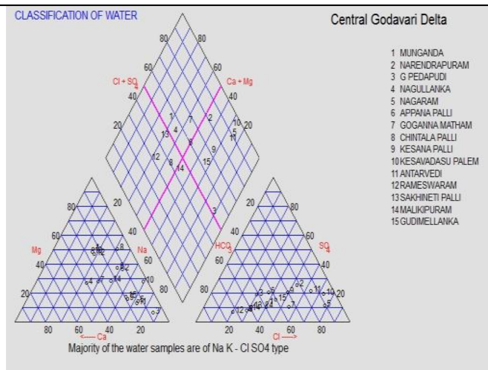

Fig. 13: Classification of Ground Water in the Study Area During Pre-monsoon.

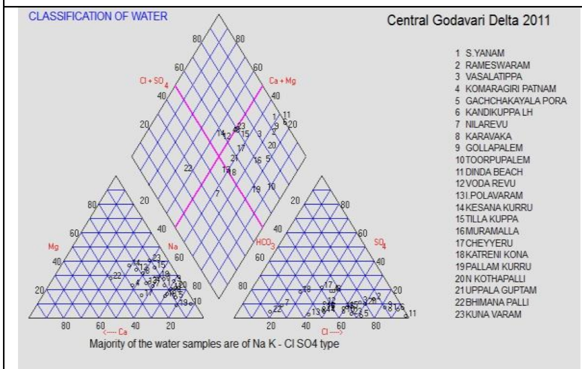

Fig. 14: Classification of Ground Water in the Study Area During Post-monsoon.

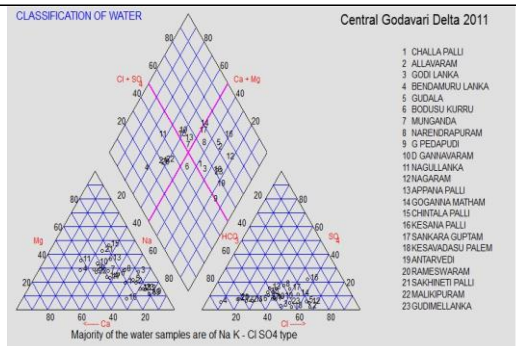

Fig. 15: Classification of Ground Water in the Study Area During Post-monsoon.

The Classification suggested by US Salinity Laboratory of these samples are presented as Fig 16 & 17 and Fig 18 & 19. These diagrams also reveal that the sodium adsorption ratio of these samples is less that 15 and the classification is mostly depending on the electrical conductivity.

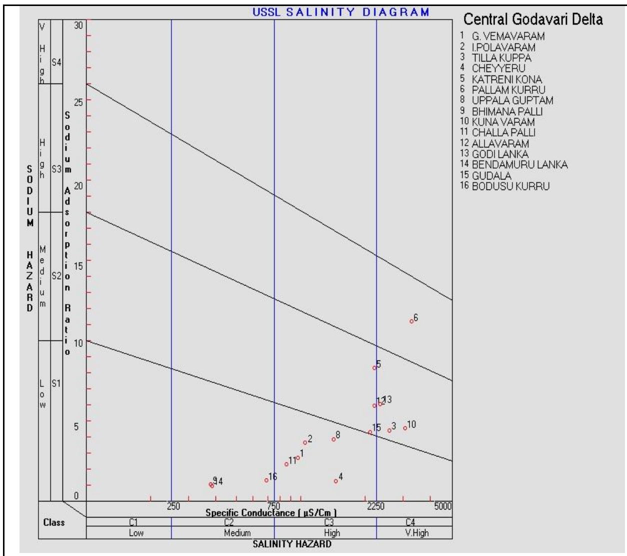

Fig. 16: Classification of Ground Water in the Study Area During Pre-monsoon.

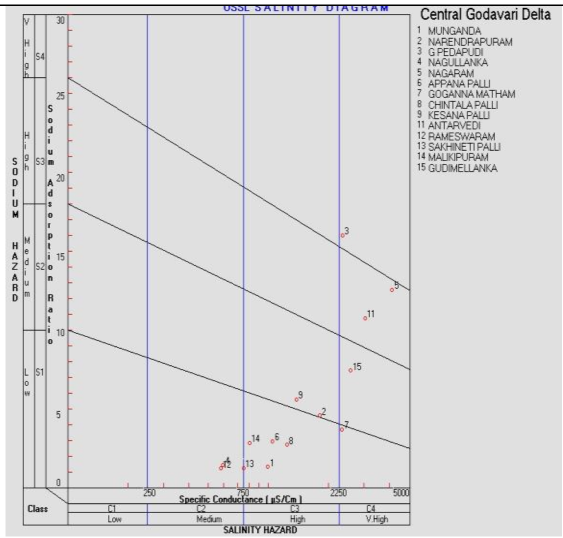

Fig. 17: Classification of Ground Water in the Study Area During Pre-monsoon.

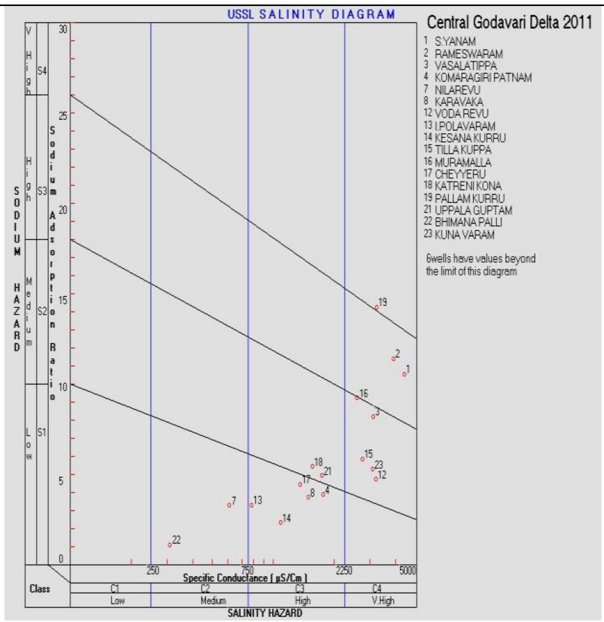

Fig. 18: Classification of Ground Water in the Study Area During Post-monsoon.

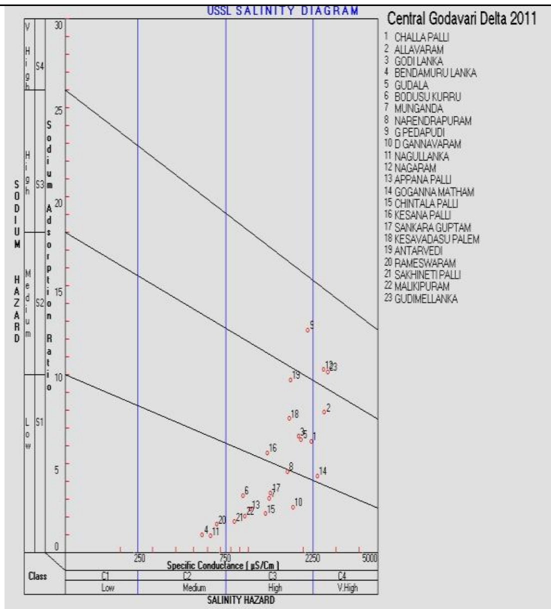

Fig. 19: Classification of Ground Water in the Study Area During Post-monsoon.

These samples were subjected to the classification suggested by Wilcox and the diagrams are presented as Fig 20 and Fig 21. These diagrams also reveal that the categorization is mostly dependant on the electrical conductivity.

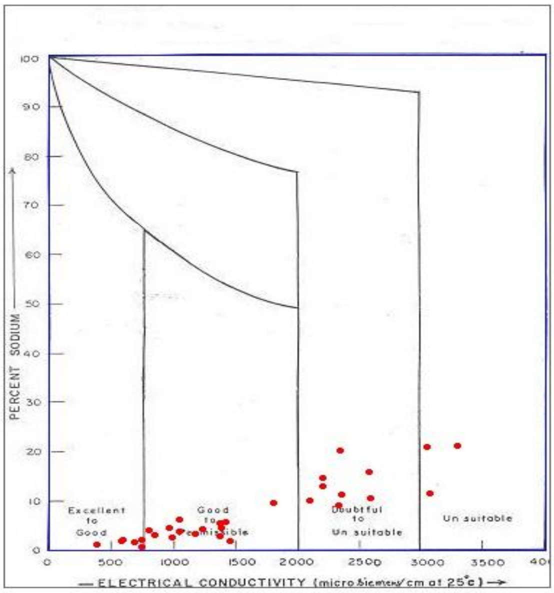

Fig. 20: Classification of Ground Water in the Study Area During Pre-monsoon (After Wilcox).

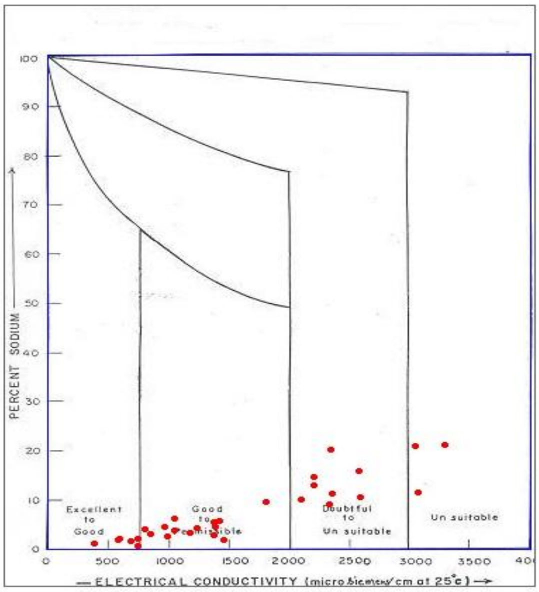

Fig. 21: Classification of Ground Water in the Study Area During Post-monsoon (After Wilcox).

CONCLUSIONS

Water levels in the area is in general in the range of 2-4m bgl except in small pockets where it is more than 4.0 m bgl near Lankala Gannavaram. Based on the recommendations of the Bureau of Indian Standards, the quality of ground water from the shallow aquifer in the area is potable except in a small pocket around Katrenikona, Uppalaguptam, Malikipuram where the Electrical conductivity is more than 3000 micro siemens/cm at 25°C. Some area in Sakhinetipalli, Malikipuram, Razole, Katrenikona and Uppalaguptam, mandals show percent sodium above 60% during pre monsoon season where as in the post monsoon season this area expands into a bigger area even covering some parts of I.Polavaram mandal. The perusal of these maps indicate that more concentration of chloride i.e. more than 1000ppm is observed in some area near the coast in Uppalaguptam, Sakhinetipalli and malikipuram mandals during pre-monsoon season. Ground water unsuitability for irrigation purpose mostly depends on the electric conductivity rather than the percent sodium or sodium adsorption ratio. The variation in electric conductivity also has a relation with the proximity to sea. Hence the suitability of the ground water has a direct relation with the proximity of sea and impact of sea water mixing. Hence there is an urgent need for monitoring the fresh water - saline water interface by constructing purpose built observation wells with predefined monitoring parameters of level and quality with reference to depth. To assess the interface on a regular basis and prepare more robust ground water management plans for this area.

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