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# Assessment of groundwater suitability for irrigation purpose: a case study of Narsapur-Mogalthur mandals, West Godavari district, Andhra Pradesh, India

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***Abstract:*** *It is known that the groundwater quality is very important parameter because it is the main factor determining its suitability for drinking, agricultural and industrial purposes. In order to assess the groundwater quality, groundwater samples have been collected from different locations in the study area of Narsapur-Mogalthur mandals, west godavari district, Andhra Pradesh, India. The water samples collected from different locations were analyzed for pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), major cations like calcium, magnesium, sodium, potassium and anions like chloride, nitrate and sulphate in the laboratory using the standard methods given by the American Public Health Association* ***(APHA, 2005).****The results are analyzed with standards given by central soil salinity research institute (CSSRI). Based on these analyses parameters like sodium adsorption ratio (SAR), sodium percentage, residual sodium carbonate (RSC) was calculated. Sodium adsorption ratio is shown 85% of groundwater samples are good for irrigation and only 15% are unsuitable indicating high salinity and low alkali water. Residual sodium carbonate (RSC) values suggesting safe to marginally suitable category for irrigation purposes. The overall quality of water in the study area is somewhat good for all constituents.*

***Key words:*** *Ground water quality, Irrigation, Total dissolved solids. Sodium adsorption ratio, Electrical conductivity, Residual sodium carbonate, Salinity*

## I. Introduction

Groundwater forms one of the important resources for developmental activities. In recent times, there has been tremendous demand for ground water due to population growth and intensive agricultural activities. So, groundwater is gaining more and more importance in India owing to the ever increasing demand for water supplies, especially in areas with inadequate surface water supplies. Groundwater is the primary source of water for human consumption, as well as for agriculture and industrial uses in many regions all over the world. Groundwater quality is the physical and chemical characterization of groundwater, which measures its suitability for human and animal consumption, irrigation and other purposes. The water composition is modified by the chemical comparison of the water that enters in to the ground water reservoir and reacts with the minerals present in the rocks and soils. Groundwater quality is controlled by both the natural and human activities. Contamination by different pollutants, mainly due to the intense agricultural and urban development, has placed the whole environment at greater risk. The quality of groundwater in agricultural area is sensitive to the contaminations originated from the agricultural chemicals and runoffs from aqua cultural ponds. An understanding of the quality of water used for irrigation and its potential negative impacts on crop growth is essential to avoid problems and to get good production. The chemical investigation of groundwater allows us to obtain important information on chemical weathering of rocks also. The quality of groundwater is an important criterion to decide the water for irrigation activities for this we have to investigate various parameters such as sodium percentage (%$Na^+$), sodium adsorption ratio (SAR), and residual sodium carbonate (RSC), by the results we may assess the suitability of water for irrigation purpose.

## II. Study area

The study area is situated in east cost of Andhra Pradesh consisting Narsapur-Mogalthur mandals. The area lies between longitudes 81°20' to 81°50' E and latitudes 16°15' to 16°35' N. The monitoring network in the study area consists of 39 bore wells and 39 tube wells. A total of 78 water samples are collected from the study area and analyzed during pre and post- monsoon seasons of 2012-14 to understand the behavior of ground water quality, suitability for irrigation. The average annual rainfall in the study area is about 720 mm. These areas get most of its seasonal rainfall from the south west monsoon. The main dominant occupation of the people is agriculture and aqua culture the main crops grown are paddy, sugarcane, groundnut, millets etc.

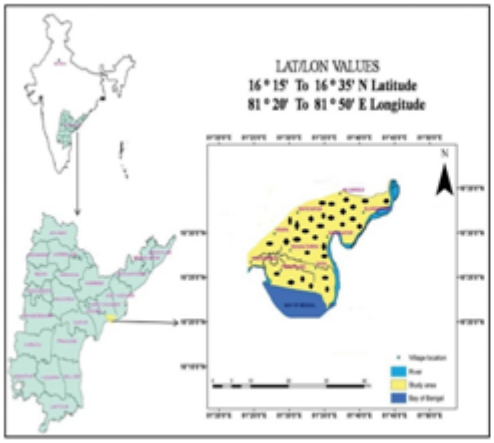


**Fig.1.** Location map of the study area

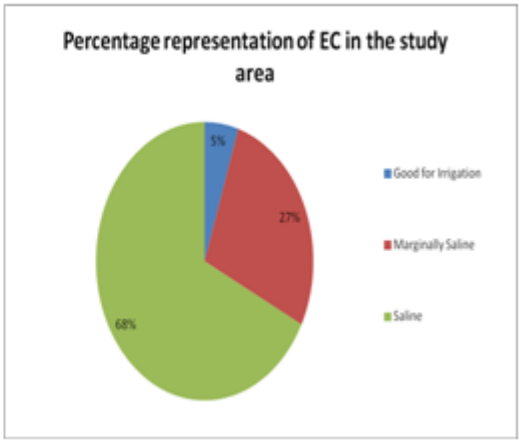


**Fig.2** Percentage representation of EC in the study area

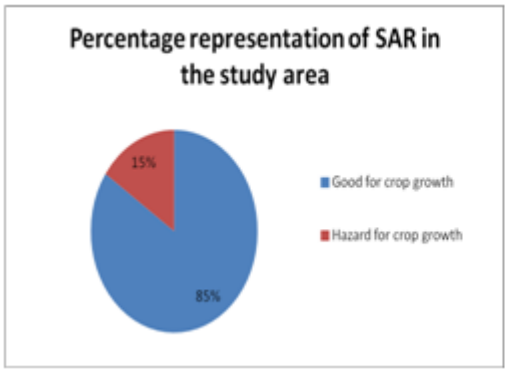


**Fig. 3** Percentage representation of SAR in the study area

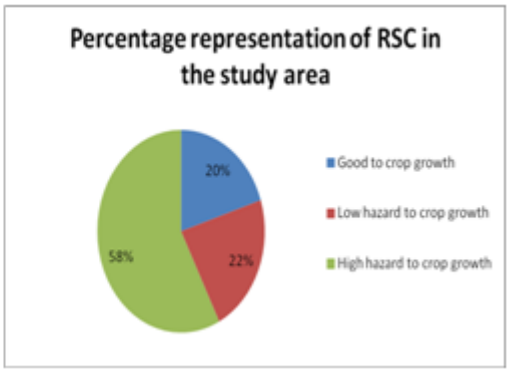


**Fig.4** Percentage representation of RSC in the study area

## III. Materials And Methods

Groundwater samples were collected from the bore wells, tube wells following the standard guidelines and analyzed for various chemical parameters as described by the American Public Health Association (APHA). These parameters include hydrogen ion concentration (pH), electrical conductivity (EC) and important cations such as calcium ($Ca^{2+}$), magnesium ($Mg^{2+}$),sodium ($Na^{+}$), potassium($K^{+}$) as well as anions such as carbonates ($CO_3^{2-}$), bicarbonates ($HCO_3^{-}$ ), chlorides ($Cl^{-}$) and sulphates ($SO_4^{2-}$). The PH and EC values were measured in using a pH meter and conductivity meter.. The reagents, including indicators and buffers, were of analytical grade (Merck). The aqueous solutions were prepared, using double distilled deionized water. The glassware employed in this study was of Borosil (India) grade. The standardization of reagents and solutions was in accordance with standard methods of water chemical analysis.

The important factors that influence the irrigation water quality are salt and sodium concentrations as represented by Electrical Conductivity (EC), Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC). Excessive amount of salt in general and sodium in particular affect the soil permeability, soil structure and create toxic condition for plants. Sodium in the irrigation water is generally taken up by the clays in return of Calcium and Magnesium due to ion exchange. In the present study, assessment of groundwater suitability for irrigation is studied based on central soil salinity research institute (CSSRI) standards.

## IV. Results And Discussion

**Electrical Conductivity (EC)**

Electrical conductivity-EC (µS/cm) of ground water is a measure concerned with the salinity indices. These groundwater samples are showing moderate to high salinity, thus may be considered as suitable for irrigation.

In the present study, the values of electrical conductivity of groundwater as per CSSRI is presented in Table 1. The results of the above study revealed that EC of the water samples varied from 1.0 to 11.1 $\mu sm^{-1}$. Only two ground water locations Rajugarithota, Jagannathapuram shows EC<2 suitable for irrigation, 11 locations namely Kothota, Royapeta, Rustumbada, Narsapur, Chamakuripalem, Saripalle, Pedalanka, Lingaboinacherla, Dharbarevu, Perupalem, Pedamainavanilanka shows marginally saline with respect to EC.

About 27 locations like Pathapadu, Navarasapuram, Komatithippa, Varathippa, Yerramsettivaripuram, Seetharamapuram North, Seetharamapuram South, Rajugarithota, Ramannapalem, Seripalem come under Saline category with respect to EC. This was shown in Table 2. The pie diagram Fig.2 shows the representation of classification of different water locations with respect to EC for irrigation suitability.

| S.NO. | Water sample location | SAR $(mmolL^{-1})^{1/2}$ | RSC $(meL^{-1})$ | Cl (mg/l) | EC $\mu sm^{-1}$ |
|---|---|---|---|---|---|
| 1 | Perupalem | 11.4 | -7.48 | 250 | 2.5 |
| 2 | Pedamainavanilanka | 7.8 | 0.61 | 196 | 2.5 |
| 3 | Biyyaputippa | 1.5 | -7.61 | 216 | 2.5 |
| 4 | Dharbarevu | 10.0 | -5.3 | 209 | 2.5 |
| 5 | Thurputallu | 1.7 | -3.67 | 513 | 4.5 |
| 6 | Vemuladeevi East | 2.2 | -5.82 | 335 | 6.1 |
| 7 | Sarva | 12.7 | -5.12 | 524 | 7.6 |
| 8 | Lakshmaneswaram | 14.7 | -3.22 | 347 | 6.5 |
| 9 | Lingaboinacherla | 1.1 | -6.63 | 382 | 3.1 |
| 10 | Pedalanka | 0.7 | -5.52 | 284 | 2.5 |
| 11 | Saripalle | 2.2 | -7.34 | 330 | 3.0 |
| 12 | Pasaladeevi | 2.1 | -5.7 | 301 | 5.6 |
| 13 | Chamakuripalem | 7.9 | -2.28 | 258 | 2.6 |
| 14 | Gondi | 1.6 | -3.29 | 298 | 5.0 |
| 15 | Narsapur | 8.9 | -2.56 | 262 | 2.5 |
| 16 | Rustumbada | 6.0 | -1.62 | 319 | 3.8 |
| 17 | Royapeta | 2.6 | -2.81 | 241 | 2.3 |
| 18 | Mallavaram | 4.2 | -2.44 | 292 | 4.4 |
| 19 | Likithapudi | 4.4 | -5.04 | 328 | 4.2 |
| 20 | Koparru | 3.7 | -6.28 | 431 | 9.4 |
| 21 | K.bethapudi | 11.0 | -4.7 | 160 | 9.9 |
| 22 | Modi | 6.9 | -2.16 | 146 | 7.0 |
| 23 | K.p.palem | 5.7 | -2.01 | 97 | 4.2 |
| 24 | Mutyalapalli | 6.3 | -4.34 | 225 | 5.2 |
| 25 | Kothota | 6.4 | 0.18 | 99 | 4.0 |
| 26 | Kalipatnam | 5.3 | -7.88 | 438 | 9.8 |
| 27 | Moglthur | 2.6 | -5.79 | 208 | 6.9 |
| 28 | Moglthur-I | 1.2 | -7.02 | 283 | 7.9 |
| 29 | Seripalem | 11.6 | -4.85 | 270 | 7.0 |
| 30 | Ramannapalem | 2.2 | -3.78 | 285 | 8.0 |
| 31 | Rajugarithota | 10.2 | 10.97 | 309 | 1.0 |
| 32 | Seetharamapuram South | 5.9 | 13.39 | 324 | 9.1 |
| 33 | Seetharamapuram North | 2.6 | -2.85 | 470 | 11.1 |
| 34 | Yerramsettivaripuram | 1.3 | -3.75 | 352 | 8.1 |
| 35 | Varathippa | 4.5 | 14.9 | 376 | 9.7 |
| 36 | Komatithippa | 2.4 | -5.46 | 283 | 5.8 |
| 37 | Jagannathapuram | 9.6 | -6.46 | 230 | 1.1 |
| 38 | Navarasapuram | 4.3 | -5.89 | 285 | 6.1 |
| 39 | pathapadu | 2.8 | -4.09 | 333 | 10.5 |

**Table 1** SAR, RSC, Cl, ECvalues of Groundwater Samples of study area for Irrigation suitability as per CSSRI

| Name of the locations in the study area | Range of Electrical Conductivity (EC) $\mu sm^{-1}$ | Result |
|---|---|---|
| Rajugarithota, Jagannathapuram | EC<2 | Good for Irrigation |
| Kothota, Royapeta, Rustumbada, Narsapur, Chamakuripalem, Saripalle, Pedalanka, Lingaboinacherla, Dharbarevu, Perupalem, Pedamainavanilanka | 2<EC>4 | Marginally Saline |
| Pathapadu, Navarasapuram, Komatithippa, Varathippa, Yerramsettivaripuram, Seetharamapuram North, Seetharamapuram South, Rajugarithota, Ramannapalem, Seripalem, Moglthur-I, Moglthur, Kalipatnam, Mutyalapalli, K.p.palem, Modi, K.bethapudi, Koparru , Likithapudi, Mallavaram, Gondi, Pasaladeevi, Lakshmaneswaram, Sarva, Vemuladeevi East, Thurputallu, Biyyaputippa, | EC>4 | Saline |

**Table 2** Classification of Groundwater locations as per Electrical Conductivity (EC) for Irrigation suitability as per CSSRI

**Index of chlorinity:**

Chloride shows the sensitivity towards the crops with low salt tolerance limit. The index concerned with the concentration of chloride ions in the groundwater (Table 3). Majority of the samples (~98% in pre and 97% in post monsoon season) fall in category-I and II showing suitability towards irrigation, whereas about 1%,0.8% samples fall in category -III, respectively. None of the samples fall under category V showing the not suitability for any crop field irrigation which is in support of salinity index result.

| S.No. | $Cl^-$ Concentration | Category | Result/Remarks |
|---|---|---|---|
| 1 | <350mg/l | I | Applicable towards all crops. |
| 2 | 350 to 750mg/l | II | Applicable to crops with salt tolerance at High-medium-low rank. |
| 3 | 700 to 900mg/l | III | Applicable to crops with salt tolerance at high-medium rank. |
| 4 | 900 to 1300mg/l | IV | Applicable to crops with salt tolerance at high rank. |
| 5 | >1300mg/l | V | Not recommended for irrigation. |

**Table 3** Ground water suitability classes for irrigation according to the chloride concentration

**Sodium Adsorption Ratio (SAR) and its significance:**

Excessive amount of salt in general and sodium in particular affect the soil permeability, soil structure and create toxic condition for plants. In the present study, the classification of groundwater with respect to SAR as per CSSRI is presented in Table 1. The results of the study revealed that revealed that SAR of the water samples varied from 0.7 to 14.7 mmoles $L^{-1}$. Out of 39 locations, six namely Perupalem, Rajugarithota, Seripalem, K.bethapudi, Sarva, Lakshmaneswaram shows sodium hazard with respect to SAR. The remaining thirty three locations shows good water for crop as per SAR. This was shown in table 4. The pie diagram Fig3 shows the representation of classification of different waters with respect to SAR for irrigation suitability.

| Name of the locations in the study area | Range of Sodium Adsorption Ratio (SAR) | Result |
|---|---|---|
| Pedamainavanilanka, Biyyaputippa, Dharbarevu, Seetharamapuram South, Seetharamapuram North, Yerramsettivaripuram, Varathippa, Komatithippa, Jagannathapuram Navarasapuram, pathapadu, Ramannapalem, Modi, K.p.palem, Mutyalapalli, Kothota, Kalipatnam, Moglthur, Moglthur-I, Lingaboinacherla, Pedalanka, Saripalle, Pasaladeevi, Gondi, Chamakuripalem, Narsapur, Rustumbada, Royapeta, Mallavaram, Likithapudi, Koparru, Thurputallu, Vemuladeevi East. | SAR<10 | Good for crop growth |
| Perupalem, Rajugarithota, Seripalem, K.bethapudi, Sarva, Lakshmaneswaram. | SAR>10 | Hazard for crop growth |

**Table 4** Classification of Groundwater locations as per Sodium Adsorption Ratio (SAR) for Irrigation suitability as per CSSRI

**Residual Sodium Carbonates (RSC) and its significance:**

The water with high Residual Sodium Carbonate (RSC) has high pH and land irrigated by such waters becomes infertile owing to deposition of sodium carbonate as known from the black colour of the soil. Further, continued usage of high RSC waters affects crop yields. The RSC value less than 2.5 is safe for irrigation, a value between (2.5-4.0) is of margin quality and a value greater than 4.0 is unsuitable for irrigation. Further the value of RSC is negative at indicating that there is no complete precipitation of calcium and magnesium.

In the present study, the classification of groundwater with respect to RSC as per CSSRI is presented in Table 1. The results of the above study revealed that RSC of the samples varied from -7.78 to 13.39me$L^{-1}$. Out of 39 ground water locations 8 locations like Pedamainavanilanka, Biyyaputippa, Chamakuripalem, Rustumbada, Mallavaram, Modi, K.p.palem, Kothota shows RSC<2.5 indicating 'Good to crop growth'. The 23 locations namely Perupalem, Dharbarevu, Vemuladeevi East, Sarva, Lingaboinacherla, Pedalanka, , Saripalle, Pasaladeevi, Likithapudi, Koparru, K.bethapudi, Mutyalapalli shows high hazard to crop growth with respect to RSC and the remaining seven stations namely Thurputallu, Lakshmaneswaram, Gondi, Narsapur, Royapeta, Ramannapalem, Seetharamapuram North, Yerramsettivaripuram comes under low hazard condition. The classification was shown in Table 5. The pie diagram Fig.4 shows the representation of classification of different waters with respect to RSC for irrigation suitability.

| Name of the locations in the study area | Range of Residual Sodium Carbonate (RSC) | Result |
|---|---|---|
| Pedamainavanilanka, Biyyaputippa, Chamakuripalem, Rustumbada, Mallavaram, Modi, K.p.palem, Kothota | RSC<2.5 | Good to crop growth |
| Thurputallu, Lakshmaneswaram, Gondi, Narsapur, Royapeta, Ramannapalem, Seetharamapuram North, Yerramsettivaripuram | 2.5<RSC<4 | Low hazard to crop growth |
| Perupalem, Dharbarevu, Vemuladeevi East, Sarva, Lingaboinacherla, Pedalanka, , Saripalle, Pasaladeevi, Likithapudi, Koparru, K.bethapudi, Mutyalapalli, Kalipatnam, Moglthur, Moglthur-I, Seripalem, Rajugarithota, Seetharamapuram South, Varathippa, Komatithippa, Jagannathapuram, Navarasapuram, Pathapadu | RSC>4 | High hazard to crop growth |

**Table 5** Classification of Groundwater locations as per Residual Sodium Carbonate (RSC) for Irrigation suitability as per CSSRI

## V. Conclusion:

The chemical analysis reveals that the groundwater in the study area is better for irrigation except in some locations. The occurrence of high EC values in the study area reflected the addition of some salts through the prevailing agricultural activities or runoffs from aqua cultural ponds. About 18.75% samples are in good line and 62.50% samples are permissible for irrigation with little danger of exchangeable sodium. Ground water of the study area contained desirable level percentage Na, SAR value for irrigation, indicated there would not be any possibility sodicity hazards from irrigation using ground water. But ground water of the study area was moderately hard. However, SAR and RSC values indicate that almost all the groundwater samples are suitable for irrigation.

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