# GIS Mapping of Groundwater Quality for Irrigation in Badhra Block of Charkhi Dadri District, Haryana, India

**Rajpaul Yadav*., Anuj., Pankaj Kumar., Sarita Rani, and Ram Prakash**

**Department of Soil Science, CCS Haryana Agricultural University, Hisar, India-125004**

***Corresponding Author**

**DOI: https://doi.org/10.51244/IJRSI.2026.13010161**

**Received: 24 January 2026; Accepted: 29 January 2026; Published: 10 February 2026**

## ABSTRACT

Groundwater represents an important resource for sustaining life.The study was conducted to evaluate groundwater in the Badhara block of Charkhi Dadri District of Haryana. GIS was used to show the spatial distribution of water quality parameters. During the study 61groundwater samples were collected from different location were estimated for sodium concentration (Na %) and sodium absorption ratio (SAR) and Residual sodium carbonate (RSC). According to the distribution map of irrigation water quality as per AICRP classification about 54% samples were found Good, 8% samples under Marginally saline and 6% water samples were classified under High SAR saline category, 22.9% water samples were categorized as Marginally alkali. The result of study indicated that the groundwater quality in the study area is mostly suitable for irrigation purpose**.**

**Key words:** Electrical conductivity, Residual Sodium Carbonate, SAR

## INTRODUCTION

maintaining groundwater quality has become essential because water is the basis of life. In recent years there has been significant decline in the groundwater quality (Gupta *et al*., 1994). In most of the arid and semi-arid region of the country and south-eastern parts of Haryana, the farmer use poor quality groundwater, due to limited availability of canals as well as good quality groundwater for sustainable crop production. The exploitation and contamination with numerous chemical and biological sources has lead to retreating of worldwide surface water sources thereby increasing tremendous pressure on groundwater resources (Singh *et al*., 2006; Bhat *et al*., 2016). The quality of groundwater encompasses the physical, chemical and biological features of groundwater. The suitability of groundwater for different uses mainly reckons on its quality, therefore, evaluation of groundwater is a major concern (Packialakshmi *et al*., 2011). In the Haryana state, on an average 37 per cent of tube-wells waters are of good, 8 per cent normal and 55 per cent waters are of poor quality. Amongst poor quality water 11 per cent saline, 18 per cent sodic and 26 per cent saline-sodic in nature (Manchanda, 1976). The quality of water for agricultural purposes is ascertained by examining the effect of water on superiority and yield of the crops in addition to distinctive changes in the soil (FAO, 1985; Zinabu *et al.*, 2010). The quality of groundwater depends upon distinct natural (precipitation, rock-water interaction, geology, geomorphology etc) and anthropogenic (agriculture, industry, domestic, land use etc.) activities that eventually make the groundwater vulnerable. Vulnerability is the characteristic of the aquifer to receive and carry contaminant from anthropogenic sources (Vrba and Zoporozec, 1994; Adhikary *et al*., 2014). Keeping in view the aforementioned facts, the present study was undertaken to evaluate the quality of groundwater for irrigation purposes in Badhra block of district Charkhi Dadri, Haryana.

## MATERIALS AND METHODS

The study area is surrounded by Mahendergarh, Rohtak, Bhiwani and Jhajjar district. The climate of the study area falls under arid to semiarid. which is mainly dry with very hot summer and cold winter except during monsoon season when moist air of oceanic origin penetrates into the district. The soils of the block are sandy to

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue I January 2026

sandy loam in texture. The dominating cropping system in this region cotton-wheat and pearlmillet -mustard under sprinkle irrigation the other main crops grown in the area are jawar, greengram and culsterbean in kharif and gram in rabi season.

In order to assess water quality of the study area, 61 groundwater samples were collected to cover the entire study area and locations were recorded using hand held GPS. The location map of the sampling point is presented in Figure 1.

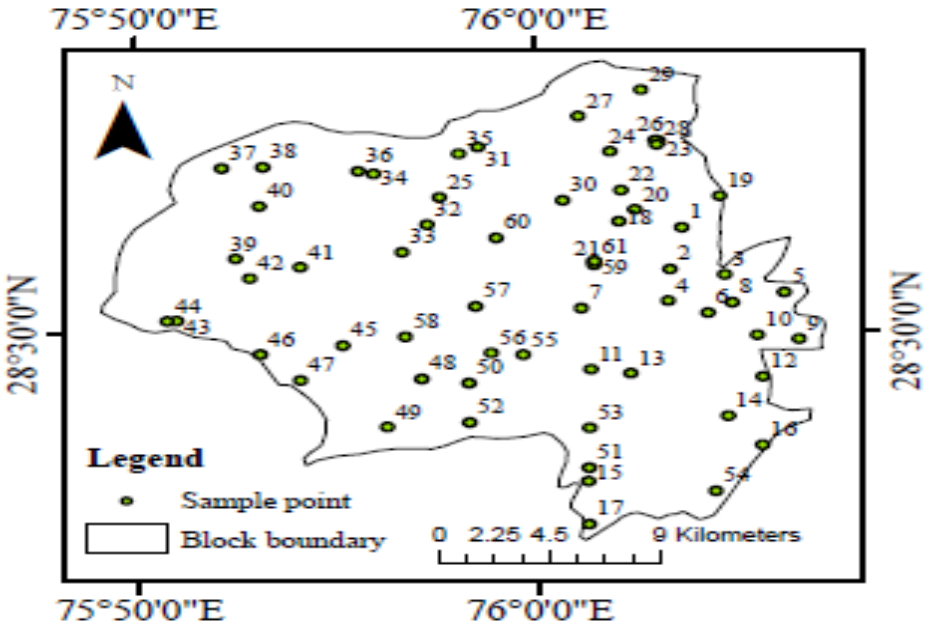


Figure-1 Location map of sampling point of Badhra block

Sampling was carried out using pre-cleaned plastic bottles, which were rinsed thrice with sample water prior to sample collection. Before analysis of groundwater, the instruments were calibrated in accordance with the manufacturer's recommendations. The chemical analysis was accomplished as per the standard methods relevant to the analysis of groundwater (Table1). Electrical Conductivity (EC) was measured by conductivity meter and pH by pH meter. Sodium ($Na^+$) and potassium ($K^+$) were measured by flame photometer. Calcium and magnesium were determined with standard EDTA solution titrimetrically. Carbonate and bicarbonate were estimated by titration with $H_2SO_4$, Chloride by titrating against standard silver nitrate ($AgNO_3$) solution. The colorimetric analysis of sulphate and nitrate was done by spectrophometer.

Table-1. Methods used for estimation of different water quality parameters of groundwater in the study area

| **Parameters** | **Method used** |
|---|---|
| pH | Glass electrode (Richards, 1954) |
| EC (Electrical Conductivity) | Conductivity Bridge method (Richards, 1954) |
| $Na^+$ (Sodium) | Flame Photometric method (Osborn and Johns, 1951) |
| $K^+$ (Potassium) | Flame Photometric method (Osborn and Johns, 1951) |
| $Ca^{2+}$ (Calcium) | EDTA titration method (Richards, 1954) |
| $Mg^{2+}$ (Magnesium) | EDTA titration method (Richards, 1954) |
| $CO_3^{2-}$ (Carbonate) | Acid titration method (Richards, 1954) |

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue I January 2026

| | |
|---|---|
| $HCO_3^-$(Bicarbonate) | Acid titration method (Richards, 1954) |
| $Cl^-$ (Chloride) | Mohr's titration method (Richards, 1954) |
| $NO_3^-$ (Nitrate) | Spectrophotometric method (Richards, 1954) |
| $SO_4^{2-}$ (Sulphate) | Turbidity method using $CaCl_2$(Chesnin and Yien, 1950) |

The water quality indices viz., SAR (Richards, 1954) and RSC (Eaton, 1950) are calculated as:

a) $$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

b) $$RSC\left(meq\ l^{-1}\right) = \left(HCO_3^- + CO_3^{2-}\right) - \left(Ca^{2+} + Mg^{2+}\right)$$

Based on EC, SAR and RSC, water samples were classified into different categories as per the classification of All India Coordinated Research Project (AICRP) on management of salt affected soils and use of saline water in agriculture (Gupta *et al*., 1994) Table 2.

Table-2: Criteria for water quality classification (AICRP, 1989)

| **Quality** | **EC (dS $m^{-1}$)** | **SAR (mmol $L^{-1})^{1/2}$** | **RSC (me $L^{-1}$)** |
|---|---|---|---|
| Good | <2 | <10 | <2.5 |
| Marginally saline | 2-4 | <10 | <2.5 |
| Saline | >4 | <10 | <2.5 |
| High SAR - saline | >4 | >10 | <2.5 |
| Marginally alkali | <2 | <10 | 2.5-4.0 |
| Alkali | <2 | <10 | >4.0 |
| Highly alkali | Variable | >10 | >4.0 |

## RESULTS AND DISCUSSION

In the Badhra block, the electrical conductivity (EC) of the water samples ranged from 0.31 to 9.62 $dSm^{-1}$ with a mean of 1.76 $dSm^{-1}$ (Table 3).

Table-3: Range and mean of different water quality parameters of Badhra block

| S.No | Quality Parameter | Range | Mean |
|---|---|---|---|
| 1 | pH | 7.4-8.86 | 7.93 |
| 2 | EC (dS $m^{-1}$) | 0.31-9.62 | 1.76 |
| 3 | RSC (me $l^{-1}$) | 0.00-3.90 | 1.16 |

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue I January 2026

| | | | |
|---|---|---|---|
| 4 | SAR (m mol $l^{-1})^{1/2}$ | 3.23-35.00 | 8.77 |
| 5 | $Ca^{2+}$ (me $l^{-1}$) | 0.20-7.30 | 0.93 |
| 6 | $Mg^{2+}$ (me $l^{-1}$) | 0.60-14.90 | 2.36 |
| 7 | $Na^{+}$ (me $l^{-1}$) | 2.50-76.32 | 13.68 |
| 8 | $K^{+}$ (me $l^{-1}$) | 0.01-3.20 | 0.61 |
| 9 | $CO_3^{2-}$ (me $l^{-1}$) | 0.00-3.20 | 0.58 |
| 10 | $HCO_3-$ (me $l^{-1}$) | 0.20-6.90 | 2.85 |
| 11 | Cl– (me $l^{-1}$) | 2.20-80.50 | 11.87 |
| 12 | $SO_4-$ (me $l^{-1}$) | 0.90-32.10 | 1.75 |

The spatial distribution of EC in the Badhra block, a spatial variability map was prepared by using Arc GIS through the interpolation of the available data at 61 sampling points (Figure 2)

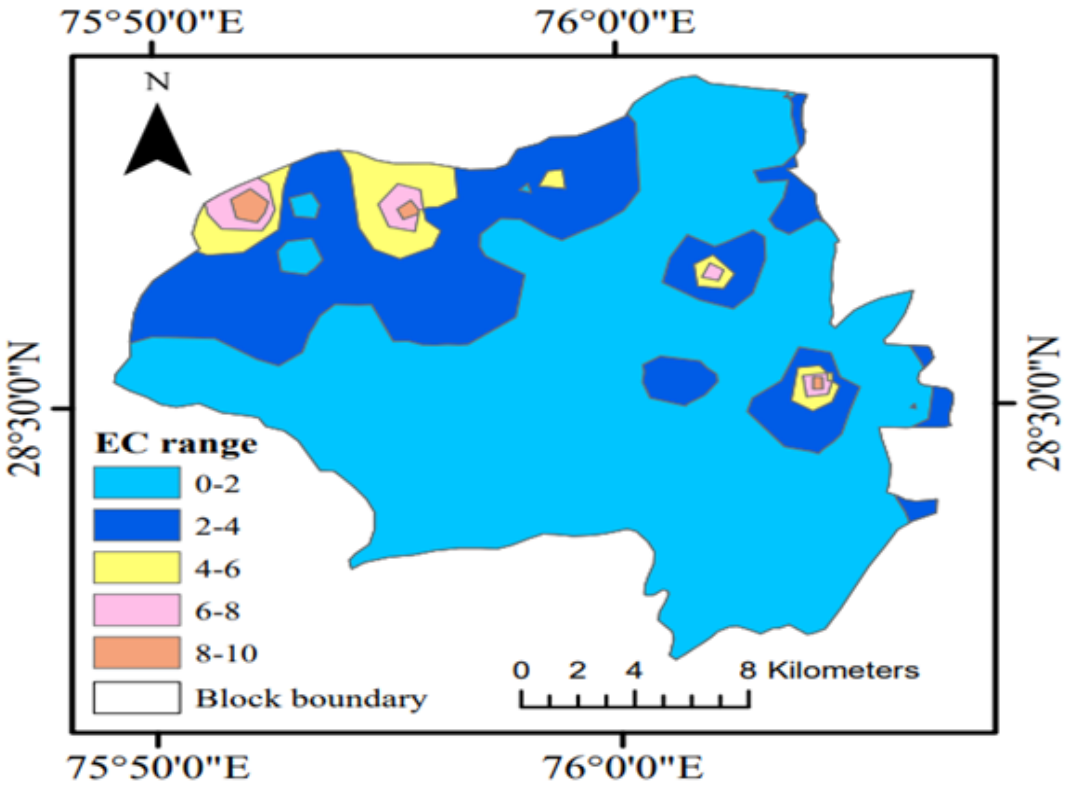


Figure-2 Spatial variability map of EC of Badhra Block

The pH of the water samples ranged from 7.40 to 8.83 with a mean of 7.93 in the study area. The spatial variability map of pH if presented in Figure 3. Bhat *et al.* (2016) reported pH in range of 7.19 - 9.72 in Gohana block of Sonipat district. Kumar *et al.* (2013) reported that EC varied from 0.79-9.38 $dSm^{-1}$ in Lakhan Majra Block of Rohtak district. Gagandeep *et al.* (2017) reported that the mean chemical composition and related quality parameters in different EC classes of block Palwal and percent distribution of sample in different EC classes.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue I January 2026

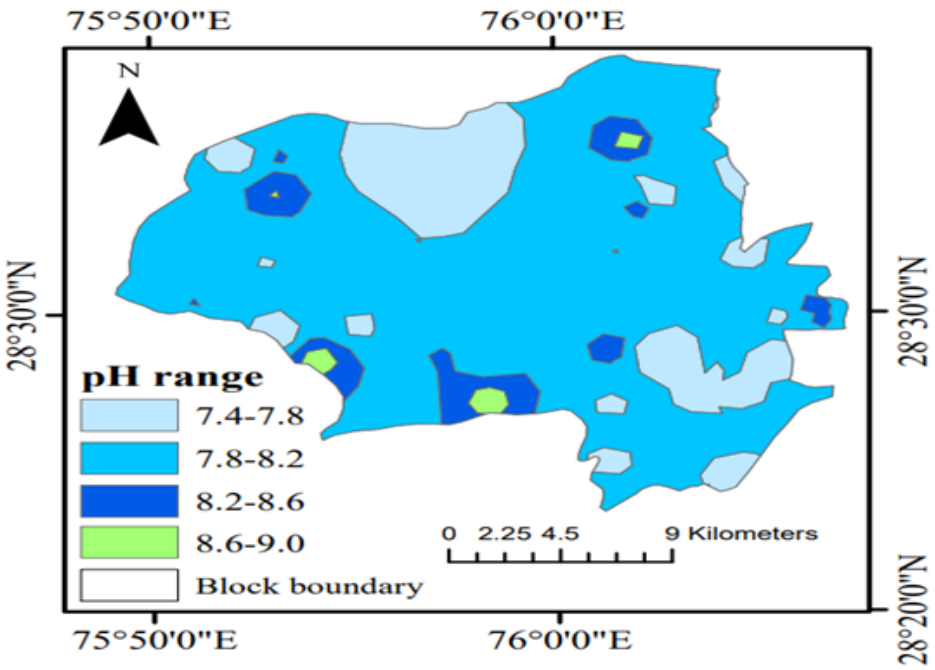


Figure-3 Spatial variability map of pH of Badhra Block

The RSC ranged from 0.00 to 3.90 $mel^{-1}$ with a mean value of 1.16 $mel^{-1}$. Spatial variable map for RSC of groundwater in Badhra block is presented in Figure 4. Naseem *et al*. (2010) reported that pH, EC and SAR of the irrigation water are significantly influenced by RSC

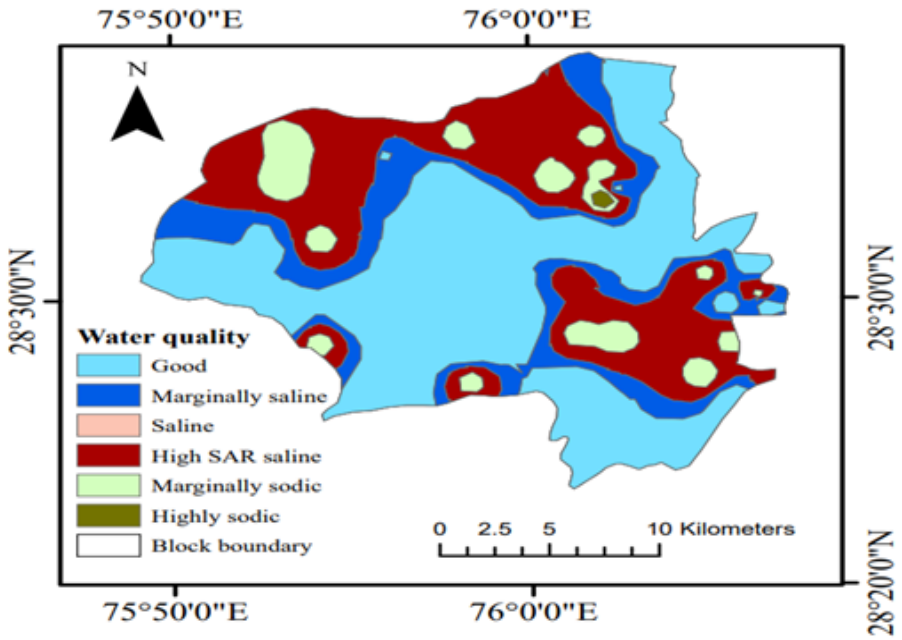


Figure-4 Spatial variability map of RSC of Badhra Block

The sodium adsorption ratio (SAR) of groundwater samples ranged from 3.23 to 35.00 $(mmol\ l^{-1})^{1/2}$ with a mean value 8.77 $(mmol\ l^{-1})^{1/2}$ in Badhra block of Charkhi Dadri district. Spatial variable map for SAR of groundwater in Badhra block presented in Figure 5. Bhat *et al*. (2016) reported that SAR varied from 4.03-24.16 $(mmol\ l^{-1})^{1/2}$ in groundwater of Gohana block, Haryana. Isaac *et al*. (2009) ascertained that the SAR of soil solution is increased with the increase in SAR of irrigation water which eventually increases the exchangeable sodium of the soil.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue I January 2026

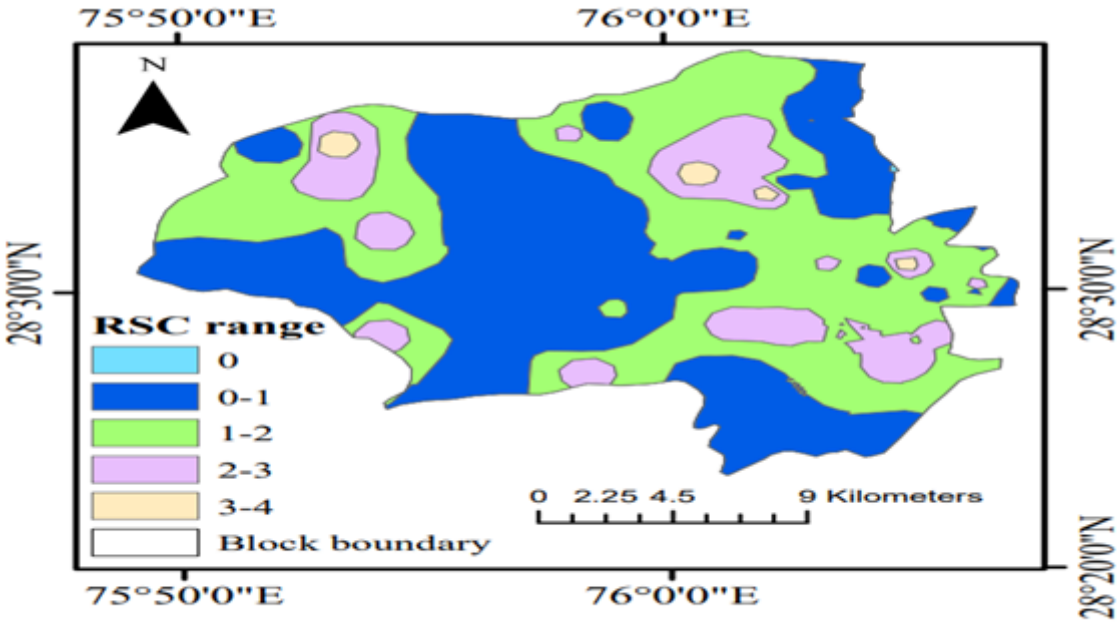


Figure-5 Spatial variability map of SAR of Badhra Block

In case of anions, chloride was the dominant anion with the maximum value 80.5 me/l and the minimum value of 2.20 me/l was recorded. Bicarbonate ranged from 0.20 to 6.90 $mel^{-1}$ with a mean value 2.85 me $l^{-1}$. The mean values for $CO_3^{2-}$, $HCO_3^-$, $Cl^-$ and $SO_4^{2-}$ were found to be 0.58, 2.85, 11.87 and 1.75 me/l, respectively (Table 3). Among cations, $Na^+$ was highest and also varied widely from 2.50 to 76.32 me/l (Table 3), followed by magnesium (0.60–14.90 me/l) and calcium (0.20-7.30 me/l). Average values for $Na^+$, $Mg^{2+}$, $Ca^{2+}$ and $K^+$ were 13.68, 2.36, 0.93 and 0.61 me/l, respectively (Table 3). The mean cationic composition was observed in order of $Na^+ > Mg^{2+} > Ca^{2+} > K^+$ likewise the anionic composition was observed in order of $Cl^- > HCO_3^- > SO_4^{2-} > CO_3^{2-}$. The reasons for carbonate ($CO_3^{2-}$) and bicarbonate ($HCO_3^-$) concentrations in groundwater can be ascribed to carbonate weathering as well as from the dissolution of carbonic acid in the aquifers. Kumar *et al.* (2013) analyzed groundwater quality of Lakhan Majra Block of Rohtak district and reported that the order of abundance of cations was $Na^+ > Mg^+ > Ca^+ > K^+$ and those of the anions were $Cl^- > HCO_3^- > SO_4^{2-} > CO_3^{2-}$. The presence of sodium in groundwater primarily results from the chemical decomposition of feldspars, feldspathoid and some iron, magnesium minerals. The amount of $Na^+$ ions in the water predicts the sodicity danger of the water (Singh, 2000).

According to All India Coordinated Research Project (AICRP) on management of salt affected soils and use of saline water in agriculture classification, out of 61 water samples in Badhra block of Charkhi Dadri district 45.00, 35.00, 15.00 and 5.00 per cent samples were found in good, marginally saline, High SAR saline and marginally alkali categories (Table 4), respectively

Table-4: Groundwater quality classification of Badhra Block

| **Water quality** | **Class** | **No of Samples** | **Percentage** |
|---|---|---|---|
| Good | A | 33 | 54.00 |
| Marginally saline | B1 | 8 | 13.11 |
| Saline | $B_2$ | 0 | 0.00 |
| High SAR saline | $B_3$ | 6 | 9.83 |

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue I January 2026

| | | | |
|---|---|---|---|
| Marginally alkali | C1 | 14 | 22.9 |
| Alkali | C2 | 0 | 0.00 |
| Highly alkali | C3 | 0 | 0.00 |
| Total | | 61 | |

The spatial distribution map using GIS techniques of Badhra block is presented in figure 6.

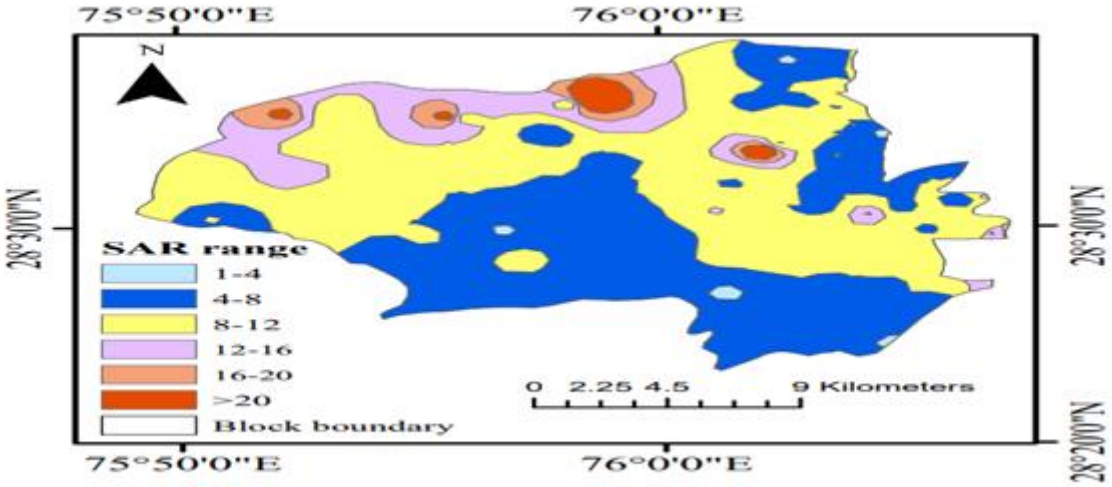


Figure-6 Spatial variability map of groundwater quality of Badhra Block

## CONCLUSION

The groundwater analysis showed that (54%) of groundwater samples of Badhra block were categorized under good category and can be used safely for irrigation purpose. whereas (6%) samples falling under high SAR category requires leaching with good quality water. The samples falling under marginally category (14%) can be used by using amendments like gypsum or any source of sulphur in Badhra block of Charkhi Dadri district of Haryana. The anions were found in order of $HCO_3^-$ > $Cl^-$> $SO_4^{2-}$> $CO_3^{2-}$ > $NO_3^-$ and cations followed the order $Na^+$ > $Mg^{2+}$> $Ca^{2+}$> $K^+$. However, at some places where the water is of doubtful category, care is to be taken to use the water for irrigation in terms of crop selection, variety selection and fertilizer management. The spatial distribution maps generated for various physico-chemical parameters using GIS techniques could be valuable for policy makers for initiating groundwater quality monitoring in the area.

## REFERENCES

1. Gupta R.K., N.T.Singh and M. Sethi 1994. Water quality for irrigation in India. Tech. Bull. 19, CSSRI, Karnal, India.
2. Adhikary, P. P., Dash, C. J., Kumar, G. and Chandrasekharan, H. (2014). Characterization of groundwater quality for irrigation and drinking purposes using a modified groundwater quality index. Indian Journal of Soil Conservation, 42 (3): 260-267.
3. Ahamed, A. J., Ananthakrishnan, S., Loganathan, K. and Manikandan, K. (2013). Assessment of groundwater quality for irrigation use in Alathur Block, Perambalur District, Tamilnadu, South India. Applied Water Science, 3:763–771.
4. Bhat, M. A., Grewal, M. S., Ramprakash, Rajpaul, Wani, S. A. and Dar, E. A. (2016). Assessment of Groundwater Quality for Irrigation Purposes using Chemical Indices. Indian Journal of Ecology, 43 (2): 574-579.
5. Eaton F.M. (1950). Significance of carbonates in irrigation waters. Soil Science 69:123–133.

6. FAO. (1985). Soil Bulletin 42, Soil Survey Investigation for Irrigation. Agriculture Organization of the United Nation. Rome, Italy.
7. Gagandeep., Ram Prakash., Kumar,Sanjay. ,Rajpaul., Satyavan and Sharma,S.K(2017). Groundwater quality assessment for irrigation in Palwal block of Palwal district, Haryana, India. Journal of Applied and Natural Science 9 (1): 34– 38.
8. Gupta, R. K., Singh, N. T. and Sethi, M. (1994). Water quality for irrigation in India. *Technical Bulletin. 19.* CSSRI, Kamal, India.
9. Isaac, R. K., Khura, T. K. and· Wurmbrand, J. R. (2009). Surface and subsurface water quality appraisal for irrigation. Environmental Monitoring Assessment, 159:465–473.
10. Jain, C. K., Bandyopadhyay, A. and Bhadra, A. (2012). Assessment of groundwater quality for irrigation purpose, district Nainital, Uttarakhand, India. Journal of Indian Water Resources Society, 32(3-4): 8-14.
11. Kumar, S., Sharma, S. K., Rajpaul, Ramprakash, Satyavan. (2013). Mapping groundwater quality for Lakhan Majra block of Rohtak district (Haryana). Annals of Agri Bio Research, 18(2):186-190.
12. Nag, S. K. and Das, S. (2014). Quality Assessment of Groundwater with Special Emphasis on Irrigation and Domestic Suitability in Suri I & II Blocks, Birbhum District, West Bengal, India. American Journal of Water Resources, 2(4):81-98.
13. Naseem, S., Hamza, S. and Bashir,. E. (2010). Groundwater Geochemistry of Winder Agricultural Farms, Balochistan, Pakistan and Assessment of Irrigation Water Quality. European Water, 31:21-32.
14. Packialakshmi, S., Ambujam, N. K. and Nelliyat, P. (2011). Groundwater market and its implications on water resources and agriculture in the southern peri-urban interface, Chennai, India. Journal of Environment, Development and Sustainability, 13(2):423–38.
15. Richards, L.A. (1954). Diagnosis and improvement of saline and alkali soils: U.S. Department of Agriculture Handbook 60, 160 p.
16. Sharma, B. K. (2005). Water Pollution, 4th edn. Goel Publishing House, Meerut.
17. Singh, J., Shanwal, A.V. and Verma, S.L., (2000). Poor quality irrigation water and secondary salinization in semiarid region of Rajasthan. Annals of Agri. Bio. Research, 5(2): 127-130.
18. Singh, K. P., Malik, A., Mohan, D., Vinod, K. S. and Sinha, S. (2006). Evaluation of Groundwater Quality in Northern Indo-Gangetic Alluvium Region. Environmental Monitoring and Assessment, 112: 211-230.
19. Vrba, J. and Zoporozec, A. (1994). Guidebook on mapping groundwater vulnerability, IAH International Contribution for Hydrogeology, Heise, Hannover, v.16, 131p.
20. Zinabu, E., Yazew, E. and Haile, M. (2010). Assessment of the Impact of Industrial Effluents on the Quality of Irrigation Water and Changes on Soil Characteristics (A Case of Kombolcha Town). Fourteenth International Water Technology Conference, IWTC 14 2010, Cairo, Egypt. pp. 711-727.