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# Analysis and Assessment of Groundwater Quality, Beohari block Shahdol District, Madhya Pradesh, India

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**Abstract:** *The paper deals with groundwater quality assessment of Beohari block, District Shahdol, Madhya Pradesh, India. Geologically, the area is occupied by the Gondwana formation the clay and mudstone facies of Tihiki stage overlying the areneceous facies of Pali bed have an aquifer system of moderate to high yield potential in Beohari block. The upper barakar sandstone of Gondwana Supergroup has a positive piezometric head and at many places auto-filling condition occurs. Twenty two groundwater samples from the area were collected in pre- monsoon and post-monsoon seasons of 2024 from different locations of study area and analysed for comically analysis for various water quality parameters such as PH, electric conductivity (EC), Total dissolved solids (TDS), Total hardness (TH), Chloride (Cl), Bicarbonate (HCO3), Sodium (Na), Potassium (K), Calcium(C), Fluoride(F),Magnesium (Mg)and Nitrate ($NO_3$).The main hydrochemical facies are Ca-Mg-$HCO_3$ and Ca-Mg-$SO_4$-Cl type. The groundwater is hard to very hard in nature. The concentrations of various cations and anions suggest that the groundwater of the area is partially suitable for drinking. The analysis of various parameters like electrical conductivity, sodium percentage, integrated sodium adsorption ratio (SAR) and EC, residual sodium carbonate suggest that groundwater of the area is suitable for irrigation.*

**Keywords**: Groundwater Quality, Beohari block , Shahdol, Madhya Pradesh, India

## I. INTRODUCTION

Ground water has been used as major sources of drinking water in both rural and urban areas in the world. In India alone, nearly 80% of the rural population depends on untreated ground water. The quality of ground water in the various part of our country has been studied by various workers. Polluted water is responsible for spread of various water borne diseases. Therefore in present study an attempt has been made to evaluate the physiochemical characteristics of ground water for drinking and irrigation purpose of Beohari block, Shahdol district Madhya Pradesh, India.

Groundwater is a valuable resource that meets a large portion of the country's domestic and agricultural needs. Its indiscriminate use is leading to a significant decline in groundwater levels in major parts of our country. India faces serious challenges in groundwater resource management due to rapidly increasing population, urbanization, industrialization, and erratic monsoon behavior. Various anthropogenic activities are adversely affecting the region's groundwater quantity and quality (Tiwari et al., 2010; Tiwari and Mishra, 2011). Recent studies (Bhanja and Mukherjee, 2019) indicate acute water scarcity in various parts of the country due to various reasons. Prudent use of this vital resource is urgently needed in areas with hard rocks with negligible porosity. A key factor for the sustainable development of groundwater resources is its scientific management. Due to the insufficient availability of surface water, groundwater is widely used for various purposes (Tiwari, 2017; Tiwari and Kushwaha, 2018). Overexploitation of groundwater has led to declining groundwater levels, drying up of wells, severe drinking water shortages, depletion of wetlands and base flows, and a decline in well-irrigated agricultural production (Das, 2020). Poor monsoon rainfall

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and uncontrolled groundwater use have forced planners to consider the proper management of this vital, life-sustaining natural resource.

Fresh water is the most precious material for survival on earth, not only human life but also for flora and fauna. Groundwater quality is one of the most important aspects in water resource studies (Ackah et al., 2011; Sayyed and Wagh, 2011). It is largely controlled by discharge recharge, nature of the host and associated rocks as well as contaminated activities (Raghunath, 1987; Sayyed and Sayadi, 2011; zhang et al., 2011). Only 2 to 3% total water on earth is fresh water. Water pollution is classified into four classes likewise-physical, chemical, biological and physiological pollution of water. Physical water pollution brings about changes in water with regard to its color, density, test, turbidity and thermal properties etc. the chemical pollution of water causes changes in acidity and alkalinity/pH. Biological pollution is caused by bacteria, algae, virus, protozoa etc. physiological pollution of water by caused by several chemical agents such as chlorine, sulphur dioxide, hydrogen sulphide ketones, phenols amines etc. according to WHO organization, about 80% of all the disease in human.

The quality of groundwater is affected by many factors such as physic-chemical characteristics of soil, weathering of rocks, and rainfall etc. (Purushotham et al., 2011). Groundwater quality assessment of different quality parameters has been carried out by various researches (Hegde, 2006; Pandian and Shankar, 2007; Popleare and Dewalkar, 2007; Mishra, 2010). The groundwater quality assessment for drinking and irrigation purpose in the Vindhyan region has carried out by few researchers (Tiwari et al., 2009, 2010; Mishra et al., 2012).

## II. STUDY AREA

The study area lies between latitude 23°50' to 24°12'N longitude and 81°15' to 81°30'E covering a total area of 1080km2 (Fig.1).Geologically, the area is occupied by the Gondwana formation the clay and mudstone facies of Tihiki stage overlying the areneceous facies of Pali bed have an aquifer system of moderate to high yield potential in Beohari block. the upper barakar sandstone of Gondwana Supergroup has a positive piezometric head and at many places auto-filling condition occurs.the area enjoys subtropical climate with extremes of temperature and dryness. The temperature ranges from 6°C to 46°C whereas the average rainfall is about 1100 mm. The area chosen for the study has witnessed acute water crisis due to exponential increase of population, some droughts in last few years, indiscriminate uses as well as improper management of water. Due to this, quality and availability of groundwater has been highly affected. Keeping these things in mind, the Beohari area of Shahdol district has been chosen for the study. Geologically the area comes under the category of Gondwana Super group. Climatically the area experiences tropical type with hot summer and cold climate. Mean annual rainfall of the area is about 1000 mm in which 90% rain occurs during monsoon season.

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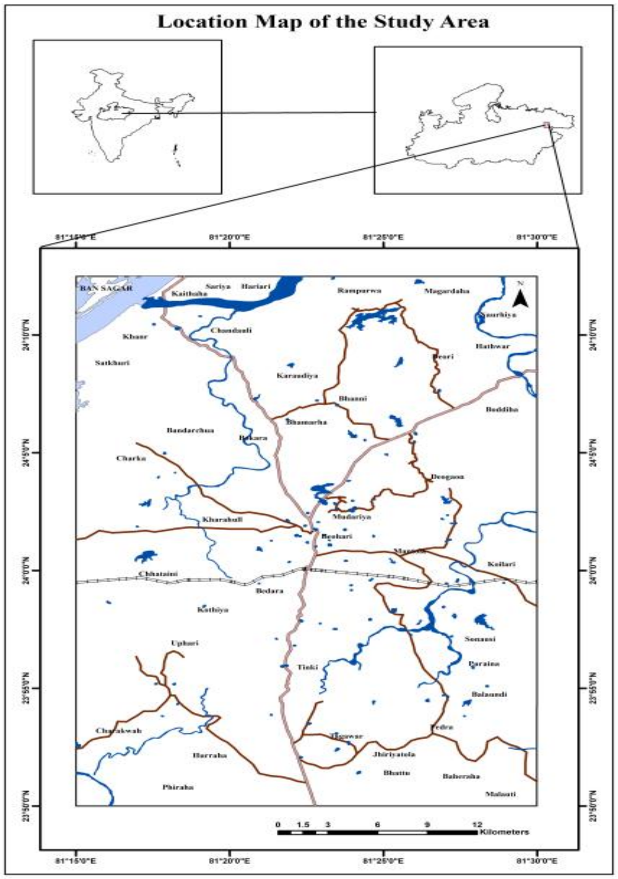


Fig. 1 Location Map of the Study A|rea

## III. METHODOLOGY

Twenty one groundwater samples were collected in one liter clean polythene bottles during Pre monsoon season and post monsoon season of 2024 to cover the entire area and analyzed for various chemical parameters following standard method (APHA, 1998) Which are extensively used for drinking and irrigation purpose. The Electrical conductivity (EC) total dissolved solids (TDS) and total hardness (TH) were measured in the field. Calcium(Ca+), magnesium(Mg+), sodium(Na+), potassium(K+), chloride(Cl-), bicarbonate(HCO3-), sulphate(SO4-), fluoride(F-) and nitrate(NO3-)were determined in the laboratory.


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Table 1 : Geochemical analysis of groundwater sample of the study area

| S.No. | Location | Mansoon | pH | EC (µs/cm) | TDS | TH | Na | K | Ca | Mg | F | Cl | $SO_4$ | $HCO_3$ | $NO_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Akauri | Pre-mansoon | 6.4 | 1180.42 | 651.20 | 385.40 | 20.70 | 18.0 | 101.5 | 22.6 | 0.80 | 85.7 | 612.0 | 418 | 25 |
| | | Post-mansoon | 7.2 | 1281.52 | 668.18 | 396.38 | 28.56 | 20.0 | 109.3 | 27.6 | 1.40 | 91.0 | 198.0 | 532.0 | 39 |
| 2. | Akhetpur | Pre-mansoon | 7.3 | 776.50 | 1151.80 | 612.37 | 24.30 | 16.0 | 108.5 | 83.2 | 1.00 | 40.2 | 415.0 | 192.0 | 12 |
| | | Post-mansoon | 8.8 | 840.51 | 2436.00 | 765.34 | 34.30 | 18.0 | 145.5 | 98.2 | 1.79 | 51.0 | 502.0 | 203.0 | 23 |
| 3. | Baheriya | Pre-mansoon | 6.7 | 768.42 | 403.00 | 264.05 | 30.70 | 3.40 | 71.00 | 21.0 | 0.80 | 45.0 | 95.2 | 405.0 | 13 |
| | | Post-mansoon | 7.5 | 920.40 | 478.28 | 298.22 | 33.80 | 5.20 | 75.0 | 27.2 | 1.45 | 55.0 | 101.0 | 501.0 | 29 |
| 4. | Banasi | Pre-mansoon | 7.3 | 1198.50 | 721.00 | 412.92 | 70.2 | 6.00 | 81.20 | 51.2 | 0.90 | 84.2 | 52.1 | 319.2 | 17 |
| | | Post-mansoon | 8.0 | 1221.65 | 826.90 | 433.4 | 74.70 | 6.70 | 84.86 | 54.0 | 1.60 | 102.0 | 65.00 | 412.0 | 21 |
| 5. | Baraundha | Pre-mansoon | 6.3 | 784.60 | 768.77 | 574.28 | 92.60 | 1.88 | 101.3 | 78.3 | 1.50 | 176.0 | 85.30 | 215.00 | 23 |
| | | Post-mansoon | 7.4 | 895.75 | 802.20 | 678.49 | 101.2 | 2.60 | 120.0 | 92.3 | 1.90 | 201.0 | 95.00 | 230.00 | 35 |
| 6. | Bijaha | Pre-mansoon | 7.2 | 1145.45 | 486.37 | 426.36 | 72.90 | 3.70 | 89.2 | 49.6 | 0.78 | 78.5 | 42.0 | 302.0 | 13 |
| | | Post-mansoon | 8.1 | 1204.56 | 502.00 | 479.32 | 89.20 | 5.10 | 101.2 | 55.2 | 1.90 | 83.7 | 51.9 | 321.1 | 43 |
| 7. | Bodra | Pre-mansoon | 6.3 | 756.42 | 501.20 | 371.92 | 71.00 | 3.20 | 81.20 | 41.20 | 0.80 | 42.0 | 101.0 | 119.00 | 25 |
| | | Post-mansoon | 7.4 | 805.39 | 564.85 | 419.98 | 75.20 | 5.20 | 87.8 | 48.9 | 1.50 | 57.9 | 115.0 | 138.00 | 45 |
| 8. | Charka | Pre-mansoon | 7.2 | 1040.58 | 481.00 | 519.46 | 43.20 | 3.90 | 174.0 | 20.6 | 0.23 | 78.30 | 198.3 | 365.0 | 14 |
| | | Post-mansoon | 7.9 | 1154.40 | 551.87 | 559.96 | 52.60 | 4.30 | 182.0 | 25.6 | 0.56 | 98.00 | 201.3 | 398.0 | 37 |
| 9. | Chhatwa | Pre-mansoon | 6.1 | 782.56 | 716.60 | 473.70 | 73.70 | 9.10 | 89.2 | 51.5 | 0.80 | 142.3 | 41.23 | 241.0 | 09 |
| | | Post-mansoon | 7.2 | 861.72 | 802.00 | 519.82 | 87.00 | 11.20 | 101.0 | 65.2 | 1.02 | 163.0 | 52.5 | 254.0 | 35 |
| 10. | Dadar | Pre-mansoon | 7.5 | 714.54 | 786.25 | 325.40 | 25.40 | 2.40 | 109.8 | 24.3 | 0.50 | 42.20 | 99.00 | 345.0 | 17 |
| | | Post-mansoon | 8.2 | 804.39 | 804.20 | 431.25 | 31.25 | 4.20 | 125.0 | 30.0 | 1.23 | 58.6 | 107.3 | 365.0 | 28 |
| 11. | Hatwar | Pre-mansoon | 7.1 | 1153.39 | 594.60 | 315.70 | 14.69 | 15.30 | 118.0 | 72.2 | 0.90 | 79.0 | 89.0 | 245.0 | 22 |
| | | Post-mansoon | 8.3 | 1226.40 | 706.00 | 425.00 | 25.00 | 24.00 | 128.0 | 84.0 | 1.56 | 90.3 | 102.0 | 274.3 | 34 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12. | Hinauta | Pre-mansoon | 7.6 | 780.35 | 679.32 | 375.1 | 75.1 | 3.20 | 102.7 | 63.8 | 0.89 | 42.2 | 74.2 | 289.0 | 10 |
| | | Post-mansoon | 8.2 | 810.23 | 700.31 | 485.0 | 85.0 | 5.00 | 112.7 | 74.2 | 1.38 | 53.7 | 81.2 | 305.0 | 25 |
| 13. | Khadda | Pre-mansoon | 7.3 | 1050.23 | 553.38 | 333.20 | 33.20 | 7.90 | 172.1 | 72.1 | 0.85 | 64.3 | 116 | 639.0 | 23 |
| | | Post-mansoon | 8.4 | 1160.34 | 560.10 | 452.00 | 52.00 | 8.50 | 182.0 | 82.0 | 1.85 | 76.4 | 201 | 703.0 | 39 |
| 14. | Madha | Pre-mansoon | 7.6 | 784.56 | 554.00 | 369.20 | 69.20 | 6.70 | 52.5 | 52.5 | 0.49 | 32.2 | 85.2 | 220.8 | 19 |
| | | Post-mansoon | 8.1 | 812.35 | 576.47 | 474.30 | 74.30 | 8.20 | 62.4 | 62.4 | 1.00 | 38.7 | 95.5 | 278.0 | 38 |
| 15. | Mahdeva | Pre-mansoon | 7.4 | 1013.45 | 498.00 | 374.00 | 74.00 | 7.30 | 131.00 | 31.00 | 1.83 | 92.1 | 437.1 | 203.2 | 25 |
| | | Post-mansoon | 8.5 | 1143.35 | 508.96 | 480.70 | 80.70 | 8.40 | 135.8 | 35.8 | 1.06 | 105.2 | 503.1 | 295.0 | 43 |
| 16. | Nakuni | Pre-mansoon | 7.1 | 784.56 | 736.50 | 313.00 | 113.00 | 8.20 | 69.3 | 57.8 | 0.75 | 51.2 | 72.0 | 182.0 | 22 |
| | | Post-mansoon | 8.3 | 816.23 | 789.40 | 435.00 | 136.00 | 9.38 | 88.00 | 68.00 | 1.40 | 55.7 | 79.0 | 201.0 | 36 |
| 17. | Sakandi | Pre-mansoon | 6.9 | 1020.45 | 546.50 | 358.21 | 58.21 | 5.40 | 78.2 | 100.8 | 0.90 | 78.20 | 205.2 | 221.2 | 21 |
| | | Post-mansoon | 7.4 | 1126.35 | 640.60 | 468.50 | 68.50 | 6.30 | 88.6 | 110.9 | 1.20 | 83.6 | 278.0 | 350.0 | 35 |
| 18. | Sonwarsha | Pre-mansoon | 7.2 | 886.25 | 549.00 | 387.40 | 87.40 | 5.90 | 79.0 | 71.0 | 0.80 | 189.2 | 74.2 | 401.5 | 24 |
| | | Post-mansoon | 8.1 | 904.35 | 662.26 | 491.70 | 91.70 | 5.30 | 95.8 | 87.6 | 1.50 | 203.0 | 78.7 | 417.05 | 45 |
| 19. | Tenduha | Pre-mansoon | 6.8 | 1038.26 | 489.00 | 351.00 | 51.00 | 6.23 | 100.0 | 46.0 | 0.70 | 45.6 | 115.7 | 502.2 | 25 |
| | | Post-mansoon | 7.2 | 1126.23 | 587.01 | 469.80 | 69.80 | 7.23 | 123.0 | 56.2 | 1.10 | 55.5 | 123.8 | 582.2 | 39 |
| 20. | Sarsi | Pre-mansoon | 7.8 | 784.15 | 497.22 | 436.3 | 36.00 | 4.90 | 108.0 | 43.00 | 1.00 | 47.20 | 101.2 | 678.0 | 41 |
| | | Post-mansoon | 8.2 | 817.18 | 542.95 | 530.13 | 41.20 | 5.38 | 119.0 | 54.30 | 1.20 | 57.3 | 112.5 | 701.0 | 48 |
| 21. | Tikhwa | Pre-mansoon | 7.3 | 920.04 | 821.44 | 544.7 | 75.00 | 6.23 | 78.12 | 67.0 | 1.00 | 54.7 | 32.3 | 321.5 | 30 |
| | | Post-mansoon | 8.1 | 1040.05 | 850.45 | 611.74 | 80.00 | 7.30 | 89.2 | 76.4 | 1.50 | 64.8 | 47.4 | 336.2 | 41 |
| 22. | Sathni | Pre-mansoon | 7.1 | 784.56 | 815.45 | 305.04 | 54.68 | 4.70 | 43.7 | 78.00 | 0.75 | 53.24 | 35.3 | 301.56 | 29 |
| | | Post-mansoon | 8.0 | 870.78 | 838.36 | 486.35 | 62.86 | 4.21 | 52.0 | 86.01 | 1.50 | 64.51 | 41.05 | 416.59 | 23 |

## III. RESULTS AND DISCUSSION

### Hydrochemical Facies

Groundwater samples of the study are have been plotted on Chadha's diagram (1999). In this scheme the difference in milliequivalent (epm) percent between alkaline earth (calcium + magnesium) expressed as percentage reacting value is plotted on the x-axis and the difference in milliequivalent (epm) percentage between weak acid anions (carbonate +bicarbonate) and strong acid anions (chloride, sulphate and nitrate) is plotted on the y-axis. The milliequivalent percentage difference between alkaline earth and alkalies and between weak acidic anions and strong acidic anions is plotted on one of the four possible sub fields of the diagram. In both pre-monsoon and post monsoon seasons 50% samples are Ca-Mg-HCO3 type and 40% samples are Ca-Mg-Cl -SO4 type(Fig. 2).


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**Suitability of Groundwater for Drinking**

PH:- It is observed that the pH varies between 6.1 to 8.8 indicating alkaline nature of groundwater.

Total dissolved solids (TDS):- The concentration of total dissolved solids varies from 403 mg/l to 2436 mg/l, nearly 6% samples exceed the permissible limit (1000 mg/l, WHO; 1993). The intake of higher TDS in human body may cause gastrointestinal problem (Jasortia and Singh, 2007).

Total Hardness (TH):- per Sawyer and McCarty (1967) Total hardness of groundwater samples varies between 264.05 to 765.34mg/l. About 59% of the samples are hard to very hard in nature due to calcite associated with sandstone aquifer as cementing material.

Na :-The concentration of sodium ranges from 14.69 to 136.0 mg/l. The groundwater samples of the area are characterized by Ca>Na>Mg:HCO3>S04>CI > NO3>F type.

Sulphate (SO4) :- The concentration of sulphate lies between 42 to 503.1 mg/l, nearly 10% samples exceed the maximum permissible limit (400 mg/l; BIS, 1991). The CaSO4.2H20 associated with shale formation seems to be responsible for higher amount of sulphate.

Potassium (K):- The potassium concentration varies between 1.88 to 24.0 mg/l, and higher concentration is attributed due to K feldspar (orthoclase, microcline) minerals associated with aquifers. The consumption of higher concentration of potassium in human body may cause nervous and digestive disorders.

Bicarbonate (HNO3) :- The bicarbonate concentration varies between 119 to 703.0mg/l. Fluoride concentration varies between 0.23to 1.79 mg/l and 15% of samples exceed the permissible limit of 1.5 mg/l (BIS 1991).

Fluoride (F) :- The higher concentration of fluoride may cause dental and skeletal fluorosis (Madhunure etal., 2007). High concentration of fluoride in groundwater may be due to phosphatic fertilisers used by farmers.

Nitrate (NO3) :- The concentration of nitrate varies between 10 to 48 mg/l in which two samples exceed the limit of 43 mg/l. The higher concentration of nitrate may cause methamogbinemia in infants. The sodium calcium, chloride and magnesium ions are within permissible limit as per standard fixed by WHO (1993) and BIS (1991). To ascertain the suitability of groundwater for drinking, hydrochemical parameters of the study area are compared with standards as per world Health organization (WHO, 1993) and Bureau of Indian standards (BIS, 1991) (Table 2), which shows that the groundwater of the area is partially suitable for drinking because the concentration with respect to TDS, TH, SO4, Cl and NO3 in few groundwater samples are higher than the recommended limit for drinking.

Table 2 : Comparison of the quality parameters of groundwater of the study area with WHO and ISI for drinking purpose.

| S.No. | Water Quality Parameters | WHO (1993) | | BIS (1991) | | No. of location which exceed max. permissible limit (WHO) | Concentration in Study Area | Undesirable Effect Produced Beyond Maximum Allowable Limit |
|---|---|---|---|---|---|---|---|---|
| | | Max. Desirable | Max. Permissible | Max. Desirable | Max. Permissible | | | |
| 1 | pH | 7.0 | 8.5 | 6.5 | 8.5 | - | 6.1 to 8.8 | Taste, effects mucus membrane and water supply system. |
| 2 | TH mg/l | 100 | 500 | 300 | 600 | 17 | 264.05 to 765.34 | Encrustation in water supply and adverse effect on domestic use. |

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| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 3 | TDS mg/l | 500 | 1500 | 500 | 1000 | 2 | 403 to 2436 | Gastrointestinal irritation. |
| 4 | Ca mg/l | 75 | 200 | 75 | 200 | - | 43.7 to 182.0 | Encrustation in water supply, scale formation. |
| 5 | Mg mg/l | 30 | 150 | 30 | 100 | - | 20.6 to 110.9 | Encrustation in water supply and adverse effect on domestic use. |
| 6 | Na mg/l | - | 200 | - | 200 | - | 14.69 to 136.0 | Hypertension |
| 7 | K mg/l | - | 12 | - | - | 4 | 1.88 to 24.00 | Nervous disorder |
| 8 | Cl mg/l | 200 | 600 | 250 | 1000 | - | 32.2 to 203.0 | Salty Taste |
| 9 | $SO_4$ mg/l | 200 | 400 | 150 | 400 | 4 | 32.3 to 503.1 | Laxative effect. |
| 10 | F mg/l | 1 | 1.5 | 1 | 1.5 | 5 | 0.23 to 1.79 | Dental Problem in children and adults causes Fluorosis |

**Suitability of Groundwater for Irrigation**

**Sodium Percentage (Na%)**

Sodium concentration in groundwater is important since increase of sodium concentration in water affect deterioration of soil properties reducing permeability (Kelly, 1951; Tijani, 1994). The sodium in irrigation water is usually denoted as percent sodium and denoted by the following formula (Wilcox, 1955)

$$Na\% = \frac{Na^{+} + K^{+}}{Ca^{++} + Mg^{++} + Na^{+} + K^{+}} \times 100$$

Where all the concentrations are expressed in epm.

The classification of groundwater samples with respect to sodium percentage and electrical conductivity is presented in (Wilcox, 1955). It is observed that during pre-monsoon season 6% of groundwater is excellent to good while 96% fall in good to permissible and another 3% sample are unsuitable. In post-monsoon season all samples are of good to permissible category.

**Sodium Adsorption Ratio (SAR)**

The relative activity of sodium ion in the exchange reaction with soil is expressed in terms of sodium adsorption ratio (SAR). It is processed as -

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

where all the concentrations are expressed in epm

The U.S. Salinity Laboratory (Richards, 1954) proposed a diagram for suitability of groundwater for irrigation purpose based on sodium adsorption ratio (SAR) and electrical conductivity (EC). Sixteen categories are demarcated in the diagram in terms of salinity hazard as low (C1), medium (C2), high (C3), very high (C4) and also in terms of sodium hazard as low (S1), medium (S2), high (S3), very high (S4). About 5% samples of pre-monsoon season fall under C2 S1 class indicating medium salinity and low alkaline; 90% under C3 S1 class indicating high salinity and low alkaline


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nature and 5% samples under C4 S1 having high salinity. During post- monsoon season, it is observed that 7% of groundwater samples fall under C2 $S_1$ and 92% of samples fall under. C3 S1. It can be inferred from the that 95% of groundwater samples for both pre-monsoon and post-monsoon season fall in the field C2 S1 and C3 S1 indicating medium to high salinity and low alkaline in nature which can be used for irrigation with little care of exchangeable sodium.

## V. CONCLUSION

The groundwater quality of Beohari block, Shahdol district were evaluate for domestic purpose and irrigation uses. The interpretation of assessment of groundwater quality analysis result of 21 representative groundwater sample from Wells and dug well in the study area that groundwater is fresh to alkaline. The order of dominance of cations and anions are Ca-Mg-HCO3 and Ca-SO4-Cl respectively. Chemistry of the groundwater of the area indicates that the alkaline earth (Ca+ and Mg++) exceeds alkalies (Na++ and K+), weak acid (HCO3) exceeds strong acid (CI, NO3 and SO4). The concentration of pH (6.1-8.8) in the area suggests alkaline nature of groundwater. The total dissolved solids increase in the post-monsoon season as a result of dissolution of minerals from the overlying layers and weathered zones by water percolation. The overall characteristics of groundwater in the study area in post-monsoon season, where majority of the cations and anions are high due to the rock water interaction. About 45% of the samples exceed the maximum permissible limit of hardness. This type of water should be used for drinking after chemical treatment. Nearly 10% of the samples exceed the maximum limit of sulphate which may cause laxative effect. Higher concentration of sulphate is attributed to gypsum associated with aquifer. The higher concentration of fluoride in 20% of the samples of the study area may be due to the phosphatic fertilizers. Except two samples nitrate concentration is within permissible limit. Hence groundwater of the area is partially suitable for drinking purpose. The values plotted on USSL diagram suggest that 95% of the samples are C2S1, and C3 S1 category in pre-monsoon and post-monsoon seasons indicating medium to high salinity and low sodium hazard. The plot of sodium percentage vs electrical conductivity suggest good to permissible category of groundwater for irrigation. Residual sodium carbonate values denote that all sample are of safe and marginal types. So it can be concluded that groundwater of the area is suitable for irrigation. The evolution of groundwater samples according to the WHO and BIS standards for domestic water purpose indicates TDS, TH, Ca, Mg, K, Na, SO4, F, HNO3, exceed there for many of the groundwater sample confirm their suitability for drinking.

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