Bulletin of Pure and Applied Sciences. ***Print version ISSN 0970 4639***
Vol.40F, Geology (Geological Science), No.2, ***Online version ISSN 2320 3234***
July-December 2021: P.260-270 ***DOI: 10.5958/2320-3234.2021.00023.8***
Original Article ***Available online at www.bpasjournals.com***

Evaluation of Irrigation Quality of Sub-Surface Water Resources of Jobat Area, Alirajpur (M.P.) W. India: Insight to Hydro-Geochemical Analysis

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(Received on 16.09.2021, Accepted on 17.11.2021)

How to cite this article: Rizwan, M., & Solanki, D. (2021). Evaluation of Irrigation Quality of Sub-Surface Water Resources of Jobat Area, Alirajpur (M.P.) W. India: Insight to Hydro-Geochemical Analysis. *Bulletin of Pure and Applied Sciences- Geology,* 40F(2), 260-270.

ABSTRACT

Current research describes the chemical quality parameters for subsurface waters within Jobat area, Alirajpur district of Madhya Pradesh. A crucial component of this study will be investigating the hydro-geochemical characteristics of the basin and deciding whether shallow groundwater would be appropriate for irrigation. In the post-monsoon season, 10 representative samples of groundwater were taken from different open dug wells to monitor ions and water chemistry in the irrigation system. Based on the physical characteristics of groundwater, all samples have been colorless, odorless, and tasteless. In the study area, hydrogen ion concentration values vary from 8.1 to 8.8 and the range of Electrical Conductivity from 400 to 2000. Compound investigation shows that water present an enormous spatial inconstancy of synthetic total hardness (TH) and Primary ions (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, SO_4^{2-}, Cl^{-}, CO_3^{2-}, and HCO_3^{-}) have been also considered in the analysis. Measurements such as Sodium percent, Kelley's Ratio, Sodium Adsorption Ratio, and Residual Sodium Carbonate are used to assess groundwater suitability for irrigation. According to USSL diagram plotted with water samples, most samples can be used for irrigation. One sample has been categorized as C_4 S_3. On the basis of a Wilcox plot, 7 of the samples are excellent or good, 2 are acceptable, and 1 is doubtful to unsuitable. Overall, in the study, area water is generally suitable for irrigation.

KEYWORDS: *Sub-Surface Water; Sustainability; Hydro-Geochemistry; Wilcox Diagram; U.S.S. Diagram; Jobat Area.*

INTRODUCTION

In recent years, it has been recognized that the quality of groundwater is of nearly equal importance to quantity. As greater development and use of groundwater continues, combined with the river of water, quality suffers unless consideration is given to protecting it. The quality required of a groundwater supply depends upon its purpose, thus the needs for drinking water, industrial water and irrigation water vary widely (Todd, 1980). As many health problems are derived from poor water and sanitation, water quality is as significant as its amount, for fulfilling fundamental human needs.

Synthetic and chemical compounds in the water for water system may likewise have consequences for soil and harvests, particularly in saline salt soil regions. Hence, it is generally fundamental to comprehend the nature of accessible groundwater for ensuring a dependable store for different purposes (Chen, J. *et al.,* 2019).

Groundwater is impacted by pollution when it is contaminated by human activities or naturally occurring materials in an aquifer, posing a threat to development and a challenge to water managers and strategists. Groundwater constitutes about 53% of the total irrigation potential of India (FAO, 2003). About 50% of the total irrigated area is dependent on groundwater irrigation and 60% of the irrigated food production is from groundwater wells (Shah *et al.,* 2000). All these lead to overexploitation and is evident from the fact that "overexploited" and "dark blocks" in the country have increased from 250 in 1985 to 1,098 in 2005 (India 2006). Apart from the decline of quantity, deterioration of quality is also a major concern.

Groundwater is extensively developed for drinking, industrial and irrigation purposes and therefore its quality should be suitable for the corresponding purpose. Color in groundwater may be due to mineral or organic matter in solution. Taste and odor in water may be derived from dissolved gases, mineral matter, or phenols. These can be established based on the maximum degree of dilution that can be distinguished from test-free and odor-free water. Turbidity is a measure of the suspended and colloidal matter in water, such as clay, silt and organic matter.

The natural filtration produced by unconsolidated aquifers largely eliminates turbidity, but other types of aquifer can produce turbid groundwater. Temperature of groundwater is more or less constant. It is usually assumed to be at a value of 1^0 C – 2^0 C greater than the annual average ambient air temperature for the region (Chahar, 2015). The quality or physico-chemical attributes of groundwater is profoundly reliant on anthropogenic exercises like agriculture, mining, urban settlements, and so forth; just as common procedures like stone water association, geological formations, and aerobic/anaerobic states of the aquifers. Thus, the assurance of concoction nature of groundwater is essential for advancement and flourishing of the nation. The present paper manages the evaluation of compound nature of the Jhobat groundwater for drinking, residential and water system applications.

LOCATION OF THE AREA

According to the India Toposheet number 56 J/11 for the Jobat sector; geological field work has been conducted based on the survey. Jobat A locality in Madhya Pradesh called Jobat is located in Alirajpur district. Jobat is located at the Latitude *22^0 25′ 00″ to 22^0 42′ 00″ N* and the longitude 74^0 *34′ 00″ to 74^0 57′ 00″ E*. It is situated at altitude of 292 meter (AMSL) on the bank of Dohi River (Figure 1).

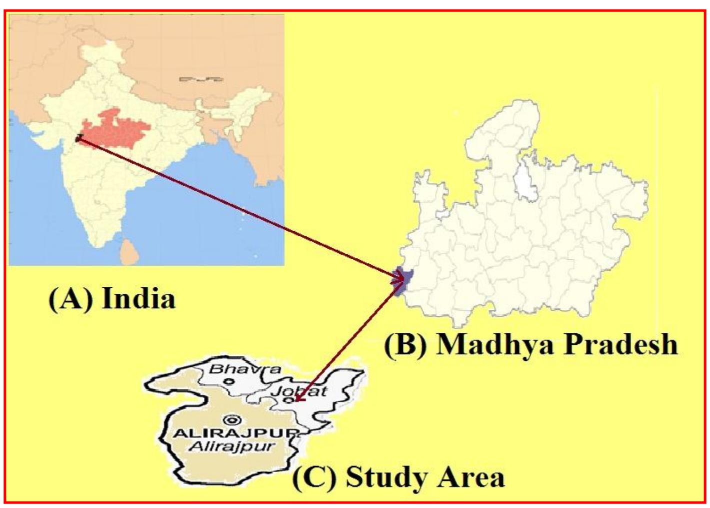

Figure 1: Location Map of Jobat area, Alirajpur District, Madhya Pradesh, India

GEOLOGACL SUCCESSION OF THE AREA

A survey of the geological literature indicates that area around jobat in Alirajpur district. Given the geological succession of the jobat area proposed by Blandford (1869) in Table 1.

Table 1: Geological Succession of Jobat area, Alirajpur district, M.P. (After modified Blandford, 1969)

S. No.	Geological Age	Formation	Rock Formation
1	Recent	--	Alluvium
2	Pleistocene	--	--
3	Cretaceous to Eocene	Deccan Trap	Basalt, Green Sand.
4	Upper Cretaceous	Lameta	Green Cherty Limestone, Coralline Limestone
5	Upper Cretaceous	Bagh Beds	Nodular Limestone, Nimar Sandstone.
6	Upper Pre Cambrian	Vindhyan	Nimar Sandstone.
7	Pre Cambrian	Aravallies	Phyllites, Slate, Schist, Amphibolites.
8	Archeans	--	Banded gneissic Complex.

The rocks are exposed as inliers of older succession surrounded by Deccan Traps of younger age. Bag Town is in the Dhar District of Madhya Pradesh and the Bagh Beds are named after it. The town itself is situated over the Archaean gneisses and schists forming the basement for the deposition of the Cretaceous rock. The Jobat and Bagh Beds exposed a few kilometer East in the main river section consists of about 30 meter thick succession of unfossiliferous sandstone and conglomerates known as Nimar Sandstone overlain by fossiliferous Nodular Limestone and Coralline Limestone (Kumar, 1984).

MEASUREMENT OF WATER QUALITY

In specifying the quality and characteristics of a water, a complete statement require chemical, physical, salinity, bacterial and biological analysis for groundwater. However, the chemical and physical analysis is most important. One liter of water samples were collected in polyethylene / plastic bottles from various dug wells during the month of November-December. The pH was measured by using portable pH meter and EC was measured by EC meter in the field.

A complete chemical analysis of a sample of groundwater includes the determination of the concentration of all the inorganic constituents present. The common anions and cations found in groundwater, together with minor constituents. The analysis also includes measurements of pH. Properties of a groundwater evaluated in a physical analysis include temperature, color, odor, turbidity and taste.

MATERIALS AND METHODS

A. MATERIALS

Data collection and analysis

A total of 10 groundwater samples were collected from different locations during August last month, before sampling, white plastic containers were rinsed 3 to 4 times with the water to be sampled, and after sampling they are immediately sealed to avoid exposure to air. After collection, the containers were labeled for identification and brought to the laboratory. Sample collection, handling and storage followed standard procedures recommended by the Indian Ministry of Water Resources to ensure data quality and consistency. Groundwater samples were analyzed in the laboratory of Central Groundwater board Jaipur, Rajasthan, Monitoring Station for 24 variables, including temperature, pH, total hardness (TH), major ions (Na^+, K^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, Cl^-, CO_3^{2-} and HCO_3^-).

B. METHODS

Physical Analysis

In physical analysis of groundwater, temperature is reported in 0^0C (degree Celsius) and obviously must be measured immediately after collecting the sample. Color is groundwater may be due to mineral or organic matter in solution and is reported in parts per million by comparison with standard solution. Turbidity is a measure of the suspended and colloidal matter in water, such as clay, silt and organic matter. Taste and odor may be derived from bacteria, dissolved gases, mineral matter or phenols. Quantitative determination of odor has been developed based on the maximum degree of dilution that can be distinguished from odor - free water. No accepted has been devised for measuring taste. Some important physical of groundwater sample of Jobat study area are recorded in following Table 2.

Table 2: Physical Parameter of Groundwater sample of Jobat study area, Madhya Pradesh

Location	Color	Odor	Taste	pH	Electrical conductivity
Jobat	CL	OL	TL	8.5	1800
Daigaon	CL	OL	TL	8.7	700
Undari	CL	OL	TL	8.6	400
Pangola	CL	OL	TL	8.2	600
Jali	CL	OL	TL	8.4	720
Morghisna	CL	OL	TL	8.7	980
KalikhetAR	CL	OL	TL	8.4	520
Ghangsia	CL	OL	TL	8.1	1140
Rampura	CL	OL	TL	8.6	580
Bara	CL	OL	TL	8.8	2000

- **Color, Odor and Test**

It has been observed that all the groundwater samples colorless, odorless and tasteless. There are absences of other physical material. All samples show the clean and neat for the drinking purpose (Table, 2).

- **Hydrogen Ion Concentration (pH)**

The negative logarithm of the concentration of H^+ ion in any aqueous solution is calling the hydrogen ion concentration of that particular solution.

pH = $\log_{10}(H^+)$, H = Hydrogen activity.

In the study area, hydrogen ion concentration values vary from 8.1 to 8.8 (Table 2). This indicates basic nature of groundwater of study area. These values are under permissible limits given by World Health Organization (1971). The standard value is indicating 6.52 to 9.2 and these values are also recommended by Indian Standard institution (1983).

- **Electrical Conductivity**

It is an important parameter of the groundwater which is defined as "The conductance of a cube of one cm. of water at a standard temperature of 25^0C, an increase of 1^0 C increases conductance by about 2%". It is also defined as or termed as specific conductivity of water. In second term or unit wise defined as reciprocal of the resistance and is expressed as micro mho / cm. A range of 400 to 2000 has been calculated for groundwater samples collected in the Jobat study area.

Chemical Analysis

The ten water samples were collected from dug wells in the study area for analysis of various physical-chemical parameters. The ionic concentrations of sodium, calcium, magnesium, potassium, carbonate, bicarbonate, chloride, sulphate and nitrate were determined by using the standard laboratory methods. The chemical quality of groundwater is determined on the basis of chemical characteristics of groundwater samples of a particular area Jobat, Alirajpur District. The chemical analysis data have been displayed (Table 3).

Table 3: Chemical parameters of groundwater for Study area Jobat, Alirajpur district, Madhya Pradesh (Values in ppm)

S.No.	Location	Ca	Mg	Cl	SO_4	$CO_3 = HCO_3$	NO_3	Na	K	Total Hardness
1	Jobat	15	1.2	646	385	140	36	27	1.3	835
2	Daigaon	16	1.9	641	386	1320	35	28	4.3	837
3	Undari	21	2.2	647	384	120	34	22	6.0	835
4	Pangola	23	2.8	642	385	110	37	24	7.0	834
5	Jali	24.5	2.0	643	384	90	37	36.66	1.5	832
6	Morghisna	100	2.4	643	382	80	34	56.66	10.2	836
7	Kalikhetar	80	0.8	644	383	140	35	59.33	4.0	833
8	Ghangsia	70	1.2	646	384	120	36	60	10.3	835
9	Rampura	75	1.6	647	384	100	35	29	5.90	839
10	Bara	15	0.15	644	384	135	33	28	4.30	838

The values determined in ppm (parts per million) were converted to equivalents per million (epm) and are displayed (Table 4).

Table 4: Chemical parameters of groundwater for Study area Jobat, Alirajpur district, Madhya Pradesh (Values in epm)

S.No.	Location	Ca	Mg	Cl	SO_4	$CO_3 = HCO_3$	NO_3	Na	K	Na%	SAR
1	Jobat	0.74	0.1	19.0	3.0	3.23	2.5	1.62	0.06	3.94	4.42
2	Daigaon	0.8	0.15	18.7	3.0	3.0	2.6	1.65	0.02	3.88	4.27
3	Undari	1.6	0.18	19.7	3.1	2.7	2.5	0.95	0.03	2.06	1.98
4	Pangola	1.1	0.23	18.0	3.2	2.5	2.5	1.04	0.03	2.20	2.03
5	Jali	1.2	0.16	18.6	3.0	2.0	2.6	1.59	0.07	3.09	2.76
6	Morghisna	2.2	0.19	18.8	3.3	1.8	2.4	2.46	0.05	3.81	2.42
7	Kalikhetar	3.9	0.06	19.0	3.0	3.2	2.5	2.57	0.02	3.30	1.37
8	Ghangsia	3.6	0.09	18.7	3.0	2.7	2.2	2.60	0.05	3.48	1.57
9	Rampura	3.7	0.13	18.8	3.3	2.3	2.3	1.26	0.03	1.76	0.81
10	Bara	0.7	0.15	19.1	3.1	3.11	2.6	1.65	0.02	4.27	4.02

SUBSURFACE WATER QUALITY FOR IRRIGATION SYSTEM

The subsurface water is the main source of water used for human consumption and for both industrial and agricultural activities in regions where surface water is scarce (Delgado *et al.,* 2010). Convergence of dissolved down constituents in groundwater decides its quality for water irrigation system use. The reasonableness of groundwater for water irrigation system relies upon the impacts of the mineral constituents in water on both the plants and soils (Richards, 1954). The higher salty water in irrigation water system causes an expansion in soil arrangement osmotic pressing factor (Thorne, and Peterson, 1954). The Efficacies of salts fixation on soil causing changes in soil construction, structure, penetrability and air circulation in straightforwardly influence plants development. Since plant roots remove water assimilation, the water take-up of plants diminishes.

High quality of water, different variety of soil and cropping practices play an important role for a reasonable water system practice. Presence of exorbitant measures of disintegrated particles in water system water influences plants and horticultural soil, lessening the usefulness. The actual impact of these particles is to bring down the osmotic pressing factor in the plant underlying cells, consequently forestalling water to arrive at the branches and leaves of the plant. The synthetic impacts disturb plant digestion. Water quality issues in water system incorporate files for saltiness, chlorinity, sodicity, and alkalinity (Mills, 2003). The factors like Sodium Percentage, Kelly's proportion, Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC), and Magnesium Hazard, have been resolved and plotted on Wilcox chart and U. S. Saltiness peril outline for depiction of groundwater appropriateness for the water system reason.

Sodium Percent:

Sodium concentration is important in classifying irrigation water system because sodium reacts with soil to decrease its permeability. Soils containing an enormous extent of sodium with carbonate as the dominating anion are termed as soluble alkali soils; those with chloride or sulfate as the prevalent anion are saline soil. Usually, either sort of sodium-advanced soil will uphold practically zero plant development (Todd 1980). Sodium content expressed in terms of sodium percentage or soluble sodium percentage defined as.

$$\%Na = \frac{Na^{+}}{Ca^{2+} + Mg^{2+} + Na^{+} + K^{+}} \times 100$$

According to Fetter (1988) the excessive of sodium percentage in irrigation water is replaced the calcium and magnesium from the soil, because due to excess of sodium percentage base exchange reaction will reduced. This affect is not important up to percentage of sodium is greater than 50%. The sodium percentage calculated is recorded in the table 4 usually; Sodium percentage should not exceed 60% in irrigation waters. The sodium percentage of all 10 groundwater samples in study area is less than or equal 60% of Sodium percentage. All samples are safe for irrigation purpose. It has been observed that the values of sodium percentage exceed of 50% and hence it shows or plays an important role in replacing the magnesium and calcium soil. Irrigation waters may have added chemical fertilizers by dissolving minerals from lithological composition, or dissolution of minerals led to the higher sodium percentage (Subba Rao *et al*., 2002).

Sodium Absorption Ratio (SAR):

Sodium adsorption ratio is a measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration. Soils that have SAR values of 13 or more may be characterized by an increased dispersion of organic matter and clay particles, reduced saturated hydraulic conductivity (Ksat) and aeration, and a general degradation of soil structure (Sreedevi, P.D. *et al.,* 2018). SAR is calculated from the ratio of sodium to calcium and magnesium. Calcium and magnesium ions are important since they are tending to counter the effect of sodium. The higher concentration of SAR leads to breakdown in the physical structure of the soil. Sodium is adsorbed and become attached to soil particles. The soil then become hard and compact when dry and impervious to water penetration (Barbele & Dev, 2016). The SAR recommended by the salinity laboratory of the U. S. Department of Agriculture (Wilcox, 1955) is calculated by using the formula:

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

The classification of irrigation water system waters concerning SAR depends fundamentally on the impact of replaceable sodium on the state of being of the soil. Sodium-delicate plants may, nonetheless, endure injury because of sodium aggregation in the plant tissue when exchangeable sodium values are lower than those effective in causing deterioration of the physical condition of the soil. Low sodium water (S1) can be utilized for water system on practically all soils with little threat of the advancement of unsafe degrees of interchangeable sodium. In any case, sodium-delicate harvests, for example, stone-natural product trees and avocados may collect damaging convergence of sodium (Aravindan 1999). Medium sodium water (S2) in fine-textured soils of high cation trade limit, particularly under low filtering conditions, except if gypsum is available in the soil, presents considerable sodium danger, however might be utilized on coarse textured or natural soils which have great permeability. Very high sodium water (S4) is generally unsatisfactory for irrigation purposes, except at low and perhaps medium salinity. Application of gypsum or other amendments may render this water feasible. Application of gypsum also increases the crust conductivity property of the soil. The SAR values in groundwater samples of the study area range from 0.81 to 4.27 indicating that all the groundwater samples are suitable for irrigation purposes (Table 4).

Magnesium Hazard (MH):

Magnesium hazard (MH) under 50 is considered appropriate for water irrigation system though more prominent than 50 are guileful and unacceptable for water irrigation system, diminishing the yield of harvests and making the soil more alkaline (Bhat *et al.*, 2016). More Mg+ present in waters affects the soil quality converting it to alkaline and decreases crop yield (Joshi *et al*., 2009). Mg hazard calculated using the formula.

$$\text{Mg} - \text{Adsorption Ratio} = \frac{Mg^{2+}}{Ca^{2+} + Mg^{2+}} \times 100$$

MH indicates the degree of damage to the soil structure caused by magnesium in irrigation water. A high level of Mg2+ in groundwater leads to soil alkalinity; furthermore, a large amount of water is absorbed between magnesium and clay a particle, which reduces the infiltration capability of soil, which has adverse effects on crops. A value of MH > 50 indicates harmful groundwater and unsuitable for irrigation, while a value of MH < 50 indicates suitable groundwater (Panpan Xu, 2019). The Hobbit region sample ranged from 2.43 to 17.64% (Table 3). The total samples have MH values below 50% for Jobat region areas, respectively and this water suitable for the irrigation.

The parameters for outline of water irrigation system quality evaluation have been resolved in the groundwater samples of the investigation region. The values upsides of water system boundaries for quality depiction of groundwater have been shown (Table 5).

Table 5: Indices derived from the geochemical parameters of study area

S. No.	Location	Sodium Percent	Sodium Adsorption Ratio	Kelly's Ratio	Residual Sodium Carbonate	Mg Hazards
1	Jobat	67.74	2.56	2.02	2.39	12.5
2	Daigaon	63.74	2.39	1.73	2.05	15.78
3	Undari	35.50	1.00	0.53	0.92	10.11
4	Pangala	44.58	1.28	0.78	1.17	17.29
5	Jali	54.96	2.09	1.16	0.64	11.76
6	Morghisna	51.22	2.25	1.02	-0.59	7.94
7	Kalikhetar	39.54	1.83	0.64	-0.76	1.51
8	Ghangsia	41.79	1.92	0.70	-0.99	2.43
9	Rampura	25.19	0.91	0.32	-1.53	3.39
10	Bara	66.26	2.53	1.94	2.26	17.64

Chemical examination of groundwater of Jobat region, demonstrates that the groundwater is appropriate for water irrigation system applications.

U. S. Salinity Laboratory's Diagram:

U.S. Salinity laboratory staff (USSL, 1954), Wilcox (1956) proposed the U.S. Salinoty digram fort the water analysis. This hazard is shown by the dissolved solids measured as specific electrical conductivity in micro mho/cm at 25^0 C. The SAR is also a characterization of sodium hazards, which can reduce soil permeability and thus inhibit the absorption of water by crops (Xu, Panpan, 2019). For rating the suitability of irrigation water, the USSL salinity diagram was used in which the graph is plotted between SAR an EC values (Xu, Panpan, 2019). Groundwater was ranked into classes from low-, medium-, high-, and very high-quality water for irrigation. The plots of chemical data of the groundwater samples in the U S Salinity Laboratory's diagram are illustrated (Figure 2). Higher Electric Conductivity in irrigation water creates a saline soil (Richards, 1954). The values of water samples as a result show that the 2 sample belong to the type C_1 S_1 (low salinity and the low sodium hazards), and 2 sample belong to C_2 S_1 (low salinity and medium sodium hazards), 2 sample belong to the class C_1 S_2 (medium salinity and low sodium hazards), next 3 sample belonging to the C_4 S_1 class (very high salinity and low sodium hazards) and the last 1 sample attached the C_4 S_3 class (very high salinity and high sodium hazards). The results show that water of the study area is generally suitable for the irrigation purpose shown by figure 2.

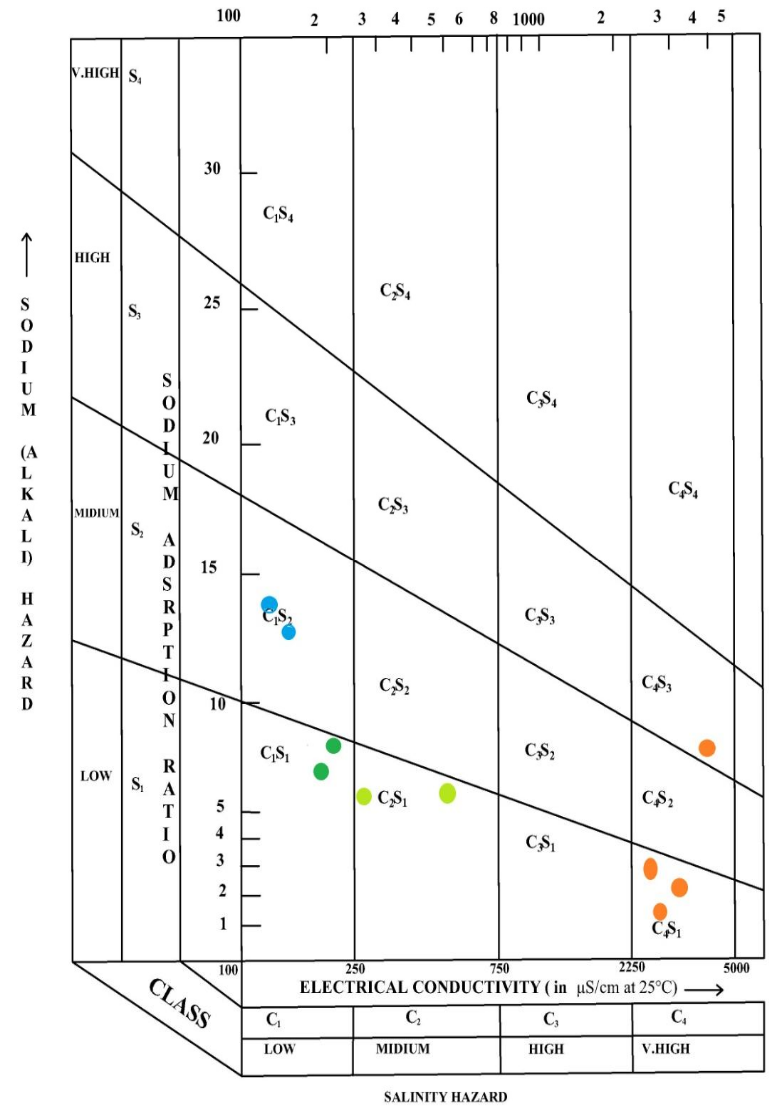

Figure 2: Salinity Diagram of the U.S. showing plots of Sodium Absorption Ratio and Electrical Conductivity of groundwater samples from study areas indicating suitability for irrigation.

Wilcox's Diagram:

Groundwater quality classification for irrigation water quality was done using Wilcox diagram (Xu, Panpan, 2019). For this diagram groundwater data were plotted between annual average values of Na+% and EC values. The groundwater data is classified as: unsuitable, doubtful to unsuitable, permissible to doubtful, good to permissible, and excellent to good for use as irrigation water. The fairness of groundwater for farming purposes relies upon the impact of mineral constituents of water on the both plants and soil. Salts may harm plant development truly by restricting the take-up of water through alteration of the osmotic cycles, or artificially/chemically by metabolic responses, for example, those brought about by toxic constituents (Singh, 2002). This exchange interaction of Na in water for Ca and Mg in soil lessens permeability and at last outcomes in soil with poor inward drainage. Thus, air and water course is limited during wet conditions, and such soils are generally hard when dry (Collins and Jenkins, 1996).

Wilcox (1955) used % sodium and electrical conductivity in evaluating irrigation waters using Wilcox diagram as given in Figure 3 The plotting of computed data on Wilcox reveals that 7 sample represent excellent to good category, 2 samples falls to permissible category, and 1 remaining is in doubtful to unsuitable category. The results show that the water of the study area is generally suitable for the irrigation purposes.

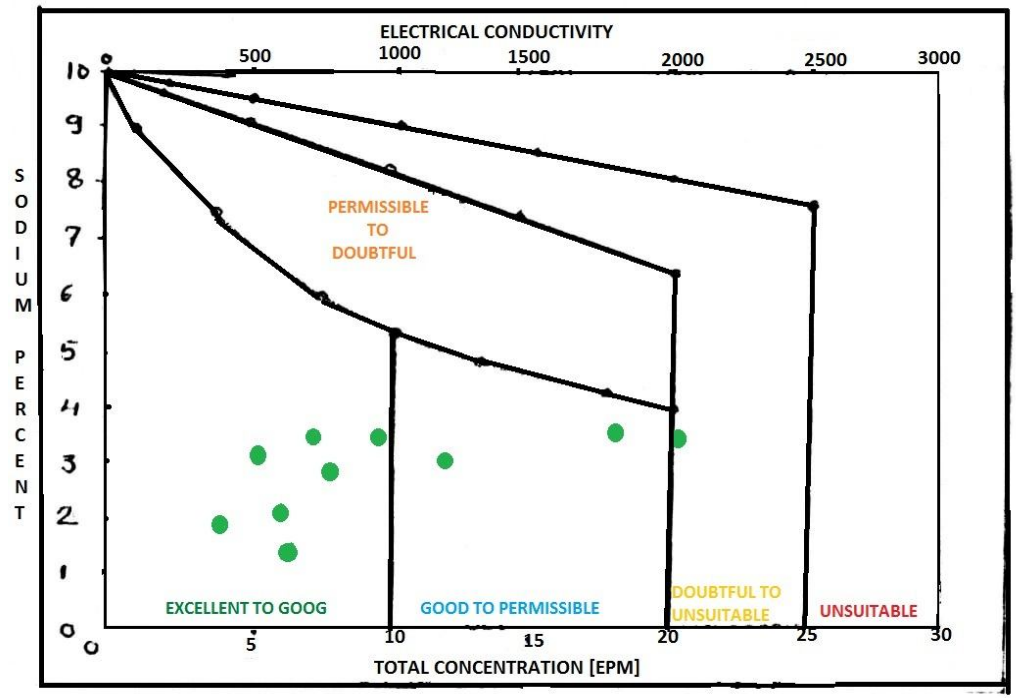

Figure 3: Determining groundwater quality by plotting Sodium Percentage versus Electrical Conductivity.

Kelley's Ratio:

Kelly's proportion (KR) presented by Kelly (1963) is a significant boundary utilized in the assessment of water quality for water irrigation system. This parameter is based the Na, Ca and Mg levels in the groundwater. As per this classification, groundwater with a KR value greater than one (KR > 1) is deemed unfit for irrigation system, which is calculated as follows.

$$\text{Kelley's Ratio} = \frac{Na^{+}}{Ca^{2+} + Mg^{2+}}$$

all ions in epm value

The Kelley's ratio has been determined for all the water samples of the study area. It differs from 0.32 to 2.02 epm (Table 5). Groundwater having more than one is by and large thought as unqualified for water irrigation system. The Kelley's proportion has been determined for all the groundwater tests of the investigation area. Some samples have been more than 1, so it is not suitable for irrigation system.

Residual sodium carbonate (RSC):

Residual Sodium Carbonate is defined as RSC = (CO_3 + HCO_3^-) – (Ca^{2+} + Mg^{2+}) where all concentrations are expressed in epm. The water having excess of carbonate and bicarbonate over the alkaline earth, mainly calcium and magnesium, in excess of permissible limits affects irrigation unfavourably (Sreedevi *et. al.,* 2018). Waters with high concentrations of HCO_3^- have the tendency to cause the precipitation of Ca^{2+} and Mg^{2+} as the water in the soil becomes more concentrated. As a result, the relative proportion of Na^+ in the water is increased in the form of sodium bicarbonate (Prasanna, *et. al*., 2011)). There has a range of values in the RSC for all field water samples (Table 2) between -0.59 and 2.39, and the RSC values less than 1.25 meq/L (RSC<1.25 meq/L) are generally considered safe for irrigation. Water with a RSC in the range of 1.25 and 2.5 meq/L is named marginal and could be utilized with good irrigation water system management techniques and soil salinity monitored by laboratory analysis (Salifu *et al.,* 2015).

CONCLUSION

Agricultural irrigation in Indian continent is largely dependent on groundwater. Some conventional techniques like water irrigation system coefficient, sodium adsorption ratio, total alkalinity, the Kelley's Ratio, Sodium and magnesium hazards, total saltiness and absolute disintegrated solids have been utilized to evaluate groundwater quality around here. Hydro-geochemical analysis of 10 groundwater samples in the study area revealed they are slightly alkaline in nature. A U S Salinity Diagram indicates that three samples fall into the C_4 S_1 class (very high salinity and low sodium hazards), while the first sample has high salinity and sodium hazards, thus it belongs to the C_4 S_3 class. According to Wilcox diagram, 7 samples are in the excellent-to-good category, 2 falls into the permissible category, and 1 is in the doubtful-to-unsuitable category. There were no samples with a RSC value exceeding 1.25 meq/L (RSC<1.25 meq/L), and all samples were found to range from -0.59 to 2.39. It has proved to be advantageous to use groundwater for irrigation in the study area.

REFERENCES

1. Aravindan S. (1999). Integrated hydro-geological studies in hard rock aquifer system of Gadilam River basin, Tamil Nadu, India. PhD thesis, Bharathidasan University, Thiruchirappalli, p 110
2. Barbele & Dev (2016). Chemical quality delineation of groundwater for irrigation purpose in Datana-Palkhanda sector of Ujjain district, Madhya Pradesh, India. *International Journal of Multidisciplinary Research and Development*. 3(9), 79-86.
3. Bhat M.A., Grewal M.S., Ramprakash R., 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.
4. Blandford WT. (1869). Geology of Tapti and lower Narmada Valley and some adjoining districts. *Mem. Geol. Sur. India* 6(3), 162-222.
5. Blanford, W.T. (1869). Geology of the area between Tapti and Narmada and Narmada valley and the adjoining districts of Malwa and Gujarat. *Geol. Surv. India Mem*. 6, 1-222.
6. Chahar, B. R. (2015). Groundwater Hydrology. McGraw-Hill Education (India) Private Limited. 669p.
7. Chen J, Huang Q, Lin Y, Fang Y, Qian H, Liu R, and Ma H. (2019). Hydrogeochemical Characteristics and Quality Assessment of Groundwater in an Irrigated Region, Northwest China. *Water*. 11(1), 96. https://doi.org/10.3390/w11010096
8. Delgado C, Pacheco J, Cabrera A, Batllori E, Orellana R, and Bautista F. (2010). Quality of groundwater for irrigation in tropical karst environment: the case of Yucata´n, Mexico. *Agric Water Manag* 97, 1423–1433. doi:10.1016/j.agwat.2010.04.006.
9. FAO (2003). The irrigation challenge: increasing irrigation contribution to food security through higer water productivity from canal irrigation system. IPTRID Issue Paper 4, IPTRID Secretariat, Food and Agricultural Organization of the United Nations, Rome. ftp://ftp.fao.org/docrep/fao/005/y4854 E/y4854 E00.pdf. Accessed 19 Jun 2016.
10. Fetter, C. W. (1988). Applied hydrogeology. Merrill Publ. Co., A. Bell Howell Information Co., Columbus, U.S.A, 529 p.
11. Kelly WP. (1963). Use of saline irrigation water. *Soil Sci* 95, 355–391
12. Kumar R. (1984). Fundamental geology and stratigraphy of India. Mohindar singh for Wiley eastern limited, 254 p.
13. Mills B. Interpreting water analysis for crop and pasture, file No. FS0334, DPI's. 2003.
14. Sreedevi P. D., Sreekanth P. D., Ahmed S, and Reddy D. V. (2018). Evaluation of groundwater quality for irrigation in a semi-arid region of South India. *Sustainable Water Resources Sustainable Water Resources Management,* 5(2), 1-14
15. Prasanna, M.V., Chidambaram, S., Hameed, A.S. et al. (2011). Hydrogeochemical analysis and evaluation of groundwater quality in the Gadilam river basin, Tamil Nadu, *India. J Earth Syst Sci*, 120, 85–98 (2011). https://doi.org/10.1007/s12040-011-0004-6
16. Richards LA. (1954). Diagnosis and improvement of saline and alkali soils. USDA Hand Book No 60:160

17. Richards, LA (US Salinity Laboratory) Diagnosis and improvement of saline and alkaline soils US Department of Agriculture hand book. 1954, 60.
18. Salifu, M., Aidoo, F., and Hayford, M.S. et al. (2017). Evaluating the suitability of groundwater for irrigational purposes in some selected districts of the Upper West region of Ghana. *Appl Water Sci* 7, 653–662. https://doi.org/10.1007/s13201-015-0277-z
19. Shah T., Molden D., Sakthivadivel R., and Seckler D. (2000). The global groundwater situation: Overview of opportunities and challenges. Colombo, Sri Lanka: International Water Management Institute. https://publications.iwmi.org/pdf/H025885.pdf (Accessed 20 Jun 2016).
20. Subba Rao N (2002) Geochemistry of groundwater in parts of Guntur district, Andhra Pradesh. India. *Environmental Geology*, 41(5), 552–562. doi: 10.1007/s002540100431.
21. Thorne DW, and Peterson HB. (1954). Irrigated Soils. Constable and Company, London, UK.
22. Todd DK. (1980). Groundwater hydrology. (2nd ed.). New York: Wiley. 315.
23. WHO, (1971). Annual report of the Director-General to the World Health Assembly and to the United Nations. World Health Organization.
24. Wilcox LV. (1955). Classification and use of irrigation waters. USDA Circular No 969, Washington, DC, p 19
25. Wilcox, L.V. (1956). Classification and use of irrigation waters, U.S Department of Agriculture, Washington D, 19 p.
26. Xu, Panpan. (2019). Hydrogeochemical Characterization and Irrigation Quality Assessment of Shallow Groundwater in the Central-Western Guanzhong Basin, China. *Int. J. Environ. Res. Public Health,* 16, 1492. doi:10.3390/ijerph16091492
27. USSL (US Salinity Laboratory) (1954). Diagnosis and improvement of saline and alkaline soils. Agriculture Handbook No. 60 USDA, p160
28. Collins, R. and Jenkins, A. (1996). The Impact of Agricultural Land Use on Stream Chemistry in the Middle Hills of the Himalayas, Nepal. *Journal of Hydrology,* 185, 71-86. http://dx.doi.org/10.1016/0022-1694(95)03008-5

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