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Government of India**

**CHEMICAL QUALITY OF GROUND WATER  
IN HYDROGRAPH NETWORK STATIONS OF BIHAR STATE**

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<b>S.no.</b>	<b>Content</b>	<b>Page No.</b>
1	Introduction	3
2	Area, Extent and Topography	3
3	Climate and Rainfall	4
4	Geology and Hydrogeology	4
5	Purpose and Objective	5
6	Methodology	5
7	Water Quality Parameters and Criteria	6
8	Chemical Quality of Groundwater in Bihar	7
8.1	Suitability of Groundwater for Potable and Irrigation purposes	7
8.1.1	Zone I	9
	Hydrogen Ion Concentration (pH)	
	Electrical Conductivity (EC)	
	Alkalinity	
	Chloride	
	Calcium	
	Magnesium	
	Total Hardness	
	Sodium and Potassium	
	Nitrate	
	Fluoride	
	Suitability of Groundwater for Irrigation purposes	

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<b>S.no.</b>	<b>Content</b>	<b>Page No.</b>
	Total Dissolved Solids (TDS)	
	United States Salinity Laboratory (USSL) Diagram	
	Alkalinity Hazard (RSC)	
	Wilcox Diagram	
	Hydrogeochemical facies of Groundwater	
8.1.2	Zone II	22
8.1.3	Zone III	29
8.1.4	Zone IV	36
8.1.5	Zone V	43
8.1.6	Zone VI	50
8.1.7	Zone VII	57
8.1.8	Zone VIII	64
8.1.9	Zone IX	71
9	Major Findings	78
10	Conclusions	79
11	Acknowledgements	82
12	References	82
13	Annexure A (Chemical Data)	I
14	Annexure B (Suitability of ground water for irrigation purposes)	XXVII

# **CHEMICAL QUALITY OF GROUND WATER IN HYDROGRAPH NETWORK STATIONS OF BIHAR STATE (2022-2023)**

## **1. INTRODUCTION**

Ground water is an essential natural resource for domestic, agricultural and industrial consumption. Quality of ground water is as much demanding as its quantity. Suitability of ground water for drinking and irrigational purpose is important for its safe and effective use. In the state of Bihar, the pressure on ground water is considerable to meet urban water requirements as well as the irrigation requirements in the semi-urban areas. Chemically, the ground water is an aqueous solution in the sub-surface geological formation. The concentration of the major ions and other dissolved ions in ground water are functions of the availability of the constituents in the aquifer matrices and their solubility. Rocks, through which water circulate, are composed of minerals and amorphous solids, which in turn are composed of chemical elements that greatly affect the ground water quality.

This report is an overview of the chemical quality of ground water as determined by analyzing water samples collected from hydrograph network stations (fixed by Central Ground Water Board) spread over the entire state of Bihar, tapping phreatic aquifer zone and interpreting the obtained data with respect to its use in various spheres of life.

## **2. AREA, EXTENT & TOPOGRAPHY**

Bihar is located in the eastern part of the country. Bihar state lies between 83° 20' and 88° 00' E Longitudes and 24° 15' and 27° 23' N Latitudes. It shares international border with Nepal in the north and is bounded in the east, west and south by West Bengal, Uttar Pradesh and Jharkhand states respectively. The state covers geographical area of 94,163 Sq.km and has its capital at Patna. Bihar is mainly a vast stretch of very fertile flat land. It is endowed with several rivers namely Ganga, Son, Bagmati, Kosi, Budhi Gandak, and Falgu. Central part of Bihar comprises of some small hills, for example the Rajgir hills. The topography of Bihar can be easily described as a fertile alluvial plain occupying the Gangetic Valley. The plain extends from the foothills of the Himalayas

in the north to a few miles south of the river Ganges as it flows through the state from the west to the east. Bihar is richly endowed with water resources, both the ground water resource and the surface water resource. It has considerable water supply from the rivers which flow within the territory of the State. Ganga is the main river which is joined by tributaries with their sources in the Himalayas. Rich farmland and lush orchards extend throughout the state.

### **3. CLIMATE & RAINFALL**

The climate of Bihar is a part of the climatic pattern of the Indian subcontinent. It enjoys a continental monsoon type of climate owing to its great distance from the sea. The winter season extends from December to February and the summers from the month of March to May. The Southwest monsoon accounts for most of the rainfall in the state extending from June to September. The retreating southwest monsoon is from October to November. Bihar is mildly cold in the winter (the lowest temperatures being around (5° to 10° C). It is very hot in the summer season (40° to 45° C). October & November and February & March is the time when the state has a pleasant climate Bihar lies in the tropical to subtropical region. Rainfall here is the most significant factor in determining the nature of vegetation. Bihar has a monsoon climate with an average annual rainfall of 1200 mm.

### **4. GEOLOGY & HYDROGEOLOGY**

The state of Bihar has diversified geology, ranging from Archean metamorphic to recent alluvial sediments. The general stratigraphic succession in the state can be grouped in Table 1 as under-

**TABLE 1 Generalized Geological Succession of Bihar**

<b>Age</b>	<b>Formation</b>	<b>Broad Lithology</b>	<b>Places of occurrence</b>
Quaternary	Alluvial deposits	Sand, clay, silt & occasional gravels	All the districts of north Bihar, Bhojpur, Patna, Jehanabad, Nalanda, parts of Aurangabad, Gaya, Monger, Nawada, Bhagalpur & southern parts of state
Tertiary	Siwaliks	Sandstone, conglomerate, clay,	North eastern parts of West Champaran district

		stone, gravel	
Cambrian	Vindhyan Super Group	Sandstone, Limestone etc.	Rohtas, parts of Aurangabad
Precambrian	Chhotanagpur Granite gneiss & rocks of Bihar Mica belt.	Granites, granite gneiss, schists, phyllites, dolomites, basic rocks, amphibolites	Parts of Aurangabad, Gaya, Nawada, Monger, & Bhagalpur

## 5. PURPOSE & OBJECTIVE

The purpose of this report on samples collected from hydrograph network stations fixed by Central Ground Water Board over the entire state of Bihar is to get an overall picture of the changing quality of ground water over the years. The objective of the study is to provide a baseline data for additional studies.

## 6. METHODOLOGY

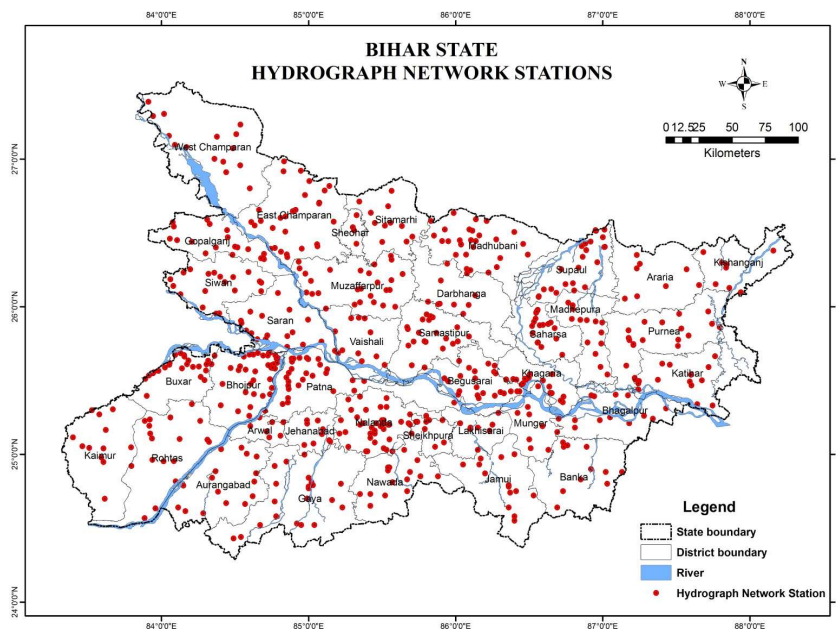
A total no. of 661 ground water samples were collected from various Hydrograph Network Stations (HNS) during pre-monsoon (May) of the 2022. Generally, the network stations are open dug wells tapping phreatic aquifer. Ground water samples were collected from hand pumps where dug wells are not in use. All the samples were analyzed for the determination of pH, EC,  $\text{CO}_3^{2-}$ ,  $\text{HCO}_3^-$ ,  $\text{Cl}^-$ ,  $\text{NO}_3^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{F}^-$ ,  $\text{PO}_4^{3-}$  Total hardness (T.H),  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^+$  &  $\text{K}^+$ , U ions. The analysis of water samples was done as per standard methods (APHA 1991). The standard methods (Table-II) that have been adopted for the chemical analysis of different constituents in water samples is given in Table 2.

**Table 2 Method used for Chemical Analysis of Ground Water Samples**

Sl. No.	Constituents	Method Used
1.	pH	pH Meter
2.	EC	EC Meter
3.	Carbonate	Titrimetric method
4.	Bi-carbonate	Titrimetric method
5.	Chloride	Mohr's Titrimetric method
6.	Total Hardness	Complexometric Titration

7.	Calcium	Complexometric Titration
8.	Magnesium	Evaluation from TH and Ca
9.	Sodium	Flame emission photometric method
10.	Potassium	Flame emission photometric method
11.	Nitrate	Ultraviolet Spectrophotometric method
12.	Sulphate	Turbidimetric method
13.	Phosphate	Ascorbic Acid method
14.	Fluoride	Ultraviolet Spectrophotometric method

The chemical analysis results for 661 nos. of samples collected from Hydrograph Network Stations (Fig. 1) spread in entire Bihar have been tabulated in Annexure A.



**Figure 1 Map showing Hydrograph Network Stations in Bihar**

## 7. WATER QUALITY NORMS AND CRITERIA

Water quality standards and guidelines have been laid down by WHO (2004), Govt. of India, National High Tech Mission (1986) and BIS (2012) and many other organizations. These guidelines are exhaustive and it becomes very difficult to analyze ground water samples for all the constituents. The water quality is judged by a common man mainly by Eyes, nose and tongue tests before using it for domestic purposes. They are-

E (Eyes): Appearance - turbidity, particles, oily layer, color etc.



N (Nose): Odor - no smell, rotten egg smell, fishy smell etc.

T (Tongue) Taste - salinity, pH, temperature, soluble iron chloride etc.

The guidelines/standards laid down by BIS (2012) with regard to some constituents for domestic and potable purposes have been tabulated below in Table 3.

**Table 3 Water Quality Guidelines**

S. No.	Parameters	Desirable limit	Max. Permissible limit
1.	Color (Hazen Units)	5	25
2.	Turbidity (NTU)	5	10
3.	pH	6.5-8.5	No relaxation
4.	Total Dissolved Solids (mg/l)	500	2000
5.	Alkalinity (mg/l)	200	600
6.	Chloride (mg/l)	250	1000
7.	Total Hardness as CaCO <sub>3</sub> (mg/l)	300	600
8.	Calcium (mg/l)	75	200
9.	Magnesium (mg/l)	30	100
10.	Sodium (mg/l)	-	-
11.	Potassium (mg/l)	-	-

## **8. CHEMICAL QUALITY OF GROUND WATER IN BIHAR**

The chemical quality of ground water depends on various factors like source of water such as rainfall, erosion, dry fall out, weathering of rocks and as a result of chemical reactions taking place on and below the surface. Thus, the chemical quality of water is dependent on geological and hydrogeological conditions prevailing in the area, climate, topography, nature of soil, physicochemical characteristics of rocks, nature of plantation and finally the activities of man resulting in environmental pollution. The pollution of ground water may lead to abandonment of wells, so in order to deal with this problem it becomes necessary to assess its suitability for drinking and irrigation purpose before corrective measures are undertaken.

### **8.1 SUITABILITY OF GROUND WATER FOR POTABLE AND IRRIGATION PURPOSES**

The suitability of ground water for drinking purposes has been assessed according to the guidelines laid down by BIS (2012), Table – III for various analyzed parameters. The minimum, maximum and average values of various constituents determined during chemical analysis have been summarized in Table 4 below.

**Table 4 Hydro-Chemical Data of Ground Water in Bihar (An Overview)**

S. No.	Constituents	Minimum	Maximum	Average
1.	pH	6.63	8.7	7.69
2	TDS mg/L	58	3004.3	629.82
3.	CO <sub>3</sub> <sup>2-</sup> mg/l	0	36	0.28
4.	HCO <sub>3</sub> <sup>-</sup> mg/l	18.3	1055.3	366.92
5.	Cl <sup>-</sup> mg/l	3.54	1306.4	87.05
6.	TH (as CaCO <sub>3</sub> ) mg/l	35	1510	323.74
7.	Ca <sup>2+</sup> mg/l	4	306	67.45
8.	Mg <sup>2+</sup> mg/l	1.21	214	37.77
9.	Na <sup>+</sup> mg/l	0	323.31	62.33
10.	K <sup>+</sup> mg/l	0	174.4	15.14
11.	NO <sub>3</sub> <sup>-</sup> mg/L	0	233	12.71
12.	SO <sub>4</sub> <sup>2-</sup> mg/L	0	221	44.53
13.	F-mg/L	0	3.56	0.65

To get a better insight on the chemical quality of ground water in Bihar, the entire state is divided in 09 zones (Table 4). In each zone the suitability of collected ground water samples has been evaluated for both drinking and irrigation purpose.

**Table 4 Zone wise distribution of Bihar**

Zone	Districts	Number of ground water samples
I.	West Champaran, East Champaran	44
II.	Gopalganj, Siwan, Saran	56
III.	Sitamarhi, Sheohar, Muzzafarpur, Vaishali, Madhubani, Darbhanga, Samastipur, Begusarai, Khagaria	157
IV.	Supaul, Araria, Kishanganj, Saharsa, Madhepura, Purnea, Katihar	110

V.	Buxar, Bhojpur, Patna, Jehanabad	98
VI.	Kaimiur, Rohtas	30
VII.	Aurangabad, Arwal, Gaya, Nalanda, Nawada, Sheikhpura	110
VIII.	Jamui, Banka	26
IX.	Lakhisarai Munger, Bhagalpur	30

### **8.1.1 Zone I**

In this zone East and West Champaran districts were taken into consideration. Geologically, east Champaran district has unconsolidated alluvial sediments of Quaternary age and west Champaran district has Siwalik sediments of tertiary age, bhabar and alluvium sediments of quaternary age.

#### **Hydrogen Ion Concentration (pH)**

pH is a measurement of the acidic and basic nature of water. It ranges from 0-14, with 7 as the neutral value. Water samples with pH value less than 7 is an indication of acidity whereas values greater than 7 indicates basic character. pH is defined as the relative amount of free hydrogen and hydroxyl ions in the water and is calculated as the negative logarithm of hydrogen ion activity. The pH range in drinking water as given by BIS 2012 is 6.5-8.5. The samples collected from zone 1, has shown slightly alkaline nature with pH values in the range of 7.55 to 8.2, with an average value of 7.89. The maximum value was observed at Chatia, Chiraiya block of East Champaran district.

#### **8.1.2 Electrical Conductivity (EC)**

Electrical Conductivity is an important measure in the determination of ground water quality. It is the ability of water to pass an electric current. It is influenced by the presence of dissolved cations ( $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Fe}$ ,  $\text{Al}^{3+}$  etc.) and anions ( $\text{Cl}^-$ ,  $\text{NO}_3^-$ ,  $\text{PO}_4^{3-}$ ,  $\text{SO}_4^{2-}$  etc.). Thus, it is directly related to the extent of mineralization and indicated degree of salinity of ground water. The EC values in zone 1 were in the range 394-3328  $\mu\text{S}/\text{cm}$ , with an average value of 1070.75  $\mu\text{S}/\text{cm}$ , respectively. The highest value of EC was observed at Bhakatiy Tola, Ghorasahan block, East Champaran district. Out of 44 locations, 02 locations have shown high EC values.

#### **8.1.3 Alkalinity**

The alkalinity of water is the measure of the capacity of water to neutralize an acid. The alkaline nature of water is due to the presence of dissolved species such as bicarbonates,

carbonates, carbon dioxide, hydroxide ions (Hem 1989). Bicarbonate ions are one of the dominant species in water bodies. According to Hem (1989), carbonate species can contribute only small amounts to alkalinity in water. Out of 44 samples studied, no sample has shown carbonate alkalinity. The variation observed in the concentration of bicarbonate species was in the range of 164.7 to 1024.8 mg L<sup>-1</sup>, with an average value of 417.9 mg L<sup>-1</sup>, respectively. The maximum value was observed at Chatia, Chiraiya block of East Champaran district. Out of 44 samples collected, 37 samples have shown alkalinity within the permissible limit. A percent distribution of collected ground water samples on the basis of alkalinity is given in Table I.1.

**Table I.1 % Distribution of Ground Water Samples in Different Alkalinity Range**

Alkalinity Range (mg/l)	Percentage
0 - 600	84.1
> 600	15.9

From **Table I.1**, it can be seen that most of the ground water samples collected from Zone I, has alkalinity values within the permissible limit of 600 mg L<sup>-1</sup>.

### Chloride

Chloride is one of the major inorganic anions in ground water. The chloride content of hard rocks is generally low. It may be found in soil deposits of old sedimentary rocks. The major source of chloride in ground water are - (i) Rain water, (ii) solution of dry fallout from the atmosphere, (iii) solution of halite and other minerals & (iv) source related to the activities of man such as domestic sewage and industrial effluents etc.

The concentration of chloride ions was in the range of 7.1 to 717.1 mg L<sup>-1</sup>, with an average value of 97.30 mg L<sup>-1</sup>, respectively. The highest concentration of chloride ions was observed at Bhakatiy Tola, Ghorasahan block, East Champaran district. From Table I.2 it is clear that chloride concentrations of less than 7% of ground water samples is exceeding the acceptable limit for drinking purposes (250 mg/L, BIS, 2012) but is well within the permissible limit of 1000 mg/L for all the samples.

**Table I.2 % Frequency Distribution of Chloride in NH Stations of Bihar**

Chloride concentration (mg/l)	Percentage
Within Acceptable limit (0 – 250)	93.18
Within Permissible limit (1000)	100

### Calcium (Ca)

Calcium is one of the most common constituents in water. It is found in minerals from sedimentary rocks such as calcite, aragonite, gypsum, anhydrite and silicate mineral like anorthite, diopside etc. The main source of calcium in ground water are (i) rain water, (ii) dissolution of evaporate deposits, (iii) weathering of calcium silicate minerals, (iv) fertilizers and soil amendments and (v) release of Ca ion by ion exchange. The absence of calcium in drinking water causes rickets in the body, while excess concentration causes gout and rheumatism. The calcium concentration in zone I ground water samples was in the range of 22-224 mg L<sup>-1</sup>, with an average value of 79.77 mg L<sup>-1</sup>. The maximum value was observed at Chatia, Chiraiya block of East Champaran district. The concentration of calcium for all the samples was found to be within the permissible limit (200 mg L<sup>-1</sup>) in 95.45 % of the samples indicating that water is suitable for potable purposes (Table I.3).

**Table I.3 % Frequency Distribution of Magnesium in NH Stations of Bihar**

Calcium concentration (mg/l)	Percentage
0-200	95.45
>200	4.55

### Magnesium (Mg)

The major sources of magnesium in ground water are (i) rain water, (ii) evaporate deposits & (iii) weathering of magnesium silicate minerals. The source of magnesium in igneous rocks are olivine, pyroxenes, amphiboles, dark-colored micas etc. Among the sedimentary rocks, the sources are chlorite, serpentine biotite, amphiboles, staurolite etc. Magnesium is one of the constituents responsible for hardness of water. The lower concentration of magnesium is not harmful but higher concentration is laxative. In the study area magnesium concentration was found in the range of 2.43 to 99.63 mg L<sup>-1</sup>, with an average value of 40.29 mg L<sup>-1</sup>. The highest concentration of magnesium ions was observed at Bhakatiy Tola, Ghorasahan block, East Champaran district. As can be seen from Table I.4, all the samples in zone I have magnesium concentration within the permissible limit of 100 mg L<sup>-1</sup>. Thus, in general, the ground water in this zone is fit for human consumption.

**Table I.4 % Frequency Distribution of Magnesium in NH Stations of Bihar**

Magnesium concentration (mg/l)	Percentage
0-100	100
>100	0

### Total Hardness (T.H. as CaCO<sub>3</sub>)

The hardness results from the divalent metallic ions of which the calcium and magnesium are the most abundant ions in ground water. These ions react with soap to form precipitates, and with certain anions present in water form scales. The degree of hardness in water can be judged from the classification presented below in Table I.5.

**Table I.5 Water Class as depicted by different T.H. range**

Total Hardness as CaCO <sub>3</sub> (mg/l)	Water Class
<75	Soft
75 – 150	Moderately hard
151-300	Hard
301-600	Very hard
>600	Extremely Hard

In the study area Zone I, the total hardness in ground water samples range from 165 to 930 mg L<sup>-1</sup>, with an average value of 365.23 mg L<sup>-1</sup>. The maximum concentration was observed at Chatia, Chiraiya block of East Champaran district. As can be seen from Table I.6, 93.18 % of the collected samples were found to have total hardness within the permissible limit of 600 mg L<sup>-1</sup>.

**Table I.6 % Frequency Distribution of T. H. (as CaCO<sub>3</sub>) in NH Stations of Bihar**

Total Hardness (as CaCO <sub>3</sub> , mg/l)	Percentage
0-600	93.18
>600	6.82

### Sodium (Na)

Sodium is found in varying concentrations in all natural waters. It is found in evaporates and sea water in high concentration. It occurs among silicate minerals in feldspar, mica, amphiboles and pyroxenes. The main sources of sodium in ground water are (i) rain water, (ii) evaporate deposits, (iii) weathering of rock minerals present in the soil, (iv) disposal of sewage and industrial wastes containing sodium. The higher concentration of Na in drinking water is harmful especially to those suffering from cardiac, renal

diseases pertaining to circulatory system of the human body. The analysis result of collected ground water samples indicated that sodium ranges from 8.87 to 323.21 mg L<sup>-1</sup>, with an average value of 66.22 mg L<sup>-1</sup>. The highest concentration of sodium ions was observed at Bhakatiy Tola, Ghorasahan block, East Champaran district.

### **Potassium (K)**

Although potassium is more abundant than sodium in sedimentary rocks, its concentration in natural waters is quite low due to greater resistance to weathering of potassium bearing minerals. The major sources of potassium in natural waters are (i) rain water, (ii) weathering of Potash silicate minerals, (iii) potash fertilizers. K enters into structure of clay and clay bearing minerals during weathering. If potassium ions are incorporated in spaces between crystal layers where these are not removable by further ion exchange reactions (Buckman & Brady, 1960). Usually, the concentration of potassium in water from natural source is small but high concentration of this ion if present, may be attributed to pollution. Potassium is an essential plant nutrient. It plays an important role in maintenance of cellular organization and in keeping the protoplasm in a proper degree of hydration by stabilizing the emulsions of highly colloidal particles. Potassium deficiency causes water imbalance. The carbohydrate metabolism is also affected by inadequate supplies of potassium.

The analysis of collected ground water samples indicated that the concentration of potassium ions varies from 1.05 to 65 mg L<sup>-1</sup>, with an average of 20.2 mg L<sup>-1</sup>. The highest concentration of potassium ions was observed at Bhakatiy Tola, Ghorasahan block, East Champaran district.

### **Nitrate (NO<sub>3</sub><sup>-</sup>)**

Nitrate is one of the end products of the biologic nitrification process, is the most ubiquitous chemical contaminant in the world's aquifers and the concentration levels are increasing. The distribution of nitrate in ground water is controlled by a number of factors. They include source availability, thickness and composition of the vadose zone, precipitation, irrigation, ground water flow, aquifer heterogeneity, dissolved oxygen concentrations and electron donor availability and dispersion. Nitrogen is also found in many organic compounds such as proteins and protein derivatives including purines, pyrimidines, and urea. Generally, inorganic nitrogen salts are quite soluble in natural waters. In the collected ground water samples concentration of nitrate ions was found to be in the range of 0 to 30.84 mg L<sup>-1</sup>, with an average value of 7.60 mg L<sup>-1</sup>. The highest

concentration of nitrate ions was observed at Shyampur, Adapur block, East Champaran district.

In all the samples, the concentration of nitrate ions was found to be within the acceptable limit of BIS 2012 ( $45 \text{ mg L}^{-1}$ ).

### **Fluoride ( $\text{F}^-$ )**

Fluorine is the lightest member of halogen group of elements and most electronegative of all elements. In solution it forms fluoride ( $\text{F}^-$ ). Fluoride forms strong solute complexes with many cations. Fluorite ( $\text{CaF}_2$ ) is a common fluoride mineral but has low solubility and occurs in sedimentary and igneous rocks. Apatite  $\text{Ca}_5(\text{Cl},\text{F},\text{OH})(\text{PO}_4)_3$  commonly contains fluoride. The occurrence of the fluoride in ground water is predominantly geogenic. Fluoride enrichment in ground water takes place mainly through leaching and weathering of the Fluoride bearing minerals present in the rocks and sediments which depends on several factors such as the origin of water, composition of water bearing medium, the length of time the water has been in contact with the medium, the temperature and pressure conditions, ion-exchange, rate of recharge and discharge etc. The important fluoride-bearing minerals are; fluorite (fluorspar), fluorapatite, cryolite, biotite, muscovite, lepidolite, tourmaline, hornblende series minerals, glucophane-riebeckite etc Besides these, there are anthropogenic source of fluoride also, like phosphatic fertilizer, cow dung and urban waste etc. Low level fluoride is required by human system as it is helpful in preventing dental carries, while consumption of high concentrations of fluoride can lead to serious health issues. The long exposures and use of ground water having high fluoride in excess of  $1.5 \text{ mg L}^{-1}$  results in Fluorosis. The types of fluorosis are dental, skeletal as well as non-skeletal type.

In the study area Zone I, the concentration of Fluoride ions was in the range of  $0.03$  to  $1.4 \text{ mg L}^{-1}$ , with an average value of  $0.60 \text{ mg L}^{-1}$ . The highest concentration was observed at Lakhwara, Motihari block, East Champaran. It was observed that in all the collected ground water samples, the concentration of fluoride ions was within the permissible limit of  $1.5 \text{ mg L}^{-1}$ .

By and large the ground water of Zone I, was found to be suitable for drinking purpose as per the available analyzed chemical parameters. The presence of some constituents beyond the permissible limit at some locations renders the water unfit for public water supply.



## SUITABILITY OF GROUND WATER FOR IRRIGATION PURPOSE

The chemical quality of water is an important factor to be considered in evaluating its suitability towards irrigation purposes. Plants absorb and transpire water but leave nearly all the salts behind in the soil, where they accumulate and eventually prevent plant growth. Excessive concentrations of solute interfere with the osmotic process by which plant root membranes are able to assimilate water and nutrients.  $\text{CaCO}_3$  has low solubility, it may precipitate harmlessly but the bulk of residual solutes present a disposal problem that must be solved effectively to maintain productivity of the irrigated soil. In areas where natural drainage is inadequate, the irrigation water infiltrating the root zone will cause water table to rise excessively. In addition to problems caused by excessive concentration of dissolved solids, certain constituents in irrigation water are especially undesirable and some may be damaging even when present in small concentrations. Various parameters viz. Total Dissolved Solids (TDS), Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC), Soluble Sodium Percentage (SSP) & Water Class have been evaluated to assess the suitability of ground water for irrigation purposes.

### Total Dissolved Solids (TDS)

Total dissolved solids represent the total concentration of dissolved substances in water. It is made up of inorganic salts and small amount of organic matter. The common inorganic salts found in water generally includes calcium, magnesium, sodium, potassium as cations and carbonates, bicarbonates, chlorides, sulphates, nitrates as anions. These minerals can also come from anthropogenic sources such as urban and agricultural runoff, wastewater discharge, industrial effluent etc.

The total load of dissolved solids in water is determined theoretically by taking into account the EC of that particular water body. It is calculated as the formula given in Equation 1.

$$\text{TDS} = \text{EC} * 0.65 \text{ mg L}^{-1} \quad (\text{Equation1})$$

where EC is in  $\mu\text{S/cm}$  at  $25^\circ \text{C}$

TDS is responsible for the mineralization of water and gives its degree of salinity. The TDS – Salinity relationship is presented below in Table I.7.

**Table I.7 Total Dissolved Solids – Salinity Relationship**

TDS (mg/l)	Degree of Salinity
0-1000	Fresh, Non-Saline

1001-3000	Slightly Saline
3001-6000	Moderately Saline
6001-10,000	Highly Saline
10,001-35,000	Excessively Saline
>35000	Brine

The TDS values in zone I were in the range of 256.1 to 2163.2 mg L<sup>-1</sup>, with an average value of 696 mg L<sup>-1</sup>. The maximum value of TDS was observed at Bhakatiy Tola, Ghorasahan block, East Champaran district. As can be seen from Table I.8, only 11.36 % of the collected ground water samples were slightly saline and rest 88.64 % were non saline.

**Table I.8 % Frequency Distribution of T.D.S. in NH Stations of Bihar**

Salinity as per T.D.S range	Percentage
Fresh, non-saline (0-1000 mg/l)	88.64
Slightly saline (1001-3000 mg/l)	11.36

### **United States Salinity Laboratory (USSL) Diagram**

The diagram illustrates the salinity and sodium hazards of irrigation water. It assumes that water is used under average conditions with respect to soil texture, drainage, infiltration rates, quantity of water used, climate and tolerance of crops. The diagram for the classification of irrigation water is based on salinity hazard i.e., Electrical Conductivity in  $\mu\text{S}/\text{cm}$  at 25° C versus the Sodium hazard i.e., Sodium Adsorption Ratio (SAR).

**Salinity Hazard** – The irrigation waters have been divided into four classes with respect to the EC value ranges as below-

**C<sub>1</sub> – Low Salinity Water** (EC range <250  $\mu\text{S}/\text{cm}$  at 25° C)

Such waters can be used for irrigation of most of the soils and crops with little or no problem of salinity and practically with no leaching requirements.

**C<sub>2</sub> – Medium Salinity Water** (EC range 250-750  $\mu\text{S}/\text{cm}$  at 25° C)

Such waters can be used for irrigation of plants with moderate salt tolerance and on soils without special practices for salinity control.

**C<sub>3</sub> – High Salinity Water** (EC range 750-2250  $\mu\text{S}/\text{cm}$  at 25° C)

Such water requires adequate drainage and special management for salinity control to grow plants with good salt tolerance.

**C<sub>4</sub> – Very High Salinity Water** (EC range >2250 µS/cm at 25° C)

Such water can be used occasionally under very special conditions. For use of such water the soil must be permeable with good drainage. Irrigation water must be applied in excess to produce considerable leaching and crop with high salt tolerance must be grown.

**Table I.9 % Frequency Distribution of E.C. in NH Stations of Bihar**

E.C range (µS/cm at 25° C)	Percentage	Class of water (for irrigation)
<250 (low saline, C <sub>1</sub> )	0	Class-1, Excellent
250-750 (medium saline, C <sub>2</sub> )	36.36	Class-2, Good
751-2250 (high saline, C <sub>3</sub> )	59.10	Class-3, Permissible
>2250 (very high saline, C <sub>4</sub> )	4.54	Class-4, Unsuitable

As per Table I.9 it is evident that in the study area Zone I, most of the water samples are observed to lie in C<sub>2</sub> & C<sub>3</sub> class exhibiting medium to high salinity. Thus 36.36 % water samples in the area are found to be of good class for irrigation and 59.1 % samples lie within the permissible limit as per class of water for irrigation. Only 4.54 % water samples exhibited unsuitable class of water for irrigation purposes. A few extremely high values, 3325 µS/cm at Bhakatiy Tola, Ghorasahan block and 3155 µS/cm at Chatia, Chiraiya block of East Champaran district were observed.

**Alkali Hazard** – The suitability of irrigation water is characterized by absolute and relative concentrations of cations. If the concentration of sodium ions is high, the alkali hazard is high and if the calcium & magnesium levels are high, this hazard is low. The alkali soils are formed by the accumulation of exchangeable sodium and are characterized by poor tilt and low permeability. The U.S. Salinity laboratory has recommended the use of sodium adsorption ratio (SAR) as it is closely related to adsorption of sodium by the soil and can be calculated by using Equation 2.

$$SAR = \frac{Na^+}{\left(\frac{Ca^{2+} + Mg^{2+}}{2}\right)^{(1/2)}} \quad \text{(Equation 2)}$$

where Na<sup>+</sup>, Ca<sup>2+</sup> and Mg<sup>2+</sup> are in meq/L.

The water with regard to SAR is classified into four categories –

(i) **S<sub>1</sub> – Low Sodium Water** (SAR <10):

Such waters can be used on practically all kinds of soils without any risk or increase in exchangeable sodium.

(ii) **S<sub>2</sub> – Medium Sodium Water** (SAR 10-18)

Such waters may produce an appreciable sodium hazard in fine textured soil having high cation exchange capacity under low leaching.

(iii) **S<sub>3</sub> – High Sodium Water** (SAR >18-26)

Such waters indicate harmful concentrations of exchangeable sodium in most of the soil and would require special management, good drainage, high leaching and addition of organic matter to the soil. If such waters are used on gypsiferous soils the exchangeable sodium could not produce harmful effects.

(iv) **S<sub>4</sub> – Very High Sodium Waters** (SAR >26)

Generally, such waters are unsatisfactory for irrigation purposes except at low or perhaps at medium salinity where the solution of calcium from the soil or addition of gypsum or other amendments make the use of such waters feasible. A classification of the collected ground water samples on the basis of SAR values is given in Table I.11. The SAR values in the study area zone I, ranges from 0.21 to 4.74, with an average value of 1.39. Thus, in the study area of 100 % of the water samples are observed to lie in S<sub>1</sub> class exhibiting low sodicity.

As per USSL diagram given in Figure I.1, the ground water in the study area zone I, mostly comes under the C2-S1 type suggesting medium salinity and low sodicity, followed by C3-S1 type and a very few in C4-S2 type. The salinity hazard is posed by the water samples as they fall in class C3 and C4. Thus, on the whole 4.54 % of the water samples indicate C4-S2 class rendering the water unsuitable for irrigation purposes under ordinary conditions, however, it may be used occasionally after taking suitable measures.

#### **Alkalinity Hazard or Residual Sodium Carbonate (RSC)**

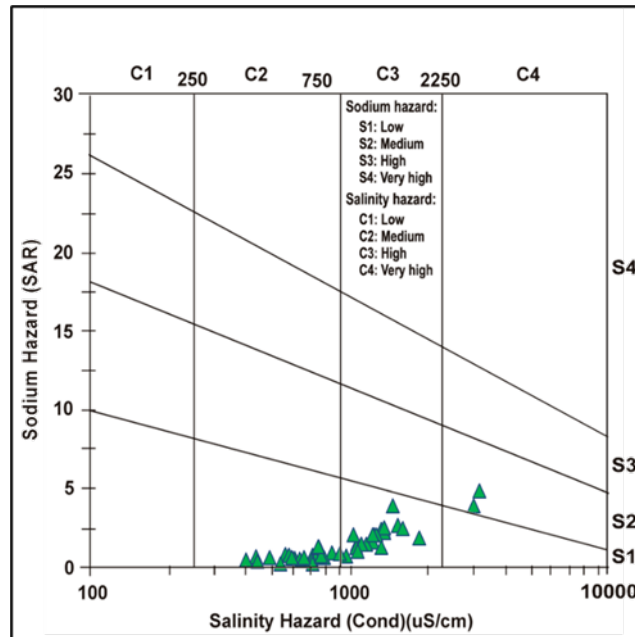
When carbonate or bicarbonate concentration in irrigation water is relatively higher than the alkaline earth metals, there is tendency for calcium and magnesium ions to precipitate as carbonates in the soil, thereby reducing the level of calcium and magnesium ions and increasing the relative levels of sodium in the soil. The highly

soluble sodium carbonate (black alkali) known as residual sodium carbonate (RSC) is defined as –

$$\text{RSC} = (\text{HCO}_3^- + \text{CO}_3^{2-}) - (\text{Ca}^{2+} + \text{Mg}^{2+})$$

where concentrations are expressed in meq/l.

In Table I.10, a classification of ground water samples as per RSC values proposed by Eaton is given.



**Figure I.1 USSL diagram of districts under Zone I**

**Table I.10 Classification of ground water Samples as per RSC values (Eaton, 1950)**

RSC range (meq/L)	Suitability for Irrigation
< 1.25	Very safe water
1.25-2.5	Marginally safe water
>2.5	Unsuitable water

The ground water samples collected from Zone I has shown that the Residual Sodium Carbonate in the area was in the range of -10 to 3.30 meq L<sup>-1</sup>, with an average value of -0.45 meq L<sup>-1</sup>.

A classification of the collected ground water samples on the basis of RSC values is given in Table I.11.

It is clear from Table I.9, that in the study area 93.18 % (with RSC <1.25 meq L<sup>-1</sup>) were found to be very safe for use in irrigation whereas 4.54 % of water samples (with RSC > 2.5 meq/l) were found to be unsuitable for irrigation purposes. The places

showing ground water associated RSC ( $> 2.5 \text{ meq L}^{-1}$ ) are Chakia, Chalkia 1 block ( $3.30 \text{ meq L}^{-1}$ ) and Chiraiya, Belia block ( $3.00 \text{ meq L}^{-1}$ ), in East Champaran district.

### 8.2.5 Soluble Sodium Percentage (S.S.P) (Wilcox Plot)

It takes into account the concentration of major ions in  $\text{meq L}^{-1}$ . It is calculated using equation 3.

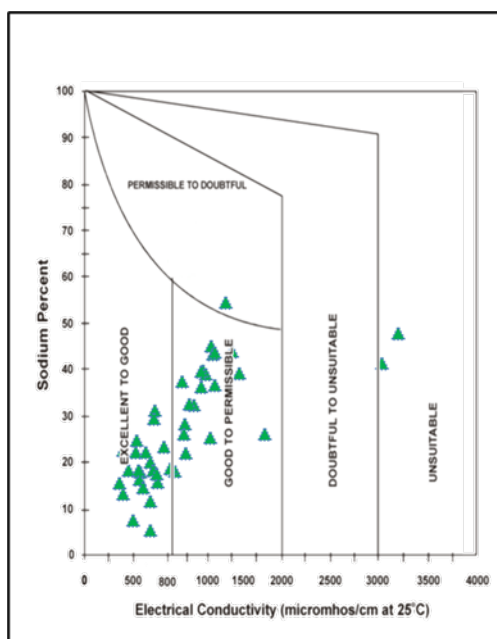
$$\% \text{ Sodium} = \frac{\text{Na}^+ + \text{K}^+}{(\text{Ca}^{2+} + \text{Mg}^{2+} + \text{Na}^+ + \text{K}^+)} \times 100 \quad (\text{Equation 3})$$

where  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  are in  $\text{meq L}^{-1}$ .

The % sodium values were in the range of 5.72 to 53.70, with an average value of 27.27. The maximum % sodium value was observed at Chiraiya, Belia block, East Champaran district.

A classification of ground water samples on the basis of % sodium values is given in Table I.11.

It was observed that 34.1 % of the samples were in the excellent category, followed by 50 % samples in good and 15.9 % in permissible category. No samples were found to be in the category of doubtful and unsuitable, according to their % sodium values. A Wilcox plot is given in Figure I.2, relating Electrical conductivity to % sodium, showing usability of ground water towards irrigation purpose. As can be seen from Figure 3 most of the ground water samples were in the category excellent to good and good to permissible zone. Only 2.27 % of the samples were in permissible to doubtful and 4.54 % of the samples were in the unsuitable zone.



**Figure I.2 Wilcox plot of districts under Zone I**

**Table I.11 Classification of GROUND WATER Samples of Zone 1 towards Irrigation purpose**

Parameter	Range	Classification	% Of samples
SAR value	<10	Excellent	100
	10-18	Good	0
	18-26	Doubtful	0
	>26	Unsuitable	0
% Sodium	<20	Excellent	34.1
	20-40	Good	50
	40-60	Permissible	15.9
	60-80	Doubtful	0
	>80	Unsuitable	0
Residual Sodium Carbonate (RSC)	< 1.25	Good	93.18
	1.25-2.5	Doubtful	2.27
	> 2.5	Unsuitable	4.55

### Hydrogeochemical facies of Ground water

Hydrogeochemical facies primarily describes the distribution of principal type of ground water. This provides information on progressive ion enrichment on the basis of residence time of ground water in subsurface and on the level of rock-water interaction.

Hydrogeochemical facies are separate zones that have concentration of cations and anions within defined composition categories. Here, the ground water samples collected from zone I, has been classified utilizing the Piper's trilinear diagram. As per the piper plot given in in Figure I.3, 90.9 % ground water samples belonged to  $\text{Ca}^{2+}\text{-Mg}^{2+}\text{-HCO}_3^-$  type, followed by 6.82 % mixed type and 2.27 % as  $\text{Ca}^{2+}\text{-Mg}^{2+}\text{-HCO}_3^-$  type. This type of ground water is due to the processes like ground water recharge, ion exchange processes and irrigation flow. The presence of mixed type of water maybe due to natural processes, ion exchange processes, anthropogenic activities such as municipal waste etc. The ground water chemistry in this zone is dominated by alkaline earth metals over alkali metals.

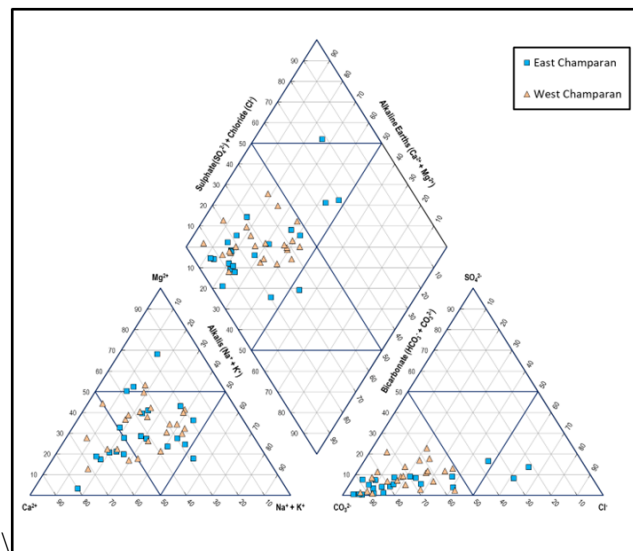


Figure I.3 Piper plot of districts under Zone I

### **8.1.2 Zone II**

In this zone Gopalganj, Saran and Siwan districts were taken into consideration. Flat alluvial formations of considerable thickness are very common in Gopalganj district. Siwan district forms a part of the vast alluvial terrain of Gandak and Ghaghra sub-basins forming a part of Indo-Gangetic alluvium consisting of a thick pile of unconsolidated quaternary sediments. Saran district has land slopes towards southeast and has rich and fertile alluvial plain with quite a few depressions and marshes

#### **Hydrogen Ion Concentration (pH)**



The samples collected from zone II, has shown mildly acidic to alkaline nature with pH values in the range of 6.63 to 8.08, with an average value of 7.22. The maximum value was observed at Manjhi 2, Manjhi block, Saran district.

### **Electrical Conductivity (EC)**

The EC values in zone II were in the range 411-2710  $\mu\text{S}/\text{cm}$ , with an average value of 973.38  $\mu\text{S}/\text{cm}$ , respectively. The highest value of EC was observed at Majhanpur New, Manjhi block, Saran district. All the samples have shown EC values within the permissible limit of 3000  $\mu\text{S}/\text{cm}$ .

### **Alkalinity**

The variation observed in the concentration of bicarbonate species was in the range of 183 to 641  $\text{mg L}^{-1}$ , with an average value of 393.31  $\text{mg L}^{-1}$ , respectively. Out of 56 samples studied, no samples have shown carbonate alkalinity. The maximum value was observed at Majhanpur New, Manjhi block, Saran district. A percent distribution of collected ground water samples on the basis of alkalinity is given in Table II.1, it was observed that 94.64 % of samples had alkalinity within the permissible range.

**Table II.1 % Distribution of Ground Water Samples in Different Alkalinity Range**

<b>Alkalinity Range (mg/l)</b>	<b>Percentage</b>
0 - 600	94.64
> 600	5.36

### **Chloride**

The concentration of chloride ions was in the range of 7.1 to 415.35  $\text{mg L}^{-1}$ , with an average value of 71.44  $\text{mg L}^{-1}$ , respectively. The highest concentration of chloride ions was observed at Majhanpur New, Manjhi block, Saran district. From Table II.2 it is clear that chloride concentrations of less than 3 % of ground water samples is exceeding the acceptable limit for drinking purposes (250  $\text{mg}/\text{L}$ , BIS, 2012) but is well within the permissible limit of 1000  $\text{mg}/\text{L}$ .

**Table II. 2 % Frequency Distribution of Chloride in Zone II**

<b>Chloride concentration (mg/l)</b>	<b>Percentage</b>
Within Acceptable limit (0 – 250)	96.43
Within Permissible limit (1000)	100

### **Calcium (Ca)**

The calcium concentration in zone II ground water samples was in the range of 22-250 mg L<sup>-1</sup>, with an average value of 89.18 mg L<sup>-1</sup>. The maximum value was observed at Bhore Police Station, Bhore block, Gopalganj district. The concentration of calcium for all the samples was found to be within the permissible limit (200 mg L<sup>-1</sup>) for 96.43 % of samples indicating that water is suitable for potable purposes (Table II.3).

**Table II.3 % Frequency Distribution of Calcium in Zone II**

Calcium concentration (mg/l)	Percentage
0-200	96.43
>200	3.57

### **Magnesium (Mg)**

In the study area Zone II, magnesium was found to be in the range from 9.72 to 214 mg L<sup>-1</sup>, with an average value of 34.15 mg L<sup>-1</sup>. The highest concentration of magnesium ions was observed at Majhanpur New, Manjhi block, Saran district. As can be seen from Table II.4, 96.43 % samples in zone II have magnesium concentration within the permissible limit of 100 mg L<sup>-1</sup>.

**Table II.4 % Frequency Distribution of Magnesium in Zone II**

Magnesium concentration (mg/l)	Percentage
0-100	96.43
>100	3.57

### **Total Hardness (T.H. as CaCO<sub>3</sub>)**

In the study area, the total hardness in ground water samples range from 175 to 990 mg L<sup>-1</sup>, with an average value of 363.57 mg L<sup>-1</sup>. The maximum concentration was observed at Majhanpur New, Manjhi block, Saran district. As can be seen form Table II.5, 92.86 % of samples were found to have total hardness within the permissible limit of 600 mg L<sup>-1</sup>.

**Table II.5 % Frequency Distribution of T. H. (as CaCO<sub>3</sub>) in Zone II**

Total Hardness (as CaCO <sub>3</sub> , mg/l)	Percentage
0-600	92.86
>600	7.14

### **Sodium (Na)**

The analysis result of collected ground water samples indicated that sodium ranges from 5.03 to 155.6 mg L<sup>-1</sup>, with an average value of 48.83 mg L<sup>-1</sup>. The maximum concentration was observed at Majhanpur New, Manjhi block, Saran district.

### **Potassium (K)**

The analysis of collected ground water samples indicated that the concentration of potassium ions varies from 0.06 to 17.47 mg L<sup>-1</sup>, with an average of 4.9 mg L<sup>-1</sup>. The highest concentration of potassium ions was observed at Majhanpur New, Manjhi block, Saran district.

### **Nitrate (NO<sub>3</sub><sup>-</sup>)**

In the collected ground water samples concentration of nitrate ions was found to be in the range of 0 to 55 mg L<sup>-1</sup>, with an average value of 8.68 mg L<sup>-1</sup>. The highest concentration of nitrate ions was observed at Mairwa near petrol pump, Mairwa block, Siwan district. Out of 56 samples studied, 55 samples reported concentration of nitrate ions within the acceptable limit of BIS 2012 (45 mg L<sup>-1</sup>).

### **Fluoride (F<sup>-</sup>)**

In the study area Zone II, the concentration of Fluoride ions was in the range of 0.05 to 1.16 mg L<sup>-1</sup>, with an average value of 0.70 mg L<sup>-1</sup>. The highest concentration was observed at Chitakal, Guthani block, Siwan district. It was observed that in all the collected ground water samples, the concentration of fluoride ions was within the permissible limit of 1.5 mg L<sup>-1</sup>.

By and large the ground water of Zone II, was found to be suitable for drinking purpose as per the available analyzed chemical parameters. The presence of some constituents beyond the permissible limit at some locations renders the water unfit for public water supply.

## **SUITABILITY OF GROUND WATER FOR IRRIGATION PURPOSE**

### **Total Dissolved Solids (TDS)**

The TDS values in zone II were in the range of 267.8 to 1761.5 mg L<sup>-1</sup>, with an average value of 634 mg L<sup>-1</sup>. The maximum value of TDS was observed at Majhanpur New, Manjhi block, Saran district. As can be seen from Table II.6, only 14.29 % of the collected ground water samples were slightly saline and rest 85.71 % were non saline.

**Table II.6 % Frequency Distribution of T.D.S. in Zone II**

Salinity as per T.D.S range	Percentage
Fresh, non-saline (0-1000 mg/l)	85.71
Slightly saline (1001-3000 mg/l)	14.29

### United States Salinity Laboratory (USSL) Diagram

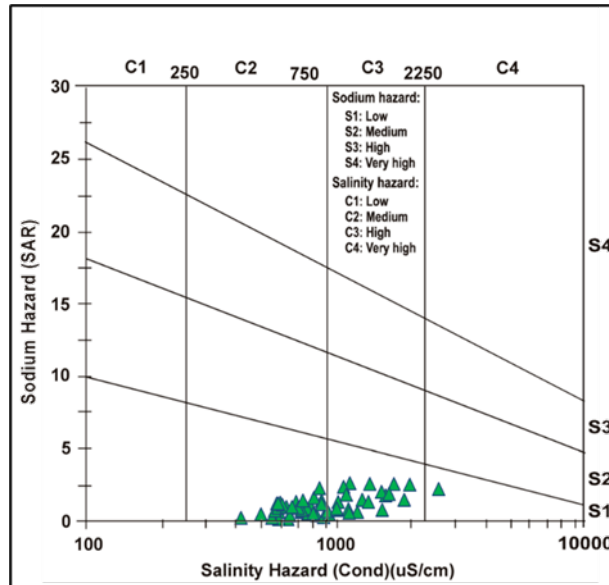
The SAR values in the study area zone II, were in the range of 0.13 to 2.52, with an average value of 1.08. Thus, in the study area of 100 % of the water samples are observed to lie in S<sub>1</sub> class exhibiting low sodicity. A classification of the collected ground water samples on the basis of SAR values is given in Table II.8

From Table II.7 it is evident that in the study area Zone II, most of the water samples are observed to lie in C<sub>2</sub> & C<sub>3</sub> class exhibiting medium to high salinity. Thus 39.28 % water samples in the area are found to be of good class for irrigation and 58.93 % samples lie within the permissible limit as per class of water for irrigation. Only 1.79 % water samples exhibited unsuitable class of water for irrigation purposes.

**Table II.7 % Frequency Distribution of E.C. in Zone II**

E.C range ( $\mu\text{S}/\text{cm}$ at 25° C)	Percentage	Class of water (for irrigation)
<250 (low saline, C <sub>1</sub> )	0	Class-1, Excellent
250-750 (medium saline, C <sub>2</sub> )	39.28	Class-2, Good
751-2250 (high saline, C <sub>3</sub> )	58.93	Class-3, Permissible
>2250 (very high saline, C <sub>4</sub> )	1.79	Class-4, Unsuitable

As per USSL diagram given in Figure II.1, the ground water in the study area zone II, mostly comes under the C<sub>2</sub>-S<sub>1</sub> type suggesting medium salinity and low sodicity, followed by C<sub>3</sub>-S<sub>1</sub> type and only 01 in C<sub>4</sub>-S<sub>1</sub> type. The salinity hazard is posed by the water samples as they fall in class C<sub>3</sub> and C<sub>4</sub>. Thus, on the whole 1.78 % of the water samples indicate C<sub>4</sub>-S<sub>1</sub> class rendering the water unsuitable for irrigation purposes under ordinary conditions.



**Figure II.1 USSL diagram of districts under Zone II**

### **Alkalinity Hazard or Residual Sodium Carbonate (RSC)**

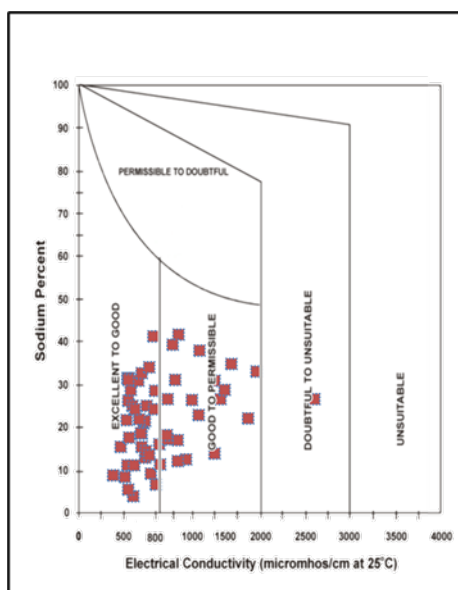
The ground water samples collected from Zone II has shown that the Residual Sodium Carbonate in the area was in the range of -9.30 to 2.189 meq L<sup>-1</sup>, with an average value of -0.85 meq L<sup>-1</sup>.

A classification of the collected ground water samples on the basis of RSC values is given in Table II.8. It is clear from Table II.8, that in the study area 94.64 % (with RSC <1.25 meq L<sup>-1</sup>) samples were found to be very safe for use in irrigation and no water samples (with RSC > 2.5 meq/l) were found to be unsuitable for irrigation purposes.

### **Soluble Sodium Percentage (S.S.P) (Wilcox Plot)**

The % sodium values were in the range of 4.43 to 41.40 with an average value of 22.27. The maximum % sodium value was observed at Breja, Manjhi block, Saran district.

A classification of ground water samples on the basis of % sodium values is given in Table II.8. It was observed that 42.85 % of the samples were in the excellent category, followed by 53.57 % samples in good and 3.57 % in permissible category. No samples were found to be in the category of doubtful and unsuitable. A Wilcox plot is given in Figure II.2, is showing that most of the ground water samples were in the category excellent to good and good to permissible zone. Only 1.78 % samples were in doubtful to unsuitable.



**Figure II.2 Wilcox plot of districts under Zone II**

**Table II.8 Classification of ground water Samples of Zone II towards Irrigation purpose**

Parameter	Range	Classification	% Of samples
SAR value	<10	Excellent	100
	10-18	Good	0
	18-26	Doubtful	0
	>26	Unsuitable	0
% Sodium	<20	Excellent	42.85
	20-40	Good	53.57
	40-60	Permissible	3.57
	60-80	Doubtful	0
	>80	Unsuitable	0
Residual Sodium Carbonate (RSC)	< 1.25	Good	94.64
	1.25-2.5	Doubtful	5.36
	> 2.5	Unsuitable	0

### Hydrogeochemical facies of Ground water

The ground water samples collected from zone II, has been classified utilizing the Piper's trilinear diagram. As per the piper plot given in in Figure II.3, 91.07 % ground water samples belonged to  $\text{Ca}^{2+}\text{-Mg}^{2+}\text{-HCO}_3^-$  type, followed by 8.93 % mixed type. The presence of mixed type of water maybe due to natural processes, ion exchange processes, anthropogenic activities such as municipal waste etc. The ground water chemistry in this zone is dominated by alkaline earth metals over alkali metals.

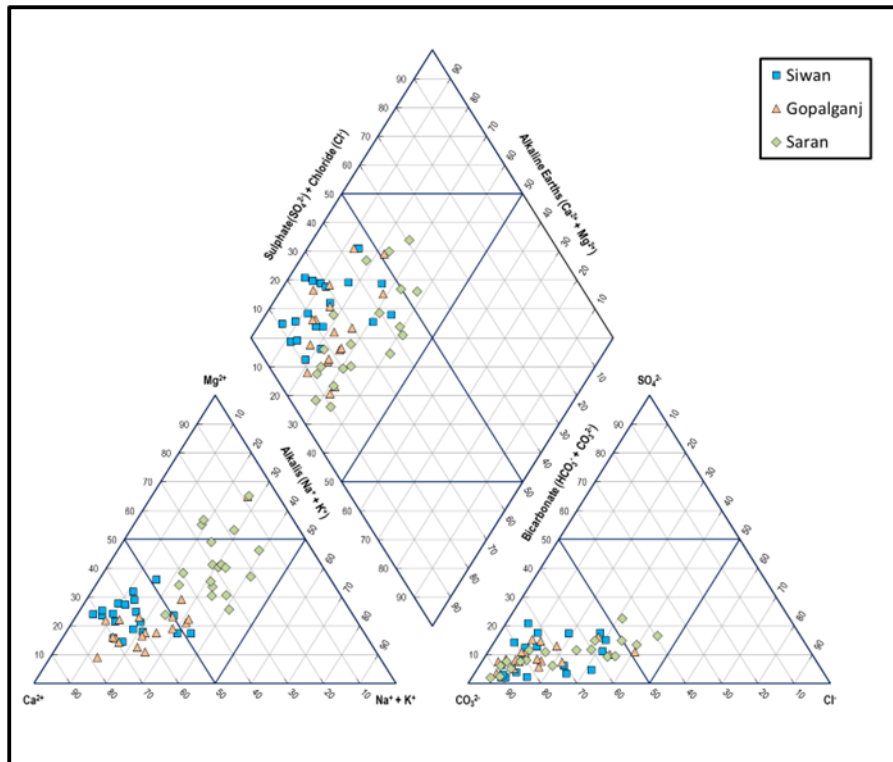


Figure II.3 Piper plot of districts under Zone II

### **8.1.3 Zone III**

In this zone Sitamarhi, Sheohar, Muzzafarpur, Vaishali, Madhubani, Darbhanga, Samastipur, Begusarai, Khagaria districts were taken into consideration. Begusarai district is part of the middle Ganges plain. The district has a terraced alluvial landscape shaped Himalayan and sub-Himalayan rivers. Darbhanga district has a vast alluvial plain devoid of any hills. Khagaria district is covered by Younger alluvial plain followed by active flood plain. The area in Madhubani district can be sub-divided in three geomorphological units namely Newer Flood Plain, Older flood plain and Older alluvial plain. In Muzzafarpur district the predominant geological formation is quaternary alluvium. The major physiographic units in Samastipur and Sitamarhi district is Gangetic Alluvium. Sheohar district lies in the North Ganga Plain and major geological formation here is Gangetic Alluvium. Vaishali district comprises extensive plain formed by the alluvium brought by the Ganga, the Gandak and distributaries of Gandak.

### Hydrogen Ion Concentration (pH)

The samples collected from zone III, has shown mildly acidic to alkaline nature with pH values in the range of 6.8 to 8.35, with an average value of 7.75. The maximum value was observed at Bitahuli, Baheri block, Darbhanga district.

### Electrical Conductivity (EC)

The EC values in zone III were in the range 355-4622  $\mu\text{S}/\text{cm}$ , with an average value of 1028.27  $\mu\text{S}/\text{cm}$ , respectively. The highest value of EC was observed at Manjhaul, Cheria Bariarpur block, Begusarai district. Out of 157 samples studied, only 02 samples have shown EC value greater than the permissible limit of 3000  $\mu\text{S}/\text{cm}$ .

### Alkalinity

The variation observed in the concentration of bicarbonate species was in the range of 152.5 to 902.8  $\text{mg L}^{-1}$ , with an average value of 394.68  $\text{mg L}^{-1}$ , respectively. The maximum value was observed at Kerian, Rosera block, Samastipur district. No samples have shown carbonate alkalinity Out of 157 samples collected; 147 samples have shown alkalinity within the permissible limit. A percent distribution of collected ground water samples on the basis of alkalinity is given in Table III.1.

**Table III.1 % Distribution of Ground Water Samples in Different Alkalinity**

Range	
Alkalinity Range (mg/l)	Percentage
0 - 600	93.63
> 600	6.37

### Chloride

The concentration of chloride ions was in the range of 7.1 to 1306.4  $\text{mg L}^{-1}$ , with an average value of 92.01  $\text{mg L}^{-1}$ , respectively. The highest concentration of chloride ions was observed at Manjhaul, Cheria Bariarpur block, Begusarai district. From Table III.2 it is clear that chloride concentrations of less than 6% of ground water samples is exceeding the acceptable limit for drinking purposes (250  $\text{mg}/\text{L}$ , BIS, 2012) but is well within the permissible limit of 1000  $\text{mg}/\text{L}$  for 99.36 % of samples.

**Table III. 2 % Frequency Distribution of Chloride in Zone III**



<b>Chloride concentration (mg/l)</b>	<b>Percentage</b>
Within Acceptable limit (0 – 250)	94.27
Within Permissible limit (1000)	99.36

### **Calcium (Ca)**

The calcium concentration in zone III ground water samples was in the range of 4-306 mg L<sup>-1</sup>, with an average value of 64.54 mg L<sup>-1</sup>. The maximum value was observed at Manjhaul, Cheria Bariarpur block, Begusarai. The concentration of calcium for 155 samples out of 157 was found to be within the permissible limit (200 mg L<sup>-1</sup>) in all the samples indicating that water is suitable for potable purposes (Table III.3).

**Table III.3 % Frequency Distribution of Calcium in Zone III**

<b>Calcium concentration (mg/l)</b>	<b>Percentage</b>
0-200	98.73
>200	1.27

### **Magnesium (Mg)**

In the study area Zone III, magnesium concentration was found to be in the range from 1.215 to 181.03 mg L<sup>-1</sup>, with an average value of 44.5 mg L<sup>-1</sup>. The highest concentration of magnesium ions was observed at Manjhaul, Cheria Bariarpur block, Begusarai district. As can be seen from Table III.4, 94.90 % samples in zone III have magnesium concentration within the permissible limit of 100 mg L<sup>-1</sup>. Thus, in general, the ground water in this zone is fit for human consumption.

**Table III.4 % Frequency Distribution of Magnesium in Zone III**

<b>Magnesium concentration (mg/l)</b>	<b>Percentage</b>
0-100	94.90
>100	5.1

### **Total Hardness (T.H. as CaCO<sub>3</sub>)**

In the study area, the total hardness in ground water samples range from 80 to 1510 mg L<sup>-1</sup>, with an average value of 344.43 mg L<sup>-1</sup>. The maximum concentration was observed at Manjhaul, Cheria Bariarpur block, Begusarai district. As can be seen form Table III.5, 93.63 % of collected samples were found to have total hardness within the permissible limit of 600 mg L<sup>-1</sup>.

**Table III.5 % Frequency Distribution of T. H. (as CaCO<sub>3</sub>) in Zone III**

<b>Total Hardness (as CaCO<sub>3</sub>, mg/l)</b>	<b>Percentage</b>
0-600	93.63
>600	6.37

#### **Sodium (Na)**

The analysis result of collected ground water samples indicated that sodium ranges from 5.92 to 292 mg L<sup>-1</sup>, with an average value of 66.26 mg L<sup>-1</sup>. The maximum concentration was observed at Manjhaul, Cheria Bariarpur block, Begusarai district.

#### **Potassium (K)**

The analysis of collected ground water samples indicated that the concentration of potassium ions varies from 0.84 to 134.2 mg L<sup>-1</sup>, with an average of 19.30 mg L<sup>-1</sup>. The highest concentration of potassium ions was observed at Manjhaul, Cheria Bariarpur block, Begusarai district.

#### **Nitrate (NO<sub>3</sub><sup>-</sup>)**

In the collected ground water samples concentration of nitrate ions was found to be in the range of 0 to 44.3 mg L<sup>-1</sup>, with an average value of 9.57 mg L<sup>-1</sup>. The highest concentration of nitrate ions was observed at Rampur, Aurai block, Muzaffarpur district. All ground water samples under study have concentration of nitrate ions within the acceptable limit of BIS 2012 (45 mg L<sup>-1</sup>).

#### **Fluoride (F<sup>-</sup>)**

In the study area Zone III, the concentration of Fluoride ions was in the range of 0.03 to 2.12 mg L<sup>-1</sup>, with an average value of 0.712 mg L<sup>-1</sup>. The highest concentration was observed at Patapara, Bibhutpur block, Samastipur district. It was observed that out of 157 collected ground water samples, only in 06 samples the concentration of fluoride ions was greater than the permissible limit of 1.5 mg L<sup>-1</sup>.

By and large the ground water of Zone III, was found to be suitable for drinking purpose as per the available analyzed chemical parameters. The presence of some constituents beyond the permissible limit at some locations renders the water unfit for public water supply.

### **SUITABILITY OF GROUND WATER FOR IRRIGATION PURPOSE**

#### **Total Dissolved Solids (TDS)**

The TDS values in zone III were in the range of 230.75 to 3004.3 mg L<sup>-1</sup>, with an average value of 668.37 mg L<sup>-1</sup>. The maximum value of TDS was observed at Manjhaul, Cheria Bariarpur block, Begusarai district. As can be seen from Table III.6, only 13.38 % of the collected ground water samples were slightly saline and rest 85.99 % were non saline.

**Table III.6 % Frequency Distribution of T.D.S. in Zone III**

Salinity as per T.D.S range	Percentage
Fresh, non-saline (0-1000 mg/l)	85.99
Slightly saline (1001-3000 mg/l)	13.38
Moderately Saline (3001-6000 mg/l)	0.67

#### **United States Salinity Laboratory (USSL) Diagram**

The SAR values in the study area zone III, were in the range of 0.15 to 3.98, with an average value of 1.56. Thus, in the study area of 100 % of the water samples are observed to lie in S<sub>1</sub> class exhibiting low sodicity. A classification of the collected ground water samples on the basis of SAR values is given in Table III.8.

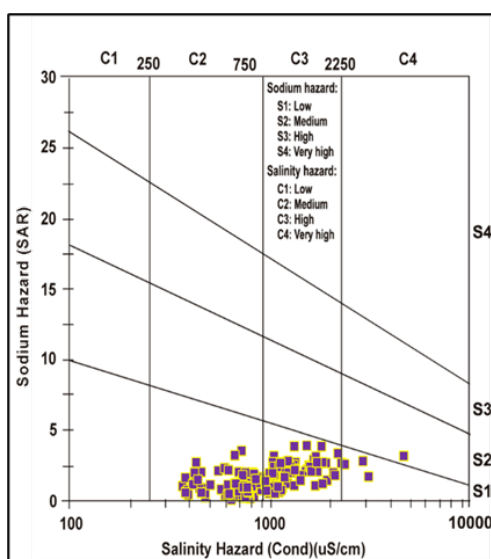
From Table III.7 it is evident that in the study area Zone III, most of the water samples are observed to lie in C<sub>2</sub> & C<sub>3</sub> class exhibiting medium to high salinity. Thus 33.12 % water samples in the area are found to be of good class for irrigation and 64.33 % samples lie within the permissible limit as per class of water for irrigation. Only 2.55 % water samples exhibited unsuitable class of water for irrigation purposes.

**Table III.7 % Frequency Distribution of E.C. in Zone III**

E.C range (µS/cm at 25° C)	Percentage	Class of water (for irrigation)
<250 (low saline, C <sub>1</sub> )	0	Class-1, Excellent
250-750 (medium saline, C <sub>2</sub> )	33.12	Class-2, Good
751-2250 (high saline, C <sub>3</sub> )	64.33	Class-3, Permissible
>2250 (very high saline, C <sub>4</sub> )	2.55	Class-4, Unsuitable

As per USSL diagram given in Figure III.1, the ground water in the study area zone III, mostly comes under the C<sub>2</sub>-S<sub>1</sub> type suggesting medium salinity and low sodicity, followed by C<sub>3</sub>-S<sub>1</sub> type. 03 samples in C<sub>4</sub>-S<sub>1</sub> type and 01 in C<sub>4</sub>-S<sub>2</sub> type. The salinity hazard is posed by the water samples as they fall in class C<sub>3</sub> and C<sub>4</sub>. Thus, on the

whole 2.54 % of the water samples indicating C4-S2. C4-S1 class, rendering the water unsuitable for irrigation purposes under ordinary conditions, however, it may be used occasionally after taking suitable measures.



**Figure III.1 USSL diagram of districts under Zone III**

#### **Alkalinity Hazard or Residual Sodium Carbonate (RSC)**

The ground water samples collected from Zone III has shown that the Residual Sodium Carbonate in the area was in the range of -22.6 to 3.70 meq L<sup>-1</sup>, with an average value of -0.42 meq L<sup>-1</sup>.

A classification of the collected ground water samples on the basis of RSC values is given in Table III.8. It is clear from Table III.8, that in the study area 81.53 % (with RSC <1.25 meq L<sup>-1</sup>) samples were found to be very safe for use in irrigation and 4.46 % water samples (with RSC > 2.5 meq/l) were found to be unsuitable for irrigation purposes.

#### **Soluble Sodium Percentage (S.S.P) (Wilcox Plot)**

The % sodium values were in the range of 6.62 to 61.80, with an average value of 31.48. The maximum % sodium value was observed at Bitahuli. Baheri block, Darbhanga district.

A classification of ground water samples on the basis of % sodium values is given in Table III.8. It was observed that 25.48 % of samples were in the excellent category, followed by 43.95 % samples in good and 28.66 % in permissible category. Only 1.91 % samples were found to be in the category of doubtful and no samples were found unsuitable for irrigation purpose.

A Wilcox plot is given in Figure III.2, showing that most of the ground water samples were in the category excellent to good and good to permissible zone. Only 2.55 % samples were in doubtful to unsuitable zone.

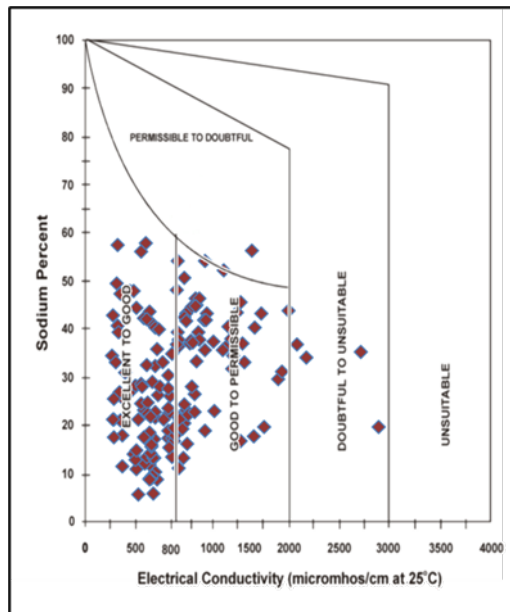


Figure III.2 Wilcox plot of districts under Zone III

Table III.8 Classification of ground water Samples of Zone III towards Irrigation purpose

Parameter	Range	Classification	% Of samples
SAR value	<10	Excellent	100
	10-18	Good	0
	18-26	Doubtful	0
	>26	Unsuitable	0
% Sodium	<20	Excellent	25.48
	20-40	Good	43.95
	40-60	Permissible	28.66
	60-80	Doubtful	1.91
	>80	Unsuitable	0
Residual Sodium Carboate (RSC)	< 1.25	Good	81.53
	1.25-2.5	Doubtful	14.01
	> 2.5	Unsuitable	4.46

### Hydrogeochemical facies of Ground water

The ground water samples collected from zone III, has been classified utilizing the Piper's trilinear diagram. As per the piper plot given in in Figure III.3, 84.08 % ground water samples belonged to  $\text{Ca}^{2+}\text{-Mg}^{2+}\text{-HCO}_3^-$  type, followed by 14.65 % mixed type and

1.27 % as  $\text{Na}^+\text{-K}^+\text{-Cl}^-$  type. This type of ground water is due to the processes like ground water recharge, ion exchange processes and irrigation flow. The presence of mixed type of water maybe due to natural processes, ion exchange processes, anthropogenic activities such as municipal waste etc. The ground water chemistry in this zone is dominated by alkaline earth metals over alkali metals.

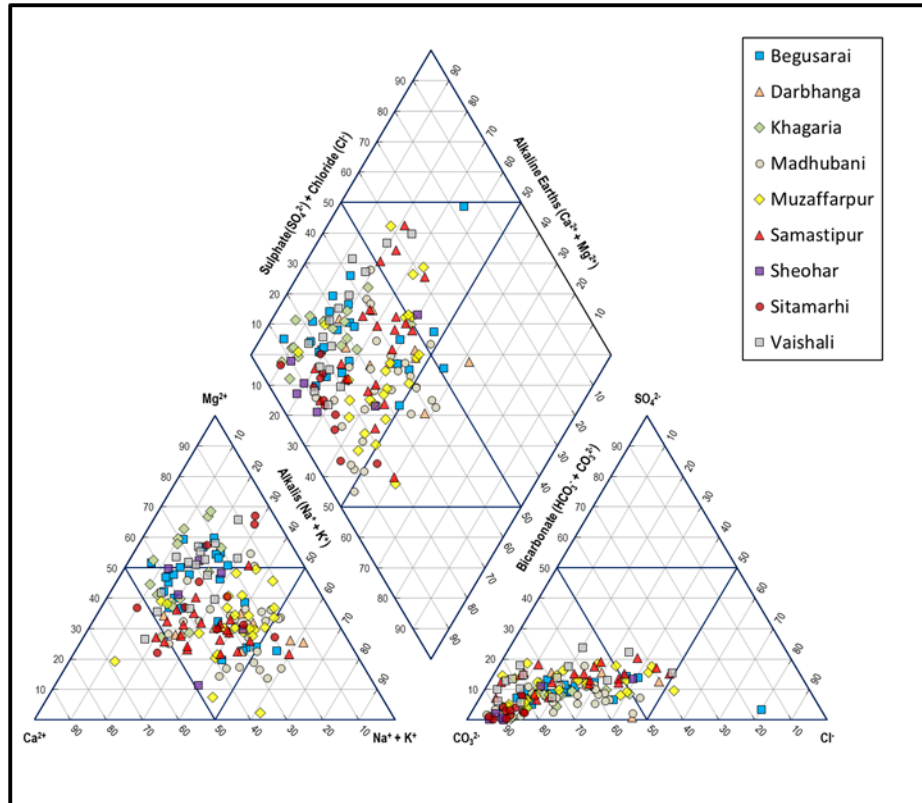


Figure III.3 Piper plot of districts under Zone III

### **8.1.4 Zone IV**

In this zone Araria, Katihar, Kishanganj, Madhepura, Purnea, Saharsa, Supaul districts were taken into consideration. In Araria and Katihar districts, the major geomorphic unit is alluvial plains. Kishanganj district lies in the Gangetic Plains falling in the Mahananda sub-basin. Madhepura districts forms a small segment of North Ganga Plain in Bihar within Kosi sub-basin. The major geomorphic unit is younger alluvium with newer flood plains. Purnea district forms a part of kosi mega fan and the major geomorphic unit is Gangetic alluvium. Saharsa and Supaul districts forms a part of the Kosi megafan. The major geomorphic unit in these districts is younger alluvium with newer flood plains.

#### **Hydrogen Ion Concentration (pH)**

The samples collected from zone IV, has shown slightly alkaline nature with pH values in the range of 7.09 to 8.27, with an average value of 7.81. The maximum value was observed at Pipra Chowk, Pipra block. Supaul district.

#### **Electrical Conductivity (EC)**

The EC values in zone IV were in the range 89-2803  $\mu\text{S}/\text{cm}$ , with an average value of 668.30  $\mu\text{S}/\text{cm}$ , respectively. The highest value of EC was observed at Simri Bakhtiarpur 1, Simri Bakhtiarpur block, Saharsa district. All the samples have shown EC values within the permissible limit of 3000  $\mu\text{S}/\text{cm}$ .

#### **Alkalinity**

The variation observed in the concentration of bicarbonate species was in the range of 18.3 to 835.7  $\text{mg L}^{-1}$ , with an average value of 256.7  $\text{mg L}^{-1}$ , respectively. The maximum value was observed at Simri Bakhtiarpur 1, Simri Bakhtiarpur block, Saharsa district. In the study area, no samples have shown carbonate alkalinity. Out of 110 samples collected, 97.3 % samples have shown alkalinity within the permissible limit. A percent distribution of collected ground water samples on the basis of alkalinity is given in Table IV.1.

**Table IV.1 % Distribution of Ground Water Samples in Different Alkalinity range**

<b>Alkalinity Range (mg/l)</b>	<b>Percentage</b>
0 - 600	97.3
> 600	2.73

#### **Chloride**

The concentration of chloride ions was in the range of 7.1 to 426  $\text{mg L}^{-1}$ , with an average value of 58.64  $\text{mg L}^{-1}$ , respectively. The highest concentration of chloride ions was observed at Simri Bakhtiarpur 1, Simri Bakhtiarpur block, Saharsa district. From Table IV.2 it is clear that chloride concentrations of less than 2 % of ground water samples is exceeding the acceptable limit for drinking purposes (250  $\text{mg}/\text{L}$ , BIS, 2012) and all samples have concentration within the permissible limit for drinking purposes (1000  $\text{mg}/\text{L}$ , BIS, 2012).

**Table IV. 2 % Frequency Distribution of Chloride in Zone IV**

<b>Chloride concentration (mg/l)</b>	<b>Percentage</b>
Within Acceptable limit (0 – 250)	98.2

Within Permissible limit (1000)	100
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### Calcium (Ca)

The calcium concentration in zone IV ground water samples was in the range of 8-132 mg L<sup>-1</sup>, with an average value of 50.27 mg L<sup>-1</sup>. The maximum value was observed at Amri Kukran (west), Dhamdaha block, Purnea district. The concentration of calcium for all the samples was found to be within the permissible limit (200 mg L<sup>-1</sup>) in all the samples indicating that water is suitable for potable purposes (Table IV.3).

**Table IV.3 % Frequency Distribution of Calcium in Zone IV**

Calcium concentration (mg/l)	Percentage
0-200	100
>200	0

### Magnesium (Mg)

In the study area Zone IV, magnesium concentration was found to be in the range from 2.43 to 93.55 mg L<sup>-1</sup>, with an average value of 25.47 mg L<sup>-1</sup>. The highest concentration of magnesium ions was observed at Amri Kukran (west), Dhamdaha block, Purnea district. As can be seen from Table IV.4, all the samples in zone IV have magnesium concentration within the permissible limit of 100 mg L<sup>-1</sup>. Thus, in general, the ground water in this zone is fit for human consumption.

**Table IV.4 % Frequency Distribution of Magnesium in Zone IV**

Magnesium concentration (mg/l)	Percentage
0-100	100
>100	0

### Total Hardness (T.H. as CaCO<sub>3</sub>)

In the study area, the total hardness in ground water samples range from 35 to 715 mg L<sup>-1</sup>, with an average value of 229.04 mg L<sup>-1</sup>. The maximum concentration was observed at Amri Kukran (west), Dhamdaha block, Purnea district. As can be seen form Table IV.5, 97.3 % of collected samples were found to have total hardness within the permissible limit of 600 mg L<sup>-1</sup>.

**Table IV.5 % Frequency Distribution of T. H. (as CaCO<sub>3</sub>) in Zone IV**

Total Hardness (as CaCO <sub>3</sub> , mg/l)	Percentage
--	------------



0-600	97.3
>600	2.7

### **Sodium (Na)**

The analysis result of collected ground water samples indicated that sodium ranges from 0 to 298.12 mg L<sup>-1</sup>, with an average value of 36.50 mg L<sup>-1</sup>. The maximum concentration was observed at Simri Bakhtiarpur 1, Simri Bakhtiarpur block, Saharsa district.

### **Potassium (K)**

The analysis of collected ground water samples indicated that the concentration of potassium ions varies from 1.2 to 172.62 mg L<sup>-1</sup>, with an average of 15.12 mg L<sup>-1</sup>. The highest concentration of potassium ions was observed at Simri Bakhtiarpur 1, Simri Bakhtiarpur block, Saharsa district.

### **Nitrate (NO<sub>3</sub><sup>-</sup>)**

In the collected ground water samples concentration of nitrate ions was found to be in the range of 0 to 30.28 mg L<sup>-1</sup>, with an average value of 11.08 mg L<sup>-1</sup>. The highest concentration of nitrate ions was observed at Narhaiya, Falka block, Katihar district. All samples have shown concentration of nitrate ions within the acceptable limit of BIS 2012 (45 mg L<sup>-1</sup>).

### **Fluoride (F<sup>-</sup>)**

In the study area Zone IV, the concentration of Fluoride ions was in the range of 0.0 to 1.9 mg L<sup>-1</sup>, with an average value of 0.47 mg L<sup>-1</sup>. The highest concentration was observed at Belhi Teghra, Kahra block, Saharsa district. It was observed that out of 110 ground water samples, only in 02 samples the concentration of fluoride ions was greater the permissible limit of 1.5 mg L<sup>-1</sup>.

By and large the ground water of Zone IV, was found to be suitable for drinking purpose as per the available analyzed chemical parameters. The presence of some constituents beyond the permissible limit at some locations renders the water unfit for public water supply.

## **SUITABILITY OF GROUND WATER FOR IRRIGATION PURPOSE**

### **Total Dissolved Solids (TDS)**

The TDS values in zone IV were in the range of 58 to 1821.95 mg L<sup>-1</sup>, with an average value of 434.39 mg L<sup>-1</sup>. The maximum value of TDS was observed at Simri Bakhtiarpur

1, Simri Bakhtiarapur block, Saharsa district. As can be seen from Table IV.6, less than 6 % of the collected ground water samples were slightly saline and rest 95.45 % were non saline.

**Table IV.6 % Frequency Distribution of T.D.S. in Zone IV**

Salinity as per T.D.S range	Percentage
Fresh, non-saline (0-1000 mg/l)	95.45
Slightly saline (1001-3000 mg/l)	4.55

#### **United States Salinity Laboratory (USSL) Diagram**

The SAR values in the study area zone IV, were in the range of 0 to 5.63, with an average value of 0.96. Thus, in the study area of 100 % of the water samples are observed to lie in S<sub>1</sub> class exhibiting low sodicity. A classification of the collected ground water samples on the basis of SAR values is given in Table IV.8

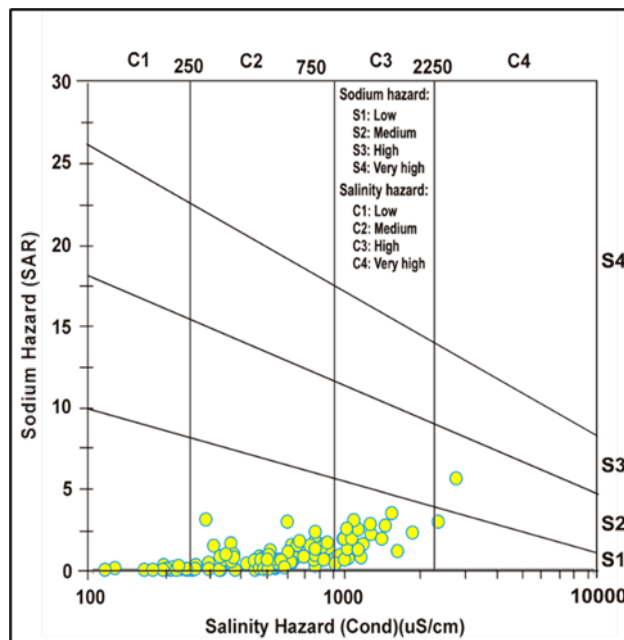
From Table IV.7 it is evident that in the study area Zone IV, 15.46 % of the collected water samples were in the excellent category and most of the water samples were observed to lie in C<sub>2</sub> & C<sub>3</sub> class exhibiting medium to high salinity. Thus 63.33 % water samples in the area are found to be of good class for irrigation and 33.33 % samples lie within the permissible limit as per class of water for irrigation. Only 1.82 % water samples exhibited unsuitable class of water for irrigation purposes.

**Table IV.7 % Frequency Distribution of E.C. in Zone IV**

E.C range ( $\mu\text{S}/\text{cm}$ at 25° C)	Percentage	Class of water (for irrigation)
<250 (low saline, C <sub>1</sub> )	15.46	Class-1, Excellent
250-750 (medium saline, C <sub>2</sub> )	46.36	Class-2, Good
751-2250 (high saline, C <sub>3</sub> )	36.36	Class-3, Permissible
>2250 (very high saline, C <sub>4</sub> )	1.82	Class-4, Unsuitable

As per USSL diagram given in Figure IV.1, the ground water in the study area zone IV, mostly comes under the C<sub>2</sub>-S<sub>1</sub> type suggesting medium salinity and low sodicity, followed by C<sub>3</sub>-S<sub>1</sub> type and only 01 in C<sub>4</sub>-S<sub>2</sub> type. Samples under the C<sub>1</sub>-S<sub>1</sub> zone have low salinity and sodicity hazard. The salinity hazard is posed by the water samples as they fall in class C<sub>3</sub> and C<sub>4</sub>. Thus, on the whole less than 1 % of the water samples in both C<sub>4</sub>-S<sub>1</sub>, C<sub>4</sub>-S<sub>2</sub> class indicates that the water unsuitable for irrigation purposes under

ordinary conditions, however, it may be used occasionally after taking suitable measures.



**Figure IV.1 USSL diagram of districts under Zone IV**

**Alkalinity Hazard or Residual Sodium Carbonate (RSC)**

The ground water samples collected from Zone IV has shown that the Residual Sodium Carbonate in the area was in the range of -3.90 to 3.10 meq L<sup>-1</sup>, with an average value of -0.40 meq L<sup>-1</sup>.

A classification of the collected ground water samples on the basis of RSC values is given in Table IV.8. It is clear from Table IV.8, that in the study area 95.45 % (with RSC <1.25 meq L<sup>-1</sup>) samples were found to be very safe for use in irrigation and 0.91 % water samples (with RSC > 2.5 meq/l) were found to be unsuitable for irrigation purposes.

**Soluble Sodium Percentage (S.S.P) (Wilcox Plot)**

The % sodium values were in the range of 1.78 to 71.57, with an average value of 24.65. The maximum % sodium value was observed at Basantpur, Prantpur block, Katihar district.

A classification of ground water samples on the basis of % sodium values is given in Table IV.8. It was observed that 44.54 % of the samples were in the excellent category, followed by 37.27 % samples in good and 15.45 % in permissible category. Only 2,73

samples were found to be in the category of doubtful and no samples were in the unsuitable category.

A Wilcox plot is given in Figure IV.2, showing that most of the ground water samples were in the category excellent to good and good to permissible zone. Only 1.82 % samples were in doubtful to unsuitable zone.

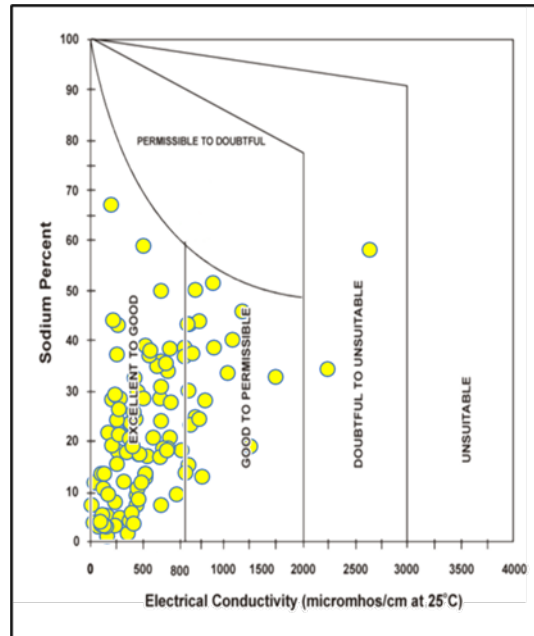


Figure IV.2 Wilcox plot of districts under Zone IV

Table IV.8 Classification of ground water Samples of Zone IV towards Irrigation purpose

Parameter	Range	Classification	% Of samples
SAR value	<10	Excellent	100
	10-18	Good	0
	18-26	Doubtful	0
	>26	Unsuitable	0
% Sodium	<20	Excellent	44.54
	20-40	Good	37.27
	40-60	Permissible	15.45
	60-80	Doubtful	2.73
	>80	Unsuitable	0
Residual Sodium Carbonate (RSC)	< 1.25	Good	95.45
	1.25-2.5	Doubtful	3.64
	> 2.5	Unsuitable	0.91

### Hydrogeochemical facies of Ground water

The ground water samples collected from zone IV, has been classified utilizing the Piper's trilinear diagram. As per the piper plot given in in Figure IV.3, 92.73 % ground water samples belonged to  $\text{Ca}^{2+}\text{-Mg}^{2+}\text{-HCO}_3^-$  type, followed by 7.27 % mixed type. This type of ground water is due to the processes like ground water recharge, ion exchange processes and irrigation flow. The presence of mixed type of water maybe due to natural processes, ion exchange processes, anthropogenic activities such as municipal waste etc. The ground water chemistry in this zone is dominated by alkaline earth metals over alkali metals.

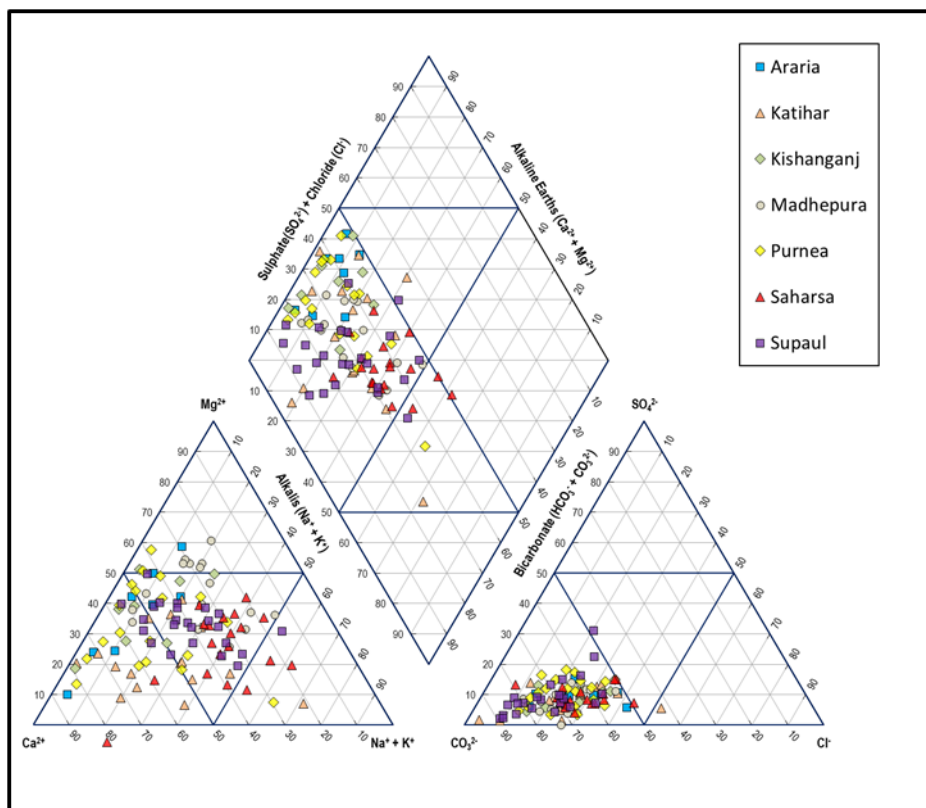


Figure IV.3 Piper plot of districts under Zone IV

### **8.1.5 Zone V**

In this zone Bhojpur, Buxar, Jehanabad and Patna districts were taken into consideration. Bhojpur district is mainly covered with alluvium and hard rocks of Vindhyan Supergroup are situated at the southwestern side beyond the district boundary. The north and northeast parts of the district are covered with Newer Alluvium and younger flood plains (diara formations) while the central and southern parts are covered with older alluvium and older flood plains. Buxar district is a part of the southern Ganga Plain. Physiography of the district is a alluvial plain having gentle slope towards

north. Jehanabad district is located within the Mid-Ganga basin, in the southern margin of the Gangetic plains. The district mainly represents flat alluvium terrain except hills in the south. Patna district forms a part of the Ganga basin and is characterized by a monotonously flat relief, almost quaternary alluvium plane.

#### **Hydrogen Ion Concentration (pH)**

The samples collected from zone V, has shown mildly acidic nature with pH values in the range of 7.04 to 8.28, with an average value of 7.62. The maximum value was observed at Maranchi, Mokama block of Patna district.

#### **Electrical Conductivity (EC)**

The EC values in zone VI were in the range 456-3076  $\mu\text{S/cm}$ , with an average value of 1036.96  $\mu\text{S/cm}$ , respectively. The highest value of EC was observed at Kako, Kako block, Jehanabad district. Only 01 sample has shown EC value beyond the permissible limit of 3000  $\mu\text{S/cm}$ .

#### **Alkalinity**

The variation observed in the concentration of bicarbonate species was in the range of 109.8 to 921.1  $\text{mg L}^{-1}$ , with an average value of 412.60  $\text{mg L}^{-1}$ , respectively. The maximum value was observed at Bharatpura, Paliganj block, Patna district. None of the samples have shown carbonate alkalinity. Out of 98 samples collected, 13 samples have shown alkalinity above the permissible limit. A percent distribution of collected ground water samples on the basis of alkalinity is given in Table V.1.

**Table V.1 % Distribution of Ground Water Samples in Different Alkalinity Range**

<b>Alkalinity Range (mg/l)</b>	<b>Percentage</b>
0 - 600	86.73
> 600	13.26

#### **Chloride**

The concentration of chloride ions was in the range of 10.65 to 472.15  $\text{mg L}^{-1}$ , with an average value of 79.77  $\text{mg L}^{-1}$ , respectively. The highest concentration of chloride ions was observed at Kako, Kako block, Jehanabad district. From Table V.2 it is clear that chloride concentrations of 5.10 % of ground water samples is exceeding the acceptable

limit for drinking purposes (250 mg/L, BIS, 2012) but is well within the permissible limit of 1000 mg/L.

**Table V. 2 % Frequency Distribution of Chloride in Zone V**

<b>Chloride concentration (mg/l)</b>	<b>Percentage</b>
Within Acceptable limit (0 – 250)	94.89
Within Permissible limit (1000)	100

### **Calcium (Ca)**

The Calcium concentration in zone V ground water samples was in the range of 20-190 mg L<sup>-1</sup>, with an average value of 80.34 mg L<sup>-1</sup>. The maximum value was observed at Churamanpur, Buxar, Buxar district. The concentration of calcium for all the samples was found to be within the permissible limit (200 mg L<sup>-1</sup>) in all samples indicating that water is suitable for potable purposes (Table V.3).

**Table V.3 % Frequency Distribution of Calcium in Zone V**

<b>Calcium concentration (mg/l)</b>	<b>Percentage</b>
0-200	100
>200	nil

### **Magnesium (Mg)**

In the study area Zone V, Magnesium was found to be in the range from 6.07 to 149.44 mg L<sup>-1</sup>, with an average value of 34.14 mg L<sup>-1</sup>. The highest concentration of magnesium ions was observed at Alubikha, Makhdumpur, Jehanabad district. As can be seen from Table V.4, only 03 the samples in zone V have magnesium concentration above the permissible limit of 100 mg L<sup>-1</sup>. Thus, in general, the ground water in this zone is fit for human consumption.

**Table VI.4 % Frequency Distribution of Magnesium in Zone VI**

<b>Magnesium concentration (mg/l)</b>	<b>Percentage</b>
0-100	96.93
>100	3.06

### **Total Hardness (T.H. as CaCO<sub>3</sub>)**

In the study area, the total hardness in ground water samples have shown range from 135 to 870 mg L<sup>-1</sup>, with an average value of 341.37 mg L<sup>-1</sup>. The maximum

concentration was observed at Kako, Kako block, Jehanabad district. As can be seen from Table V.5, only 04 out of all the collected samples were found to have total hardness above the permissible limit of 600 mg L<sup>-1</sup>.

**Table V.5 % Frequency Distribution of T. H. (as CaCO<sub>3</sub>) in Zone V**

<b>Total Hardness (as CaCO<sub>3</sub>, mg/l)</b>	<b>Percentage</b>
0-600	95.98
>600	4.08

### **Sodium (Na)**

The analysis result of collected ground water samples indicated that sodium ranges from 0.78 to 265.1 mg L<sup>-1</sup>, with an average value of 63.55 mg L<sup>-1</sup>. The maximum concentration was observed at Kako, Kako, Jehanabad district.

### **Potassium (K)**

The analysis of collected ground water samples indicated that the concentration of potassium ions varies from 0.44 to 167 mg L<sup>-1</sup>, with an average of 16.70 mg L<sup>-1</sup>. The highest concentration of potassium ions was observed at Maranchi, Mokama block, Patna district.

### **Nitrate (NO<sub>3</sub><sup>-</sup>)**

In the collected ground water samples concentration of nitrate ions was found to be in the range of 0 to 233 mg L<sup>-1</sup>, with an average value of 18.65 mg L<sup>-1</sup>. The highest concentration of potassium ions was observed at Udwantnagar, Udwantnagar block, Bhojpur district. Out of 98 samples studied, only 02 samples have concentration of nitrate ions beyond the acceptable limit of BIS 2012.

### **Fluoride (F<sup>-</sup>)**

In the study area Zone V, the concentration of fluoride ions was in the range of 0.0 to 1.37 mg L<sup>-1</sup>, with an average value of 0.44 mg L<sup>-1</sup>. The highest concentration was observed at Garhani (Nahsi), Garhani block, Bhojpur district. It was observed that in all the collected ground water samples, the concentration of fluoride ions was within the permissible limit of 1.5 mg L<sup>-1</sup>.

By and large the ground water of Zone V, was found to be suitable for drinking purpose as per the available analyzed chemical parameters. The presence of some constituents beyond the permissible limit at some locations renders the water unfit for public water supply.



## SUITABILITY OF GROUND WATER FOR IRRIGATION PURPOSE

### Total Dissolved Solids (TDS)

The TDS values in zone V were in the range of 296.4 to 1999.4 mg L<sup>-1</sup>, with an average value of 674.05 mg L<sup>-1</sup>. The maximum value of TDS was observed at Kako, Kako block, Jehanabad district. As can be seen from Table V.6, less than 16 % of the collected ground water samples were slightly saline and rest 84.69 % were non saline.

**Table V.6 % Frequency Distribution of T.D.S. in Zone V**

Salinity as per T.D.S range	Percentage
Fresh, non-saline (0-1000 mg/l)	84.69
Slightly saline (1001-3000 mg/l)	15.31

### United States Salinity Laboratory (USSL) Diagram

The Sodium adsorption ratio (SAR) values in the study area zone V, were in the range of 0.02 to 5.50, with an average value of 1.45. Thus, in the study area of 100 % of the water samples are observed to lie in S<sub>1</sub> class exhibiting low sodicity. A classification of the collected ground water samples on the basis of SAR values is given in Table V.8

From Table V.7 it is evident that in the study area Zone V, most of the water samples are observed to lie in C<sub>2</sub> & C<sub>3</sub> class exhibiting medium to high salinity. Thus 34.69 % water samples in the area are found to be of good class for irrigation and 64.28 % samples lie within the permissible limit as per class of water for irrigation. Only 1.02 % water samples exhibited unsuitable class of water for irrigation purposes.

**Table V.7 % Frequency Distribution of E.C. in Zone V**

E.C range (µS/cm at 25° C)	Percentage	Class of water (for irrigation)
<250 (low saline, C <sub>1</sub> )	0	Class-1, Excellent
250-750 (medium saline, C <sub>2</sub> )	34.69	Class-2, Good
751-2250 (high saline, C <sub>3</sub> )	64.28	Class-3, Permissible
>2250 (very high saline, C <sub>4</sub> )	1.02	Class-4, Unsuitable

As per USSL diagram given in Figure V.1, the ground water in the study area zone V, mostly comes under the C<sub>2</sub>-S<sub>1</sub> type, followed by C<sub>3</sub>-S<sub>1</sub> type suggesting medium to high salinity and low sodicity. Few samples were in the category of C<sub>3</sub>-S<sub>2</sub> suggesting high salinity and medium sodium hazard, and only 01 in C<sub>4</sub>-S<sub>2</sub> type which indicates

very high salinity hazard and medium sodicity. The salinity hazard is posed by water samples as they fall in class C3 and C4. Thus, on the whole 1.02 % of the water samples indicate C4-S2 class rendering the water unsuitable for irrigation purposes under ordinary conditions, however, it may be used occasionally after taking suitable measures.

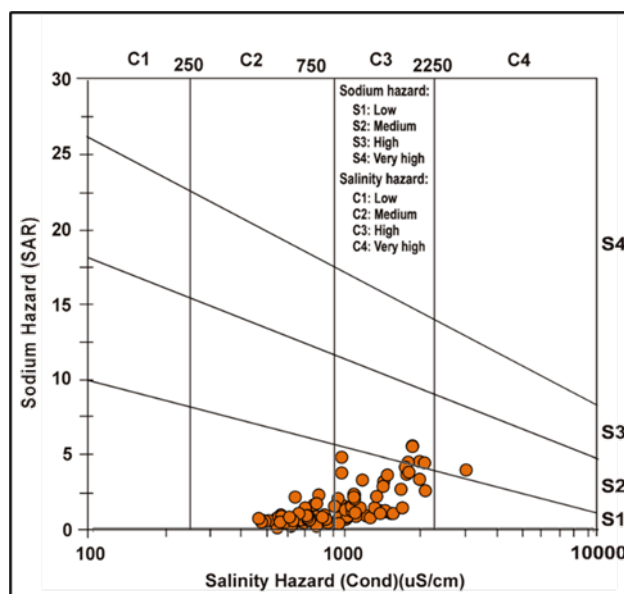


Figure V.1 USSL diagram of districts under Zone V

#### Alkalinity Hazard or Residual Sodium Carbonate (RSC)

The ground water samples collected from Zone V has shown that the Residual Sodium Carbonate in the area was in the range of -5.59 to 6.90 meq L<sup>-1</sup>, with an average value of -0.06 meq L<sup>-1</sup>.

A classification of the collected ground water samples on the basis of RSC values is given in Table V.8. It is clear from Table V.8, that in the study area 77.56 % (with RSC <1.25 meq L<sup>-1</sup>) samples were found to be very safe for use in irrigation and only 8.16% water samples (with RSC > 2.5 meq/l) were found to be unsuitable for irrigation purposes.

#### Soluble Sodium Percentage (S.S.P) (Wilcox Plot)

The % sodium values were in the range of 3.58 to 65.37, with an average value of 28.17. The maximum % sodium value was observed at Dumraon, Dumraon block, Buxar district.

A classification of ground water samples on the basis of % sodium values is given in Table V.8. It was observed that 36.73 % of the samples were in the excellent category,

followed by 41.84 % samples in good, 17.35 % in permissible category, 4.08 % samples in doubtful category. No samples were found to be in the category of unsuitable, according to their % sodium values. A Wilcox plot is given in Figure V.2, is showing that most of the ground water samples were in the category excellent to good and good to permissible zone. Only 1.02 % samples were in doubtful to unsuitable.

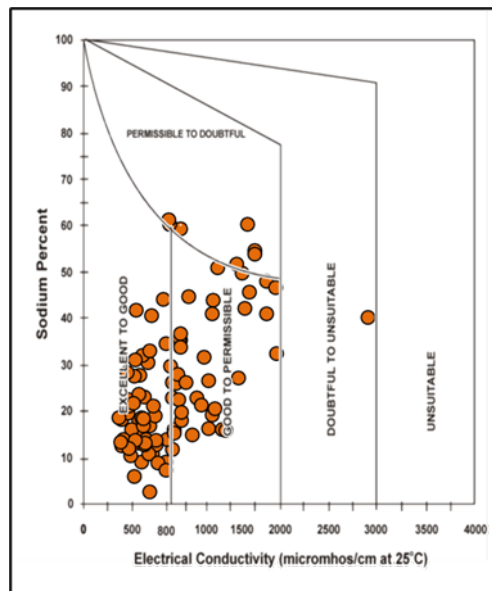


Figure V.2 Wilcox plot of districts under Zone V

Table V.8 Classification of ground water Samples of Zone V towards Irrigation purpose

Parameter	Range	Classification	% Of samples
SAR value	<10	Excellent	100
	10-18	Good	0
	18-26	Doubtful	0
	>26	Unsuitable	0
% Sodium	<20	Excellent	36.73
	20-40	Good	41.84
	40-60	Permissible	17.35
	60-80	Doubtful	4.08
	>80	Unsuitable	0
Residual Sodium Carbonate (RSC)	< 1.25	Good	77.56
	1.25-2.5	Doubtful	14.28
	> 2.5	Unsuitable	8.16

### Hydrogeochemical facies of Ground water

The ground water samples collected from zone V, has been classified utilizing the Piper's trilinear diagram. As per the piper plot given in in Figure V.3, 83.67 % ground water samples belonged to  $\text{Ca}^{2+}\text{-Mg}^{2+}\text{-HCO}_3^-$  type, followed by 13.26 % mixed type and 2.04 % as  $\text{Na}^+\text{-K}^+\text{-HCO}_3^-$  and 1.02 %  $\text{Ca}^{2+}\text{-Mg}^{2+}\text{-Cl-SO}_4^{2-}$  type. This type of ground water is due to the processes like ground water recharge, ion exchange processes and irrigation flow. The presence of mixed type of water maybe due to natural processes, ion exchange processes, anthropogenic activities such as municipal waste etc. The ground water chemistry in this zone is dominated by alkaline earth metals over alkali metals.

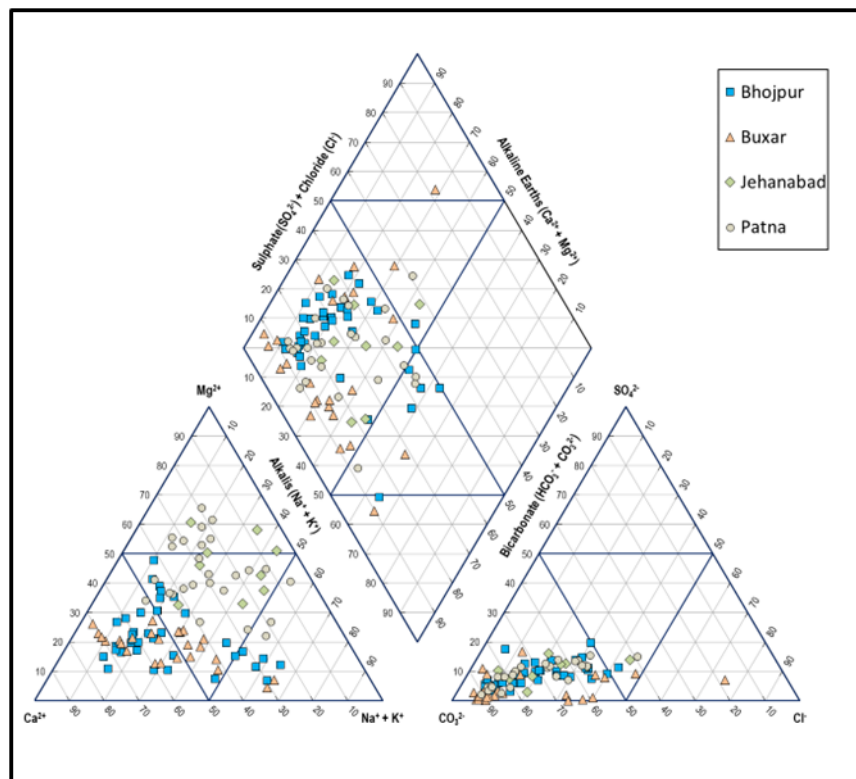


Figure V.3 Piper plot of districts under Zone V

### **8.1.6 Zone VI**

In this zone Kaimur (Bhabhua) and Rohtas districts were taken into consideration. Geomorphologically, Kaimur district is divided into two major divisions; the flat alluvial plain in the northern part and the Bhabua Plateau in the southern part. In Rohtas district, the district has complex features having alluvium in the northern part to the sub-hilly region in the south.

#### **Hydrogen Ion Concentration (pH)**

The samples collected from zone VI, has shown mildly alkaline nature with pH values in the range of 7.2 to 8.03, with an average value of 7.67. The maximum value was observed at Chainpur, Chainpur block of Kaimur district.

#### **Electrical Conductivity (EC)**

The EC values in zone VI were in the range 218-1931  $\mu\text{S/cm}$ , with an average value of 926.46  $\mu\text{S/cm}$ , respectively. The highest value of EC was observed at Bikramganj, Bikramganj block, Rohtas district. All the samples have shown EC values within the permissible limit of 3000  $\mu\text{S/cm}$ .

#### **Alkalinity**

The variation observed in the concentration of bicarbonate species was in the range of 97.6 to 640.5  $\text{mg L}^{-1}$ , with an average value of 386.5  $\text{mg L}^{-1}$ , respectively. The maximum value was observed at Bikramganj, Bikramganj block, Rohtas district. None of the collected ground water samples have shown carbonate alkalinity. Out of 30 samples collected, only 01 sample have shown alkalinity above the permissible limit. A percent distribution of collected ground water samples on the basis of alkalinity is given in Table VI.1.

**Table VI.1 % Distribution of Ground Water Samples in Different Alkalinity**

<b>Range</b>	
<b>Alkalinity Range (mg/l)</b>	<b>Percentage</b>
0 - 600	96.67
> 600	3.33

#### **Chloride**

The concentration of chloride ions was in the range of 17.75 to 248.5  $\text{mg L}^{-1}$ , with an average value of 72.06  $\text{mg L}^{-1}$ , respectively. The highest concentration of chloride ions was observed at Rajandih, Dinara block, Rohtas district. All samples have shown concentrations within the acceptable limit (250 $\text{mg/L}$ , BIS, 2012) and thus all samples have concentration within the permissible limit for drinking purposes (1000  $\text{mg/L}$ , BIS, 2012).

**Table VI. 2 % Frequency Distribution of Chloride in Zone VI**

<b>Chloride concentration (mg/l)</b>	<b>Percentage</b>
--------------------------------------	-------------------

Within Acceptable limit (0 – 250)	100
Within Permissible limit (1000)	100

### Calcium (Ca)

The calcium concentration in zone VI ground water samples was in the range of 22-184 mg L<sup>-1</sup>, with an average value of 85.26 mg L<sup>-1</sup>. The maximum value was observed at Auraiya, Nawhatta block, Rohtas district. The concentration of calcium for all samples was found to be within the permissible limit (200 mg L<sup>-1</sup>) in all samples indicating that water is suitable for potable purposes (Table VI.3).

**Table VI.3 % Frequency Distribution of Calcium in Zone VI**

Calcium concentration (mg/l)	Percentage
0-200	100
>200	0

### Magnesium (Mg)

In the study area Zone VI, magnesium was found to be in the range from 3.65 to 37.67 mg L<sup>-1</sup>, with an average value of 20.33 mg L<sup>-1</sup>. The highest concentration of magnesium ions was observed at Jahanabad, Kudra block, Rohtas district. As can be seen from Table VI.4, all the samples in zone VI have magnesium concentration within the permissible limit of 100 mg L<sup>-1</sup>. Thus, in general, the ground water in this zone is fit for human consumption.

**Table VI.4 % Frequency Distribution of Magnesium in Zone VI**

Magnesium concentration (mg/l)	Percentage
0-100	100
>100	0

### Total Hardness (T.H. as CaCO<sub>3</sub>)

In the study area, the total hardness in ground water samples range from 80 to 605 mg L<sup>-1</sup>, with an average value of 296.83 mg L<sup>-1</sup>. The maximum concentration was observed at Auraiya, Nawhatta block, Rohtas district. As can be seen form Table VI.5, only 01 out of the collected samples was found to have total hardness above the permissible limit of 600 mg L<sup>-1</sup>.

**Table VI.5 % Frequency Distribution of T. H. (as CaCO<sub>3</sub>) in Zone VI**

<b>Total Hardness (as CaCO<sub>3</sub>, mg/l)</b>	<b>Percentage</b>
0-600	96.67
>600	3.33

### **Sodium (Na)**

The analysis result of collected ground water samples indicated that sodium ranges from 7.85 to 254 mg L<sup>-1</sup>, with an average value of 70.74 mg L<sup>-1</sup>. The maximum concentration was observed at Chainpur, Chainpur block, Kaimur district.

### **Potassium (K)**

The analysis of collected ground water samples indicated that the concentration of potassium ions varies from 0 to 31 mg L<sup>-1</sup>, with an average of 3.98 mg L<sup>-1</sup>. The highest concentration of potassium ions was observed at Kochas, Dinara block, Rohtas district.

### **Nitrate (NO<sub>3</sub><sup>-</sup>)**

In the collected ground water samples concentration of nitrate ions was found to be in the range of 0.27 to 95 mg L<sup>-1</sup>, with an average value of 15.69 mg L<sup>-1</sup>. The highest concentration of nitrate ions was observed at Chand, Chand block, Kaimur district. Out of 30 samples studied, only 03 samples have shown concentration of nitrate ions above the acceptable limit of BIS 2012.

### **Fluoride (F<sup>-</sup>)**

In the study area Zone VI, the concentration of Fluoride ions was in the range of 0.12 to 1.31 mg L<sup>-1</sup>, with an average value of 0.59 mg L<sup>-1</sup>. The highest concentration was observed at Chainpur, Chainpur block, Kaimur district. It was observed that in all the collected ground water samples, the concentration of fluoride ions was within the permissible limit of 1.5 mg L<sup>-1</sup>.

By and large the ground water of Zone VI, was found to be suitable for drinking purpose as per the available analyzed chemical parameters. The presence of some constituents beyond the permissible limit at some locations renders the water unfit for public water supply.

## **SUITABILITY OF GROUND WATER FOR IRRIGATION PURPOSE**

### **Total Dissolved Solids (TDS)**

The TDS values in zone VI were in the range of 142 to 1255 mg L<sup>-1</sup>, with an average value of 602.26 mg L<sup>-1</sup>. The maximum value of TDS was observed at Bikramganj,

Bikramganj block, Rohtas district. As can be seen from Table VI.6, only 01 out of the collected ground water samples were slightly saline and rest 96.67 % were non saline.

**Table VI.6 % Frequency Distribution of T.D.S. in Zone VI**

Salinity as per T.D.S range	Percentage
Fresh, non-saline (0-1000 mg/l)	96.67
Slightly saline (1001-3000 mg/l)	3.33

### United States Salinity Laboratory (USSL) Diagram

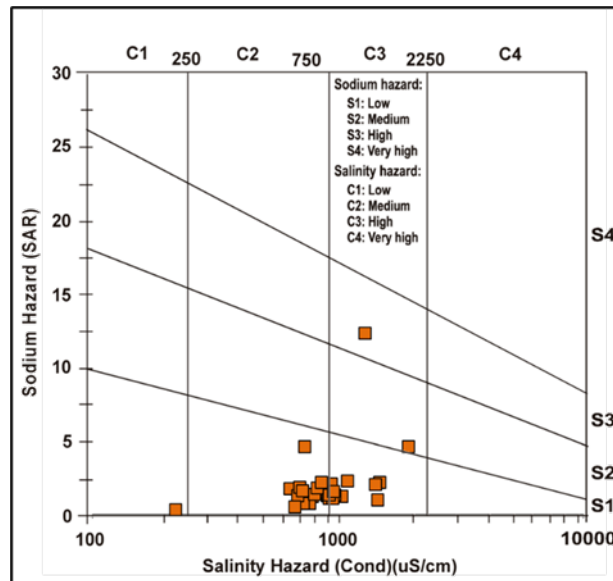
The Sodium adsorption ratio (SAR) values in the study area zone VI, were in the range of 0.34 to 12.34, with an average value of 1.99. Thus, in the study area of 96.67 % of the water samples are observed to lie in S<sub>1</sub> class exhibiting low sodicity. A classification of the collected ground water samples on the basis of SAR values is given in Table VI.8 From Table VI.7 it is evident that in the study area Zone VI, most of the water samples are observed to lie in C<sub>2</sub> & C<sub>3</sub> class exhibiting medium to high salinity. Thus 30 % water samples in the area are found to be of excellent to good class for irrigation and 70 % samples lie within the permissible limit as per class of water for irrigation. No water samples exhibited unsuitable class of water for irrigation purposes.

**Table VI.7 % Frequency Distribution of E.C. in Zone VI**

E.C range ( $\mu\text{S}/\text{cm}$ at 25° C)	Percentage	Class of water (for irrigation)
<250 (low saline, C <sub>1</sub> )	3.33	Class-1, Excellent
250-750 (medium saline, C <sub>2</sub> )	26.67	Class-2, Good
751-2250 (high saline, C <sub>3</sub> )	70	Class-3, Permissible
>2250 (very high saline, C <sub>4</sub> )	0	Class-4, Unsuitable

As per USSL diagram given in Figure VI.1, the ground water in the study area zone VI, mostly comes under the C<sub>2</sub>-S<sub>1</sub> and C<sub>3</sub>-S<sub>1</sub> type suggesting medium followed by high salinity and low sodicity and only 01 sample each in C<sub>1</sub>-S<sub>1</sub>, C<sub>3</sub>-S<sub>2</sub> and C<sub>3</sub>-S<sub>3</sub> type. One sample in each category of C<sub>3</sub>-S<sub>2</sub> and C<sub>3</sub>-S<sub>3</sub> indicate high salinity and medium to high sodicity.





**Figure VI.1 USSSL diagram of districts under Zone VI**

#### **Alkalinity Hazard or Residual Sodium Carbonate (RSC)**

The ground water samples collected from Zone VI has shown that the Residual Sodium Carbonate in the area was in the range of -3.49 to 5.60 meq L<sup>-1</sup>, with an average value of 0.40 meq L<sup>-1</sup>. A classification of the collected ground water samples on the basis of RSC values is given in Table VI.8. It is clear from Table VI.8, that in the study area 80 % (with RSC <1.25 meq L<sup>-1</sup>) samples were found to be very safe for use in irrigation and 6.7 % water samples (with RSC > 2.5 meq/l) were found to be unsuitable for irrigation purposes.

#### **8.2.5 Soluble Sodium Percentage (S.S.P) (Wilcox Plot)**

The % sodium values were in the range of 12.94 to 87.37, with an average value of 33.43. The maximum % sodium value was observed at Chainpur, Chainpur block, Kaimur district. A classification of ground water samples on the basis of % sodium values is given in Table VI.8. It was observed that 16.67 % of the samples were in the excellent category, followed by 63.33 % samples in good and 13.33 % in permissible category. Only 6.67 % samples were found to be in the category of doubtful and unsuitable, according to their % sodium values.

A Wilcox plot is given in Figure VI.2, showing that most of the ground water samples may be used for irrigation purpose. Most of the ground water samples were in the

category excellent to good and good to permissible zone. Only 3.3% samples were in permissible to doubtful category.

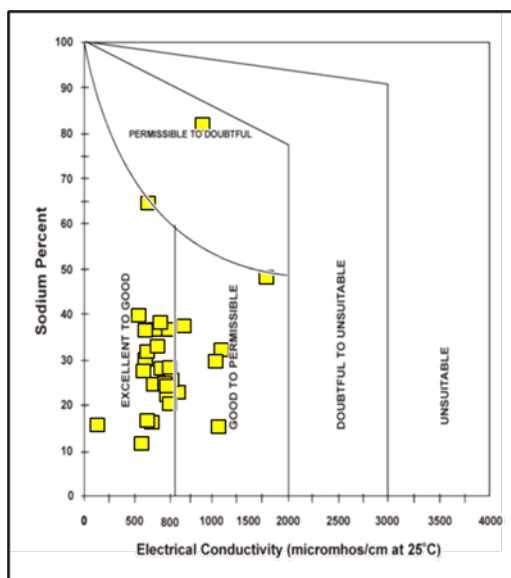


Figure VI.2 Wilcox plot of districts under Zone VI

Table VI.8 Classification of ground water Samples of Zone VI towards Irrigation purpose

Parameter	Range	Classification	% Of samples
SAR value	<10	Excellent	96.67
	10-18	Good	3.33
	18-26	Doubtful	0
	>26	Unsuitable	0
% Sodium	<20	Excellent	16.67
	20-40	Good	63.33
	40-60	Permissible	13.33
	60-80	Doubtful	3.33
	>80	Unsuitable	3.33
Residual Sodium Carboate (RSC)	< 1.25	Good	80
	1.25-2.5	Doubtful	13.33
	> 2.5	Unsuitable	6.7

### Hydrogeochemical facies of Ground water

The ground water samples collected from zone VI, has been classified utilizing the Piper’s trilinear diagram. As per the piper plot given in in Figure VI.3, 83.33 % ground water samples belonged to  $Ca^{2+}$ - $Mg^{2+}$ - $HCO_3^-$  type, followed by 16.67 % mixed type. This type of ground water is due to the processes like ground water recharge, ion

exchange processes and irrigation flow. The presence of mixed type of water maybe due to natural processes, ion exchange processes, anthropogenic activities such as municipal waste etc. The ground water chemistry in this zone is dominated by alkaline earth metals over alkali metals.

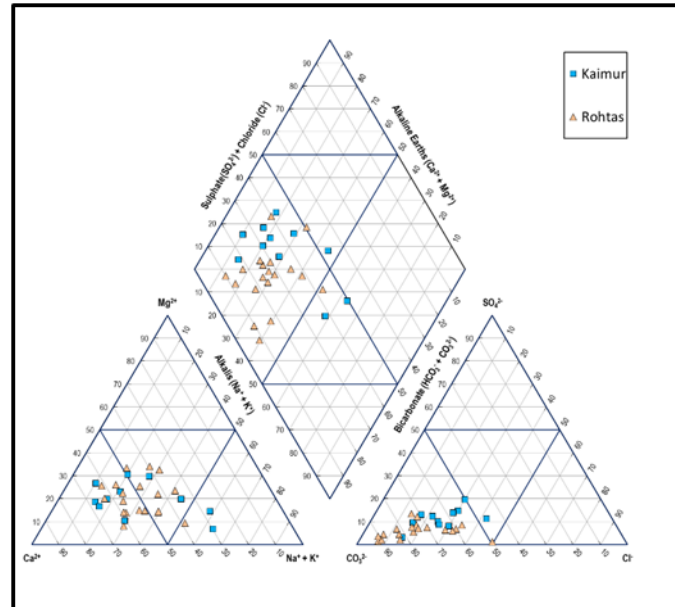


Figure VI.3 Piper plot of districts under Zone VI

### **8.1.7 Zone VII**

In this zone Arwal, Aurangabad, Gaya, Nalanda, Nawada, Sheikhpura districts were taken into consideration. Arwal district is characterized by flat quaternary alluvial plain. The two main physiographic units in Aurangabad district are Northern Gangetic Plains and southern hilly ranges. Gaya district can be classified into four distinct geomorphic units namely a) rocky upland b) plateau and the pediplain c) high level marginal alluvial terrace (Dobhi Gaya terrace) and d) Sone-Ganga plain. Nalanda district is located within the Mid-Ganga basin, in the southern margin of the Gangetic plain. Nawada district can be broadly divided into two major physiographic units northern alluvial plain and southern hilly terrain which is an extension of southern fringes of Chhotanagpur Plateau. Sheikhpura district is part of Mid-Ganga basin, in the southern margin of the Gangetic plains. The district mainly represents flat alluvium terrain except some hilly area in the middle part.

#### **Hydrogen Ion Concentration (pH)**

The samples collected from zone VII, has shown slightly alkaline nature with pH values in the range of 6.92 to 8.7, with an average value of 7.61. The maximum value was observed at Ariari, Ariari block, Sheikhpura district.

#### **Electrical Conductivity (EC)**

The EC values in zone VII were in the range 246-3310  $\mu\text{S/cm}$ , with an average value of 1201.03  $\mu\text{S/cm}$ , respectively. The highest value of EC was observed at Bhui, Silao Block, Nalanda district. Out of 110 samples, only 02 samples have shown EC values greater than the permissible limit of 3000  $\mu\text{S/cm}$ .

#### **Alkalinity**

The variation observed in the concentration of bicarbonate species was in the range of 103.7 to 1055.3  $\text{mg L}^{-1}$ , with an average value of 421.23  $\text{mg L}^{-1}$ , respectively. The maximum value was observed at Dhobitola Goh, Goh block, Aurangabad district. Out of 110 samples studied, 03 samples have shown carbonate alkalinity. The carbonate concentration was in the range of 0-36  $\text{mg L}^{-1}$ . The highest concentration was observed at Ariari, Ariari block, Sheikhpura. A percent distribution of collected ground water samples on the basis of alkalinity is given in Table VII.1. It can be seen from Table VII.1, that 91.82 % of collected water samples have shown alkalinity within the permissible range of 600  $\text{mg L}^{-1}$ .

**Table VII.1 % Distribution of Ground Water Samples in Different Alkalinity**

<b>Range</b>	
<b>Alkalinity Range (mg/l)</b>	<b>Percentage</b>
0 - 600	91.82
> 600	8.18

#### **Chloride**

The concentration of chloride ions was in the range of 10.65 to 521.85  $\text{mg L}^{-1}$ , with an average value of 129.03  $\text{mg L}^{-1}$ , respectively. The highest concentration of chloride ions was observed at Bihar Sharif Railway Station, Bihar Sharif block, Nalanda district. From Table VII.2 it is clear that chloride concentrations of less than 12% of ground water samples is exceeding the acceptable limit for drinking purposes (250  $\text{mg/L}$ , BIS, 2012) and all samples have concentration within the permissible limit for drinking purposes (1000  $\text{mg/L}$ , BIS, 2012).

**Table VII. 2 % Frequency Distribution of Chloride in Zone VII**

<b>Chloride concentration (mg/l)</b>	<b>Percentage</b>
Within Acceptable limit (0 – 250)	88.18
Within Permissible limit (1000)	100

**Calcium (Ca)**

The calcium concentration in zone VII ground water samples was in the range of 12-264 mg L<sup>-1</sup>, with an average value of 70.61 mg L<sup>-1</sup>. The maximum value was observed at Bihar sharif Railway Station, Bihar sharif block, Nalanda district. The concentration of calcium for 97.27% samples was found to be within the permissible limit (200 mg L<sup>-1</sup>) in all the samples indicating that water is suitable for potable purposes (Table VII.3).

**Table VII.3 % Frequency Distribution of Calcium in Zone VII**

<b>Calcium concentration (mg/l)</b>	<b>Percentage</b>
0-200	97.27
>200	2.73

**Magnesium (Mg)**

In the study area Zone VII, magnesium concentration was found to be in the range from 7.29 to 148.23 mg L<sup>-1</sup>, with an average value of 51.82 mg L<sup>-1</sup>. The highest concentration of magnesium ions was observed at Ekanagarsarai (Ekangardih), Ekanagarsarai block, Nalanda district. As can be seen from Table VII.4, 95.55 % samples in zone VII have magnesium concentration within the permissible limit of 100 mg L<sup>-1</sup>. Thus, in general, the ground water in this zone is fit for human consumption.

**Table VII.4 % Frequency Distribution of Magnesium in Zone VII**

<b>Magnesium concentration (mg/l)</b>	<b>Percentage</b>
0-100	95.55
>100	5.45

**Total Hardness (T.H. as CaCO<sub>3</sub>)**

In the study area, the total hardness in ground water samples range from 95 to 1070 mg L<sup>-1</sup>, with an average value of 389.82 mg L<sup>-1</sup>. The maximum concentration was observed at Bhui, Silao block, Nalnada district. As can be seen form Table VII.5, 88.12 % of

collected samples were found to have total hardness within the permissible limit of 600 mg L<sup>-1</sup>.

**Table VII.5 % Frequency Distribution of T. H. (as CaCO<sub>3</sub>) in Zone VII**

<b>Total Hardness (as CaCO<sub>3</sub>, mg/l)</b>	<b>Percentage</b>
0-600	88.12
>600	11.82

### **Sodium (Na)**

The analysis result of collected ground water samples indicated that sodium ranges from 12.55 to 250.95 mg L<sup>-1</sup>, with an average value of 85.82 mg L<sup>-1</sup>. The maximum concentration was observed at Aurangabad, Aurangabad block, Aurangabad district.

### **Potassium (K)**

The analysis of collected ground water samples indicated that the concentration of potassium ions varies from 0.97 to 174.4 mg L<sup>-1</sup>, with an average of 18.74 mg L<sup>-1</sup>. The highest concentration of potassium ions was observed at Dhobitola Goh, Goh block, Aurangabad district.

### **Nitrate (NO<sub>3</sub><sup>-</sup>)**

In the collected ground water samples concentration of nitrate ions was found to be in the range of 0 to 40.21 mg L<sup>-1</sup>, with an average value of 13.80 mg L<sup>-1</sup>. The highest concentration of nitrate ions was observed at Meskaur, Meskaur block, Nawada district. All samples collected from the study area have shown concentration of nitrate ions within the acceptable limit of BIS 2012 (45 mg L<sup>-1</sup>).

### **Fluoride (F<sup>-</sup>)**

In the study area Zone VII, the concentration of Fluoride ions was in the range of 0.09 to 1.67 mg L<sup>-1</sup>, with an average value of 0.89 mg L<sup>-1</sup>. The highest concentration was observed at 02 locations, Kawakol Ashram, Kawakol block, Nawada and Ariari, Ariari block, Sheikhpura. It was observed that out of 110 collected ground water samples, in 11 samples the concentration of fluoride ions was greater than the permissible limit of 1.5 mg L<sup>-1</sup>.

By and large the ground water of Zone VII, was found to be suitable for drinking purpose as per the available analyzed chemical parameters. The presence of some constituents beyond the permissible limit at some locations renders the water unfit for public water supply.

## SUITABILITY OF GROUND WATER FOR IRRIGATION PURPOSE

### Total Dissolved Solids (TDS)

The TDS values in zone VII were in the range of 159.9 to 2151.5 mg L<sup>-1</sup>, with an average value of 780.67 mg L<sup>-1</sup>. The maximum value of TDS was observed at Bhui, Silao Block, Nalanda district. As can be seen from Table VII.6, 26.64 % of the collected ground water samples were slightly saline and rest 76.36 % were non saline.

**Table VII.6 % Frequency Distribution of T.D.S. in Zone VII**

Salinity as per T.D.S range	Percentage
Fresh, non-saline (0-1000 mg/l)	76.36
Slightly saline (1001-3000 mg/l)	26.64

### United States Salinity Laboratory (USSL) Diagram

The SAR values in the study area zone VII, were in the range of 0.46 to 3.77, with an average value of 1.88. Thus, in the study area of 100 % of the water samples are observed to lie in S<sub>1</sub> class exhibiting low sodicity. A classification of the collected ground water samples on the basis of SAR values is given in Table VII.8

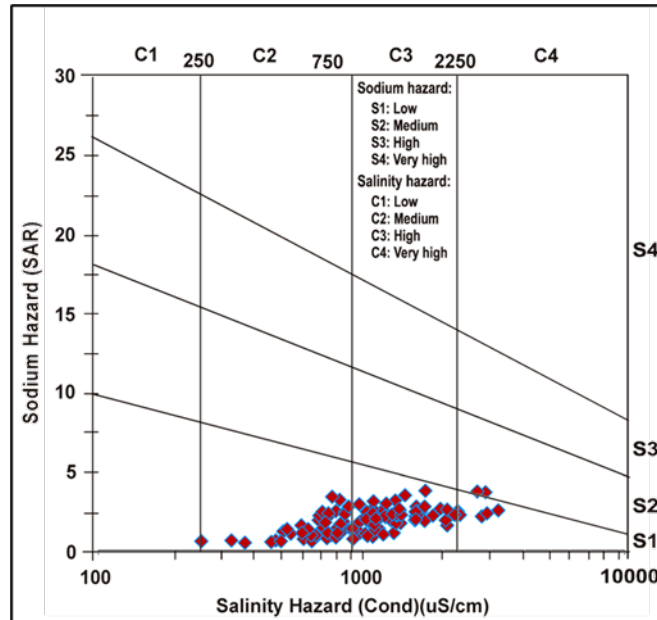
From Table VII.7 it is evident that in the study area Zone VII, 0.91 % of the samples werw in the excellent category and most of the water samples are observed to lie in C<sub>2</sub> & C<sub>3</sub> class exhibiting medium to high salinity. Thus 63.33 % water samples in the area are found to be of good class for irrigation and 33.33 % samples lie within the permissible limit as per class of water for irrigation. Only 7.23 % water samples exhibited unsuitable class of water for irrigation purposes.

**Table VII.7 % Frequency Distribution of E.C. in Zone VII**

E.C range (µS/cm at 25° C)	Percentage	Class of water (for irrigation)
<250 (low saline, C <sub>1</sub> )	0.91	Class-1, Excellent
250-750 (medium saline, C <sub>2</sub> )	23.64	Class-2, Good
751-2250 (high saline, C <sub>3</sub> )	68.18	Class-3, Permissible
>2250 (very high saline, C <sub>4</sub> )	7.23	Class-4, Unsuitable

As per USSL diagram given in Figure VII.1, the ground water in the study area zone VII, mostly comes under the C<sub>3</sub>-S<sub>1</sub> type suggesting high salinity and low sodicity, followed by C<sub>2</sub>-S<sub>1</sub> type suggesting medium salinity and low sodicity. The salinity

hazard is posed by the water samples as they fall in class C3 and C4. Thus, on the whole 4.54 % of the water samples in C4-S1 and C4-S2 category are water unsuitable for irrigation purposes under ordinary conditions, however, it may be used occasionally after taking suitable measures.



**Figure VII.1 USSL diagram of districts under Zone VII**

**Alkalinity Hazard or Residual Sodium Carbonate (RSC)**

The ground water samples collected from Zone VII has shown that the Residual Sodium Carbonate in the area was in the range of -11.30 to 3.80 meq L<sup>-1</sup>, with an average value of -0.87 meq L<sup>-1</sup>.

A classification of the collected ground water samples on the basis of RSC values is given in Table VII.8. It is clear from Table VII.8, that in the study area 85.54 % (with RSC <1.25 meq L<sup>-1</sup>) samples were found to be very safe for use in irrigation and water 6.36 % samples (with RSC > 2.5 meq/l) were found to be unsuitable for irrigation purposes.

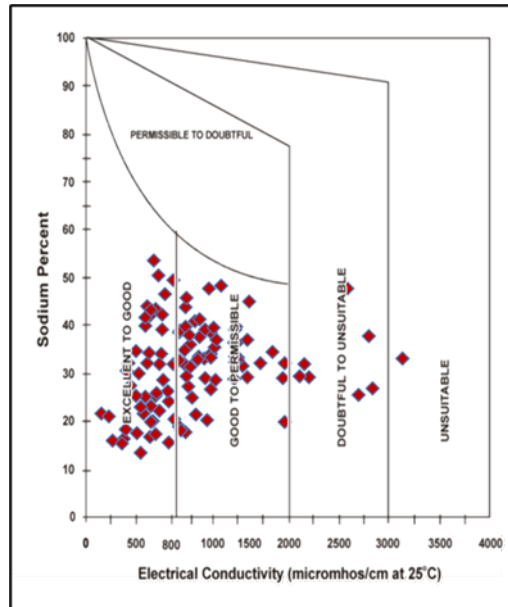
**Soluble Sodium Percentage (S.S.P) (Wilcox Plot)**

The % sodium values were in the range of 14.79 to 54.41, with an average value of 34.11. The maximum % sodium value was observed at Nawabganj, Sirdala block, Nawada district.

A classification of ground water samples on the basis of % sodium values is given in Table VII.8. It was observed that 10 % of the samples were in the excellent category, followed by 61.82 % samples in good and 28.18 % in permissible category. No samples



were found to be in the category of doubtful and unsuitable. A Wilcox plot is given in Figure VII.2, is showing that most of the ground water samples were in the category excellent to good and good to permissible zone. Only 6.4 % samples were in doubtful to unsuitable zone and 0.91 % samples were in unsuitable zone.



**Figure VII.2 Wilcox plot of districts under Zone VII**

**Table VII.8 Classification of ground water Samples of Zone VII towards Irrigation purpose**

Parameter	Range	Classification	% Of samples
SAR value	<10	Excellent	100
	10-18	Good	0
	18-26	Doubtful	0
	>26	Unsuitable	0
% Sodium	<20	Excellent	10
	20-40	Good	61.82
	40-60	Permissible	28.18
	60-80	Doubtful	0
	>80	Unsuitable	0
Residual Sodium Carbonate (RSC)	< 1.25	Good	85.54
	1.25-2.5	Doubtful	9.10
	> 2.5	Unsuitable	6.36

### Hydrogeochemical facies of Ground water

The ground water samples collected from zone VII, has been classified utilizing the Piper's trilinear diagram. As per the piper plot given in in Figure VII.3, 75.55 % ground water samples belonged to  $Ca^{2+}$ - $Mg^{2+}$ - $HCO_3^-$  type, followed by 25.45 % mixed type.

This type of ground water is due to the processes like ground water recharge, ion exchange processes and irrigation flow. The presence of mixed type of water maybe due to natural processes, ion exchange processes, anthropogenic activities such as municipal waste etc. The ground water chemistry in this zone is dominated by alkaline earth metals over alkali metals.

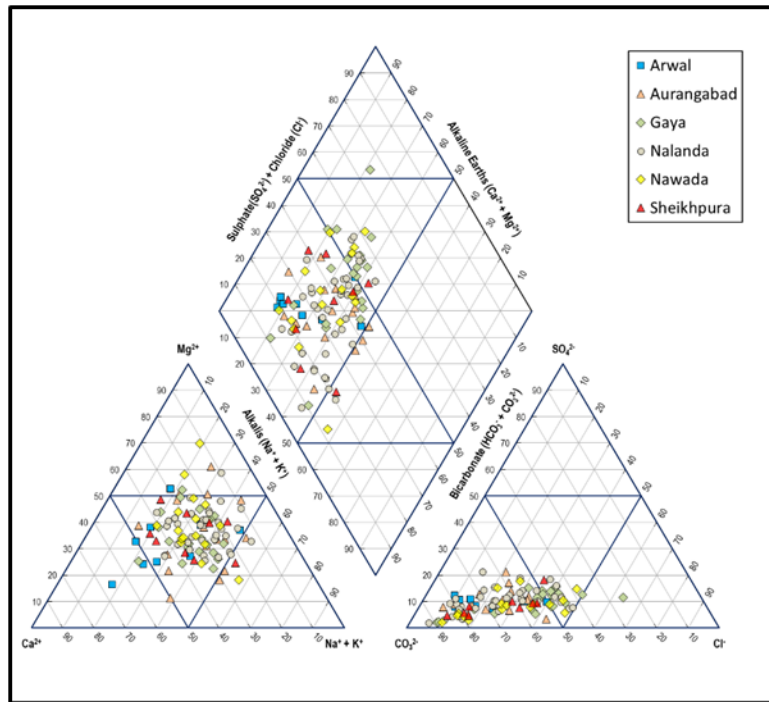


Figure VII.3 Piper plot of districts under Zone VII

### **8.1.8 Zone VIII**

In this zone Jamui and Banka districts were taken into consideration. The major geomorphic units in Jamui are Rocky upland, plateau /pediplain and alluvial plain. In Banka district, the major geomorphic units are Alluvial Plain, Hills & Pediments.

#### **Hydrogen Ion Concentration (pH)**

The samples collected from zone VIII, has shown slightly alkaline nature with pH values in the range of 7.25 to 8.51, with an average value of 7.90. The maximum value was observed at Mirjapur, Shambhuganj block of Banka district.

#### **Electrical Conductivity (EC)**

The EC values in zone VIII were in the range 381-1320  $\mu\text{S}/\text{cm}$ , with an average value of 653.54  $\mu\text{S}/\text{cm}$ , respectively. The highest value of EC was observed at Karharia, Shambhuganj block, Banka district. All the samples have shown EC values within the permissible limit of 3000  $\mu\text{S}/\text{cm}$ .

#### **Alkalinity**

The variation observed in the concentration of bicarbonate species was in the range of 110.7 to 350.55 mg L<sup>-1</sup>, with an average value of 208.86 mg L<sup>-1</sup>, respectively. The maximum value was observed at Mirjapur, Shambhuganj block, Banka district. Out of 26 samples studied, 07 samples have shown carbonate alkalinity. The carbonate concentration was in the range of 0-15 mg L<sup>-1</sup>. The highest concentration was observed at Mirjapur, Shambhuganj block, Banka district. Out of 30 samples collected, all samples have shown alkalinity within the permissible limit. A percent distribution of collected ground water samples on the basis of alkalinity is given in Table VIII.1.

**Table VIII.1 % Distribution of Ground Water Samples in Different Alkalinity Range**

<b>Alkalinity Range (mg/l)</b>	<b>Percentage</b>
0 - 600	100
> 600	0

### **Chloride**

The concentration of chloride ions was in the range of 3.54 to 340 mg L<sup>-1</sup>, with an average value of 64.62 mg L<sup>-1</sup>, respectively. The highest concentration of chloride ions was observed at Karharia, Shambhuganj block, Banka district. From Table VIII.2 it is clear that chloride concentrations of less than 4% of ground water samples is exceeding the acceptable limit for drinking purposes (250 mg/L, BIS, 2012) but is well within the permissible limit of 1000 mg/L.

**Table VIII. 2 % Frequency Distribution of Chloride in Zone VIII**

<b>Chloride concentration (mg/l)</b>	<b>Percentage</b>
Within Acceptable limit (0 – 250)	96.15
Within Permissible limit (1000)	100

### **Calcium (Ca)**

The Ca concentration in zone VIII ground water samples was in the range of 14-66 mg L<sup>-1</sup>, with an average value of 33.46 mg L<sup>-1</sup>. The maximum value was observed at Baunsi, Baunsi block, Banka district. The concentration of Ca for all the samples was found to be within the permissible limit (200 mg L<sup>-1</sup>) in all the samples indicating that water is suitable for potable purposes (Table VIII.3).

**Table VIII.3 % Frequency Distribution of Calcium in Zone VIII**

Calcium concentration (mg/l)	Percentage
0-200	100
>200	0

### **Magnesium (Mg)**

In the study area Zone VIII, magnesium concentration was found to be in the range from 7.29 to 77.76 mg L<sup>-1</sup>, with an average value of 25.50 mg L<sup>-1</sup>. The highest concentration of magnesium ions was observed at Karharia, Shambhuganj block, Banka district. As can be seen from Table VIII.4, all the samples in zone VIII have magnesium concentration within the permissible limit of 100 mg L<sup>-1</sup>. Thus, in general, the ground water in this zone is fit for human consumption.

**Table VIII.4 % Frequency Distribution of Magnesium in Zone VIII**

Magnesium concentration (mg/l)	Percentage
0-100	100
>100	0

### **Total Hardness (T.H. as CaCO<sub>3</sub>)**

In the study area, the total hardness in ground water samples range from 95 to 415 mg L<sup>-1</sup>, with an average value of 188.69 mg L<sup>-1</sup>. The maximum concentration was observed at Karharia, Shambhuganj block, Banka district. As can be seen form Table VIII.5, all the collected samples were found to have total hardness within the permissible limit of 600 mg L<sup>-1</sup>.

**Table VIII.5 % Frequency Distribution of T. H. (as CaCO<sub>3</sub>) in Zone VIII**

Total Hardness (as CaCO <sub>3</sub> , mg/l)	Percentage
0-600	100
>600	0

### **Sodium (Na)**

The analysis result of collected ground water samples indicated that sodium ranges from 22.48 to 127.15 mg L<sup>-1</sup>, with an average value of 59.88 mg L<sup>-1</sup>. The maximum concentration was observed at Mirjapur, Shanbhuganj, Banka district.

### **Potassium (K)**

The analysis of collected ground water samples indicated that the concentration of potassium ions varies from 0.13 to 44.28 mg L<sup>-1</sup>, with an average of 3.99 mg L<sup>-1</sup>. The

highest concentration of potassium ions was observed at Englishmore, Amarpur block, Banka district.

**Nitrate (NO<sub>3</sub><sup>-</sup>)**

In the collected ground water samples concentration of nitrate ions was found to be in the range of 1.8 to 44 mg L<sup>-1</sup>, with an average value of 21.34 mg L<sup>-1</sup>. The highest concentration of potassium ions was observed at Jamui, Jamui block, Jamui district. From 26 samples studied, all samples have concentration of nitrate ions within the acceptable limit of BIS 2012.

**Fluoride (F<sup>-</sup>)**

In the study area Zone VIII, the concentration of Fluoride ions was in the range of 0.04 to 3.56 mg L<sup>-1</sup>, with an average value of 0.93 mg L<sup>-1</sup>. The highest concentration was observed at Manjhwa, Jamui block, Jamui district. It was observed that out of 26 samples, 05 samples have shown concentration of fluoride ions greater than the permissible limit of 1.5 mg L<sup>-1</sup>.

The fluoride rich minerals in the host rocks may be probable source of dissolution of high fluoride in ground water in favorable condition. The weathering and dissolution of fluoride rich mineral i.e fluorite, apatite, sphene, biotite etc. in granite or gneissic terrain under favorable geochemical condition releases fluoride in ground water. The rain water harvesting structures for artificial recharge in the fluoride affected aquifer may be very effective management intervention to lower the concentration of fluoride through dilution.

By and large the ground water of Zone VIII, was found to be suitable for drinking purpose as per the available analyzed chemical parameters. The presence of some constituents beyond the permissible limit at some locations renders the water unfit for public water supply.

**SUITABILITY OF GROUND WATER FOR IRRIGATION PURPOSE**

**Total Dissolved Solids (TDS)**

The TDS values in zone VIII were in the range of 247.65 to 858 mg L<sup>-1</sup>, with an average value of 424.8 mg L<sup>-1</sup>. The maximum value of TDS was observed at Karharia, Shambhganj, Banka district. As can be seen from Table VIII.6, all the samples were non saline.

**Table VIII.6 % Frequency Distribution of T.D.S. in Zone VIII**

Salinity as per T.D.S range	Percentage
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Fresh, non-saline (0-1000 mg/l)	100
Slightly saline (1001-3000 mg/l)	0

### United States Salinity Laboratory (USSL) Diagram

The SAR values in the study area zone VIII, were in the range of 0.80 to 4.51 with an average value of 1.98. Thus, in the study area of 100 % of the water samples are observed to lie in S<sub>1</sub> class exhibiting low sodicity. A classification of collected ground water samples on the basis of SAR values is given in Table VIII.8.

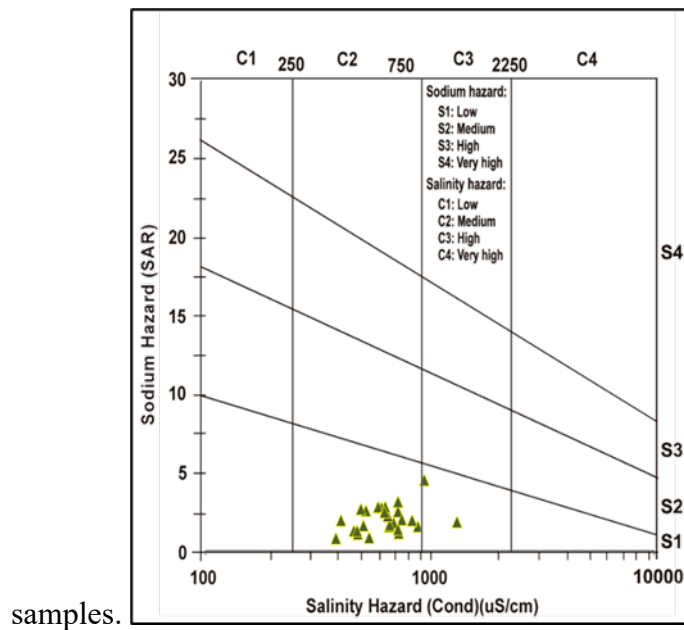
From Table VIII.7 it is evident that in the study area Zone VIII, most of the water samples are observed to lie in C<sub>2</sub> & C<sub>3</sub> class exhibiting medium to high salinity. Thus 84.62 % water samples in the area are found to be of good class for irrigation and 18.18 % samples lie within the permissible limit as per class of water for irrigation. Only 3.33 % water samples exhibited unsuitable class of water for irrigation purposes. No samples were found unsuitable for irrigation.

**Table VIII.7 % Frequency Distribution of E.C. in Zone VIII**

E.C range ( $\mu\text{S}/\text{cm}$ at 25° C)	Percentage	Class of water (for irrigation)
<250 (low saline, C <sub>1</sub> )	0	Class-1, Excellent
250-750 (medium saline, C <sub>2</sub> )	84.62	Class-2, Good
751-2250 (high saline, C <sub>3</sub> )	15.38	Class-3, Permissible
>2250 (very high saline, C <sub>4</sub> )	0	Class-4, Unsuitable

As per USSL diagram given in Figure VIII.1, the ground water in the study area zone VIII, mostly comes under the C<sub>2</sub>-S<sub>1</sub> type suggesting medium salinity and low sodicity,

followed by C3-S1 type, indicating medium salinity and low sodicity for most of the



samples.

**Figure VIII.1 USSSL diagram of districts under Zone VIII**

#### **Alkalinity Hazard or Residual Sodium Carbonate (RSC)**

The ground water samples collected from Zone VIII has shown that the Residual Sodium Carbonate in the area was in the range of -5.58 to 3.25 meq L<sup>-1</sup>, with an average value of -0.26 meq L<sup>-1</sup>.

A classification of the collected ground water samples on the basis of RSC values is given in Table VIII.8. It is clear from Table VIII.8 that in the study area 76.92 % (with RSC <1.25 meq L<sup>-1</sup>) samples were found to be very safe for use in irrigation and only 3.25% of water samples (with RSC > 2.5 meq/l) were found to be unsuitable for irrigation purposes.

#### **8.2.5 Soluble Sodium Percentage (S.S.P) (Wilcox Plot)**

The % sodium values were in the range of 22.81 to 65.93, with an average value of 42.17. The maximum % sodium value was observed at Mirjapur, Shambhuganj block of Banka district.

A classification of ground water samples on the basis of % sodium values is given in Table VIII.8. It was observed that 50 % samples were in good category, followed by 46.15 % in permissible category and only 3.85 % in doubtful category. No samples were found in unsuitable category.

A Wilcox plot is given in Figure VIII.2, showing that most of the ground water samples were in the category excellent to good and good to permissible zone. Only 3.85 % samples were in doubtful to unsuitable category.

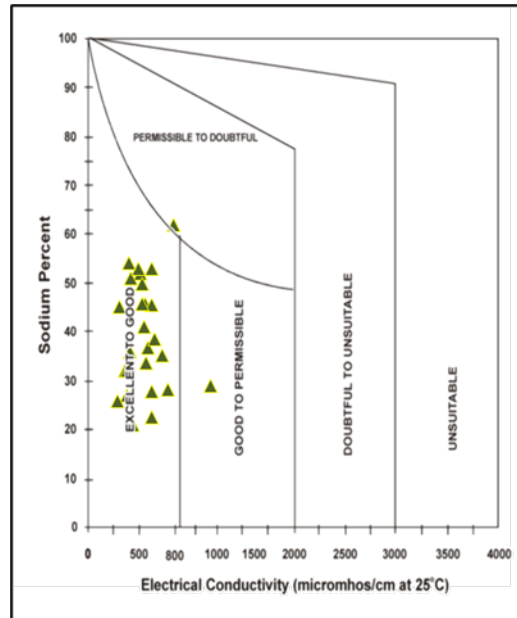


Figure VIII.2 Wilcox plot of districts under Zone VIII

Table VIII.8 Classification of ground water Samples of Zone VIII towards Irrigation purpose

Parameter	Range	Classification	% Of samples
SAR value	<10	Excellent	100
	10-18	Good	0
	18-26	Doubtful	0
	>26	Unsuitable	0
% Sodium	<20	Excellent	0
	20-40	Good	50
	40-60	Permissible	46.15
	60-80	Doubtful	3.85
	>80	Unsuitable	0
Residual Sodium Carbonate (RSC)	< 1.25	Good	76.92
	1.25-2.5	Doubtful	19.23
	> 2.5	Unsuitable	3.85

### Hydrogeochemical facies of Ground water



The ground water samples collected from zone VIII, has been classified utilizing the Piper's trilinear diagram. As per the piper plot given in in Figure VIII.3, 53.84 % ground water samples belonged to  $\text{Ca}^{2+}\text{-Mg}^{2+}\text{-HCO}_3^-$  type, followed by 42.30 % mixed type and 3.85 % as  $\text{Na}^+\text{-K}^+\text{-Cl}^-$  type. This type of ground water is due to the processes like ground water recharge, ion exchange processes and irrigation flow. The presence of mixed type of water maybe due to natural processes, ion exchange processes, anthropogenic activities such as municipal waste etc. The ground water chemistry in this zone is dominated by alkaline earth metals over alkali metals.

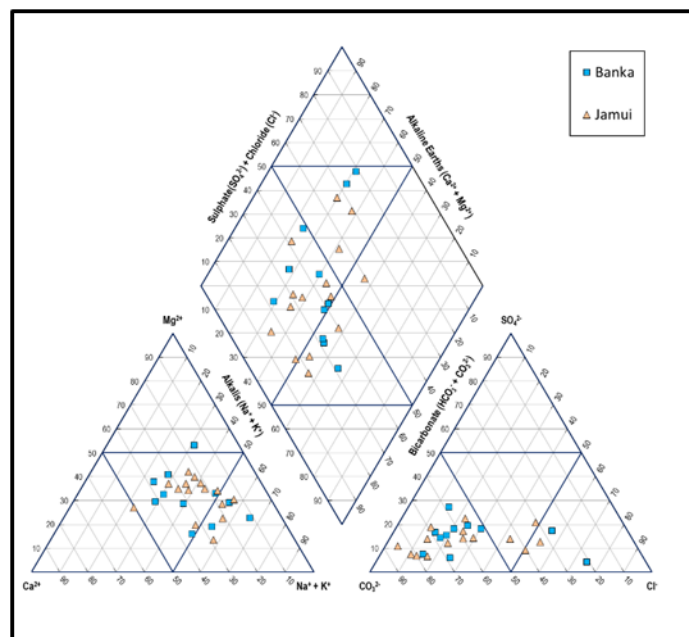


Figure VIII.3 Piper plot of districts under Zone VIII

### **8.1.9 Zone IX**

In this zone Lakhisarai, Munger and Bhagalpur districts were taken into consideration. The major geomorphic units in Lakhisarai are rocky upland, pediplain, alluvial plain and flood plains. In Munger district, the major geomorphic units are rocky upland, pediplain and alluvial plain. In Bhagalpur district, the major geomorphic units are Indo-Gangetic Alluvium Tract and Marginal Alluvium Tract.

#### **Hydrogen Ion Concentration (pH)**

The samples collected from zone IX, has shown slightly alkaline nature with pH values in the range of 7.14 to 8.43, with an average value of 7.87. The maximum value was observed at Harchandpur, Colgong block of Bhagalpur district.

#### **Electrical Conductivity (EC)**

The EC values in zone IX were in the range 372-2360  $\mu\text{S}/\text{cm}$ , with an average value of 842.3  $\mu\text{S}/\text{cm}$ , respectively. The highest value of EC was observed at Arma, Surajgarha block, Lakhisarai district. All the samples have shown EC values within the permissible limit of 3000  $\mu\text{S}/\text{cm}$ .

### Alkalinity

The variation observed in the concentration of bicarbonate species was in the range of 109.8 to 578.1  $\text{mg L}^{-1}$ , with an average value of 274.45  $\text{mg L}^{-1}$ , respectively. The maximum value was observed at Arma, Surajgarha, Lakhisarai district. Out of 30 samples studied, 05 samples have shown carbonate alkalinity. The carbonate concentration was in the range of 0-12  $\text{mg L}^{-1}$ . The highest concentration was observed at Harchandpur, Colgong block of Bhagalpur district. Out of 30 samples collected, all samples have shown alkalinity within the permissible limit. A percent distribution of collected ground water samples on the basis of alkalinity is given in Table IX.1.

**Table IX.1 % Distribution of Ground Water Samples in Different Alkalinity Range**

Alkalinity Range (mg/l)	Percentage
0 - 600	100
> 600	-

### Chloride

The concentration of chloride ions was in the range of 14.2 to 287.58  $\text{mg L}^{-1}$ , with an average value of 83.80  $\text{mg L}^{-1}$ , respectively. The highest concentration of chloride ions was observed at Arma, Surajgarha block, Lakhisarai district. From Table IX.2 it is clear that chloride concentrations of less than 4% of ground water samples is exceeding the acceptable limit for drinking purposes (250  $\text{mg}/\text{L}$ , BIS, 2012) and all samples have concentration within the permissible limit for drinking purposes (1000  $\text{mg}/\text{L}$ , BIS, 2012).

**Table IX. 2 % Frequency Distribution of Chloride in Zone IX**

Chloride concentration (mg/l)	Percentage
Within Acceptable limit (0 – 250)	96.67

Within Permissible limit (1000)	100
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### Calcium (Ca)

The calcium concentration in zone IX ground water samples was in the range of 10-120 mg L<sup>-1</sup>, with an average value of 44.33 mg L<sup>-1</sup>. The maximum value was observed at Naugachia, Naugachia block, Bhagalpur district. The concentration of calcium for all the samples was found to be within the permissible limit (200 mg L<sup>-1</sup>) in all the samples indicating that water is suitable for potable purposes (Table IX.3).

**Table IX.3 % Frequency Distribution of Calcium in Zone IX**

Calcium concentration (mg/l)	Percentage
0-200	100
>200	0

### Magnesium (Mg)

In the study area Zone IX, magnesium concentration was found to be in the range from 12.15 to 95.17 mg L<sup>-1</sup>, with an average value of 39.02 mg L<sup>-1</sup>. The highest concentration of magnesium ions was observed at Bariarpur, Bariarpur block, Munger district. As can be seen from Table IX.4, all the samples in zone IX have magnesium concentration within the permissible limit of 100 mg L<sup>-1</sup>. Thus, in general, the ground water in this zone is fit for human consumption.

**Table IX.4 % Frequency Distribution of Magnesium in Zone IX**

Magnesium concentration (mg/l)	Percentage
0-100	100
>100	0

### Total Hardness (T.H. as CaCO<sub>3</sub>)

In the study area, the total hardness in ground water samples range from 105 to 570 mg L<sup>-1</sup>, with an average value of 271.47 mg L<sup>-1</sup>. The maximum concentration was observed at Arma, Surajgarha block, Lakhisarai district. As can be seen form Table IX.5, all the collected samples were found to have total hardness within the permissible limit of 600 mg L<sup>-1</sup>.

**Table IX.5 % Frequency Distribution of T. H. (as CaCO<sub>3</sub>) in Zone IX**

<b>Total Hardness (as CaCO<sub>3</sub>, mg/l)</b>	<b>Percentage</b>
0-600	100
>600	0

**Sodium (Na)**

The analysis result of collected ground water samples indicated that sodium ranges from 5.02 to 268.49 mg L<sup>-1</sup>, with an average value of 59.50 mg L<sup>-1</sup>. The maximum concentration was observed at Arma, Surajgarha block, Lakhisarai district.

**Potassium (K)**

The analysis of collected ground water samples indicated that the concentration of potassium ions varies from 0.01 to 150.24 mg L<sup>-1</sup>, with an average of 7.60 mg L<sup>-1</sup>. The highest concentration of potassium ions was observed at Asarganj, Asarganj block, Munger district.

**Nitrate (NO<sub>3</sub><sup>-</sup>)**

In the collected ground water samples concentration of nitrate ions was found to be in the range of 0 to 62 mg L<sup>-1</sup>, with an average value of 15.28 mg L<sup>-1</sup>. The highest concentration of nitrate ions was observed at Naugachia, Naiugachia block, Bhagalpur district. Out of 30 samples studied, 29 samples have concentration of nitrate ions within the acceptable limit of BIS 2012 (45 mg L<sup>-1</sup>).

**Fluoride (F<sup>-</sup>)**

In the study area Zone IX, the concentration of Fluoride ions was in the range of 0.0 to 1.49 mg L<sup>-1</sup>, with an average value of 0.46 mg L<sup>-1</sup>. The highest concentration was observed at Kajra, Surajgarha block, Lakhisarai district. It was observed that in all the collected ground water samples, the concentration of fluoride ions was within the permissible limit of 1.5 mg L<sup>-1</sup>.

By and large the ground water of Zone IX, was found to be suitable for drinking purpose as per the available analyzed chemical parameters. The presence of some constituents beyond the permissible limit at some locations renders the water unfit for public water supply.

**SUITABILITY OF GROUND WATER FOR IRRIGATION PURPOSE**

**Total Dissolved Solids (TDS)**

The TDS values in zone IX were in the range of 241.8 to 1534 mg L<sup>-1</sup>, with an average value of 547.49 mg L<sup>-1</sup>. The maximum value of TDS was observed at Arma, Surajgarha,

Lakhisarai district. As can be seen from Table IX.6, only 10 % of the collected ground water samples were slightly saline and rest 90 % were non saline.

**Table IX.6 % Frequency Distribution of T.D.S. in Zone IX**

<b>Salinity as per T.D.S range</b>	<b>Percentage</b>
Fresh, non-saline (0-1000 mg/l)	90
Slightly saline (1001-3000 mg/l)	10

### **United States Salinity Laboratory (USSL) Diagram**

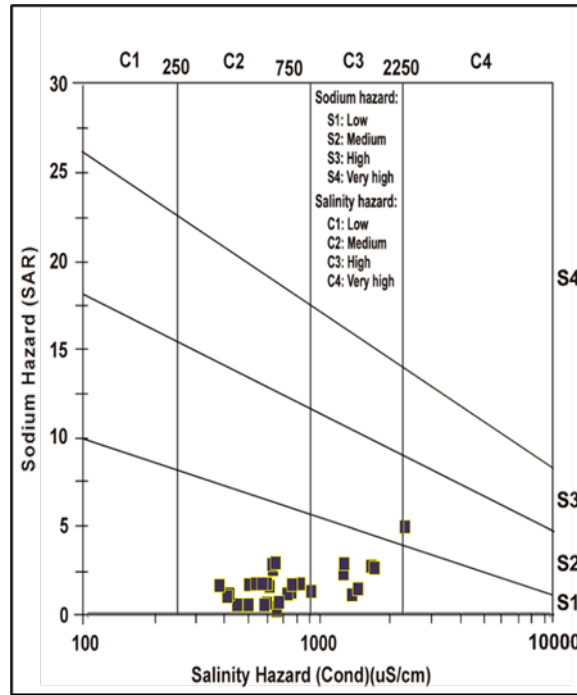
The SAR values in the study area zone IX, were in the range of 0.126 to 4.9, with an average value of 1.55. Thus, in the study area of 100 % of the water samples are observed to lie in S<sub>1</sub> class exhibiting low sodicity. A classification of the collected ground water samples on the basis of SAR values is given in Table IX.8

From Table IX.7 it is evident that in the study area Zone IX, most of the water samples are observed to lie in C<sub>2</sub> & C<sub>3</sub> class exhibiting medium to high salinity. Thus 63.33 % water samples in the area are found to be of good class for irrigation and 33.33 % samples lie within the permissible limit as per class of water for irrigation. Only 3.33 % water samples exhibited unsuitable class of water for irrigation purposes.

**Table IX.7 % Frequency Distribution of E.C. in Zone IX**

<b>E.C range (<math>\mu\text{S/cm}</math> at 25° C)</b>	<b>Percentage</b>	<b>Class of water (for irrigation)</b>
<250 (low saline, C <sub>1</sub> )	0	Class-1, Excellent
250-750 (medium saline, C <sub>2</sub> )	63.33	Class-2, Good
751-2250 (high saline, C <sub>3</sub> )	33.33	Class-3, Permissible
>2250 (very high saline, C <sub>4</sub> )	3.33	Class-4, Unsuitable

As per USSL diagram given in Figure IX.1, the ground water in the study area zone IX, mostly comes under the C<sub>2</sub>-S<sub>1</sub> type suggesting medium salinity and low sodicity, followed by C<sub>3</sub>-S<sub>1</sub> type and only 01 in C<sub>4</sub>-S<sub>2</sub> type. The salinity hazard is posed by the water samples as they fall in class C<sub>3</sub> and C<sub>4</sub>. Thus, on the whole 3.33 % of the water samples indicate C<sub>4</sub>-S<sub>2</sub> class rendering the water unsuitable for irrigation purposes under ordinary conditions, however, it may be used occasionally after taking suitable measures.



**Figure IX.1 USSL diagram of districts under Zone IX**

**Alkalinity Hazard or Residual Sodium Carbonate (RSC)**

The ground water samples collected from Zone IX has shown that the Residual Sodium Carbonate in the area was in the range of -5.65 to 2.14 meq L<sup>-1</sup>, with an average value of -0.89 meq L<sup>-1</sup>.

A classification of the collected ground water samples on the basis of RSC values is given in Table IX.8. It is clear from Table IX.8, that in the study area 93.33 % (with RSC <1.25 meq L<sup>-1</sup>) samples were found to be very safe for use in irrigation and no water samples (with RSC > 2.5 meq/l) were found to be unsuitable for irrigation purposes.

**Soluble Sodium Percentage (S.S.P) (Wilcox Plot)**

The % sodium values were in the range of 5.22 to 54.41, with an average value of 31.62. The maximum % sodium value was observed at Gangatamore, Kharagpur block, Munger district.

A classification of ground water samples on the basis of % sodium values is given in Table IX.8. It was observed that 26.67 % of the samples were in the excellent category, followed by 50 % samples in good and 23.33 % in permissible category. No samples were found to be in the category of doubtful and unsuitable.

A Wilcox plot is given in Figure IX.2, showing that most of the ground water samples were in the category excellent to good and good to permissible zone. Only 3.3% samples were in doubtful to unsuitable category.

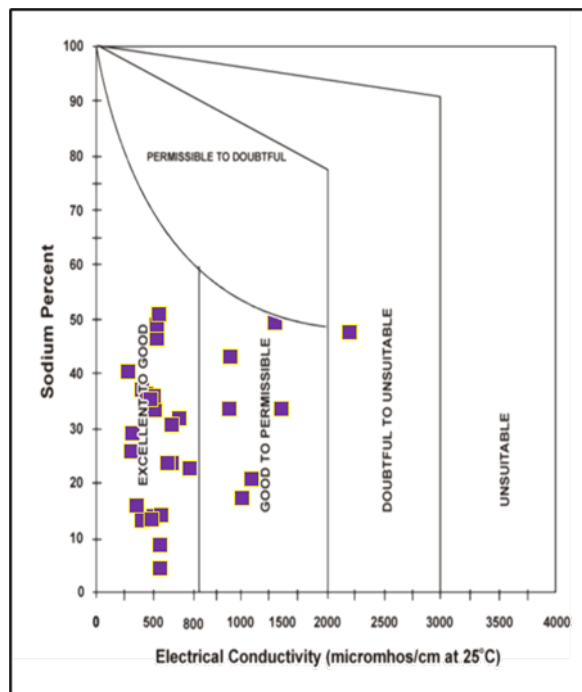


Figure IX.2 Wilcox plot of districts under Zone IX

Table IX.8 Classification of ground water Samples of Zone IX towards Irrigation purpose

Parameter	Range	Classification	% Of samples
SAR value	<10	Excellent	100
	10-18	Good	0
	18-26	Doubtful	0
	>26	Unsuitable	0
% Sodium	<20	Excellent	26.67
	20-40	Good	50
	40-60	Permissible	23.33
	60-80	Doubtful	0
	>80	Unsuitable	0
Residual Sodium Carbonate (RSC)	< 1.25	Good	93.33
	1.25-2.5	Doubtful	6.67
	> 2.5	Unsuitable	0

### Hydrogeochemical facies of Ground water

The ground water samples collected from zone IX, has been classified utilizing the Piper's trilinear diagram. As per the piper plot given in in Figure IX.3, 53.33 % ground water samples belonged to  $\text{Ca}^{2+}\text{-Mg}^{2+}\text{-HCO}_3^-$  type, followed by 43.33 % mixed type and 3.33 % as  $\text{Na}^+\text{-K}^+\text{-Cl}^-$  type. This type of ground water is due to the processes like ground water recharge, ion exchange processes and irrigation flow. The presence of mixed type of water maybe due to natural processes, ion exchange processes, anthropogenic activities such as municipal waste etc. The ground water chemistry in this zone is dominated by alkaline earth metals over alkali metals.

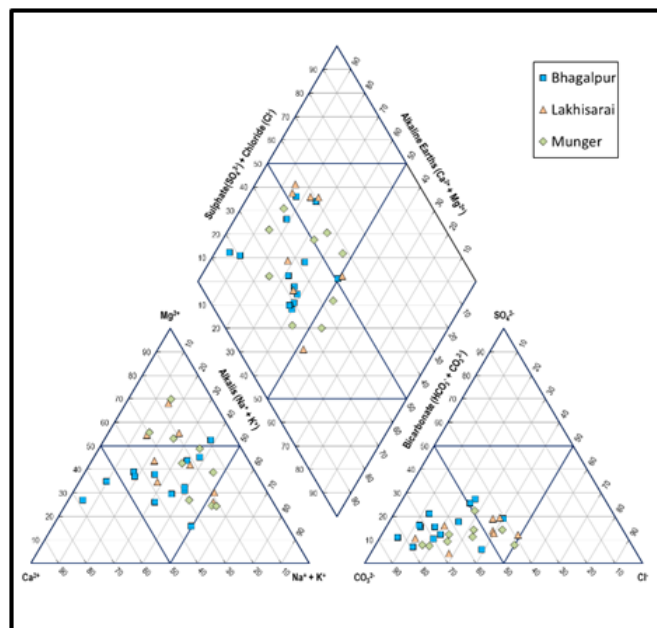


Figure IX.3 Piper plot of districts under Zone IX

## 9. MAJOR FINDINGS

1. The study of zone wise distribution of Bihar state has revealed that inspite of the geological differences in districts, the ground water type in maximum samples has followed  $\text{Ca}^{2+}\text{-Mg}^{2+}\text{-HCO}_3^-$  type. The presence of mixed type of water at certain places indicates the occurrence of processes such as ion exchange, ground water recharge. It was observed that the ground water chemistry was dominated by alkaline earth metals over alkali metals.
2. The alkalinity studies have shown that most of the collected ground water samples has alkalinity due to the presence of bicarbonate ions. Very few samples have shown alkalinity due to carbonate ions.



3. Fluoride study in all zones has suggested that higher concentrations are found in the districts which are a part of South Bihar, adjoining Jharkhand state border. The fluoride concentrations in these locations was found to be greater than the permissible limit.

4. As compared with the earlier chemical report of the state, it was observed that there was no significant change in the quality of ground water in terms of parameters studied. The parameters studied followed the similar pattern in most of the locations.

5. The quality of collected ground water samples was found to be suitable for both drinking and irrigation purpose for majority of the locations. Very few samples were found to be unsuitable for the said purpose and may require some corrective measures.

## 10. CONCLUSIONS

Evaluating the ground water quality for drinking purpose it is observed that-

1. In the study area of Bihar, 88.80 % of water samples (with EC upto 1600  $\mu\text{S}/\text{cm}$  at 25° C) were found to be fresh and non-saline whereas only 10.14 % water samples (EC range 1601 – 3000  $\mu\text{S}/\text{cm}$  at 25° C) exhibit slightly saline water. Very high EC values > 3000  $\mu\text{S}/\text{cm}$  at 25° C and more were observed in 1.06 % of samples. These samples were from Jehanabad (3076  $\mu\text{S}/\text{cm}$ , Kako, Kako block), Samastipur (3068  $\mu\text{S}/\text{cm}$ , Kishanpur 1, Warisnagar block), Nalanda (3310  $\mu\text{S}/\text{cm}$ , Bhui, Silao block, 3009  $\mu\text{S}/\text{cm}$  Bihar sharif Railway station, Bihar sharif block), East Champaran (3155  $\mu\text{S}/\text{cm}$ , Chatia, Chiraiya Block, 3328  $\mu\text{S}/\text{cm}$ , Bhaktiya Tola, Ghorasahan block) and Begusarai (4622  $\mu\text{S}/\text{cm}$ , Manjhaul, Cheria Bariarpur).

2. Ground water samples in the study area are found to be mildly alkaline in nature. In less than 7% of the ground water samples bicarbonate concentration exceeded the maximum permissible limit of 600 mg/l with highest  $\text{HCO}_3^-$  concentration of 1055 mg  $\text{L}^{-1}$  at Dhobitola Goh, Goh block, Aurangabad. Highly alkaline water is usually unpalatable.

3. Chloride concentration of less than 6% water samples from hydrograph network stations was found to exceed the desirable limit for drinking purposes (250mg/l, BIS, 2012) and for 99.85 % samples it was well within the permissible limit of 1000 mg/l. The highest concentration was observed at Begusarai (1306.4 mg  $\text{L}^{-1}$ , Manjhaul, Cheria Bariarpur).

4. In the study area of Bihar, ~ 83% of the water samples exhibit hard to very hard water and only 1.0 % water samples are soft water. Values of total hardness beyond the permissible limit is observed in 5.75 % ground water samples. High values of total

hardness were observed at Samastipur (1205 mg L<sup>-1</sup>, Kishanpur 1, Warisnagar block), Nalanda (1065 mg L<sup>-1</sup>, Bhui, Silao block, 1070 mg L<sup>-1</sup>, Bihar sharif Railway station, Bihar sharif block), Gaya (1040 mg L<sup>-1</sup>, Konch, Konch block) and Begusarai (1510 mg L<sup>-1</sup>, Manjhaul, Cheria Bariarpur). Concentration of calcium ions exceeded the permissible limit of 200 mg L<sup>-1</sup> in 1.36 % of samples. The highest concentrations were observed at Gopalganj (250 mg L<sup>-1</sup>, Bhore police station, Bhore block), Samastipur (260 mg L<sup>-1</sup>, Kishanpur 1, Warisnagar block), Nalanda (230 mg L<sup>-1</sup>, Bhui, Silao block, 264 mg L<sup>-1</sup>, Bihar sharif Railway station, Bihar sharif block), Gaya (228 mg L<sup>-1</sup>, Konch, Konch block) and Begusarai (306 mg L<sup>-1</sup>, Manjhaul, Cheria Bariarpur). The concentration of magnesium ions exceeded the permissible limit of 100 mg L<sup>-1</sup> in 2.87 % of samples. The highest concentrations were observed at Jehanabad (149.44 mg L<sup>-1</sup>, Alubikha, Makhdumpur block), Samastipur (134.86 mg L<sup>-1</sup>, Kishanpur 1, Warisnagar block), Nalanda (148.23 mg L<sup>-1</sup>, Ekanagarsarai, Ekanagarsarai (Ekangardih)), Muzaffarpur (139.72 mg L<sup>-1</sup>, Rajwara NHS, Sahebganj block) and Begusarai (181.03 mg L<sup>-1</sup>, Manjhaul, Cheria Bariarpur).

5. Very high values of sodium i.e > 300 mg L<sup>-1</sup>, was observed in the sample from East Champaran (323.21 mg L<sup>-1</sup>, Bhaktiya Tola, Ghorasahan block). Higher concentration of sodium ions was observed in other locations such as Saharsa (298.12 mg L<sup>-1</sup>, Simri Bakhtiarapur 1, Simri Bakhtiatpur block) and Begusarai (290.3 mg L<sup>-1</sup>, Manjhaul, Cheria Bariarpur block). High concentration of sodium in drinking water is harmful especially to those suffering from cardiac, renal diseases pertaining to circulatory system of the human body.

6. High values of potassium are observed at few places such as Aurangabad (174.4 mg L<sup>-1</sup>, Dhobitola Gog, Goh block), Saharsa (172.62 mg L<sup>-1</sup>, Simri Bakhtiarapur 1, Simri Bakhtiatpur block), Patna (167 mg L<sup>-1</sup>, Maranchi, Mokama block) and Munger (150.24 mg L<sup>-1</sup>, Asarganj, Asarganj block). These high values may be due to recharge of ground water through return irrigation flow as well as human activities.

7. The presence of nitrate ions in higher concentrations than the permissible limit is harmful to human health. In 96.52 % samples the concentration of nitrate ions was within the permissible limit of 45 mg L<sup>-1</sup>. Higher concentrations were observed at Rohtas (50 mg L<sup>-1</sup>, Bikramganj, Bikramganj block, 50 mg L<sup>-1</sup>, Dinara, kochas block), Siwan (55 mg L<sup>-1</sup>, Mairwa near petrol pump, Mairwa), Bhagalpur (62 mg L<sup>-1</sup>,

Naugachia, Naugachia block), Kaimur (95 mg L<sup>-1</sup>, Chand, Chand), Buxar (175 mg L<sup>-1</sup>, Chausa, Chausa) and Bhojpur (233 mg L<sup>-1</sup>, Udwananagar, Udwananagar block).

8. The presence of high concentration of fluoride in groundwater is a threat and may result in harmful situations. The study of collected groundwater samples showed that in 3.79 % of samples have shown fluoride concentration greater than the permissible limit of 1.5 mg L<sup>-1</sup>. The highest concentrations were observed at Jamui (3.56 mg L<sup>-1</sup>, Jamui, Jamui block, 2.19 mg L<sup>-1</sup>, Jhajha, Jamui block).

By and large, the ground water of Bihar state was found to be suitable for drinking purposes as per available analyzed chemical parameters. Presence of some constituents beyond the permissible limit at some locations renders the water unfit for public water supply.

#### **Evaluating the ground water quality for Irrigation purpose it is observed that-**

1. In the study area of Bihar, 87.14 % of water samples (with TDS upto 1000 mg/l) were found to be fresh and non-saline whereas only 12.71 % water samples (TDS range 1001-3000 mg/l) exhibit slightly saline water.

2. Classification as per salinity hazard shows that most of the water samples are observed to lie in C2 and C3 class exhibiting medium to high salinity. Thus, 37.82 % water samples in the area is found to be of good class for irrigation and 56.43 % samples lie within the permissible limit as per class of water for irrigation. Only 2.87 % water samples exhibited unsuitable class of water for irrigation purposes.

3. Classification as per sodicity hazard shows that that by and large in the study area of Bihar there is no sodium hazard as all of the water samples fall in S1 class. Such waters can be used on practically all kinds of soil for irrigating the crops.

4. Thus, on the whole 2.12 % of the water samples indicate C4-S1 and C4-S2 class, rendering the water unsuitable for irrigation purposes under ordinary conditions, however, it may be used occasionally after taking suitable measures.

5. As per RSC values ~ 85.93 % of water samples (with RSC < 1.25 meq/l) were found to be very safe for use in irrigation whereas 4.24 % water samples (with RSC > 2.5 meq/l) were found to be unsuitable for irrigation purposes. The locations with very high RSC (> 5 meq/l) are Chainpur, Chainpur block, Rohtas, Bharatpura, Palihanj block, Patna, Chausa, Chausa block, Buxar, Jarawarpur Milki, Arrah block, Bhojpu and Dumraon, Dumraon block, Buxar.

6. As per Soluble Sodium Percentage, 0.15 % samples showed unsuitability for its use in irrigation, whereas 98.03 % samples from the area exhibit water suitable for irrigation purposes. Groundwater collected from Chainpur, Chainpur block, Kaimur has S.S.P value greater than 80 %. Thus, this may require addition of gypsum to the soil to make it suitable for agricultural purposes.

Thus, on the whole ground water samples in the study area is fit for irrigation purposes except for a few places where corrective measures are to be taken before agricultural usage.

## 11. ACKNOWLEDGEMENTS

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## ANNEXURE A

### Major Chemical Parameters of Ground Water Samples of HNS Collected During in Bihar (Zone I)

S.no	District	BLOCK	LOCATION	pH	EC	TDS	TH	Ca <sup>2+</sup>	Mg <sup>2+</sup>	Na <sup>+</sup>	K <sup>+</sup>	HCO <sub>3</sub> <sup>-</sup>	CO <sub>3</sub> <sup>2-</sup>	Cl <sup>-</sup>	NO <sub>3</sub> <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>	F <sup>-</sup>	
					( $\mu\text{S cm}^{-1}$ )	in (mg L <sup>-1</sup> )												
1	E.Champaran	Chakia (Pipra)	Uttari Gavandra	7.7	565	367.25	225	58	19.44	28.5	1.8	305	0	7.1	1.14	20.5	0.3	
2	E.Champaran	Chakia	Chakia 1	7.87	1360	884	375	52	59.535	104.01	59.2	658.8	0	74.55	7.63	27.5	1.1	
3	E.Champaran	Kalyanpur	Dharampur	7.78	615	399.75	250	60	24.3	21.5	6.64	317.2	0	17.75	2.28	22.41	0.91	
4	E.Champaran	Chiraiya	Chatia	8.2	3155	2050.75	930	224	89.91	267.12	50.17	1024.8	0	415.35	8.45	136.65	1.31	
5	E.Champaran	Patahi	Patahi	8.04	602	391.3	250	96	2.43	20.87	3.4	286.7	0	35.5	2.55	15.3	0.18	
6	E Champaran	Chiraiya	Belai	8.05	1509	980.85	350	86	32.805	163.2	40.04	610	0	142	10.3	40.21	0.98	
7	E.Champaran	Chiraiya	Chiraiya (Noliatola)	7.94	723	469.95	290	86	18.225	29.49	7.32	384.3	0	28.4	0.48	3.53	0.26	
8	E Champaran	Ghorasahan	Bhakatiy Tola	7.88	3328	2163.2	880	188	99.63	323.21	65	610	0	717.1	14.56	131.13	1.16	
9	E.Champaran	Ghorasahan	Ghorasahan	7.9	1927	1252.55	710	208	46.17	111.38	6.79	256.2	0	440.2	1.66	126.34	0.72	
10	E.Champaran	Motihari	Chaudadanu	8.03	643	417.95	275	22	53.46	20.42	2.61	323.3	0	28.4	0.57	12.42	0.53	
11	E Champaran	Adapur	Shyampur	8.06	1383	898.95	395	82	46.17	106.2	50.28	292.8	0	223.65	30.84	106	1.26	
12	E.Champaran	Raxaul	Raxaul	8.02	432	280.8	165	48	10.935	20.32	3.19	225.7	0	14.2	4.09	7.12	0.44	
13	E.Champaran	Ramgarhwa	Raghunathpur	7.92	436	283.4	190	30	27.945	11.9	2.89	244	0	10.65	0	0.89	0.17	
14	E.Champaran	Motihari	Motihari (Banjaria thana)	8.06	864	561.6	330	64	41.31	37.22	15.36	506.3	0	10.65	0.92	2.1	0.64	
15	E Champaran	Motihari	Lakhwara	7.97	1254	815.1	400	52	65.61	73.25	51.82	427	0	177.5	0.75	23.35	1.4	
16	E Champaran	Motihari	Bairiya Bazar	7.55	745	484.25	305	96	15.795	24.64	11.75	378.2	0	39.05	1.51	4.03	0.28	
17	E.Champaran	Harshidhi	Murarpur	7.93	769	499.85	265	64	25.515	45.95	14.95	317.2	0	63.9	1.95	31.09	0.56	
18	E.Champaran	Sangrampur	Dubey Tola	7.81	582	378.3	220	40	29.16	25.24	13.74	305	0	14.2	3.73	14.21	0.51	
19	E.Champaran	Harsidhi	Sheoraha	7.8	802	521.3	335	104	18.225	26.47	4.7	341.6	0	60.35	0.36	35.27	0.16	
20	E.Champaran	Areraj	Radia	7.93	718	466.7	315	54	43.74	17.25	4.23	408.7	0	14.2	2.36	2.24	0.5	
21	E.Champaran	Paharpur	Bishunpur Matiyarwan	7.71	1084	704.6	390	94	37.665	64.21	10.72	488	0	56.8	16.23	44.24	0.5	
22	W. Champaran	Chanpatia	Gurwalia	7.77	1182	768.3	400	98	37.665	66.13	35.52	536.8	0	71	11.07	40.05	0.52	

23	W. Champaran	Lauria	Lauria	7.8	1395	906.75	445	82	58.32	104.73	20.29	427	0	170.4	17.32	84.83	1.38
24	W Champaran	Lauriya	Shishwania	7.92	1079	701.35	400	78	49.815	56.31	15.03	481.9	0	81.65	0.05	26.26	0.33
25	W. Champaran	Bagha	Belwa	7.8	1355	880.75	505	88	69.255	65.23	22.4	451.4	0	159.75	5.23	75.67	0.21
26	W. Champaran	Bagha -1	Bagha	7.85	489	317.85	200	58	13.365	19.54	2.3	164.7	0	71	1.54	5.43	0.44
27	W. Champaran	Bagha	Mangalpur	7.79	724	470.6	340	72	38.88	8.87	1.05	396.5	0	14.2	14.08	4.99	0.49
28	W. Champaran	Ramnagar	Harnatanr	7.81	1275	828.75	385	100	32.805	91.08	41.28	463.6	0	134.9	30.23	40.18	1.01
29	W. Champaran	Bagha	Naurangia	7.9	1128	733.2	380	112	24.3	65.09	32.03	488	0	67.45	24.09	47.81	0.45
30	W. Champaran	Sidhaw	Valmiki Nagar (Laxmipur)	7.9	1397	908.05	395	68	54.675	112.35	44.17	524.6	0	127.8	15.64	72.42	0.54
31	W. Champaran	Ramnagar	Taulaha	7.94	1302	846.3	400	52	65.61	92.05	41.03	469.7	0	117.15	29.98	70.39	0.79
32	W. Champaran	Narkatia-ganj	BanspurPipra	8.02	671	436.15	260	74	18.225	23.37	18.44	359.9	0	17.75	10.25	6.46	0.99
33	W. Champaran	Narkatiyaganj	Korigawa Chowk	7.98	394	256.1	165	56	6.075	13.47	1.31	213.5	0	14.2	0.71	1.98	0.59
34	W. Champaran	Chanpatia	Chanpatia	7.8	598	388.7	245	54	26.73	22.65	4.51	305	0	14.2	1.21	23.71	0.52
35	W. Champaran	Majhwalia	Majhwalia (Guruchurwa)	7.91	1052	683.8	330	68	38.88	84.01	9.8	396.5	0	78.1	3.54	85.82	0.03
36	E.Champaran	Sugauli	Chapwa (Sugauli)	7.87	983	638.95	400	84	46.17	33.82	12.53	427	0	63.9	9.02	43.21	0.21
37	E.Champaran	Areraj	Govindganj	8.05	1254	815.1	380	66	52.245	90.45	37.65	439.2	0	106.5	6.81	105.86	0.95
38	E.Champaran	Turkaulia	Nawada	8.16	785	510.25	325	46	51.03	29.66	3.82	402.6	0	17.75	0.09	32.43	0.65
39	E.Champaran	Sangrampur (Areraj)	Dumaria	7.67	1579	1026.35	445	84	57.105	125.04	55.17	542.9	0	117.15	0.55	172.72	0.12
40	E.Champaran	Kesaria	Rampur Kajuria Bazar	7.82	1095	711.75	425	82	53.46	47.89	12.73	481.9	0	24.85	5.61	109.79	0.25
41	E.Champaran	Kotwa	Dipau	7.89	538	349.7	250	70	18.225	8.91	1.6	256.2	0	24.85	4.35	17.35	0.51
42	E.Champaran	Kesariya	Hussaini	7.76	1652	1073.8	505	70	80.19	124.02	41.03	677.1	0	95.85	27.16	106.35	0.36
43	E.Champaran	Kesaria	Kizerpura	7.9	928	603.2	375	58	55.89	37.71	4.13	457.5	0	24.85	2.7	50.26	0.35
44	E Champaran	Kesaria	Lala Chapra	7.68	762	495.3	270	82	15.795	49.07	4.37	317.2	0	74.55	1.03	10.17	0.94

### Major Chemical Parameters of Ground Water Samples of HNS Collected During in Bihar (Zone II)

S.no	District	BLOCK	LOCATION	pH	EC	TDS	TH	Ca <sup>2+</sup>	Mg <sup>2+</sup>	Na <sup>+</sup>	K <sup>+</sup>	HCO <sub>3</sub> <sup>-</sup>	CO <sub>3</sub> <sup>2-</sup>	Cl <sup>-</sup>	NO <sub>3</sub> <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>	F <sup>-</sup>
					( $\mu\text{S cm}^{-1}$ )	In mg L <sup>-1</sup>											
1	Siwan	Bhagwanpur	Malmaliachok	7.46	497	323	175	40	18.225	15	0.06	183	0	14.2	0.47	35	0.66
2	Siwan	Basantpur	Basantpur	7.66	763	496	285	88	15.795	33	3.38	353.8	0	35.5	17	7.79	1.06
3	Siwan	Tarwara	Barharia	7.25	1633	1061	590	160	46.17	97	3.32	530.7	0	170.4	2.36	116	1.03
4	Siwan	Siwan	Haradia	7.76	593	385	240	74	13.365	22	3.53	274.5	0	17.75	12.27	34	0.8
5	Siwan	Siwan	Bhada Khurd, Mahajanmistri Mandir	7.31	736	478	305	86	21.87	24	3.86	353.8	0	24.85	0.93	33	0.9
6	Siwan	Mairwa	Mairwa, Near Petrol pump	6.98	1575	1024	660	216	29.16	46	6.8	488	0	142	55	123	0.83
7	Siwan	Mairwa	Mairwa, Shitalpura	7.3	642	417	300	90	18.225	5.03	2.32	274.5	0	24.85	21	37	1.02
8	Siwan	Guthani	Chitakal	7.03	411	267	180	50	13.365	6.85	2.81	213.5	0	14.2	1.53	7.58	1.16
9	Siwan	Guthani	Deoria	7.13	848	551	375	110	24.3	17	2.35	353.8	0	71	8.95	13.5	1
10	Siwan	Darauli	Mairwa-Darauli Rd.	7.11	582	378	250	64	21.87	13	3.23	305	0	14.2	10	5.6	0.94
11	Siwan	Ander	Ander	7.09	737	479	285	84	18.225	28	3.69	378.2	0	21.3	1.75	6.6	0.76
12	Siwan	Raghunathpur	Murarpatti	6.77	1761	1145	565	166	36.45	136	2.9	591.7	0	188.15	17	90	0.78
13	Siwan	Siswan	Bhagar	6.85	904	588	415	124	25.515	13	2.77	396.5	0	17.75	2.02	89	0.91
14	Siwan	Siswan	Gangpur-Siswan	7.06	657	427	275	76	20.655	14	4.16	305	0	10.65	2.33	43	0.81
15	Siwan	Maharajganj	Maharajganj-Pansouli	6.85	1573	1022	520	156	31.59	104	4.5	585.6	0	166.85	0.55	34.41	0.89
16	Siwan	Panchrukhi	Sadikpur	7.12	592	385	260	76	17.01	5.5	3.8	305	0	14.2	0.56	8.4	0.9
17	Siwan	Siwan	Siwan	6.72	952	619	410	124	24.3	22	5.17	396.5	0	74.55	16	27	1.01
18	Siwan	Basantpur	Chimapura	6.63	780	507	330	88	26.73	22	1.84	402.6	0	14.2	9.02	22.79	0.96
19	Siwan	Bhagwanpur	Sarripatti	6.7	1146	745	460	152	19.44	41	5	414.8	0	71	28	89	0.74
20	Gopalganj	Kateya	Kateya-Bankata Rd.	7.03	552	359	250	76	14.58	9.26	3.33	250.1	0	17.75	0.42	40.34	1
21	Gopalganj	Kateya	Lalpachmaha	7.07	567	369	200	62	10.935	24	3.16	244	0	28.4	0.55	20	0.88
22	Gopalganj	Bijaipur	Bijaipur	6.79	588	382	190	46	18.225	28	5.09	219.6	0	39.05	5.74	18	0.68
23	Gopalganj	Bhore	Bhore Police Station	6.74	1948	1266	745	250	29.16	90	13.2	561.2	0	269.8	29	99	0.89
24	Gopalganj	Bhore	Mishir Batraha	6.84	1246	810	525	188	13.365	33	4.8	408.7	0	117.15	25	92	0.64
25	Gopalganj	Hathua	Hathua Palace	6.95	786	511	300	98	13.365	20	6.4	341.6	0	24.85	1.23	36	0.7
26	Gopalganj	Thawe	Lacchawar	6.98	798	519	275	94	9.72	40	4.33	372.1	0	21.3	0.92	29	0.95
27	Gopalganj	Barauli	Barauli	6.76	775	504	285	90	14.58	34	3.57	402.6	0	14.2	0.58	12	0.83

28	Gopalganj	Manjha	Phulwaria/Imilia	7.07	581	378	195	54	14.58	39	3.58	305	0	7.1	0.71	21	0.94
29	Gopalganj	Manjha	Bishmbarapur	7.1	598	389	200	54	15.795	40	3.85	292.8	0	10.65	0.76	23	0.87
30	Gopalganj	Manjha	Manjha	6.86	1154	750	495	148	30.375	28	7.5	481.9	0	71	2.44	71	0.67
31	Gopalganj	Kuchaikot	Jalalpur	6.7	1685	1095	580	170	37.665	102	9.6	549	0	191.7	25	78	1.06
32	Gopalganj	Kuchaikot	Police Thana	6.87	635	413	235	72	13.365	33	5.39	317.2	0	21.3	0.86	23	0.78
33	Gopalganj	Gopalganj	Yadavpur	6.86	822	534	350	114	15.795	23	4.67	396.5	0	24.85	1.04	43	0.83
34	Gopalganj	Gopalganj	Gopalganj Town	6.7	1309	851	470	22	100.845	72	10.3	616.1	0	74.55	2.38	36	0.97
35	Gopalganj	Sidhawalia	Sidhawalia	6.72	941	612	380	126	15.795	29	8.4	402.6	0	39.05	7.47	64	0.67
36	Gopalganj	Mohammadpur	Bhojpurwa	6.75	1032	671	415	120	27.945	35	9.4	530.7	0	35.5	0.79	25	0.6
37	Gopalganj	Baikunthpur	Deokoli	6.8	1040	676	380	104	29.16	58	9.6	488	0	53.25	6.9	42	0.52
38	SARAN	DIGHWARA	Ammi	7.62	890	578.5	315	32	57	56.8	1.9	403	0	63.9	0.06	26.46	0.25
39	SARAN	EKMA	Bishunpur	7.74	612	397.8	215	36	30	37.36	3.71	354	0	10.65	0	5.72	0.34
40	SARAN	JALALPUR	Bisunpur	7.67	698	453.7	240	40	34	46.8	3.78	336	0	28.4	9.58	26.83	0.42
41	SARAN	MANJHI	Breja	7.94	1160	754	340	50	52	106.81	5.67	403	0	110.05	11.03	82.5	0.91
42	SARAN	CHAPRA	Chhapra	7.6	735	477.75	295	38	49	30.02	2.69	317	0	39.05	19.09	37.51	0.28
43	SARAN	CHAPRA	Chirand	7.63	1097	713.05	330	32	61	96.1	2.94	384	0	131.35	0.03	48.71	0.52
44	SARAN	CHAPRA	Daldali Bazar A	7.45	1024	665.6	415	50	70	41.2	2.9	329	0	124.25	24.55	45.08	0.26
45	SARAN	GARKHA	Garkha	7.55	588	382.2	200	32	29	39.5	2.99	311	0	14.2	0.28	21.89	0.05
46	SARAN	MANJHI	Majhanpura New	7.51	2710	1761.5	990	44	214	155.6	17.47	641	0	415.35	25.53	212.2	0.45
47	SARAN	MANJHI	Manjhi 2	8.08	710	461.5	275	56	33	34.2	2.88	348	0	24.85	9.12	25.65	0.55
48	SARAN	MANJHI	Mansath	7.74	668	434.2	250	68	19	35.1	2.62	354	0	21.3	0	16.59	0.49
49	SARAN	MARHAURA	Marhaura	7.92	742	482.3	250	50	30	49.5	9.5	354	0	28.4	0	41.5	0.64
50	SARAN	MASHRAKH	Masrakh	7.71	825	536.25	270	58	30	59.8	5.6	458	0	21.3	0	10.06	0.34
51	SARAN	MASHRAKH	Masrakh1	7.66	1125	731.25	390	76	49	79.8	2.16	421	0	113.6	0	64.2	0.26
52	SARAN	GARKHA	Minapur	7.61	1402	911.3	435	88	52	119.2	3.59	390	0	152.65	12.49	150.2	0.43
53	SARAN	SONEPUR	Nayagaon	7.48	1389	902.85	530	118	57	67.5	9.5	397	0	195.25	4.52	90.2	0.15
514	SARAN	PARSA	Saguni	7.86	885	575.25	330	46	52	47.87	1.66	482	0	17.75	0	26.2	0.44
55	SARAN	REVELGANJ	Sanghar Tola	7.56	2050	1332.5	685	110	100	148.6	9.83	616	0	248.5	25.02	144.2	0.46
56	SARAN	SONEPUR	Sonepur1	7.65	872	566.8	255	58	27	81.2	1.35	329	0	71	26.2	46.73	0.28



### Major Chemical Parameters of Ground Water Samples of HNS Collected During in Bihar (Zone III)

S.no	District	BLOCK	LOCATION	pH	EC	TDS	TH	Ca <sup>2+</sup>	Mg <sup>2+</sup>	Na <sup>+</sup>	K <sup>+</sup>	HCO <sub>3</sub> <sup>-</sup>	CO <sub>3</sub> <sup>2-</sup>	Cl <sup>-</sup>	NO <sub>3</sub> <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>	F <sup>-</sup>
					( $\mu\text{S cm}^{-1}$ )	In mg L <sup>-1</sup>											
1	Begusarai	Barauni	Chakiya	7.04	1497	973.05	330	64	41.31	166.3	43.12	427	0	188.15	40.91	98.7	0.21
2	Begusarai	Barauni	Barauni 0 - mile	7.33	932	605.8	375	82	41.31	37.12	5.28	451.4	0	49.7	2.57	22.74	0.62
3	Begusarai	Barauni	Barauni	7.43	747	485.55	305	62	36.45	29.87	4.43	292.8	0	63.9	0.43	38.76	0.34
4	Begusarai	Teghra	Nayanagar	7.25	949	616.85	340	40	58.32	55.8	9.65	451.4	0	46.15	1.19	38.21	0.2
5	Begusarai	Teghra	Teghra	7.93	972	631.8	415	84	49.815	27.5	9.38	420.9	0	53.25	3.9	61.88	0.33
6	Begusarai	Begusarai	Harpur dhala	7.63	791	514.15	340	64	43.74	21.23	9.12	390.4	0	39.05	0.16	17.23	0.43
7	Begusarai	Cheria bariarpur	Cheria bariarpur	7.65	2155	1400.75	570	126	61.965	187.32	76.12	579.5	0	298.2	43.23	140.21	0.93
8	Begusarai	Begusarai	Bareibighu	7.74	828	538.2	295	42	46.17	49.83	6.42	359.9	0	49.7	20.14	31.41	0.56
9	Begusarai	Balia	Bariarpur	7.82	625	406.25	290	52	38.88	5.92	6.02	335.5	0	17.75	2.24	10.81	0.32
10	Begusarai	Matihani	Badalpur	7.86	798	518.7	350	46	57.105	17.83	5.54	378.2	0	39.05	0.65	33	0.26
11	Begusarai	Sahebpur Kamal	Heera tola	7.76	581	377.65	245	40	35.235	15.9	7.71	262.3	0	31.95	0	30.7	0.38
12	Begusarai	Balia	Choti balia	7.64	744	483.6	325	60	42.525	18.21	7.21	305	0	60.35	0	32.12	0.37
13	Begusarai	Balia	Laxminia	7.44	1319	857.35	355	82	36.45	121.12	33.57	445.3	0	127.8	41.56	74.54	0.45
14	Begusarai	Sahebpur Kamal	New jafar nagar	7.87	1097	713.05	425	90	48.6	52.1	6.13	427	0	81.65	36.86	51.74	0.53
15	Begusarai	Sahebpur Kamal	Bintoli kalyanpur	7.54	990	643.5	395	40	71.685	34.65	18.21	414.8	0	63.9	30.21	40.2	0.33
16	Begusarai	Sahebpur Kamal	Sabdalpur	8.12	720	468	295	36	49.815	9.89	35.3	335.5	0	28.4	21.52	23.67	0.45
17	Begusarai	Begusarai	Hardia	7.32	1512	982.8	460	68	70.47	113.2	37.12	506.3	0	195.25	22.16	46.22	0.4
18	Begusarai	Begusarai	Mohanpur usrai	7.47	968	629.2	390	64	55.89	34.72	12.54	463.6	0	39.05	2.55	44.6	0.67
19	Begusarai	Cheria bariarpur	Gopalpur	7.48	1086	705.9	465	82	63.18	33.93	4.96	390.4	0	113.6	2.07	56.5	0.32
20	Begusarai	Bakhri	Simri	7.51	1008	655.2	380	42	66.825	41.64	23.8	408.7	0	85.2	2.13	45.2	0.42
21	Begusarai	Bakhri	Bakhri Saluna	7.57	1205	783.25	305	64	35.235	112.2	43.2	488	0	88.75	4.5	66.2	0.76
22	Begusarai	Bakhri	Bagrash	7.65	1231	800.15	355	94	29.16	99.4	32.8	445.3	0	113.6	21.2	70.31	0.43
23	Begusarai	Cheria bariarpur	Manjhaul	7.4	4622	3004.3	1510	306	181.035	290.3	134.2	463.6	0	1306.4	8.56	76.93	1
24	Begusarai	Balia	Parihara	8.03	628	408.2	240	28	41.31	30.21	5.05	335.5	0	24.85	0.69	3.43	0.72
25	Begusarai	Begusarai	Lakho	7.76	939	610.35	355	42	60.75	45.32	13.2	469.7	0	31.95	1.52	32.1	0.84
26	Darbhanga	Darbhanga Sadar	Darbhanga Sadar	6.8	793	515.45	260	56	29.16	57.83	9.6	311.1	0	39.05	28.55	55.61	1.22
27	Darbhanga	Keoty	Darima	7.5	1290	838.5	355	60	49.815	112.09	34.6	420.9	0	205.9	5.8	4.83	0.55
28	Darbhanga	Benipur	Bahera (Brahmnathyhogma)	8.18	1113	723.45	415	104	37.665	56.23	13.51	488	0	85.2	5.35	29.14	0.94

29	Darbhanga	Baheri	Baheri	8.06	1090	708.5	400	98	37.665	62.12	6.54	390.4	0	117.15	3.76	53.34	1
30	Darbhanga	Baheri	Bithauli	8.35	703	456.95	135	18	21.87	96.57	6.57	170.8	0	113.6	6.58	41.6	0.77
31	Darbhanga	Baheri	Jorja	8.11	1302	846.3	275	42	41.31	150.32	39.71	481.9	0	117.15	7.04	78.21	1.05
32	Darbhanga	Hayaghat	Pouram	7.9	1876	1219.4	505	118	51.03	141.14	99.54	610	0	188.15	30.51	137.12	1.04
33	Darbhanga	Hayaghat	Rustampur	7.65	1150	747.5	345	58	48.6	80.7	41.21	427	0	88.75	25.58	75.14	1.16
34	Darbhanga	Sakri	Sakri	7.91	789	512.85	320	74	32.805	31.06	4.51	335.5	0	56.8	1.13	36.45	0.78
35	Khagaria	Khagaria	Khagaria	7.54	985	640.25	400	84	46.17	33.15	14.2	439.2	0	78.1	1.77	20.82	0.57
36	Khagaria	Khagaria	Ranko	7.87	1194	776.1	425	102	41.31	65.2	21.7	488	0	88.75	31.5	45.1	0.4
37	Khagaria	Gogri	Jamalpur	7.86	815	529.75	365	74	43.74	15.76	4.39	457.5	0	17.75	5.47	4.21	0.23
38	Khagaria	Gogri	Gogri	7.56	1134	737.1	430	62	66.825	48.16	24.14	488	0	85.2	3.05	44.1	0.25
39	Khagaria	Parbatta	Baisa(Pz)	7.63	777	505.05	365	64	49.815	9.8	3.82	384.3	0	35.5	2.8	17.79	0.38
40	Khagaria	Parbatta	Mohaddipur	7.55	801	520.65	305	32	54.675	39.62	5.87	359.9	0	39.05	0.41	47.3	0.88
41	Khagaria	Parbatta	Dewri	7.61	2237	1454.05	675	142	77.76	162.21	69.2	683.2	0	319.5	16.15	91.15	0.71
42	Khagaria	Khagaria	Sonhauili	7.73	930	604.5	370	74	44.955	40.5	6.05	372.1	0	63.9	20.74	48.27	0.26
43	Khagaria	Khagaria	Sabdalpur	7.46	688	447.2	295	62	34.02	18.38	4.57	366	0	21.3	1.49	12.07	0.58
44	Khagaria	Chautham	Mansi	7.34	708	460.2	300	26	57.105	20.12	6.41	402.6	0	14.2	2.14	3.24	0.33
45	Khagaria	Chautham	Lohiya chowk	7.7	1907	1239.55	750	196	63.18	93.4	1.69	634.4	0	220.1	36.97	86.24	0.48
46	Khagaria	Chautham	Chautham	7.68	776	504.4	330	26	64.395	21.58	7.71	353.8	0	46.15	0.38	31.22	0.87
47	Khagaria	Khagaria	Kasimpur	7.65	760	494	340	46	54.675	14.93	4.68	408.7	0	31.95	0	1.41	0.3
48	Khagaria	Khagaria	Labhgaon	7.69	767	498.55	340	48	53.46	16.43	4.12	408.7	0	31.95	0.09	3.85	0.47
49	Khagaria	Khagaria	Gangaur	7.42	997	648.05	400	86	44.955	36.03	14.52	402.6	0	85.2	0	45.42	0.9
50	Khagaria	Khagaria	Durgapur	7.76	738	479.7	330	40	55.89	12.54	7.5	347.7	0	35.5	3.57	31.32	0.32
51	Madhubani	Benipatti	Kapasias	7.8	772	501.8	215	64	13.365	65.32	21.41	262.3	0	60.35	25.32	62.36	0.79
52	Madhubani	Phulparas	Siswar	7.81	1160	754	345	54	51.03	87.53	33.24	488	0	81.65	27.54	39.05	1.23
53	Madhubani	Phulparas	Phulparas1	7.58	1309	850.85	360	100	26.73	101.23	56.64	530.7	0	127.8	5.65	33.01	0.75
54	Madhubani	Karmauli	Karmauli	7.5	539	350.35	130	16	21.87	57.43	9.58	189.1	0	53.25	12.77	27.81	0.74
55	Madhubani	Jhanjharpur	Jhanjharpur	7.41	414	269.1	115	22	14.58	34.55	10.75	152.5	0	46.15	7.51	10.15	0.65
56	Madhubani	Laukaha (Khutauna)	Ambedkar Nagar	7.86	579	376.35	140	18	23.085	64.81	4.87	329.4	0	7.1	2.98	4.51	1.3
57	Madhubani	Babu Barhi	Babubarhi	7.74	604	392.6	160	20	26.73	65.55	1.71	329.4	0	14.2	0.96	6.78	0.89
58	Madhubani	Harlakhi	Baurahar Chowk	7.68	873	567.45	280	24	53.46	66.53	8.12	353.8	0	56.8	23.51	44.75	1.15
59	Madhubani	Benipatti	Benipatti	7.47	355	230.75	110	20	14.58	26.27	5.97	183	0	10.65	6.87	7.11	0.43

60	Madhubani	Khajauli	Bentadih	8.02	933	606.45	315	24	61.965	67.04	5.24	353.8	0	81.65	3.11	52.13	0.88
61	Madhubani	Pandaul	Bhawanipur	8.01	680	442	185	26	29.16	65.73	8.21	341.6	0	31.95	5.79	9.01	0.86
62	Madhubani	Madhwapur	Bihari	7.96	556	361.4	195	42	21.87	26.98	17.43	250.1	0	42.6	6.27	6.87	0.7
63	Madhubani	Benipatti	Dhakjari	7.85	1023	664.95	215	58	17.01	109.72	43.2	341.6	0	124.25	27.9	31.56	0.66
64	Madhubani	Harlakhi	Harlakhi	7.75	1783	1158.95	355	82	36.45	170.2	128.13	616.1	0	209.45	15.34	74.36	0.99
65	Madhubani	Andhratharhiy	Harari	7.69	797	518.05	225	40	30.375	70.56	14.25	353.8	0	56.8	5.92	21.98	0.95
66	Madhubani	Jaynagar	Jaynagar	7.83	683	443.95	255	58	26.73	37.34	3.05	372.1	0	21.3	1.2	5.68	0.52
67	Madhubani	Jhanjharpur	Jhanjharpur	7.65	724	470.6	290	50	40.095	30.12	3.2	231.8	0	113.6	4.92	7.32	0.74
68	Madhubani	Ladania	Jogiya	7.85	600	390	210	40	26.73	38.75	6.21	298.9	0	28.4	10.1	3.5	0.57
69	Madhubani	Benipatti	Kapasias	7.91	368	239.2	100	20	12.15	38.3	1.28	201.3	0	7.1	0.08	6.11	0.47
70	Madhubani	Kakraul, Madhubani	Kapileshwar Asthan	7.83	1096	712.4	250	64	21.87	101.38	58.905	427	0	99.4	16.3	41.47	1.05
71	Madhubani	Karmnali	Karmnali	8.01	442	287.3	110	24	12.15	50.8	1.65	231.8	0	10.65	3.5	9.2	0.64
72	Madhubani	Khajauli	Khajauli	7.91	1220	793	315	84	25.515	110.14	42.21	347.7	0	184.6	28.06	41.1	0.57
73	Madhubani	Madhubani	Madhubani	7.95	1013	658.45	245	60	23.085	99.46	33.57	353.8	0	110.05	24.4	39.23	0.69
74	Madhubani	Khajauli	Narar	8.05	1037	674.05	315	58	41.31	67.01	43.92	384.3	0	99.4	7.59	54.25	0.78
75	Madhubani	Pandaul	Pandaul	8.11	885	575.25	340	86	30.375	34.23	21.19	317.2	0	92.3	3.19	49.02	0.43
76	Madhubani	Rajnagar	Pariharpur	7.95	1165	757.25	305	46	46.17	102.1	44.12	402.6	0	120.7	28.81	53.5	0.36
77	Madhubani	Pandaul	Shambhuar	7.85	1249	811.85	370	72	46.17	91.24	42.1	585.6	0	49.7	6.55	65.14	0.83
78	Madhubani	Khajauli	Thantola (Khajauli)	7.91	1200	780	450	120	36.45	62.31	9.8	427	0	149.1	2.44	36.11	0.62
79	Muzaffarpur	Paroo	Paroo NHS	8.01	2050	1332.5	700	82	120.285	124.5	44.5	506.3	0	298.2	27.66	149.5	1.2
80	Muzaffarpur	Paroo	Jaffarpur NHS	7.59	750	487.5	315	68	35.235	24.56	3.74	329.4	0	35.5	3.34	37.47	1.12
81	Muzaffarpur	Paroo	Deoria NHS	7.86	1120	728	465	100	52.245	41.5	7.6	274.5	0	166.85	2.24	94.2	1.31
82	Muzaffarpur	Sahebganj	Daha Chhapra NHS	7.84	1485	965.25	455	80	61.965	105.8	41.5	451.4	0	198.8	2.55	93.4	1.55
83	Muzaffarpur	Sahebganj	Rajwara NHS	7.77	2330	1514.5	735	64	139.725	165.5	51.5	725.9	0	326.6	2.74	102.5	1.49
84	Muzaffarpur	Sahebganj	Pratap Patti Baraun NHS	7.8	1025	666.25	295	48	42.525	97.19	3.06	463.6	0	24.85	1.31	91.5	1.22
85	Muzaffarpur	Baruraj (Motipur)	Mahammadpur Balmi (Malang Sthan) NHS	7.82	710	461.5	230	40	31.59	54.71	3.82	341.6	0	14.2	1.05	45.87	0.99
86	Muzaffarpur	Dholi	Barkurwa More NHS	7.81	1389	902.85	415	110	34.02	86.39	70.05	530.7	0	117.15	4.32	87.5	1.16
87	Muzaffarpur	Dholi (Muraul)	Digra NHS	7.83	1111	722.15	300	54	40.095	107.93	18.8	366	0	102.95	4.71	96.88	1.2
88	Muzaffarpur	Turki	Mahant Maniyari (New Well)	7.25	1242	807.3	315	42	51.03	99.5	72.5	610	0	56.8	1.98	40.1	1.26
89	Muzaffarpur	Sakra	Seho NHS	7.9	1587	1031.55	500	70	78.975	130.5	9.12	475.8	0	177.5	9.33	132.8	1.75

90	Muzaffarpur	Dholi (Muraul)	Jahangirpur Tola NHS	7.8	1804	1172.6	510	40	99.63	144.8	58.6	725.9	0	106.5	35.8	122.5	1.81
91	Muzaffarpur	Gayghat	Maithi	7.73	765	497.25	265	62	26.73	49.5	10.42	359.9	0	39.05	1.26	28.9	1.1
92	Muzaffarpur	Bochaha	Maidapur Shukrahat NHS	7.71	1205	783.25	310	36	53.46	116.5	25.74	536.8	0	78.1	2.56	46.5	1.29
93	Muzaffarpur	Bochaha	Bochaha NHS	7.63	1031	670.15	305	60	37.665	77.2	31.02	463.6	0	46.15	4.85	61.2	1.15
94	Muzaffarpur	Katra	Ramnagar NHS	7.65	1088	707.2	290	100	9.72	96.2	26.4	561.2	0	31.95	9.96	26.1	1.41
95	Muzaffarpur	Katra	Katra 1 NHS	7.91	1542	1002.3	440	86	54.675	123.8	53.5	646.6	0	110.05	12.42	71.5	0.95
96	Muzaffarpur	Mushahri	Bhagwanpur Chowk NHS	7.65	1175	763.75	350	90	30.375	89.49	30.36	463.6	0	74.55	10.88	91.2	0.99
97	Muzaffarpur	Mushahri	Patahi NHS	7.7	1112	722.8	305	56	40.095	110	5.58	555.1	0	56.8	1.5	21.2	0.87
98	Muzaffarpur	Aurai	Rajkhand NHS	7.52	1622	1054.3	435	84	54.675	142.05	54.88	518.5	0	216.55	14.3	61.4	0.99
99	Muzaffarpur	Aurai	Aurai NHS	8	417	271.05	80	30	1.215	57.06	2.2	207.4	0	17.75	1.32	11.61	1.01
100	Muzaffarpur	Mushahri	Japaha NHS	7.87	1665	1082.25	430	70	61.965	151.5	61.5	591.7	0	152.65	41.2	92.5	0.65
101	Muzaffarpur	Aurai	Rampur	7.53	2080	1352	695	108	103.275	114.2	79.5	463.6	0	376.3	44.3	92.5	0.02
102	Muzaffarpur	Minapur	Gargalia Minapur NHS	7.69	464	301.6	205	64	10.935	9.69	6.84	244	0	14.2	6.88	9.5	0.55
103	Muzaffarpur	Paroo	wazitpur/Bazidpur	7.74	970	630.5	300	62	35.235	80.1	4.16	488	0	7.1	1.06	66.8	0.89
104	SAMASTIPUR	Vidyapatnagar	Sahit (Bajidpur)	7.85	1706	1108.9	550	112	65.61	115.78	41.12	396.5	0	259.15	18.64	137.1	0.78
105	SAMASTIPUR	KALYANPUR	Basudebpur	8.06	1566	1017.9	465	118	41.31	121.14	44.21	475.8	0	188.15	23.09	99.2	1.37
106	SAMASTIPUR	UJIARPUR	Dandia Asadpur	8.09	1013	658.45	305	64	35.235	80.21	19.15	433.1	0	60.35	2.82	60.02	1.02
107	SAMASTIPUR	JITWARPUR	Harpur Aloth	7.84	1219	792.35	390	82	44.955	92.26	13.15	414.8	0	113.6	3.27	102.25	0.49
108	SAMASTIPUR	KALYANPUR	Jakhra	7.63	1302	846.3	515	122	51.03	59.21	3.99	384.3	0	163.3	7.19	94.3	1.09
109	SAMASTIPUR	KALYANPUR	Jathmalpur	7.94	651	423.15	130	24	17.01	86.12	4.99	317.2	0	24.85	4.14	25.84	0.55
110	SAMASTIPUR	BIBHUTPUR	Kalyanpur	8.17	737	479.05	195	40	23.085	66.28	20.82	347.7	0	39.05	2.63	23.44	1.21
111	SAMASTIPUR	ROSERA	Kerian	8.05	2884	1874.6	895	168	115.425	197.25	90.64	902.8	0	362.1	18.64	168.2	1.24
112	SAMASTIPUR	WARISNAGAR	Kishanpur I	7.87	3068	1994.2	1205	260	134.865	140.1	18.45	671	0	521.85	18.64	221	1.69
113	SAMASTIPUR	WARISNAGAR	Kuseya	7.97	1305	848.25	400	92	41.31	102.1	20.82	463.6	0	110.05	22.4	92.45	0.88
114	SAMASTIPUR	MOHIUDDINAGAR	Madudabad	7.83	656	426.4	240	50	27.945	38.3	2.8	305	0	17.75	2.02	48.83	0.61
115	SAMASTIPUR	HASANPUR	Malipur	7.85	816	530.4	250	52	29.16	70.7	2.51	366	0	53.25	1.65	29.25	1
116	SAMASTIPUR	TAJPUR MORWA (MORWA)	Motipur	7.93	848	551.2	295	64	32.805	52.6	10.4	402.6	0	21.3	1.05	59.85	0.68
117	SAMASTIPUR	BIBHUTPUR	Patapara	7.92	719	467.35	265	66	24.3	42.28	3.69	384.3	0	7.1	1.51	25.14	2.12
118	SAMASTIPUR	WARISNAGAR	Raghunathpur	7.67	794	516.1	300	56	38.88	43.2	3.5	305	0	60.35	1.02	58.14	1.35
119	SAMASTIPUR	UJIARPUR	Raipur	8.21	1581	1027.65	520	48	97.2	111.4	20.82	506.3	0	149.1	18.64	141.4	1.6

120	SAMASTIPUR	ROSERA	Rosera	7.93	653	424.45	225	60	18.225	43.3	4.79	305	0	31.95	4.12	25.66	0.84
121	SAMASTIPUR	SARAIKARANJAN	Sarai Ranjan	8.09	1165	757.25	405	106	34.02	79.35	2.71	427	0	113.6	2.75	65.18	1.08
122	SAMASTIPUR	BIBHUTPUR	Singhia Ghat	7.99	930	604.5	345	80	35.235	53.2	2.42	335.5	0	88.75	4.96	57.43	0.83
123	SAMASTIPUR	TAJPUR MORWA (MORWA)	Tajpur1	7.89	735	477.75	295	78	24.3	32.27	3.4	372.1	0	7.1	4.69	42.76	0.75
124	SAMASTIPUR	UJIARPUR	Ujiarpur	8.11	715	464.75	195	46	19.44	59.42	24.21	305	0	24.85	8.3	61.36	0.95
125	SAMASTIPUR	TAJPUR MORWA (MORWA)	Vikrampur	7.73	1049	681.85	405	108	32.805	52.26	6.36	268.4	0	134.9	6.36	101.09	0.85
126	Sheohar	Sheohar	Sarsaula Khurd NHS	7.68	1688	1097.2	505	164	23.085	144.5	15.4	469.7	0	227.2	37.8	106.2	0.35
127	Sheohar	Piprahi	Purnahiya Bazar NHS	7.59	833	541.45	240	46	30.375	57.46	43.2	372.1	0	42.6	7.76	43.76	0.71
128	Sheohar	Sheohar	Sheohar	7.41	682	443.3	275	54	34.02	28.41	2.73	390.4	0	14.2	0.08	0.87	0.35
129	Sheohar	Sheohar	Sasaula khurd	7.91	459	298.35	165	22	26.73	27.53	2.63	256.2	0	10.65	0	4.53	0.37
130	Sheohar	Tariiyani	sarbarpur	7.61	609	395.85	265	46	36.45	15.28	2.87	335.5	0	21.3	1.73	0.16	0.31
131	Sheohar	Piprahi	Purnhaiya bazar	7.85	464	301.6	185	26	29.16	18.44	3.67	256.2	0	14.2	0.5	1.54	0.78
132	Sitamarhi	Runnisaidpur	Thumba	8.28	432	280.8	155	6	34.02	26.92	3.54	219.6	0	10.65	11.98	8.37	0.43
133	Sitamarhi	Sitamarhi	Sitamarhi	8.15	373	242.45	145	30	17.01	18.59	2.51	183	0	17.75	5.23	4.47	0.38
134	Sitamarhi	Sitamarhi	Khaptola	8.17	378	245.7	135	4	30.375	22.07	2.7	201.3	0	14.2	1.63	2.62	0.45
135	Sitamarhi	Bajpatti	Bangaon	8.02	401	260.65	130	28	14.58	31.98	2.07	213.5	0	14.2	2.31	0.63	0.38
136	Sitamarhi	Pupri	Pupri	8.05	409	265.85	95	16	13.365	46.2	4.93	207.4	0	21.3	1.02	4.61	0.1
137	Sitamarhi	Nanpur	Nanpur	7.99	425	276.25	120	22	15.795	39.07	2.24	237.9	0	10.65	0.92	0.36	0.12
138	Sitamarhi	Riga	Riga	7.91	381	247.65	155	18	26.73	13.71	5.41	183	0	14.2	2.1	14.84	0.17
139	Sitamarhi	Suppi	Dheng	7.71	736	478.4	330	78	32.805	12.25	7.5	420.9	0	14.2	0.87	3.4	0.19
140	Sitamarhi	Bathnaha	Yogwana	8.02	443	287.95	170	28	24.3	19.57	6.1	237.9	0	14.2	1.23	6.21	0.25
141	Sitamarhi	Sitamarhi	Karhaniya chowk	7.95	367	238.55	140	40	9.72	17.23	3.51	189.1	0	14.2	1.12	7.14	0.35
142	Sitamarhi	Sonbarsa	Dastiya	8.1	491	319.15	165	26	24.3	34.73	5.23	256.2	0	17.75	0.89	7.2	0.13
143	VAISHALI	GORAUL	Bhaluhia (Garaul)	7.4	1399	909.35	525	108	62	77.9	3.27	299	0	241.4	0.79	102.2	0.31
144	VAISHALI	BIDUPUR	Chak Sikandar	7.65	598	388.7	255	52	30	17.2	3.49	305	0	24.85	0	17.02	0.48
145	VAISHALI	GORAUL	Baksama	7.73	763	495.95	320	40	53	28.42	2.86	360	0	21.3	0	54.02	0.67
146	VAISHALI	GORAUL	Chandpur Kala	7.63	988	642.2	380	40	68	45.2	2.75	500	0	14.2	0	60.99	0.45
147	VAISHALI	HAJIPUR	Hajipur	7.67	759	493.35	310	84	24	28.5	2.41	281	0	49.7	22.41	61.5	0.37
148	VAISHALI	GORAUL	Harpur	7.78	931	605.15	325	32	60	61.25	4.1	494	0	10.65	0.07	44.71	0.25

149	VAISHALI	BIDUPUR	Kachanpur	7.53	662	430.3	230	40	32	44.2	3.14	317	0	21.3	1.83	31.95	0.29
150	VAISHALI	MAHNAR	Mahnar	7.46	1660	1079	680	88	112	69.5	0.84	537	0	184.6	26.49	101.2	0.28
151	VAISHALI	MAHUA	Mahua1	7.63	610	396.5	250	58	26	20.5	3.53	268	0	42.6	4.07	21.86	0.04
152	VAISHALI	BIDUPUR	Mathura	7.57	721	468.65	270	40	41	37.57	3.29	354	0	14.2	1.53	46.73	0.41
153	VAISHALI	LALGANJ	Namidh	7.51	1802	1171.3	730	108	112	78.5	3.58	470	0	209.45	25.2	188.5	0.4
154	VAISHALI	SAHDEI	Sahdei Bujurg	7.48	1038	674.7	450	70	67	28.31	1.76	342	0	71	24.35	114.5	0.18
155	VAISHALI	HAIJIPUR	Sahjadpur	7.59	940	611	395	60	60	34.67	3.78	372	0	56.8	23.5	60.2	0.25
156	VAISHALI	VAISHALI	Vaishali High School	7.44	1070	695.5	420	56	68	49.5	2.68	500	0	21.3	0.44	92.5	0.31
157	VAISHALI	JANDAHA	Silautha Bisnupur	7.72	752	488.8	285	16	60	38.8	3.55	409	0	14.2	0	22.14	0.49

### Major Chemical Parameters of Ground Water Samples of HNS Collected During in Bihar (Zone IV)

S.no	District	BLOCK	LOCATION	pH	EC	TDS	TH	Ca <sup>2+</sup>	Mg <sup>2+</sup>	Na <sup>+</sup>	K <sup>+</sup>	HCO <sub>3</sub> <sup>-</sup>	CO <sub>3</sub> <sup>2-</sup>	Cl <sup>-</sup>	NO <sub>3</sub> <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>	F <sup>-</sup>
					( $\mu\text{S cm}^{-1}$ )												
1	Araria	Araria	Araria	7.91	203	132	95	34	2.43	0	3.46	97.6	0	10.65	0.03	6	0
2	Araria	Forbisganj	Bathnaha 1	7.93	410	267	175	38	19.44	10.6	3.03	128.1	0	60.35	0.75	11	0.21
3	Araria	Bhargama	Bhargama	7.8	237	154	100	30	6.075	0	3.82	67.1	0	14.2	29	13	0.18
4	Araria	Forbisganj	Hariarpur	7.79	532	346	220	64	14.58	2.37	16	225.7	0	24.85	22	24	0.53
5	Araria	Jokihat	Jokihat/Jhanpur	7.9	533	346	230	42	30.375	4.21	9.26	170.8	0	53.25	28	24	0.26
6	Araria	Forbisganj	Matiyari	7.97	226	147	100	22	10.935	1.25	3.09	61	0	24.85	20	9.78	0.28
7	Araria	Palasi	Palasi	7.89	793	515	285	54	36.45	21	19	305	0	63.9	6.83	35	0.38
8	Araria	Raniganj	Raniganj	7.99	542	352	225	30	36.45	8.36	9.65	176.9	0	53.25	28	23	0.29
9	Katihar	Amdabad	Balrampur	7.54	638	414.7	265	84	13.365	26	3.59	378.2	0	7.1	1.49	5.1	0.26
10	Katihar	Barari	Barari 1	7.61	353	229.45	95	26	7.29	36	2.67	152.5	0	28.4	2.07	12.53	0.34
11	Katihar	Pranpur	Basantpur	7.32	280	182	40	12	2.43	45	2.24	128.1	0	10.65	0	18.64	0.36
12	Katihar	Pranpur	Bastaul 1	7.91	852	553.8	315	106	12.15	35	12.77	286.7	0	88.75	13.61	50.07	0.55
13	Katihar	Sameli	Dumaria	8.01	122	79.3	45	14	2.43	0.96	3.74	36.6	0	14.2	3.25	5.73	0.57
14	Katihar	Katihar	Hafla 1	7.63	353	229.45	135	48	3.645	13	3.95	189.1	0	10.65	0.95	2.51	0.22
15	Katihar	Kadwa	Kadwa	7.71	289	187.85	85	24	6.075	8.94	14.25	128.1	0	21.3	0.5	6.06	0.64

16	Katihar	Katihar	Katihar	7.92	771	501.15	230	82	6.075	63.15	5.83	323.3	0	53.25	8.36	33.13	0.61
17	Katihar	Korha	Khiria	7.71	835	542.75	255	78	14.58	58.27	16.1	268.4	0	88.75	29.38	50.91	0.19
18	Katihar	Korha	Korha	7.9	757	492.05	250	70	18.225	47.48	6.94	323.3	0	49.7	8.1	28.72	0.39
19	Katihar	Kursela	Kursela	7.38	965	627.25	375	82	41.31	39	6.91	420.9	0	88.75	1.79	6.2	0.05
20	Katihar	Falka (Belari)	Mahendarpur	7.73	1195	776.75	400	86	44.955	73	12.44	305	0	216.55	7.11	31.06	0.53
21	Katihar	Manihari	Manihari	7.21	1636	1063.4	625	120	78.975	66	15.47	597.8	0	156.2	30	67.04	0.24
22	Katihar	Falka	Narahaiya	7.56	1170	760.5	500	118	49.815	38	1.2	427	0	106.5	30.28	54.02	0.17
23	Katihar	Pranpur	Pranpur	7.73	248	161.2	100	30	6.075	0	5.14	91.5	0	17.75	7.26	4.86	0.13
24	Katihar	Kadwa	Sonali	7.71	244	158.6	105	84	13.365	0.55	2.81	85.4	0	21.3	1.84	11.34	0.13
25	Kishanganj	Bahadurganj	Bahadurganj	7.65	111	72	50	12	4.86	0.21	1.56	42.7	0	10.65	0	3.95	0.14
26	Kishanganj	Bahadurganj	Bahadurganj B	7.69	208	135	80	22	6.075	3.18	3.03	73.2	0	17.75	0.77	10.83	0.14
27	Kishanganj	Bahadurganj	Bhagalbari	7.72	89	58	35	8	3.645	0	2.52	18.3	0	7.1	11.43	4.27	0.06
28	Kishanganj	Bahadurganj	Gunsagar	7.63	257	167	85	22	7.29	5.57	11.13	97.6	0	10.65	23.75	13.67	0.15
29	Kishanganj	Pothia	Kaswa Kaliganj	7.75	442	287	210	68	9.72	0.07	3.85	207.4	0	21.3	9.15	9.14	0.63
30	Kishanganj	Kishanganj	Kishanganj	7.68	460	299	165	22	26.73	23.13	5.05	146.4	0	49.7	15.73	22.49	0.13
31	Kishanganj	Kochadhamin	Kochadhamin	7.75	160	104	75	14	9.72	0	2.42	73.2	0	10.65	2.14	4.44	0.29
32	Kishanganj	Teragachhi	Teragachhi	7.82	341	222	140	24	19.44	11.69	2.61	103.7	0	39.05	13.56	16.68	0.1
33	Madhepura	Chausa	Chausa	7.76	833	541.45	330	44	53.46	37.77	1.86	292.8	0	78.1	23.98	45.09	0.56
34	Madhepura	Chausa	Abhaytola	7.52	788	512.2	315	44	49.815	35.02	3.39	317.2	0	53.25	22.81	36.27	0.52
35	Madhepura	Chausa	Ganeshpur	7.7	476	309.4	175	26	26.73	21.88	10.28	213.5	0	35.5	0.68	11.75	0.58
36	Madhepura	Bihariganj	Uda kisanganj	7.94	1466	952.9	415	74	55.89	126.4	32.71	585.6	0	149.1	17.2	28.12	0.45
37	Madhepura	Gwalpara	Gwalpara	7.76	1038	674.7	430	62	66.825	33.24	11.47	402.6	0	92.3	2.2	55.33	0.3
38	Madhepura	Murliganj	Rampur	7.95	768	499.2	350	82	35.235	10.07	8.27	372.1	0	31.95	1.63	31.92	0.61
39	Madhepura	Murliganj	Bhatkora bazar	7.58	1558	1012.7	395	46	68.04	159.21	27.21	488	0	195.25	21.08	82.1	0.95
40	Madhepura	Murliganj	Rajui	7.69	922	599.3	410	102	37.665	17.33	8.74	366	0	67.45	24.48	44.1	0.58
41	Madhepura	Bihariganj	Kusthan	7.7	1281	832.65	375	84	40.095	97.7	42.2	445.3	0	127.8	26.43	67.89	0.29
42	Madhepura	Madhepura	Bhimpura	7.68	1009	655.85	430	62	66.825	29.74	9.32	457.5	0	60.35	3.5	36.33	0.63
43	Madhepura	Murliganj	Murliganj	7.7	863	560.95	300	66	32.805	52	12.55	372.1	0	67.45	14.58	19.18	0.28
44	Madhepura	Madhepura	Madhepura	7.63	1104	717.6	405	74	53.46	62.44	10.36	408.7	0	85.2	25.99	70.11	0.37
45	Madhepura	Singheswar	Singheswar	7.62	617	401.05	180	26	27.945	47.21	21.4	244	0	53.25	23.85	10.36	0.67
46	Madhepura	Singheswar	Barhari	7.87	549	356.85	250	52	29.16	10.55	3.12	256.2	0	35.5	0.42	11.48	0.26

47	Madhepura	Singheswar	Jiwacchpur	7.79	548	356.2	220	22	40.095	21.07	4.68	195.2	0	46.15	15.91	34.55	0.57
48	Madhepura	Gamharia	Suryaganj	7.09	190	123.5	80	12	12.15	5.3	2.1	85.4	0	17.75	1.7	0	0.27
49	Purnea	Amour	Amour	7.63	328	213	105	28	8.505	19	5.46	134.2	0	17.75	9.77	17.64	0.31
50	Purnea	Dhamdaha	Amri Kukran (East)	7.69	2390	1554	715	132	93.555	180	22.29	799.1	0	287.55	21.48	70.59	0.52
51	Purnea	Dhamdaha	Amri Kukran (west)	7.51	289	188	95	28	6.075	1.05	17.94	109.8	0	10.65	22.05	20.26	0.71
52	Purnea	Baisi	Basi 2	7.63	1050	683	380	66	52.245	58.47	1.22	414.8	0	106.5	4.32	16.82	0.44
53	Purnea	Banmankhi	Banmankhi	7.49	368	239	155	44	10.935	0.03	7.32	146.4	0	24.85	19.56	5.18	0.3
54	Purnea		Barsoni	7.83	594	386	100	32	4.86	68	18	231.8	0	46.15	1.46	33.52	0.45
55	Purnea	Banmankhi	Budhia Gola	7.91	438	285	165	50	9.72	16.53	3.42	146.4	0	42.6	9.11	24.32	0.04
56	Purnea	Baisi	Chadia (Chariya)	7.83	323	210	135	36	10.935	0	10.39	128.1	0	14.2	25.57	14.41	0.63
57	Purnea	Rupauli	Dargaha (SupauliSthan)	7.94	318	207	145	30	17.01	0	4.87	158.6	0	14.2	1.14	7	0
58	Purnea	Dhamdaha	Dhamdaha	7.61	618	402	255	52	30.375	17.56	5.5	207.4	0	49.7	30.01	39	0.08
59	Purnea	Jalalgarh	Jalalgarh	7.73	255	166	100	18	13.365	1.23	7.35	109.8	0	10.65	7.2	10	0.41
60	Purnea	Dhamdaha	Kajha	7.79	542	352	150	44	9.72	11.49	36.35	207.4	0	49.7	19.42	15	0.19
61	Purnea	Kasba	Kasba	7.75	196	127	85	18	9.72	1.05	2.68	67.1	0	14.2	10	15	0
62	Purnea	Srinagar	Khata Hat	7.91	189	123	85	20	8.505	0	2.93	61	0	10.65	9	14	0.11
63	Purnea	Barhara	Mangujan	7.89	235	153	110	34	6.075	0.78	2.22	91.5	0	14.2	9.66	16	0
64	Purnea	Purnea	Purnea	7.93	214	139	100	16	14.58	0	3.27	79.3	0	17.75	5.05	11	0.29
65	Purnea	Purnea E	Ranipatra	7.7	460	299	210	72	7.29	3.43	3.13	134.2	0	46.15	30	28	0.14
66	Purnea	Rupauli	Tikapati chowk	7.99	761	495	295	78	24.3	24	11.91	256.2	0	78.1	30	28	0.5
67	Purnea	Rupauli	Tikapati	7.82	173	112	75	14	9.72	0	3.09	73.2	0	7.1	7.35	4.48	0.33
68	Saharsa	Sata Katya	Gangora Bihra	7.46	336	218.4	125	40	6.075	15.87	7.98	152.5	0	7.1	10.53	19.92	0.74
69	Saharsa	Kahra	Belhi Teghra	7.57	996	647.4	290	52	38.88	73.98	35.87	402.6	0	85.2	4.35	38.94	1.9
70	Saharsa	Simri Bakhtiyarpur	Jamunia	7.62	1042	677.3	280	38	44.955	88.76	39.06	353.8	0	120.7	5.36	50.37	0.99
71	Saharsa		Jamunia	7.14	507	329.55	165	30	21.87	34.26	11.84	183	0	56.8	3.3	16.84	0.48
72	Saharsa		Jamunia	7.33	302	196.3	80	24	4.86	30.13	5.08	122	0	24.85	1.85	10.8	0.39
73	Saharsa	Sour Bazar	Arrha	8.03	1032	670.8	350	72	41.31	54.32	39.12	427	0	74.55	15.93	42.65	0.64
74	Saharsa	Norha	Bangaon.	7.95	998	648.7	300	60	36.45	75.41	26.1	372.1	0	110.05	1.96	34.12	1.26
75	Saharsa	Kahara	Basudeva	7.81	1139	740.35	420	78	54.675	57.16	21.01	390.4	0	134.9	9.09	44.2	1.32
76	Saharsa	Sour Bazar	Chandaur Purvi	7.89	355	230.75	135	40	8.505	14.09	8.06	146.4	0	35.5	1.34	6.73	0.37



77	Saharsa	Kahara	Kharkutti	8.05	770	500.5	180	54	10.935	71.34	40.845	280.6	0	67.45	17.81	38.31	1.66
78	Saharsa	Kahara	Niralatola	8.03	734	477.1	230	38	32.805	50.44	23.15	305	0	56.8	7.28	26.75	0.8
79	Saharsa	Satar Katya	Punchgachi	8.11	1276	829.4	285	60	32.805	109.25	89.12	384.3	0	152.65	13.9	90.88	1.23
80	Saharsa	Sata Katya	Patodi Bazar	7.98	814	529.1	250	32	41.31	50.65	34.9	341.6	0	71	4.45	22.53	0.4
81	Saharsa	Sata Katya	Patodibazar	7.91	1075	698.75	320	78	30.375	77.26	37.51	396.5	0	110.05	17.9	42.29	0.65
82	Saharsa	Saharsa	Potwaha	7.85	363	235.95	125	26	14.58	23.74	3.17	152.5	0	28.4	1.06	15.8	0.47
83	Saharsa	Saharsa	Saharsa 1	7.72	652	423.8	195	56	13.365	48.81	18.2	195.2	0	74.55	15.18	45.39	1.08
84	Saharsa	Simri Bakhtiarapur	Simri Bakhtiarapur 1	7.95	2803	1821.95	530	102	66.825	298.12	172.625	835.7	0	426	15.8	98.14	0.99
85	Saharsa	Sonbarsaraj	Sonbarsaraj 1	7.84	1413	918.45	450	104	46.17	91.52	43.61	567.3	0	102.95	13.12	82.81	0.67
86	Saharsa	Kahara	Tulsiyahi	7.79	858	557.7	250	56	26.73	60.1	35.91	353.8	0	74.55	5.7	28.21	0.51
87	Supaul	Tribeniganj	Tribeniganj	8.26	1140	741	300	76	26.73	98.14	43.01	353.8	0	95.85	26.05	118.64	0.75
88	Supaul	Basantpur	Bhimnagar	7.8	1098	713.7	255	34	41.31	112.45	40.21	433.1	0	74.55	6.05	77.75	0.65
89	Supaul	Basantpur	Birpur	7.58	768	499.2	285	62	31.59	34.87	19.51	384.3	0	21.3	12.08	23.57	0.87
90	Supaul	Raghopur	Ganpatganj	7.64	665	432.25	195	48	18.225	55.9	10.92	280.6	0	53.25	4.27	23.24	0.43
91	Supaul	Marauna	Andauli	7.68	467	303.55	180	40	19.44	18.23	9.84	256.2	0	14.2	0.05	4.8	0.31
92	Supaul	Balua	Balua 1	7.81	516	335.4	190	52	14.58	19.8	20.14	219.6	0	28.4	18.1	19.24	0.43
93	Supaul	Chhatarpur	Balua Bazar	8.18	479	311.35	225	42	29.16	1.08	11.07	244	0	14.2	11.64	7.09	0.3
94	Supaul	Raghopur	Basawanpatti	8.15	498	323.7	240	56	24.3	1.71	5.92	250.1	0	21.3	3.2	8.21	0.3
95	Supaul	Basantpur	Bhawanipur 1	8.13	829	538.85	330	66	40.095	25.11	21.82	396.5	0	46.15	2.31	21.61	0.52
96	Supaul	Marauna	Hardi	8.17	619	402.35	265	58	29.16	16.05	6.73	274.5	0	31.95	14.23	26.21	0.71
97	Supaul	Tribeniganj	Jadia	8.17	615	399.75	260	66	23.085	18.2	4.8	213.5	0	49.7	19.29	45.71	0.33
98	Supaul	Raghopur	Kaithtola	8.2	320	208	110	22	13.365	19.24	7.02	91.5	0	21.3	5.6	46.2	0.52
99	Supaul	Marauna	Kario	8.23	1883	1223.95	610	122	74.115	128.2	42.25	646.6	0	216.55	6.25	91.2	1.66
100	Supaul	Raghopur	Karzain	8.14	597	388.05	205	50	19.44	36.23	9.75	250.1	0	46.15	1.29	27.4	0.31
101	Supaul	Supaul	Malhani	8.18	561	364.65	225	60	18.225	20.1	7.62	280.6	0	17.75	0.23	24.12	0.5
102	Supaul	Raghopur	Norha	8.22	362	235.3	130	24	17.01	19.32	7.78	158.6	0	28.4	0.236	7.34	0.28
103	Supaul	Pipra	Pipra Chowk	8.27	219	142.35	95	20	10.935	5.59	3.56	115.9	0	7.1	0	2.44	0.1
104	Supaul	Raghopur	Pratapganj	8.14	694	451.1	270	62	27.945	29.87	10.65	274.5	0	53.25	18.64	27.9	0.45
105	Supaul	Basantpur	Ratanpura	8.11	769	499.85	255	46	34.02	46.83	20.12	317.2	0	71	1.9	21.86	0.48
106	Supaul	Pipra	Shym Nagar	8.13	502	326.3	180	40	19.44	28.2	6.68	244	0	21.3	3.2	17.4	0.65
107	Supaul	Supaul	Supaul	8.16	1029	668.85	275	62	29.16	96.05	23.14	372.1	0	117.15	10.23	35.62	0.82

108	Supaul	Supaul	Thumha	8.2	496	322.4	195	40	23.085	19.76	6.36	201.3	0	28.4	14.23	30.06	0.37
109	Supaul	Supaul	Malhani-New	8.17	337	219.05	100	22	10.935	21.65	15.64	140.3	0	24.85	3.37	15.71	0.34
110	Supaul	Basantpur	Bhimnagar	8.03	581	377.65	250	60	24.3	5.2	20.82	280.6	0	21.3	14.32	18.77	0.63

### Major Chemical Parameters of Ground Water Samples of HNS Collected During in Bihar (Zone V)

S.no	District	BLOCK	LOCATION	pH	EC	TDS	TH	Ca <sup>2+</sup>	Mg <sup>2+</sup>	Na <sup>+</sup>	K <sup>+</sup>	HCO <sub>3</sub> <sup>-</sup>	CO <sub>3</sub> <sup>2-</sup>	Cl <sup>-</sup>	NO <sub>3</sub> <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>	F <sup>-</sup>
					( $\mu\text{S cm}^{-1}$ )							In mg L <sup>-1</sup>					
1	Bhojpur	Udwanthnagar	Harnathkundi	7.67	1886	1226	390	102	32.805	250	3.74	689.3	0	191.7	42	71	0.73
2	Bhojpur	Koilwar	Mohammadpur	7.1	1401	911	375	128	13.365	53	29	366	0	113.6	31	76.27	0.8
3	Bhojpur	Koilwar	Rajpurbazaar	7.48	953	619	420	118	30.375	19	4.93	408.7	0	49.7	29	40.89	0.6
4	Bhojpur	Udwanthnagar	SasaramChhota	7.47	1437	934	550	156	38.88	58	16	549	0	120.7	32	66	0.61
5	Bhojpur	Barhara	Simariya	7.35	784	510	325	102	17.01	23	2.74	372.1	0	39.05	7.25	11	0.73
6	Bhojpur	Barhara	Bakhorapur	7.04	478	311	170	42	15.795	16	6.08	183	0	24.85	11	27	0.86
7	Bhojpur	Barhara	Balua	7.51	1102	716	135	44	6.075	29	133	189.1	0	63.9	29	58	0.84
8	Bhojpur	Barhara	Barhara	7.26	1544	1004	625	190	36.45	58	6.78	518.5	0	149.1	31	98	0.68
9	Bhojpur	Sandesh	Baruna	7.15	1780	1157	485	124	42.525	182	3.62	488	0	255.6	32	93	0.83
10	Bhojpur	Bihiya	Bihiya(Dogra)	7.12	1015	660	325	76	32.805	37	38	396.5	0	74.55	9.72	58	0.83
11	Bhojpur	Koilwar	Birampur	7.46	1228	798	505	162	24.3	43	4.63	481.9	0	110.05	2.14	50	0.78
12	Bhojpur	Arrah	Chandwa	7.58	700	455	300	64	34.02	26	1.71	372.1	0	24.85	5.02	14	0.99
13	Bhojpur	Barhara	Dhusariya	7.42	1463	951	485	106	53.46	60	7.26	408.7	0	142	39	60	0.85
14	Bhojpur	Barhara	Ekauna	7.57	666	433	250	72	17.01	20	5.51	305	0	21.3	6.69	23	0.76
15	Bhojpur	Barhara	Farhda	7.54	1272	827	425	118	31.59	34	52	481.9	0	92.3	31	80	0.78
16	Bhojpur	Garhani	Garhani(Nahsi)	7.72	1188	772	310	106	10.935	130	2.3	542.9	0	63.9	25	42	1.37
17	Bhojpur	Koilwar	Giddha	8.02	668	434	250	62	23.085	27	2.28	329.4	0	21.3	0.27	10	0.7
18	Bhojpur	Sahar	Guljarpur	7.56	692	450	310	58	40.095	16	0.61	359.9	0	14.2	13	18	1
19	Bhojpur	Koilwar	Inglishpur	7.69	1018	662	430	90	49.815	28	3.72	427	0	71	0.25	50	0.66
20	Bhojpur	Jagdishpur	Jagdishpur	7.27	994	646	310	96	17.01	61	11	305	0	106.5	27	48	0.91

21	Bhojpur	Barhara	Jagatpur	7.63	958	623	395	102	34.02	33	0.5	481.9	0	31.95	0	27	1.2
22	Bhojpur	Arrah	JarawarpurMilki	7.69	983	639	175	46	14.58	145	2.31	524.6	0	21.3	1.93	34.06	1
23	Bhojpur	Sahpur	Karnamepur	7.4	2012	1308	480	126	40.095	226	12	664.9	0	248.5	40	69.87	0.88
24	Bhojpur	Udwantnagar	Kasap	7.58	585	380	240	72	14.58	23	1.5	298.9	0	17.75	8.28	14.71	0.74
25	Bhojpur	Sandesh	Kori	7.51	1032	671	410	90	44.955	35	9.07	427	0	71	31	33.24	1
26	Bhojpur	Koilwar	Kulhariya	7.61	780	507	315	72	32.805	32	1.63	366	0	35.5	5.82	33.93	0.99
27	Bhojpur	Koilwar	Lodhipur	7.64	1115	725	425	128	25.515	37	19	469.7	0	53.25	31	63.48	0.99
28	Bhojpur	Arrah	MilkiDera	7.85	804	523	350	116	14.58	22	0.61	427	0	17.75	3.35	18.02	1.08
29	Bhojpur	Koilwar	Mokhalisa	7.17	842	547	355	112	18.225	25	3.54	384.3	0	17.75	0.3	70.26	0.83
30	Bhojpur	Sandesh	Nasaratpur	7.23	1034	672	425	124	27.945	39	1.17	420.9	0	63.9	30	46.2	0.71
31	Bhojpur	Koilwar	Panchrukhiya	7.31	766	498	330	90	25.515	17	6.68	359.9	0	35.5	5.8	31.55	0.66
32	Bhojpur	Sandesh	Pawana	7.45	1886	1226	400	116	26.73	251	0.44	628.3	0	213	27	99.11	1.02
33	Bhojpur	Pirro	Pirro	7.4	1325	861	505	146	34.02	70	0.99	494.1	0	124.25	28	52.71	0.41
34	Bhojpur	Koilwar	Sakkadiu	7.6	836	543	325	102	17.01	38	2.37	353.8	0	56.8	2.18	41.15	0.88
35	Bhojpur	Sandesh	Sandesh	7.45	2100	1365	515	144	37.665	228	14	622.2	0	284	45	89.59	0.66
36	Bhojpur	Koilwar	Songhata	7.36	741	482	310	108	9.72	25	1.86	372.1	0	28.4	1.8	22	0.83
37	Bhojpur	Udwantnagar	Udwantnagar	7.98	758	493	255	86	9.72	57	0.7	183	0	21.3	233	11	0.95
38	Bhojpur	Tarari	Bagar	7.45	656	426	270	86	13.365	21	0.47	311.1	0	31.95	1.75	18	0.42
39	Buxar	Brahmpur	Bagen bazar	7.76	703	457	225	64	15.795	48	11.11	366	0	28.4	3.98	11.09	0.03
40	Buxar	Brahmpur	Brahmpur	7.67	720	468	250	72	17.01	31	13	372.1	0	28.4	3.68	5.89	0
41	Buxar	Buxer	Buxer	7.79	1056	686	370	122	15.795	63	6.79	109.8	0	266.25	29	33.86	0.11
42	Buxar	Chausa	chausa	7.81	1808	1175	275	96	8.505	168	105	671	0	63.9	175	123	0
43	Buxar	Buxar	Churamanpur	7.7	1575	1024	640	190	40.095	57	9.14	634.4	0	177.5	5.45	13.47	0
44	Buxar	Buxar	Danikutia	7.89	946	615	295	90	17.01	78	4.6	475.8	0	17.75	25	38.85	0.19
45	Buxar	Buxer	Dhudharchak	7.75	695	452	250	66	20.655	27	4.05	244	0	85.2	1.49	1.48	0
46	Buxar	Simri	Dumri	7.68	674	438	195	52	15.795	18	35	341.6	0	17.75	7.39	13.59	0
47	Buxar	Simri	Karthar	7.67	538	350	205	58	14.58	22	8.24	189.1	0	74.55	8.11	2.54	0
48	Buxar	Brahmpur	Kochariwan	7.73	1104	718	340	90	27.945	94	3.01	335.5	0	149.1	30	40.2	0.21
49	Buxar	Buxer	Kritpur	7.81	1096	712	335	94	24.3	95	2.03	488	0	56.8	22	44.52	0.07
50	Buxar	Brahmpur	Maharajganj	7.92	621	404	160	50	8.505	7.21	51	311.1	0	28.4	4.1	7.21	0.1
51	Buxar	Buxar	Misharvaliya	7.85	613	398	165	54	7.29	3.95	48	329.4	0	21.3	0.46	3.95	0

52	Buxar	Buxer	Thodagam	7.81	620	403	285	86	17.01	8.16	2.59	347.7	0	10.65	0.97	8.16	0
53	Buxar	Simri	BarkaRajpur	7.56	865	562	375	116	20.655	17	3.84	341.6	0	99.4	0.16	0	0
54	Buxar	Dumraon	Dumraon	7.71	981	638	150	48	7.29	105	43	530.7	0	24.85	3.82	12.13	0.05
55	Buxar	Simri	Durasan	7.82	718	467	315	96	18.225	22	3.21	414.8	0	17.75	0.36	1.36	0
56	Buxar	Brahmpur	Hathilpur	7.85	849	552	350	108	19.44	26	4.75	457.5	0	28.4	0.09	0.78	0
57	Buxar	Brahmpur	Jugiyadera	7.6	638	415	175	52	10.935	64	2.94	347.7	0	21.3	0.04	3.65	0
58	Buxar	Simri	Manikpur	7.81	921	599	200	64	9.72	48	59	475.8	0	10.65	4.36	47.62	0
59	Buxar	Simri	Niyajipur	7.65	544	354	145	38	12.15	0.78	49	305	0	14.2	0.11	0.78	0
60	Buxar	Brahmpur	Raghunathpur	7.73	1397	908	560	178	27.945	55	2.04	433.1	0	170.4	32.71	54.96	0.15
61	Buxar	Rajpur	Rajpur	7.95	779	506	370	108	24.3	5.52	1.36	420.9	0	17.75	7.31	5.52	0.35
62	Buxar	Buxer	Ramonariya	7.65	953	619	425	130	24.3	16	3.33	506.3	0	24.85	0.74	16.1	0
63	Buxar	Simri	Sohiar	7.79	1715	1115	555	148	44.955	73.46	56	433.1	0	284	29	73.46	0.42
64	Jehanabad	Makhdumpur	Alubikha	8.03	2117	1376.05	690	30	149.445	150.87	32.98	823.5	0	145.55	9.98	161.24	0.55
65	Jehanabad	Ghosi	Bholapur	7.85	559	363.35	210	28	34.02	30.56	1.25	268.4	0	24.85	6.38	19.65	0.23
66	Jehanabad	Jehanabad	Gaurakshini	7.44	1444	938.6	380	44	65.61	140.45	26.87	677.1	0	102.95	2.23	20.07	0.19
67	Jehanabad	Ghoshi	Ghoshi	7.51	1016	660.4	380	86	40.095	55.76	3.8	433.1	0	63.9	28.14	39	0.56
68	Jehanabad	Hulasganj	Hulasganj	7.65	1082	703.3	410	64	60.75	52.41	14.64	384.3	0	95.85	28.49	62.22	0.53
69	Jehanabad	Kako	Kako	7.49	3076	1999.4	870	146	122.715	265.1	66.84	774.7	0	472.15	29.37	203	0.51
70	Jehanabad	Ghosi	Lakhwar	7.8	729	473.85	310	36	53.46	21.95	4.08	262.3	0	60.35	28.07	41.23	0.31
71	Jehanabad	Makhdumpur	Makhdumpur	7.89	794	516.1	225	22	41.31	76.54	6.1	384.3	0	21.3	12	37.81	0.6
72	Jehanabad	Jehanabad	Teni Bigha	8.02	2008	1305.2	560	20	123.93	178.21	42.65	664.9	0	230.75	26.87	108.64	0.23
73	Patna	Bihta	Amraha	7.76	502	326.3	210	30	32.805	16.66	1.79	225.7	0	24.85	4.14	27.43	0.04
74	Patna	Bihta	Baliapakar	8.01	1492	969.8	340	56	48.6	152.2	60.32	488	0	166.85	27.83	81.02	1.07
75	Patna	Paliganj	Bharatpura	7.46	1755	1140.75	410	22	86.265	190.34	43.12	921.1	0	46.15	15.47	38.71	0.87
76	Patna	Bihta	Bishambharpur	7.73	714	464.1	290	32	51.03	28.24	3.22	347.7	0	24.85	11.17	27.54	0.4
77	Patna	Danapur	Darbeshpur	7.54	1436	933.4	400	32	77.76	128.53	28.65	567.91	0	106.5	28.46	76.12	0.56
78	Patna	Punpun	Deokoli	7.81	550	357.5	215	28	35.235	25.91	1.89	250.1	0	24.85	11.43	25.65	0
79	Patna	Bikram	Din Bigha	7.83	485	315.25	210	44	24.3	14.97	1.05	189.1	0	42.6	7.3	19	0.17
80	Patna	Phulwari	Etwarpur	7.41	1072	696.8	375	64	52.245	64.68	17.61	420.9	0	81.65	16.39	59	0.2
81	Patna	Naubatpur	Faridpur	7.89	820	533	315	36	54.675	30.78	21.29	311.1	0	67.45	5.47	54.32	0.11
82	Patna	Danapur	Goptal Danapur	7.53	1164	756.6	415	66	60.75	63.64	20.72	457.5	0	81.65	27.6	68.14	0.23

			(Gobhtal)														
83	Patna	Maner	Gyaspur(purvatora)	7.49	1823	1184.95	465	98	53.46	185.65	34.76	616.1	0	184.6	27.9	117.02	0.28
84	Patna	Phulwari	Hulas Chak	8.06	581	377.65	255	38	38.88	13.8	2.97	298.9	0	17.75	8.5	14.13	0
85	Patna	Danapur_Cum Khagaul	Khaspur	7.86	563	365.95	215	32	32.805	27.32	3.85	311.1	0	14.2	1.85	5.9	0.16
86	Patna	Patna Sadar	Khazpura	7.57	712	462.8	285	26	53.46	32.07	2.06	335.5	0	31.95	2.03	29.82	0.25
87	Patna	Maner	Lalbegam	7.7	662	430.3	245	46	31.59	36.27	4.65	317.2	0	24.85	12.94	25.27	0.21
88	Patna	Maner	Maner	7.52	628	408.2	265	24	49.815	20	3.33	323.3	0	28.4	2.3	7.36	0.11
89	Patna	Maner	Maner New	7.59	1114	724.1	435	94	48.6	50.02	8.52	561.2	0	35.5	2.54	43.52	0.14
90	Patna	Bikram	Mariyawa	7.51	558	362.7	240	38	35.235	15.07	3.26	286.7	0	17.75	11.92	10.43	0
91	Patna	Bikrma	Noniatola	7.17	1105	718.25	335	36	59.535	82.84	30.21	372.1	0	106.5	28.49	68.34	0.37
92	Patna	Phulwari	Parsa bazar	7.81	605	393.25	230	46	27.945	26.99	9.91	317.2	0	17.75	10.01	9.68	0.27
93	Patna	Bihta	Raghopur	7.91	468	304.2	200	48	19.44	13.74	3.9	237.9	0	14.2	6.07	9.98	0.24
94	Patna	Naubatpur	Snehitola	7.1	1354	880.1	445	106	43.74	103.2	4.9	420.9	0	149.1	28.27	96.32	0
95	Patna	Dulhin Bazar	Dulhin Bazar	7.45	1098	713.7	350	46	57.105	89.21	5.65	250.1	0	170.4	28.37	75.84	0.05
96	Patna	Fathua	Fathua	7.18	781	507.65	250	42	35.235	60.17	5.6	384.3	0	39.05	7.97	16.58	0.32
97	Patna	Daniyawar	Daniyawar	7.31	456	296.4	185	40	20.655	20.86	1.68	170.8	0	46.15	1.2	15.21	0.52
98	Patna	Mokama	Maranchi	8.28	1689	1097.85	375	76	44.95	116.25	167	535.05	0	171.3	26.24	88.24	0.41

### Major Chemical Parameters of Ground Water Samples of HNS Collected During in Bihar (Zone VI)

S.no	District	BLOCK	LOCATION	pH	EC	TDS	TH	Ca <sup>2+</sup>	Mg <sup>2+</sup>	Na <sup>+</sup>	K <sup>+</sup>	HCO <sub>3</sub> <sup>-</sup>	CO <sub>3</sub> <sup>2-</sup>	Cl <sup>-</sup>	NO <sub>3</sub> <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>	F <sup>-</sup>
					( $\mu\text{S cm}^{-1}$ )	In mg L <sup>-1</sup>											
1	Kaimur	Adhaura	Adhaura	7.4	218	142	100	30	6.075	7.85	3.02	97.6	0	21.3	2.22	13.66	0.17
2	Kaimur	Ramgrah	Bandipur	7.6	1092	710	320	90	23.085	93.67	9.63	549	0	35.5	5.7	36.93	0.21
3	Kaimur	Ragrah	Bevnaliya	7.75	728	473	110	38	3.645	111.32	2.47	262.3	0	99.4	1.16	7.09	0.2
4	Kaimur	Bhabua	Bhabua	7.78	934	607	270	72	21.87	78.23	4.52	347.7	0	102.95	10	16.68	0.13
5	Kaimur	Chainpur	Chainpur	8.03	1286	836	80	22	6.075	254	1.18	439.2	0	177.5	1	26.56	1.31

6	Kaimur	Chand	Chand	7.74	1473	957	450	126	32.805	107	5.86	567.3	0	31.95	95	104.5	0.6
7	Kaimur	Chainpur	Kh...riava	7.91	901	586	310	84	24.3	52	12	384.3	0	78.1	16	12.94	0.42
8	Kaimur	Mohania	Mohania(N.W.)	7.84	866	563	305	92	18.225	61	1.06	378.2	0	60.35	12	30.2	0.44
9	Kaimur	Nuwan	Nuwan	7.89	698	454	215	58	17.01	46.4	1.92	183	0	110.05	9.3	7.55	0.12
10	Kaimur	Bhagwanpur	Saraiya	7.69	1034	672	380	112	24.3	56	2.76	512.4	0	24.85	28	26.37	0.28
11	Kaimur	Bhagwanpur	Tori check post	8	635	413	175	58	7.29	54	10.37	250.1	0	67.45	3.47	13.14	0.26
12	Rohtas	Rohtas	Akbarpur	7.2	970	631	340	110	15.795	56	7.46	408.7	0	42.6	31	59	0.69
13	Rohtas	Sasaram	Amwan Gate	7.44	785	510	285	92	13.365	48	0	378.2	0	28.4	11	25	1.14
14	Rohtas	Sasaram	Amoliya	7.46	919	597	340	102	20.655	46	6.95	396.5	0	53.25	21	36	1.22
15	Rohtas	Nawhatta	Auraiya	7.42	1450	943	605	184	35.235	56	0.63	524.6	0	166.85	9.64	47	0.98
16	Rohtas	Karakat	Bahuara	7.6	766	498	300	82	23.085	30	0.12	347.7	0	31.95	26	15	0.48
17	Rohtas	Kargahar	Belthari	7.57	721	469	295	70	29.16	30	0.54	384.3	0	17.75	6.03	15	1
18	Rohtas	Bikramganj	Bikramganj	7.36	1931	1255	465	150	21.87	229	0.63	640.5	0	223.65	50	75	1.13
19	Rohtas	Chenari	Chenari	7.5	951	618	365	104	25.515	48	0.16	414.8	0	60.35	16	31	1.23
20	Rohtas	Dinara	Dinara	7.55	905	588	330	86	27.945	56	0.37	420.9	0	56.8	7.28	24	0.51
21	Rohtas	Kudra	Jahanabad (kudra)	7.62	918	597	335	72	37.665	55	0.57	390.4	0	71	7.09	32	0.5
22	Rohtas	Sasaram	Karbindia	7.51	684	445	220	78	6.075	43	0.35	286.7	0	35.5	2.39	23	0.5
23	Rohtas	Rohtas	Karma	7.74	953	619	330	70	37.665	66	2.36	414.8	0	53.25	1.35	55	0.89
24	Rohtas	Dinara	Kochas	7.84	800	520	215	66	12.15	46.42	31	396.5	0	17.75	50	4.73	0.27
25	Rohtas	Dawath	Maliabagh	7.83	698	454	210	64	12.15	61.76	1.73	353.8	0	35.5	6.13	6.66	0.85
26	Rohtas	Nokha	Nokha	7.85	664	432	290	82	20.655	19.32	0.88	366	0	17.75	0.6	6.34	0.91
27	Rohtas	Dinara	Rajandih	7.66	1421	924	480	150	25.515	102.52	3.43	427	0	248.5	0.79	7.34	0.18
28	Rohtas	Sasaram	Sasaram	7.87	717	466	270	84	14.58	61.6	5.53	457.5	0	17.75	0.27	14.19	0.15
29	Rohtas	Kargahar	Sinsiyau	7.89	823	535	265	70	21.87	66.72	0.9	311.1	0	81.65	20	23.74	0.76
30	Rohtas	Tilaothu	Tilothu	7.76	853	554	250	60	24.3	79.59	1.06	305	0	92.3	20.45	22.97	0.42

**Major Chemical Parameters of Ground Water Samples of HNS Collected During in Bihar (Zone VII)**

S.no	District	BLOCK	LOCATION	pH	EC	TDS	TH	Ca <sup>2+</sup>	Mg <sup>2+</sup>	Na <sup>+</sup>	K <sup>+</sup>	HCO <sub>3</sub> <sup>-</sup>	CO <sub>3</sub> <sup>2-</sup>	Cl <sup>-</sup>	NO <sub>3</sub> <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>	F <sup>-</sup>
					( $\mu\text{S cm}^{-1}$ )	In mg L <sup>-1</sup>											
1	Arwal	Arwal	Arwal	7.66	471	306.15	195	28	30.375	19.07	0.98	219.6	0	17.75	12.18	17	0.15
2	Arwal	Karpi	Bairbigaha	7.47	1753	1139.45	455	52	78.975	185.01	16.45	597.8	0	195.25	29.02	81.46	0.7
3	Arwal	Sonbhadra	Bansi (Surajpur)	7.59	795	516.75	290	76	24.3	49.49	1.66	341.6	0	39.05	23.43	39.5	0.35
4	Arwal	Arwal	Dirpal Bigha	7.62	361	234.65	150	48	7.29	12.84	3.1	164.7	0	10.65	7.7	20.4	0.2
5	Arwal	Arwal	Imamganj	7.39	1989	1292.85	625	142	65.61	150.43	32.04	597.8	0	273.35	29.13	92.35	0.58
6	Arwal	Ratni Faridpur	Jhunathi	7.63	602	391.3	245	52	27.945	25.34	2.05	280.6	0	24.85	7.32	27.12	0.18
7	Arwal	Kurtha	Kinjer	7.48	455	295.75	190	46	18.225	16.78	1.61	207.4	0	17.75	7.8	22.54	0.15
8	Arwal	Kurtha	Kurtha	7.33	979	636.35	320	52	46.17	72.27	8.69	408.7	0	81.65	6	34.02	0.38
9	Arwal	Arwal	Madhubani	7.5	246	159.9	95	26	7.29	12.55	1.51	103.7	0	14.2	7.43	9.24	0.15
10	Aurangabad	Aurangabad	Aurangabad	7.52	2969	1929.85	885	170	111.78	250.95	43.54	957.7	0	443.75	27.53	47.8	0.29
11	Aurangabad	Daudnagar	Daudnagar	7.75	1344	873.6	330	74	35.235	131.15	45	439.2	0	152.65	19.23	75	0.45
12	Aurangabad	Deo	Deo 1	7.45	688	447.2	195	12	40.095	61	10.81	237.9	0	49.7	8.46	68.72	0.68
13	Aurangabad	Goh	Deohara	7.78	743	482.95	205	32	30.375	68	15.76	372.1	0	17.75	11.97	27.43	0.92
14	Aurangabad	Kutumba	Dhanibar	7.64	771	501.15	300	42	47.385	37.3	1.89	372.1	0	28.4	8.01	32.46	0.57
15	Aurangabad	Goh	Dhobitola Goh	7.66	2752	1788.8	675	170	60.75	220.45	174.4	1055.3	0	280.45	28.26	85.71	1.1
16	Aurangabad	Haspura	Etwan	7.34	505	328.25	170	46	13.365	35.4	5.32	164.7	0	39.05	24.54	38	0.16
17	Aurangabad	Madanpur	Madandpur	7.61	988	642.2	385	58	58.32	48.23	4.33	329.4	0	106.5	26.05	48	0.22
18	Aurangabad	Nabinagar	Mahuli	7.62	1464	951.6	355	42	60.75	150.54	39.65	524.6	0	134.9	10.72	97	0.28
19	Aurangabad	Nabinagar	Nabinagar	7.76	873	567.45	300	32	53.46	57.2	7.86	390.4	0	49.7	12.82	35.24	0.21
20	Aurangabad	Barun	Narari Kala	7.43	538	349.7	190	46	18.225	33.5	5.54	201.3	0	49.7	4.37	27.49	0.1
21	Aurangabad	Obra	Obra	7.51	1619	1052.35	465	78	65.61	136.98	37.76	536.8	0	184.6	29.2	81.03	0.22
22	Aurangabad	Madanpur	Pataya (Pandrawan)	7.53	1233	801.45	395	64	57.105	94.7	13.54	463.6	0	106.5	25.31	61.24	0.12

23	Aurangabad	Aurangabad	Patrava	7.54	647	420.55	275	60	30.375	21.3	1.1	262.3	0	35.5	25.36	37.55	0.39
24	Aurangabad	Rafiganj	Rafiganj	8.02	1145	744.25	350	114	15.795	87.65	23.87	481.9	0	85.2	24.27	37.65	0.09
25	Aurangabad	Rafiganj	Tineri Morh	7.95	1166	757.9	425	28	86.265	65.46	10.86	542.9	0	67.45	15.61	29.46	0.7
26	Gaya	Wazirganj	Wazirganj	7.91	2314	1504.1	760	156	89.91	157.43	44.27	616.1	0	369.2	25.63	101.2	1.28
27	Gaya	Fatehpur	Fatehpur	7.69	592	384.8	185	34	24.3	48.34	3.98	244	0	49.7	10.21	15.32	1.32
28	Gaya	Fatehpur	Baraila More	8.03	801	520.65	215	44	25.515	82.98	4.74	427	0	21.3	8.06	7.73	1.57
29	Gaya	Manpur	Manpur	7.73	1245	809.25	370	70	47.385	103.54	20.25	384.3	0	156.2	23.8	63.84	0.93
30	Gaya	Gaya Sadar	Sangat Gali	7.54	865	562.25	240	40	34.02	86.74	8.16	268.4	0	88.75	23.8	60.14	1.33
31	Gaya	Gaya Sadar	Chand Chowra Chowk	7.56	1198	778.7	335	66	41.31	103.54	27.98	372.1	0	145.55	24.02	64.32	1.39
32	Gaya	Bodhgaya	Bodhgaya	7.43	321	208.65	125	18	19.44	15.32	2.86	140.3	0	17.75	7.3	10.21	1.01
33	Gaya	Dobhi	Dobhi	7.54	1104	717.6	295	68	30.375	103.54	27.21	366	0	138.45	21.8	32.3	1.39
34	Gaya	Mohanpur	Dangra More	7.61	1091	709.15	340	44	55.89	89.04	7.32	329.4	0	138.45	2.2	74.07	1.1
35	Gaya	Barachatti	Bhadeya	7.65	1862	1210.3	610	130	69.255	124.24	41.25	414.8	0	319.5	26.6	110.2	1.1
36	Gaya	Banke Bazar	Banke Bazar	7.6	854	555.1	270	38	42.525	68.47	5.33	353.8	0	67.45	6.26	34.55	1.26
37	Gaya	Imamganj	Baseta	7.63	1608	1045.2	515	74	80.19	110.67	39.08	427	0	230.75	25.18	98.23	1.21
38	Gaya	Dumaria	Magra	7.77	1635	1062.75	525	130	48.6	110.53	41.94	463.6	0	227.2	20.87	92.97	1.02
39	Gaya	Amas	Akauna	7.74	1101	715.65	450	82	59.535	42.15	12.24	329.4	0	159.75	13.88	42.14	1.38
40	Gaya	Gurua	Raghunath Khap.	7.54	1305	848.25	450	62	71.685	93.14	1.9	378.2	0	188.15	25.18	50.43	1.27
41	Gaya	Guraru	Guraru	7.44	1625	1056.25	495	104	57.105	126.76	32.23	439.2	0	227.2	5.5	121.57	1.17
42	Gaya	Konch	Konch	7.68	2870	1865.5	1040	228	114.21	156.98	44.12	976	0	386.95	8.65	72.23	1.37
43	Gaya	Tekari	Tekari (Bahaliya bigha more)	7.63	1325	861.25	515	68	83.835	56.45	17.89	372.1	0	177.5	19.35	87.12	1.02
44	Gaya	Gaya Sadar	Ram Kund	7.58	1295	841.75	415	64	61.965	87.94	30.54	384.3	0	163.3	25.18	76.9	1.41
45	Gaya	Gaya	Bitho Sharif	7.29	2111	1372.15	825	170	97.2	103.54	1.7	317.2	0	465.05	25.18	114.3	0.89
46	Gaya	Bela	Paligaon	7.83	748	486.2	295	80	23.085	36.3	1.8	396.5	0	21.3	7.25	8.14	1.09
47	Nalanda	Hilsa	Karaiparsurai	7.42	1412	917.8	490	106	54.675	86.13	25.03	579.5	0	85.2	5.21	95.83	0.55



48	Nalanda	Hilsa	Hilsa	7.43	1031	670.15	300	64	34.02	84	22.8	506.3	0	56.8	2.98	16.91	0.89
49	Nalanda	Ekangarsarai	Ekangarsarai (Ekangardih)	7.76	2090	1358.5	715	42	148.23	116.3	56.7	719.8	0	223.65	28.3	111.65	0.9
50	Nalanda	Islampur	Sherpur	7.3	521	338.65	170	26	25.515	39.21	3.77	268.4	0	17.75	0.66	7.47	0.66
51	Nalanda	Islampur	Islampur	7.5	692	449.8	190	28	29.16	69.54	1.47	390.4	0	14.2	1.11	5.97	0.52
52	Nalanda	Neemchak	Ankuri Bazar	7.29	864	561.6	250	42	35.235	82.6	1.44	384.3	0	53.25	10.23	30.54	0.89
53	Nalanda	Rajgir	Pilkhi	7.46	711	462.15	190	22	32.805	76.89	1.33	341.6	0	31.95	0.68	27.5	0.95
54	Nalanda	Rajgir	Rajgir	7.11	689	447.85	250	46	32.805	36.5	10.59	341.6	0	31.95	0.06	19.22	0.65
55	Nalanda	Silao	Bhui	7.53	3310	2151.5	1065	230	119.07	188.35	140	890.6	0	504.1	27.47	182.45	0.78
56	Nalanda	Silao	Silao	7.39	1732	1125.8	595	122	70.47	104.65	34.85	494.1	0	252.05	7.07	96.58	0.65
57	Nalanda	Bari	Nirpur	7.46	828	538.2	190	22	32.805	101.65	1.28	402.6	0	31.95	0.42	35.47	0.91
58	Nalanda	Rajgir	Nalanda	7.5	1611	1047.15	465	66	72.9	121.1	57.5	591.7	0	149.1	14.75	95.35	0.93
59	Nalanda	Silao	Kundalpur	7.3	747	485.55	200	40	24.3	76.4	5.23	353.8	0	24.85	8.6	39.01	0.8
60	Nalanda	Noorsarai	Papanhosa	7.29	1355	880.75	480	118	44.955	85.13	7.19	353.8	0	184.6	26.72	100.7	0.68
61	Nalanda	Prawalpur	Parwalpur	7.44	1244	808.6	345	26	68.04	125.87	0.97	329.4	0	205.9	21.64	42.47	0.99
62	Nalanda	Ekangarsara	Parwalpur1	7.13	1364	886.6	430	42	78.975	112.98	1.77	433.1	0	170.4	25.44	60.21	0.84
63	Nalanda	Ekangarsarai	Nishchalganj	7.25	1112	722.8	285	50	38.88	119.38	11.59	433.1	0	106.5	3.52	48.69	0.8
64	Nalanda	Noorsarai	Daudpur	7.29	1089	707.85	355	46	58.32	72.47	22.31	433.1	0	85.2	26.05	41.99	0.95
65	Nalanda	Bihar Sharif	Maghra	7.43	833	541.45	315	62	38.88	44.43	2.12	347.7	0	49.7	15.08	45.17	0.62
66	Nalanda	Biharsharif	Biharsharif	7.27	1364	886.6	440	70	64.395	106.32	10.56	469.7	0	149.1	22.31	65.16	0.5
67	Nalanda	Bihar Sharif	Sohdh	7.21	1395	906.75	430	80	55.89	120.21	1.53	457.5	0	142	26.72	90.42	0.44
68	Nalanda	Noorsarai	Heganpura	7.35	1153	749.45	380	78	44.955	88.241	1.74	372.1	0	106.5	20.21	101.88	0.48
69	Nalanda	Rahui	Doiya	7.29	832	540.8	270	42	40.095	63.6	2.73	329.4	0	39.05	0.14	83.92	0.7
70	Nalanda	Bihar Sharif	Ranabigha	7.33	1682	1093.3	555	106	70.47	130.61	1.17	451.4	0	213	26.05	145.78	0.67
71	Nalanda	Giriak	Pawapuri	7.41	671	436.15	255	48	32.805	35.41	1.15	341.6	0	28.4	2.43	13.75	0.62
72	Nalanda	Rajgir	Sithuara	7.43	2110	1371.5	690	104	104.49	153.88	22.68	677.1	0	269.8	4.06	99.87	1.5
73	Nalanda	Chandi	Bhathar	7.47	1632	1060.8	530	70	86.265	118.14	24.55	561.2	0	166.85	18.07	102.43	0.4

74	Nalanda	Chandi	Chandi	7.75	1044	678.6	305	52	42.525	96.97	6.05	518.5	0	53.25	0.26	22.56	0.63
75	Nalanda	Chandi	Nagarnausa	6.92	1225	796.25	395	58	60.75	98.01	1.96	341.6	0	191.7	0.06	57.88	0.61
76	Nalanda	Harnaut	Harnaut1	7.3	1732	1125.8	520	70	83.835	145.11	21.95	530.7	0	205.9	25.44	114.59	0.86
77	Nalanda	Rahui	Vena	7.25	928	603.2	345	46	55.89	50.35	9.91	366	0	71	25.68	44.38	0.83
78	Nalanda	Asthawan	Jakhaur	7.26	739	480.35	300	56	38.88	29.87	1.76	280.6	0	67.45	0.18	40.01	0.63
79	Nalanda	Sarmera	Sarmera	7.28	1128	733.2	400	62	59.535	58.87	29.68	475.8	0	92.3	0.7	45.3	0.91
80	Nalanda	Bihar Sharif	Muraura	8.27	1361	884.65	400	64	58.32	105.3	41.23	549	12	127.8	1.81	42.32	1.29
81	Nalanda	Bihar Sharif	Bihar Sharif (Rly Stn)	8.14	3009	1955.85	1070	264	99.63	175.3	43.15	786.9	0	521.85	1.4	110.21	1.54
82	Nalanda	Asthawan	Asthawan	8.15	1105	718.25	315	70	34.02	95.87	20.21	420.9	0	74.55	20.23	79.13	1.61
83	Nalanda	Asthawan	Sare	8.21	894	581.1	225	40	30.375	95.61	12.35	433.1	0	39.05	1.12	29.76	1.52
84	Nalanda	Asthawan	Jangipur	8.06	715	464.75	235	38	34.02	50.84	10.41	353.8	0	21.3	0.04	30.97	1.21
85	Nalanda	Giriak	Giriak	7.84	745	484.25	280	50	37.665	41.25	3.2	286.7	0	56.8	19.38	34.99	0.98
86	Nawada	Warshaliganj	Shahpur Morh	7.98	1307	849.55	380	88	38.88	103.2	39.8	433.1	0	124.25	4.41	110	1.16
87	Nawada	Warshaliganj	Warshaliganj	7.87	1421	923.65	430	82	54.675	105.32	41.95	469.7	0	177.5	7.98	60.54	1.45
88	Nawada	Pakribarwan	Pakribarwan	8.06	1040	676	335	62	43.74	81.6	2.9	347.7	0	124.25	23.8	37.63	1.35
89	Nawada	Kawakol	Kawakol Ashram	8.08	798	518.7	325	18	68.04	33.14	2.9	390.4	0	35.5	1.84	20.83	1.67
90	Nawada	Nawada	Nawada2	7.77	643	417.95	240	40	34.02	33.88	4.7	305	0	39.05	6.8	8.94	1.21
91	Nawada	Nawada	Gonama	7.76	1115	724.75	380	80	43.74	71.74	15.7	445.3	0	102.95	6.95	37.1	1.57
92	Nawada	Nawada	Garhpar	7.78	1033	671.45	410	84	48.6	47.53	2.68	298.9	0	142	25.63	42.84	1.15
93	Nawada	Pakribarwan	Roh	7.6	1598	1038.7	550	112	65.61	103.51	17.62	427	0	244.95	25.63	78.21	1.61
94	Nawada	Kauakol	Rupau	7.86	2365	1537.25	810	162	98.415	145.38	43.27	671	0	397.6	3.92	65.14	0.78
95	Nawada	Gobindpur	Bishunpur	8.09	496	322.4	200	22	35.235	18.81	6.87	195.2	0	42.6	0.87	21.78	1.22
96	Nawada	Rajauli	Dopata	8.23	625	406.25	210	26	35.235	43.87	3.7	311.1	0	28.4	3.05	13.95	1.35
97	Nawada	Hisua	Hisua	7.96	595	386.75	215	28	35.235	36.35	1.46	286.7	0	31.95	4.21	11.76	1.12
98	Nawada	Narhat	Khanwa	7.87	1136	738.4	335	46	53.46	83.22	39.31	427	0	81.65	21.96	80.21	1.2
99	Nawada	Sirdala	Nawabganj	7.8	775	503.75	165	38	17.01	99.12	3.58	414.8	0	24.85	2.89	8.02	1.65

100	Nawada	Meskaur	Meskaur	7.75	2265	1472.25	775	122	114.21	142.14	40.21	512.4	0	362.1	40.21	155.92	1.63
101	Nawada	Hisua	Tungi	7.84	925	601.25	330	64	41.31	57.94	3.84	347.7	0	85.2	21.58	36.54	1.36
102	Sheikhpura	Berbiga	Keoti	7.08	1602	1041.3	485	112	49.815	123.21	34.5	524.6	0	209.45	0.93	72.97	0.7
103	Sheikhpura	Berbiga	Koeri Biga	7.28	1055	685.75	425	94	46.17	43.2	8.81	475.8	0	56.8	15.3	40.1	0.65
104	Sheikhpura	Berbiga	Sherpar	7.41	931	605.15	385	64	54.675	32.63	6.1	341.6	0	106.5	0.07	34.4	0.19
105	Sheikhpura	Barbiga	Barbiga	7.29	1208	785.2	465	106	48.6	50.11	25.43	390.4	0	145.55	25.07	52.15	0.58
106	Sheikhpura	Sheikhpura	Nemdarganj	7.35	811	527.15	290	46	42.525	43.05	14.73	390.4	0	42.6	0.84	22.53	0.91
107	Sheikhpura	Ariari	Ariari	8.7	1608	1045.2	525	118	55.89	103.54	43.12	524.6	36	159.75	3.92	76.85	1.67
108	Sheikhpura	Chewara	Chewara	8.62	981	637.65	230	44	29.16	101.2	29.42	390.4	33	56.8	14.46	21.24	1.63
109	Sheikhpura	Ghat Kusumba	Ghat Kusumba	7.89	731	475.15	230	34	35.235	60.46	2.5	378.2	0	24.85	0.83	16.21	1.37
110	Sheikhpura	Barbiga	Ambari	7.82	1385	900.25	400	48	68.04	121.09	24.87	384.3	0	163.3	24.96	117.65	1.04

**Major Chemical Parameters of Ground Water Samples of HNS Collected During in Bihar (Zone VIII)**

S.no	District	BLOCK	LOCATION	pH	EC	TDS	TH	Ca <sup>2+</sup>	Mg <sup>2+</sup>	Na <sup>+</sup>	K <sup>+</sup>	HCO <sub>3</sub> <sup>-</sup>	CO <sub>3</sub> <sup>2-</sup>	Cl <sup>-</sup>	NO <sub>3</sub> <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>	F <sup>-</sup>
					( $\mu\text{S cm}^{-1}$ )	In mg L <sup>-1</sup>											
1	Banka	Banka	Banka	7.41	690	448.5	190	40	21.87	56.22	1.38	215.25	0	55.39	18.62	59.24	0.22
2	Banka	Barahat	Barahat	7.34	608	395.2	130	18	20.65	71.38	5.29	264.45	0	30.85	BDL	50.98	1.17
3	Banka	Baunsi	Baunsi	8.19	884	574.6	310	66	35.23	61.68	0.91	129.15	0	153.28	25.47	65.29	1.39
4	Banka	Chandan	Chandan	7.48	476	309.4	180	42	18.225	32.84	1.74	209.1	0	21.92	18.5	16	0.77
5	Banka	Amarpur	Englishmore	7.82	660	429	160	44	12.15	44.36	44.28	202.95	0	28.75	19.37	74.3	0.04
6	Banka	Shambhuganj	Fullidumar	7.64	518	336.7	120	28	12.15	64.25	2.87	227.55	0	32.36	15.43	38	1.13
7	Banka	Katauria	Katauria	8.11	729	473.85	310	62	37.665	45.1	1.59	221.4	0	74.6	25.4	61	0.44
8	Banka	Shambhuganj	Mirjapur	8.51	945	614.25	150	20	24.3	127.15	10.78	350.55	15	78.24	BDL	26	1.77
9	Banka	Baunsi	Panjwara	7.63	381	247.65	150	26	20.65	22.48	7.09	166.05	0	28.05	BDL	30.89	0.37

10	Banka	Shambhuganj	Shambhuganj	7.76	724	470.6	180	26	28.31416	76.92	4.29	252.15	0	48.35	BDL	59	0.54
11	Banka	Shambhuganj	Karharia	8.42	1320	858	415	38	77.76	85.37	1.26	141.45	12	340	19.35	26	1.01
12	Jamui	Jamui	Aghara	7.88	665	432.25	215	36	30.13696	55.32	0.89	276.75	0	28.87	1.8	41.9	0.48
13	Jamui	Jhajha	Ambedkar Nagar	7.79	537	349.05	230	60	19.44	29.41	3.14	184.5	0	44.21	23	42.38	0.28
14	Jamui	Sono	Batia	7.29	506	328.9	170	30	22.84	48	1.17	196.8	0	35.45	8.47	28.3	0.79
15	Jamui	Chakai	Chakai	7.41	832	540.8	265	38	41.31	71.95	3.8	141.5	0	127.85	13.95	75.12	0.28
16	Jamui	Chakai	Chandra Mandih	8.35	750	487.5	205	30	31.59	64.9	1.92	196.8	3	113.6	BDL	51.26	1.51
17	Jamui	Jhajha	Harna	8.39	401	260.65	105	26	9.72	45	0.13	110.7	9	35.4	28.6	25.69	2.19
18	Jamui	Jamui	Jamui	7.31	649	421.85	200	30	30.137	71.25	1.06	209.1	0	47.36	15	67.54	1.24
19	Jamui	Jhajha	Jhajha	8.28	723	469.95	255	48	32.805	49.13	1.35	123	0	114.85	44	36.9	0.49
20	Jamui	Lakshmipur	Lalmatia	8.28	458	297.7	140	20	21.87	33.58	0.74	221.4	0	3.54	18.9	22.5	1.59
21	Jamui	Lakshmipur	Lakshmipur	7.25	589	382.85	117	14	19.80776	69.31	0.95	123	0	89.31	35.6	21.8	0.15
22	Jamui	Jamui	Manjhwe	8.43	633	411.45	154	24	22.84	79.67	1.68	295.2	15	35.4	BDL	22.32	3.56
23	Jamui	Khaira	Purna Khaira	7.75	492	319.8	95	26	7.29	58.76	1.28	172.2	0	41.62	BDL	31.9	0.83
24	Jamui	Sikandra	Sikandra	8.39	627	407.55	165	22	26.73	71.6	1.87	295.2	12	23.74	BDL	22.85	0.36
25	Jamui	Sono	Sono	8.33	722	469.3	145	28	18.225	85.74	1.12	319.8	3	29.65	17.28	21.8	0.69
26	Jamui	Chakai	Tarakhakhar	8.08	473	307.45	150	28	19.44	35.6	1.34	184.5	0	17.35	35.4	39.8	0.78

**Major Chemical Parameters of Ground Water Samples of HNS Collected During in Bihar (Zone IX)**

S.no	District	BLOCK	LOCATION	pH	EC	TDS	TH	Ca <sup>2+</sup>	Mg <sup>2+</sup>	Na <sup>+</sup>	K <sup>+</sup>	HCO <sub>3</sub> <sup>-</sup>	CO <sub>3</sub> <sup>2-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>	NO <sub>3</sub> <sup>-</sup>	F <sup>-</sup>
					( $\mu\text{S cm}^{-1}$ )	In mg L <sup>-1</sup>											
1	Bhagalpur	Rangra	Madrauni chowk	7.34	657	427	300	86	20.655	5.02	4.38	323.3	0	14.2	34.04	1.74	0.11

2	Bhagalpur	Bihpur	Bihpur	7.9	445	289	170	36	19.44	12.81	6.24	109.8	0	35.5	50.79	28.79	0.03
3	Bhagalpur	Naugachia	Naugachia	7.85	1390	904	550	120	60.75	56	4.17	420.9	0	173.95	36	62	0.14
4	Bhagalpur	Bihpur	Mairwa	7.79	659	428	285	70	26.73	12	3.54	286.7	0	28.4	20.26	31	0.12
13	Bhagalpur	Sultanganj	Akbarnagar	7.33	499	324.35	155	30	19.44	45.9	1.83	227.55	0	21.2	38.6	4.19	0.61
14	Bhagalpur	Bhagalpur	Bhagalpur	7.96	534	347.1	170	32	21.87	49.38	1.14	246	0	38.99	28.7	0	0.35
15	Bhagalpur	Kahalgaon	Ghogha	8.38	763	495.95	285	56	35.23	45	0.01	153.8	9	99	63.81	31.26	0.31
16	Bhagalpur	Colgong	Harchandpur	8.43	411	267.15	145	36	13.365	29.65	1.55	141.45	12	17.36	41.85	11.4	0.5
17	Bhagalpur	Colgong	Jaganathpur	7.55	613	398.45	185	40	20.65	46.87	1.04	227.55	0	41.23	33.56	20.51	0.34
18	Bhagalpur	Pirpanti	Pirpanti	7.49	829	538.85	255	34	41.23	60.5	1.2	270.6	0	67.35	66	25.37	0.25
19	Bhagalpur	Sabour	Sabour	7.83	633	411.45	160	44	12.15	71.5	1.95	184.5	0	53.7	75.49	29.8	0.55
20	Bhagalpur	Shahkund	Shahkund	7.27	597	388.05	170	10	35.23	48.34	0.98	246	0	36.05	44.9	0	0.69
21	Bhagalpur	Sultanganj	Sultanganj	8.31	571	371.15	185	20	32.8	51.26	1.33	270.6	3	24.69	49.1	0	0.38
5	Lakhisarai	Surajgarha	Arma	8.37	2360	1534	570	88	85.05	268.49	5.05	578.1	9	287.58	139.34	41.8	0.59
6	Lakhisarai	Barhaiya	Barhaiya	7.14	629	408.85	155	28	20.65	78	1.02	319.8	0	30.39	35.12	2.8	0.51
7	Lakhisarai	Barhaiya	Dariyapur	8.16	730	474.5	255	26	46.17	38.51	2.9	153.75	0	112	38	42	0.25
8	Lakhisarai	Surajgarha	Kajra	8.33	1278	830.7	380	52	60.75	98.69	0.7	510.45	3	121.95	25.11	17	1.49
9	Lakhisarai	Surajgarha	Kiul	7.94	496	322.4	207	30	32	15	1.78	129.15	0	60.15	43.7	0	0.79
10	Lakhisarai	Lakhisarai	Lakhisarai	7.66	403	261.95	145	30	17.01	25.3	1.02	153.75	0	28.74	30.85	5.7	0.2
11	Lakhisarai	Surajgarha	Rishi Paharpur	8.09	598	388.7	230	18	44.95	18.57	0.9	166.05	0	81	35.49	0	0.48
12	Lakhisarai	Surajgarha	Saidpur	7.36	1482	963.3	560	98	76.54	74.27	1.12	338.25	0	181.53	125	15.64	0.81
22	Munger	Asarganj	Asarganj	8.29	1692	1099.8	415	80	52.24	124.25	150.24	535.05	0	184.6	86.24	21.53	0.39
23	Munger	Bariarpur	Bariarpur	7.62	1749	1136.85	512	48	95.17	131.85	2.08	418.05	0	235.85	108.97	17	0.55
24	Munger	Kharagpur	Gangatamore	8.14	648	421.2	140	26	18.225	76.35	0.85	270.6	0	59.3	30.85	0	0.47
25	Munger	Kharagpur	Gobadda	8.28	927	602.55	355	42	60.75	52.67	1.09	430.5	0	65	34.26	1.27	0.84
26	Munger	Jamalpur	Jamalpur	8.19	670	435.5	260	18	52.24	21.4	0.7	199	0	68.31	41.9	11.85	0.49
27	Munger	Munger	Purabsarai	7.78	764	496.6	275	40	42.525	61.28	1.54	215.25	0	71.18	77	27.46	0.28
28	Munger	Sangrampur	Rampur	8.12	372	241.8	105	22	12.15	35.82	1.89	184.5	0	23.76	15.25	0	0

29	Munger	Jamalpur	Singhiya Chowk	7.55	1290	838.5	320	36	55.89	114.35	19.8	295.2	0	201.73	44	8.3	0.95
30	Munger	Tarapur	Tarapur	7.65	580	377	245	34	38.88	15.9	5.9	227.55	0	49.2	35.25	0	0.47

## ANNEXURE B

### Suitability of ground water towards irrigation purpose in Zone I

S.no	District	Block	Location	SAR	% Na	RSC
1	E.Champaran	Chakia (Pipra)	Uttari Gavandra	0.83	22.22	0.50026
2	E.Champaran	Chakia	Chakia 1	2.34	44.60	3.30081
3	E.Champaran	Kalyanpur	Dharampur	0.59	18.10	0.20033
4	E.Champaran	Chiraiya	Chatia	3.81	40.95	-1.7988
5	E.Champaran	Patahi	Patahi	0.57	16.59	-0.3
6	E.Champaran	Chiraiya	Belai	3.79	53.70	3.00044
7	E.Champaran	Chiraiya	Chiraiya (Noliatola)	0.75	20.21	0.50025
8	E.Champaran	Ghorasahan	Bhakatiy Tola	4.74	47.17	-7.5987
9	E.Champaran	Ghorasahan	Ghorasahan	1.82	26.11	-9.9994
10	E.Champaran	Motihari	Chaudadanu	0.54	14.79	-0.1993
11	E.Champaran	Adapur	Shyampur	2.32	42.77	-3.0994
12	E.Champaran	Raxaul	Raxaul	0.69	22.63	0.40015
13	E.Champaran	Ramgarhwa	Raghunathpur	0.38	13.47	0.20038
14	E.Champaran	Motihari	Motihari (Banjaria thana)	0.89	23.36	1.70056
15	E.Champaran	Motihari	Lakhwara	1.59	36.05	-0.9991
16	E.Champaran	Motihari	Bairiya Bazar	0.61	18.36	0.10021
17	E.Champaran	Harshidhi	Murarpur	1.23	30.99	-0.0997
18	E.Champaran	Sangrampur	Dubey Tola	0.74	24.77	0.60039
19	E.Champaran	Harsidhi	Sheoraha	0.63	15.95	-1.0998
20	E.Champaran	Areraj	Radia	0.42	11.99	0.40059
21	E.Champaran	Paharpur	Bishunpur Matiyarwan	1.41	28.22	0.20051
22	W. Champaran	Chanpatia	Gurwalia	1.44	32.11	0.80051
23	W. Champaran	Lauria	Lauria	2.16	36.31	-1.8992

24	W Champaran	Lauriya	Shishwania	1.22	26.15	-0.0993
25	W. Champaran	Bagha	Belwa	1.26	25.24	-2.6991
26	W. Champaran	Bagha -1	Bagha	0.60	18.51	-1.2998
27	W. Champaran	Bagha	Mangalpur	0.21	5.72	-0.2995
28	W. Champaran	Ramnagar	Harnatanr	2.02	39.45	-0.0996
29	W. Champaran	Bagha	Naurangia	1.45	32.44	0.40033
30	W. Champaran	Sidhaw	Valmiki Nagar (Laxmipur)	2.46	43.23	0.70074
31	W. Champaran	Ramnagar	Taulaha	2.00	38.71	-0.2991
32	W. Champaran	Narkatia-ganj	BanspurPipra	0.63	22.25	0.70025
33	W. Champaran	Narkatiyaganj	Korigawa Chowk	0.46	15.80	0.20008
34	W. Champaran	Chanpatia	Chanpatia	0.63	18.34	0.10036
35	W. Champaran	Majhwalia	Majhwalia (Guruchurwa)	2.01	37.16	-0.0995
36	E.Champaran	Sugauli	Chapwa (Sugauli)	0.74	18.29	-0.9994
37	E.Champaran	Areraj	Govindganj	2.02	39.18	-0.3993
38	E.Champaran	Turkaulia	Nawada	0.72	17.59	0.10069
39	E.Champaran	Sangrampur (Areraj)	Dumaria	2.58	43.49	0.00077
40	E.Champaran	Kesaria	Rampur Kajuria Bazar	1.01	22.08	-0.5993
41	E.Champaran	Kotwa	Dipau	0.25	7.89	-0.7998
42	E.Champaran	Kesariya	Hussaini	2.40	38.94	1.00109
43	E.Champaran	Kesaria	Kizerpura	0.85	18.88	0.00076
44	E Champaran	Kesaria	Lala Chapra	1.30	29.37	-0.1998



**Suitability of ground water towards irrigation purpose in Zone II**

S.no	District	Block	Location	SAR	% Na	RSC
1	Siwan	Bhagwanpur	Malmaliachok	0.49301	15.7389	-0.4998
2	Siwan	Basantpur	Basantpur	0.84991	21.0667	0.10021
3	Siwan	Tarwara	Barharia	1.73632	26.7196	-3.0994
4	Siwan	Siwan	Haradia	0.61744	17.9044	-0.2998
5	Siwan	Siwan	Bhada Khurd, Mahajanmistri Mandir	0.59751	15.7721	-0.2997
6	Siwan	Mairwa	Mairwa, Near Petrol pump	0.77851	14.1406	-5.1996
7	Siwan	Mairwa	Mairwa, Shitalpura	0.12627	4.4288	-1.4998
8	Siwan	Guthani	Chitakal	0.22199	9.31331	-0.0998
9	Siwan	Guthani	Deoria	0.38169	9.63058	-1.6997
10	Siwan	Darauli	Mairwa-Darauli Rd.	0.35749	11.471	0.0003
11	Siwan	Ander	Ander	0.72114	18.7087	0.50025
12	Siwan	Raghunathpur	Murarpatti	2.48769	34.6348	-1.5995
13	Siwan	Siswan	Bhagar	0.27746	7.11819	-1.7997
14	Siwan	Siswan	Gangpur-Siswan	0.36707	11.5062	-0.4997
15	Siwan	Maharajganj	Maharajganj-Pansouli	1.98295	30.8374	-0.7996
16	Siwan	Panchrukhi	Sadikpur	0.14831	6.075	-0.1998
17	Siwan	Siwan	Siwan	0.4724	11.7216	-1.6997
18	Siwan	Basantpur	Chimapura	0.52656	13.1994	0.00036
19	Siwan	Bhagwanpur	Sarripatti	0.83116	17.1957	-2.3997
20	Gopalganj	Kateya	Kateya-Bankata Rd.	0.25464	8.88871	-0.8998
21	Gopalganj	Kateya	Lalpachmaha	0.73786	21.9411	0.00015
22	Gopalganj	Bijaipur	Bijaipur	0.88322	26.18	-0.1998
23	Gopalganj	Bhore	Bhore Police Station	1.43365	22.1963	-5.6996

24	Gopalganj	Bhore	Mishir Batraha	0.6262	12.9178	-3.7998
25	Gopalganj	Hathua	Hathua Palace	0.50205	14.6913	-0.3998
26	Gopalganj	Thawe	Lacchawar	1.04875	25.1692	0.60013
27	Gopalganj	Barauli	Barauli	0.87566	21.5915	0.9002
28	Gopalganj	Manjha	Phulwaria/Imilia	1.21431	31.4262	1.1002
29	Gopalganj	Manjha	Bishmbarapur	1.22978	31.4798	0.80021
30	Gopalganj	Manjha	Manjha	0.54719	12.4612	-1.9996
31	Gopalganj	Kuchaikot	Jalalpur	1.84148	28.7492	-2.5995
32	Gopalganj	Kuchaikot	Police Thana	0.93597	25.0721	0.50018
33	Gopalganj	Gopalganj	Yadavpur	0.53453	13.7875	-0.4998
34	Gopalganj	Gopalganj	Gopalganj Town	1.44407	26.5301	0.70137
35	Gopalganj	Sidhawalia	Sidhawalia	0.64682	16.2603	-0.9998
36	Gopalganj	Mohammadpur	Bhojpurwa	0.74701	17.5133	0.40038
37	Gopalganj	Baikunthpur	Deokoli	1.29366	26.6933	0.40039
38	SARAN	DIGHWARA	Ammi	1.39248	28.587	0.31597
39	SARAN	EKMA	Bishunpur	1.11185	28.7115	1.53455
40	SARAN	JALALPUR	Bisunpur	1.31373	30.7598	0.7103
41	SARAN	MANJHI	Breja	2.52239	41.3978	-0.1726
42	SARAN	CHAPRA	Chhapra	0.75786	18.806	-0.7355
43	SARAN	CHAPRA	Chirand	2.29662	39.1187	-0.3247
44	SARAN	CHAPRA	Daldali Bazar A	0.88142	18.4229	-2.8669
45	SARAN	GARKHA	Garkha	1.21644	31.0341	1.11192
46	SARAN	MANJHI	Majhanpura New	2.14957	26.6892	-9.3021
47	SARAN	MANJHI	Manjhi 2	0.8954	22.0544	0.18932
48	SARAN	MANJHI	Mansath	0.96872	24.2975	0.83975
49	SARAN	MARHAURA	Marhaura	1.36543	32.5256	0.83455
50	SARAN	MASHRAKH	Masrakh	1.58691	33.817	2.13947

51	SARAN	MASHRAKH	Masrakh1	1.75326	31.0363	-0.9306
52	SARAN	GARKHA	Minapur	2.48786	37.7999	-2.2857
53	SARAN	SONEPUR	Nayagaon	1.27535	23.0801	-4.0824
54	SARAN	PARSA	Saguni	1.14754	24.4029	1.32251
55	SARAN	REVELGANJ	Sanghar Tola	2.46595	32.8367	-3.6307
56	SARAN	SONEPUR	Sonepur1	2.20612	41.0388	0.27159

### Suitability of ground water towards irrigation purpose in Zone III

S.no	District	Block	Location	SAR	% Na	RSC
1	Begusarai	Barauni	Chakiya	3.98	55.81	0.40056
2	Begusarai	Barauni	Barauni 0 - mile	0.83	18.91	-0.09944
3	Begusarai	Barauni	Barauni	0.74	18.80	-1.29951
4	Begusarai	Teghra	Nayanagar	1.32	28.22	0.60079
5	Begusarai	Teghra	Teghra	0.59	14.75	-1.39933
6	Begusarai	Begusarai	Harpur dhala	0.50	14.53	-0.39941
7	Begusarai	Cheria bariarpur	Cheria bariarpur	3.41	46.96	-1.89916
8	Begusarai	Begusarai	Bareibighu	1.26	28.32	0.000625
9	Begusarai	Balia	Bariarpur	0.15	6.62	-0.29947
10	Begusarai	Matihani	Badalpura	0.41	11.58	-0.79923
11	Begusarai	Sahebpur Kamal	Heera tola	0.44	15.35	-0.59952
12	Begusarai	Balia	Choti balia	0.44	13.06	-1.49942
13	Begusarai	Balia	Laxminia	2.80	46.31	0.200494
14	Begusarai	Sahebpur Kamal	New jafar nagar	1.10	22.18	-1.49934
15	Begusarai	Sahebpur Kamal	Bintoli kalyanpur	0.76	19.98	-1.09903
16	Begusarai	Sahebpur Kamal	Sabdapur	0.25	18.43	-0.39933
17	Begusarai	Begusarai	Hardia	2.29	38.96	-0.89905

18	Begusarai	Begusarai	Mohanpur usrai	0.76	19.01	-0.19924
19	Begusarai	Cheria bariarpur	Gopalpur	0.68	14.70	-2.89914
20	Begusarai	Bakhri	Simri	0.93	24.15	-0.89909
21	Begusarai	Bakhri	Bakhri Saluna	2.79	49.52	1.900477
22	Begusarai	Bakhri	Bagrash	2.29	42.09	0.200395
23	Begusarai	Cheria bariarpur	Manjhaul	3.25	34.71	-22.5975
24	Begusarai	Balia	Parihara	0.85	23.11	0.70056
25	Begusarai	Begusarai	Lakho	1.05	24.53	0.600823
26	Darbhanga	Darbhanga Sadar	Darbhanga Sadar	1.56	34.67	-0.09961
27	Darbhanga	Keoty	Darima	2.59	44.79	-0.19933
28	Darbhanga	Benipur	Bahera (Brahmnathyhogma)	1.20	25.16	-0.29949
29	Darbhanga	Baheri	Baheri	1.35	26.39	-1.59949
30	Darbhanga	Baheri	Bithauli	3.61	61.80	0.100296
31	Darbhanga	Baheri	Jorja	3.94	57.86	2.40056
32	Darbhanga	Hayaghat	Pouram	2.73	46.23	-0.09931
33	Darbhanga	Hayaghat	Rustampur	1.89	39.81	0.100658
34	Darbhanga	Sakri	Sakri	0.75	18.64	-0.89956
35	Khagaria	Khagaria	Khagaria	0.72	18.41	-0.79937
36	Khagaria	Khagaria	Ranko	1.38	28.51	-0.49944
37	Khagaria	Gogri	Jamalpur	0.36	9.85	0.200592
38	Khagaria	Gogri	Gogri	1.01	23.97	-0.59909
39	Khagaria	Parbatta	Baisa(Pz)	0.22	6.70	-0.99933
40	Khagaria	Parbatta	Mohaddipur	0.99	23.49	-0.19926
41	Khagaria	Parbatta	Dewri	2.71	39.52	-2.29895
42	Khagaria	Khagaria	Sonhauili	0.92	20.56	-1.29939
43	Khagaria	Khagaria	Sabdalpur	0.47	13.44	0.100461

44	Khagaria	Chautham	Mansi	0.51	14.76	0.600774
45	Khagaria	Chautham	Lohiya chowk	1.48	21.48	-4.59914
46	Khagaria	Chautham	Chautham	0.52	14.68	-0.79913
47	Khagaria	Khagaria	Kasimpur	0.35	10.16	-0.09926
48	Khagaria	Khagaria	Labhgaon	0.39	10.76	-0.09928
49	Khagaria	Khagaria	Gangaur	0.78	19.50	-1.39939
50	Khagaria	Khagaria	Durgapur	0.30	10.05	-0.89924
51	Madhubani	Benipatti	Kapasia	1.94	44.07	0.000181
52	Madhubani	Phulparas	Siswar	2.05	40.29	1.100691
53	Madhubani	Phulparas	Phulparas1	2.32	44.83	1.500362
54	Madhubani	Karmauli	Karmauli	2.19	51.33	0.500296
55	Madhubani	Jhanjharpur	Jhanjharpur	1.40	43.59	0.200197
56	Madhubani	Laukaha (Khutauna)	Ambedkar Nagar	2.38	51.24	2.600313
57	Madhubani	Babu Barhi	Babubarhi	2.25	47.49	2.200362
58	Madhubani	Harlakhi	Baurahar Chowk	1.73	35.64	0.200724
59	Madhubani	Benipatti	Benipatti	1.09	37.05	0.800197
60	Madhubani	Khajauli	Bentadih	1.64	32.61	-0.49916
61	Madhubani	Pandaul	Bhawanipur	2.10	45.33	1.900395
62	Madhubani	Madhwapur	Bihari	0.84	29.33	0.200296
63	Madhubani	Benipatti	Dhakjari	3.25	57.74	1.30023
64	Madhubani	Harlakhi	Harlakhi	3.93	60.06	3.000494
65	Madhubani	Andhratharhiy	Harari	2.05	43.27	1.300411
66	Madhubani	Jaynagar	Jaynagar	1.02	25.02	1.000362
67	Madhubani	Jhanjharpur	Jhanjharpur	0.77	19.35	-1.99946
68	Madhubani	Ladania	Jogiya	1.16	30.51	0.700362
69	Madhubani	Benipatti	Kapasia	1.67	45.92	1.300165
70	Madhubani	Kakraul, Madhubani	Kapileshwar Asthan	2.79	54.19	2.000296

71	Madhubani	Karmnali	Karmnali	2.11	50.57	1.600165
72	Madhubani	Khajauli	Khajauli	2.70	48.23	-0.59965
73	Madhubani	Madhubani	Madhubani	2.76	51.40	0.900313
74	Madhubani	Khajauli	Narar	1.64	39.05	0.00056
75	Madhubani	Pandaul	Pandaul	0.81	22.99	-1.59959
76	Madhubani	Rajnagar	Pariharpur	2.54	47.72	0.500625
77	Madhubani	Pandaul	Shambhuar	2.06	40.53	2.200625
78	Madhubani	Khajauli	Thantola (Khajauli)	1.28	24.75	-1.99951
79	Muzaffarpur	Paroo	Paroo NHS	2.05	31.88	-5.69837
80	Muzaffarpur	Paroo	Jaffarpur NHS	0.60	15.59	-0.89952
81	Muzaffarpur	Paroo	Deoria NHS	0.84	17.69	-4.79929
82	Muzaffarpur	Sahebganj	Daha Chhapra NHS	2.16	38.35	-1.69916
83	Muzaffarpur	Sahebganj	Rajwara NHS	2.65	36.68	-2.79811
84	Muzaffarpur	Sahebganj	Pratap Patti Baraun NHS	2.46	42.18	1.700576
85	Muzaffarpur	Baruraj (Motipur)	Mahammadpur Balmi (Malang Sthan) NHS	1.57	35.00	1.000428
86	Muzaffarpur	Dholi	Barkurwa More NHS	1.84	40.06	0.400461
87	Muzaffarpur	Dholi (Muraul)	Digra NHS	2.71	46.30	0.000543
88	Muzaffarpur	Turki	Mahant Maniyari (New Well)	2.44	49.52	3.700691
89	Muzaffarpur	Sakra	Seho NHS	2.54	37.14	-2.19893
90	Muzaffarpur	Dholi (Muraul)	Jahangirpur Tola NHS	2.79	43.32	1.70135
91	Muzaffarpur	Gayghat	Maithi	1.32	31.34	0.600362
92	Muzaffarpur	Bochaha	Maidapur Shukrahat NHS	2.88	48.00	2.600724
93	Muzaffarpur	Bochaha	Bochaha NHS	1.92	40.49	1.50051
94	Muzaffarpur	Katra	Ramnagar NHS	2.46	45.58	3.400132

95	Muzaffarpur	Katra	Katra 1 NHS	2.57	43.41	1.800741
96	Muzaffarpur	Mushahri	Bhagwanpur Chowk NHS	2.08	40.00	0.600411
97	Muzaffarpur	Mushahri	Patahi NHS	2.74	44.68	3.000543
98	Muzaffarpur	Aurai	Rajkhand NHS	2.96	46.56	-0.19926
99	Muzaffarpur	Aurai	Aurai NHS	2.77	61.33	1.800016
100	Muzaffarpur	Mushahri	Japaha NHS	3.18	48.69	1.100839
101	Muzaffarpur	Aurai	Rampur	1.88	33.49	-6.2986
102	Muzaffarpur	Minapur	Gargalia Minapur NHS	0.29	12.70	-0.09985
103	Muzaffarpur	Paroo	wazitpur/Bazidpur	2.01	37.43	2.000477
104	SAMASTIPUR	Vidyapatnagar	Sahit (Bajidpur)	2.15	35.62	-4.49911
105	SAMASTIPUR	KALYANPUR	Basudebpur	2.44	40.76	-1.49944
106	SAMASTIPUR	UJIARPUR	Dandia Asadpur	2.00	39.47	1.000477
107	SAMASTIPUR	JITWARPUR	Harpur Aloth	2.03	35.79	-0.99939
108	SAMASTIPUR	KALYANPUR	Jakhra	1.13	20.63	-3.99931
109	SAMASTIPUR	KALYANPUR	Jathmalpur	3.28	59.83	2.60023
110	SAMASTIPUR	BIBHUTPUR	Kalyanpur	2.06	46.68	1.800313
111	SAMASTIPUR	ROSERA	Kerian	2.87	37.84	-3.09844
112	SAMASTIPUR	WARISNAGAR	Kishanpur1	1.75	21.41	-13.0982
113	SAMASTIPUR	WARISNAGAR	Kuseya	2.22	38.33	-0.39944
114	SAMASTIPUR	MOHIUDDINAGAR	Madudabad	1.07	26.57	0.200379
115	SAMASTIPUR	HASANPUR	Malipur	1.94	38.56	1.000395
116	SAMASTIPUR	TAJPUR MORWA (MORWA)	Motipur	1.33	30.20	0.700444
117	SAMASTIPUR	BIBHUTPUR	Patapara	1.13	26.72	1.000329
118	SAMASTIPUR	WARISNAGAR	Raghunathpur	1.08	24.70	-0.99947
119	SAMASTIPUR	UJIARPUR	Raipur	2.12	34.08	-2.09868

120	SAMASTIPUR	ROSERA	Rosera	1.26	30.82	0.500247
121	SAMASTIPUR	SARAIANJAN	Sarai Ranjan	1.71	30.29	-1.09954
122	SAMASTIPUR	BIBHUTPUR	Singhia Ghat	1.25	25.61	-1.39952
123	SAMASTIPUR	TAJPUR MORWA (MORWA)	Tajpur1	0.82	20.16	0.200329
124	SAMASTIPUR	UJIARPUR	Ujiarpur	1.85	45.09	1.100263
125	SAMASTIPUR	TAJPUR MORWA (MORWA)	Vikrampur	1.13	23.11	-3.69956
126	Sheohar	Sheohar	Sarsaula Khurd NHS	2.80	39.80	-2.39969
127	Sheohar	Piprahi	Purnahiya Bazar NHS	1.61	42.88	1.300411
128	Sheohar	Sheohar	Sheohar	0.74	19.18	0.900461
129	Sheohar	Sheohar	Sasaula khurd	0.93	27.70	0.900362
130	Sheohar	Tariyani	sarbarpur	0.41	12.22	0.200494
131	Sheohar	Piprahi	Purnhaiya bazar	0.59	19.49	0.500395
132	Sitamarhi	Runnisaidpur	Thumba	0.94	28.92	0.500461
133	Sitamarhi	Sitamarhi	Sitamarhi	0.67	23.13	0.10023
134	Sitamarhi	Sitamarhi	Khaptola	0.83	27.59	0.600411
135	Sitamarhi	Bajpatti	Bangaon	1.22	35.70	0.900197
136	Sitamarhi	Pupri	Pupri	2.06	52.91	1.500181
137	Sitamarhi	Nanpur	Nanpur	1.55	42.25	1.500214
138	Sitamarhi	Riga	Riga	0.48	19.16	-0.09964
139	Sitamarhi	Suppi	Dheng	0.29	9.89	0.300444
140	Sitamarhi	Bathnaha	Yogwana	0.65	22.85	0.500329
141	Sitamarhi	Sitamarhi	Karhaniya chowk	0.63	23.05	0.300132
142	Sitamarhi	Sonbarsa	Dastiya	1.18	33.25	0.900329
143	VAISHALI	GORAUL	Bhaluhia (Garaul)	1.48	24.84	-5.6004
144	VAISHALI	BIDUPUR	Chak Sikandar	0.47	14.17	-0.06873



145	VAISHALI	GORAUL	Baksama	0.69	17.06	-0.45978
146	VAISHALI	GORAUL	Chandpur Kala	1.01	21.13	0.600935
147	VAISHALI	HAJIPUR	Hajipur	0.71	17.40	-1.56843
148	VAISHALI	GORAUL	Harpur	1.47	29.75	1.560902
149	VAISHALI	BIDUPUR	Kachanpur	1.26	30.17	0.56341
150	VAISHALI	MAHNAR	Mahnar	1.16	18.27	-4.81331
151	VAISHALI	MAHUA	Mahua I	0.56	16.30	-0.64612
152	VAISHALI	BIDUPUR	Mathura	1.00	24.22	0.429348
153	VAISHALI	LALGANJ	Namidh	1.26	19.34	-6.91167
154	VAISHALI	SAHDEI	Sahdei Bujurg	0.58	12.40	-3.40694
155	VAISHALI	HAJIPUR	Sahjadpur	0.76	16.81	-1.8391
156	VAISHALI	VAISHALI	Vaishali High School	1.05	20.92	-0.19907
157	VAISHALI	JANDAHA	Silautha Bisnupur	1.00	23.66	0.967459

#### **Suitability of ground water towards irrigation purpose in Zone IV**

S.no	District	Block	Location	SAR	% Na	RSC
1	Araria	Araria	Araria	0.00	4.45	-0.29997
2	Araria	Forbisganj	Bathnaha 1	0.35	13.33	-1.39974
3	Araria	Bhargama	Bhargama	0.00	4.66	-0.89992
4	Araria	Forbisganj	Hariarpur	0.07	10.43	-0.6998
5	Araria	Jokihat	Jokihat/Jhanpur	0.12	8.36	-1.79959
6	Araria	Forbisganj	Matiyari	0.05	6.25	-0.99985
7	Araria	Palasi	Palasi	0.54	19.71	-0.69951
8	Araria	Raniganj	Raniganj	0.24	11.94	-1.59951

9	Katihar	Amdabad	Balrampur	0.69	18.74	0.900181
10	Katihar	Barari	Barari 1	1.61	46.23	0.600099
11	Katihar	Pranpur	Basantpur	3.09	71.57	1.300033
12	Katihar	Pranpur	Bastaul 1	0.86	22.68	-1.59984
13	Katihar	Sameli	Dumaria	0.06	13.24	-0.29997
14	Katihar	Katihar	Hafla 1	0.49	19.79	0.400049
15	Katihar	Kadwa	Kadwa	0.42	30.70	0.400082
16	Katihar	Katihar	Katihar	1.81	38.62	0.700082
17	Katihar	Korha	Khiria	1.59	36.61	-0.6998
18	Katihar	Korha	Korha	1.31	30.96	0.300247
19	Katihar	Kursela	Kursela	0.88	19.98	-0.59944
20	Katihar	Falka (Belari)	Mahendarpur	1.59	30.39	-2.99939
21	Katihar	Manihari	Manihari	1.15	20.71	-2.69893
22	Katihar	Falka	Narahaiya	0.74	14.41	-2.99933
23	Katihar	Pranpur	Pranpur	0.00	6.17	-0.49992
24	Katihar	Kadwa	Sonali	0.01	1.78	-3.89982
25	Kishanganj	Bahadurganj	Bahadurganj	0.01	4.67	-0.29993
26	Kishanganj	Bahadurganj	Bahadurganj B	0.15	11.88	-0.39992
27	Kishanganj	Bahadurganj	Bhagalbari	0.00	8.43	-0.39995
28	Kishanganj	Bahadurganj	Gunsagar	0.26	23.66	-0.0999
29	Kishanganj	Pothia	Kaswa Kaliganj	0.00	2.36	-0.79987
30	Kishanganj	Kishanganj	Kishanganj	0.78	25.59	-0.89964
31	Kishanganj	Kochadhamin	Kochadhamin	0.00	3.96	-0.29987

32	Kishanganj	Teragachhi	Teragachhi	0.43	17.04	-1.09974
33	Madhepura	Chausa	Chausa	0.90	20.39	-1.79928
34	Madhepura	Chausa	Abhaytola	0.86	20.35	-1.09933
35	Madhepura	Chausa	Ganeshpur	0.72	25.76	0.000362
36	Madhepura	Bihariganj	Uda kisanganj	2.70	43.28	1.300757
37	Madhepura	Gwalpara	Gwalpara	0.70	16.82	-1.99909
38	Madhepura	Murliganj	Rampur	0.23	8.49	-0.89952
39	Madhepura	Murliganj	Bhatkora bazar	3.48	49.09	0.100922
40	Madhepura	Murliganj	Rajui	0.37	10.65	-2.19949
41	Madhepura	Bihariganj	Kusthan	2.19	41.53	-0.19946
42	Madhepura	Madhepura	Bhimpura	0.62	15.12	-1.09909
43	Madhepura	Murliganj	Murliganj	1.31	30.09	0.100444
44	Madhepura	Madhepura	Madhepura	1.35	26.90	-1.39928
45	Madhepura	Singheswar	Singheswar	1.53	41.94	0.400379
46	Madhepura	Singheswar	Barhari	0.29	9.72	-0.79961
47	Madhepura	Singheswar	Jiwaccchpur	0.62	19.06	-1.19946
48	Madhepura	Gamharia	Suryaganj	0.26	15.08	-0.19984
49	Purnea	Amour	Amour	0.81	31.50	0.100115
50	Purnea	Dhamdaha	Amri Kukran (East)	2.93	37.00	-1.19873
51	Purnea	Dhamdaha	Amri Kukran (west)	0.05	20.98	-0.09992
52	Purnea	Baisi	Basi 2	1.30	25.30	-0.79929

53	Purnea	Banmankhi	Banmankhi	0.00	5.73	-0.69985
54	Purnea		Barsoni	2.96	63.08	1.800066
55	Purnea	Banmankhi	Budhia Gola	0.56	19.63	-0.89987
56	Purnea	Baisi	Chadia (Chariya)	0.00	8.96	-0.59985
57	Purnea	Rupauli	Dargaha (SupauliSthan)	0.00	4.12	-0.29977
58	Purnea	Dhamdaha	Dhamdaha	0.48	15.06	-1.69959
59	Purnea	Jalalgarh	Jalalgarh	0.05	10.77	-0.19982
60	Purnea	Dhamdaha	Kajha	0.41	32.27	0.400132
61	Purnea	Kasba	Kasba	0.05	6.29	-0.59987
62	Purnea	Srinagar	Khata Hat	0.00	4.22	-0.69988
63	Purnea	Barhara	Mangujan	0.03	3.96	-0.69992
64	Purnea	Purnea	Purnea	0.00	4.01	-0.6998
65	Purnea	Purnea E	Ranipatra	0.10	5.17	-1.9999
66	Purnea	Rupauli	Tikapati chowk	0.61	18.60	-1.69967
67	Purnea	Rupauli	Tikapati	0.00	5.01	-0.29987
68	Saharsa	Sata Katya	Gangora Bihra	0.62	26.34	8.23E-05
69	Saharsa	Kahra	Belhi Teghra	1.89	41.62	0.800527
70	Saharsa	Simri Bakhtiyarpur	Jamunia	2.31	46.46	0.200609
71	Saharsa		Jamunia	1.16	35.20	-0.2997
72	Saharsa		Jamunia	1.46	47.37	0.400066
73	Saharsa	Sour Bazar	Arrha	1.26	32.45	0.00056

74	Saharsa	Norha	Bangaon.	1.89	39.68	0.100494
75	Saharsa	Kahara	Basudeva	1.21	26.46	-1.99926
76	Saharsa	Sour Bazar	Chandaur Purvi	0.53	23.27	-0.29988
77	Saharsa	Kahara	Kharkutti	2.31	53.53	1.000148
78	Saharsa	Kahara	Niralatola	1.45	37.71	0.400444
79	Saharsa	Satar Katya	Punchgachi	2.81	55.22	0.600444
80	Saharsa	Sata Katya	Patodi Bazar	1.39	38.23	0.60056
81	Saharsa	Sata Katya	Patodibazar	1.88	40.29	0.100411
82	Saharsa	Saharsa	Potwaha	0.92	30.81	0.000197
83	Saharsa	Saharsa	Saharsa 1	1.52	39.89	-0.69982
84	Saharsa	Simri Bakhtiarpur	Simri Bakhtiarpur 1	5.63	62.11	3.100905
85	Saharsa	Sonbarsaraj	Sonbarsaraj 1	1.88	36.15	0.300625
86	Saharsa	Kahara	Tulsiyahi	1.65	41.40	0.800362
87	Supaul	Tribeniganj	Tribeniganj	2.46	47.22	-0.19964
88	Supaul	Basantpur	Bhimnagar	3.06	53.71	2.00056
89	Supaul	Basantpur	Birpur	0.90	26.12	0.600428
90	Supaul	Raghopur	Ganpatganj	1.74	41.00	0.700247
91	Supaul	Marauna	Andauli	0.59	22.49	0.600263
92	Supaul	Balua	Balua 1	0.62	26.58	-0.1998
93	Supaul	Chhatarpur	Balua Bazar	0.03	6.83	-0.49961
94	Supaul	Raghopur	Basawanpatti	0.05	4.49	-0.69967
95	Supaul	Basantpur	Bhawanipur 1	0.60	20.00	-0.09946

96	Supaul	Marauna	Hardi	0.43	14.10	-0.79961
97	Supaul	Tribeniganj	Jadia	0.49	14.95	-1.69969
98	Supaul	Raghobpur	Kaithtola	0.80	31.60	-0.69982
99	Supaul	Marauna	Kario	2.26	35.30	-1.599
100	Supaul	Raghobpur	Karzain	1.10	30.80	0.000263
101	Supaul	Supaul	Malhani	0.58	19.19	0.100247
102	Supaul	Raghobpur	Norha	0.74	28.55	0.00023
103	Supaul	Pipra	Pipra Chowk	0.25	14.96	0.000148
104	Supaul	Raghobpur	Pratapganj	0.79	22.54	-0.89962
105	Supaul	Basantpur	Ratanpura	1.28	33.34	0.100461
106	Supaul	Pipra	Shym Nagar	0.91	27.96	0.400263
107	Supaul	Supaul	Supaul	2.52	46.44	0.600395
108	Supaul	Supaul	Thumha	0.62	20.76	-0.59969
109	Supaul	Supaul	Malhani-New	0.94	40.14	0.300148
110	Supaul	Basantpur	Bhimnagar	0.14	13.17	-0.39967

**Suitability of ground water towards irrigation purpose in Zone V**

S.no	District	Block	Location	SAR	% Na	RSC
1	Bhojpur	Udwantnagar	Harnathkundi	5.50	58.44	3.500444
2	Bhojpur	Koilwar	Mohammadpur	1.19	28.88	-1.49982
3	Bhojpur	Koilwar	Rajpurbazaar	0.40	10.18	-1.69959

4	Bhojpur	Udwantnagar	SasaramChhota	1.08	21.04	-1.99947
5	Bhojpur	Barhara	Simariya	0.55	14.14	-0.39977
6	Bhojpur	Barhara	Bakhorapur	0.53	20.02	-0.39979
7	Bhojpur	Barhara	Balua	1.09	63.33	0.400082
8	Bhojpur	Barhara	Barhara	1.01	17.74	-3.99951
9	Bhojpur	Sandesh	Baruna	3.59	45.22	-1.69942
10	Bhojpur	Bihiya	Bihiya(Dogra)	0.89	28.42	0.000444
11	Bhojpur	Koilwar	Birampur	0.83	16.45	-2.19967
12	Bhojpur	Arrah	Chandwa	0.65	16.37	0.100461
13	Bhojpur	Barhara	Dhusariya	1.18	22.37	-2.99928
14	Bhojpur	Barhara	Ekauna	0.55	16.81	0.00023
15	Bhojpur	Barhara	Farhda	0.72	24.83	-0.59957
16	Bhojpur	Garhani	Garhani(Nahsi)	3.21	47.95	2.700148
17	Bhojpur	Koilwar	Giddha	0.74	19.77	0.400313
18	Bhojpur	Sahar	Guljarpur	0.40	10.29	-0.29946
19	Bhojpur	Koilwar	Inglishpur	0.59	13.24	-1.59933
20	Bhojpur	Jagdishpur	Jagdishpur	1.51	32.12	-1.19977
21	Bhojpur	Barhara	Jagatpur	0.72	15.49	0.000461
22	Bhojpur	Arrah	JarawarpurMilki	4.77	64.52	5.100197
23	Bhojpur	Sahpur	Karnamepur	4.49	51.35	1.300543
24	Bhojpur	Udwantnagar	Kasap	0.65	17.79	0.100197
25	Bhojpur	Sandesh	Kori	0.75	17.62	-1.19939
26	Bhojpur	Koilwar	Kulhariya	0.78	18.53	-0.29956

27	Bhojpur	Koilwar	Lodhipur	0.78	19.77	-0.79965
28	Bhojpur	Arrah	MilkiDera	0.51	12.19	0.000197
29	Bhojpur	Koilwar	Mokhalisa	0.58	14.23	-0.79975
30	Bhojpur	Sandesh	Nasaratpur	0.82	16.88	-1.59962
31	Bhojpur	Koilwar	Panchrukhiya	0.41	12.12	-0.69965
32	Bhojpur	Sandesh	Pawana	5.46	57.73	2.300362
33	Bhojpur	Pirro	Pirro	1.35	23.30	-1.99954
34	Bhojpur	Koilwar	Sakkadiu	0.92	20.86	-0.69977
35	Bhojpur	Sandesh	Sandesh	4.37	49.93	-0.09949
36	Bhojpur	Koilwar	Songhata	0.62	15.47	-0.09987
37	Bhojpur	Udwantnagar	Udwantnagar	1.55	32.86	-2.09987
38	Bhojpur	Tarari	Bagar	0.56	14.63	-0.29982
39	Buxar	Brahmpur	Bagen bazar	1.39	34.51	1.500214
40	Buxar	Brahmpur	Brahmpur	0.85	25.15	1.10023
41	Buxar	Buxer	Buxer	1.42	28.25	-5.59979
42	Buxar	Chausa	chausa	4.40	64.49	5.500115
43	Buxar	Buxar	Churamanpur	0.98	17.48	-2.39946
44	Buxar	Buxar	Danikutia	1.97	37.29	1.90023
45	Buxar	Buxer	Dhudharchak	0.74	20.35	-0.99972
46	Buxar	Simri	Dumri	0.56	30.08	1.700214
47	Buxar	Simri	Karthar	0.67	22.16	-0.9998
48	Buxar	Brahmpur	Kochariwan	2.22	37.98	-1.29962
49	Buxar	Buxer	Kritpur	2.26	38.43	1.300329



50	Buxar	Brahmpur	Maharajganj	0.25	33.58	1.900115
51	Buxar	Buxar	Misharvaliya	0.13	29.78	2.100099
52	Buxar	Buxer	Thodagam	0.21	6.88	0.00023
53	Buxar	Simri	BarkaRajpur	0.38	10.04	-1.89972
54	Buxar	Dumraon	Dumraon	3.73	65.38	5.700099
55	Buxar	Simri	Durasan	0.54	14.15	0.500247
56	Buxar	Brahmpur	Hathilpur	0.60	15.17	0.500263
57	Buxar	Brahmpur	Jugiyadera	2.10	44.95	2.200148
58	Buxar	Simri	Manikpur	1.48	47.34	3.800132
59	Buxar	Simri	Niyajipur	0.03	30.74	2.100165
60	Buxar	Brahmpur	Raghunathpur	1.01	17.91	-4.09962
61	Buxar	Rajpur	Rajpur	0.12	3.58	-0.49967
62	Buxar	Buxer	Ramonariya	0.34	8.41	-0.19967
63	Buxar	Simri	Sohiar	1.36	29.42	-3.99939
64	Jehanabad	Makhdumpur	Alubikha	2.50	34.92	-0.29798
65	Jehanabad	Ghosi	Bholapur	0.92	24.47	0.200461
66	Jehanabad	Jehanabad	Gaurakshini	3.13	47.20	3.500889
67	Jehanabad	Ghoshi	Ghoshi	1.24	24.91	-0.49946
68	Jehanabad	Hulasganj	Hulasganj	1.13	24.45	-1.89918
69	Jehanabad	Kako	Kako	3.91	43.21	-4.69834
70	Jehanabad	Ghosi	Lakhwar	0.54	14.59	-1.89928
71	Jehanabad	Makhdumpur	Makhdumpur	2.22	43.64	1.80056
72	Jehanabad	Jehanabad	Teni Bigha	3.27	44.11	-0.29832

73	Patna	Bihta	Amraha	0.50	15.50	-0.49956
74	Patna	Bihta	Baliapakar	3.59	54.55	1.200658
75	Patna	Paliganj	Bharatpura	4.09	53.36	6.901169
76	Patna	Bihta	Bishambharpur	0.72	18.43	-0.09931
77	Patna	Danapur	Darbeshpur	2.79	44.14	1.311053
78	Patna	Punpun	Deokoli	0.77	21.46	-0.19952
79	Patna	Bikram	Din Bigha	0.45	13.90	-1.09967
80	Patna	Phulwari	Etwarpur	1.45	30.32	-0.59929
81	Patna	Naubatpur	Faridpur	0.75	23.01	-1.19926
82	Patna	Danapur	Goptal Danapur (Gobhtal)	1.36	28.43	-0.79918
83	Patna	Maner	Gyaspur(purvatola)	3.74	49.07	0.800724
84	Patna	Phulwari	Hulas Chak	0.38	11.70	-0.19947
85	Patna	Danapur_Cum Khagaul	Khaspur	0.81	23.03	0.800444
86	Patna	Patna Sadar	Khazpura	0.83	20.25	-0.19928
87	Patna	Maner	Lalbegam	1.01	25.71	0.300428
88	Patna	Maner	Maner	0.53	15.27	0.000675
89	Patna	Maner	Maner New	1.04	21.57	0.500658
90	Patna	Bikram	Mariyawa	0.42	13.34	-0.09952
91	Patna	Bikrma	Noniatola	1.97	39.50	-0.59919
92	Patna	Phulwari	Parsa bazar	0.77	23.68	0.600379
93	Patna	Bihta	Raghopur	0.42	14.84	-0.09974

94	Patna	Naubatpur	Snehitola	2.13	34.14	-1.99941
95	Patna	Dulhin Bazar	Dulhin Bazar	2.07	36.50	-2.89923
96	Patna	Fathua	Fathua	1.65	35.56	1.300477
97	Patna	Daniyawar	Daniyawar	0.67	20.43	-0.89972
98	Patna	Mokama	Maranchi	2.61	55.43	1.272332

### Suitability of ground water towards irrigation purpose in Zone VI

S.no	District	Block	Location	SAR	% Na	RSC
1	Kaimur	Adhaura	Adhaura	0.34	17.31	-0.39992
2	Kaimur	Ramgrah	Bandipur	2.28	40.29	2.600313
3	Kaimur	Ragrah	Bevnaliya	4.61	69.03	2.100049
4	Kaimur	Bhabua	Bhabua	2.07	39.44	0.300296
5	Kaimur	Chainpur	Chainpur	12.35	87.38	5.600082
6	Kaimur	Chand	Chand	2.19	34.79	0.300444
7	Kaimur	Chainpur	Kh...riava	1.28	29.29	0.100329
8	Kaimur	Mohania	Mohania(N.W.)	1.52	30.52	0.100247
9	Kaimur	Nuwan	Nuwan	1.38	32.46	-1.29977
10	Kaimur	Bhagwanpur	Saraiya	1.25	24.79	0.800329
11	Kaimur	Bhagwanpur	Tori check post	1.77	42.75	0.600099
12	Rohtas	Rohtas	Akbarpur	1.32	27.86	-0.09979
13	Rohtas	Sasaram	Amwan Gate	1.24	26.80	0.500181
14	Rohtas	Sasaram	Amoliya	1.08	24.26	-0.29972

15	Rohtas	Nawhatta	Auraiya	0.99	16.84	-3.49952
16	Rohtas	Karakat	Bahuara	0.75	17.89	-0.29969
17	Rohtas	Kargahar	Belthari	0.76	18.26	0.400395
18	Rohtas	Bikramganj	Bikramganj	4.62	51.75	1.200296
19	Rohtas	Chenari	Chenari	1.09	22.27	-0.49965
20	Rohtas	Dinara	Dinara	1.34	27.03	0.300379
21	Rohtas	Kudra	Jahanabad (kudra)	1.31	26.42	-0.29949
22	Rohtas	Sasaram	Karbindia	1.26	29.92	0.300082
23	Rohtas	Rohtas	Karma	1.58	30.75	0.20051
24	Rohtas	Dinara	Kochas	1.38	39.53	2.200165
25	Rohtas	Dawath	Maliabagh	1.85	39.39	1.600165
26	Rohtas	Nokha	Nokha	0.49	12.95	0.20028
27	Rohtas	Dinara	Rajandih	2.03	32.13	-2.59965
28	Rohtas	Sasaram	Sasaram	1.63	34.30	2.100197
29	Rohtas	Kargahar	Sinsiyau	1.78	35.55	-0.1997
30	Rohtas	Tilaothu	Tilothu	2.19	41.09	0.000329

**Suitability of ground water towards irrigation purpose in Zone VII**

S.no	District	Block	Location	SAR	% Na	RSC
1	Arwal	Arwal	Arwal	0.59	17.97	-0.29959
2	Arwal	Karpi	Bairbiga	3.77	48.19	0.70107
3	Arwal	Sonbhadra	Bansi (Surajpur)	1.26	27.45	-0.19967
4	Arwal	Arwal	Dirpal Biga	0.46	17.53	-0.2999

5	Arwal	Arwal	Imamganj	2.62	37.06	-2.69911
6	Arwal	Ratni Faridpur	Jhunathi	0.70	19.07	-0.29962
7	Arwal	Kurtha	Kinjer	0.53	16.86	-0.39975
8	Arwal	Kurtha	Kurtha	1.76	34.46	0.300625
9	Arwal	Arwal	Madhubani	0.56	23.52	-0.1999
10	Aurangabad	Aurangabad	Aurangabad	3.67	40.46	-1.99849
11	Aurangabad	Daudnagar	Daudnagar	3.14	50.94	0.600477
12	Aurangabad	Deo	Deo 1	1.90	42.89	0.000543
13	Aurangabad	Goh	Deohara	2.07	45.04	2.000411
14	Aurangabad	Kutumba	Dhanibar	0.94	21.78	0.100642
15	Aurangabad	Goh	Dhobitola Goh	3.69	50.99	3.800823
16	Aurangabad	Haspura	Etwan	1.18	33.01	-0.69982
17	Aurangabad	Madanpur	Madandpur	1.07	22.28	-2.29921
18	Aurangabad	Nabinagar	Mahuli	3.47	51.57	1.500823
19	Aurangabad	Nabinagar	Nabinagar	1.44	30.94	0.400724
20	Aurangabad	Barun	Narari Kala	1.06	29.61	-0.49975
21	Aurangabad	Obra	Obra	2.76	42.67	-0.49911
22	Aurangabad	Madanpur	Pataya (Pandrawan)	2.07	36.11	-0.29923
23	Aurangabad	Aurangabad	Patrava	0.56	14.79	-1.19959
24	Aurangabad	Rafiganj	Rafiganj	2.04	38.71	0.900214
25	Aurangabad	Rafiganj	Tineri Morh	1.38	26.88	0.401169
26	Gaya	Wazirganj	Wazirganj	2.48	34.42	-5.09878

27	Gaya	Fatehpur	Fatehpur	1.55	37.33	0.300329
28	Gaya	Fatehpur	Baraila More	2.46	46.45	2.700346
29	Gaya	Manpur	Manpur	2.34	40.42	-1.09936
30	Gaya	Gaya Sadar	Sangat Gali	2.43	45.33	-0.39954
31	Gaya	Gaya Sadar	Chand Chowra Chowk	2.46	43.78	-0.59944
32	Gaya	Bodhgaya	Bodhgaya	0.60	22.82	-0.19974
33	Gaya	Dobhi	Dobhi	2.62	46.84	0.100411
34	Gaya	Mohanpur	Dangra More	2.10	37.38	-1.39924
35	Gaya	Barachatti	Bhadeya	2.19	34.61	-5.39906
36	Gaya	Banke Bazar	Banke Bazar	1.81	36.57	0.400576
37	Gaya	Imamganj	Baseta	2.12	36.07	-3.29891
38	Gaya	Dumaria	Magra	2.10	35.89	-2.89934
39	Gaya	Amas	Akauna	0.86	19.25	-3.59919
40	Gaya	Gurua	Raghunath Khap.	1.91	31.29	-2.79903
41	Gaya	Guraru	Guraru	2.48	39.02	-2.69923
42	Gaya	Konch	Konch	2.12	27.66	-4.79845
43	Gaya	Tekari	Tekari (Bahaliya bigha more)	1.08	22.04	-4.19886
44	Gaya	Gaya Sadar	Ram Kund	1.88	35.68	-1.99916
45	Gaya	Gaya	Bitho Sharif	1.57	21.60	-11.2987
46	Gaya	Bela	Paligaon	0.92	21.59	0.600313
47	Nalanda	Hilsa	Karaiparsurai	1.69	30.91	-0.29926

48	Nalanda	Hilsa	Hilsa	2.11	41.38	2.300461
49	Nalanda	Ekangarsarai	Ekangarsarai (Ekangardih)	1.89	31.27	-2.49799
50	Nalanda	Islampur	Sherpur	1.31	34.63	1.000346
51	Nalanda	Islampur	Islampur	2.19	44.62	2.600395
52	Nalanda	Neemchak	Ankuri Bazar	2.27	42.05	1.300477
53	Nalanda	Rajgir	Pilkhi	2.43	47.06	1.800444
54	Nalanda	Rajgir	Rajgir	1.00	27.09	0.600444
55	Nalanda	Silao	Bhui	2.51	35.59	-6.69839
56	Nalanda	Silao	Silao	1.87	31.38	-3.79905
57	Nalanda	Bari	Nirpur	3.21	53.96	2.800444
58	Nalanda	Rajgir	Nalanda	2.44	42.01	0.400987
59	Nalanda	Silao	Kundalpur	2.35	46.35	1.800329
60	Nalanda	Noorsarai	Papanhosa	1.69	28.81	-3.79939
61	Nalanda	Prawalpur	Parwalpur	2.95	44.35	-1.49908
62	Nalanda	Ekangarsara	Parwalpur1	2.37	36.57	-1.49893
63	Nalanda	Ekangarsarai	Nishchalganj	3.07	49.05	1.400527
64	Nalanda	Noorsarai	Daudpur	1.67	34.39	0.00079
65	Nalanda	Bihar Sharif	Maghra	1.09	23.97	-0.59947
66	Nalanda	Biharsharif	Biharsharif	2.20	35.73	-1.09913
67	Nalanda	Bihar Sharif	Sohdh	2.52	37.98	-1.09924
68	Nalanda	Noorsarai	Heganpura	1.97	33.81	-1.49939
69	Nalanda	Rahui	Doiya	1.68	34.43	0.000543

70	Nalanda	Bihar Sharif	Ranabigha	2.41	33.96	-3.69905
71	Nalanda	Giriak	Pawapuri	0.96	23.53	0.500444
72	Nalanda	Rajgir	Sithuara	2.55	34.51	-2.69858
73	Nalanda	Chandi	Bhathar	2.23	35.23	-1.39883
74	Nalanda	Chandi	Chandi	2.41	41.75	2.400576
75	Nalanda	Chandi	Nagarnausa	2.14	35.31	-2.29918
76	Nalanda	Harnaut	Harnaut1	2.77	39.78	-1.69886
77	Nalanda	Rahui	Vena	1.18	26.15	-0.89924
78	Nalanda	Asthawan	Jakhaur	0.75	18.30	-1.39947
79	Nalanda	Sarmera	Sarmera	1.28	29.32	-0.19919
80	Nalanda	Bihar Sharif	Muraura	2.29	41.32	1.40079
81	Nalanda	Bihar Sharif	Bihar Sharif (Rly Stn)	2.33	28.96	-8.49865
82	Nalanda	Asthawan	Asthawan	2.35	42.65	0.600461
83	Nalanda	Asthawan	Sare	2.77	49.85	2.600411
84	Nalanda	Asthawan	Jangipur	1.44	34.51	1.100461
85	Nalanda	Giriak	Giriak	1.07	25.09	-0.89949
86	Nawada	Warshaliganj	Shahpur Morh	2.30	42.01	-0.49947
87	Nawada	Warshaliganj	Warshaliganj	2.21	39.66	-0.89926
88	Nawada	Pakribarwan	Pakribarwan	1.94	35.09	-0.99941
89	Nawada	Kawakol	Kawakol Ashram	0.80	18.90	-0.09908
90	Nawada	Nawada	Nawada2	0.95	24.92	0.200461
91	Nawada	Nawada	Gonama	1.60	31.66	-0.29941



92	Nawada	Nawada	Garhpar	1.02	20.66	-3.29934
93	Nawada	Pakribarwan	Roh	1.92	31.04	-3.99911
94	Nawada	Kauakol	Rupau	2.22	31.44	-5.19867
95	Nawada	Gobindpur	Bishunpur	0.58	19.90	-0.79952
96	Nawada	Rajauli	Dopata	1.32	32.28	0.900477
97	Nawada	Hisua	Hisua	1.08	27.34	0.400477
98	Nawada	Narhat	Khanwa	1.98	40.83	0.300724
99	Nawada	Sirdala	Nawabganj	3.36	57.15	3.50023
100	Nawada	Meskaur	Meskaur	2.22	31.75	-7.09845
101	Nawada	Hisua	Tungi	1.39	28.40	-0.89944
102	Sheikhpura	Berbigha	Keoti	2.43	39.15	-1.09933
103	Sheikhpura	Berbigha	Koeri Bigha	0.91	19.84	-0.69937
104	Sheikhpura	Berbigha	Sherpar	0.72	16.98	-2.09926
105	Sheikhpura	Barbigha	Barbigha	1.01	23.33	-2.89934
106	Sheikhpura	Sheikhpura	Nemdarganj	1.10	27.94	0.600576
107	Sheikhpura	Ariari	Ariari	1.96	34.80	-0.69924
108	Sheikhpura	Chewara	Chewara	2.90	52.83	2.900395
109	Sheikhpura	Ghat Kusumba	Ghat Kusumba	1.73	36.93	1.600477
110	Sheikhpura	Barbigha	Ambari	2.63	42.45	-1.69908

**Suitability of ground water towards irrigation purpose in Zone VIII**

S.no	District	Block	Location	SAR	% Na	RSC
1	Banka	Banka	Banka	1.77	39.49	-0.27102

2	Banka	Barahat	Barahat	2.72	55.48	1.735937
3	Banka	Baunsi	Baunsi	1.52	30.38	-4.0819
4	Banka	Chandan	Chandan	1.06	29.03	-0.17188
5	Banka	Amarpur	Englishmore	1.52	48.89	0.127214
6	Banka	Shambhuganj	Fullidumar	2.55	54.43	1.330492
7	Banka	Katauria	Katauria	1.11	24.41	-2.56998
8	Banka	Shambhuganj	Mirjapur	4.51	65.93	3.24705
9	Banka	Baunsi	Panjwara	0.80	27.87	-0.27718
10	Banka	Shambhuganj	Shambhuganj	2.48	48.76	0.503607
11	Banka	Shambhuganj	Karharia	1.82	31.09	-5.58009
12	Jamui	Jamui	Aghara	1.64	36.20	0.256885
13	Jamui	Jhajha	Ambedkar Nagar	0.84	22.81	-1.57515
14	Jamui	Sono	Batia	1.61	38.51	-0.1533
15	Jamui	Chakai	Chakai	1.92	37.84	-2.97977
16	Jamui	Chakai	Chandra Mandih	1.97	41.19	-0.77334
17	Jamui	Jhajha	Harna	1.91	48.28	0.014886
18	Jamui	Jamui	Jamui	2.20	43.98	-0.55213
19	Jamui	Jhajha	Jhajha	1.34	29.86	-3.08316
20	Jamui	Lakshmipur	Lalmatia	1.23	34.57	0.829804
21	Jamui	Lakshmipur	Lakshmipur	2.79	56.59	-0.31361
22	Jamui	Jamui	Manjhwe	2.79	53.24	2.259818
23	Jamui	Khaira	Purna Khaira	2.62	57.66	0.92305

24	Jamui	Sikandra	Sikandra	2.42	48.93	1.939706
25	Jamui	Sono	Sono	3.10	56.44	2.44287
26	Jamui	Chakai	Tarakhakhar	1.26	34.53	0.024853

### **Suitability of ground water towards irrigation purpose in Zone IX**

S.no	District	Block	Location	SAR	% Na	RSC
1	Bhagalpur	Rangra	Madrauni chowk	0.126016	5.217713	-0.69972
2	Bhagalpur	Bihpur	Bihpur	0.427183	17.40763	-1.59974
3	Bhagalpur	Naugachia	Naugachia	1.038234	18.76897	-4.09918
4	Bhagalpur	Bihpur	Mairwa	0.309061	9.700325	-0.99964
5	Bhagalpur	Sultanganj	Akbarnagar	1.603014	39.71955	0.630591
6	Bhagalpur	Bhagalpur	Bhagalpur	1.646712	39.02769	0.633083
7	Bhagalpur	Kahalgaon	Ghogha	1.159034	25.55912	-2.8778
8	Bhagalpur	Colgong	Harchandpur	1.070598	31.42352	-0.18097
9	Bhagalpur	Colgong	Jaganathpur	1.49838	35.81749	0.031019
10	Bhagalpur	Pirpanti	Pirpanti	1.648397	34.31947	-0.65679
11	Bhagalpur	Sabour	Sabour	2.457703	49.67549	-0.17525
12	Bhagalpur	Shahkund	Shahkund	1.612171	38.4878	0.633676
13	Bhagalpur	Sultanganj	Sultanganj	1.638759	37.95314	0.836921
14	Lakhisarai	Surajgarha	Arma	4.889729	50.87017	-1.6218

15	Lakhisarai	Barhaiya	Barhaiya	2.724265	52.44052	2.143314
16	Lakhisarai	Barhaiya	Dariyapur	1.048582	25.53365	-2.57888
17	Lakhisarai	Surajgarha	Kajra	2.201289	36.184	0.868856
18	Lakhisarai	Surajgarha	Kiul	0.453659	14.44208	-2.0161
19	Lakhisarai	Lakhisarai	Lakhisarai	0.913537	27.97136	-0.37928
20	Lakhisarai	Surajgarha	Rishi Paharpur	0.532437	15.29471	-1.87685
21	Lakhisarai	Surajgarha	Saidpur	1.364645	22.53529	-5.65347
22	Munger	Asarganj	Asarganj	2.652002	52.69544	0.472431
23	Munger	Bariarpur	Bariarpur	2.534515	36.12192	-3.37835
24	Munger	Kharagpur	Gangatamore	2.805668	54.40927	1.636312
25	Munger	Kharagpur	Gobadda	1.215476	24.61361	-0.0418
26	Munger	Jamalpur	Jamalpur	0.577093	15.4271	-1.93659
27	Munger	Munger	Purabsarai	1.606746	32.95967	-1.97074
28	Munger	Sangrampur	Rampur	1.519918	43.33291	0.924755
29	Munger	Jamalpur	Singhiya Chowk	2.779451	46.12242	-1.5599
30	Munger	Tarapur	Tarapur	0.441682	14.66819	-1.16915