Water Quality Assessment in parts of Mohuddinagar Block, Samastipur, Bihar.

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Abstract

Ground water contamination has become very important issue of concern these days. People of Bihar mostly use ground water sources for household and agricultural needs. In Mohuddinagar block people are dependent on agriculture for their livelihoods and groundwater was the major source. An inclusive assessment of ground water resources was done in the study area from 12 station points in the month of November,2021. The study was done to understand hydrogeochemical facies of groundwater along with the suitability of groundwater in household and for agricultural needs. The physico chemical parameters of water including EC (Electrical conductivity), TDS (Total dissolved solids), pH, major cations and and anions was investigated. The outcomes were compared with the Bureau of Indian Standards-2012. Among heavy metals Arsenic and Iron were tested in water samples and the map showing the distribution of these heavy metals was created. The analysis of samples was done based upon APHA standard methods. Piper trilinear diagram and Chadha's plot represented different hydrogeochemical facies of the groundwater. The SAR, Na% and RSC values were calculated to assess its suitability for agricultural purposes. Most of the statistical operations were done using MS-EXCEL software. Except few all the major ions were found to be present within the prescribed limits of Bureau of Indian Standards-2012. As and Fe concentration at some sampling locations was found to be beyond the permissible limits. In the study area Mg^{2+} - Ca^{2+} − HCO_3^- and Mg^{2+} -HCO_3^-—Cl^- were dominant hydrochemical facies. For agriculture purpose 50% of the water samples had high salinity and it needs to be managed before use in irrigation, it is represented by US_salinity diagram. Wilcox plot represented the relation between Na% and EC and it was concluded that groundwater of study area falls under following categories:

- Excellent to good
- Good to permissible quality and so it can be used for irrigation purposes.

Keywords: Groundwater, Physico-chemical, Wilcox Diagram, Piper Diagram, Hydrochemical facies, Aquifer, Samastipur.

1.Introduction

Availability and purity of drinking water is necessary for the well-being and good health of people. Access to clean drinking water is one of the basic human rights for every citizen. We know very well that the resources are limited so there should be a sustainable approach while using this natural resource. Groundwater resource is utilised by billions around the world today but the irony in the fact is that it is over extracted and polluted by them those who use it for their benefits. Use of groundwater for agricultural purposes is done in major parts of the world including India. At present groundwater is over-extracted by various anthropogenic activities which results in rapid depletion as well as the contamination of this precious resource. In the last couple of years groundwater extraction has increased at tremendous rate. Scientists have found that each day very large amount of groundwater is extracted to fulfil the human being's requirements which includes the commercial, agricultural and industrial use (Sirajudeen and Vahith, 2014). Other anthropogenic activities that lead to groundwater pollution includes residential, and municipal activities like wastewater and solid waste disposal. It is estimated that about 50% of groundwater is used for irrigation in India (Central Water Commission, 2000). Agricultural activities like excess use of fertilizers, pesticides insecticides and rodenticides in agricultural fields is responsible for contaminating the groundwater resource. Many chemicals and heavy metals from manmade sources contaminate the groundwater resource (Rapant and Krcmova, 2007). According to Mclauglin et al (2000) to the biotic components of ecosystem due to the consumption of food crops and vegetables grown on heavy metal contaminated soils or due to the consumption of contaminated drinking water that percolates under the ground in soil may be hazardous.

It is estimated that about 83% population of Samastipur district depends upon agriculture for their livelihoods. Apart from normal monsoon groundwater is the major source of water for irrigation, maintenance of cropping intensity and ultimately for betterment of agricultural economy. Agricultural fields are irrigated by many groundwater sources (handpumps, open wells etc.) as well as surface water sources (rivers, lakes, tanks etc.). A heavy amount of groundwater is extracted every year for irrigating the agricultural fields (CGWB-2013).

Heavy metals which are found naturally in rocks or soils, are iron, manganese, arsenic, fluorides, etc. which becomes dissolved in groundwater and contaminate it. Heavy metal contamination of groundwater by arsenic and Iron has been observed in many parts of the state. Arsenic is a naturally occurring metalloid which combines with both metals and non-metals and forms different types of compounds. Contamination of groundwater by increased level of arsenic in it has been observed in many Indian states like Assam, Manipur, west Bengal, Jharkhand, Bihar, Uttar Pradesh, Chhattisgarh Punjab and Haryana wherein most of the states are flood plains of Ganga, Brahmaputra and Imphal rivers. In Bihar 40 percent of its districts di have arsenic contaminated groundwater. According to Thakur et al (2016) 15 districts of Bihar and its 67 blocks has arsenic contamination in their groundwater. According to WHO-2010 many types of health ailments in human beings that includes mainly skin problems like hard patches on foot and palm, keratosis, melanosis, rain drop pigmentation, change in the colour of skin and ultimately to the deadly disease cancer (cancer of skin, bladder, lungs, kidneys). Also, reproductive disorders, hypertension and diabetes are triggered by excessive intake of arsenic contaminated water over a long period of time.

Iron is an element that is naturally present in underground rocks. It is dissolved there and gets collected in aquifers from where we extract water and it becomes the source of contamination of groundwater. If this contaminated groundwater is consumed by us then it leads to many types of complications to human health like liver cirrhosis, heart related ailments, diabetes, infertility and even the most dangerous liver cancer (Kumar et al., 2017).

In the current study, groundwater quality assessment has been done to know its suitability for household and agricultural purposes.

2.Materials and Methods

12 groundwater samples from the entire study area were collected. For arsenic and iron analysis, water samples were filtered using Whatman 0.45µm filter paper and preserved using HNO_3 in the field and were taken to laboratory for further analysis. It was ensured that all the samples were tested within two week of sample collection.

Some of the physicochemical parameters like temperature, TDS, pH were measured on the spot at the time of sample collection. However other parameters like major cations and anions analysis were done in the laboratory using various volumetric methods for Ca^{2+}, Mg^{2+}, Cl^{-}, HCO_3^{-}, TH. The Na^{+} and K^{+} concentration was found with the help of instrument- flame emission photometer (systornics-128) and Sulphate, Nitrate and Phosphate by UV-Visible spectrophotometer(systornics-2202). APHA standard methods was strictly referred for all above analysis. Concentration of arsenic and iron was analysed with the help of ICP-MS at the laboratory of CGWB-Lucknow. Analytical data charge balance% error for reliability of data was also calculated.

2.1 Study Area

Figure-1 indicates the map of my study area. In this map few parts of Mohuddinagar Block are represented where from I collected the water samples. It is situated in 25.599262°North latitude and 85.701775°East longitude with an altitude 52m above sea level (Kumari et al,2016). The climate of the entire district (including Mohuddinagar block) is tropical having hot and humid summer season and cold winter season. From the Month of November to February is considered winter season with January being the coldest month where minimum daily mean temperature is 7°C and maximum daily mean temperature reaches to 25°C. March to June is considered the summer months of summer season. The average daily maximum temperature in the district reaches about 36.5°C. After this rainy season begins and continues up to September month. South-west monsoon winds brings substantial amount of rainfall in these rainy months. Rainfall up to 1142 mm is the average annual precipitation for this district, recharge of groundwater is mainly by rain water. Rabi crops like wheat, maize, pulses and edible oils are majorly grown here among kharif rice, sugarcane and tobacco is cultivated here and spices like garlic and turmeric are cultivated, also many types of seasonal vegetables are grown here. Soil of this region is fertile alluvial soil with high organic matter content hence fertile. (CGWB-Report,2013).

3.Results and Discussion:

In Table-1 is mentioned the analytical results of various parameters including its average value for all station points.

The results of all physicochemical parameters of water are summarised here. The pH was found to be in the range of 6.79 to 7.3. and is within the acceptable limits given by Bureau of Indian Standards-2012, it is highest for station13 and lowest for station6 and the mean value was 7.03. Most of the samples exhibit EC in the range of 800 to 1200 µS/cm and the mean value for EC was 872.08 microS/cm. TDS is the sum of all solids including all inorganic and organic solids in water which was between 242.9 and 976.5 mg/l. In 41.66% samples it was within the acceptable limit (desirable quantity) however in 58.33% samples it was more than the acceptable limit but within the permissible limit (in case if there is no alternate source) and the mean value was 610.46mg/l. Rock-soil interaction results in the presence of magnesium in groundwater generally (Gupta et al,2019). The range of magnesium was between 12.15 to 65.61mg/l and in 33.33% samples it was under acceptable limits, remaining 66.66% had more than that but within permissible limits. Hence Water is safe for drinking in terms of magnesium concentration the mean value was 38.30 mg/l. The concentration of Calcium concentration was in between 34mg/l and 66mg/l which was within the acceptable limits for all stations with the average of 47 mg/l. Total hardness of samples lied between 150mg/l to 465mg/l.i.e. for all stations the TH value was within the acceptable limits and the mean value for TH was 310.83 mg/l. The alkalinity ranged between 190.65 to 615mg/l. At station10 it was beyond permissible limit of 600mg/l however at all other stations it was within permissible limits the mean value calculated for alkalinity was 414.6 mg/l. Sodium concentration in groundwater was between 4.3mg/l to 134.47mg/l which was within the permissible limit and its mean value came to be 61.94 mg/l. Potassium was in the range of 1.6mg/l to 10.07mg/l which was within the acceptable limits, mean value calculated was 4.18mg/l. Sulphate was found to be between -1.33mg/l to 43.1mg/l which was all within acceptable limits. The mean value of sulphate was 16.89mg/l. The concentration of nitrate was within acceptable limits in the range of 0 to 24.59mg/l and the mean value was 6.4mg/l. Phosphate was not found in most of the samples but at stations 2,11 and 12 it was 0.11,0.28 and 0.24 mg/l respectively which is above acceptable limits and so the water was not fit for drinking at these stations. The mean of these values was 0.21 mg/l. The concentration of chloride was found to be between 7.09mg/l to 164mg/l which was also acceptable in drinking water and the average value was 51.06 mg/l. The Arsenic concentration in 33.33% samples were found to be beyond acceptable limits.i.e. 10ppb and of 16.6% samples beyond permissible limits.i.e. 50ppb which is alarming for the people of Mohuddinagar block as they are totally dependent upon the groundwater source for cooking and drinking purposes. The mean value of arsenic was 13.98 ppb. Arsenic above acceptable limits causes many health ailments including many types of cancer. Arsenic distribution is shown in Figure-2. Iron in 58.33% of the groundwater samples had concentration above permissible limits which was also an alarming as excess consumption of iron leads to many types of gastrointestinal diseases. It had fallen in the range of -0.01mg/l to 4.90mg/. The mean value calculated was 0.91 mg/l which is above permissible limit. Iron distribution is shown in Figure3.

In Table-2 it is explained that if the correlation between the parameters having r-value is => 0.6 it is considered to be in good correlation. The boxes with red have good correlation. The strongest correlation is found between Iron and arsenic with value of 0.94 as ferric oxide coating is found over arsenic mineral which dissolves under acidic conditions and arsenic is hence exposed so the presence of iron may be marked for the presence of arsenic in groundwater. EC is showing good correlation with $HCO3^-$ and Cl^- revealing that among anions bicarbonate and chloride are the main contributors for electrical conductivity. The $HCO3^-$ and EC shows good correlation value of 0.86 and between EC and Cl^- it is 0.85 Similarly, among cations EC shows good correlation with Na^+(0.88) which reveals that sodium is the major contributor for EC. Correlation between Mg^{+2} and TH is 0.73, between Ca^{+2} and $SO4^{-2}$ it is 0.62 and between $HCO3^-$ and $NO3^-$ it is 0.68.

The Piper diagram and Chadha's plot (Figure 4a and Figure 4b) was prepared to understand different hydrogeochemical facies of groundwater and to know groundwater types by knowing the major ion composition of groundwater. As per Piper's plot and Chadha's plot it is clear that 75% of the water type is of Mg-Ca-HCO3 group and 25% of water type is of Mg-HCO3-Cl group rest of it belonged to mixed type.

Groundwater assessment for irrigation purpose:

The soil generally has two kinds of problems sodium problem and salinity problem and irrigation water becomes the source of these as the ions are dissolved in it. The SAR, Na% and RSC values were calculated for all stations. Table-3 mentions the calculated values of these parameters. The combination of these factors is represented through Wilcox- plot and Salinity plot for the assessment of groundwater and its use in agriculture.

The ionic concentration in irrigation water is classified, if EC value is <=250 micro simens/cm- it is low, 250 to 750micro simens/cm- it is moderate, 750-2250 micro simens/cm- it is high and 2250 to 5000 micro simens/cm- it is very high (Sinha et al,2008). Alkaline soil indicates high sodium concentration and saline soils indicates high concentration of salts through irrigation water. US-Salinity diagram is for classifying irrigation water where combination of alkali hazard (SAR) and salinity hazard (EC) is represented. In Figure-5 it is observed that all the values fall in either C2S1 or C3S1 class. C2S1 class indicates that water is less alkaline and it can be hence used for irrigating most of the crops. According to Richards (1954) C3S1 class indicates low alkali and at the same time high salinity hazard. Hence that type of water can damage crops. The SAR ratio helps us to understand alkali hazard caused to crops. SAR is calculated by Sodium concentration divided by half of the square root of sum of calcium and magnesium concentration (all calculated in milliequivalents per litre). The SAR value calculated for my study area is in between 0.091 and 4.186. Concentration of sodium and electrical conductivity are the major factors for classifying irrigation water type and its suitability for crops. Salt concentration in groundwater impacts aeration, soil structure and permeability and all these are responsible for normal growth and development of plants. The calculated valve of Na% lies between 3.814 %to 60.471%. According to Karanth (1987), high Na% through irrigation water in soil results into tilth and permeability in the soil, for irrigation water the maximum sodium of 60% is recommended according to Bureau of Indian Standard – 1991, here at Station 9 Na% value was found to be 60.471 which is slightly above the recommended value.

Relationship between EC and sodium percent (Wilcox 1955) is represented by Wilcox diagram in Figure-6. This classifies groundwater of my study area as follows:

1.Excellent to good

2. Good to permissible quality

Hence may be used for irrigation purposes.

Residual sodium carbonate is the difference between sum of carbonates and bicarbonates and alkaline earths (Ca+Mg). According to Raghunath (1987) positive RSC value means Ca and Mg ions is completely precipitated. RSC values> 5 meq/l are not suitable for the growth of plants rather they become harmful at this concentration as it enhances sodium absorption in soil (Eaton 1950). Here the calculated values of RSC fall between -0.898 to 3.762meq/l , only at stations 9,10 and 12 it is found to be unsuitable for irrigation.

4.Conclusion

Results on comparison with BIS-2012 it can be concluded that most of the drinking water parameters of Mohuddinagar block lied within the permissible limits. However, alkalinity at all the stations were within the permissible limit except at station10 where it was 615mg/l which was more than the permissible limit, hence people residing at this place are advised to go for some other source as drinking water is not fit to be consumed. Also, the concentration of PO_4^{3-} at station2, station11 and station12 was found to be greater than permissible limit and the probable sources of phosphate in my study area may be fertilizer runoff or laundry and cleaning wastewater. Hence people are advised to go for some alternate source as excess intake of phosphate in body may be harmful.

Heavy metal contamination for arsenic was found in 33.33% of the water samples(>10ppb) hence water source should be changed if there is some other drinking water source available, contamination was alarming in 16.6% of the samples(>50ppb) hence change of groundwater source is compulsory at such places. The study area was highly contaminated with iron in groundwater, more than 58.33% of the samples had iron concentration above acceptable and permissible limits (>0.3 mg/l) hence immediate change of alternate source of drinking water is required.

For agriculture purpose half of the water samples were found saline and so its proper management is required before use in irrigation. From Wilcox plot and US-Salinity diagram groundwater categories are of: -

1. Excellent to good and
2. Good to permissible quality

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TABLES AND FIGURES

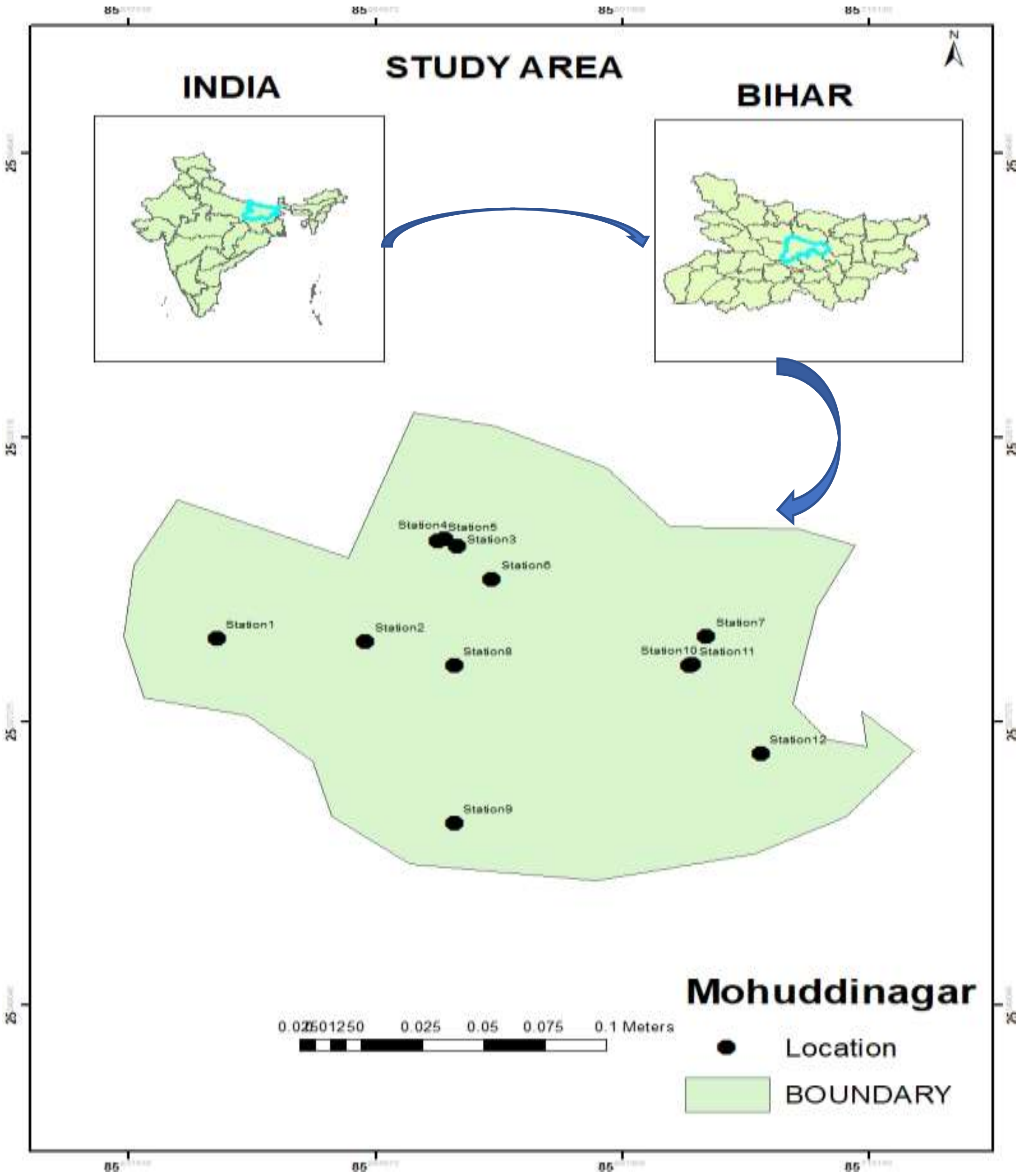

Figure 1: Map of Study Area

Table 1: Summary of the physicochemical parameters of water resource of study area.

	Station1	Station2	Station3	Station4	Station5	Station6	Station7	Station8	Station9	Station10	Station11	Station12	AVG	A.Limit	P.Limit
pH	6.86	6.79	7.01	7.03	6.8	6.96	7.08	7.22	7	7.1	7.38	7.13	7.03	6.5 to 8.5	no relax.
EC	874	347	770	742	1371	1136	697	361	1009	1196	567	1395	872.1		2000
TH	210	215	150	375	335	465	365	270	195	455	435	260	310.8	200	600
TDS	611.8	242.9	539	519.4	959.7	795.2	487.9	252.7	706.3	837.2	396.9	976.5	610.5	500	200
Calcium	60	38	44	52	44	52	58	38	38	66	34	40	47	75	200
Magnisium	36.45	12.15	24.5	40.195	54.675	65.61	36	15.795	24.3	40	65	44.955	38.3	30	100
Sodium	50.6	7.05	33.73	36.19	106.78	95.37	31.48	23.4	134.47	77	4.3	142.97	61.95		200
Potassium	1.6	6.77	3.4	2	5.11	1.27	3.01	2.45	4.66	10.07	3.62	6.2	4.18	12	300
Alkalinity	442.8	190.65	313.65	461.25	479.7	498.15	393.6	215.25	467.4	615	375.15	522.75	414.6	200	600
Chloride	28.36	10.635	10.635	7.09	165.2	38.99	10.635	10.635	74.44	81.535	10.63	164	51.07	250	1000
Sulphate	18.56	4.12	14.22	14.22	14.22	43.1	34.27	12.84	12.84	20.09	-1.33	15.63	16.9	200	400
Nitrate	24.13	0.82	0	0	22.8	0	0	0	0.26	0	4.11	24.59	6.393	45	no relax.
Phosphate	nil	0.11	nil	nil	nil	nil	Nil	nil	nil	nil	0.28	0.24	0.21	0.1	
Arsenic	0.11	10.94	0.61	0.52	0.37	1.01	0.04	10.11	55.09	3.62	84.64	0.69	13.98	10.00	50.00
Iron	0.46	0.54	-0.01	1.43	-0.01	-0.01	-0.01	0.61	2.27	0.18	4.90	0.52	0.91	0.30	no relax.

*P.Limit is Permissible Limit and A.Limit is acceptable limit.

*Units for all in ppm except As in ppb and EC in microS/cm

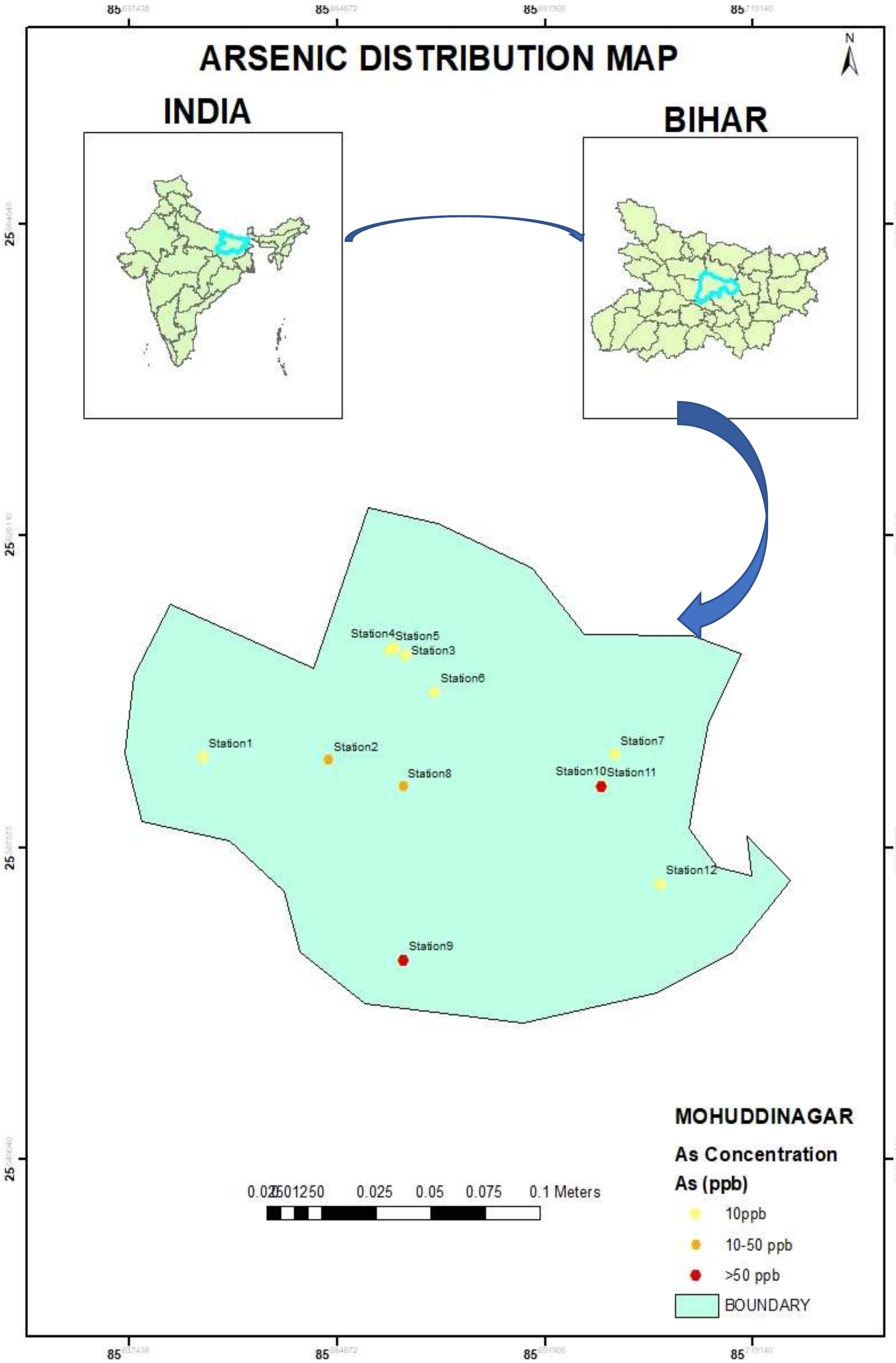

Figure 2: Arsenic Distribution Map

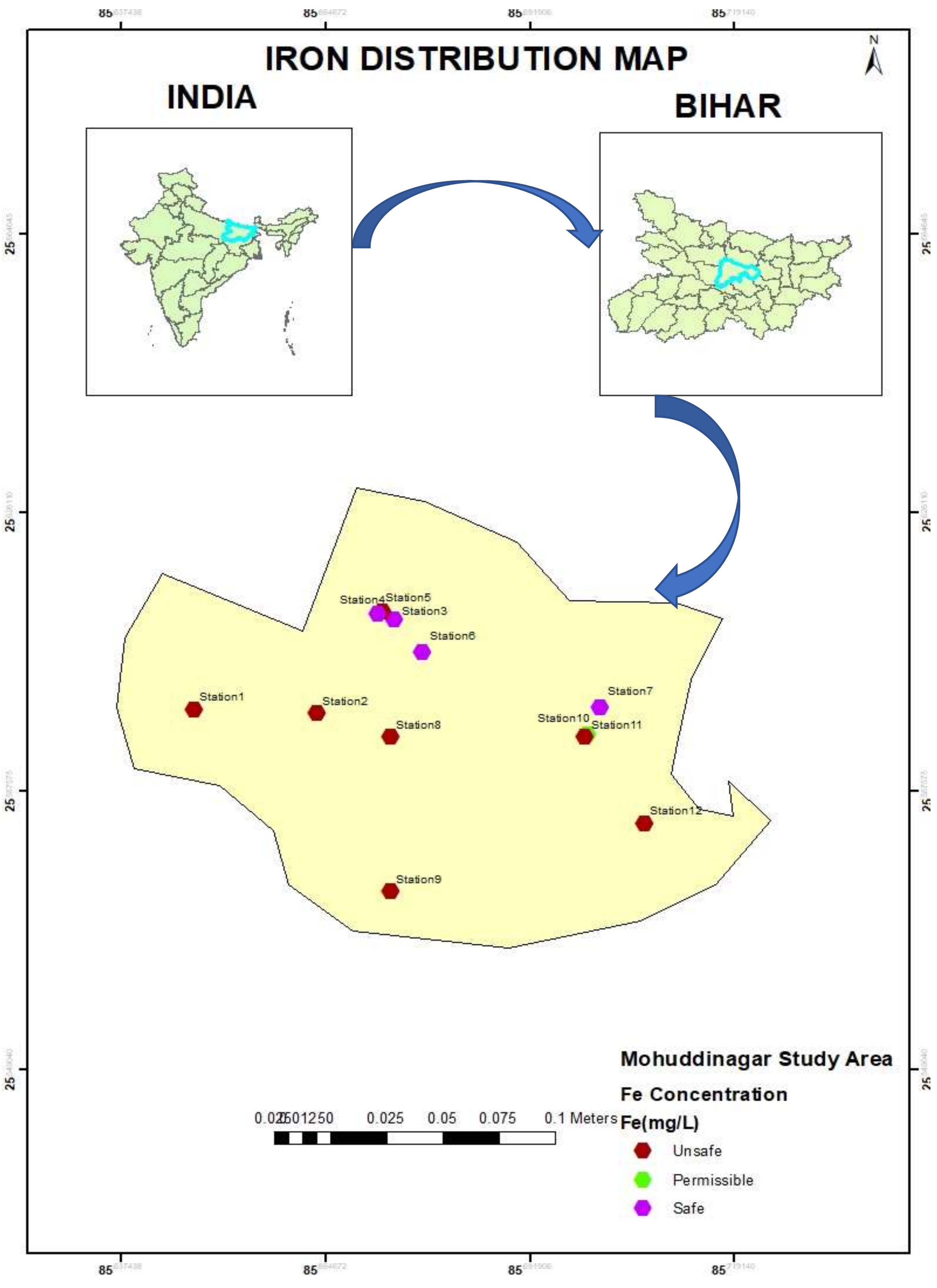

Figure 3: Iron Distribution Map

Table 2: Correlation matrix for different parameters

	pH	EC	TH	Ca	Mg	Na	K	Fe	HCO3	Cl	SO4	NO3	As
pH	1												
EC	-0.22	1											
TH	0.36	0.21	1										
Ca	-0.23	0.30	0.37	1									
Mg	0.22	0.53	0.73	0.15	1								
Na	-0.21	0.88	-0.04	0.03	0.26	1							
K	-0.03	0.30	0.07	0.07	-0.16	0.24	1						
Fe	0.60	-0.29	0.18	-0.50	0.28	-0.22	-0.09	1					
HCO3	0.00	0.86	0.48	0.55	0.60	0.69	0.27	-0.07	1				
Cl	-0.20	0.85	0.02	-0.06	0.31	0.83	0.47	-0.22	0.58	1			
SO4	-0.20	0.37	0.36	0.62	0.29	0.30	-0.29	-0.59	0.40	0.02	1		
NO3	-0.28	0.54	-0.22	0.01	0.28	0.44	0.03	-0.15	0.31	0.68	-0.10	1	
As	0.54	-0.26	0.10	-0.56	0.19	-0.12	0.01	0.94	-0.11	-0.16	-0.54	-0.21	1

Red Good Correlation (r=>0.6)

Yellow Poor Correlation (r=<0)

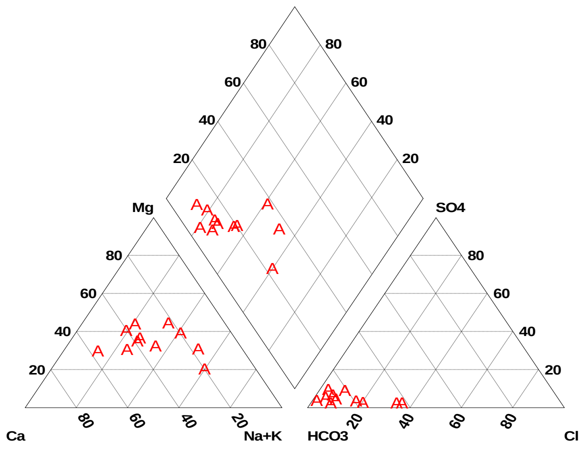

Figure-4a

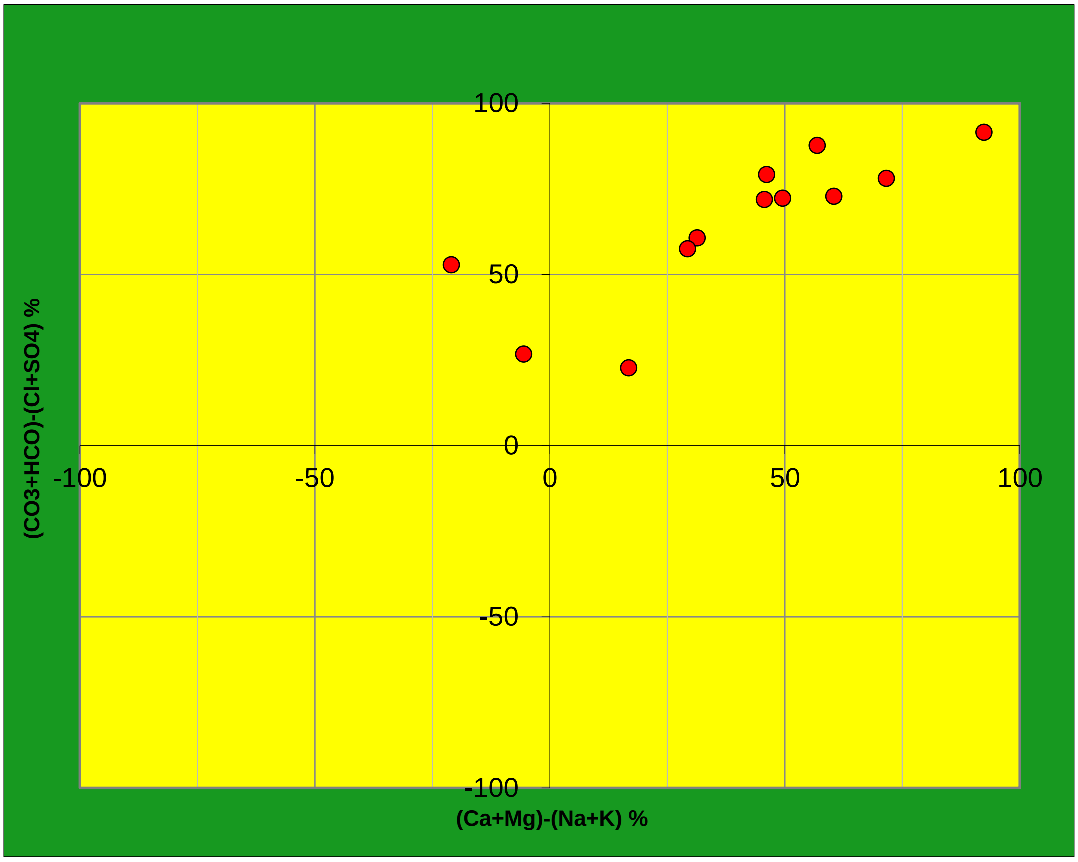

Figure-4b

Figure 4–(a) Piper diagram and **(b)** Chadha's plot showing major ion composition and groundwater types.

Table 3- Na%, SAR and RSC values calculated for all stations.

Stations	**SAR**	**RSC (meq/l)**	**%Na**
Station 1	1.27	1.26	27.2
Station 2	0.25	0.22	14.19
Station 3	1.01	0.92	26.92
Station 4	0.91	1.65	21.57
Station 5	2.54	1.16	41.60
Station 6	2.07	0.17	34.31
Station 7	0.8	0.6	19.78
Station 8	0.80	0.33	25.23
Station 9	4.19	3.76	60.47
Station 10	1.84	3.5	35.35
Station 11	0.09	-0.89	3.81
Station 12	3.68	2.87	52.8

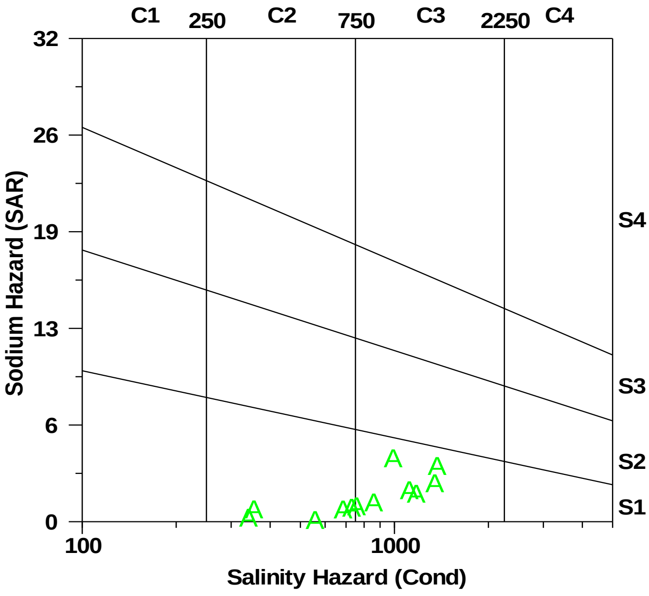

Figure 5 - US salinity diagram

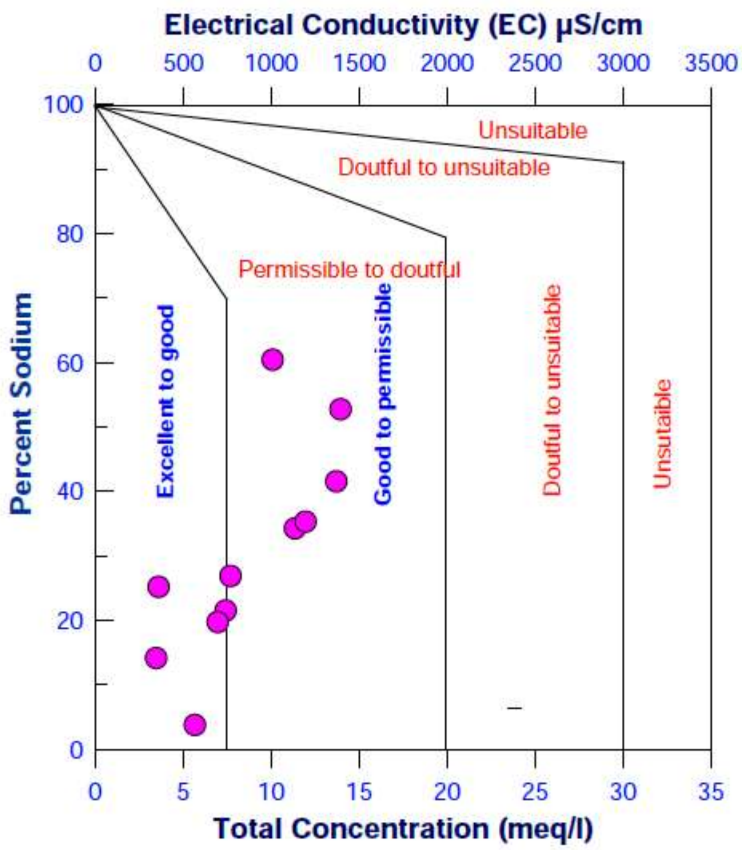

Figure-6 : Wilcox plot