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Evaluation of Ground Water Quality for Irrigation and Drinking Purposes from Dighalbank Block, Kishanganj District, Bihar

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ABSTRACT

Hydrochemical evaluation of groundwater has been conducted in Dighalbnk Blocks of Kishanganj district. Ground water sample were analysed and determining in this area. GPS based collected fifteen groundwater samples were analysed their chemical properties using standard laboratory methods. The constituents have the following ranges in the water: pH 4.63–5.53, electrical conductivity 0.12–0.94 dsm^{-1}, total hardness 128–758 mg/L, Ca^{2+} 4.2– 222.6 mg/L, Na^{+} 22.44–272.54 mg/L, Mg^{2+} 25.76– 147.59 mg/L, Na^{+} 1.2-4.1 mg/L, Fe^{+} 2.08-3.76 mg/L whereas WHO standard level is 0.3 mg/L, CO_3^{--} 0.0 mg/L, HCO_3^{-} 0.061–0.366 mg/L, Cl^{-} 15.9– 48.5 mg/L, sodium adsorption ratio (SAR) 0.10-0.39 meq/L, residual sodium carbonate (RSC)(-327.0) –(-35.2) ,magnesium adsorption ratio (MAR) were found ranges between 28.6 -67.0 meq/L. The values of Sodium Adsorption Ratio indicate and electrical conductivity that the groundwater of the area falls under the category of low sodium hazard and salt concentration. So, there is neither salinity nor toxicity problem of irrigation water, and hence the ground water can safely be used for long-term irrigation. The iron concentration was found higher in water samples on the basis of WHO guideline maximum samples found not suitable for the drinking purpose.

Keywords: Groundwater, Water quality, Iron contamination, Hydrology.

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INTRODUCTION

Safe portable water is absolutely essential for healthy living. Groundwater is renewable natural resources and is one of the pure sources of water because it is bacteriologically free and contains more health required nutrients in the right proportion than surface water. Groundwater is an inevitable component of natural resources and plays an important role to serve as many purposes like drinking, irrigation, and other domestic usage (Verma *et al.* 2018). World-wide groundwater is estimated to provide approximately 50% of current potable water supplies, 40% of the water demand of self-supplied industry and 20% of water use in irrigation. In Dighal bank block, Kishangnj district many parts of the area were found iron contamination availability of the safe drinking water is the major issue of this district. Soil of the Dighalbank block was found sandy loam soil. The rain Intensity is also high compare to the other district of Bihar, So leaching of harmful materials is also grater and its effect appears on ground water quality (Rajendran *et al.* 2021). The iron contamination in groundwater is one of the most discussed issues as groundwater is an important resource for livelihoods and food security of billions of people. Iron (Fe^{+}) contamination in groundwater is now a vital problem in Koshi region in Bihar. Iron is the second most abundant metal in the earth's crust, of which it accounts for about 5%. Elemental Fe is rarely found in nature, as the Fe ions Fe^{2+} and Fe^{3+} readily combine with oxygen- and sulphur-containing compounds to form oxides, hydroxides, carbonates and sulphides (Kushalan *et al.*2023). It is most commonly found in nature in the form of its oxides (Nata *et al.* 2011). In Dighalbank block, Kishanganj district iron contamination in ground water was presence through natural process. Determination of groundwater quality is important to observe the suitability of water for a particular use. The problems of ground water quality are more acute in areas that are densely populated and thickly industrialized and have shallow groundwater tube wells. In developing world, 80% of diseases are directly related to poor drinking water and unsanitary conditions (UNESCO 2007).

MATERIALS AND METHOD

In Bihar, Dighalbank block, Kishangnj district situated in eastern zone – II between Latitude 26.36286 N' and Longitude 87.96821 E'. The economy of the area is based on agriculture and the agriculture is dependent partly on groundwater. Hydrogeological the weathered overburden is characterized by high porosity and loss of water due to leaching of water, but, due to its relatively high sand content soil, it has a high permeability. Global Positioning System (GPS) based fifteen ground water (Deep and shallow tub well) samples were collected in month of December-January 2023, in air tight preconditioned high-density polythene bottles of 1.0 litre capacity. All bottles were thoroughly washed and rinsed with water before collecting ground water samples. The polythene

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bottles were completely filled without any air bubble before sealing the cap. The locations from where water samples have been collected are marked on the study area. All the ground water samples were analysed in the laboratory using the standard method (APHA 2012), Iron (Fe^{+}) in water samples measure by using the Atomic Absorption Spectrophotometer. The parameters such as sodium adsorption ratio (SAR), residual sodium carbonate (RSC), Total hardness (TH) magnesium adsorption ratio (MAR) and Kelly's ratio (KR) was calculated to evaluate the suitability of the water quality for Agricultural purposes and are shown in (Table 1).

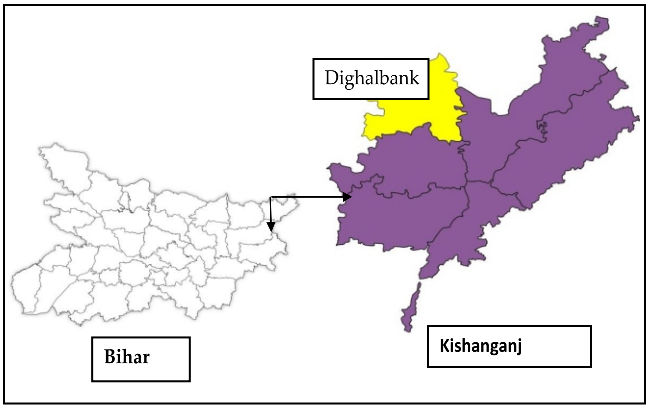

Fig. 1: Map of the study area dighalbank block of Kisangani, district.

SAR

Total salt concentration and probable sodium hazard of the irrigation water are the two major constituents for determining sodium adsorption ratio (SAR). Salinity hazard is based on electrical conductivity (EC) measurements. If water used for irrigation is high in Na^{+} and low in Ca^{2+} the ion exchange complex may become saturated with Na^{+} which destroys the soil structure, due to the dispersion of clay particles.

$$SAR = Na^{+} / (Ca^{2+} + Mg^{2+}/2)^{1/2}$$

RSC

Residual sodium carbonate (RSC) values of the water samples of the present area have been calculated using the formula.

$$RSC = (CO_2^{-} + HCO_3^{--}) - (Ca^{2+} + Mg^{2+})$$

Where, all ions are calculated in meq/L.

A negative RSC value indicates that sodium build-up is unlikely since sufficient calcium and magnesium are in excess of that can be precipitated as carbonates.

MAR

Magnesium adsorption ratio (MAR) for irrigation water of the present area has been calculated by using the formula:

$$MAR = (Mg^{2+} \quad 100) / (Ca^{2+} + Mg^{2+})$$

Where, all ions are calculated in meq/L.

Commonly Ca^{2+} and Mg^{2+} maintain a state of equilibrium in most groundwater (Hem, 1985). Throughout equilibrium more Mg^{2+} in groundwater will adversely affect the soil quality representation it alkaline resulting in decrease of crop yield (Kumar *et al.* 2007).

KR

Kelly's ratio (KR) is defined as the excess amount of sodium over calcium and magnesium. KR is used to find out the suitability of groundwater for irrigation. According to (Kelly, 1963) the KR is expressed by the equation:

$$KR = Na^{+} / (Ca^{2+} + Mg^{2+})$$

Where, concentration of all constituents is expressed in meq/L.

Result and Discussion

Safe drinking water in India has increased over the past decade; the incredible adverse impact of unsafe water on health continues (WHO/UNICEF 2012). It is now generally recognized that the quality of groundwater is just as important as its quantity. The chemistry of water were observed the pH ranges were found slightly acidic to acidic nature 4.63 -5.53, the salt concentration in water denoted by the value of the electrical conductivity of the water found ranges 0.12–0.94 dsm^{-1}. The general acceptance level of hardness is 300 mg/L, although WHO has set an allowable limit of 600 mg/L. The total hardness were varies between 128–758 mg/l, the some samples has exceed the permissible limit (Marove *et al.* 2022). Ca^{2+} contain in water samples between 22.4– 272.54 mg/L, Mg^{2+} 25.76– 147.59 mg/L, Na^{+} 1.2-4.1 mg/L, Fe^{+} 2.08-3.76 mg/L (Table.1) whereas Indian standard level of Fe^{+} is 1.00 mg/L, while WHO standard level is 0.3 mg/L. Iron is an essential element in human (Hossain *et al.* 2013). Although iron has little concern as a health hazard, it is still considered as a nuisance in excessive quantities. It causes staining of clothes and utensils (Vipin *et al.* 2017). It is also not suitable for processing of food, beverages, bleaching, dyeing etc. (Behera *et al.* 2012). It is observed that the all the samples were exceed the permissible limit of the drinking purposes. So all the samples of Dighalbank, block was found unsuitable for the drinking use. Anions contain in water ground samples was observed like CO_3^{-} 0.0 mg/L, HCO_3^{-} 0.061–0.366 mg/L, Cl^{-} 15.9–48.5 mg/L. In the purpose of the irrigation use the sodium adsorption ratio (SAR) Total salt concentration and probable sodium hazard of the irrigation water are the two major constituents for determining sodium adsorption ratio (SAR) (Sharma *et al.* 2017). Salinity hazard is based on EC measurements. If water used for irrigation is high in Na^{+} and low in Ca^{2+} the ion exchange complex may become saturated with Na^{+} which destroys the soil structure, due to the dispersion of clay particles (Todd, 1980) and reduces the plant growth. Excess salinity reduces the osmotic activity of plants (Vasanthavigar *et al.* 2012). The sodium adsorption ratio (SAR) of the irrigation water is 0.10-0.39 meq/L (Table 1) it's excellent for the irrigation use. Residual sodium carbonate (RSC) is calculated to determine the hazardous effect of carbonate and bicarbonate on the quality of water used for agricultural activities (Jurec *et al.* 2017). Suitability of groundwater used for irrigation depends upon the concentration of bicarbonate and carbonate higher than calcium and magnesium. Residual sodium carbonate (RSC) values of the water samples of the present area have been calculated using the formula . Residual sodium carbonate was found ranges between (-327.0) – (-35.2). A negative RSC value indicates that sodium build-up is unlikely since sufficient calcium and magnesium are in excess of that can be precipitated as carbonates (Singh and Sharma

Table 1: Physicochemical characteristics of groundwater samples in Dighalbank Block

Particular	Latitude	Longitude	pH	EC (dsm^{-1})	Hardness (mg/l)	Ca^{++} (mg/l)	Mg^{++} (mg/l)	Na^{+} (mg/l)	Fe+ (mg/l)	CO_3^{--} (mg/l)	HCO_3^{--} (mg/l)	Cl^- (mg/l)	SAR	RSC	MAR	KR
W1	26.36286	87.96821	5.21	0.37	254	27.25	55.33	1.3	2.2	0.0	0.061	22.5	0.18	-54.9	67.0	0.016
W2	26.41012	87.89518	5.21	0.62	236	51.30	45.07	1.2	3.3	0.0	0.122	35.0	0.14	-73.7	46.8	0.012
W3	26.39088	87.88798	5.02	0.58	304	40.08	64.40	2.4	2.75	0.0	0.244	42.5	0.28	-72.0	61.6	0.023
W4	26.38143	87.88614	5.53	0.94	354	76.15	67.79	4.1	2.1	0.0	0.061	20.5	0.39	-110.0	47.1	0.028
W5	26.37055	87.88775	4.75	0.48	214	23.25	46.54	2.5	2.4	0.0	0.183	30.0	0.37	-46.3	66.7	0.036
W6	26.35376	87.90619	5.06	0.82	202	47.29	37.75	1.8	3.15	0.0	0.061	18.0	0.22	-66.1	44.4	0.021
W7	26.34925	87.91295	4.63	0.12	560	112.22	109.26	3.2	3.55	0.0	0.305	44.0	0.25	-166.5	49.3	0.014
W8	26.34476	87.92077	5.31	0.46	720	272.54	109.18	3.8	2.95	0.0	0.183	28.0	0.21	-327.0	28.6	0.010
W9	26.33294	87.92104	4.95	0.68	128	22.44	25.76	1.2	3.3	0.0	0.122	45.5	0.20	-35.2	53.4	0.025
W10	26.34776	87.90418	5.2	0.41	218	41.68	43.02	1.6	2.08	0.0	0.366	22.0	0.20	-62.8	50.8	0.019
W11	26.33893	87.80369	4.96	0.34	316	71.34	59.70	1.4	2.2	0.0	0.244	28.8	0.14	-100.9	45.6	0.011
W12	26.37066	87.80159	5.03	0.56	520	103.41	101.65	1.3	2.45	0.0	0.366	32.5	0.10	-153.9	49.6	0.006
W13	26.38311	87.80146	5.32	0.68	624	168.34	111.18	1.5	3.35	0.0	0.122	21.0	0.10	-223.8	39.8	0.005
W14	26.41516	87.79249	4.82	0.67	438	75.35	88.49	2.8	3.76	0.0	0.061	48.5	0.26	-119.5	54.0	0.017
W15	26.43163	87.82104	5.1	0.57	758	153.11	147.59	1.9	2.9	0.0	0.305	15.9	0.13	-226.6	49.1	0.006
Max.			**5.53**	**0.94**	**758**	**272.54**	**147.59**	**4.1**	**3.76**	**0.0**	**0.366**	**48.5**	**0.39**	**-35.2**	**67.0**	**0.036**
Min.			**4.63**	**0.12**	**128**	**22.44**	**25.76**	**1.2**	**2.08**	**0.0**	**0.061**	**15.9**	**0.10**	**-327.0**	**28.6**	**0.005**

Table 2: Correlation between different water quality parameters

	pH	EC	Hardness	Ca^{++}	Mg^{++}	Na^{+}	Fe+	HCO_3^{--}	Cl^-	SAR	RSC	MAR	KR
pH													
EC	0.512**												
Hardness	0.119*	-0.164*											
Ca++	0.294*	-0.099*	0.896**										
Mg++	0.027*	-0.183*	0.977**	0.781**									
Na+	0.090*	0.083*	0.359*	0.415**	0.306*								
Fe+	-0.365*	0.082*	0.264*	0.243*	0.255*	0.046*							
HCO_3^{-}	-0.275**	-0.564**	0.309*	0.169*	0.353*	-0.135*	-0.260**						
Cl^-	-0.624**	-0.216**	-0.172*	-0.215*	-0.139*	0.082*	0.517**	0.014*					
SAR	-0.109*	0.215**	-0.322**	-0.297**	-0.311**	0.707**	-0.171*	-0.291**	0.173*				
RSC	-0.249*	0.120*	-0.946**	-0.991**	-0.856**	-0.408**	-0.255**	-0.213**	0.207*	0.310*			
MAR	-0.415**	-0.148*	-0.541**	-0.779**	-0.388**	-0.247**	-0.266**	-0.040*	0.243*	0.345*	0.726**		
KR	-0.182*	0.256*	-0.680**	-0.620**	-0.659**	0.300**	-0.231**	-0.326**	0.172*	0.874**	0.651**	0.546**	

2023). Mostly calcium and magnesium maintain equilibrium in water. Magnesium adsorption ratio (MAR) for irrigation water of the present area has been found ranges between 28.6 - 67.0 meq/L (Table 1). Irrigation water with MAR above 50 is usually not suitable. On the basis of MAR value approximate 40% (per cent) water is not suitable for irrigation. Kelly's ratio (KR) is defined as the excess amount of sodium over calcium and magnesium. KR is used to find out the suitability of groundwater for irrigation (KR value <1- Suitable, >1- not suitable). All the samples of the dighalbank block were found ranges 0.005- 0.036 meq/L. It's a under the permissible limit and suitable for the irrigation purpose (Kumar *et al.* 2016).

Correlation between different water quality parameters

Water samples of the dighalbank, block is correlated with different quality parameters the calculated value we observed that the pH is positively correlated with EC (r =0.512**), Hardness (r =0.119*), Ca^{++} (r= 0.294**), Mg^{++} (r=0.027*), Na^{+} (r= 0.090*) and negatively correlated with Fe (r =-0.365**), HCO_3^- (r= -0.275**), Cl (r= -0.624**), SAR (r= -0.109*), RSC (r=-0.249*),MAR (r=0.415**), KR (r=-0.182*)(Table.2). Electrical conductivity (EC) is Positively correlated with Na^{+} (r= 0.083*), Fe^{+} (r=0.082*), SAR (r=0.215**), RSC(r=0.120*) , MAR (r=0.256**) and negatively correlated with Hardness (r =-0.164*), Ca^{++} (r= -0.099*), Mg^{++} (r=-0.183*), HCO_3^- (r= -0.564**), Cl^- (r= -0.216**) and with MAR (r=-0.148*) (Table.2).Hardness is an important drinking quality parameters is positively correlated with Ca^{++} (r= 0.896**), Mg^{++} (r=0.977**), Na^{+} (r= 0.359**), Fe^{+} (r=0.264**), HCO_3^- (r=0.309**) and negatively correlated with Cl^- (r= -0.172*), SAR (r=-0.322**), RSC(r= -0.946**), MAR (r= -0.541**) and KR(r= -0.680**) (Table.2).

Classification of water for the irrigation purposes

All the analysed water samples data plot on U.S. salinity diagram on the basis of the EC and SAR value. The water samples of the dighalbank were found under the C1S1 class (Table 3).

The Class of C1S1 are considering under the safe zone for the irrigation purpose. So it is evident that all the groundwater samples are suitable for irrigation purposes throughout the year according to US Salinity Diagram.

Table 3: Criteria of irrigation water quality of Dighalbank block

Latitude	Longitude	Class	Remark
26.36286	87.96821	C1S1	Suitable for Irrigation
26.41012	87.89518	C1S1	Suitable for Irrigation
26.39088	87.88798	C1S1	Suitable for Irrigation
26.38143	87.88614	C1S1	Suitable for Irrigation
26.37055	87.88775	C1S1	Suitable for Irrigation
26.35376	87.90619	C1S1	Suitable for Irrigation
26.34925	87.91295	C1S1	Suitable for Irrigation
26.34476	87.92077	C1S1	Suitable for Irrigation
26.33294	87.92104	C1S1	Suitable for Irrigation
26.34776	87.90418	C1S1	Suitable for Irrigation
26.33893	87.80369	C1S1	Suitable for Irrigation
26.37066	87.80159	C1S1	Suitable for Irrigation
26.38311	87.80146	C1S1	Suitable for Irrigation
26.41516	87.79249	C1S1	Suitable for Irrigation
26.43163	87.82104	C1S1	Suitable for Irrigation

United States Salinity Laboratory (1954)

CONCLUSION

The ground water quality of the dighalbank block of Kishanganj, district were characterise through the chemical composition. The underground water is the main and probably the only source for drinking and irrigation water in Kishangnj, district. Evolution of the suitability of water for the irrigation and drinking purpose on the basis of Electrical conductivity (EC), Sodium adsorption ration (SAR), Residual sodium carbonate (RSC) and iron (Fe^{+}) contain in ground water. pH of the water samples was slightly acidic in nature and all the analysed water samples were found suitable for the irrigation use and crop production. The concentration of iron (Fe^{+}) in the water samples were exceeds the permissible limit and all the ground water was found not suitable for the human consumption. In order to control the pollution of water bodies, it is very necessary to install effluent treatment plants in the district and to enforce their usage. To avoid the poisonous effects of water from contaminated sources, it is required to make use of water purification devices, which can be provided in the villages by government bodies.

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