



Assessment of Irrigation Water Quality of Pabna District (North-Western Part) of Bangladesh for Securing Risk-Free Agricultural Production

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Abstract: Agriculture mostly depends on suitable supply of water for irrigation. Before application of water, water quality must be measured because of secure in-toxic food production. If the poor quality of irrigation water is not managed properly then it poses many hazards to plant production. So for the better plant and crop production the quality of the water need to be analyzed properly and improving further management. With the finality to analyze the irrigation water quality (physico-chemical parameters), different places of Pabna District were evaluated. Twenty water samples were collected in the winter season (January-march) and then they were examined for temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), sodium adsorption ratio (SAR), soluble sodium percentage (SSP), residual sodium carbonate (RSC), and so on. The study indicates that waters were found within the permissible limits for irrigation purposes. So, The irrigation water samples from surface water, Ground water and deep tube-wells water can be used in agricultural purposes.

Keywords: Groundwater, Surface Water and Ground Water, Hydro Geochemistry, Water Quality, Sustainable Agriculture

1. Introduction

Bangladesh is an agricultural based economy but it's not totally depends on rainwater. Huge amount of irrigation requires for agricultural practice. Pabna is the north-western district of the country where irrigation is the main criteria for food production except in the rainy season. Irrigation water can come from groundwater, surface water or from non-conventional sources like treated waste water and/or drainage water [19, 21]. Irrigation helps grow agricultural crops and this crops are dependent on water quality. It has a great importance of this analysis of different parameters of the water of the Pabna district. Due irrigation water is contained a higher salt than potable water sources, it is important to use a good quality of water in to the field. So it is necessary to analyses the parameters whether it is good or not. For a specific use, water quality refers to the characteristics that

will influence its suitability. These are physical, chemical and biological characteristics. Irrigation water evaluation is placed on the chemical and physical characteristics [21]. If we use a good quality water, it will give sustainable yield. Therefore, the analysis of the parameters of the water sample is important. Depending on this we will get a good quality of water that will be usable for the growing crops or other respectable uses. Water can be polluted by using different fertilizer and pesticides like diazinon into land for better food production [22].

Soil of the north-western part (floodplain soil) of the country is fertile but in toxic level, so the water quality is also good in ground and surface water [4, 14]. It covers an area of 2,371.50 sq. km. with annual average maximum temperature of 36.8°C and the minimum of 9.6°C. The average precipitation is around 3mm in December and 300 mm in August. The annual total rainfall is 1603 mm. The average humidity is 36 mm in

February and 76 mm in August. However, overall humidity is around 57.3 mm over the year. Pabna forms the south-east boundary of Rajshahi division and Sirajgong and nature district is situated in north-east and North West part of the district. Other borders are cover with Padma and other rivers. Around 2.1 million people's lives in the districts where most of the peoples depends on agricultural production. Its agriculture is mainly dependent on irrigation.

Nevertheless, a detailed investigation regarding the irrigation water quality and its suitability for crops has not yet been done. Therefore, an assessment of irrigation of this district is much more essential for agricultural and food safety to find out whether the concentration of physico-chemical properties is tolerate able or not. There are some important factors which are climate related to irrigation and water quality Different crops need different irrigation water quality. The quality of the irrigation water may affect both crop yields and soil physical conditions even if all other conditions and cultural practices [2, 18]. There are three types of characteristics that are physical, chemical and biological which affect the quality of irrigation water [2]. To evaluate the quality of irrigation water, we need to identify the characteristics that are important. Having the water tested by a reputable laboratory is the first step in this process. To avoid problems there must also be sound planning to ensure that the quality of water available is put to the best use. Pabna district lies in the north-western part of Bangladesh.

Agriculture in Pabna District depends on an adequate supply of water for irrigation. If the quality irrigation water is

not managed properly then it poses many hazards to plant production. Above mention the goal of this research consist in analyze the irrigation water (physico-chemical parameters), of different places of Pabna District, to find out the better quality of irrigation water and assess the usability of water in irrigation purpose for crop production which is the crying needs of time.

2. Materials and Methods

To evaluate the suitability of groundwater for irrigated agriculture of Pabna District a field research was conducted. It is located 24.01 latitude and 89.24 longitude; it is at elevation 19 meters above sea level (Figure. 1). Pabna district water have less chance to polluting water due to floodplain region. Floodplain region have less chances to pollute water than hill soil [23]. On the same way, Padma river has less chance to riverbank erosion than other rivers like Jamuna [24] A total of twenty water samples were collected from various sites Samples were collected from 5 Deep Tubewells Water (DTW), 5 Shallow Tubewells Water (STW), 5 rivers and 5 canals. Each sample was a composite of 10 sub-samples to minimize error and heterogeneity. The samples were must use as soon as possible. Before sampling a high density PVC bottles were used and thoroughly cleaned by rinsing with 8N HNO₃. Before we started for sampling from a well sufficient amount of water should be pumped out [16]. For the identification the bottles were kept air tight and labeled properly.

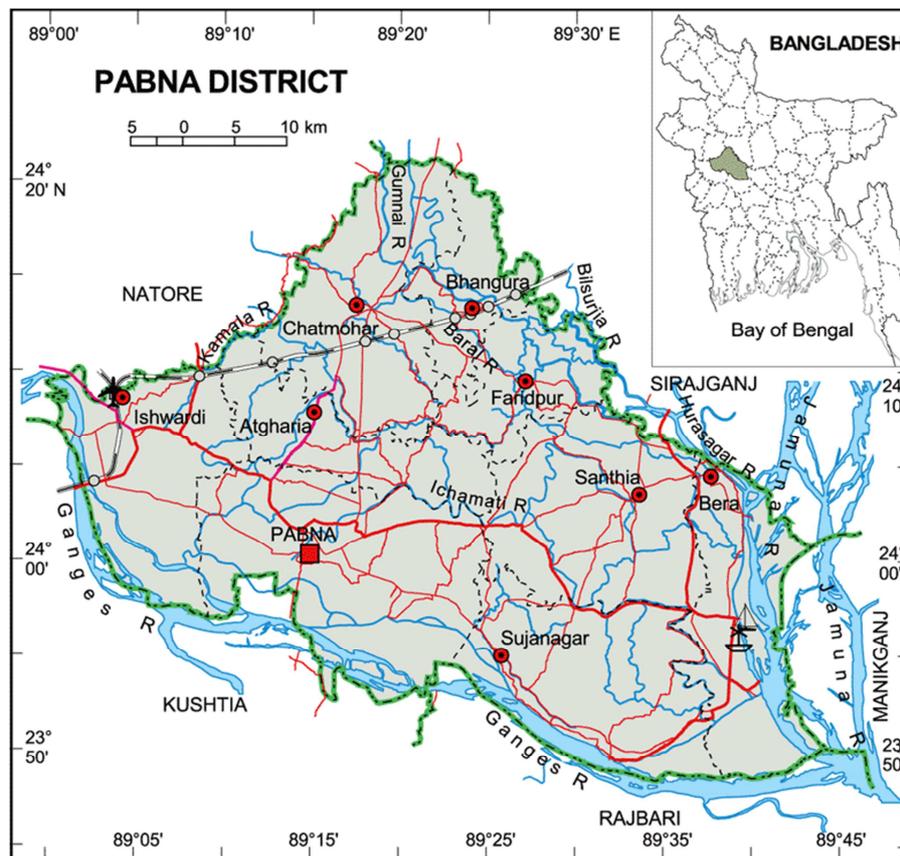


Figure 1. Representation of study area map (Pabna District).

Variables evaluated. EC, pH and temperature of the samples were analyzed using portable EC-meter, pH-meter and thermometer, respectively. Also, was analyzed the relation between EC and TDS, Ionic TDS was simply determined by multiplying the measured EC values (in $\mu\text{S}/\text{cm}$) by 0.64. Samples were kept for analysis in the laboratory in a refrigerator. The determination of Na^+ and K^+ were done by flame photometry [11]; Ca^{2+} , Mg^{2+} , Fe by visible spectrophotometry [11]; Cl^- and HCO_3^- by titration method [11]; by using the values obtained for, Ca^{2+} , Mg^{2+} in me/l the sodium adsorption ratio (SAR) was estimated [17]; by the equation using the values obtained for Na^+ , K^+ , Ca^{2+} , Mg^{2+} in me/l the soluble sodium percentage was determined; by the equation using the values obtained for CO_3^{2-} , HCO_3^- in me/l the residual sodium carbonate was determined [7] and by the equation using the values obtained for Na^+ , Ca^{2+} and Mg^{2+} in me/l the Kelly's ratio was determined [12].

3. Results and Discussion

Because the physico-chemical properties has a strong impact of Irrigation water quality and on the productivity of plants and crops, health soils, and the surrounding ecosystems, was important find out the quality of the irrigation water of Pabna District. The results are showed in Table 1, indicated the results of physico-chemical parameters of the study area of Pabna. Table 2 shows the suitability of water quality for irrigation purposes. The EC value of the samples ranges from 318 to 739 $\mu\text{S}/\text{cm}$ with an average value of 522.8 $\mu\text{S}/\text{cm}$ and standard deviation is 109.63 $\mu\text{S}/\text{cm}$. We know that, the EC value of $< 700 \mu\text{S}/\text{cm}$ refers the water to 'none' criteria. The pH value of the samples ranges from 6.0 to 7.9 with an average value of 7.0. Table 1 reveals that the average temperature of the samples was 20.7°C and in the range of 18 to 22°C.

Table 1. Physico-chemical irrigation water quality of different point in Pabna District.

Sample no	Sampling area	Sources of sample	Temperature (°C)	EC ($\mu\text{S}/\text{m}$)	pH	TDS (mg/l)
1	Atghoria, Akdauta	STW	19	318	7.2	333
2	Atghoria, Debattar	STW	19	435	7.4	329
3	Bera, Chakla	Brahmaputra River	20	455	7	349
4	Bera, kaitola	Brahmaputra River	19	319	6.3	339
5	Bhangura, Dillpashar	DTW	20	633	7.9	319
6	Bhangura, Par Bhangura	Canal	21	555	7.3	206
7	Chatmohor, Foilijana	DTW	19	519	7.5	249
8	Chatmohor, Bilchalon	DTW	20	548	7.6	459
9	Faridpur, Demra	DTW	20	433	7.3	329
10	Faridpur, Hadal	Canal	19	467	6	329
11	Ishurdi, Sara	Padma river	19	567	6.2	339
12	Ishurdi, Paksey	Padma river	21	567	6.1	326
13	Ishurdi, Dashuria	STW	18	517	6.1	303
14	Pabna, Barara	Canal	20	629	6.1	320
15	Pabna, Dapunia	Canal	20	458	7.3	319
16	Pabna, Malanchi	Canal	21	647	7.2	309
17	Santhia, Karamja	Canal	19	693	7.5	344
18	Santhia, Dropadha	STW	20	529	7.2	228
19	Sujanagar, Dulai	STW	19	428	7.3	347
20	Sujanagar, Hatkhali	DTW	22	739	6	489
	Average	-	20.7	522.8	7	328.25
	Range	-	18-22	318-739	6.0-7.9	206-489
	SD	-	0.94	109.63	0.622	61.95
	CV%	-	4.77	20.96	8.99	18.87

Table 1. Continued.

Sample no	Sampling area	SAR	SSP%	RSC me/l	Kalley's Ratio	Fe (me/l)	Cl (me/l)	HCO ₃ (me/l)
1	Atghoria, Akdauta	0.11	13.56	1.36	0.287	0.02	2.24	4.1
2	Atghoria, Debattar	0.13	13.53	2.37	0.286	0.023	2.38	3.33
3	Bera, Chakla	0.17	18.89	1.41	0.387	0	2.36	3.41
4	Bera, kaitola	0.15	16.79	1.79	0.133	0.002	1.18	3.14
5	Bhangura, Dillpashar	0.45	14.54	2.17	0.193	0	2.9	3.13
6	Bhangura, Par Bhangura	0.19	23.43	1.36	0.228	0	1.24	3.09
7	Chatmohor, Foilijana	0.12	12.34	2.33	0.167	0.112	0.49	2.9
8	Chatmohor, Bilchalon	0.13	11.59	1.37	0.127	0	2.29	4.43
9	Faridpur, Demra	0.18	14.43	2.5	0.133	0.2	3.22	2.19
10	Faridpur, Hadal	0.14	20.95	1.03	0.118	0.004	1.02	3.46
11	Ishurdi, Sara	0.19	34	1.91	0.27	0.003	0.79	3.48
12	Ishurdi, Paksey	0.28	35.41	1.27	0.297	0	0.2	5.33
13	Ishurdi, Dashuria	0.13	16.57	1.32	0.197	0	1.03	4.67
14	Pabna, Barara	0.29	18.34	3.54	0.397	0	2.04	5.18
15	Pabna, Dapunia	0.39	28.27	1.31	0.489	0.002	1.3	5

Sample no	Sampling area	SAR	SSP%	RSC me/l	Kalley's Ratio	Fe (me/l)	Cl (me/l)	HCO ₃ (me/l)
16	Pabna, Malanchi	0.39	33.12	2.87	0.789	0	1.41	5.44
17	Santhia, Karamja	0.55	32.21	3.35	0.396	0	2.01	4.1
18	Santhia, Dropadha	0.32	24.43	1.33	0.28	0.005	1.15	3.27
19	Sujanagar, Dulai	0.22	24.35	2.12	0.298	0.019	1	2.59
20	Sujanagar, Hatkhali	0.24	22.86	1.5	0.29	0	1.3	3.49
	Average	0.24	21.48	1.91	0.29	0.02	1.58	3.79
	Range	0.11-0.55	11.59-35.41	1.03-3.54	0.13-0.79	0.00-0.20	0.20-3.22	2.19-5.44
	SD	0.12	7.54	0.709	0.152	0.05	0.79	0.92
	CV%	50.9	35.1	37.1	52.8	253.7	49.8	24.2

EC=Elective conductivity; pH: Potential of Hydrogen; TDS: Total Dissolved Solid; SAR: Sodium Adsorption Ratio; SSP: Soluble Sodium Percentage; RSC: Residual Sodium Carbonate;
STW: Shallow Tube well Water;
DTW: Deep Tube well Water.

Table 2. Guideline for interpretation of water quality for irrigation (13).

Salinity (affects crop water availability)	Degree of Restriction on Use		
Potential Irrigation Problem	None	Slight-Moderate	Severe
EC μ S/cm	<7000	700-3000	>3000
TDS mg/l	<450	450-2000	>2000

Infiltration (affects infiltration rate of water into the soil. Evaluate using EC and SAR together)			
SAR = 0.3 and EC =	> 700	700-200	<200
=3-6 =	>1200	1200-300	<300
=6-12 =	>1900	1900-500	<500
=12-20 =	>2900	2900-1300	>1300
=20-40 =	>500	5000-2900	<2900

Specific Ion Toxicity			
Sodium (Na) meq/l	<3	3-9 >9	0.69-3.09
Chloride (Cl) meq/l	<4	4-10 >10	0.59-5.63
Miscellaneous effect			
pH (Normal Range)	6.5-8.5		6.7-7.9

The TDS values range from 206-489 mg/l with an average value of 328.25 mg/l. In terms of 'Degree of restrictions on use', the TDS values <450, 450-2000 and >2000 mg/l represent the irrigation water as 'none'; 'slight to moderate' and 'severe', respectively (Table 2). The values of SAR range from 0.11 -0.55 with an average value of 0.24 (Table 1). The values of soluble sodium percentage (SSP) range from 11.59 to 35.41% with an average value of 21.48% (Table 1).

From the Table 1 we get the highest residual sodium carbonate (RSC) value of the irrigation water was 3.54 which was collected from a canal near barara village under Pabna Upazilla. The average value of RSC of the collected irrigation water samples was 1.91. The Kelly's ratio ranged from 0.133 to 0.789 with an average value of 0.29 (Table 1). Iron (Fe) content ranged from 0.00 to 0.20 me/l with an average value of 0.02 me/l. Chloride (Cl⁻) content ranged from 0.20 to 3.22 me/l with an average value of 1.58me/l (Table 1). Bicarbonate ranged from 2.19 and 5.44 me/l with an average value of 3.79 me/l (table 1). So, the upper and lower limit of the Kelly's ratio, iron, chlorine, Bicarbonate limit is not toxic for soil health and for production.

Based on the result the temperature and pH is within the permissible for irrigation purposes. (Doe and UCCC). The EC according to is excellent too good. It is easily presumable from the data in Table 2 that the EC value falls under category 'none'. As EC and TDS values are interrelated so TDS is suitable for irrigation purpose. The SAR of all the

irrigation water samples fell under 'excellent' class. (17). The SSP of few samples fell under "Excellent class" The RSC of few samples fell under "Good" class (7). The Kelly's Ratio showed all values were under acceptable range and suitable for irrigation purposes (12). About 10 samples no Fe was detected. Highest Fe concentration was recorded in Foilijana village under Chatmohor Upazilla from DTW. The water sample of DTW near Demra village under Faridpur Upazilla showed the highest value of Cl⁻. It is evident that the values of Cl of the study area were within the recommended limit (2) and suitable for irrigation (13). The HCO₃⁻ of all the water was suitable for irrigation (2). Most of the values fell into 'slight to moderate'. The B of all samples are within the permissible limits (2).

So, the overall assessment justify the usability of irrigation water of Pabna District. No toxic substance found in the water sampling sources in the present time. So, Farmer and other people can use it without further thinking about the water quality of irrigation water. No toxic chemical and hazardous element cannot found in an excess able level due to absent of over capitalization, Industries, mills and garments factory. But, In the near future government are planning to founded some industry, mills and most importantly Rooppur atomic power plant station which require huge amount of water and energy which discharged polluted water into river, canal and so on. As a consequence ground water, deep and shallow tube well water also can be polluted in the surrounding water that can damage our ecosystem, aquatic life, fish production, food and soil

quality, biodiversity and human health. So, government should not planned for Rooppur atomic plant in the areas where the ecosystem price is much higher. It can be planned in somewhere else where bio resources is not sufficient. By the way, after a certain time of internal, assessment of irrigation water quality should be measured due to protect our bio resources and sustainability for food production.

4. Conclusion

Different physico-chemical properties of irrigation water of Pabna District were matched with the water quality standards set for irrigation. Electrical Conductivity (EC) of collected irrigation water samples fall in the class 'Good' some samples which fall in the 'Excellent' class of EC; SAR, in 'Excellent', SSP in 'Good to Excellent' RSC in 'Good to Marginal' and Fe and CI contents within the Maximum Allowable Concentration (MAC). On the basis of SAR, RSC, and SSP values, no permeability problem was found to exist in Pabna District. If we gone through the other physical-chemical properties of the Rajshahi division then it will come to know that the physical-chemical properties of Pabna District is quite good at irrigation purposes [1]. The result and quality of water is closely similar with Faridpur District [25]

Competing Interests

Authors have declared that no competing interests exist.

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