



Determination of Surface Water Quality for Irrigation in Dinajpur

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ABSTRACT

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A research was carried out to assess the suitability of surface water for irrigation purposes. For this reason, 56 samples of surface water were collected from each union of Dinajpur sadar upazilla, Dinajpur. The analysis was included pH, EC, TDS, Ca, Mg, S, P, Na, K, Cl⁻ and HCO₃⁻ to evaluate the suitability of surface water for irrigation purposes. Almost all the water samples were within the recommended pH value for irrigation and a great impact on crop production. With respect to electrical conductivity (EC) samples were low to medium salinity. For total dissolved solids (TDS), all samples were considered as freshwater for irrigation. On the basis of Ca, Mg, S, P, Na, K, Cl⁻ and HCO₃⁻ all samples could safely be used for irrigation and would not affect the soils.

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Introduction

Surface water is the water that collects on the surface of the earth. This includes lakes, rivers, oceans, seas, or wetlands. Fresh surface water is maintained by rainfall or other precipitation, and lost through evaporation, seepage through the ground or use by animals and plants. Surface water is an important source of fresh water for agricultural and domestic uses in many regions of the world including Bangladesh. The demand for surface water has been increasing day by day for irrigation by bringing more area under cultivation. Water generally contains different species of cations and anions in varying amounts. The principle soluble ions are Ca, Mg, Na and K as cations and Cl, SO₄, CO₃ and HCO₃⁻ as anions. Besides these, Cu, PO₄, Fe, Mn, Zn, As, B, Si and F are present in small amounts. Out of soluble constituents Ca, Mg, Fe, Na, Cl⁻, HCO₃⁻, SO₄ and B are of prime importance in determining the quality and suitability of irrigation water. The high concentrations of certain soluble ions have a direct toxic effect on sensitive crops. The toxic elements are B, Na, Cl, and Li. Symptoms of boron injury may include

characteristic leaf 'burning', chlorosis and necrosis, although some boron sensitive species do not develop obvious symptoms. Boron toxicity symptoms first appear on older leaves as yellowing, spotting, or drying of leaf tissues at the tips and edges. The drying and chlorosis often progresses toward the center of the leaf, between the veins as boron accumulates over time (Ayers and Westcot 1985). Ayers and Westcot (1985) reported that Cl toxicity on plants appears first at the leaf tips (which is a very common symptom for chloride toxicity), and progresses from the leaf tip back along the edges as severity of the toxic effect increases. Excessive necrosis is often accompanied by early leaf drop

or even total plant defoliation. A large Na content might have adverse effects on soil physical properties, such as a reduced hydraulic conductivity. The concentrations of some important chemical constituents of water are necessary to assess their suitability for irrigation drinking and industrial uses. Water quality for irrigation is a prime factor for successful crop production. There are many

factors that affect water quality. The concentration and consumption of dissolved constituents in water are on important determinant concerning its quality. The different ions in varying amounts present in dissolved forms at toxic levels are generally regarded as water pollutants. The water that runs off the field's carrier with sediments, fertilizers, herbicides, pesticides (if these chemicals are used on the fields) and natural salts leach out the soil and flow into rivers, lakes and surface water supplies, and make water quality low. Using this poor quality of water, it might deteriorate soil properties, crop yield and quality (Sarker et al. 2000). The high concentration of Na, B, Cl and HCO₃⁻ ions of water affects directly the soils and crop yield (Sarker et al. 2000; Sarker et al. 2009). A large Na content might have adverse effects on soil physical properties, such as a reduced hydraulic conductivity. Osmotic effects of excessive salinity cause adverse soil physical properties and reduce crop growth. Salts from the irrigation water accumulate in the soil profile and cause soil dispersion and surface seal development during irrigation, thus decreasing the infiltration rate and amount (Sarker, 2001). Thus, even though the soil in the field

appears to have plenty of moisture, the plants will wilt. This occurs because the plant roots are unable to take up soil-water due to its high osmotic potential. Water is one of the most natural resources on earth. In the global water resources, about 97.2% is saltwater mainly in oceans, and only 2.8% is available as freshwater. Out of 2.8%, about 2.2% is available as surface water and 0.6% as ground water (Raghunath, 1987). Surface water seems to be pure and free from suspended material in comparison to other sources, yet many compounds and/or ions in varying amounts may be dissolved and/or ionic forms. If low-quality water is used for drinking and beneficial uses, ionic toxicity, as well as health hazards, may occur. Due to the application of poor or hazardous quality water the agriculture land/soil is affected and damages the crop yield in several ways. The accumulation of salts in root zone, limited the availability of water and plant can take up lesser water which resulted in high plant stress and decreased crop yields (Shakoor, 2015). The presence of metals in irrigation water also has adverse effects on crop production. Also, high concentration of salts can change the plant nutrients balance in the soil meanwhile some salts are toxic to certain plants (Shakoor et al., 2015; Irfan et al., 2014). Sometimes, those substances are found at an objectionable level in surface water and considered as contaminated. When these waters are used in various irrigation, drinking and industrial purposes, they deteriorate the quality of the products. In some cases, ionic toxicity may occur and respective products become unsuitable for beneficial uses. For each use, there is a water quality recipe that specifies limiting concentrations of such variables like pH, total dissolved solids (TDS), total hardness (H_T), temperature and some ionic constituents. According to PCRWR (2007) the highest desirable concentration of TDS is 500 mgL⁻¹ hardness 200 mgL⁻¹ in drinking water. In spite of these chlorine and sulfate are the significant variables to assess the toxicity and suitability of the water for industrial usage (Raghunath, 1987). Agriculture is the greatest use of water accounting for 80% of all consumption. Irrigation Water quality is the most important criterion for successful crop production as it contains different ions in varying concentrations. Besides, agricultural points of view, the water of desirable quality is absolutely essential for irrigation usage are shown in Figure 1 below. The total

arable land area of Dinajpur sadar upazilla is about 25987 hectares, permanently uncultivable 4633 hectares, fellow 2071 hectares; single crop 10%, double-crop 60%, and triple cropland 25%. About 65% of its arable land is irrigated by surface water for successful crop production in different crop seasons. In view of importance for the formulation of a baseline data, an investigation has been conducted to assess the toxicity of surface water for categorize on the basis of standard criteria and predict the suitability and acceptability of water for irrigation usage in Dinajpur sadar upazilla, Dinajpur.

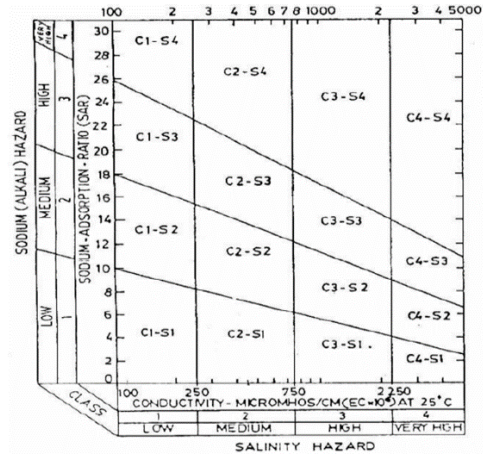


Figure 1. Diagram for classification of irrigation waters (Richards, 1968).

Materials and Methods

Selection of Study Area

The study was conducted in sadar upazilla (25.6333°N 88.6500°E). of Dinajpur district (Figure 2). The area of the sadar upazilla is 354.34 sq km. Surface water sampling sites were selected from different ponds and irrigation fields under Dinajpur sadar upazilla, Dinajpur.



Figure 2. Dinajpur sadar upazilla map

Collection of Surface Water Sample

The sample of surface water was collected from the different ponds and irrigation fields used for irrigation purposes in Dinajpur sadar upazilla. There were randomly 56 samples were collected from different ponds and irrigation fields. The sample was collected in liter plastic

bottles. The sample carried to the laboratory of the Department of Agricultural Chemistry, HSTU, Dinajpur for testing. The sample was analyzed as quickly as possible on the arrival at the laboratory. The information on different surface water samples was collected for analysis was mention in Table 1.

Table 1. Information regarding ponds and irrigation field water sampling

Sample no	Sources	Location (Dinajpur sadar upazilla), Dinajpur.	
		Union	Village
1.	River	Fazilpur	Chadgonj
2.	Pond-1		Udropur
3.	Pond-2		Moharajpur
4.	Pond-3		Fazilpur
5.	Irrigation field-1		Bala para
6.	Irrigation field-2		Naindon
7.	Pond-1	Sundarban	Kalikapur
8.	Pond-2		Kamarer mor
9.	Pond-3		Budharusha para
10.	Irrigation field-1		Kamar para
11.	Irrigation field-2		Telipara
12.	Pond-1	Chehelgazi	Bonkali
13.	River		Kornai
14.	Pond-2		Rudropur
15.	Irrigation field-1		Majhadanga
16.	Irrigation field-2		Mohabolipur
17.	Pond-1	Pourashava	Matasagar
18.	Pond-2		Rajbati
19.	Pond-3		Sukhsagar
20.	Irrigation field-1		Khalpara
21.	Irrigation field-2		Bidhasori
22.	Pond-1	Sekhpura	Hosenpur
23.	Pond-2		Paluapara
24.	Irrigation field-1		Nulaibari
25.	Irrigation field-2		Nahona
26.	Pond-3		Vatapara
27.	Pond-1	Auliapur	Nalaher
28.	Pond-2		Sikandar hut
29.	Pond-3		Ghughudanga
30.	Irrigation field-1		Foridpur
31.	Irrigation field-2		Joldou
32.	Pond-1	Askarpur	Raghobpur
33.	Pond-2		Tajhut
34.	Pond-3		Notunhut
35.	Irrigation field-1		Askarpur
36.	Irrigation field-2		Khanpur
37.	Pond-1	Kamalpur	Kamalpur
38.	Pond-2		Danor
39.	Pond-3		Tetulpukurr
40.	Irrigation field-1		Udoibazar
41.	Irrigation field-2		Mollapara
42.	Pond-1	Uthrail	Rothinathpur
43.	Pond-2		Chowdhuri para
44.	Pond-3		Nunshahar
45.	Irrigation field-1		Muradpur
46.	Irrigation field-2		Subdangha
47.	Pond-1	Shankarpur	Sonar para
48.	Pond-2		Pachakur
49.	Pond-3		Jalalpur
50.	Irrigation field-1		Shadipur
51.	Irrigation field-2		Shankarpur
52.	Pond-1	Shashra	Jaliapara
53.	River		Pachbibibi
54.	Pond-1		Kauga
55.	Irrigation field-1		Paikpara
56.	Irrigation field-1		Chunia para

Analytical Method for Analysis of Surface Water

The major chemical constituents or compounds which are contained in the surface water for analysis as follows:

The pH of the water sample was determined electrometrically following the procedure mentioned by Ghosh et al. (1983) using pH meters (Hanna instrument-211 model) in the laboratory of the Agricultural Chemistry Department, Hajee Mohammad Danesh Science and Technology University, Dinajpur.

Electrical Conductivity (EC)

The electrical conductivity of a system actually represents the concentration of total dissolved solids (TDS) or total salinity in water excluding the amount of silica. The EC of collected water samples was determined by the conductivity bridge (Hanna instrument-HI8033 model) as outline by Ghosh et al. (1983) in the laboratory of the Agricultural Chemistry Department, Hajee Mohammad Danesh Science and Technology University, Dinajpur.

Total Dissolved Solids (TDS)

Total dissolved solids (TDS) were determined by weighing the solid residue obtained by evaporating a measured aliquot of filtered water samples to dryness, according to the procedure described by Chopra and Kanwar (1980).

Calcium (Ca)

The basic sources of calcium are carbonate rocks (limestones, dolomites) that are dissolved by carbonic acid contained in water. When the availability of carbon dioxide (with which it is in a balance), is low, however, the reaction begins to proceed in a reverse direction, accompanied by precipitation of CaCO_3 . Another source of Ca^{2+} in natural waters is gypsum, is common in sedimentary rocks. Calcium ions dominate in the cation composition of low-mineralized waters. According to Islam et al. (2020) 40 ML of irrigation water sample was taken in a 250 ML conical flask. About 50 ML of hot distilled water was added. After added 5 ML NaOH (10%) solution, the flask was shaken thoroughly. Hydroxylamine hydrogen chloride, Potassium ferrocyanide, Triethanolamine were added 10 drops each and the flask is shaken. Then, added 4-5 drops of calcon indicator solution and shake the flask. Titrated the solution from a burette against $\text{Na}_2\text{-EDTA}$ (0.01M). The experiment was repeated at least 3 times. Conducted a blank experiment taking all the reagents except irrigation water. The data was tabulated and the calculated amount calculated from the irrigation water supplied.

Magnesium (Mg)

By the procedure of Islam et al. (2020) At first, exactly 40 ML wastewater sample was taken into a 250 ML conical flask. Then, 50 ML hot distilled water and 5 ML $\text{NH}_3\text{-NH}_4$ buffer solution were added. Shake the flask thoroughly. After those 10 drops each of Sodium tungstate solution, Hydroxylamine hydrogen chloride, Potassium ferrocyanide, Triethanolamine were added and the flask was shaken thoroughly. Then, 4-5 drops of EBT indicator solution were added and the flask was shaken thoroughly. Titrated the solution against $\text{Na}_2\text{-EDTA}$ (0.01M) from a

burette to conical flux. The experiment was added at least 3 times. Blank experiment was conducted taking all the reagents except irrigation water. Tabulated the data and calculated the amount of calcium from the supplied sample.

Sodium (Na) and Potassium (K)

Amount of Sodium and Potassium were determined with the help of Flame Emission Spectrophotometer using sodium and potassium filter respectively. The sample was aspirated into a gas flame and excitation was carried out in carefully controlled and reproducible conditions. The air pressure was fixed at 10 psi. The desired spectral line was isolated using interference filters. The intensity of light at 589 nm and 768 nm is approximately proportional to the concentration of the element's sodium and potassium, respectively. The percent emission was recorded according to the methods outlined by Golterman (1971) and Ghosh et al. (1983).

Phosphorus (P)

According to Islam et al. (2020) firstly, exactly 5 ML water sample was taken in a 100 ML volumetric flask and 4 ML of sulphomolybdic acid solution was added. It followed by the addition of distilled water up to 2/3rd volume of the flask. Secondly, the solution was mixed thoroughly after the addition of 5-6 drops of stannous chloride solution. Then, the volume of solution was made up to the mark with distilled water. Developed the full-color intensity within 3-4 minutes and then read the colored solution instantly in a spectrophotometer at 660 nm wavelength. After that blank solution were prepared by taking all the reagents as described except phosphorus solution. Standard or calibration curve were prepared by plotting the absorbance (optical density) of light in the Y-axis and concentrations of the solutions in X-axis in a graph paper. By plotting the spectrophotometer reading on the standard curve, the concentration of the test sample was easily obtained.

Sulphur (S)

At the beginning dissolved 0.769g of Epsom salt ($\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$) in a 1000 ML volumetric flask to was made a standard solution of 100 ppm sulfur. Then from the 100-ppm solution, a standard series sulfur solution was prepared and added about 0.3 g (1 scoop) barium chloride to each standard series. After that about 0.3 g (1 scoop) barium chloride was added to 20 ml of the unknown test solution. It was mixed until barium chloride dissolves completely and allowed to stand it for 30 minutes before reading. Took spectrophotometer reading at 425 nm wavelength putting the cuvette in the cuvette chamber against the blank one. Then found out the concentration of sulfate from the standard curve.

Chloride (Cl)

Firstly, 3.4 g of AgNO_3 were taken in a 1000 ML volumetric flask and 200-300 ML distilled water was added and then mixed it to dissolve properly and added distilled water to make up the volume. Secondly, 1.2 g K_2CrO_4 were taken into 250 ML volumetric flask and 100-150 ML distilled water and 1-2 drops saturated AgNO_3 solution were added

to made volume up to the mark adding distilled water. Then 5 ML of sample was taken in a 250 ML conical flask and 20 ML distilled water added and 5-6 drops K_2CrO_4 added then titrated against 0.02 N $AgNO_3$ solution until red brick tinge appeared or brick red precipitation. 1ML 1N $AgNO_3$ solution equivalent 0.03546 g Cl

Bicarbonate (HCO_3^-)

Bicarbonate of wastewater samples was determined by the acidimetric method of titration using phenolphthalein indicator ($C_2OH_{14}O_4$) for carbonate, with diluted sulphuric acid, bicarbonate forms rose-red color complex at the end of titration. The bicarbonate was estimated titrimetric ally after Chopra and Kanwar (1980) and Ghosh et al. (1983).

Result and Discussion

The ionic concentration of Ca, Mg, Na, K, P, S, Cl^- and HCO_3^- were present in variable quantities in the collected surface water samples. The advantages of water testing are initially judged by the nature and extent of its relationship with soil and crop. The rating of waters on the basis of chemical analyses is usually done after USEPA standards. These criteria followed worldwide by scientists working on water quality. Different leading organizations also follow USEPA criteria such as FAO, UNICEF and USDA etc.

Surface Water Rating for Irrigation

The value of the pH of the studied sample was the range 6.20 to 6.95. The mean value was 6.73 (Table 2) out of 56 samples. It indicates that the samples were slightly acidic. All samples were below pH 7 and were slightly acidic in nature and might be due to the presence of a lower concentration of Ca, Mg, Na and HCO_3^- . Ayers and Westcot (1985) mentioned that the normal pH range of irrigation usually varied from 6.0 to 8.5. So, it indicated that all surface water samples were within the normal range and this water might not be harmful to soil and crops.

Electrical Conductivity (EC)

The EC of all samples was within the limit of 110 to 870 μscm^{-1} with the mean value of 290.29 μscm^{-1} (Table 2). The EC of 34 samples was less than mean values and the rest of the samples were higher than the mean value. The highest value (870 μscm^{-1}) obtained in sample number 11 and the lowest value (110 μscm^{-1}) obtained in sample number 52. According to Richards (1968), as illustrated in Figure 2, all the surface water under test were rated as "low to medium(C_1 - C_2)" salinity. So, these surface water can be used for irrigation purposes without harmful effects on soils and crops but moderate leaching will be required. Excess salt increases the osmotic pressure of the soil solution, a situation that can result in a physiological drought condition. Thus, even though the soil in the field appears to have plenty of moisture, the plants will wilt. This occurs because the plant roots are unable to take up soil-water due to its high osmotic potential. Thus, water lost from the plant shoot via transpiration cannot be replenished, and wilting occurs.

Total Dissolved Solids (TDS)

The TDS of the tested surface water samples were varied from 20.51 to 360.32 mgL^{-1} and the mean value

133.48 mgL^{-1} (Table 2). There were 32 samples value was below the mean value and the rest of the 24 samples value was higher than the mean value. The highest value (360.32 mgL^{-1}) and the lowest value (20.51 mgL^{-1}) were the samples number 29 and 24 respectively. According to Freeze and Cherry (1979), as reported in Table 5, all the surface water under investigation contained less than 1000 mgL^{-1} TDS and were classified as "freshwater" in quality. These waters would not affect the osmotic pressure of soil solution and cell sap of the plants when applied to soil as irrigation water.

Calcium (Ca)

The basic sources of calcium are carbonate rocks (limestones, dolomites) that are dissolved by carbonic acid contained in water. When the availability of carbon dioxide (with which it in a balance), is low, however, the reaction begins to proceed in a reverse direction, accompanied by precipitation of $CaCO_3$. Another source of Ca in natural waters is gypsum, is common in sedimentary rocks. Calcium dominates in the cation composition of low-mineralized waters. The concentration of Ca was found within the range of 6.412 to 40.08 mgL^{-1} with a mean value of 19.72 mgL^{-1} (Table 2). Out of the samples, 33 samples values were lower than the mean value and the rest 23 samples values were higher than the mean value. Irrigation water containing less than 20 mgL^{-1} Ca was suitable for irrigating crops plants (Ayers and Westcot, 1985) reported as Table 6. On the basis of Ca content, the entire surface water samples can safely be used for irrigation and would not affect the soil.

Magnesium (Mg)

Magnesium is less abundant than calcium in the Earth's crust. It enters surface water as a result of the processes of chemical weathering and dissolution of dolomites, marls, and other rocks. Magnesium ions occur in all natural waters, but very seldom dominate. Its concentration in river waters ranges from one to tens of mgL^{-1} . The Mg content in the collected surface water samples was within the range of 6.8 to 39.86 mgL^{-1} . The mean value of the samples 22.32 mgL^{-1} (Table 2). In tested 26 samples values lower than the mean value and 30 samples values higher than the mean value. The highest values (39.86 mgL^{-1}) and the lowest value (6.8 mgL^{-1}) were found in samples number 11 and 21 respectively. According to Ayers and Westcot (1985), all the irrigation water was within a safe limit reported as Table 6. The area of this study, all the surface water samples were "suitable" for irrigation with respect to Mg content. Girdhar and Yadav (2004) and Kanaskar (2007) mentioned that if the Mg content is more, it results increase in clay volume which yields dispersion.

Sulphur (S)

The concentration of S was found within the range of 1.094 to 8.388 mgL^{-1} with a mean value of 3.40 mgL^{-1} (Table 3). In tested 34 samples values lower than the mean value and 22 samples values higher than the mean value. The highest values (8.388 mgL^{-1}) and the lowest value (1.094 mgL^{-1}) was found in samples number 26 and 28 respectively. The concentration of S of tested samples was found recommended limit as per Ayers and Westcot (1985) reported as Table 6.

Table 2. Chemical constituents of water collected from different sources of Dinajpur sadar upazilla.

Sample no	Constituents				
	pH	EC μScm^{-1}	TDS mgL^{-1}	Ca mgL^{-1}	Mg mgL^{-1}
1	6.91	120	98.2	9.619	22.36
2	6.87	240	100.1	25.65	22.36
3	6.96	210	128.35	24.048	23.338
4	6.87	180	220.2	28.85	20.41
5	6.80	190	120.2	12.825	12.63
6	6.81	400	190.1	17.635	19.44
7	6.87	290	140.0	19.238	20.41
8	6.95	276	128.7	20.84	27.22
9	6.95	360	145.0	20.84	26.24
10	6.79	260	130.0	14.428	13.61
11	6.90	870	108.6	40.08	39.86
12	6.95	220	110.71	17.635	28.19
13	6.77	210	101.23	14.428	23.33
14	6.82	225	78.08	33.667	26.24
15	6.85	310	84.15	35.27	34.03
16	6.79	150	130.2	36.87	33.05
17	6.64	228	118.75	33.667	33.05
18	6.85	490	260.5	35.27	34.03
19	6.91	220	120.32	8.016	20.41
20	6.73	350	170.102	6.412	14.58
21	6.64	340	175.69	6.412	6.8
22	6.75	290	148.23	9.619	7.77
23	6.77	400	200.12	11.222	7.77
24	6.74	340	20.51	8.016	22.36
25	6.74	420	60.24	27.254	28.19
26	6.60	380	200.0	27.254	26.24
27	6.82	308	183.07	28.85	27.22
28	6.85	225	190.73	28.85	28.19
29	6.92	760	360.32	40.08	41.8
30	6.75	260	130.11	30.46	16.52
31	6.74	270	120.5	19.238	17.49
32	6.20	120	20.81	19.238	30.13
33	6.41	130	80.11	27.254	27.22
34	6.73	300	150.11	12.825	28.19
35	6.76	270	140.12	14.428	31.11
36	6.65	280	132.91	11.222	30.13
37	6.63	160	100.75	9.619	28.19
38	6.78	460	230.0	9.619	24.31
39	6.82	355	180.0	16.032	25.27
40	6.80	380	190.0	17.635	7.77
41	6.68	378	221	19.238	16.52
42	6.92	195	90.1	27.254	13.61
43	6.70	140	70.82	25.65	25.27
44	6.63	221	78.36	8.016	31.11
45	6.78	360	150.21	28.85	30.13
46	6.68	370	144.3	12.825	17.49
47	6.81	290	150.60	8.016	21.38
48	6.93	250	89.0	12.825	20.41
49	6.72	340	170.15	8.016	12.63
50	6.45	150	80.53	8.016	11.66
51	6.48	220	100.21	19.238	18.47
52	6.32	110	60.26	20.84	11.66
53	6.33	150	70.74	19.238	12.63
54	6.43	260	90.71	17.635	18.47
55	6.47	250	110.11	17.635	17.49
56	6.60	325	100.0	20.84	13.61
Mean	6.73	290.29	133.48	19.72	22.32
Max	6.95	870	360.32	40.08	39.86
Min	6.20	110	20.51	6.412	6.8

Table 3. Chemical constituents of water collected from different sources of Dinajpur sadar upazilla.

Sample no	constituents					
	Sulphur mgL ⁻¹	Phosphorus mgL ⁻¹	Potassium mgL ⁻¹	Sodium mgL ⁻¹	Chloride mgL ⁻¹	Bicarbonate mgL ⁻¹
1	4.138	0.1744	7.5	2.5	397.15	2.2
2	4.36	0.302	45.0	6.25	411.37	2.8
3	1.88	0.86	30.0	3.75	382.96	2.4
4	2.36	0.523	37.5	5.0	411.37	2.6
5	2.36	0.406	15.0	2.5	382.96	2.2
6	5.166	2.209	45.0	6.25	382.96	2.2
7	4.027	0.918	37.5	3.75	382.96	2.2
8	4.22	0.767	45.0	6.25	368.78	2.6
9	6.75	0.406	37.5	6.25	354.6	2.6
10	2.722	0.802	35.0	6.25	354.6	2.2
11	7.63	1.546	47.5	7.5	354.6	2.0
12	2.83	0.686	37.5	5.0	326.23	2.4
13	5.08	1.348	37.5	6.25	340.42	2.6
14	4.83	0.674	35.0	5.0	340.42	2.6
15	1.777	0.406	12.5	2.5	354.6	2.8
16	1.88	0.825	30.0	3.75	382.96	2.6
17	3.833	0.848	30.0	3.75	382.96	2.2
18	1.694	0.651	37.5	2.5	397.15	2.2
19	1.944	0.627	35.0	6.25	368.78	2.2
20	2.25	0.662	12.5	2.5	368.78	2.2
21	3.33	0.383	10.0	2.5	312.04	2.0
22	2.944	0.337	10.0	2.5	312.04	2.0
23	2.5	0.395	10.0	2.5	326.23	2.6
24	4.08	0.383	27.5	6.25	326.23	2.2
25	4.58	0.453	30.0	5.0	326.23	2.4
26	8.388	3.27	32.5	6.25	297.86	2.4
27	5.722	0.872	30.0	5.0	312.04	2.6
28	5.22	0.906	57.5	8.75	297.86	2.6
29	4.08	0.965	87.5	11.25	354.6	2.8
30	1.97	0.965	10.0	3.75	397.15	2.4
31	1.094	0.848	15.0	2.5	397.15	2.6
32	2.25	0.767	5.0	1.25	354.6	2.6
33	1.638	0.941	7.5	2.5	326.23	2.5
34	3.8	0.523	15.0	5.0	297.86	2.4
35	1.88	0.569	22.5	3.75	297.86	2.8
36	2.805	0.744	15.0	3.75	312.04	2.8
37	2.22	0.732	37.5	2.5	283.68	1.8
38	3.5	0.406	60.0	7.5	283.68	1.8
39	2.11	0.534	30.0	6.25	297.86	2.2
40	2.08	0.337	30.0	6.25	312.04	2.2
41	6.36	0.639	22.5	5.0	354.6	2.4
42	1.416	0.360	5.0	3.75	368.78	2.4
43	2.944	0.418	5.0	2.5	354.6	2.6
44	2.027	0.511	15.0	2.5	354.6	2.6
45	2.944	0.72	7.5	3.75	411.37	2.8
46	3.388	0.802	25.0	3.75	397.15	2.8
47	2.63	0.686	5.0	3.75	397.15	2.2
48	3.305	0.732	12.5	3.75	326.23	2.0
49	2.527	0.883	5.0	3.75	326.23	2.0
50	2.138	0.744	17.5	3.75	397.15	2.2
51	3.0	0.813	10.0	2.5	255.31	1.8
52	1.722	0.825	7.5	2.5	411.37	2.2
53	2.805	0.79	5.0	2.5	397.15	2.6
54	4.638	0.837	35.0	5.0	411.37	2.6
55	6.97	0.36	37.5	5.0	354.6	2.4
56	3.88	0.616	27.5	3.75	326.23	2.6
Mean	3.40	.745	25.63	4.40	352.07	2.39
Max	8.388	3.27	87.5	11.25	411.37	2.8
Min	1.094	0.1744	5.0	1.25	255.31	1.8

Table 4. Irrigation water classification on the basis of EC and SSP (Wilcox, 1995)

water class	Percent sodium EC $\mu\text{S cm}^{-1}$	
Excellent	<20	<250
Good	20-40	250-750
Permissible	40-60	750-2000
Doubtful	60-80	2000-3000
Unsuitable	>80	>3000

Table 5. Irrigation water classification on the basis of TDS (Freeze and Cherry, 1979)

water class	Total dissolved solid TDS, mgL^{-1}
Fresh water	0-1000
Brackish water	1000-10000
Saline water	10000-100000
Brine water	>100000

Table 6. Guidelines for nutrient concentration in irrigation water (mgL^{-1}).

Macronutrient	Low	Normal	High	Very high
Phosphorus	<0.01	0.1-0.4	0.4-0.8	>0.8
Potassium	<5	5-20	20-30	>30
Calcium	<20	20-60	60-80	>80
Magnesium	<10	10-25	25-35	>35
Sulphur	<10	10-30	30-60	>60

Table 7. Guidelines for nutrient concentration in irrigation water (mgL^{-1}).

Elements	Symbol For water Continuously all soil	
Bicarbonate	HCO_3	1.50 meqL^{-1}
Chloride	Cl	4.0 meqL^{-1}
Phosphate	PO_4	$0-2.0 \text{ mgL}^{-1}$
Potassium	K	2.0 mgL^{-1}
Sulphate	SO_4	0.2 mgL^{-1}

Source: Ayers, R.S. and Westcot, D.W. 1985. Water quality for agriculture, FAO irrigation and Drainage paper 29, p. 81.

Phosphorus (P)

Phosphorus (P) occurs in water in the form of inorganic and organic compounds in a dissolved state and in the form of suspended and colloidal substances. Phosphorus, being an anionogenic element, forms phosphorous acid H_3PO_4 of neutral strength that dissociates into some derivative forms: H_2PO_4 , HPO_4^{2-} , PO_4^{3-} , the relation between which is determined by the pH value of water. The concentration of P was found in the collected samples within the range of 0.1744 to 3.27 mgL^{-1} with the mean value of 0.745 mgL^{-1} (Table 3). In tested 34 samples values lower than the mean value and 22 samples values higher than the mean value. The highest values (3.27 mgL^{-1}) and the lowest value (0.1744 mgL^{-1}) was found in samples number 26 and 1 respectively. The concentration of P of 34 tested samples was found recommended limit as per Ayers and Westcot (1985) and 22 samples values were very high as recommended reported as Table 7.

Potassium (K)

Potassium in terms of the magnitude of its content in the Earth's crust and the solubility of its compounds, is very similar to sodium. However, it occurs in lower concentrations in surface waters as it has weak migratory ability. This is due to its active participation in biological processes, e.g., absorption by living plants and microorganisms. Potassium is a naturally occurring element like sodium and remains in solution without undertaking any precipitation. The concentration of K was found in the

collected samples within the range of 5.0 to 87.5 mgL^{-1} with a mean value of 25.63 mgL^{-1} (Table 3). From tested samples, 27 samples values lower than the mean value and 29 samples values higher than the mean value. The presence of higher quality of K in some surface water samples might be due to the presence of some potash bearing minerals like sylvite (KCl) and nitrate (KNO_3) in the aquifers (Karanth, 1994). The detected quantity K in all the collected surface water samples had no significant influence on water quality for irrigation. The presence of higher K content in the surface water might have a beneficial effect as it acts as an essential nutrient element for plant growth and development.

Sodium (Na)

The sources of Na in waters are deposits of various salts (rock-salt), weathering products of limestone rocks, and its displacement from the absorbed complex of rocks and soils by calcium and magnesium. Sodium is one of the most important cations present in water. It is highly soluble in water. The sodium related to chloride and sulfate which creates the water unportable. The high sodium contain water is not suitable for agriculture because it tends to deteriorate the soil for crops. Although sodium contributes directly to the total salinity and may also be toxic to sensitive crops, such as fruit trees, the main problem with a high sodium concentration is its effect on the physical properties of soil (soil structure degradation). The concentration of Na in the surface water samples were

within 1.25 to 11.25 mgL⁻¹ (Table 3). The mean value of these samples was 4.40 mgL⁻¹. In tested 32 samples values lower than the mean value and 24 samples values higher than the mean value. The highest value (11.25 mgL⁻¹) and the lowest value (1.25 mgL⁻¹) were found in samples number 29 and 32 respectively. The recorded Na content in all samples under test was far below this specified limit (Ayers and Westcot, 1985). So, the Na content all water of the study area can safely be applied for long term irrigation without the harmful effects of soils and crops.

Chloride (Cl⁻)

Chloride has a large migratory ability in connection with the very high solubility of chloride salts of sodium, magnesium and calcium. Their presence in water is naturally associated with the processes of leaching from minerals (e.g., gallite, sylvite, carnallite, bischofite), from rocks (e.g., nephelines), and from saline deposits. It is also present in atmospheric precipitation, and today it is particularly associated with industrial and municipal wastes. Chlorides are necessary for plant growth, though in high concentrations they can inhibit plant growth, and can be highly toxic to some plant species. Water must, thus, be analyzed for Cl⁻ concentration when assessing water quality. The concentration of Cl⁻ in the surface water samples were within range 255.31 to 411.37 mgL⁻¹ (Table 3). The mean value of these samples was 352.07 mgL⁻¹. From tested samples, 20 samples values lower than the mean value and 36 samples values higher than the mean value. The highest value (411.37 mgL⁻¹) was found in sample numbers 4, 44, 52, 54. The lowest value (1.25 mgL⁻¹) was found in sample number 51.

Bicarbonate (HCO₃⁻)

Bicarbonate occurs in natural waters in dynamic equilibrium with carbonic acid in certain quantitative proportions and form a carbonate system of chemical equilibrium connected with the pH of water. When the pH of a water system is 7 to 8.5 the predominant ion is hydrocarbonate. When pH is less than 5, the content of hydrocarbonate ions is close to zero. Usually in surface fresh waters HCO₃⁻ content does not exceed 250 mgL⁻¹ (with the exception of soda alkaline waters in which HCO₃⁻ and CO₃²⁻ content can reach grams and even dozens of grams per kilogram). Waters high in bicarbonates (HCO₃⁻) will tend to precipitate magnesium carbonate (MgCO₃), when the soil solution becomes concentrated through evapotranspiration. This situation, in turn, will increase the sodium hazard of the soil-water to a level greater than indicated by the SAR value. The concentration of HCO₃⁻ in the surface water samples were within range 1.8 to 2.8 mgL⁻¹ (Table 3). The mean value of these samples was 2.39 mgL⁻¹. From tested samples, 24 samples values lower than the mean value and 32 samples values higher than the mean value. The highest value (2.8 mgL⁻¹) was found in sample numbers 2, 15, 29, 35, 36, 45, 46. The lowest value (1.8 mgL⁻¹) was found in sample numbers 37, 38, 51. Bicarbonate content was recorded comparatively higher among the ionic constituents. In respect of HCO₃⁻ content, most of the surface water samples were not toxic for irrigation because of HCO₃⁻ content was within the recommended limit as mentioned.

Summary and Conclusion

The study was performed to determine the quality of surface water for irrigation purposes in the Dinajpur sadar upazilla, Dinajpur. Surface water was collected from different 56 locations for the determination of chemical quality and to classify the waters on the basis of their suitability for irrigation purposes. The concentration of total cations and anions under study were within the safe limit for soils and crops. The research work was accomplished to assess the extent of water quality and to predict the suitability and acceptability for irrigation purposes. In order to assess the suitability classes for irrigation purposes, we measured pH, EC, TDS, Ca, Mg, S, P, K, Na, Cl⁻ and HCO₃⁻. On the basis of pH values, almost all water samples were within the recommended pH value for irrigation and have a great impact on crop production. According to Wilcox (1995), above half of the samples were excellent and the rest of the samples were good with respect to EC reported as Table 4. According to Ayers and Westcot (1985), suitability rating, all the collected surface water samples were considered as "fresh" for irrigation. On the basis of Ca, Mg, S, K, and Na content, the entire water samples can safely be used for irrigation and would not affect the soils. The status of Cl, P, and HCO₃ of all tested surface water samples was found within the recommended limit as per Ayers and Westcot (1985). From the present study, it can be concluded that the surface water samples should be treated to remove the pollutants before the use of water for a specific purpose. Surface water samples were found suitable for irrigation. Most of the samples were suitable for irrigation based on PH, TDS, EC, Ca, Mg, S, P, K, Na, Cl, and HCO₃⁻. In addition to the chemical quality of water, biological and radiological qualities should also be assessed in the future for the efficient management of water used for irrigation.

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