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Quality assessment of surface water resources of Dumki upazila in Bangladesh for irrigation, aquaculture and livestock consumption

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Abstract: A study was conducted to determine the quality of surface water resources of Dumki Upazila in Bangladesh. Eighteen samples were collected from the different locations during April to May 2010. Chemical analyses of different parameters were done to assess the quality of water sources. All the waters were acidic in nature, 10 samples were found “unsuitable" for aquaculture and irrigation due to pH <6.5. Electrical conductivity (EC) categorized 7 samples as "excellent" and 11 as "good" class for irrigation. Salinity and alkalinity hazard rated the 6 samples “low salinity" and "low alkalinity" (C1S1); and 12 samples as "medium salinity" and "low alkalinity"(C2S1) group for irrigation. Total dissolved solids of the sample were “fresh water" for irrigation and most of the sample suitable for aquaculture and safe for livestock consumption. Two sample (No. 3, TDS 478.72 and 6, TDS 477.47mgL^{-1}) were unsuitable for aquaculture as a result of higher TDS. Ten samples were unsuitable for livestock because of Cl concentrations were more than 30 mgL^{-1}. Ca, Na and K contents rated all the waters suitable for aquaculture whereas most of the waters unsuitable for aquaculture because their Mg concentrations were >15 mgL^{-1}. The SAR and SSP values classified almost all the samples “excellent" for irrigation. Hardness categorized 10 samples "hard" and 8 samples "moderately hard" in class for irrigation. RSC classified 9 samples “suitable" and 9 samples "marginal" for irrigation.
Key words: Water quality, Surface water, Irrigation, Aquaculture and Livestock consumption.

Introduction

Quality water is a great challenge for this country. Most of the water on this planet is stored in ocean and polar ice caps which is difficult to be recovered for our diverse needs. This sounds like a great deal of water, but on a global scale, the amount of fresh water is relatively quite small. The great majority of the earth’s water, 97.4% of the total is in the oceans, water that is not suitable for drinking and irrigation. The remaining 2.6% is all the fresh water we have, but almost all of the world’s fresh water is permanently frozen in glaciers and ice caps. Only about 0.01% of the earth’s total water is conveniently located in lakes, rivers and streams as fresh water (Stanitski et. al., 2003). Due to the global warming, the amount of fresh water is decreasing and undrinkable. Sea and ocean water level is increasing day by day. The rising of sea and ocean water are responsible for increasing the water level of estuaries and river that tends to reduced the amount of fresh water reservoir.

It is generally said that no water is pure or clean because of the presence of some quantities of compounds, elements, gases and life. The universal solvent property of water has got a much greater tendency to get polluted by the dissociation of different elements and compounds. But pure water is necessary for all practical purposes, like irrigation, aquaculture and livestock consumption. For every type use, there are some international standards of dissolved substances which make its suitable for specific use. Quality standards vary on the basis of use of water. For example the recommended limit for TDS for aquaculture < 400 ppm (Meade,1989) but for irrigation the limit is 1000-10,000 ppm (Freeze and Cherry, 1979). Water containing any substance above internationally recommended limit may be treated as low quality water. The main soluble constituents of water are Ca, Mg, Na, and sometimes K as cations and Cl, SO_4, HCO_3, and sometimes CO_3 as anions. However, ions of some other elements such as Li, Si, Br, I, Cu, Ni, Co, F, B, Zr,Ti,V, Ba, Ru, Ce, As, Bi, Sb, Be, Cr, Mn, Pb, Mo, Se, and P and organic matter are present in minor quantities (Michael,1997). Quality water is necessary for every type of use. The chemical composition of water is major factor in determining its quality (Gupta and Gupta, 1998). If low quality water is used for irrigation, drinking, aquaculture, livestock and poultry consumption and other purposes, ionic toxicity may appear (Zaman and Rahman, 1996). Water plays a vital role by conserving lives and their healthy environment. Low quality water has both direct and indirect impact on human health, aquatic organism, field crops and livestock. Sometimes low quality water shows direct effect on the organism’s position in the food chain and their environment while others are based upon genetic abnormalities resulting in physiological impairment. Water containing >45 ppm NO_3 has been reported to methanoglobinemia disease in infants and water containing large amounts of NO3 (>100 ppm) is bitter tasting and may cause physical distress (Todd, 1980). Therefore, considering the importance of water quality for irrigation , aquaculture and livestock consumption this study was conducted to determine the quality of surface water resources of Dumki Upazila in Bangladesh.

Materials and Methods

Eighteen surface water samples were collected from the different locations of Dumki Upazila in Bangladesh during April to May 2010. Samples were collected following methods outline by APHA(2000) .The analytical works were performed in the Department of Agricultural Chemistry, Patuakhali Science and Technology University, Dumki, Patuakhali. The pH, EC and TDS were determined following methods mentioned by Tandon (1995). CO_3 and HCO_3 were determined acidimetrically and argentometric titration was followed for the determination of Cl after Upadhyay and Sharma (2002). Ca and Mg were determined by complexometric method of titration Chopra and Kanwar (1986). Na and K were determined flame photometrically following method outlined by APHA (2000). Sodium Adsorption Ratio (SAR), Soluble Sodium Percentage (SSP), Residual Sodium Carbonate (RSC) and Hardness (H_T) of samples were calculated following standard formula mentioned by Mishra and Ahmed (1993), Richards (1968) and Michael (1997). Statistical analyses

were done following methods outlined by Gomez and Gomez (1984) with the help of computer package M-STAT.

Results and Discussion

pH: The pH of the surface water samples ranged from 6.10 to 6.90, with the mean value of 6.48. The respective standard deviation (SD) and % co- efficient of variation (CV) were 0.23 and 3.70 (Table1). All the samples were slightly acidic in nature. According to Ayers and Westcot (1985), Meade (1989), 10 samples were unsuitable for irrigation and aquaculture (Table 2 and 3).

Electrical Conductivity (EC): The electrical conductivity of the surface water fluctuated from 219 to 748 μScm^{-1}, with the respective mean SD and CV 367.67, 185.60 and 50.48 (Table1). Based on the classification of Wilcox (1955), EC categorized 7 samples as "excellent" and 11 samples “good" for irrigation (Table 2).

Table 1. Sampling information and chemical parameters of surface water

SL. NO.	Sampling location	Source of water	pH	EC μSCm^{-1}	TDS mgL^{-1}	Cl mgL^{-1}	CO_3 mgL^{-1}	HCO_3 mgL^{-1}	Ca mgL^{-1}	Mg mgL^{-1}	Na mgL^{-1}	K mgL^{-1}
1	Dumki bazar	Canal	6.60	219	140.16	28.50	Trace	213.50	20.92	17.92	6.60	0.10
2	Farm ,PSTU	Pond	6.55	518	331.52	27.30	Trace	213.50	18.75	17.91	13.33	1.50
3	PSTU (Neel kamal)	Pond	6.80	748	478.72	25.40	Trace	140.30	18.75	10.05	20.00	0.20
4	PSTU (Lal kamal)	Pond	6.82	602	385.28	22.50	Trace	128.10	16.60	9.61	20.00	0.30
5	PSTU (Salsa bil)	Pond	6.90	609	389.76	27.50	Trace	164.70	19.50	17.40	13.30	0.20
6	PSTU (Taragatanu)	Pond	6.80	746	477.47	29.40	Trace	152.50	16.50	13.55	20.00	0.20
7	Srerampur	River	6.40	229	146.56	32.30	Trace	280.60	23.08	25.78	6.66	0.60
8	Muradia	River	6.3	236	151.04	33.50	Trace	274.50	25.25	21.07	6.66	0.60
9	Srerampur	Gher	6.45	301	192.64	30.50	Trace	305.00	34.62	32.77	6.66	0.70
10	Srerampur	Gher	6.35	244	156.16	32.50	Trace	274.50	28.13	28.40	6.66	0.60
11	Gabtali Bandh	Canal	6.40	276	176.64	31.60	Trace	301.95	24.52	29.27	6.66	0.80
12	Mridha Bazar	Canal	6.10	291	186.24	34.20	Trace	280.60	25.25	24.90	6.66	0.80
13	Srerampur South	River	6.50	244	156.16	35.20	Trace	271.45	19.47	24.02	6.66	1.10
14	Srerampur South	Gher	6.60	272	174.08	29.50	Trace	256.20	28.13	27.09	6.66	1.10
15	South Srerampur	Gher	6.24	332	212.48	28.70	Trace	244.00	25.34	24.96	6.66	0.90
16	Zamla	River	6.18	219	140.16	36.20	Trace	286.70	23.80	25.78	6.66	1.00
17	Zamla(East)	Gher	6.38	245	156.80	30.50	Trace	268.40	25.24	26.22	6.66	1.00
18	Zamla	River	6.20	287	183.68	33.20	Trace	280.60	22.36	26.71	6.66	0.80
Range			6.10 - 6.90	219.00 - 748.00	140.16 - 478.72	22.50 - 36.20	-	128.10 - 305.00	16.50 - 34.62	9.61 - 32.77	6.66 - 20.00	0.10 - 1.50
Mean			6.48	367.67	233.64	30.47	-	240.95	23.12	22.14	9.66	0.70
SD			0.23	185.60	115.35	3.52	-	57.81	4.60	7..32	5.23	0.38
%CV			3.70	50.48	49.37	11.55	-	23.99	19.90	33.06	54.14	54.28

Trace- < $0.001 mgL^{-1}$

Table 2. Quality rating and suitability of waters for irrigation (Ayers and Westcot,1985; Freeze and Cherry,1979; Todd,1980; Sawyer and McCarty,1967; Eaton,1950 and Richards,1968)

SL. NO.	pH		EC		TDS		SAR		SSP		RSC		HT		Alkalinity and salinity hazard
	Value	Class	μSCm^{-1}	Class	mgL^{-1}	Class	Ratio	Class	%	Class	meL^{-1}	Class	mgL^{-1}	Class	
1	6.60	Suit.	219	Ex.	140.16	Fw.	0.24	Ex.	15.54	Ex	1.91	Mar.	125.77	MH	C1S1
2	6.55	Suit.	518	Good	331.52	Fw.	0.53	Ex.	28.57	Good	1.95	Mar.	120.31	MH	C2 S1
3	6.80	Suit.	748	Good	478..72	Fw.	0.93	Ex.	33.33	Good	0.54	Suit.	88.08	MH	C2 S1
4	6.82	Suit.	602	Good	385.28	Fw.	0.97	Ex.	35.20	Good	0.48	Suit.	80.90	MH	C2 S1
5	6.90	Suit.	609	Good	389.76	Fw.	0.53	Ex.	19.73	Ex	0.30	Suit.	120.09	MH	C2 S1
6	6.80	Suit.	746	Good	477.47	Fw.	0.89	Ex.	31.21	Good	0.56	Suit.	96.80	MH	C2 S1
7	6.40	Unsuit	229	Ex.	146.56	Fw.	0.23	Ex.	8.66	Ex	1.33	Mar.	163.40	H	C1 S1
8	6.3	Unsuit	236	Ex.	151.04	Fw.	0.24	Ex.	9.39	Ex	1.51	Mar.	149.51	MH	C2 S1
9	6.45	Unsuit	301	Good	192.64	Fw.	0.19	Ex.	6.55	Ex	0.50	Suit.	220.91	H	C2 S1
10	6.35	Unsuit	244	Ex.	156.16	Fw.	0.21	Ex.	7.65	Ex	0.76	Suit.	186.77	H	C1 S1
11	6.40	Unsuit	276	Good	176.64	Fw.	0.21	Ex.	7.87	Ex	1.32	Mar.	181.31	H	C2 S1
12	6.10	Unsuit	291	Good	186.24	Fw.	0.23	Ex.	9.01	Ex	1.29	Mar.	165.22	H	C2 S1
13	6.50	Suit	244	Ex.	156.16	Fw.	0.24	Ex.	9.79	Ex	1.50	Mar.	147.16	MH	C1 S1
14	6.60	Suit	272	Good	174.08	Fw.	0.21	Ex.	8.10	Ex	0.57	Suit.	181.40	H	C2 S1
15	6.24	Unsuit	332	Good	212.48	Fw.	0.22	Ex.	8.54	Ex	0.68	Suit.	165.69	H	C2 S1
16	6.18	Unsuit	219	Ex.	140.16	Fw.	0.23	Ex.	8.82	Ex	1.39	Mar.	165.20	H	C1 S1
17	6.38	Unsuit	245	Ex.	156.80	Fw.	0.22	Ex.	8.56	Ex	0.98	Suit.	170.00	H	C1 S1
18	6.20	Unsuit	287	Good	183.68	Fw.	0.22	Ex.	8.56	Ex	1.29	Mar.	177.71	H	C2 S1
Range	6.10 - 6..90	-	219.00 - 748.00	-	140.16 - 478.72	-	0.19 - 0.97	-	6.55 - 35.20	-	0.48 - 1.95		80.90 - 220.91	-	-
Mean	6.48	-	367.67	-	233.64	-	0.37	-	14.72	-	1.05		150.35	-	-
SD	0.23	-	185.60	-	115.35	-	0.27	-	10.09	-	0.52		37.73	-	-
%CV	3.70	-	50.48	-	49.37	-	72.97	-	68.54	-	49.52		25.09	-	-

Keys: Suit.- Suitable, Unsuit.- Unsuitable, Ex.- Excellent, Fw.- Fresh water, Mar. - Marginal, H_T- Hardness, MH.- Moderately Hard, H- Hard, C1- Low salinity,C2- Medium salinity and S1- Low alkalinity.

Table 3. Quality rating and suitability of water for aquaculture (Based on Meade,1989)

SL.NO.	pH		TDS		H_T		Ca		Mg		Na		K	
	Value	Class	mgL^{-1}	Class	mgL^{-1}	Class	mgL^{-1}	Class	mgL^{-1}	Class	mgL^{-1}	Class	mgL^{-1}	Class
1	6.60	Suit.	140.16	Suit.	125.77	Suit.	20.92	Suit.	17.92	Unsuit.	6.60	Suit	0.10	Suit
2	6.55	Suit.	331.52	Suit.	120.31	Suit.	18.75	Suit.	17.91	Unsuit.	13.33	Suit	1.50	Suit
3	6.80	Suit.	478..72	Unsuit.	88.08	Suit.	18.75	Suit.	10.05	Suit.	20.00	Suit	0.20	Suit
4	6.82	Suit.	385.28	Suit.	80.90	Suit.	16.60	Suit.	9.61	Suit	20.00	Suit	0.30	Suit
5	6.90	Suit.	389.76	Suit.	120.09	Suit.	19.50	Suit.	17.40	Unsuit.	13.30	Suit	0.20	Suit
6	6.80	Suit.	477.47	Unsuit.	96.80	Suit.	16.50	Suit.	13.55	Suit	20.00	Suit	0.20	Suit
7	6.40	Unsuit.	146.56	Suit.	163.40	Suit.	23.08	Suit.	25.78	Unsuit.	6.66	Suit	0.60	Suit
8	6.3	Unsuit.	151.04	Suit.	149.51	Suit.	25.25	Suit.	21.07	Unsuit.	6.66	Suit	0.60	Suit
9	6.45	Unsuit.	192.64	Suit.	220.91	Suit.	34.62	Suit.	32.77	Unsuit.	6.66	Suit	0.70	Suit
10	6.35	Unsuit.	156.16	Suit.	186.77	Suit.	28.13	Suit.	28.40	Unsuit.	6.66	Suit	0.60	Suit
11	6.40	Unsuit.	176.64	Suit.	181.31	Suit.	24.52	Suit.	29.27	Unsuit.	6.66	Suit	0.80	Suit
12	6.10	Unsuit.	186.24	Suit.	165.22	Suit.	25.25	Suit.	24.90	Unsuit.	6.66	Suit	0.80	Suit
13	6.50	Suit.	156.16	Suit.	147.16	Suit.	19.47	Suit.	24.02	Unsuit.	6.66	Suit	1.10	Suit
14	6.60	Suit.	174.08	Suit.	181.40	Suit.	28.13	Suit.	27.09	Unsuit.	6.66	Suit	1.10	Suit
15	6.24	Unsuit.	212.48	Suit.	165.69	Suit.	25.34	Suit.	24.96	Unsuit.	6.66	Suit	0.90	Suit
16	6.18	Unsuit.	140.16	Suit.	165.20	Suit.	23.80	Suit.	25.78	Unsuit.	6.66	Suit	1.00	Suit
17	6.38	Unsuit.	156.80	Suit.	170.00	Suit.	25.24	Suit.	26.22	Unsuit.	6.66	Suit	1.00	Suit
18	6.20	Unsuit.	183.68	Suit.	177.71	Suit.	22.36	Suit.	26.71	Unsuit.	6.66	Suit	0.80	Suit

Keys: Suit.- Suitable, Unsuit.- Unsuitable, H_T- Hardness

Total Dissolved Solids (TDS): TDS of the surface water varied from 140.16 to 478.72 mgL^{-1}. The respective mean, SD and %CV were 233.64, 115.35 and 49.37(Table1). TDS categorized all the samples "freshwater" (Table2) class for irrigation (Freeze and Cherry, 1979). With respect to TDS values all the waters were suitable for irrigation as these were " fresh water" class and 2 samples were "unsuitable"(Table 3) for aquaculture since TDS >400 mgL^{-1} (Meade, 1989).

Chloride (Cl): Chloride contents of the samples ranged from 22.50 to 36.20, having mean, SD and % CV of 30.47, 3.52 and 11.5, respectively. The recommended concentration of Cl for livestock consumption is 30mgL^{-1} Ayers and Westcot (1985). According to their recommendation 10 samples were unsuitable for livestock drinking because Cl values were > 30 mgL^{-1}.

CO_3 and HCO_3 : HCO_3 values fluctuated from 128.10 to 305.00 mgL^{-1}. The respective mean, SD and %CV were 240, 95, 57.81 and 23.99. None of the samples were responded to CO_3 test.

Calcium (Ca): Calcium concentration of the surface waters ranged from 16.50 to 34.62 mgL^{-1} having mean, SD and %CV 23.12, 4.60 and 19.90, respectively (Table1). The Ca contents rated all the samples suitable (Table3) for aquaculture (Meade, 1989).

Magnesium (Mg): Magnesium quantities of surface water samples ranged from 9.61 to 32.77 mgL^{-1}, with the mean, SD and %CV of 22.14, 7.32 and 33.06, respectively (Table1). Based on the recommendation of Meade (1989) , out of 18 samples only 3 samples collected from Neel Kamal (Mg, 10.05 mgL^{-1}), Lal Kamal (Mg, 9.61 mgL^{-1}) and Taranga Tanu (Mg,13.55 mgL^{-1}) ponds were found suitable for aquaculture, and rest of the 15 were unsuitable for aquaculture(Table3).

Sodium(Na): Na values water fluctuated from 6.6 to 20.00 mgL^{-1} with the mean value of 9.66 mgL^{-1}(Table2). The
SD and % CV were 5.23 and 54.14(Table1). Na concentrations of waters were found within recommended limit for aquaculture (Meade, 1989).

Potassium (K): K concentration of water samples fluctuated from 0.10 to 1.50 mgL^{-1} with the mean value of 0.70 mgL^{-1}). The SD and %CV were 0.38 and 54.28, respectively (Table1). K contents of surface waters were found suitable for aquaculture based on the recommendation (Meade, 1989).

Sodium Adsorption Ratio (SAR): The SAR of the samples varied from 0.19 to 0.97; having mean SD and %CV of 0.37, 0.27 and 72.97. Based on Todd (1980) SAR categorized all the samples excellent for irrigation. SAR and EC combinedly classified the 6 samples "low salinity" and "low alkalinity" (C1S1); and 12 samples as "medium salinity" and "low alkalinity"(C2S1) group for irrigation.

Soluble Sodium Percentage (SSP): SSP values ranged from 6.55 to 35.20, with the mean value of 14.72. According to the classification Wilcox (1955) SSP rated 4 samples "good" and 14 samples "excellent" for irrigation.

Residual Sodium Carbonate (RSC): RSC of the waters fluctuated from 0.48 to 1.95 meL^{-1}; having mean, SD and % CV o1.05, 0.52 and 49.52, respectively. On the basis of RSC Eaton (1950) classified irrigation water into suitable (RSC<1.25 meL^{-1}), marginal (RSC1.25-2.50 meL^{-1}) and unsuitable (RSC>2.50 meL^{-1}). Based on his classification 9 samples were "suitable" and 9 samples were "marginal" for irrigation.

Hardness (H_T): The hardness values of surface water varied from 80.90 to 220.91 mgL^{-1}, with the mean value of 150.35 mgL^{-1} (Table1). Hardness of all the waters was found suitable for aquaculture. Out of 18 samples 10 were "hard" and 8 were "moderately hard"(Table 2) class for irrigation Sawyer and McCarty (1967).

From the investigation, it is observed that the pH of a good number of samples were unsuitable for irrigation and aquaculture. The Ca , Na and K contents were safe for irrigation, aquaculture and livestock. On the other hand most of the waters unsuitable for aquaculture because of higher Mg concentrations. A good number of samples were unsuitable for livestock due to Cl concentrations more than 30 mgL^{-1}. Therefore, it is recommended that the water quality must be checked before using irrigation, aquaculture and livestock consumption.

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