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Suitability study of some surface water samples of Madhupur tract for irrigation, aquaculture and livestock consumption

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Abstract

Surface water samples from *beel*, river and canal of Madhupur Tract in Bangladesh were collected and analysed to find out the suitability of those water for irrigation, aquaculture and livestock consumption. Most of the samples were alkaline in nature only two samples were found acidic (pH 4.25 and 4.00). Out of 17 samples, 11 were limiting for irrigation and 15 were unsuitable for aquaculture with respect to pH values. Electrical conductivity (EC) rated maximum samples as "good" category for irrigation. TDS categorized the samples as "fresh water" for irrigation and were suitable for livestock, drinking and aquaculture. Chloride content of a few samples were beyond recommended limit for livestock. Micronutrient concentrations were alarming for livestock and aquaculture. Cu, Mn, Fe and Zn quantities categorized all the samples unsuitable for aquaculture. Most of the samples were also unsuitable for livestock due to higher Fe and Mn contents. Ca, Na, K and P quantities of all the samples were within safe limit for irrigation, aquaculture and livestock, but Mg contents of 8 samples were above recommended limit for aquaculture. Boron level classified 4 samples as "good"13 as "excellent" for irrigation. SAR and EC combinedly rated all the samples as "medium salinity" and "low alkalinity" class (C2S1) and hardness categorized the waters in "soft", "moderately hard" and "hard water" class for irrigation. Considering all parameters not a single sample was found suitable for irrigation, livestock consumption, and aquaculture.

Key words: Madhupur tract, suitability, surface water, irrigation, aquaculture, livestock consumption

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Introduction

Water is an important element for the existence of life. It is prime component for irrigation, aquaculture and livestock farming. For every purpose, water should fulfill some standard. The supply of quality water is very difficult for different purpose of use as it is a natural substance. The quality of water varies widely for irrigation, aquaculture, and livestock consumption. Water is an universal solvent, various types of constituents are dissolved in it. Among soluble constituents in water, common major secondary constituents are Ca, Mg, Na, K, Fe, B, NO_3 , HCO_3, SO_4 and Cl but minor or trace constituents are As, Cd ,Cr, Cu , Mn , P and Zn (Davis and Weist, 1966) . Generally higher amount of dissolved constituents are present in ground water than in surface water because of the greater exposure to soluble materials in geologic strata (Todd, 1980). But sometimes surface water contains more dissolved constituents due to unusual activities of human. Surface water bodies of natural sources are polluted if the portions of water bodies are constantly getting some pollutants. Dissolved constituents above recommended limit for definite purpose treated as pollutants and they deteriorate the quality of water. For different types of use all constituents of water has an international standard limit such as the recommended concentration of Cu and Fe for irrigating soil are 0.2 and 5.0mgL^{-1} (Ayers and Westcot, 1985) ; for livestock consumption is 0.5 and 0.3 mg L^{-1} and for aquaculture, 0.03 and < .01ppm, respectively (Meade,1989). Most heavy metals and trace elements have reported to be extremely toxic to fish. Many fishes show respiratory distress with heavy metal toxicity. Lead can kill fishes at 0.33 ppm level. Similarly, Hg, Cd, Cr, As, Cu can also be lethal at various concentrations. A concentration greater than 0.06 mg L^{-1} of cadmium can drastically affect the fish in water (Goel, 2006). Lethal Cu concentrations for fish and aquatic invertebrates range from 0.015 to 3.0 mg L^{-1}. Mn in trace amounts is an essential nutrient element, required for normal function of cells. However, it is toxic at higher concentrations, and chronic exposure causes neurological disorders (Varshney, 2002).

The quality of water is judged by its total salt concentration, relative proportions of cations and anions; and the presence of toxic substances. So the chemical composition of water is a major factor in determining its suitability for different types of use. Irrigation water containing toxic ions such as Na, Li, B, HCO_3 and Cl at higher levels play an important role on the growth and development of crop plants because many field and fruit crops are susceptible to those elements (Bohn *et al.*, 1985). Copper is toxic to many aquatic life at low concentrations. Algae are very sensitive to copper and can be killed at concentration as low as 0.5 mg L^{-1} (Goel, 2006). The use of low quality water for irrigation, aquaculture, and livestock farming may create ionic toxicity in plants, fishes and animals (Zaman and Rahman, 1996). In low land area of Madhupur Tract most of the farmers use natural surface water for irrigating HYV and local *boro* rice. Besides this, they use surface water for their livestock. The larval stages of fishes are highly sensitive to trace elements even at low concentration. A good number of indigenous fish species are going to be extinct due to the impairment of surface water quality. Since water is most important component of food chain, the suitability of water must be taken under consideration for irrigation, aquaculture and livestock consumption.

Materials and Methods

Seventeen surface water samples were collected from the *Beel*, river, canal and ponds of Madhupur Tract in Bangladesh following methods outline by APHA (2005).The analytical works were performed in the Department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh.

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 while Zn, Cu, Fe and Mn were determined with the help of AAS following method outlined by APHA (2005). Spectrophotometric method was followed for the determination of P and B (Page *et al.*, 1982). 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). Quality rating of the samples for irrigation was done following standard as mentioned by Wilcox (1955), Ayers and Westcot (1985), Freeze and Cherry (1979), Todd (1980), Sawyer and McCarty (1967), Eaton (1950) and Richards (1968). Aquaculture and livestock water quality was rated following standard outlined by Meade (1989), and Ayers and Westcot (1985), respectively. Statistical analyses were done following methods outlined by Gomez and Gomez (1984) with the help of computer package M-STAT.

Results and Discussion

pH, electrical conductivity (EC) and total dissolved solids (TDS)

The pH of the surface water samples ranged from 4.00 to 10.13 with the mean value of 8.38 (Table1). Most of the waters were alkaline in nature. Only two samples collected from the *beel* water of *Goair* and *Bandhabo* village were acidic and the pH were 4.25 and 4.00, respectively (Table1). According to Ayers and Westcot (1985) the maximum recommended limit of pH for irrigation is 6.5 to 8.5. Based on their recommendation 11 samples were unsuitable for irrigation (Table2). The standard pH range for aquaculture is 6.5 to 8.0 Meade (1989). Most of the samples were also unsuitable for aquaculture.

Electrical conductivity (EC) of the waters varied from 177.92 to 533.76 μS cm^{-1} having mean value of 358.40 (Table1). 15 samples were "good" and 2 were "excellent" class for irrigation after Wilcox (1955). Salinity and alkalinity hazard rated the samples "medium salinity" (C2) and "low alkalinity" (S1) class (Richards, 1968).

Total dissolved solids (TDS) of the samples ranged from 110.50 to 500.00 mg L^{-1} with the mean value of 358.40 mg L^{-1} (Table1). TDS categorized all the samples under "fresh water" for irrigation (Freeze and Cherry, 1979) and suitable for livestock drinking (Ayers and Westcot, 1985); according to Meade (1989) only one sample (TDS, 500.00 mg L^{-1}, sample no. 7) was unsuitable for aquaculture (Table 2, 3 and 4) .

Chloride (Cl), carbonate (CO_3) and bicarbonate (HCO_3)

The Cl concentration of the samples fluctuated from 0.4 to 2.00 me L^{-1}, with the mean, SD and %CV were 0.75, 0.39 and 52.09, respectively (Table1). Average Cl status of the present study was far below the Cl contents of the samples studied by Karim *et al*. (2013). They obtained higher Cl content because their study area was very close to the coastal belt of Bangladesh. From the Cl content of the present study, it was also clear that the Cl content of surface water generally decreased with the increase of distance of sea level. The recommended concentration of Cl for livestock is 30 mg L^{-1} (Ayers and Westcot, 1985). Based on their classification, Cl contents rated 12 samples suitable and 5 samples unsuitable for livestock drinking due to higher Cl (30 mg L^{-1}) concentration (Table 4).

Two samples responded to CO_3 test and the values were1.00 and 2.00 me L^{-1}. HCO_3 ranged from 0.50 to 5.00 me L^{-1}, with the average value of 2.88 me L^{-1}. The presented average value of HCO_3 was higher than that of the result of Karim *et al*. (2013) and similar to the findings of Nizam *et al*. (2010) and Taslima (2012). HCO_3 content of the present samples would not be harmful for water supplying pipes.

Calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K)

The quantities of Ca, Mg, Na and K were within the limit of 0.10 to 1.70, 0.40 to 4.00, 0.086 to 0.282 and 0.006 to 0.045 me L^{-1}, respectively. The respective mean values were 0.72, 1.67, 0.17 and 0.02me L^{-1} (Table 1). Ca and Mg concentrations of the water samples of present study were almost similar to the findings of Karim *et al*. (2013) and Nizam *et al*. (2010). The Ca concentration of water for aquaculture should be within the range of 4.00 to 160.00 mg L^{-1}, Mg < 15.00 mg L^{-1} and Na is 75.00 mg L^{-1} (Meade, 1989). The Ca and Na concentrations presented in Table 3 indicated that all the samples were suitable for aquaculture with respect to Ca and Na contents, while the Mg contents of 8 samples were above recommended limit and were unsuitable for aquaculture as Mg values were >15 mg L^{-1} (Table 3). K contents also categorized all the samples suitable for aquaculture.

Zinc (Zn), copper (Cu), iron (Fe) and manganese (Mn)

Zn, Cu, Fe and Mn concentration of the samples fluctuated from 0.017 to 0.156, trace to 0.320, 0.088 to 0.1.795 and 0.030 to 0.926 mg L^{-1}, respectively

(Table 1). Zn and Fe contents rated all the samples suitable for irrigation. Fe and Mn concentrations of most of the samples were unsuitable for livestock drinking since Fe contents were >0.3 mg L^{-1} and Mn contents were >0.05 mg L^{-1}, only two samples for Fe and one sample for Mn were within the recommended limit and were not toxic for livestock consumption (Table 4). Table 2 indicated that 6 samples for Cu and 5 samples for Mn concentrations were unsuitable for irrigating continuously on all soils (Ayers and Westcot, 1985). Zn and Cu values were within safe limit for livestock.

The larval stage of fishes are very sensitive to higher concentration of trace elements in natural water sources, which hampers the hatching of eggs and survibility of newly hatched larvae. As shown in Table 3, according to Meade (1989), Zn, Cu, Fe and Mn contents categorized all the samples unsuitable for aquaculture due to higher concentrations of these elements. It is assumed that a large number of indigenous fish species are going to extinct from the natural water bodies because of higher concentrations of trace elements.

Phosphorus (P) and boron (B)

P and B contents of the samples ranged from trace to 0.320 and 0.09 to 0.660 mg L^{-1}, having mean value of 0.092 and 0.300 mgL^{-1}, respectively (Table1). Boron concentration is very important factor for irrigation. The recommended concentration of B for water used continuously on all soils is < 0.75 mg L^{-1}. Based on Wilcox (1955), B contents rated 13 samples under “excellent” and 4 were “good” class for irrigation (Table2).

Soluble adsorption ratio (SAR), soluble sodium percentage (SSP), residual sodium carbonate (RSC) and hardness (H_T)

The SAR values fluctuated from 0.063 to 0.297. On the other hand, the SSP values ranged from 2.38 to 17.4% (Table 2). Based on the classification of Todd (1980) and Wilcox (1955) the SAR and SSP values categorized all the samples under “excellent” class for irrigation (Table2). Regarding salinity and alkalinity hazard SAR and EC rated the samples as “medium salinity” (C2) and “low alkalinity” (S1) and, combinedly expressed as (C2S1).

Residual sodium carbonate (RSC) and hardness (HT) ranged from – 2.70 to + 2.40 and 29.94 to 284.45 mg L^{-1}, respectively. According to Eaton (1950), RSC rated 9 samples as “suitable” and 8 samples “marginal” for irrigation (Table2). Following Sawyer and McCarty's (1967) classification, 5 samples were rated as “soft”, 9 were “moderately hard” and 3 were “hard water” for irrigation (Table2). In the present study the higher hardness values of sample no. 4, 7 and 12 indicates higher Mg contents of the samples Similar findings were observed by Karanth (1994) in relation to water hardness and Mg concentration.

Conclusion

From results of chemical analysis of the water samples and comparison of the values with international standard recommendations of different organization and authors regarding irrigation, aquaculture and livestock drinking, it was found that elemental pollution existed in the surface water sources of Madhupur Tract. When one sample was found suitable for irrigation then it was unsuitable for aquaculture, on the other hand when another was found suitable for aquaculture then it was unsuitable for livestock consumption. None of the sample was found suitable for all the three purposes, irrigation, livestock drinking and aquaculture. Finally it can be concluded that the chemical quality of surface water sources of the study area must be checked to know its suitability for definite purpose and it will be help to protect any economic damage of field crops, fishes and livestock.

References

APHA (2005). *Standard Methods for the Examination of Water and Wastewater*. 21st Edn. American Public Health Association, Washington DC, 20005.

Table1. Sampling information and chemical constituents of water samples

Samle No.	Sampling location (Name of village)	Sources of water	pH	EC ($\mu S\ cm^{-1}$)	TDS ($mg\ L^{-1}$)	Cl	CO_3	HCO_3	Ca	Mg	Na	K	Zn	Cu	Fe	Mn	P	B
						me L^{-1}							mg L^{-1}					
1	Goair	BW	4.25	177.92	150.00	0.40	Trace	1.50	0.10	1.20	0.086	0.025	0.086	0.120	0.721	0.169	0.020	0.310
2	Boa	BW	9.32	378.08	310.50	0.60	Trace	4.00	0.50	1.20	0.108	0.012	0.040	0.280	0.928	0.206	0.010	0.240
3	Kanserkul	RW	8.20	400.32	335.50	0.60	Trace	4.00	0.80	2.20	0.173	0.022	0.076	0.220	0.530	0.081	0.180	0.210
4	Rajai	RW	8.50	378.08	300.00	0.40	Trace	3.50	0.90	2.30	0.163	0.022	0.075	0.190	0.546	0.030	0.200	0.180
5	Rajai	BW	8.33	400.32	290.50	0.60	Trace	3.50	0.40	1.00	0.119	0.019	0.084	0.160	0.629	0.179	Trace	0.145
6	Balijuri	BW	9.65	311.26	250.00	0.40	Trace	3.00	0.50	0.80	0.108	0.006	0.062	0.320	0.695	0.157	0.320	0.090
7	Rajai	BW	8.18	533.76	500.00	1.00	Trace	5.00	1.70	2.70	0.200	0.038	0.085	0.090	0.605	0.114	0.250	0.320
8	Bhaluka	BW	8.65	355.84	170.00	0.40	1.00	1.00	1.00	2.40	0.141	0.040	0.104	0.118	0.493	0.231	Trace	0.455
9	Bhaluka	PW	9.75	333.60	190.00	1.00	2.00	0.50	0.80	2.00	0.260	0.045	0.097	0.109	0.182	0.109	Trace	0.380
10	Bhaluka	RW	8.90	378.08	295.60	1.00	Trace	3.50	0.60	2.40	0.260	0.026	0.097	0.172	0.308	0.222	Trace	0.320
11	Chandalgaon	BW	9.00	311.36	300.00	1.00	Trace	3.00	0.60	2.00	0.217	0.012	0.052	0.290	0.752	0.183	Trace	0.315
12	Meduary	BW	7.95	533.76	310.00	0.60	Trace	3.00	1.70	4.00	0.108	0.031	0.013	0.149	0.750	0.926	Trace	0.260
13	Meduary	RW	10.05	222.40	160.00	0.60	Trace	1.50	1.00	0.80	0.248	0.012	0.017	0.053	0.529	0.120	0.01	0.060
14	Lohabari	PW	9.60	378.08	300.00	0.80	Trace	3.50	0.40	1.20	0.173	0.009	0.039	0.230	0.594	0.117	0.104	0.310
15	Habirbari	CW	10.13	378.08	279.00	0.60	Trace	3.50	0.40	0.70	0.217	0.015	0.060	0.230	1.795	0.067	0.170	0.520
16	Gadumeah	CW	8.00	333.00	250.30	0.80	Trace	3.00	0.70	1.10	0.282	0.015	0.156	0.086	0.088	0.082	0.110	0.660
17	Bhandabo	BW	4.00	289.00	110.50	2.00	Trace	2.00	0.20	0.40	0.086	0.012	0.062	Trace	0.452	0.231	0.010	0.320
Range			4.00 - 10.13	177.92 - 533.76	110.50 - 500.00	0.40 - 2.00	Trace - 2.00	0.50 - 5.00	0.10 - 1.70	0.40 - 4.00	0.086 - 0.282	0.006 - 0.045	0.017 - 0.156	Trace - 0.320	0.088 - 1.795	0.030 - 0.926	Trace - 0.320	0.090 - 0.660
Mean			8.38	358.40	264.79	0.75	-	2.88	0.72	1.67	0.17	0.02	0.070	0.170	0.620	0.190	0.092	0.300
SD			1.75	89.63	91.14	0.39	-	1.19	0.45	0.93	0.07	0,01	0.030	0.090	0.370	0.200	0.110	0.150
%CV			19.51	25.01	34.42	52.09	-	41.42	62.22	55.92	38.66	57.91	49.49	51.85	59.33	105.26	122.22	50.24

Legend: BW= *Beel* water; CW= Canal water; PW = Pond water; RW = River water; Trace means < 0.001 me L^{-1} and 0.001 mg L^{-1}

Table 2. Quality rating and suitability of water samples for irrigation

Samle no.	pH		EC		TDS		SAR		SSP		RSC		H_T		Alkalinity and salinity hazard	Mn		Cu		B	
	Value	Clas	µScm^{-1}	Class	mgL^{-1}	Class	Ratio	Class	%	Class	meL^{-1}	Class	mgL^{-1}	Class		mgL^{-1}	Class	mgL^{-1}	Class	mgL^{-1}	Class
1	4.25	Unsuit.	177.92	Ex.	150.00	FW	0.106	Ex	7.86	Ex	0.20	Suit.	64.78	Soft	C2S1	0.169	Suit.	0.120	Suit	0.310	Ex.
2	9.32	Unsuit.	378.08	Good	310.50	FW	0.117	Ex	6.56	Ex	2.30	Mar.	84.82	MH	C2S1	0.206	Unsuit.	0.280	Unsuit	0.240	Ex
3	8.20	Suit.	400.32	Good	335.50	FW	0.141	Ex	6.10	Ex	1.00	Suit.	149.67	MH	C2S1	0.081	Suit.	0.220	Unsuit	0.210	Ex
4	8.50	Suit	378.08	Good	300.00	FW	0.128	Ex	5.46	Ex	0.30	Suit.	159.68	H	C2S1	0.030	Suit.	0.190	Suit	0.180	Ex
5	8.330	Suit	400.32	Good	290.50	FW	0.142	Ex	8.97	Ex	2.10	Mar	69.86	Soft	C2S1	0.179	Suit.	0.160	Suit	0.145	Ex
6	9.65	Unsuit.	311.26	Good	250.00	FW	0.133	Ex	8.06	Ex	1.70	Mar.	64.91	Soft	C2S1	0.157	Suit.	0.320	Unsuit	0.090	Ex
7	8.18	Suit	533.76	Good	500.00	FW	0.134	Ex	5.13	Ex	0.60	Suit.	219.69	H	C2S1	0.114	Suit.	0.090	Suit	0.320	Ex
8	8.65	Unsuit.	355.84	Good	170.00	FW	0.106	Ex	5.05	Ex	-1.40	Mar.	169.68	MH	C2S1	0.231	Unsuit	0.118	Suit	0.455	Good
9	9.75	Unsuit.	333.60	Good	190.00	FW	0.219	Ex	9.82	Ex	-1.30	Suit.	139.71	MH	C2S1	0.109	Suit.	0.109	Suit.	0.380	Good
10	8.90	Unsuit.	378.08	Good	295.60	FW	0.212	Ex	8.70	Ex	0.50	Suit.	149.64	MH	C2S1	0.222	Unsuit	0.172	Suit	0.320	Ex
11	9.00	Unsuit.	311.36	Good	300.00	FW	0.190	Ex	8.09	Ex	0.40	Mar.	129.69	MH	C2S1	0.183	Suit.	0.290	Unsuit	0.315	Ex
12	7.95	Suit	533.76	Good	310.00	FW	0.063	Ex	2.38	Ex	-2.70	Suit.	284.45	H	C2S1	0.926	Unsuit	0.149	Suit	0.260	Ex
13	10.05	Unsuit.	222.40	Ex.	160.00	FW	0.261	Ex	8.49	Ex	-0.30	Suit.	89.96	MH	C1S1	0.120	Suit.	0.053	Suit	0.060	Ex
14	9.60	Unsuit.	378.08	Good	300.00	FW	0.193	Ex	10.21	Ex	1.90	Mar.	79.81	MH	C2S1	0.117	Suit.	0.230	Unsuit	0.310	Ex
15	10.13	Unsuit.	378.08	Good	279.00	FW	0.292	Ex	17.41	Ex	2.40	Mar.	74.82	Soft	C2S1	0.067	Suit.	0.230	Unsuit	0.520	Good
16	8.00	Suit	333.00	Good	250.30	FW	0.297	Ex	14.14	Ex	1.20	Suit.	79.88	MH	C2S1	0.082	Suit.	0.086	Suit.	0.660	Good
17	4.00	Unsuit.	289.00	Good	110.50	FW	0.157	Ex	14.04	Ex	2.40	Mar.	29.94	Soft	C2S1	0.231	Unsuit	Trace	Suit	0.320	Ex

Legend: Trace < 0.001 mg L^{-1}, FW= Fresh water, Ex. = Excellent, Suit. = Suitable, Unsuit.= Unsuitable Mar.= Marginal, H= Hard water, MH = Moderately Hard water , C2= Medium Salinity and S1=Low alkalinity. H_T =Hardness.

Table 3. Quality rating and suitability of water samples for aquaculture

Samle no.	pH		TDS		H_T		Ca		Mg		Zn		Cu		Fe		Mn		Na	
	Value	Clas	mgL^{-1}	Class	mgL^{-1}	Class	mgL^{-1}	Class	mgL^{-1}	Class	mgL^{-1}	Class	mgL^{-1}	Class	mgL^{-1}	Class	mgL^{-1}	Class	mgL^{-1}	Class
1	4.25	Unsuit.	150.00	Suit.	64.78	Suit	2.00	Suit	14.58	Suit.	0.086	Unsuit	0.120	Unsuit	0.721	Unsuit	0.169	Unsuit	1.98	Suit
2	9.32	Unsuit.	310.50	Suit.	84.82	Suit	10.02	Suit	14.58	Suit	0.040	Unsuit	0.280	Unsuit	0.928	Unsuit	0.206	Unsuit	2.48	Suit
3	8.20	Unsuit	335.50	Suit.	149.67	Suit	16.04	Suit	26.74	Unsuit.	0.076	Unsuit	0.220	Unsuit	0.530	Unsuit	0.081	Unsuit	3.98	Suit
4	8.50	Unsuit	300.00	Suit.	159.68	Suit	18.04	Suit	27.95	Unsuit.	0.075	Unsuit	0.190	Unsuit	0.546	Unsuit	0.030	Unsuit	3.75	Suit
5	8.330	Unsuit	290.50	Suit.	69.86	Suit	8.02	Suit	12.15	Suit	0.084	Unsuit	0.160	Unsuit	0.629	Unsuit	0.179	Unsuit	2.74	Suit
6	9.65	Unsuit.	250.00	Suit.	64.91	Suit	10.02	Suit	9.72	Suit	0.062	Unsuit	0.320	Unsuit	0.695	Unsuit	0.157	Unsuit	2.48	Suit
7	8.18	Unsuit	500.00	Unsuit.	219.69	Suit	30.07	Suit	32.81	Unsuit.	0.085	Unsuit	0.090	Unsuit	0.605	Unsuit	0.114	Unsuit	4.6	Suit
8	8.65	Unsuit.	170.00	Suit.	169.68	Suit	20.04	Suit	29.16	Unsuit.	0.104	Unsuit	0.118	Unsuit	0.493	Unsuit	0.231	Unsuit	3.24	Suit
9	9.75	Unsuit.	190.00	Suit.	139.71	Suit	16.03	Suit	24.31	Unsuit.	0.097	Unsuit	0.109	Unsuit	0.182	Unsuit	0.109	Unsuit	5.98	Suit
10	8.90	Unsuit.	295.60	Suit.	149.64	Suit	12.02	Suit	29.17	Unsuit.	0.097	Unsuit	0.172	Unsuit	0.308	Unsuit	0.222	Unsuit	5.98	Suit
11	9.00	Unsuit.	300.00	Suit.	129.69	Suit	12.02	Suit	24.31	Unsuit.	0.052	Unsuit	0.290	Unsuit	0.752	Unsuit	0.183	Unsuit	4.99	Suit
12	7.95	Suit.	310.00	Suit.	284.45	Suit	34.07	Suit	48.61	Unsuit.	0.013	Unsuit	0.149	Unsuit	0.750	Unsuit	0.926	Unsuit	2.48	Suit
13	10.05	Unsuit.	160.00	Suit.	89.96	Suit	20.04	Suit	9.72	Suit.	0.017	Unsuit	0.053	Unsuit	0.529	Unsuit	0.120	Unsuit	5.70	Suit
14	9.60	Unsuit.	300.00	Suit.	79.81	Suit	8.02	Suit	14.58	Suit.	0.039	Unsuit	0.230	Unsuit	0.594	Unsuit	0.117	Unsuit	3.98	Suit
15	10.13	Unsuit.	279.00	Suit.	74.82	Suit	8.02	Suit	8.51	Suit	0.060	Unsuit	0.230	Unsuit	1.795	Unsuit	0.067	Unsuit	4.99	Suit
16	8.00	Suit.	250.30	Suit.	79.88	Suit	14.3	Suit	13.37	Suit.	0.156	Unsuit	0.086	Unsuit	0.088	Unsuit	0.082	Unsuit	6.49	Suit

17	4.00	Unsuit.	110.50	Suit.	29.94	Suit	4.01	Suit	4.86	Suit	0.062	Unsuit	Trace	Unsuit	0.452	Unsuit	0.231	Unsuit	1.98	Suit

Legend: Trace < 0.001 mgL^{-1} , Suit.= Suitable, Unsuit.= Unsuitable, H_T = Hardness

Table 4. Suitability test of water samples for livestock consumption

Samle no.	TDS		H_T		Cl		Fe		Mn		Zn		Cu	
	mgL^{-1}	Class	mgL^{-1}	Class	mgL^{-1}	Class	mgL^{-1}	Class	mgL^{-1}	Class	mgL^{-}	Class	mgL^{-}	Class
1	150.00	Suit.	64.78	Suit.	14.20	Suit.	0.721	Unsuit.	0.169	Unsuit.	0.086	Suit	0.120	Suit
2	310.50	Suit.	84.82	Suit.	21.30	Suit.	0.928	Unsuit.	0.206	Unsuit.	0.040	Suit	0.280	Suit
3	335.50	Suit.	149.67	Suit	21.30	Suit.	0.530	Unsuit.	0.081	Unsuit.	0.076	Suit	0.220	Suit
4	300.00	Suit.	159.68	Suit.	14.20	Suit.	0.546	Unsuit.	0.030	Suit	0.075	Suit	0.190	Suit
5	290.50	Suit.	69.86	Suit.	21.30	Suit.	0.629	Unsuit.	0.179	Unsuit.	0.084	Suit	0.160	Suit
6	250.00	Suit.	64.91	Suit.	14.20	Suit.	0.695	Unsuit.	0.157	Unsuit.	0.062	Suit	0.320	Suit
7	500.00	Suit.	219.69	Unsuit.	35.50	Unsuit.	0.605	Unsuit.	0.114	Unsuit.	0.085	Suit	0.090	Suit
8	170.00	Suit.	169.68	Suit.	14.20	Suit.	0.493	Unsuit.	0.231	Unsuit.	0.104	Suit	0.118	Suit
9	190.00	Suit.	139.71	Suit.	35.50	Unsuit.	0.182	Suit	0.109	Unsuit.	0.097	Suit	0.109	Suit
10	295.60	Suit.	149.64	Suit	35.50	Unsuit.	0.308	Unsuit.	0.222	Unsuit.	0.097	Suit	0.172	Suit
11	300.00	Suit.	129.69	Suit.	35.50	Unsuit.	0.752	Unsuit.	0.183	Unsuit.	0.052	Suit	0.290	Suit
12	310.00	Suit.	284.45	Unsuit	21.30	Suit.	0.750	Unsuit.	0.926	Unsuit.	0.013	Suit	0.149	Suit
13	160.00	Suit.	89.96	Suit	21.30	Suit.	0.529	Unsuit.	0.120	Unsuit.	0.017	Suit	0.053	Suit
14	300.00	Suit.	79.81	Suit	28.40	Suit.	0.594	Unsuit.	0.117	Unsuit.	0.039	Suit	0.230	Suit
15	279.00	Suit.	74.82	Suit	21.30	Suit.	1.795	Unsuit.	0.067	Unsuit.	0.060	Suit	0.230	Suit
16	250.30	Suit.	79.88	Suit.	28.40	Suit.	0.088	Suit	0.082	Unsuit.	0.156	Suit	0.086	Suit
17	110.50	Suit.	29.94	Suit.	71.00	Unsuit.	0.452	Unsuit.	0.231	Unsuit.	0.062	Suit	Trace	Suit

Legend: Trace < 0.001 mgL^{-1}, Suit.= Suitable, Unsuit.= Unsuitable , H_T = Hardness

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