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Bio-physical Attributes of Coastal Villages under Climate Stressed Environmental Conditions in Bengal Delta, Bangladesh

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Abstract: The bio-physical attributes of two coastal villages—Bara Kupat and Henchi—situated in the Ganges Tidal Floodplain are assessed through estimation of chemical attributes of surface and groundwater and soil, and appraisal of floristic composition following standard methods. The dissolved cationic abundance in surface water follows the trend as $Na^+ > Ca^{2+} > Mg^{2+} > K^+$ while that of groundwater is $Na^+ > Mg^{2+} > Ca^{2+} > K^+$. The trend of dissolved anions in surface water is $Cl^- > SO_4^{2-} > HCO_3^- > PO_4^{3-}$ and that in groundwater is $Cl^- > HCO_3^- > PO_4^{3-} > SO_4^{2-}$. The major controls of hydrochemistry is the process of evaporation and crystallization and the samples represent Na^+-Cl^- type water where the alkali metals are exceeding the alkaline earths and strong acidic anions exceed weak acidic anions. Such water generally creates salinity problems both in irrigation and potable uses. The soils of the villages are strongly saline but alkaline. Such physical attributes support only 56 floral species in Bara Kupat and 20 in Henchi—much fewer than already observed in home gardens of coastal Bangladesh. The environmentally stressed conditions—as revealed by analysis of water and soil, and floristic composition—may aggravate when the consequences of rapid changes in climate pattern is taken in to consideration.

Keywords: Bio-physical attributes; Coastal villages; Bengal delta; Southwest Bangladesh.

Introduction

The lower Ganges-Brahmaputra-Meghna (GBM) drainage basin—the Bengal delta, Bangladesh—is one of the 15 most climate-induced vulnerable regions of the world (Islam et al., 2015; Islam, 2016; Islam et al., 2016). This region is experiencing recurrent hydro-climatic disasters (Mirza, 2002; Islam et al., 2016; Islam and Hasan, 2016) and is enduring intense infrastructural interferences to the surficial processes under the realm of rapid climate change (Gain et al., 2017).

The biophysical attributes that support coastal landform and livelihood are dynamic and often characterized by complex and multifaceted variables. These attributes respond at contrasting dimensions when subjected to driving forces responsible for climate change such as sea level rise, changing pattern in rainfall and runoff etc. (Rogers and Woodroffe, 2016). Such responses render coastal population at risk (Fenster and Dolan, 1996; Mirza, 2003; IPCC, 2007a; Balica et al., 2012).

The environmental stresses in south-western coastal Bangladesh generates from inefficient natural drainage systems, enhanced rate of sedimentation on river beds, waterlogged floodplains, salinity intrusion, structural interferences to flow paths of the tidal rivers and

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polderization (Datta and Ghosh, 2015; Gain et al., 2017 and elsewhere). Such hindrances may intensify with time (Ahmed, 2008) because this region has a history of human-induced environmental changes triggered by upstream withdrawal of river flow and construction of enclosures (*polders*) and regulators (sluice gates etc.). The environmental changes thus ensue effect on agriculture, fishery and forest resources of the region and eventually, livelihoods of the south-western coastal people (Mirza, 1998; Islam et al., 2015). To cope with such stresses the region endures intense land use changes that results in abrupt changes of bio-physical attributes (Ahmed, 2011).

Environmental issues such as salinization of coastal aquifers, waterlogging etc. are increasingly recognized in this *polderized* ecosystems of southwest coastal Bangladesh in recent years (Abedin et al., 2014) affecting people by reducing soil and water quality and thereby, agricultural diversity and productivity (Alam, 1996; Gain et al., 2007; Dearing et al., 2014). A good number of studies on the consequences of climate change and adaptation approaches have been conducted in this area (e.g. Ali, 1996; Ali, 1999; Shaw et al., 2013; Younus, 2014; Islam et al., 2015 and elsewhere). However, state and vulnerability of the bio-physical attributes of the region have not been treated in such studies. Therefore, this paper endeavours to assess the current state of bio-physical attributes of the livelihood support system of two coastal villages in south-western Bangladesh that are enduring climate stressed environmental conditions.

Study Area

Two villages Bara Kupot and Henchi, geographically situated between 22°18´ to 2222°´ N and 89°08´ to 89°14´ E on the western side of the river Kholpetua (Figure 1) and located within Polder 15 where rapid human induced changes have occurred, were purposively selected to assess their biophysical attributes. They are positioned in Atulia union (union is the smallest administrative unit of local government)—a 39 km^2 area—of Shyamnagar upazila of Satkhira district in south-western coastal Bangladesh. These villages were

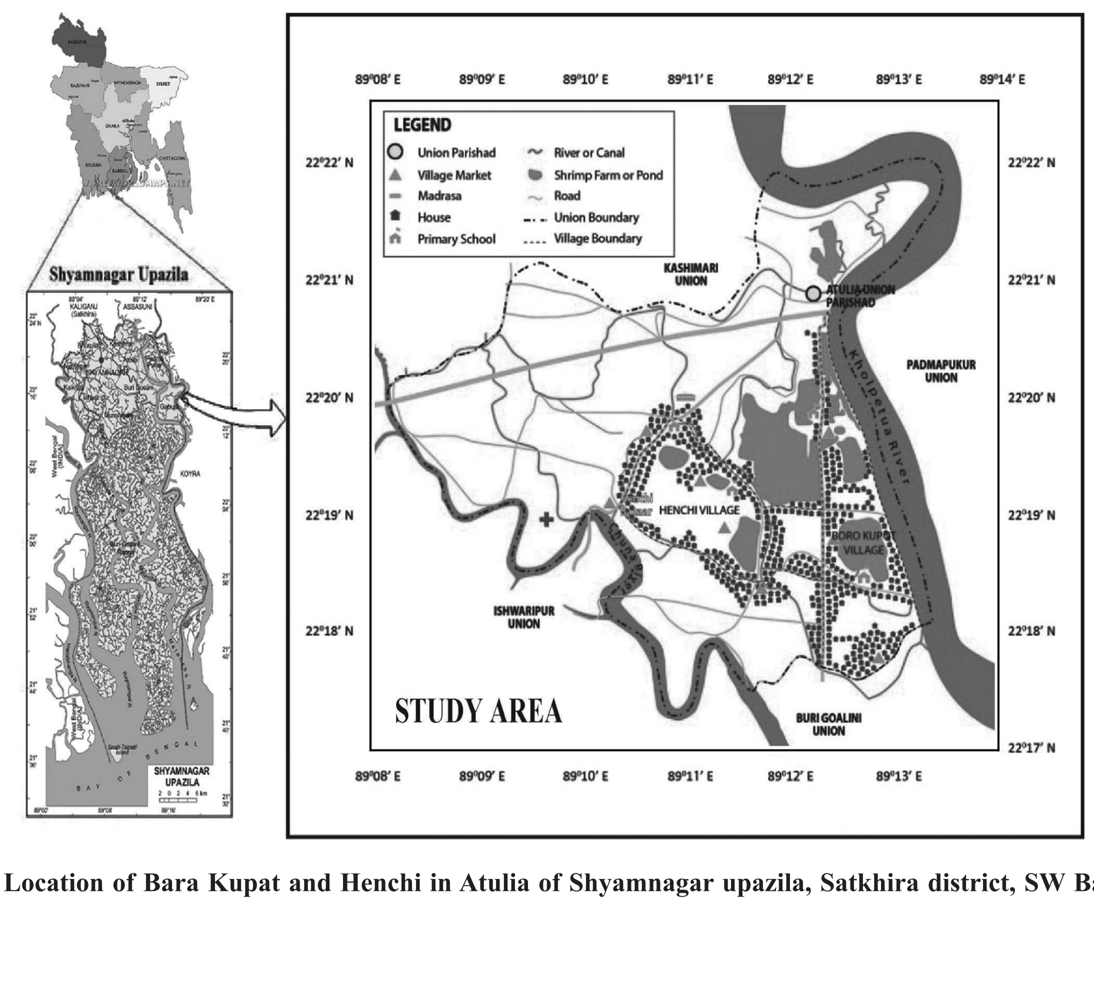

Figure 1: Location of Bara Kupat and Henchi in Atulia of Shyamnagar upazila, Satkhira district, SW Bangladesh.

severely affected by cyclones *Sidr* during November 15, 2007 and *Aila* during May 25, 2009 in recent past. The Atulia union is on the periphery of the *Sundarbans*, the largest single tract mangrove forest globally being separated by the river Malancha from the later and is about 78 km away from the district headquarters. Bara Kupot is closer to the Kholpetua and is separated from Henchi by a canal, locally called Arpangashia-Henchikhal, originated from the river Kholpetua (BBS, 2011).

The Atulia union lies in the Ganges Tidal Floodplain in general and located within the immature delta in particular. It is characterized by non-calcareous grey floodplain and acid sulphate soils (Rashid, 1991; Brammer, 1996). The relief of the area is flat and the elevation varies from 1-5 m above mean sea level. The highest mean maximum temperature of 35.5°C and above was recorded during March to May and the lowest mean minimum is 12.5°C during December to January (Ashraf, 2012). The mean annual rainfall in the area is approximately 1710 mm and about 78% of the total rainfall is received between July and October—the monsoon season (Miah, 2010; Abedin and Shaw, 2014).

Materials and Methods

The bio-physical attributes of the Bara Kupat and Henchi villages were estimated by analysing surface- and groundwater chemistry, soil pH and electrical conductivity (EC) and by estimating floral composition.

A total of 13 water samples from 13 stations (8 surface water and five groundwater samples) and nine soil samples from nine different stations of the coastal villages were collected during January, 2017 to estimate the physico-chemical attributes. The surface water samples were collected from different sources (such as tidal river, pond, *gheers*, *gheer* drains) in pre-washed 1 L polyethylene bottles from a depth of about 50 cm from the surface of the water body. The groundwater samples were collected from hand tubewells that were pumped for sufficient time until a relatively constant pH is observed in 1 L polyethylene bottles as well. The samples were sealed with labels and were transported to the laboratory to keep below 4°C. The temperature, pH, EC and HCO_3^- were estimated at the field and the major ions were determined at the laboratory following standard methods as mentioned in Table 1. The EC and pH of soil samples were estimated using portable EC/TDS meter (H1-9635, portable water proof multi-range conductivity/TDS meter, HANNA) following standard procedure.

Floral composition of the homestead gardens was estimated following quadrate method by purposively selected six plots (three from each village) of size 8×8 m^2. The plants were identified and recorded at species level, sometimes with local name that has been confirmed later. Vegetation at height lower than about 25 cm were not included in the estimation procedure; however their habit such as tree, shrub, hurb etc. were taken into account.

Results and Discussion

Chemical Attributes of Water

Following Huh et al. (1998) the Normalized Inorganic Charge Balance (NICB) was calculated for both surface and groundwater and is plotted against total cation (T_z^+) (Figure 2). The plot suggests that there are more cations than anions and the anions not analyzed may be of organic origin and have not contributed significantly to the solute load.

Table 1: Analytical methods followed for estimating the major dissolved ions in water

Parameter	*Method*	*Reference*
pH	Glass electrode	Instrument manual
Na^+, K^+	Flame photometric method (Flame photometer PFP7)	Instrument manual
Ca^{2+}, Mg^{2+}	Titrimetric method using standard EDTA	Greenberg et al. (1995)
HCO_3^-	Potentiometric method	Greenberg et al. (1995)
Cl^-	Ion selective electrode methods (Cole-Palmer Model 27502-13)	Instrument manual
SO_4^{2-}	Turbidimetric method	Greenberg et al. (1995)
PO_4^{3-}	Ascorbic Acid method	Greenberg et al. (1995)
SiO_2	Molybdosilicate method	Greenberg et al. (1995)

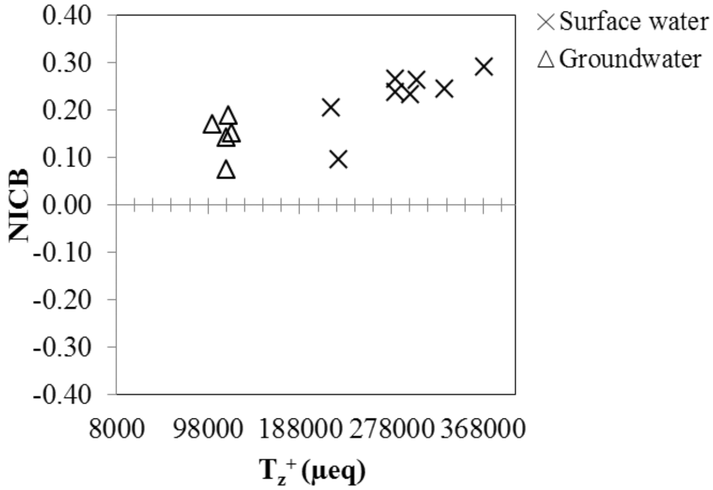

Figure 2: Plot for NICB against T_z^+ for water.

Physico-chemical Characteristics of Water

The physico-chemical attributes of surface and groundwater are presented in Table 2A-B. The surface waters are generally alkaline in nature. The pH of surface water varies between 7.56 and 8.46 (7.79 ± 0.30). However pH of groundwater ranges from 6.76 to 6.96 (6.91 ± 0.09) and are slightly acidic in nature. The electrical conductivity (EC) of surface water ranges from 13680 to 20600 $\mu S.cm^{-1}$ (16628 ± 2181$\mu S.cm^{-1}$) and that of groundwater ranges from 6560 to 8240 $\mu S.cm^{-1}$ (7604 ± 710$\mu S.cm^{-1}$). The estimated Total Dissolved Solid (TDS) of surface water varies from 10864 to 16235 $mg.L^{-1}$ (13398 ± 1827 $mg.L^{-1}$) and that of groundwater from 5330 to 6373 $mg.L^{-1}$ (5965 ± 394 $mg.L^{-1}$). The surface water shows higher EC and TDS than that of groundwater in the region suggests that contribution of saline water (sea water) is more in surface water.

The relative abundance of dissolved ions in surface and groundwater is shown in Figures 3 and 4. The cationic abundance (in $meq.L^{-1}$) in surface water follows the trend as Na^+ (83.44%) > Ca^{2+} (11.40%) > Mg^{2+} (3.81%) > K^+ (1.35%) and that of groundwater is Na^+ (82.49%) > Mg^{2+} (9.26%) > Ca^{2+} (7.52%) > K^+ (0.73%). The dissolved anions in surface water shows the trend as Cl (96.23%) > SO_4^{2-} (2.46%) > HCO_3^- (1.30%) > PO_4^{3-} (0.01%). Such anionic trend in groundwater is Cl (87.02%) > HCO_3^- (12.77%) > PO_4^{3-} (0.21%) > SO_4^{2-} (0.01%).

The ionic concentration varies significantly between surface and groundwater. Such variations are well observed for EC (t = 8.86; p = 0.000), TDS (t = 8.73; p = 0.000), Na^+ (t = 7.71; p = 0.000), Ca^{2+} (t = –3.65; p = 0.004), K^+ (t = 5.49; p = 0.000), HCO_3^- (t = –7.79; p =

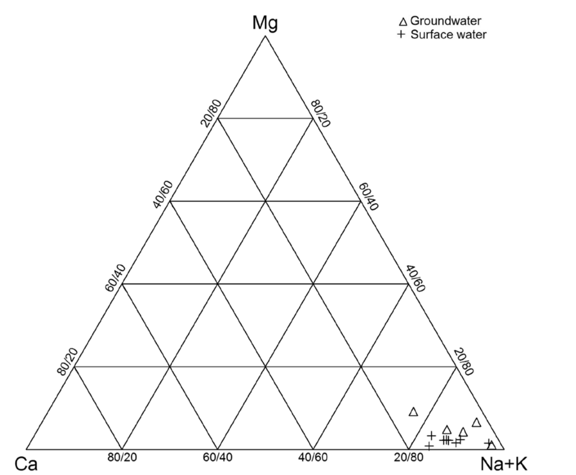

Figure 3: Ternary plot for Ca, Mg and (Na+K) for the surface and groundwater.

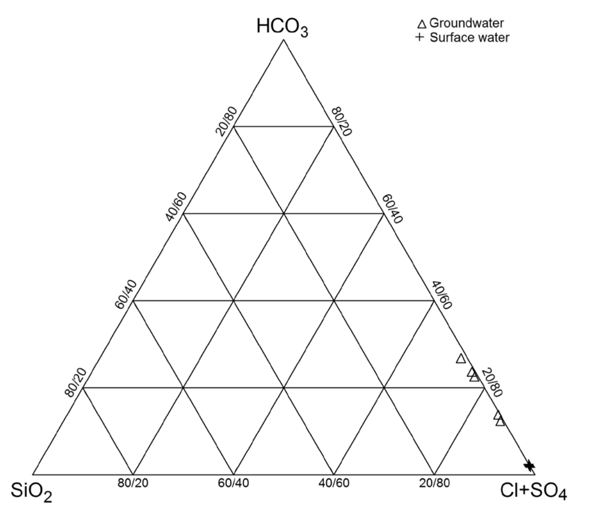

Figure 4: Ternary plot for HCO_3, SiO_2 and (Cl+SO_4) for the surface and groundwater.

Table 2A: Physico-chemical attributes of surface water collected from Bara Kupat and Henchi in Atulia of Shyamnagar upazila, Satkhira district, SW Bangladesh

Sampling station	*Station name*	*Latitude*	*Longitude*	*pH*	*EC (µS/cm)*	*TDS (mg/L)*	*Cation (mg/L)*				*Anion (mg/L)*				*SiO_2 (mg/L)*	*Tz^+ (meq/L)*	*Tz^- (meq/L)*
							Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3^-	Cl^-	SO_4^{2-}	PO_4^{3-}			
01	Chunna River (Low Tide)	22°17’89”N	89°11’06”E	7.70	16800	13714	4827	103	620	133	190	7586	248	0.34	6.25	254	222
02	Henchi Drain beside Gheer	22°18’16”N	89°11’30”E	7.73	18800	15369	5691	187	522	157	215	8295	300	0.36	1.65	291	244
03	HenchiGheer	22°18’30”N	89°11’45”E	8.46	20600	16235	5692	180	1069	60	160	8862	210	0.96	1.35	310	257
04	HenchiKhal	22°18’56”N	89°11’55”E	7.65	16000	12736	4608	155	575	121	160	6814	300	0.16	3.00	243	201
05	Khalpetua River (High Tide)	22°18’63”N	89°12’95”E	7.6	13680	10864	4424	120	118	71	145	5742	240	0.2	4.00	207	169
06	Bara Kupat Gheer	22°18’62”N	89°12’89”E	8.02	14840	11406	3326	120	562	139	180	6877	200	0.56	1.45	187	201
07	Chunna River (High Tide)	22°17’89”N	89°11’06”E	7.63	16300	12927	4564	70	619	121	155	7090	300	0.11	7.50	241	209
08	Khalpetua River (Low Tide)	22°18’63”N	89°12’95”E	7.56	16000	13932	5248	122	562	97	155	7535	210	0.42	2.95	267	219
Maximum				8.46	20600	16235	5692	187	1069	157	215	8862	300	0.96	7.50	310	257
Minimum				7.56	13680	10864	3326	70	118	60	145	5742	200	0.11	1.35	187	169
Mean				7.79	16628	13398	4798	132	581	112	170	7350	251	0.39	3.52	250	215
Standard deviation				0.30	2181	1827	774	40	256	34	23	959	44	0.27	2.29	41	27
Coefficient of variation				3.90	13.12	13.64	16.14	29.91	44.12	30.02	13.71	13.04	17.36	70.48	64.99	16.25	12.62

Table 2B: Physico-chemical composition of the groundwater collected from Bara Kupat and Henchi in Atulia of Shyamnagar upazila, Satkhira district, SW Bangladesh

Sampling station	*Station name*	*Latitude*	*Longitude*	*pH*	*EC (µS/cm)*	*TDS (mg/L)*	*Cation (mg/L)*				*Anion (mg/L)*				*SiO_2 (mg/L)*	*Tz^{+} (meq/L)*	*Tz^{-} (meq/L)*
							Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3^-	Cl^-	SO_4^{2-}	PO_4^{3-}			
01	Henchi Tubewell (River Side)	22°18’53”N	89°11’47”E	6.96	8240	6161	2060	24	57	152	478	3362	0.10	0.54	27	106	103
02	Bara Kupat Tubewell Mohendra Moor	22°18’59”N	89°12’15”E	6.76	8090	6373	2398	56	52	29	858	2919	1.00	31	29	111	97
03	Bara Kupat Tubewell beside Khalpetua River	22°18’61”N	89°12’88”E	6.96	7190	6060	1989	30	146	97	900	2872	0.31	0.18	26	103	96
04	Bara Kupat Household	22°18’62”N	89°12’87”E	6.92	6560	5330	1588	20	180	91	925	2481	0.10	0.26	45	86	85
05	Tubewell beside Arpangashia Canal	22°17’81”N	89°12’15”E	6.96	7940	5901	1400	15	267	170	560	3474	0.25	0.22	15	89	107
Maximum				6.96	8240	6373	2398	56	267	170	925	3474	1.00	31.00	45	111	107
Minimum				6.76	6560	5330	1400	15	52	29	478	2481	0.10	0.18	15	86	85
Mean				6.91	7604	5965	1887	29	140	108	744	3022	0.35	6.44	28	98.70	97.64
Standard deviation				0.09	710	394	396	16	90	56	209	402	0.37	13.73	10.76	10.82	8.31
Coefficient of variation				1.25	9.33	6.60	21.00	55.39	64.10	51.71	28.08	13.30	106.21	213.20	37.89	10.97	8.51

0.000), Cl^- (t = 9.46; p = 0.000) and SO_4^{2-} (t = –12.65; p = 0.001) at 95% confidence level. However variation is not observed statistically significant for Mg^{2+} (t = –0.19; p = 0.856) and PO_4^{3-}(t = –1.28; p = 0.226) at 5% significance level.

Thus the abundance pattern of dissolved attributes shows that sodium and chloride are the principal ions in both surface and groundwater. The relative abundance of potassium and sulphate in surface water suggests influence of anthropogenic contamination from *gheers* and other aquaculture fields.

Geochemical Mechanism Controlling Nature of Solute Load

The driving forces responsible for the variation in dissolved ionic composition in surface and groundwater may be deciphered by plotting TDS against as weight ratio (Gibbs, 1970) as in Figure 5. The position of the samples indicate that the dominant geochemical mechanisms determining the chemical composition of both the surface and ground water are evaporation and crystallization processes. The villages Bara Kupat and Henchi are experiencing waterlogged condition for long time that may add to enhance the consequences of evaporation and crystallization processes.

The molar ionic ratios also may be employed for better understanding the geochemical sources of ions following Haunslow (1995). The plot of TDS *vs* Na^+/Cl^- (Figure 6A) suggests contribution from seawater to at least 50% of both surface and groundwater. Similar observations for both surface and ground is evident when the plot of TDS *vs* $Na^+/(Na^+ + Cl^-)$ is considered (Figure 6B). Such plots also suggest that a considerable number of samples are having contribution from sources

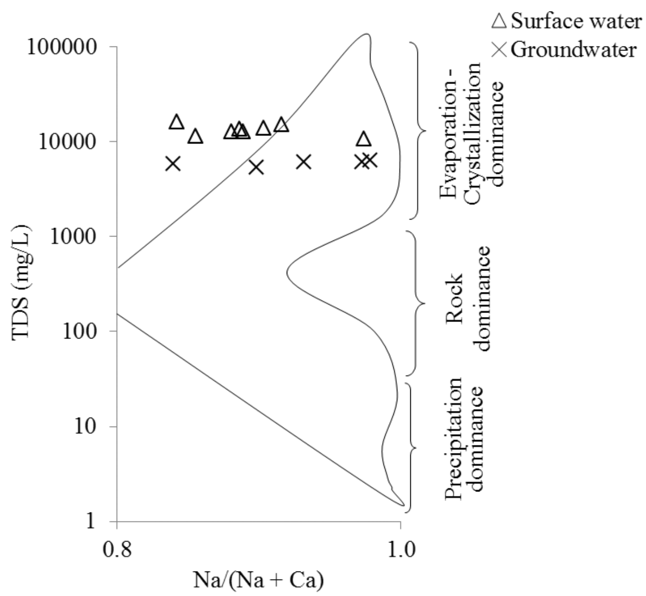

Figure 5: Gibbs' plot for surface and groundwater.

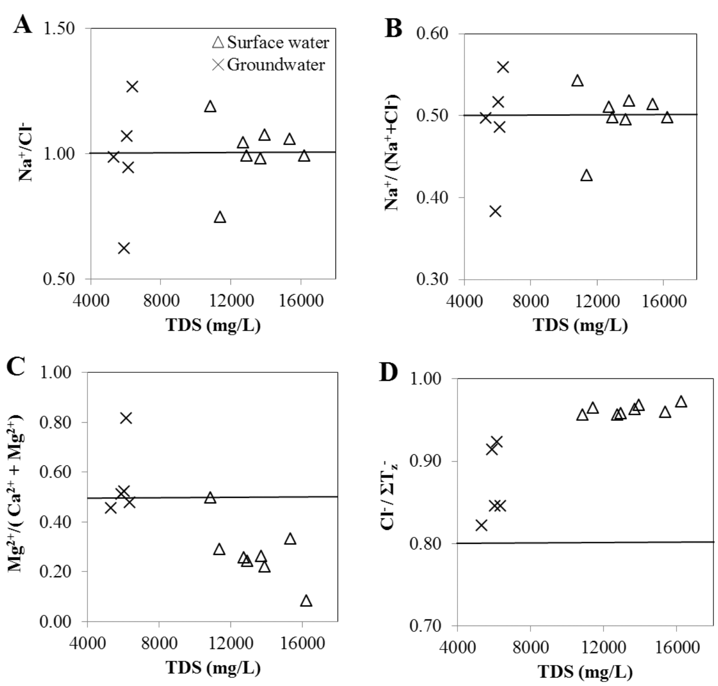

Figure 6: Molar ionic ratios for surface and groundwater: (A) TDS vs Na^+/Cl^-, (B) TDS vs $Na^+/(Na^+ + Cl^-)$, (C) TDS vs $Mg^{2+}/(Ca^{2+} + Mg^{2+})$ and (D) TDS vs $Cl^-/\Sigma T_z^-$.

other than halite. The plot of TDS *vs* $Mg^{2+}/(Ca^{2+} + Mg^{2+})$ (Figure 6C) reflects a mix of geochemical processes contributing to the water chemistry for both surface and groundwater. However, the plot of TDS *vs* $Cl^-/\Sigma Tz^-$ (Figure 6D) for both the surface and groundwater where the $Cl^-/\Sigma Tz^-$ ratio is more than 0.80 and the TDS is more than 500 mg/L suggests that seawater is the contributing attribute in water chemistry. The water samples were collected from diverse sources such as from river (tidal), pond, *gheers*, *gheer* drains and groundwater. Thus the distribution pattern of these high TDS water suggests both waterlogged condition and seawater contribution that is responsible for the current water chemistry.

Water Type

Plotting chemical attributes dissolved in water as percentage of the total in milliequivalents per litre on the trilinear diagram following Piper (1944) (Figure 7) indicates that the water occupies the position representing seawater and brine. This suggests that the samples are Na^+- Cl^-type.

Similarly water samples when plotted on Chadha's diagram as proposed by Chadha (1999) to decipher their geochemical class as in Figure 8 suggests that the alkali metals are exceeding the alkaline earths and strong acidic anions exceed weak acidic anions. Such water generally creates salinity problems both in irrigation and potable uses (Chadha, 1999).

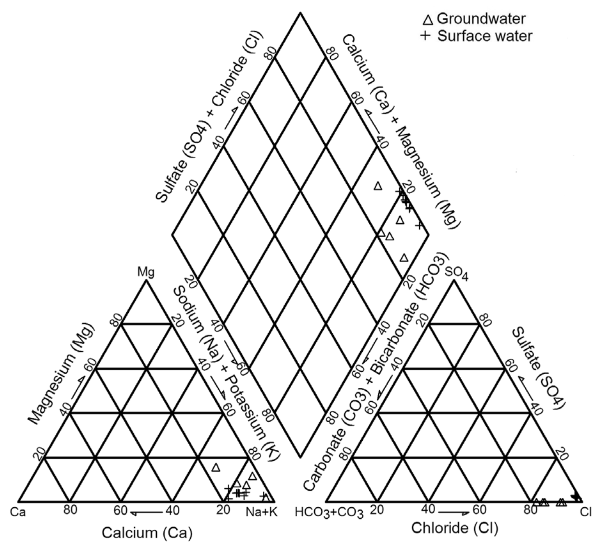

Figure 7: Piper plot for surface and groundwater.

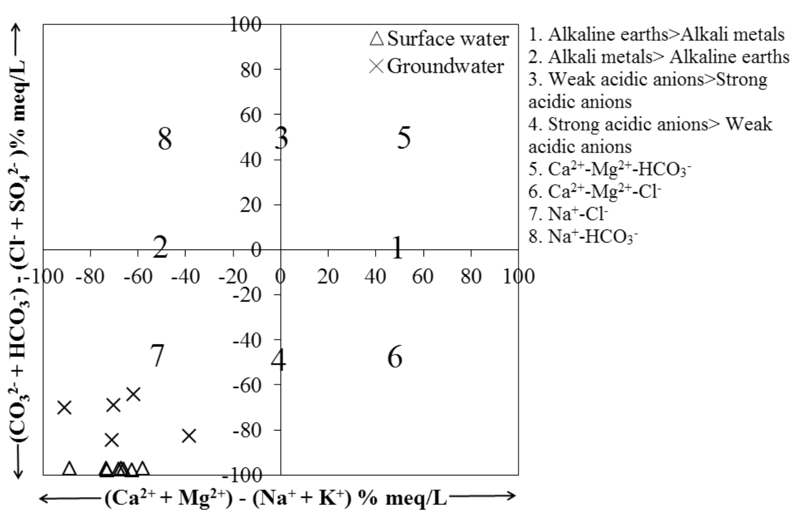

Figure 8: Chadha's plot for surface and groundwater.

Water Quality

The potable quality of water when assessed with reference to the drinking water quality standards as recommended by WHO (1993) (as shown in Table 3) suggests that the waters are not suitable for potable purpose with respect to TDS, sodium and chloride concentration. Plotting the sodium ion percentage in terms of SAR (sodium adsorption ratio) against EC as in Figure 9—commonly known as Wilcox diagram (Wilcox, 1955)—suggests that none of the water are supporting irrigational usage as well.

Soils

The soils of the villages are classified on the basis of their EC and pH as proposed by Rahman and Ahsan (2001) and presented in Table 4 that suggests that most soils are strongly saline in character; however mostly alkaline.

Floral Composition

The biological attributes of an area can be best elucidated through characterization of its floristic composition. The floral species and their individual number in Bara Kupat and Henchi are listed in Table 5.

The number of home garden floral species estimated in Bara Kupat is 56 while it is 20 in Henchi. Fifteen fruit species identified in Bara Kupat; however presence of wood producing plant in Henchi is rare. Homestead floral species grows in a modified environment controlled by the perception and choice of homestead owners and may not necessarily represent the natural floral composition. There are 419 plant species pertaining to 109 families identified in home-gardens of southwest Bangladesh, and in Satkhira district the number of plant species identified is 321 (Kabir, 2007). Kabir (2007) also estimated that 75% of these species are planted and the species rarity is high in this region. The current study is not an exhaustive one, but shows low diversity of plant species in Bara Kupat and Henchi and suggest that the support system for growth of plants in the villages are not favourable.

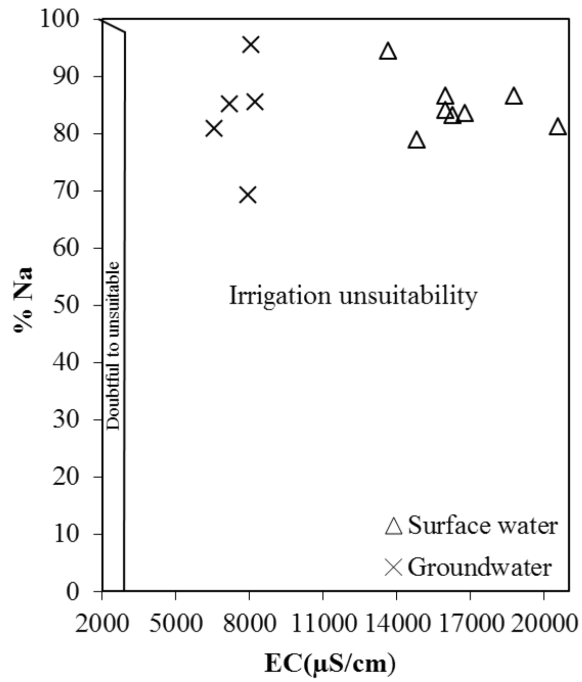

Figure 9: Wilcox's diagram for surface and groundwater.

Table 3: Water quality of Bara Kupat and Henchi in Atulia of Shyamnagar upazila, Satkhira (WHO, 1993)

Parameter	*WHO standard*		*Percentage of samples exceeding the desirable limit*		*Percentage of samples exceeding the maximum allowable limit*	
	Desirable limit	*Maximum allowable limit*	*Groundwater*	*Surface water*	*Groundwater*	*Surface water*
pH	7.0-8.5	9.2	100%	Nil	Nil	Nil
TDS ($mg.L^{-1}$)	500	1500	100%	100%	100%	100%
Na^+ ($mg.L^{-1}$)	–	200	–	–	100%	100%
K^+($mg.L^{-1}$)	–	12	–	–	100%	100%
Ca^{2+} ($mg.L^{-1}$)	75	200	60%	100%	20%	88%
Mg^{2+} ($mg.L^{-1}$)	50	150	80%	100%	40%	13%
Cl^- ($mg.L^{-1}$)	200	600	100%	100%	100%	100%
SO_4^{2-} ($mg.L^{-1}$)	200	400	Nil	88%	Nil	Nil

Table 4: Classification of soils collected from Bara Kupat and Henchi in Atulia of Shyamnagar upazila, Satkhira district, SW Bangladesh according to Rahman and Ahsan (2001)

Station no.	*Station name*	*Latitude*	*Longitude*	*pH*	*Soil class*	*EC (mS/cm)*	*Soil class*
01	Bara Kupat homegarden	22°18’62”N	89°12’87”E	6.83	Slightly alkaline	3.84	Non saline
02	Henchigheer	22°18’30”N	89°11’45”E	7.94	Moderately alkaline	10.82	Strongly saline
03	Bara Kupat agri-land beside the Kholpetua	22°17’89”N	89°11’06”E	7.80	Slightly alkaline	7.11	Moderately saline
04	Henchi drain	22°18’30”N	89°11’45”E	7.72	Slightly alkaline	9.63	Strongly saline
05	Henchi surface	22°18’57”N	89°11’64”E	7.20	Neutral	24.58	Strongly saline
06	Bara Kupat fallow land	22°18’62”N	89°12’87”E	5.25	Strongly acidic	10.19	Strongly saline
07	Bara Kupotgheer	22°18’62”N	89°12’89”E	7.69	Slightly alkaline	23.24	Strongly saline
08	Bara Kupot agri-land	22°18’62”N	89°12’89”E	7.68	Slightly alkaline	8.55	Moderately saline
09	Henchi school pond	22°18’57”N	89°11’64”E	7.68	Slightly alkaline	16.33	Strongly saline

Table 5: Floral composition at Bara Kupat and Henchi in Atulia of Shyamnagar upazila, Satkhira district, SW Bangladesh

Species Categories	*Bara Kupat*		*Henchi*	
	Species Name	*Number of Individuals*	*Species Name*	*Number of Individuals*
Fruits	*Psidium Guyava*	5	*Psidium Guyava*	2
	Syzygium samarangense	3	*Syzygium samarangens*	2
	Puncia granatum	2	Cocus nusifera	2
	Zizyphus mauritiana	3	*Musa sapientum*	7
	Syzygium cumini	3	*Borassus flabellifer*	1
	Phoenix syluestris	3	*Phoenix syluestris*	3
	Mangifera indica	5		
	Citrus maxima	3		
	Zinnia violacea	1		
	Vitis vinifera	1		
	Litchi chinensis	1		
	Manikara zapota	4		
	Citrus lemon	4		
	Cocus nusifera	3		
	Musa sapientum	4		
	Borassus flabellifer	2		
	Sesbaniagrandiflora	3	*Sesbaniagrandiflora*	2
	Dalbergia sissoo	3	*Dalbergia sissoo*	2
	Bomboxceiba	2	*Bomboxceiba*	3
	Ficus repnes	3	*Ficus repne*	2

Wood	*Mimusops elengi*	2	*Mimusops elengi*	1
	Albizia lebbeck	1	*Albizia lebbeck*	2
	Azadirachta indica	3	*Azadirachta indica*	3
	Swietenia macrophylla	3	*Swietenia macrophylla*	2
	Melia sempervire	3	*Melia sempervire*	2
	Eucalyptus rubra	1	*Eucalyptus rubra*	1
	Cinnamomum tamala	1		
Vegetable	*Centella asiatica*	2	*Centaticella asia*	4
	Colocasia esculenta	3	*Colocasia esculenta*	4
	Lycopersicum lycopersicum	7	*Brassica campestris var. turnip*	7
	Daucus carota	7	Rafannus sativus	4
	Brassica campestris	10		
	Brassica oleraciavar. brotytis	6		
	Solonum nigrum	14		
	Brassica oleracea var. capitata	12		
	Alium cepa	12		
	Solonum tuberosum	19		
	Capcicum frutecens	7		
	Trichosanthesangunia	6		
	Rafannus sativus	12		
Herbs	*Acacia auriculiformis*	1		
	Asparagus racemosus	1		
	Spinacea oleracea	12		
	Coriandrum sativum	14		
	Hibiscus rosa sinensis	2		
	Tagetes patula	1		
	Gardenia jasminoides	4		
	Ocimum sanctum	2		
	Amaranthus gangeticus	19		
	Amarunthus blitum	45		
	Lablab purpurcus	14		
	Basella rubra	7		
	Crinum amoenum	6		
	Amarunthus tricolor	2		

Conclusion

The physicochemical attributes of water and soil in Bara Kupat and Henchi are commanded by seawater and not effective in fortifying the livelihood support system of the locality. The floristic resources good for livelihood support are quite inadequate and low compared with that of coastal Bangladesh. With such biophysical constraints the villages are presumed to experience more stressed conditions that may generate vulnerability to the livelihood support systems.

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