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Temporal Variability of Soil and Water Salinity and Its Effect on Crop at Kalapara Upazila

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Abstract

Salinity is a serious threat to the crop production in the southern region of Bangladesh and it is especially important during dry period of a year. A study was undertaken to examine the changes in water and soil salinity over the period from February to April, 2014 at Kalapara upazila of Patuakhali district. Water samples were periodically collected from lake, pond, earthen well, deep tube-wells (5, 15 and 30 km away from the sea) and rivers (Tulatoli, Khaprabhanga, Sonatala and Andharmanik). Soil sampling was done from different crop fields (mustard, sweet gourd, potato, chilli, Khira-cucumber) and water melon and also from Sonatala and Andharmanik River flooded soils inside and outside polders. The electrical conductivity (EC) value of lake and pond waters was below 4 dS/m showing quite safe for irrigation while the EC value of earthen well exceeded 4 dS/m which are suitable in April. Water salinity of deep tube-wells (DTWs) increased as the DTW was closer to the sea, however all EC values were below 4 dS/m that suitable for irrigation, but not suitable for drinking purpose. Salinity level of all rivers tended to rise with the advancement of drying period, and for all dates of sampling, the EC value showed more than 4 dS/m. Soil salinity varied between inside and outside polder, and between mustard and sweet gourd fields, the higher EC values were observed outside polder and in the sweet gourd field. Soil EC levels were all above 4 dS/m particularly in April, crops showed varying degrees of leaf injury depending on the types of crops and extent of soil salinity. The EC values were positively correlated with Na and K contents of soil.

Key words: Coastal region, Soil salinity, Water salinity

Introduction

The southern region of Bangladesh is recognized as an agro ecologically disadvantaged region. The major challenges of this region are threat of climate change, soil and water salinity, water-logging and resource (land and water) degradation (MoA and FAO, 2013). Both magnitude and extent of soil salinity in Bangladesh are increasing with time, being 0.83 mha in 1973, 1.02 mha in 2002 and 1.06 mha in 2009 (SRDI, 2010). These changes negatively impact on soil fertility and crop productivity which underpins the rural economy of coastal Bangladesh. The reasons for salinity increase can be attributed to reduction in upstream fresh water flow, sea level rise and also due to the shift from rice to shrimp cultivation using tidal water. The saline affected districts of the southern Bangladesh are Patuakhali, Barguna, Bhola and Pirojpur. These areas are relatively flat and suffer from saline soil and saline water to different degrees. Annual precipitation does not exceed evapotranspiration, soluble salts tend to accumulate and build-up in the soil of coastal regions, instead of being leached out, and can reach the levels inhibitory to plant growth and development. Intensive irrigation with light saline surface water in such areas has further complicated the problem, leaving behind huge salt deposits after evaporation, leading to secondary salinization and alkalinization (Roychoudhury and Chakraborty, 2013).

The challenge to Bangladesh is now how best to adapt to these changes and implications for water resource availability for irrigating crops and clean water for drinking purpose in coastal regions. Recent attention has been paid to the impact of soil and water salinity on crop production (CIP, 2013), and there are additional implication for salt contamination of drinking water. The present study was undertaken to provide better understanding of temporal and spatial variability of soil and water salinity during dry period and its effect on crops in southern region of Bangladesh.

Materials and Methods

The study was done at Kalapara upazila of Patuakhali district. It is one of the most cyclone prone salt affected coastal upazila in southern Bangladesh. It lies between 21°48´ and 22°05´ North latitude and between 90°05´ and 90°20´ East latitude. Soil and water samples were collected periodically from different locations and sites of the upazila. Surface irrigation water samples were collected from three different water reservoirs - lake, pond and earthen well. Many farmers in their fields dig earthen wells having 2-3 m diameter and 4-5 m depth for storing of water for irrigation purpose in dry season crops. Drinking water samples were taken from three different deep tube-wells (above 1000 ft depth) that were 5, 15 and 30 km away from the sea. River water was collected from four large rivers- Tulatoli, Khaprabhanga, Sonatala and Andharmanik, and another sample was collected directly from Kuakata sea beach. Soil samples were collected from inside and outside polder, and some selected crop fields. Salinity induced plant leaf burning and crop growth loss data were recorded by visual observation. An optimum and vigorously grown crop was used as a control crop. The soil and water samples were analyzed for electrical conductivity (EC). Water EC value was directly measured by inserting the probe of EC meter to the saline water. Soil EC was measured in soil-water suspension (1:5) using EC meter. The potassium (K) and sodium (Na) content (exchangeable + soil solution) of soil was extracted by ammonium acetate (NH_4OAc) extraction method. Extraction was done by repeated shaking and centrifugation of the soil with neutral 1N NH_4OAc followed by decantation. The K and Na concentration in the extract was determined by flame photometer (Knudsen et al., 1982).

Results and Discussion

Surface irrigation water salinity

There was s severe crisis of safe irrigation water at Kalapara upazila of Patuakhali district. The farmers in the area use irrigation water from three sources: lake water, pond water and earthen well water. The lake was very close to the sea, but was not contaminated with sea water. The EC of this water was only 0.219 dS/m as recorded on the 20 February sampling (Table 1) and it increased to 0.251 dS/m on 4 April. The study pond was located about half kilometer away from Kuakata sea beach. The pond water salinity was 0.258 dS/m on the 20 February sampling and slowly increased to 0.525 dS/m on 25 April. Among three surface water sources, earthen well water showed a different scenario. The earthen well water EC value was recorded as 2.91 dS/m on the 20 February and sharply increased with advancement of time and reached to a value of 7.03 dS/m on 25 April sampling. At this stage, the earthen well water became unsuitable for irrigation purpose.

Drinking water salinity

Drinking water was collected from three different tube-wells located at 5, 15 and 30 km away from sea. The EC value of tube-well water collected from 5 km and 15 km from the sea was close to about 1.7 dS/m on 20 February sampling (Table 1). On this date, the EC value at 30 km distance was 0.94 dS/m and it did not change much in the next three sampling dates. At 5 and 15 km away the EC value slowly increased and reached its peak on 25 April sampling. Considering 25 April sampling and EC values, the tube-wells can be ranked as 5km > 15km > 30 km. Result in table 1 further indicates that across the locations and sampling dates the EC value of drinking water ranged from 0.83 to 2.91 dS/m. The WHO and Bureau of Indian standard of safe drinking water is 0.3 dS/m. Thus it is evident that the tube-well water that is commonly used by the local people is not safe for drinking purpose.

Table 1. Status of water salinity at different sampling dates

Water sources	GPS reading	EC value (dS/m)			
		1st sampling (20/02/2014)	2nd sampling (13/03/2014)	3rd sampling (04/04/2014)	4th sampling (25/04/2014)
Surface water					
Lake	N21°48.881ʹ E90°7.537ʹ	0.219	1.590	0.251	0.289
Pond	N21°49.135ʹ E90°7.254ʹ	0.258	0.219	0.417	0.525
Earthen well	N21°50.784ʹ E90°8.605ʹ	2.91	4.03	4.41	7.03
Deep tube-well at different distances from the sea					
5 km	N21°51.320ʹ E90°7.395ʹ	1.682	2.91	1.573	2.12
15 km	N21°55.940ʹ E90°8.466ʹ	1.760	1.82	1.637	2.21
30 km	N21°58.868ʹ E90°12.915ʹ	0.944	1.11	1.160	1.209
River water					
Sea beach	N21°48.775ʹ E90°7.332ʹ	18.25	31.7	30.8	35.1
Tulatoli	N21°49.245ʹ E90°7.211ʹ	12.46	20.7	24.0	24.8
Khaprabhanga	N21°51.360ʹ E90°7.488ʹ	17.76	18.4	31.3	38.1
Sonatala	N21°53.701ʹ E90°8.383ʹ	18.28	20.1	31.4	37.4
Andharmanik	N21°58.947ʹ E90°13.051ʹ	9.45	13.54	14.63	30.2

River water salinity

Water was collected from four major rivers located at Kalapara upazila - Tulatoli, Khaprabhanga, Sonatala and Andharmanik and also from Kuakata sea beach. Among the sampling sites, the lowest EC value of 9.45 dS/m was found in Andharmanik river at Nilganj point which was 30 km distance from the Kuakata sea beach. On this date the sea, Tulatoli, Khaprabhnaga and Sonatala river waters had the EC values of 18.3, 12.5, 17.8 and 18.3 dS/m, respectively (Table 1). Salinity level in all water samples from all rivers progressively increased up to 13 March except sea water, where a dramatic increase was found. After this date, a sharp increase of EC value was found in all the rivers. In 25 April sampling, all the rivers showed the highest salinity levels recording 35.1, 24.8, 38.1, 37.4 and 30.2 dS/m in Kuakata sea beach, Tolatoli, Khaprabhanga, Sonatala and Andharmanik river water, respectively.

Effects of polder on soil salinity

The government of Bangladesh has constructed earthen high road longitudinally along the rivers which serves as an embankment so that saline river water canơt flew into the crop field. Because of frequent cyclone and full moon, due to high tidal water pressure the polders sometimes fail to protect the sea water to go into crop field. The earthen road which is used to protect river water is called polder. In this study, soil samplings have been done periodically from outside and inside the polder of two big rivers- Sonatala and Andharmanik river. It appears that soil salinity of outside polder was found much higher compared to inside polder. The soil EC of outside polder of Sanatala river for the first sampling was 4.93 dS/m which increased to 9.83 dS/m on 25 April sampling (Fig. 1). But inside the polder the scenario was different and the rate of increment is little with the passage of time. Regarding Andharmanik river, the pattern of salinity development was similar to that of Sonatala river, however the rate of increment was much higher in Andharmanik river. For this river and outside polder the EC value was 8.32 dS/m in the first sampling date which increased to 16.67 dS/m on 25 April sampling. Inside the polder, the EC value on 20 February was 3.67 dS/m and in 25 April was 5.51 dS/m.

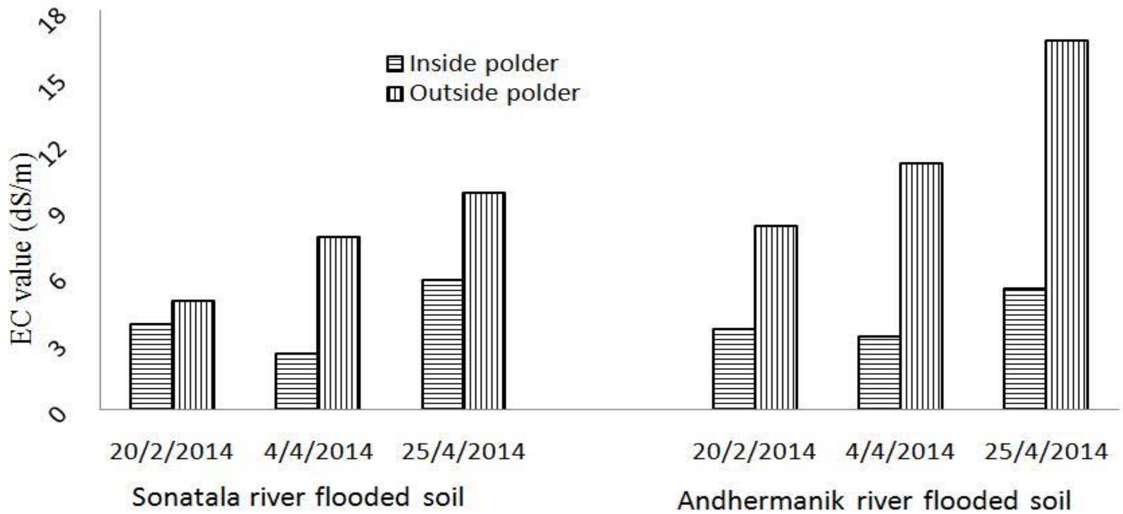

Fig. 1 Effects of polder on soil salinity at different sampling dates

Soil salinity in crop fields

We collected soil samples from some selected crop fields periodically to monitor the level of temporal and spatial variation in soil salinity. It was found that in all the four crop fields EC was the lowest in 20 February sampling, and then increased and reached its peak on 25 April sampling, except sweet gourd field where the peak value was recorded on 4 April. Among the crop fields, in sweet potato field the EC value was lower in the study period and increased from 2.41 dS/m on 20 February to 3.88 dS/m on 25 April sampling (Table 2). The mustard and sweet gourd fields had EC value of 3.8 and 4.59 dS/m in 20 February, and 6.66 and 9.71 dS/m in 25 April sampling, respectively. In potato field, the initial EC value was 4.21 dS/m as recorded on 20 February which increased to 13.71 dS/m in 4 April and then it decreased to 10.48 dS/m in 25 April.

Table 2. Status of soil salinity in different crop fields at different sampling dates

Crop fields	GPS reading	EC value (dS/m)			
		1st sampling (20/02/2014)	2nd sampling (13/03/2014)	3rd sampling (04/04/2014)	4th sampling (25/04/2014)
Sweet gourd	N21°50.788″E90°8.600″	4.59	5.21	6.8	9.71
Mustard	N21°50.792″E90°8.671″	3.8	4.91	5.32	6.66
Sweet potato	N21°50.772″E90°8.671″	2.41	2.61	2.82	3.88
Potato	N21°50.778″E90°8.672″	4.21	8.61	13.71	10.48

Sodium and potassium contents of soil

The sodium (Na) content of 13 selected soils varied from 0.63 to 5.15 %. There was found a linear relationship between sodium content and EC value indicating that with the increase of Na content the EC value also increased (Fig. 2A), the regression equation being y = 3.004x + 0.246 (R^2 = 0.911). The K content of soil varied from 153 to 859 mg/kg. Like Na, the EC value also increased with the increase of K contents, showing the equation y = 0.021x - 1.294 (R^2 = 0.860) (Fig. 2B). Haque et al. (2008) and Naher et al. (2011) also reported that increased salinity caused increases in the water soluble cations like Na, K, Ca and Mg.

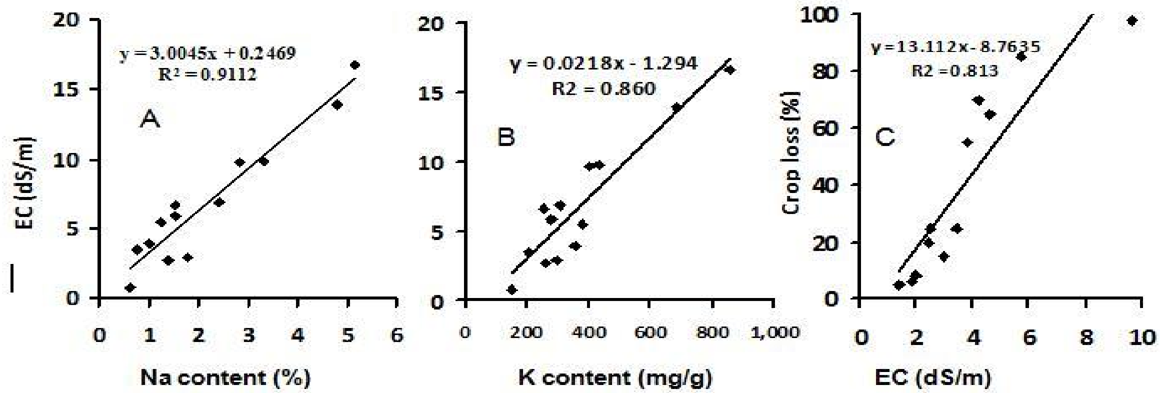

Fig. 2. Relationship of soil EC with Na content (A), K content (B) and crop loss (C)

Effects of salinity on crop loss

In this study we collected data from several crop fields to determine the extent of leaf damage due to salinity.

Table 3. Extent of crop loss due to varying degrees of soil salinity

Crop	Field No.	EC value (dS/m)	Leaf burning/ crop loss (%)	Crop	Field No.	EC value (dS/m)	Leaf burning/ crop loss (%)
Sweet gourd	1	1.95	8	Potato	1	2.48	25
Sweet gourd	2	4.59	65	Potato	2	4.21	70
Mustard	1	1.37	5	Chilli	1	3.4	25
Mustard	2	3.8	55	Chilli	2	9.7	98
Sweet potato	1	1.83	6	Khira	1	5.7	85
Sweet potato	2	2.41	20	Melon	1	2.96	15

Table 3 shows that when EC value was less than 2 dS/m, the leaf burning was found to be lower than 8%. Beyond this level, increase of single unit of EC value, the leaf burning increased linearly (Fig. 2C). When EC value exceeded 4 dS/m about 70% leaves were dried out. When the EC value of soil went beyond 9 dS/m most of the crops fell into death

Conclusions

Soil and water salinity is a great limitation for successful crop production in Kalapara upazila of Patuakhali district. After monsoon salinity starts to rise up. In February, the crops are less affected by salinity. The highest crop damage occurs in April due to higher EC values of soil and water.

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