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RESEARCH PAPER

Water and Soil Quality Assessment on the Basis of Macronutrients for Agriculture from Seashore to Inside of Patuakhali District of Bangladesh

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ABSTRACT

A study was conducted on quality assessment of water and soils for agricultural production from sea shore to inside of southern tidal area of Bangladesh. The study was conducted in some selected areas during the month of June–July, 2015 (summer season) from different locations in 0-85 km distance from sea shore to inside in Patuakhali district. Soil Phosphrus (P) and Sulpher (S) contents were found minimum (1.2 mgkg^{-1} and 13.99 mgkg^{-1}, respectively) near sea shore and maximum (10.91 mgkg^{-1} and 68.3 mgkg^{-1}, respectively) at a distance of 56–85 km from sea shore. Soil potassium (K) was found maximum (141.6 mgkg^{-1}) at a distance of 56–85 km and minimum (51.4 mgkg^{-1}) at a distance 0–25 km from sea shore. Calcium (Ca) content in soil was found maximum (494 mgkg^{-1}) at a distance of 41–70 km and minimum (21.7 mgkg^{-1}) at a distance of 26–40 km. Magnesium (Mg) content was observed to be maximum (462.8 mgkg^{-1}) at a distance of 56–70 km and minimum (37.4 mgkg^{-1}) at a distance of 0–10 km from sea shore. An increasing trend was visible in case of soil P, K, S and Mg, except Ca from sea shore to inside. P, S and Mg content were found to increase from sea shore to inside. K and Ca content in sea and river water decreased gradually from sea shore to inside. The soil quality was assessed to be suitable for crop production on the basis of availability of most of the macronutrients contents.

Key words: Bangladesh, macronutrients, seashore, soil, water

Introduction

The economy of Bangladesh is predominantly based on agriculture. Most of the land areas of Patuakhali and Barisal districts are under tidal floodplains which are situated in the Ganges Tidal Floodplain Agro-Ecological Zone of Bangladesh. The tidal floodplain has a distinctive, almost level landscape crossed by innumerable interconnecting tidal rivers (Haque, 2006). Tidal flooding through a network of tidal creeks and drainage channels connected to the main river system inundates the soil and impregnates them with soluble salts thereby rendering both the top and subsoil saline. In the coastal and offshore areas cover about 0.83 million hectares are arable lands which are affected by varying degree of salinity and tidal submergence (Karim *et al.*, 1990). Most of the land remains fallow in the dry season (January–May) because of high soil salinity and lack of good quality irrigation water (Mondal, 1999). Bangladesh is in top of the climate change vulnerability list and has been experiencing recurrent natural disasters like–cyclones, floods, storm surge, river bank erosion etc. Irrigated water demand is highly affected by salinity intrusion in surface water (Shahid, 2010) and salt accumulation in the root zone of soil affects plant growth in coastal soil (Yadav *et al.*, 2009). Salt contaminated soils have several effects on crops. The osmotic problem, where high salt levels in the soil solution will draw water out of germinating seedlings and the roots of plants, causing desiccation and inhibition of nutrient uptake by plant are the major problem in saline area. Sedimentation, associated with tidal flooding, is an important source of nitrogen, phosphorus and potassium in island soils. In the sediments N is deposited mostly as a component of organic matter, whereas P is associated primarily with the fine–grained clay minerals (Odum, 1988). Local hydrological factors, as well as local geomorphology can influence the spatial pattern of sediment deposition and, hence, soil nutrient availability (Darke and Megonigal, 2003). From sea shore to inside in the land area there must be a different nutritional gradient.

However, no detailed studies on the monitoring of macro and micronutrients in water and agricultural soils in the studied areas of Bangladesh have been conducted so far, and concentration of studied elements data is severely insufficient to assess the water and soil quality parameters. Considering the above mentioned circumstances the researcher conducted the study to assess soil and water quality based on macronutrients status for agriculture from sea shore to inside in Patuakhali district of Bangladesh.

Materials and Methods

Sampling sites

In order to make quality assessment of water and soils from sea shore to inside of southern tidal areas, the study was conducted in some selected areas mostly of Patuakhali district. The soil and water samples were collected during the month of June–July, 2015 (summer season) from different locations with distance from sea shore to inside in Patuakhali district of Bangladesh. The samples were brought to the laboratory, processed and reserved accordingly for analysis. The areas from where the water and soils were collected are from 0–85 km from sea shore to inside. The locations of sample collections are cited below with their distances from sea shore to inside.

Table 1: Type and location of sample collection with distance from sea shore to inside

Sample type	Location of collection	Distance
Crop field and sea beach soil	Kuakata region	0–10 km
Crop field and river bank soil	Mohipur region	11-25 km
Crop field and river bank soil	Hajipur, Pakhimara region	26-40 km
Crop field and river bank soil	Kalapara sadar region	41-55 km
Crop field and river bank soil	Patuakhali sadar region	56-70 km
Crop field and river bank soil	Lebukhali, Dumki region	71-85 km
Sea water	The Bay of Bengal, Kuakata	0–10 km
River water	Branch of Andarmanik river, Mohipur	11-25 km
River water	Sonatala river, Hajipur	26-40 km
River water	Andarmanik river, Kalapara	41-55 km
River water	Paira river, Patuakhali sadar	56-70 km
River water	Paira river, Lebukhali, Dumki	71-85 km

Location and agro-ecological zone

Patuakhali district and the study areas are situated in the southern part of Bangladesh and located at 22° 35" N latitude to 90° 31" E longitude with an altitude of 1.5 meter from mean sea level (MSL). The study area belongs to the agro-ecological zone of the Ganges tidal floodplain and falls under AEZ 13.

Climate

The study areas were under the subtropical climatic region which is characterized by high temperature, high humidity and heavy rainfall with occasionally gusty winds in Kharif season (April-September) and less rainfall associated with moderately low temperature during the Robi season (October-March). The monthly average temperature ranges from 13-36°c throughout the year. The monthly average relative humidity ranges from 69 to 88%. The whole region lies within the cyclone zone. South-eastern parts are most frequently affected; they are also most exposed to associated storm surges passing up estuarine channels and flooding adjoining land, sometimes with saline water.

Collection, preparation and analysis of soil and water samples

The soil samples were collected from two ecosystems, namely crop field and river bank in the study areas. Soil samples were collected by the auger at a depth of 0-15 cm i.e. surface soil. The soil samples were collected and stored following the instructions reported by Allen *et al.* (1990). The soil samples were then dried at room temperature, ground to pass through twenty mesh sieve and kept separately for chemical analysis. At the same time water samples were collected from water bodies near the locations of soil sample collection during tide. The samples were collected and stored following the instructions reported by Allen *et al.* (1990) and APHA (2005). The water samples were collected from the Bay of Bengal, Paira, Andermanik and Sonatala River.

Chemical analysis of soil samples for determining available S, exchangeable Ca, exchangeable Mg, available P and exchangeable K were carried out following the methods as described by Jackson (1973) and APHA (1998). The chemical analysis of water samples for determining P, K, S, Ca and Mg were carried out following the methods described by Ghosh *et al.* (1983); APHA (1998); Tandon (1995) and Page *et al.* (1982). The soil and water samples were analyzed in the Laboratory of the Department of Agricultural Chemistry and Central Laboratory, Patuakhali Science and Technology University, Dumki, Patuakhali.

Available soil phosphorus was determined by Olsen's method (Olsen *et al.*, 1954) calorimetrically using $SnCl_2$ as reductant. Exchangeable potassium was determined with the help of flame emission spectrophotometer using potassium filter in the Laboratory of Agricultural Chemistry, PSTU (Ghosh *et al.*, 1983 and APHA, 2005). Sulphur was determined by turbidimetric method with the help of a spectrophotometer (Page *et al*., 1982). Calcium and magnesium were determined by complexometric method of titration using Na_2-EDTA as a complexing agent (Page *et al.*, 1982 and APHA, 2005).

Results and Discussion

Phosphorus content in crop field soil, river bank and sea beach soil and river and sea water from sea shore to inside

Soil phosphorus (P) content in the crop fields was observed to show an increasing trend from sea shore to inside. P content was 1.74 mg kg^{-1} in 0-10 km from sea shore. The P content increased gradually up to 85 km from sea shore to inside except at the distance of 11-25 km. The P content was 6.4 mg kg^{-1} at a distance of 71-85 km. P content in river bank and sea beach soils showed an increasing trend from sea shore to inside. P content was 1.23 mgkg^{-1} in 0-10 km from sea shore. The P content was 10.91 mgkg^{-1} at a distance of 71-85 km from sea shore to inside. P content in river and sea water showed an increasing trend after 55 km from sea shore to inside. P content was nil (0 mgkg^{-1}) in 0-55 km from sea shore. The P content was 0.405 mgkg^{-1} at a distance of 71-85 km from sea shore to inside.

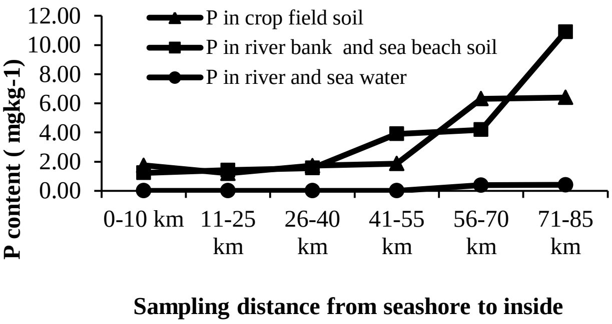

Figure 1. Phosphorus content in crop field soil, river bank and sea beach soil and river and sea water from sea shore to inside

P content was determined in the range from 1.2 mgkg^{-1} to 10.91 mgkg^{-1} in the soil samples and 0-0.405 mgkg^{-1} in the water samples. Optimum P content in the soil was prescribed 4.1-7 ppm by Jokela *et al.* (2004). Carrie *et al.* (2012) stated that optimum P content in soil should be 16-32 ppm for agriculture. P content determined in the present study was relevant to the optimum level except a few locations and could be considered as suitable for agriculture. Factors such as weathering, leaching, soil water retention, soil water discharge, soil reaction etc. may give variations in P content with huge irregularity from sea to inland and vice versa (Bouwman *et al.*, 2013).

Potassium content in crop field soil, river bank and sea beach soil and river and sea water from sea shore to inside

K content in the crop fields was increased from sea shore to inside. K content was 51.4 mg kg^{-1} in 0-10 km from sea shore. The K content was 52.2 mg kg^{-1} at a distance of 71-85 km. The K content in river bank and sea beach soils showed an irregularly increasing trend from sea shore to inside. K content was 62.4 mgkg^{-1} in 0-10 km from sea shore. The K content was 140.4 mgkg^{-1} at a distance of 71-85 km from sea shore to inside. A decreasing trend was found in K content in the river and sea water from sea shore to inside mostly. K content was 88.757 mgkg^{-1} in 0-10 km from sea shore. The K content was 14.858 mgkg^{-1} at a distance of 71-85 km.

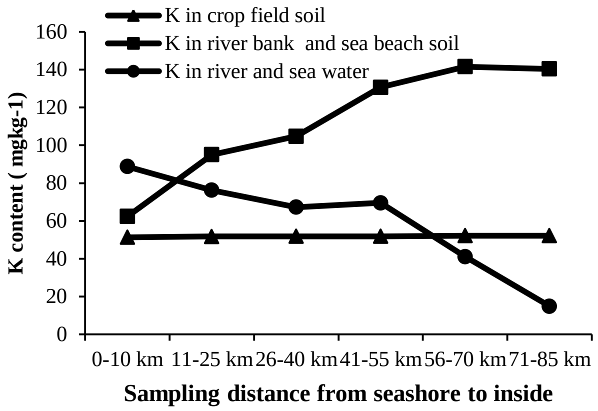

Figure 2. Potassium content in crop field soil, river bank and sea beach soil and river and sea water from sea shore to inside

K content ranged from 51.4 mg kg^{-1} to 140.4 mgkg^{-1} in soil and 14.858 mg kg^{-1} to 88.757 mgkg^{-1} in water samples in the present study. Jokela *et al.* (2004) and Carrie *et al.* (2012) showed that optimum K content in soil for crop production should be 101-130 ppm. The K content in the soils of the study areas were found suitable for crop cultivation but the K content in the irrigation water supply from river and sea water were found to fluctuate randomly. Fresh water irrigation in the soils of the study areas could be appropriate for crop cultivation. Sedimentation, river bank infiltration, flooding, weathering, soil retention, nutrient release by organic or inorganic fertilizer use, rhizospheric nutrient deposition etc. influences K content in crop fields from sea to in-stream (Blair *et al.*, 2004).

Sulpher content in crop field soil, river bank and sea beach soil and river and sea water from sea shore to inside

Sulpher (S) content in the crop fields was found to increase from sea shore to inside. S content was 13.99 mg kg^{-1} in 0-10 km from sea shore. The S content was 39.4 mg kg^{-1} at a distance of 71-85 km. S content in river bank and sea beach soils showed an increasing trend from sea shore to inside. Sulpher content was 17.07 mgkg^{-1} in 0-10 km from sea shore. The S content was increased gradually and reached at 68.3 mgkg^{-1} at a distance of 71-85 km from sea shore to inside. The S

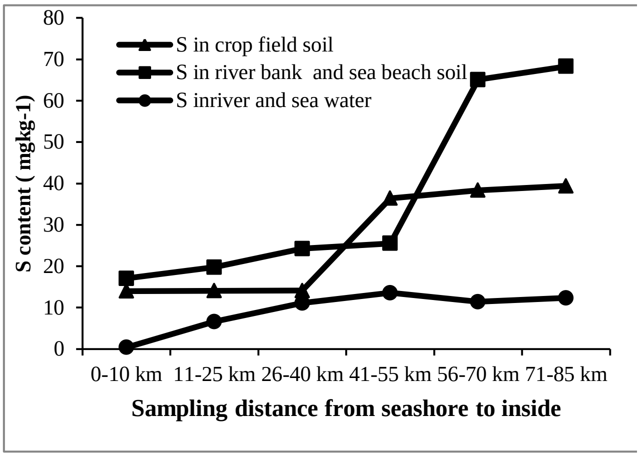

Figure 3. Sulpher content in crop field soil, river bank and sea beach soil and river and sea water from sea shore to inside

content in river and sea water showed an irregular but increasing trend from sea shore to inside. The S content was 0.401 mgkg^{-1} in 0-10 km from sea shore. The S content was 12.34 mgkg^{-1} at a distance of 71-85 km from sea shore to inside. S content was measured in the range from 13.99 mgkg^{-1} to 68.3 mgkg^{-1} in soil samples and from 0.401 mgkg^{-1} to 13.59 mgkg^{-1} in water samples. An increasing trend was observed in case of soil samples from sea shore to inside about S content but an irregularly increasing trend was found in water samples in case of S content.

Calcium content in crop field soil, river bank and sea beach soil and river and sea water from sea shore to inside

Calcium content in crop fields showed an irregular but increasing trend from sea shore to inside. Ca content was 423.6 mgkg^{-1} in 0-10 km from sea shore. The Ca content was 460.7 mgkg^{-1} at a distance of 71-85 km. The Ca content in river bank and sea beach soils showed an irregular trend from sea shore to inside. Ca content was 468 mgkg^{-1} in 0-10 km from sea shore. The Ca content was 422 mgkg^{-1} at a distance of 71-85 km from sea shore to inside.

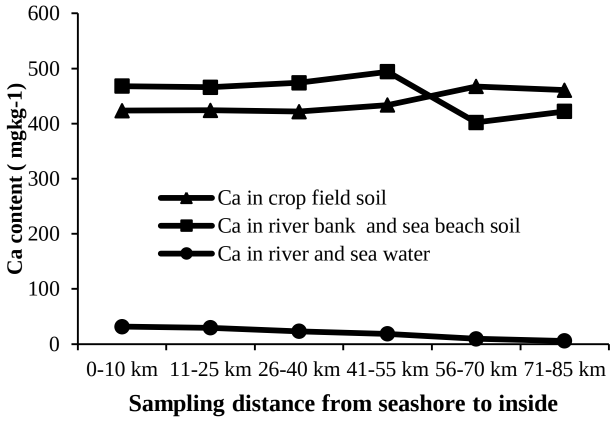

Figure 4. Calcium content in crop field soil, river bank and sea beach soil and river and sea water from sea shore to inside

A decreasing trend was found in Ca content in the river and sea water from sea shore to inside mostly. Ca content was 31.57 mgkg^{-1} in 0-10 km from sea shore. The Ca content was 5.81 mgkg^{-1} at a distance of 71-85 km i.e. lower. It was found that Ca content ranged from 421.7 mg kg^{-1} to 494 mg kg^{-1} in soil samples and 5.81 mgkg^{-1} to 31.57 mgkg^{-1} in water samples. Tabi *et al.* (2012) showed that the critical value of Ca in soil is 401-600 ppm for sandy soil and 601-1000 ppm for loamy soil. The findings of this study showed availability of Ca in soils for agriculture in the study areas. However, the Ca content in water samples varied randomly. This might be caused due to river water flow, tidal surge etc.

Magnesium content in crop field soil, river bank and sea beach soil and river and sea water from sea shore to inside

Magnesium content in crop fields showed an increasing trend from sea shore to inside. The Mg content was 260 mgkg^{-1} in 0-10 km from sea shore. The Mg content was 459.6 mgkg^{-1} at a distance of 71-85 km from sea shore to inside. Mg content in river bank and sea beach soils showed an irregular but increasing trend from sea shore to inside. Mg content was 37.7 mgkg^{-1} in 0-10 km from sea shore. Mg content was 61.3 mgkg^{-1} at a distance of 71-85 km from sea shore to inside. An increasing trend was found in Mg content in the river and sea water from

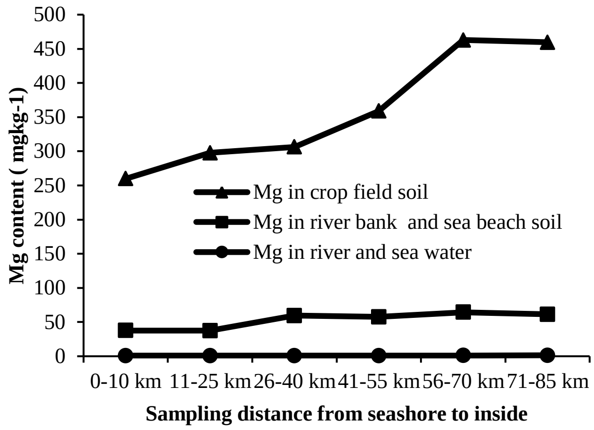

Figure 5. Magnesium content in crop field soil, river bank and sea beach soil and river and sea water from sea shore to inside

sea shore to inside mostly. Mg content was 0.8263 mgkg^{-1} in 0-10 km from sea shore. Mg content was 1.357 mgkg^{-1} at a distance of 71-85 km. Mg content was observed in the range from 37.4 mgkg^{-1} to 462.8 mgkg^{-1} in the soil samples and 0.8263 mgkg^{-1} to 1.357 mgkg^{-1} in the water samples. Jokela *et al.* (2004) showed that optimum Mg level in soil should be 51-100 ppm for agriculture. Carrie *et al.* (2012) showed that optimum Mg level in soil for crop production should be 51-250 ppm for sandy soil and 101-500 ppm for loamy soil. The present research showed availability of Mg in soils for agriculture in the study areas. But no relevant data was found on Mg content for water in tidal areas. As a general view, fresh water irrigation for agriculture in the study areas might be recommended. The most uncertain cause of nutrient fluctuation is weathering. Weathering is a source of dissolved inorganic Ca, Mg, K, P, S, organic C etc. Key factors that control chemical weathering processes in the field are lithology, runoff, temperature, physical erosion, morphology, soil, ecosystems, land use as well as tectonic activity (Hartmann and Moosdorf, 2011). These are the major causes behind the macronutrient content variations in soil from sea shore to inside. Macronutrient contents in river and sea water and tube well water might have variations due to surface-subsurface exchange processes, nutrient cycling and biodiversity in rivers (Malard *et al.*, 2002). As a general discussion, it could be concluded from the findings of this research that the soil quality was assessed to be suitable for crop production and agriculture on the basis of availability of most of the macronutrient contents except Ca. Appropriate soil management practices would be helpful to mitigate the nutrient problems in soil. But the water quality assessment showed random variations on the basis of their nutrient availability and suitability for irrigation purpose. Fresh water irrigation rather than river or sea water use in irrigation might be suitable for agriculture in the study areas.

Conclusion

Soil macronutrients were observed to increase mostly in amount as we moved inside from sea shore to inside over the study area. An increasing trend was visible in case of soil P, K, S and Mg, except Ca content from sea shore to inside. In sea and river waters, P, S and Mg content were found to increase from sea shore to inside respectively. K and Ca content in sea and river water decreased gradually as we moved inside from sea. Please try to add recommended fertilizers/nutrient source for specific macronutrient deficiencies before general agricultural practices. It may be concluded from the present research that the soil quality in the study areas was suitable for agriculture based on macronutrients, while the water quality was observed to show some irregularities. These variations might have been found due to tide, evaporation, leaching, dehydration, flooding, soil reactions and variations in fertilizer applications, seasons, locations, climate and geography, sedimentation and many other factors. Considering these factors and the macronutrient status found in the study areas, fertilizer recommendations and agricultural practices along with improvement of cropping pattern and crop rotation might be recommended. Rain water conservation in reservoir, deep irrigation and fresh water irrigations might be recommended for irrigation purpose near sea shore areas.

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