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Micromineral status of soil, salt-tolerant plants and goats in tidal estuarine ecosystem of Indian Sundarban

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The Sundarban delta is the largest mangrove swamp in the world. The Sundarban biosphere is unique for its flora and fauna and geographically intersected by a complex network of tidal waterways, mudflats and small islands of salt-tolerant mangroves and halophytes. Zones of tidal inundation influence on soil characteristics and mangrove vegetation pattern that is central to estuarine ecosystem. Millions of people in this ecosystem depend on rearing of small livestock like goats and sheep for their livelihood and subsistence as agricultural activity is in bottleneck due to high soil salinity. As quality feed and fodder resources are scanty in tidal coastal area, local Black Bengal goats are traditionally adapted on feeding of mangrove leaves and halophytes. Production performance of goats might be influenced by feeding of substantial amount of mangrove leaves and halophytes (Al-Shorepy *et al*. 2010). Micro-minerals are one of the critical factors for maintaining optimum production in small ruminants (McDowell 1997). Although, some studies on micro-mineral status on soil-fodder-animal system had been conducted in various ecosystems (Das *et al*. 2009, Bhausaheb *et al*. 2014), no such work has been carried out in tidal estuarine ecosystem of Sundarban delta. Conception of micromineral status in soil-mangrove -animal system in tidal estuarine ecosystem might improve the animal production system in that area. Objective of present study was to reveal micronutrient status of soil, mangrove and halophytic plants as well as of native Black Bengal goat in tidal coast area of Sundarban and to explore possible inter relations between plant and animal components.

The study was conducted from a single site (GPS coordinates: 21.7757865, 88.3753665) of Patharpratima block of Sundarban, West Bengal, India. Soil samples (20) were collected randomly from the tidal coast with the help of augur up to 15 cm depth. The soil samples thus collected were air dried and then grinded and stored in airtight polythene packet for laboratory analysis. Soil pH was determined using a digital pH meter. Electrical conductance (EC_e) of the soils was determined using a digital EC meter. Easily oxidizable organic carbon of the soils was determined as per Walkley and Black (1934). Leaf samples (10) for each plant species were taken to laboratory in acid washed polythene packets and then washed thoroughly by demineralized water. Then samples were dried in a hot air oven at 100°±5°C overnight and were ground and stored in an airtight polythene packet for analysis. Blood samples (20) were collected from local goats that graze and browse on mangrove and halophyte leaves. Aspirated blood samples (3 ml) were centrifuged at 5000 rpm for 5 min. Plasma samples thus produced were transferred to small micro-centrifuge tube and later stored at -80°C for further analysis. Soil and plant samples were digested with tri acid mixture (HNO_3, H_2SO_4, and $HClO_4$ in 5:1:1 ratio) as per Allen *et al*. (1986). Plasma samples were digested as per Kolmer *et al.* (1951). Concentrations of Fe, Cu, Zn and Mn in the filtrate of digested soil, plants and plasma samples were estimated by using an atomic absorption spectrophotometer (Analyst 200, Perkin Elmer, USA). The instrument was fitted with specific lamp of particular metal. Data of soil, plant and plasma samples were statistically analysed as per the method described by Snedecor and Cochran (1994) for mean and standard error. Plant sample data were partitioned by one way ANOVA using SPSS v.16.0. Mean comparisons were made by Duncan's Multiple Range Tests (Duncan 1955). Pearson correlation coefficients were calculated for determination of relationship between plant sample and plasma sample using Microsoft Excel program.

Soil in tidal coast was extremely saline (4.91), due to inundation of various salts from tidal waves, and the condition is only suitable for survival of mangroves and halophytes (Table 1). pH of tidal coast was highly alkaline

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Table 1. Summary of sample collection site with chemical parameters of soil

	Site I (Estuarine Tidal Coast)
Distance from tidal coast (m)	50 m
Tides	Regular diurnal tides
Soil salinity (Electrical Conductivity, mS/cm)	4.91±0.38
Soil pH	8.58±0.09
Soil organic carbon (%)	0.88±0.07
Main plant types used as feed for local goats	Mangrove tree leaves, halophytes and grass
Number of blood samples taken from local goats	20

(8.58), and contained high organic matter, which may be resulted from the cyclical deposition of organically enriched sedimentation, particularly marine aquatic planktons and plant residues. Tidal estuarine soil can accumulate high level of heavy metals and many factors like pH, salinity, redox conditions might affect the metal accumulation process in saline tidal zone. Present study showed higher than critical level values in Fe, Cu, Zn and Mn content of tidal soil (Table 2). Mn concentration in studied soil was maximum 24 times higher than critical level) and may represent a negative factor for the plants.

Significant ($P<0.05$) variation was recorded in Fe concentrations in leaf samples of mangroves and halophytes (Table 3). It was lowest (462.30 ppm) in *Derris trifoliate* and highest (3013 ppm) in *Saudea maritima*. This Fe concentration was manifold higher than the suggested level of 40 ppm (Underwood 1981). Level of Cu varied from 22.53 ppm to 67.67 ppm, whereas Zn varied from 65.33 ppm to 99.58 ppm. However, no significant ($P<0.05$) difference was observed in Cu and Zn concentration in mangrove leaves and halophytes. Results were in accordance with Chakroborty *et al*. (2013). It was also observed that Cu and Zn concentration in plants in tidal coastal area was higher than the suggested levels of 10 ppm and 40 ppm respectively (Underwood 1981). Mn concentration in all mangrove and halophytes was far more than the suggested level of 20 ppm (Underwood 1981), particularly, *Sonneratia apetala* leaves showed significantly high ($P<0.05$) concentration of Mn (934.95 ppm) among all the recorded plants. Significant correlation between soil and leaf micronutrients was earlier reported by Madi *et al*. (2015). Therefore higher levels of micronutrients in leaf samples might be attributed to higher micro-nutrient concentration in soil.

Fe and Cu concentration of goats were recorded as 0.67 ppm and 0.39 ppm that is far lower than critical level of 1 ppm and 0.65 ppm respectively (Table 4) (Mc Dowell 1997). This paradoxical result may be due to presence of plant alkaloids like tanins in various mangrove leaves (Ghosh *et al*. 2015) in coastal area. Tanins are well known inhibitor of Fe absorption. This might be a contributing factor for low level of Fe in plasma despite high concentration of Fe in plant feed materials. Fe concentration is also affected by Cu concentration itself because of feroxidase activity of ceruloplasmin. High level of Mn antagonises Fe concentration in animals (Kaneko *et al*. 2008). In this context leaves of *Sonneratia apetala* with high level of Mn in its leaves may also interfere Fe absorption in goats. Reduced level of plasma Fe may manifested as anaemia. Earlier report (Das 2015) on adaptive physiology of Black Bengal goats inhabited in Sundarban area pointed out lower than normal haemoglobin content. Zn is one of the critical

Table 2. Micronutrient concentration (ppm) of soil at tidal coast

Element	Concentration (ppm)	Normal range * (ppm)
Fe	28.13±0.74	4.5
Cu	6.69±0.60	0.2
Zn	1.36±0.18	0.6
Mn	24.05±0.69	1

*Department of Agriculture, Government of West Bengal (2005)

Table 4. Micronutrient concentration (ppm) of blood plasma

Element	Concentration (ppm)	Critical value *(ppm)
Fe	0.67±0.07	1
Cu	0.39±0.13	0.65
Zn	0.53±0.09	0.6
Mn	0.1±0.02	0.2

*Mc Dowell (1997)

Table 3. Micronutrient concentration (ppm) in mangrove and halophyte leaves

Plant species	Local name	Element			
		Fe	Cu	Zn	Mn
Mangroves					
Sonneratia apetala	*Keora*	573.88±76.96^{b}	25.88±7.81^{a}	72.95±9.99^{a}	934.95±194.34^{a}
Avicennia marina	*Bani*	544.83±164.09^{b}	35.00±0.58^{a}	65.33±5.89^{a}	260.33±78.71^{b}
Bruguiera gymnorrhiza	*Kankra*	649.83±233.65^{b}	35.83±4.91^{a}	58.00±7.97^{a}	259.33±18.63^{b}
Halophytes					
Aeluropus lagopoides	*Nona Doorba*	1836.50±158.66^{ab}	67.67±33.92^{a}	90.00±22.42^{a}	193.83±17.14^{b}
Derris trifoliate	*Kele Lata*	462.30±54.20^{b}	22.53±7.47^{a}	99.58±18.92^{a}	168.93±120.57^{b}
Saudea maritima	*Giri Shaak*	3013.00±942.99^{a}	41.33±3.49^{a}	82.17±9.45^{a}	197.50±42.88^{b}

Means bearing at least one common superscript in each column do not differ significantly ($P<0.05$).

factor for optimum reproductive performance and immunity and its level in present study (0.53 ppm) was moderately close to the critical value (0.6 ppm) suggested by Mc Dowell (1997). Mn acts as the prosthetic group of various metalloenzymes required for normal metabolism. It is also critical for steroid biosynthesis and reproduction. Present study indicated low levels of Mn in goat plasma (0.1ppm) which is below critical level (0.2 ppm). Biswas and Samanta (2002) reported 0.27 ppm Mn level in goat plasma in old alluvial zones of West Bengal. Relative abundance of micro-minerals in blood plasma of goat was in the order of Fe >Zn >Cu >Mn and in agreement with Biswas and Samanta (2002).

Fe and Cu levels in plants and animals were moderately correlated (r, 0.724; P>0.05 and r, 0.568; P>0.05) whereas negative correlations were observed in Zn and Mn (r, 0.076; P>0.05 and r, -0.42; P>0.05). These plant-plasma relationships corroborated with Shukla *et al*. (2010).

SUMMARY

It could be concluded that tidal coastal zones contain high level of micro-minerals in soil and plants. Paradoxically, local goats inhabiting in this particular ecosystem are deficient in Fe, Cu and Mn. This might be an adaptive response of animals in that area. Tanins are well-known inhibitor of Fe absorption from intestine. Regular consumption of tanins and other plant alkaloids during grazing and browsing might also be responsible for low bio-availability of the minerals in the plasma. Further research is warranted to have more insight on mineral status of small ruminants in fascinating ecosystem of Sundarbans.

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