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EFFECT OF LONG TERM BRACKISH WATER SUBMERGENCE OF AGRICULTURAL LAND IN SHRIMP CULTIVATION

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Abstract: A long term (1990-2000) soil and water salinity monitoring programme was undertaken to address the salinization problem in paddy cum brackish water shrimp cultivation area . The information generated during this period has been presented in this paper. In monsoon season, particularly from August to October soil salinity had increased from 1.4 dS/m to 10.3 dS/m. In between November and February depth of ground water table remained within 0.12 m to 0.33 m and rest of the year it remained at or close to the surface. So, due to presence of ground water table at shallow depth and slower permeability downward movement of soluble salts from the top is very limited. Under Pashur river system average submerged water salinity was found to be 13.8 dS/m to 17.5 dS/m in between March and-May. In Shibsha river system it was found to be 13.2 dS/m to 24.2 dS/m in between February and June. More soluble salts have been accumulated in the topsoil over long period brackish water shrimp cultivation. Increasing tendency of soil pH from 7.5 to 8.2 may be due to high amount of cations like Ca, Mg, and K. High amount of S may be one of the possible reasons for P deficiency in brackish water submerged condition. Soils are rich in B, Cu, Fe except Zn. Late transplantation, without or very little fertilization, without insecticides, use of aged seedlings, wider spacing, relatively high flooding at the time of *aman* transplantation, minimum tillage and little opportunity of flushing and leaching of fresh water are the common constraints of paddy cultivation in paddy cum brackish water shrimp cultivation area.

Key words: Brackish water; Shrimp cultivation; Soil salinity; Flushing; Leaching; Submerged soil

Introduction

An area covering around 2.86 million hectares that is over 30% of the net cultivable area of the country constitutes coastal and offshore lands of Bangladesh. Out of these 2.86 million hectares, about 0.833 million hectares are affected by different degrees of soil salinity in certain parts of the year (Karim *et al.*, 1990). About 53% of the coastal area is affected by salinity. Agricultural landuse in these areas are poor (Haque, 1990). The present landuse in the coastal areas of Bangladesh consists mainly of growing one wet season rice, brackish water shrimp and occasionally in some places sesame and rabi crops. About 2 decades ago paddy cum brackish water shrimp cultivation practice was introduced in high saline areas of Bangladesh. Landsat MSS and TM and SPOT imagery in February, 1975 showed that there was only about 1,360 hectares of land was occupied by shrimp cultivation. In greater Khulna district about 31,200 hectares of land was covered under the shrimp cultivation in 1982-83 and about 98,850 hectares during 1993-94 (Shahid *et al.*, 1998). Over 12 years brackish water shrimp cultivation has been increased about 215% (Ministry of Fishery and Livestock, 1995). A large scale prolonged submergence of arable lands with brackish water is responsible for changes in soil properties due to the developments of reduction reaction under brackish environment. Enormous changes are also like to occur in respect of soil microbial population, soil fertility, soil salinity and hydrology of the region due to such extensive brackish water submergence. The emission of various types of gaseous products, viz. CH_4, CO_2, H_2S etc. from large areas under prolonged brackish water submergence may have an adverse influence on coastal ecology and in turn, on livelihood pattern of the coastal farmers (Bandhyopaddya, 1998).

Modern technology of this sector could not be disseminated to the field level. In our country production of shrimp per hectare under traditional management is still well below the international standard. The objectives of this study were to know a) the effect of paddy cum brackish water shrimp cultivation on soil salinity b) the constraints of cultivation in this area c) the cultural practices of transplanted *aman* under paddy cum shrimp cultivated land and d) the present salt characteristics and chemical properties of the soil.

Materials and methods

Description of the Study Area:

The study area lies between 22° 11' and 22° 46' N latitude and 89° 41' and 89° 50' E longitude. This area is bounded by Jessore and Narail districts in the north; Baleswar-Haringhata river in the east; Sundarbans in the south and India in the west. In this paper special emphasis has been given to the brackish water shrimp

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cultivation area only. The area is submerged by saline river water for at least 7-8 months in a year.

Working procedure:

Two sites have been selected under the Pashur and Shibsha river system. One site has been selected in Mongla Upazila under Bagerhat district, and another in Paikgachha Upazila under Khulna district. The identified soil series are Dumria and Barisal respectively and landtype is medium highland. To determine the soil and water salinity, soil samples were collected by auger from 0-15cm, 15-30cm and 30-60cm depths, ground water samples from auger holes and surface at 15 days intervals from January to June and once in a month from July to December. To determine the EC_e of the collected soil samples 100 gm dry pulverized soil was taken and then 100 cc distilled water was added to make 1:1 soil-water solution. After shaking half an hour filtrate was collected in a test tube using ordinary filter paper. Finally electric conductivity was measured by Beta 21 and Eijkelkamp pH/EC 18.38 meters. To convert EC_1 value to EC_e value the following conversion factor was used.

$Y = X * 1.267+1.269$
where, Y = ECe value
X = EC meter reading

Water salinity (EC_w) was directly determined by EC meter (Islam *et. al.*,1993). To determine soluble salts and chemical properties soil samples were collected in April. Chemical analysis of soil samples were done in central laboratory, Dhaka and regional laboratory, SRDI, Khulna. N was determined by Kjeldal; P by revised Olsen; K, Ca, Mg by ammonium acetate; S and B by calcium biphosphate extraction; Zn, Cu, Fe and Mn by DTPA extraction and organic matter by dry combustion methods respectively. Soluble salts are determined following US salinity laboratory manual.

Results and Discussions

Soil and land characteristics:

In the study area the dominant soil series was identified as Dumuria and Barisal (Typic Endoaquepts). This soil is developed on Ganges tidal floodplain. It is deep to very deep, with texture grading from siltyclay to clay within the profile. The surface and subsurface horizon (A & B)) has grey (5 Y 5/1 M) to dark grey (2.5 Y 4/1 M) colour which grades to also dark grey (N4 M) in the substratum (Table-1). The various shades of mottles was observed ranging from yellowish brown to dark yellowish brown. Structurally they grade from massive in the surface and weak to moderate, very coarse to coarse, prismatic in the subsurface horizons. Structure in the substratum is massive. Consistencies of these soils are sticky and plastic wet in surface and subsurface horizon but in the substratum it is very sticky and very plastic wet. Most of the land under paddy cum shrimp cultivation area belongs to medium highland to medium lowland and drainage condition is poor. Normally after mid December submerged water recedes from the land. It is considered as late draining. Late draining is one of the major constraints for dryland crops in coastal saline areas of Bangladesh.

Table-1: Soil and land characteristics under paddy cum shrimp cultivation area.

Soil series	Soil characteristics					Land characteristics		
	Horizon	Colour	Texture	Struct-ure	Consis-tence	Land type	Drainage	Water removal from the surface
Barisal	A	2.5Y 4/1 Grey- Dark grey	Silty clay	Massive	Sticky & Plastic	Medium highland	Poor	Late
	B	2.5Y 4/1 Grey- Dark grey	Silty clay	1-2Vc Prismatic	Sticky & Plastic			
	C	N4 Dark grey	Silty clay	Massive	V.Sticky & v. Plastic			

Soil slinity (dS/m)

In long term monitoring activities it was observed that only two years i.e. in 1990 and 1991 the topsoil remained non saline in monsoon season. But after 1991 it remained saline throughout the year and salinity intensity has gradually increased with time. Maximum topsoil salinity EC_e 12.3 dS/m was observed in May, 1999. In monsoon season topsoil salinity had increased from 1.5 dS/m to 10.3 dS/m in August, 1.4 dS/m to

8.5 dS/m in September and 1.4 dS/m to 9.8 dS/m in October during last eleven years (Table 2). Maximum soil salinity was recorded in April and May. Due to high water salinity of Shibsha river soil salinity in western site was found to be higher than that of eastern site. Table -2 indicates that soil in western site possessed about 57% more salinity than that of eastern site. In both the sites topsoil salinity had gradually increased with time. Maximum topsoil salinity ECe 15.2 dS/m was found in May, 1999.

Table 2. Topsoil salinity (dS/m) under paddy cum shrimp cultivation areas (1990-2000), Mongla, Baherhat.

Year	Months											
	J	F	M	A	M	J	J	A	S	O	N	D
1990	-	-	-	8.2	6.1	7.8	6.5	1.5	1.4	1.4	2.0	5.7
1991	5.8	7.3	8.1	7.3	10.7	8.1	5.4	2.2	1.6	1.7	1.8	3.2
1992	3.1	5.0	6.0	6.8	7.9	7.0	6.2	4.1	4.5	4.0	4.2	4.7
1993	5.3	9.1	6.5	6.9	7.5	6.6	5.6	4.2	5.3	4.4	4.4	4.2
1994	5.7	6.6	7.4	11.0	7.0	7.1	5.7	5.7	4.1	4.0	3.8	4.7
1995	5.8	7.8	6.4	8.2	8.9	7.3	6.1	6.0	5.1	4.9	4.9	5.7
1996	10.7	9.0	-	8.0	9.2	7.2	8.0	6.2	6.9	4.8	-	5.7
1997	-	10.2	7.4	6.1	10.0	6.6	-	5.5	8.5	7.8	6.1	7.9
1998	7.2	6.1	12.2	9.0	9.9	7.9	-	-	-	-	-	-
1999	-	-	-	9.6	12.3	7.1	-	7.3	7.8	8.0	6.1	4.9
2000	6.8	6.5	8.6	-	9.1	5.6	6.3	5.2	7.3	5.7	6.1	7.4

Source: SRDI, 2000.

Table-3 also indicates that from late monsoon season topsoil salinity had gradually increasd from 4.1 to 11.4 dS/m in September, 4.2 to 8.5 dS/m in November and 6.1 to 9.1 dS/m in December during last six years. Any kind of moisture stress in flowering of transplanted *aman* may cause severe yield reduction due to salinity.

Table 3. Topsoil salinity (dS/m) under paddy cum shrimp cultivation areas (1995-2000), Paikgachha, Khulna.

Year	Months											
	J	F	M	A	M	J	J	A	S	O	N	D
1995	-	8.5	8.2	9.4	12.0	8.7	7.8	8.9	4.1	4.2	9.5	6.3
1996	4.6	8.2	-	8.3	107	9.7	7.4	3.8	4.6	7.8	10.3	6.5
1997	11.7	11.9	8.0	-	10.8	9.7	9.1	7.9	11.4	7.7	10.3	8.1
1998	9.6	-	13.4	7.9	14.1	11.3	-	-	-	-	-	-
1999	-	-	-	-	15.2	14.2	8.4	8.4	8.6	8.5	8.0	9.1
2000	10.3	11.8	8.7	11.5	13.3	12.0	9.6	6.5	5.8	4.9	4.3	2.0

Source: SRDI, 2000.

It was also observed that the whole profile under shrimp cultivation became saline throughout the year and the soil salinity intensity remained almost similar from topsoil to substratum. On the other hand the land having fallow-transplanted *aman* cropping pattern possessed highest salinity at the topsoil only and then it gradually decreased with depth. From the experiment it is evinced that use of high saline water during brackish water aquaculture resulted salinization of the soils. Salinization is the seasonal accumulation of soluble salts in the soil profile by natural process. In an experiment it was found that use of highly saline water (ECw 7.0-41.1dS/m) during brackish water aquaculture resulted maximum amount of soil salinity ECe 24.1dS/m (Chattapadhyay *et.al.*,1987).In another short term experiment it was found that in brackish water aquaculture the ECe of the soil and water increased with time (Mehta *et al.*,1994).

But on the other hand, experiment conducted in high saline water zone it was found that due to introduction of brackish water (ECw 22.5 to 34.2 dS/m) in summer the soil salinity at the experimental land increased from 14.0 to 24.8 dS/m. With the onset of monsoon the soil salinity decreased to 3.5 dS/m -7.5 dS/m, which then thereafter remained at the same level for rest of the season. Thus no trend of salt accumulation was observed in the rest of the time in this study (Biswas *et al.*, 1991).

A comparative figure regarding salt accumulation in topsoil under brackish water shrimp cultivation environment over 11 years is shown in Figure-1. It indicates that about 1.3 to 5.4 times more soluble salts has been accumulated over 11 years. The accumulation of some of the products of reduction reaction in soil, particularly the metallic sulphides, are harmful for soil health from the point of views of both crop production and fish culture (Bandhyopaddya, 1998).

Surface water salinity (dS/m):

In general for shrimp cultivation saline water is pushed in the agricultural land from nearby creeks/canals during high tides in February/March and it continues up to April-May. Fig. 3 indicate that average surface water salinity was found at 13.8 dS/m in February, 17.6 dS/m in March and 17.4 dS/m in April. Pashur and its adjacent channels were the sources of brackish water for shrimp cultivation. After April, water salinity had started to decline with sufficient amount of precipitation. Minimum salinity 1.4 dS/m was recorded in August. According to meteorological station, Khulna average total rainfall between August to October was about 664 mm.

Figure-1. Accumulation of soluble salts in topsoil over 11 years.

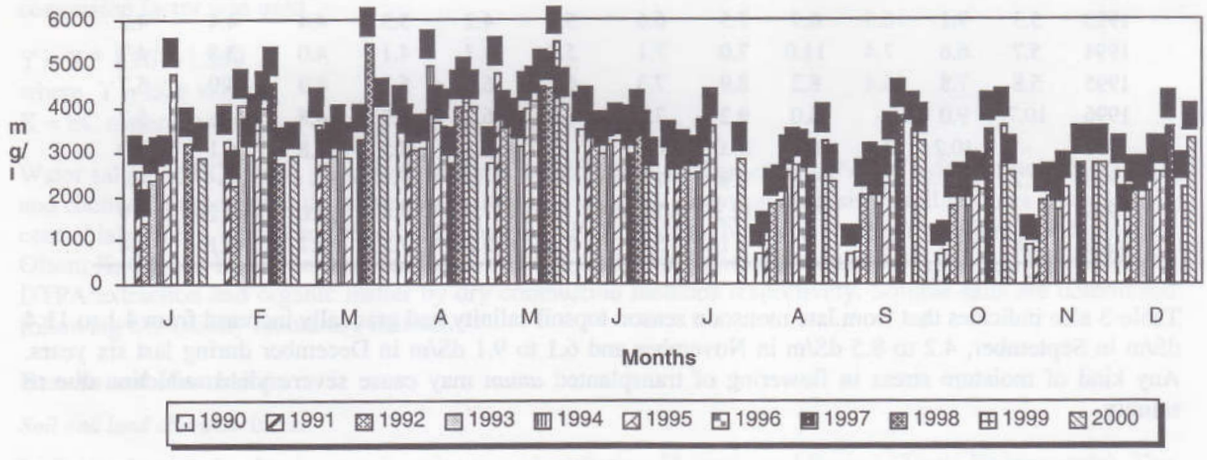

Figure -2 indicate that the average surface water salinity of western side was higher that of eastern side. In western side water salinity was found at 13.2 dS/m in February, 12.4 dS/m in March, 15.8 dS/m in April, 24.2 dS/m in May and 23.8 dS/m in June. Duration of brackish submergence was two months more than that of eastern side. After June, surface water salinity had also started to decline with the onset of sufficient precipitation. Minimum surface water salinity was found to be 2.4 dS/m in September.

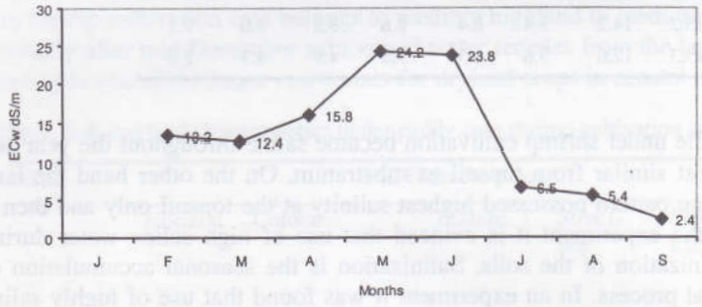

Fig. 2. Average surface water salinity in shrimp cultivation (1995-2000),, Paikgacha, Khulna.

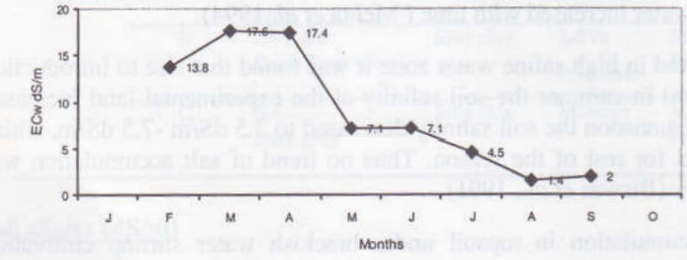

Fig. 3. Av. surface water salinity in shrimp cultivation (1990-2000), Mongla, Bagerhat.

Ground water table and its salinity (dS/m):

From November to January/February, only 3-4 months, ground water salinity could be measured and its average salinity ranged from 5.2 ds/m to 9.6 dS/m in both the sides. In these period depth of ground water table remained within 0.12 m to 0.33 m. During rest of the year it remained at the surface. In this condition due to the presence of ground water table at very shallow depth and slow permeability possibility of soluble salts movement from the top to downward was very limited.

Cultural practices of transplanted *aman*:

Within late August to early September most of the paddy cum brackish water shrimp cultivation area, land become free for paddy cultivation. Within a minimum time farmers has to manage their lands for transplantation with minimum tillage. At the time of transplantation, the depth of standing water remained at about 30 to 60 cm with respect to elevation of the land. Average age of seedling is 45 to 55 days (SRDI, 2000). Farmers do not apply any fertilizer or insecticides. The identified local varieties are Ranisalot, Katchra, Jamainuru, Marichshail etc. and common HYV variety is BR 23.

Constraints of paddy cultivation:

In fact most of the shrimp growers are outsider and rich people. They hire the land for a certain period, specifically for shrimp cultivation. They are very much concerned about lateral expansion of shrimp culture area without considering the soil, land and water quality suitable for shrimp cultivation rather than vertical expansion. After harvesting shrimp they occupied the land until the last harvest of brackish water fish other than shrimp cultivation. So, farmers are bound to transplant the paddy within high water depth at the surface. Late transplantation, without or very little fertilizer application, without insecticides, aged seedlings, wider spacing, relatively high water depth at the time of transplantation, minimum tillage and little opportunity of flushing the land with fresh water are the common constraints of paddy cultivation in paddy cum brackish water shrimp cultivation area. As a result they get poor yield. It was evident that after harvesting of the brackish water aquaculture high rate of monsoon precipitation was utilized for lowering down the acquired soil salinity through frequent runoff and leaching (Chattopadhyay *et. al,* 1987).After harvesting shrimp, flushing and leaching the land with fresh water will play an important role for lowering down the soil salinity. In our country due to several unavoidable circumstances farmers do not get any opportunity to flush their lands by rain or canal/river water for leaching the soluble salts after harvesting shrimp.

Nutrient status:

A slightly higher pH was observed over three years, may be due to the deposition of high significant amount of cations like Ca, Mg and K. Organic matter status remained almost similar. In submerged soil the decomposition of organic matter was much slower and almost entirely done by the facultative and obligate anaerobes. Nitrogen content also remained almost similar over three years. Addition of high amount of sulpher, Boron and Iron was observed (Table 4).

One of the most striking difference between fresh water submerged soils and brackish water submergence is probably the SO_4^{2-} reduction (Patrick and Reddy, 1978). Submergence brings about a variety of electrical changes in soil. But submergence with brackish water adds further to the nature of such changes as a) it contains excess of cations and anions b) it has very high specific conductance and c) it contains high amount of sulphate salts unlike the fresh water flooding (Patrick and Reddy, 1978). In this soil P was found deficient. Exchangeable and non exchangeable phosphate in soil may be replaced by SO_4^{2-} and Cl^- ions, which were dominant in brackish water and may be lost from the soil making it deficient in P. On the other hand decreasing trend was observed in case of Copper, Manganese and Zinc. Except Zn these soils are rich in micronutrients (Table-4).

Table 4. Nutrient status of submerged soil under paddy cum brackish water shrimp cultivation area, 1998 and 2000 (eastern side).

Year	pH	OM%	Ca	Mg	K	N %	P	S	B	Cu	Fe	Mn	Zn
			meq/100mL				microgram/gm of soil						
1998	7.5	3.3	13.0	10.8	1.23	0.18	14.9	255	0.83	10.1	126	47.9	1.46
1999	8.2	2.4	21.3	16.3	1.94	0.13	4.87	302	1.10	6.6	158	44.7	0.41
2000	8.1	3.5	27.1	12.3	1.45	0.15	3.53	514	1.91	7.6	364	43.7	0.63

Source: SRDI, 2000

Conclusion

Results and discussion revealed that large scale submergence of coastal soils with brackish water has influence on the properties of the soil. It is felt that research on different soil properties under this condition should be intensified to generate sufficient data base for developing management practices in future.

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