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Brackishwater Aquaculture in Acid Sulfate Soils of Sri Lanka

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Abstract - New and 4-year-old (maintained) ponds in acid sulfate soils of coastal swamps in Sri Lanka were compared. Production of shrimp *(Penaeus indicus)* and fish *(Etroplus suratensis* and *Chanos chanos)* was lower in the new ponds than in the old ponds by a factor of 10. The pH of the water averaged 4.2 in new ponds, 6.1 in old ponds. Acetate soluble sulfates were high: 4,510 and 3,142 $mg \cdot kg^{-1}$ in new and old ponds, respectively.

The total extent of lagoons and estuaries of Sri Lanka has been estimated to be 121,300 ha. Adjoining these estuaries and lagoons are extensive areas of low lying delta lands estimated at 70,000 ha (Wickramasoriya 1969) which are potential areas for brackishwater aquaculture. However, the soil characteristics in some of these low lying delta lands are acid sulfate in nature and several aquaculture projects in these areas have ended in failure. Sudden mortalities during rainy periods, slow growth of cultured organisms and poor fertilizer response have been identified by Singh (1980) as the major problems in aquaculture practices on similar soils. The toxic effects of soluble iron, aluminum and manganese also act adversely on growth and survival of cultured organisms. Although vast areas of acid sulfate soil are found in many Southeast Asian countries, little work has been carried out to understand the chemistry of such soils and to utilize these resources judiciously except for a few studies in the Philippines (Singh 1980) and Malaysia (Sivalingam et al. 1983).

This present work studies some chemical properties of acid sulfate soils in Muthurajawela, the largest coastal swamp in the west coast of Sri Lanka covering 2,500 ha, and evaluates the possibility of utilizing these for culture of fish and shrimps.

A series of ponds, 0.03 ha each, constructed bordering the upper reaches of the Negombo lagoon in the southwest coast of Sri Lanka was used. Six newly constructed ponds (treatment I) and six four-year-old ponds, flushed and drained several times for four years with protectional vegetation cover on bunds (treatment II), were stocked with *Penaeus indicus*, *Etroplus suratensis* and *Chanos chanos* at 30,000, 6,000 and 6,000·ha^{-1}, respectively in duplicate under each treatment. The average sizes at stocking were 0.85 g (5.8 cm) for *P. indicus*; 1.1 g (3.5 cm) for *E. suratensis* and 2.1 g (6.4 cm) for *C. chanos*. Fertilization was done after liming (1,000 kg·ha^{-1}) using 100 kg of triple superphosphate (T.S.P.) (40%)·ha^{-1} initially. Subsequent dosages of 10 kg·ha^{-1} urea and 5 kg·ha^{-1} T.S.P. were added every 15 days. Fish and shrimps in treatment I were collected when the first sign of mortalities were observed during rainy periods, while in treatment II harvesting was done after 71-91 days (Table 1). The following environmental parameters were monitored weekly at the surface between 0800 and 1000 hours: salinity (by refractometer); dissolved oxygen (by Chemistrix type 300 DO meter); pH (by Chemistrix type 40 pH meter); and temperature. Soil samples were analyzed for pH - H_2O and pH - KCl (FAO 1980), organic matter (Walkely and Black method), acetate soluble sulfate and available iron (FAO 1980).

Table 1. Harvest data from the two types of ponds.

Species	Treatment	Days of culture	Survival (%)	Total production (kg·ha^{-1})
P. indicus	I	48	24	18.1
	II	70	43	175.4
E. suratensis	I	62	46	27.8
	II	91	64	280.0
C. chanos	I	48	37	42.3
	II	91	58	591.5

Table 2 gives the variation of mean values of some soil chemical properties with pond age in treatments I and II. Soil pH (KCl and H_2O) values were considerably higher in older ponds than the

Table 2. Main values of some chemical properties of bottom sediments in the two types of ponds.

Pond age	pH		Organic matter (%)	Chemical properties	
	KCl	H_2O		Acetate soluble sulfate ($mg \cdot kg^{-1}$)	Available iron ($mg \cdot kg^{-1}$)
Newly constructed (treatment I)	4.0	4.2	6.8	4,510.1	1,302.4
4 years (treatment II)	5.7	6.1	9.9	3,141.9	1,391.2

newer ones. The organic matter contents of newly constructed ponds were lower (6.8%) than in the older ponds (9.9%). Relatively higher acetate soluble sulfate content and lower available iron were recorded in newly constructed ponds. Fluctuations in water quality are presented in Table 3. Salinity in both treatments varied widely during the culture period. The ponds became less saline during the intermonsoonal months of May and June. Dissolved oxygen levels ranged from 2.2 to 6.7 ppm and there was not much difference in the values between the two types of ponds. The pH dropped rapidly with the onset of rains after prolonged dry spells and remained more acidic throughout the rainy period.

Table 3. Characteristics of water quality in the two types of ponds.

Pond age	Salinity (%)	DO (ppm)	pH	Surface temperature (°C)
Newly constructed	3-19	2.2-6.4	3.2-6.8	24.0-29.2
4 years old	3-21	2.7-6.7	4.9-7.4	24.0-29.2

The differences in chemical conditions of the two types of ponds were also reflected in the survival and total production values of the cultured species. Survival rates of fish and shrimp species in newly constructed ponds were significantly lower than those in older ponds. Total production values for each species (175 $kg \cdot ha^{-1}$, 280 $kg \cdot ha^{-1}$ and 591 $kg \cdot ha^{-1}$, respectively) were also higher in seasoned

ponds than in newly constructed ponds (18 kg·ha^{-1}, 27 kg·ha^{-1}, 42 kg·ha^{-1}). However, even the production recorded in older ponds was lower than the production values for culture trials recorded by Jayasinghe (1985) under favorable soil conditions in the lower reaches of the same lagoon. The production of *C. chanos* was relatively higher than those of other species in all treatments.

The soil analysis indicates the presence of highly acidic soil conditions in the bottom sediments of the fishponds. Soil pH tends to increase with increasing pond age. High acidity of the surface soil (Table 4) also suggests the possibility of decrease in pH in the pond environment during rainy periods with the erosion of pond dikes or by the drainage of rain water into the ponds. The analysis also reveals high concentrations of acetate soluble sulfates (567-5,270 mg·kg^{-1}). Similar values have been recorded for fishponds constructed in acid sulfate soils in the Philippines (Singh 1980). Sulfates contribute towards the formation of acidity in soils. Sulfate concentrations in bottom sediments decreased with pond age with average values of 4,510 mg·kg^{-1} in newly constructed and 3,141 mg·kg^{-1} in the 4-year old ponds.

Available iron concentrations were also high in the present study. The values ranged from 1,302 to 1,391 mg·kg^{-1} in pond bottom sediments. High iron concentrations together with high sulfate concentrations indicate the possibility of forming pyrites as proposed by van Breemen and Pons (1978). The recorded values are higher

Table 4. Variations of some chemical properties of soil at different depths along the dikes of a newly constructed pond.

Depth (cm)	pH		Organic matter (%)	Chemical properties	
	KCl	H_2O		Acetate soluble sulfate (mg·kg^{-1})	Available iron (mg·kg^{-1})
0-30	3.55	3.93	9.86	567.5	1,465.2
30-60	2.30	3.35	8.85	1,510.1	1,287.6
60-90	2.74	3.00	9.10	5,270.2	1,687.2
90-120	4.30	4.61	11.26	4,560.8	680.8
120-150	4.20	4.41	11.03	4,915.5	1,278.7

than those recorded for acid sulfate soils in Leganes, Iloilo, Philippines, by Singh (1980). The organic matter content in the bottom sediment of the old ponds was relatively higher (9.9%) than that of the newly constructed ponds (6.8%). Gradual accumulation of organic matter in the pond bottom as ponds age has been described by Hepher (1965).

Amphipods, polychaetes and bivalves were the dominant benthic organisms in the pond environment. Benthic organisms were initially absent in the newly constructed ponds. Polychaetes were the first organisms to establish in the ponds after the treatment of lime and fertilizer, followed by the bivalves and amphipods. Amphipods predominated the benthic communities in older ponds. The same aggregation of benthos has been observed in estuarine sediments of clayey silt texture by Jayasinghe (1979).

Vegetative covers on dikes, selection of suitable cultured organisms and adjustment of culture periods to avoid continuous rainy periods after prolonged droughts were important in increasing survival rate and production of cultured organisms when acid sulfate soils are used in aquaculture.

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