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UTILISATION OF BOTTOM SLUSH FROM SLIGHTLY POLLUTED ESTUARINE AREAS FOR PLANKTON PRODUCTION

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ABSTRACT

The effect of the addition of small doses of estuarine slush to pond soil for increasing the production of fish food organisms in brackishwater medium is reported. Experiments were conducted in glass jars using brackishwater (15+1 ppt) with slightly alkaline pond soil low in phosphorus, nitrogen and organic matter as substratum. Air dried and powdered estuarine sediments formed mainly from city sewage was added uniformily to these experimental jars @ 50% of pond soil. Super phosphate and trace elements, namely molybdenum, boron and zinc were also applied separately to study their added effect in improving the nutrient status. Molybdenum gave the best plankton growth followed by boron, super phosphate and zinc. Better plankton production was obtained with estuarine slush alone when compared with pond soil. The changes in the nutrient status of water and soil were also studied.

INTRODUCTION

SEWAGE is considered to be a rich fertilizer with nitrogen and phosphorus as its main chemical constitutents. It is a common practice in various countries including India to use dilute sewage as a pond fertilizer. Sludge is also used as pond manure in many countries. In India, Gopalakrishanan and Srinath (1963) used activated sludge as a manure to study the effect of adding different doses of the substance on plankton production and fish growth. The present account deals with the results obtained from the preliminary laboratory experiments carried out to study the effect of addition to pond soil of air dried and powedered estuarine slush formed mainly from city sewage as reflected in the production of planktonic organisms, the most important link in the food chain of fish.

Banerjea and Banerji (1966) and Sreenivasan *et al.* (1975) found that trace elements play an important role in freshwater aquaculture by increasing plankton production. Joseph *et al.* (1981) in a similar study in a brackishwater medium observed that nanonutrients (molybdenum, boron and zinc) have a major role to play. The maintenance of soil organic matter at normal or even high level will not generally solve problems due to lack of phosphorus in most soils. So they require fertilizer application. Therefore, in this study attempt was made to observe the added effect of these trace elements and super phosphate along with estuarine sediment in enhancing fertility and biological productivity of brackishwater medium.

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MATERIAL AND METHODS

The pond soil for this study was collected from Adyar brackishwater fish farm in Madras. The relevant data on the physical and chemical characteristics of the soil are presented in Table 1. This soil is composed of sandy loam, low in nitrogen, phosphorus and organic carbon and alkaline in reaction.

TABLE 1. *Physical and chemical characteristics of the pond soil and estuarine sediment*

	Pond soil	Estuarine sediment
Sand (%)	67.2	24.0
Silt (%)	24.0	31.5
Clay (%)	7.8	44.5
pH	8.15	6.55
Organic carbon (%)	0.54	3.99
Total N (%)	0.04	0.65
Available P (mg/100g)	4.00	15.50
Free Ca Co_3 (%)	3.46	1.30
Chloride (%)	0.38	0.70

The estuarine slush was collected from slightly polluted Adyar Estuary which receives untreated sewage of the Madras city. It was air-dried and powdered. This sediment is clayey, rich in organic carbon, nitrogen, phosphorus and slightly acid in reaction (pH 6.55).

For the estimation of metals, the sediment sample was oven-dried at 100-110°C. One g of the sediment was treated with 10 ml of acid solution (3:1 :: concentrated HCl : concentrated HNO_3). The sample was immersed in a water bath (90°C) for 30 minutes and then diluted to 50 ml with glass distilled water that was free of heavy metals. A Carl-Zeiss PMQ II Atomic Absorption Spectrophotometer was used for the estimation of heavy metal contents. The results are given in Table 2.

TABLE 2. *Concentrations of some heavy metals in Adyar estuarine sediment*

Metals	Concentrations (μg/g. dry weight
Zn	70.0
Pb	40.0
Cu	17.0
Ni	5.6
Cr	1.6
Cd	BDL

BDL - Below Detection Limit
Values are mean of 3 individual estimations

Two kg of pond soil was placed in 14 cylindrical glass jars of 12 litre capacity and water logged with 10 litre pond water (Table 3) in each till equilibrium was established between the soil and water. Two jars were kept as control with pond soil alone. Treatment consisted of:

T_0 - Pond soil

T_1 - Pond soil + super phosphate @100 kg/ha soil

T_2-Pond soil + estuarine sediment @1 kg/jar

T_3-Pond soil + estuarine sediment @ 1 kg/jar + super phosphate @ 100 kg/ha

T_4-Pond soil + estuarine sediment @1 kg/jar + zinc @0.5 ppm based on water volume

T_5-Pond soil + estuarine sediment @1 kg/jar + molybdenum @ 0.5 ppm based on water volume

TABLE 3. *Characteristics of pond water used*

Dissolved oxygen (ppm)	7.6
Salinity (ppt)	15.2
pH	8.0
Total alkalinity (ppm)	90.0
Nitrate (ppm)	0.01
Phosphate (ppm)	0.03

T_6-Pond soil + estuarine sediment @1 kg/jar + boron @ 0.5 ppm based on water volume.

The whole set was replicated once.

Total plankton in each case was estimated by filtering the entire volume of water through a plankton net made of No. 25 bolting silk at 15 days and 30 days after treatment. The plankton was analysed quantitatively and qualitatively using standard methods.

Samples of water were collected once in a week and analysed following Standard Methods (A.P.H.A., 1955). Soil analysis was done only at the beginning and at the end of the experiments adopting methods recommended by the International Bureau of Soil Science (Piper, 1950).

Results and Discussion

The data on water and soil analysis are given in Table 4. The salinity of water was kept at 15± 1 ppt during the course of the experiments. The water pH was highest in molybdenum treatment (T_5) and it ranged from 8.0-8.75 and lowest in T_0 and T_1 (7.8-8.4). The higher pH values are an index of greater productivity. The total alkalinity was highest in T_5 (122-252 ppm) follwed by T_6 (144-236 ppm). Lowest was noted in jars treated with sediment alone (T_2).

In all the cases phosphate was detected throughout the period inspite of increased plankton production and an increase of available phosphorus content in soil phase. This may be due to the releasing of inorganic phosphate by the decomposition of organic matter in the sediment. Mandal (1979) and Mandal and Chatterjee (1972) observed that the application of organic matter to soil has helped to maintain higher amount of added phosphorus in the solution phase over that in no organic matter series. This may be the reason for the high phosphorus content in T_3.

Table 4. *Details of water and soil analysis*

	Treatments						
	T_0	T_1	T_2	T_3	T_4	T_5	T_6
Water (pH)	7.80-8.40	7.80-8.40	8.00-8.50	8.00-8.60	7.80-8.50	8.00-8.75	8.10-8.50
D.O. (ppm)	6.00-8.00	5.20-8.00	2.40-8.40	2.40-8.40	2.40-8.00	2.00-8.80	2.40-8.00
Salinity (ppt)	15.50-16.0	15.00-15.5	14.00-15.5	15.00-16.0	15.00-15.6	15.50-16.0	14.50-15.5
Total alkalinity (ppm)	90-120	90-130	114-200	114-226	114-220	122-252	114-236
Phosphate (ppm)	0.02-0.03	0.03-0.72	0.02-0.60	0.03-0.92	0.03-0.66	0.03-0.69	0.03-0.50
Nitrate (ppm)	0.01-0.02	0.01-0.02	0.01-0.05	0.01-0.04	0.01-0.05	0.01-0.05	Nil-0.04
BOD_5	1.6	1.6	3.6	3.8	4.2	4.0	3.8
COD	1.3	1.4	3.8	3.8	3.6	3.8	3.6
Soil (pH)	7.70-8.05	7.70-8.10	7.90-8.25	7.90-8.50	7.90-8.40	7.90-8.55	7.90-8.30
Organic carbon (%)	0.54-0.66	0.54-0.60	1.38-1.71	1.38-1.74	1.38-1.71	1.38-1.84	11.38-1.77
Available P. (mg/100 gms)	3.70-4.00	4.80-8.20	5.10-7.00	10.00-13.0	5.00-9.00	5.00-9.80	5.00-8.50
Total N (%)	0.04	0.03-0.04	0.26-0.28	0.26-0.27	0.26-0.28	0.26-0.40	0.26-0.40

According to Hutchinson (1957) nature of the pond can be known from the dissolved oxygen values than from any other chemical parameter. The D. O. ranged from 2.0 to 8.8 ppm in T_5, 2.4 to 8.0 ppm both in T_4 and T_6 and in T_2 and T_3 it was 2.4 to 8.4 ppm. In T_1 it was 5.2 to 8.0 ppm. All the samples were collected between 0930 to 0945 hrs. T_5 had lowest dissolved oxygen (2.0 ppm) and T_1 had highest (5.2 ppm). Low oxygen in the early mornings and super saturation values in the afternoons indicate high rate of production. The marked fluctuations observed in dissolved oxygen, pH and alkalinity in the treated jars may be due to the increased biological turnover in these jars.

In the trace element treatment the phosphate content of water was always higher when compared to that of sediment alone. This may probably be due to the effect of trace element on the mineralisation of organic matter (Joseph *et al.*, 1981). Quick mineralisation of organic matter will not only help to improve the productivity of pond, but also remove the adverse effect of pollution caused by the incorporation of organic matter. The increase in the amount of nitrogen in the nitrate form in water was rather negligible in all the cases, even though the total nitrogen content in soil phase has increased considerably.

The soil pH at the end of the experiment was higher in T_5 (8.55) followed by T_3 (8.50),

T_4 (8.40) and T_6 (8.30). Comparatively higher values of organic carbon were observed in T_5, T_4, T_3 and T_6. This may be due to the presence of higher number of benthic organisms as suggested by Sreenivasan *et al.* (1975).

Plankton Production

The results (Table 5) show that the application of air-dried estuarine sediment increased the plankton production significantly (31.0 ml/l)

Table 5. *Yield of plankton in different treatments*

Treatment No.	Plankton production Av. total vol. (ml/10 l)	Av. number/l	Dominant forms
T_0	2.75	12,000	*Navicula* sp., *Amphora* sp., *Oscillatoria* sp.
T_1	12.00	55,000	*Navicula* sp., *Amphora* sp., *Pleurosigma* sp., *Surirella* sp., *Anabaena* sp., *Oscillatoria* sp., *Lyngbya* sp.
T_2	31.00	84,000	*Chlorella* sp., *Navicula* sp. *Amphora* sp., *Oscillatoria* sp., *Lyngbya* sp.
T_3	43.00	1,61,000	*Chlorella* sp., *Amphora* sp. *Pleurosigma* sp., *Surivella* *Cyclotella* sp., *Anabaena* sp., *Oscillatoria* sp., *Lyngbya* sp.
T_4	34.00	1,39,000	-do-+ *Brachionus* sp. ciliates
T_5	57.00	2,36,000	-do-+ *Synedra* sp., *Brachionus* sp., ciliates
T_6	47.00	2,00,000	-do-+ *Synedra* sp., *Brachionus* sp., ciliates

over that in the control of pond soil alone (2.75 ml/l) and pond soil + super phosphate (12.0 ml/l). Best plankton production was obtained in T_5 with molybdenum (57.0 ml/l) followed by T_6 with boron (47.50 ml/l), T_3 (43.0 ml/l) with super phosphate and T_4 with zinc (34.0 ml/l).

In all the cases the prominent groups of phytoplankton were diatoms and blue-green algae. Zooplankton was represented mainly by rotifers. Both phyto-and zooplankton forms were present in T_4, T_5 and T_6, but in T_1, T_2 and T_3 there were only phytoplankton forms.

The phytoplankton encountered were mainly *Chlorella* sp., *Navicula* sp. *Amphora* sp., *Surirella* sp. *Pleurosigma* sp. *Cyclotella* sp. *Synedra* sp., *Anabaena* sp., *Oscillatoria* sp., and *Lyngbya* sp. and zooplankters were *Brachionus* spp. and ciliates.

It has been shown that plankton production and fish growth can be increased by applying activated sludge to a body of water (Gopalakrishnan and Srinath, 1963). The present experiments indicate that the air-dried and powdered estuarine sediment can be utilised for increasing the nutrient status of pond. This estuarine slush is available in large quantities in Adyar Estuary, which can be conveniently removed from the river bed during summer months. By this method the river bed is getting desilted and thereby reducing the effect of pollution which is aggravated during summer months. As suggested by Ramachandran Nair (1978) this pollutant of the ecosytem can be beneficially utilised in coastal aquaculture. Moreover the incorporation of the clayey sediment will improve the physical structure of the pond soil and may reduce the rate of seepage in the ponds which are notorious for heavy seepage.

A serious disadvantage that may arise by using activated sludge will be accumulation of organic matter at the bottom of the pond (Gopalakrishanan and Srinath, 1963). But by mixing the sediment with the top layer soil of summer dried ponds of Madras region, this danger can be overcome easily. Further the quick mineralisation by added trace elements particularly Molybdenum will reduce the adverse effect of pollution caused by the addition of organic matter.

Sewage effluents (Nair, 1944; David, 1959) and activated sludge (Gopalakrishanan and Srinath, 1963) given in larger quantities are known to be harmful to fish life affecting the oxygen budget of the pond. But the present observations indicate that air-dried estuarine sediment when used at the present rate (pond soil : sediment :: 2:1) does not produce any total depletion of oxygen. As per ISI specification (IS: 7967 - 1976), the maximum limit for Biochemical Oxygen Demand (BOD) after receiving discharges in shell fish and commercial fish culture is 5 mg/1. The BOD and Chemical Oxygen Demand (COD) as indicated by dichromate oxidisability was not more than 5 ppm during the course of the experiment.

The bottom slush from the estuary at Adyar when analysed for heavy metal residues was found to contain only very insignificant quantities of these metals. However the concentration of lead and nickel was little high, but was not high enough to cause any detriment to fish life. Synergistic and antagonistic effects of these elements were not studied. But it is clear that none of these were coming into play as a limiting factor to plankton production as is evident from the enhanced plantkton growth in the experimental jars. However the effects of these residual metals individually and in combination could form the subject of a detailed study later.

Here the edaphological interest in the use of estuarine sediment is its cheapness and easy availability reducing the cost of inputs such as artificial and commercial fertilizers. Utilisation of the bottom sediment from a polluted environment like Adyar Estuary for enhancing production in coastal aquaculture ponds, not only gives a fillip to the culture practices by providing an inexpensive and effective source of fertilisation, but also as a secondary benefit, improves the ecosystem by removing the accumulated pollutants. Large scale scooping out of these bottom sediment for aquaculture purposes will in addition improve the bottom hygiene of the estuary creating conditions more conducive to entry of prawn and fish seed which again is a plus point for batckishwater aquaculture development in the area.

It should also be mentioned that the above experiments were carried out in glass jars under controlled conditions and these obviously have certain limitations with regard to space, temperature, seepage, etc. Similar studies have to be carried out in natural ponds to corroborate the above findings under field conditions.

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