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UTILIZATION OF WASTE WATERS IN FISH PRODUCTION: PRELIMINARY RESULTS FROM FISH CULTURE STUDIES IN FLOATING CAGES IN A SEWAGE POND, NEW BUSSA, NIGERIA.

By

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ABSTRACT

The utilization of waste waters in aquaculture were briefly reviewed. At NIFFR, stocking density (20 to 160 fish/m^3) experiments using *Sarotherodon galilaeus* (without supplementary feeding) in floating cages were carried out in a sewage pond (0.4ha surface area). Cage culture of *S. galilaeus* was observed to have potentials in waste waters aquaculture. Recommendations were made on the execution of an intergrated waste water management and utilization.

1. INTRODUCTION

Waste water aquaculture as a possible means of water renovation, environmental protection and food production have all along been practised in some countries and is even receiving serious attention in future planning in some arid countries (Allen and Hepher, 1976, Gaigher, 1983). As human population increases protein requirements also increase. Apart from human sewage, other types of organic waste from factories and other related industrial set-up can also be expected to increase. Studies have shown that all these forms of organic waste can be utilized for fish production although there is a general lack of information on waste water aquaculture technology (Gaigher, 1983). The possibility of using waste water from sewage system for fish production was outlined by Tapiador (1973) cited in Hjul (1974). Chan (1972) reported on the use of pollutants for aquaculture through the conditioning of wastes Slack (1972) also gave a detailed report on sewage and aquaculture production. Tapiador (1973) reported on a commercial private fish farm utilising sewage water. The farm was producing 28.00 metric tons (Tilapia) per hectare per year in three ponds with a total surface area of 2.5 hectares. Pillay (1973) further drew attention to the use of domestic waste water as an ancient practice in fish culture and he mentioned the very high production obtained in sewage fish farming.

Otubusin (1989) enumerating some definite advantages of cage fish culture system reported inter alia that the system can be used not only primarily for producing high quality protein cheaply, but also for cleaning up eutrophic water bodies through the culture and harvesting of caged planktivorous fish species as practised in Singapore and Malaysia. In Alabama, U.S.A., *Sarotherodon aureus* were cultured in experimental floating cages in ponds (in which other fish were also cultivated) fertilized regularly to develop either moderate or dense plankton blooms In West Java (Indonesia), common carp, *Cyprinus carpio* are cultured as on a commercial scale in fixed cages placed in canals and streams heavily enriched by agro-industrial and domestic effluents. In the Philippines, large scale commercial tilapis/milk fish culture in fixed cages and pens is carried out on a eutrophic natural water body, Laguna Lake (900 km^2 surface area) which is fed by industrial and domestic effluents from Manila, the capital city (population 6 million plus). Okoye *et al* (1986) at New Bussa, Nigeria reported a favourable use of a waste water in common carp/tilapia *(Sarotherodon galilaeus)* production by directly stocking the said waste water. The experiments reported in this paper were carried out utilizing the same waste water in order to determine its potential fish productions *(S. galilaeus)* at different stocking densities in floating net-cages (without supplementary feeding).

2. MATERIALS AND METHODS

2.1 The site of the Experiment

The site used for the experiemnts was the NEPA (National Electric Power Authority) sewage pond (0.4ha surface area) situated within New Bussa township. The sewage pond receives waste waters from the New Bussa resettlement quarters and the NEPA residential quarters with a population of over 3,000 people. The bottom of the pond is muddy while its inner slope is concreted to fortify the dikes. It has a 30-cm diameter inlet pipe which brings the residential waste water into the pond and a 23-cm diameter pipe at another end of the pond for spilling excess water especially during the rainy season. During the experimental period, the pond water surface was occasionally covered by duck weeds *Lemma sp.*

2.2 The Experiments

Two modules of 6m x 6m raft each with sixteen, 1.5m x 1.5m apartment fitted with 1m x 1m x 1.25m (210/9, 25.4mm mesh) net-cages were used for the experiments. The construction procedures are as described in Otubusin (1985); Otubusin and Amaechi (1987) and Otubusin *et al.*(1988).

Two experiments using *Sarotherodon galilaeus* fingerlings at different fish stocking density (viz 20 - 80 fislm/^{3} and 40 - 160 fish/m^3) were carried out simultaneously using eight apartments in each module. The treatments for the first experiments were 20, 40, 60 and 80 fish *(S. galilaeus* mean weight 10.8g) per m^3 of the net-cage. The second experiment had the following treatments: 40, 80, 120 and 160 fish *(S. galilaeus*, mean weight 10.8g) per m^3 of the net-cage. The fish fingerlings were stocked using completely randomized design and the treatment in each experiment were replicated twice. 50% of the fish were sampled thrice (i.e at day 1, day 70 and day 150) during the 150-day culture period in order to minimize mortality through sampling stress. No supplementary feeding was given throughout the duration of the experiment. Some physico-chemical parameters of the sewage pond water were monitored using standard methods of APHA (1966).

3. RESULTS AND DISUCSSION

Since the two experiments were carried out simultaneously in the same water body and the treatments were in multiples of 20, the results were pooled together as shown in Table 1.

3.1 Survival

The mean survival rates varied from 62.5% to 91.9%. The highest mean survival rate of 91.0% was recorded under treatment VI (160 fish/m^3) and the least 62.5% under treatment

V. (120 fish/m³) (Table 1). The mean survival rates were not signicantly different ($P>0.05$). The range of survival rates 62.5% to 91.9% obtained in this study were comparable to the range 60% to 100% reported by Gaigher (1983) rearing *O. mossambicus* in cages without artificial feeding in various waste water treatment systems. The mortalities recorded in this study were due to sampling stress. The pysico-chemical parameters of the waste water recorded in this study (Table 2) were within tolerable limits for tilapia culture (Swingle, 1961; Solarin, 1979 and Guerrero, 1982), and therefore there was no adverse environmental effect on survival.

3.2 Growth Rates

The mean growth rates ranged from 0.10 to 0.26g/d (Table 1). These values were observed

Table 1.

Pooled results for S. galilaeus production at different stocking densities ($20 - 160/m^3$) in floating cages in a sewage pond for 150 days

Treatment	Ave. Wt. (g) Initial	Ave. Wt. (g) Final	Ave. daily Wt. gain (g/d)	Survival (%)	Production (kg/m3)
I $20/m^3$	[illegible] 10.0 11.[illegible]	[illegible] [illegible] 50.0[illegible]	[illegible] [illegible] 0.20a	[illegible] 70.0 73.0a	0.[illegible] 0.[illegible] 0.748a
II $40/m^3$	[illegible] 10.0 9.9	[illegible] [illegible] 34.7b	0.1[illegible] 0.18 0.17b	[illegible] 92.5 76.3a	0.775 1.369 1.072b
III $60/m^3$	[illegible] 10.0 [illegible]	[illegible] 23.5 [illegible]	0.10 0.09 0.13b	77.0 83.0 80.0a	1.492 1.170 1.331b
IV $80/m^3$	11.[illegible] 10.0 1[illegible].0	[illegible] [illegible] [illegible]	0.07 0.1[illegible] 0.1[illegible]	83.8 67.0 75.4a	1.502 1.502 1.502b
V $120/m^3$	[illegible] [illegible] 10.[illegible]	[illegible] 27.3 [illegible]	0.[illegible] 0.11 0.10b	40.0 85.0 62.5a	1.066 2.785 1.926b
VI $160/m^3$	10.[illegible] [illegible] 10.[illegible]	25.[illegible] [illegible] [illegible]	0.10 0.09 0.10b	90.0 93.8 91.9a	3.686 3.617 3.652b

Means in a column with the same superscript are not significantly different at 5% DMRT.

TABLE 2: RANGE AND MEAN OF SOME PHYSICO-CHEMICAL PARAMETERS OF THE SEWAGE POND WATER DURING THE EXPERIMENTAL PERIOD

Parameters	Range	Means
Water temperature (°C)	22.5 - 24.0	23.2
P^H	6.9 - 8.2	7.6
Dissolved oxygen (mg/l)	5.1 - 7.9	7.0
Transparency (m)	0.2 - 0.5	0.3
Pelagic primary production (gC/m³/day)	1.9 - 3.1	2.3

to be inversely proportional to the stocking densities i.e. the growth rates decreased as the stocking densities increased. This corroborate the effect of the space factor as opined by Weatherly (1972). Despite the fact that *S. galilaeus* stocked in the cages at the sewage pond subsisted solely on natural food in the water medium, the range of growth rates (0.10 to 0.26g/d) compared very well with the range (0.16 to 0.34 g/d) recorded under the supplementary feeding of *O. niloticus* (25 to 100/m³) in net-cages in a drinking water reservoir at New Bussa. Even though, Bardach et al.(1972) reported than *S. galilaeus* the comparably good growth exhibited by the latter could be attributed to the adequacy of the natural productivity of the sewage pond water.

Aquino and Nielsen (1983) observed the relationship between growth rate of *O. niloticus* in cages and the gross primary productivity (GPP) in a lake of volcanic origin in the Philippines. They reported that the lowest weight increment of 0.12g/d was observed when the GPP was only 0.6gC/m³/day while a GPP of less than 0.5gC/m³/day gave no growth of fish. In this sewage pond study the range of growth rates (g/d) was 0.10 to 0.26 whereas the mean primary productivity observed was 2.2gC/m³/day (Table 2). This was similar to the value of 2.14gC/m³/day reported for another euthrophic lake (Lagun) in the Philippines (Bhent, 1981). the lower growth rate of *S. galilaeus* observed in the sewage pond could be attributable to the decreased efficiency of plankton utilization by the larger fish stocked and the slower growth characteristic of *S. galilaeus* (Bardach et al., 1972). This was corroborated by Gaigher (1983) who reported that the efficiency of plankton utilization apparently decreased in large fish.

The mean growth rates of 0.10g to 0.26g/d observed in this study were higher than the growth rate of 0.05g/d reported by Okoye et al (1986) when they stocked *S. galilaeus* at 2,274 per 400m² (i.e. about 6 fish/m²) directly into the same sewage pond. This means that the caged fish even though stocked at higher densities grew faster than the same fish species stocked directly into the sewage pond. This observation is similar to that of Rifai (1980) who observed that growth rates of fish *(O. niloticus)* reared in cages were higher than those reared in pond. The caged fish did not have to search for food and thus more of the food eaten was converted into flesh. Moreso, even though the caged fish spawned during the period of study, the eggs were often lost through the mesh of the net-cage (25.4mm) and there was no over-population in the cage. This fact had earlier been observed by pagan - Font (1975). Okoye et al. (1986) noted there was overpopulation and stunting of tilapia as a result of the direct stocking. Within the 300 days (10 months) culture period, Okoye et al (1986) observed that *S. galilaeus* grew from an average initial weight of 36.1g to 51.3g. But at the least stocking density of 20 fish/m^3 under the cage culture study, *S. galilaeus* was grown from a mean weight of 11.8g to 50.0g in 150 days (i.e 86.8g in 300 days). The mean growth rate at 20 fish/m^3 was significantly different from the means of all the other treatments. ($P<0.05$).

3.3 Production

Generally, the total fish production (kg fish/m^3) increased as the stocking density increased (Table I). The highest mean production was recorded under treatment VI, 3.652 kg/m^3 and least in treatment I, 0.748 kg/m^3. The mean production under treatment I was significantly different from all the means of the other treatments ($P. <0.05$).

The successful fish production in cages in the sewage pond without supplementary feeding could be seen as a cost-saving exercise considering the fact that feed represents 40 - 60% of the total operating cost in intensive aquaculture (coche, 1978, 1979; ADCP, 1983). considering the surface area (400 m^2) of the sewage pond, the least stocking density of 20/m^3 for the cage system and 6/m^2 for the direct stocking into the sewage pond and assuming a survival rate of 75% for both systems, the estimated total fish production in the cage system, 520.8kg/400m^2 is about six times higher than in the pond (direct stocking) system. Even though cage system appeared a surer and more reliable way of utilizing waste waters in fish culture, the direct stocking of waste waters could be an additional method. For example, Tapiador (1973) suggested that a 50-hectare sewage fish farm would be able to support a fishmeal plant turning out about 500 metric tons of fishmeal a year based on an average production rate of, say, 50 metric tons per hectare of the farm per year.

4. CONCLUSION AND RECOMMENDATION

Even though the experiments on the utilization of waste waters in fish production in cages were preliminary in nature, they did prove that cage culture of the local stain of *S. galilaeus* has potentials in waste waters aquaculture.

Based on the experience from these experiments, it is recommended that:

a) the harvested tilapia for human consumption be first depurated such as is often done in cleaning bivalves before marketing (Hickling, 1962). This will serve as a precautionary measure against transmission of pathogenic organisms on waste water reared fish. The portion of the harvested fish which could be too small for human consumption would need no depuration and could be used directly in fish meal production.

b) more studies should be carried out on utilization of waste waters in fish production in order to harness the immense potentials of such water bodies that abound in Nigeria

c) an inventory survey be carried out on the available waste waters in Nigeria and their adequacy for fish production.

d) a holistic ecosystem approach involving all facets of aquaculture (especially cage system), water quality and pollution studies, pathobiological studies, waste water treatment techniques and all other related disciplines should be adopted in the integrated waste water management and utilization.

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