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Review

Livestock waste-menace: Fish wealth-solution

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A review of the use of livestock wastes for sustainable fish wealth creation was done, using information from literature and data from field observation and experimentation. Livestock wastes including animal manure and poultry by-products, which are a menace to the environment, are sources of wealth creation in fish farming. In Nigeria, about 932.5 metric tonnes of manure is produced annually from the well established livestock industries which keep expanding at the rate of 8% year^{-1}. Nigeria is the largest importer of frozen fish in the world with a fish demand of between 106,200 - 128,052 metric tonnes year^{-1}. This situation calls for increased fish production which can be achieved through the effective utilization of livestock wastes. Properly treated animal manure can serve as organic fertilizer/feed component. Consequently, there is enhanced fish farming profitability, efficient resources utilization and conservation of environment due to waste management.

Key words: Wastes, manure, fish, plankton, livestock, fertilizer, feed

INTRODUCTION

Fish plays an important role in the diet of the people of developing nations. It is a very rich source of animal protein. In Nigeria, fish and fishing contribute immensely to the national economy by providing high animal food protein and generating employment, which is a means of poverty alleviation. The need for fish protein has been emphasized with the projected population of 88.50 - 106.71 million and a population growth rate of 2.1% yr^{-1}. Nigeria is the largest importer of frozen fish in the world with a fish demand of between 106,200 - 128,052 metric tonnes year^{-1} from 1991 - 2000 and a fish per caput consumption of 12 kg (Solarin, 1992).

Feeding of formulated feed to fish has become extravagant for the average Nigerian farmer. This has therefore called for sustainable aquaculture feed development. Such package must, as of necessity, include integrating fish farming with other agricultural production as livestock. Integration of fish with livestock has been found to make aquaculture and animal husbandry sustainable husbandry sustainable ventures for common man and his immediate family. Such integration involves the recycling of livestock wastes and processing by-products as manure and/or direct food for fish.

The effectiveness of cow, chicken and pig manure as a direct fish feed has been tested in a variety of fish including: Common carp (*Cyprinus carpio*), (Shiloh and Viola, 1973; Compos and Sampaio, 1976; Kerns and Roelofs, 1977), Tilapias (*Sarotherodon mossambica*) (Stickney and Simmons, 1977), channel catfish (*Ictalurus punctatus*), (Fowler and Lock, 1974; Lu and Kevern, 1975) the African catfish, (*Clarias gariepinus*), Oladosu et al., 1990) and gold fish (*Carassius auratus*), (Lu and Kevern, 1975). The usual approach in these experiments was to incorporate the dried manure into a standard feed pellet as a replacement for higher quality components as well as direct consumption of the manure as pellets. The use of livestock wastes for fish production has been in practice for some time in tropical countries like Nigeria. This study intends to review the extent of use and the profitability of usage in fish production.

THE MENACE OF LIVESTOCK WASTES

In Nigeria, about 932.5 metric tonnes (MT) of manure is produced annually from the well established poultry/livestock

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Abbreviations: BOD, Biological oxygen demand; **DO,** dissolved oxygen.

Table 1. The average weight and unit weight of droppings of layers in a stair-case type battery cage.

Type of feed	Av. wt of feed (g/bird-day)	Vol. of water (ml/bird-day)	Av.wt of droppings (g/bird-day)	Unit wt. of droppings, kg/m^3
Growers' marsh	125	500	160. 5	1.20
Layer's march	135	540	161. 5	1.20

Source: Adewumi and Adewumi (1996).

Table 2. Percentage proximate constitution (dry matter) of chicken excrement.

Constituent	Raising above pond/cage	Ground raising	Dry grass/sawdust bedding
Moisture	11.4	12.3	15.5
Crude protein	26.7	21.9	22.3
Crude fat	1.7	1.7	2.3
Nitrogen-free extract	30.6	30.0	27.1
Crude cellulose	13.0	17.2	18.7
Minerals	16.5	16.9	14.1

Source: NACA (1989).

industries which keep expanding at 8% yr^{-1} (Adejinmi, 2000). Adewumi and Adewumi (1996) reported that a layer produced an average of 161 g of droppings/bird day^{-1} (Table 1). This large turnout of wastes from poultry, piggery, cattle rearing etc encourages the growth of microbes, attracts houseflies, constitutes health hazard to man, animals and thus become a menace to the environment.

Litter materials often need to be provided beneath cages to reduce drudgery of daily cleaning. The droppings readily produce maggots when not cleaned or mixed with litter. Litter materials itself becomes wet and a nuisance when its moisture content exceeds 30% and temperature is below 10°C. Oluyemi and Roberts (1988) reported that such wet litter materials provide a suitable medium for the growth of *Aspergillus* and *Coccidia* which cause aspergillosis and coccidiosis respectively in chicks. In this wet condition, ammonia in the litter increases. A continuous exposure of birds to a 20 ppm ammonia concentration reduces feed intake, growth, egg production and predisposes chicks to Newcastle disease and air sacculitis (Oluyemi and Roberts, 1988).

LIVESTOCK WASTES AS ASSETS

Integration with fish farming makes livestock wastes become assets in production. Livestock wastes are rich source of nutrients. The digestive tract of a chicken is very short, only six times its body length. Therefore, some of the eaten foodstuffs are excreted by the chicken before being fully digested. Research has shown that about 80% (dry weight) of feedstuff is utilized and digested by the poultry thus making 20% available to the fish in an integrated fish cum poultry culture system. Furthermore, while picking the feedstuffs, the chicken scatters 10% of their food and these, drop directly for fish consumption. Usually, good chicken feedstuff have a protein content of over 18% and the total protein content of dry chicken excrement is between 10 - 30% (Table 2), energy between 1100 - 1400 Kcal kg^{-1} manure and soluble vitamins are synthesized in high concentration (Tuleun, 1992). Metabolizable energy in cow and chicken manure is reported to range from 600 - 800 and from 900 - 1200 Kcal/kg for conventional feed pellets (Shiloh and Viola, 1973) and 3,000 to 4,000 Kcal/kg for zooplankton (Yurkowski and Tabachnek, 1979).

Use of livestock wastes in fish culture thus has a synergistic effect. Rangayya (1977) reported that battery system of raising poultry on fish pond makes maintenance and management easy and economical while it also helps in the production of 'clean' eggs. It is thus a NO WASTE, low cost and low energy production system in which the by-products of one enterprise is recycled into another as input.

USE OF WASTES AS MANURE

The gap between the demand and supply of inorganic fertilizers is increasing day-by-day due to intensive cropping of the high yielding varieties of cereals. Biodegrading livestock wastes can be used as manure in pond fertilization. Fish ponds are frequently located in a manner that wastes from chickens, raised in suspended battery cages, drop directly into the pond. For cattle, pig, sheep or goat, it may be more practical to transport the manure from cattle farms to the fish ponds. Nitrogenous wastes from these farms efficiently influence the pond water productivity as it supplies the plankton with

Table 3. The 24 h biochemical oxygen demand (BOD_g-O_2/kg at 30°C) for various fish foods and manures used for pond fertilization.

Material	% Dry matter	BOD
Pellets (25% protein, 10% fish meal)	90	140
Milled wheat and sorghum mixture (1:1)	90	96
Wheat grains	91	40
Chicken manure	95	20 to 40
Sorghum grains	88	18
Field dried manure	*36	10
Liquid cowshed manure	*12.5	7
Liquid calf manure	*9	5

*Levels of animal waste application to ponds as fertilizer. (Source: Schroeder, 1975).

essential nutrients needed for multiplication and growth. Planktons are life food organisms for fish and fish-food organisms.

The wastes also serve as direct feed to fish in ponds. Livestock manure contains considerable quantities of nutrients for fish production. Animal manure contains considerable quantities of nutrients for fish production among which are non-digested feed, metabolic excretory products and residues resulting from microbial synthesis (Falayi, 1998; Fashakin et al., 2000). These can be utilized to replace reasonable parts of feedstuffs used in conventional fish feed thereby causing reasonable decrease in fish feed production cost. Spartan (1979) reported that the benefit of manure when fed directly to *Thorichthys aureus* was in the production of benthic organisms in addition to tilapia hybrid ingesting the manure directly. Moav (1977), also confirmed that Chinese carp utilized about 95% of the valuable ingredients in poultry manure and that catfish and tilapia also have enormous potentials for direct manure consumption (Meyer, 1977). Cowdung or pig faeces are also eaten by certain fish in the raw condition. Fish farming using cow manure has long been practiced in China. Cows are ruminants and because of the repeated grinding and digestive decomposition catalyzed by the micro-organisms in the rumen, cow manure has fine texture.

THE APPLICATION OF MANURE

The animal manure is applied either fresh/untreated or after composting it in pits for some time. The application of fresh, untreated animal wastes to fish ponds is common in Asia and this practice has given high yields but excessive amounts can cause fish kills due to oxygen depletion in the water. Such oxygen depletion could be predicted from biological oxygen demand (BOD) measurements in manured ponds. The BOD can also be estimated from the percentage dry matter content of manures. Schroeder and Hepher (1979) reported that manure is applied to ponds at daily rates of more than 1.5 MT/ ha under Israeli conditions. Central Institute of Fisheries Technology (C.I.F.T (1972) recommended an estimate of 154 kg weight poultry manure per hectare of fish pond week^{-1} as requirement for excellent results for fish protein in Gabon. These observations may be a useful guideline for the management of manured ponds in the tropics to avoid dangerously low dissolved oxygen (DO), particularly at night when no photosynthetic activity takes place. Poultry manure has higher BOD, as compared to ruminant manure, a reflection of the higher food value both of the food eaten and manure produced (Table 3). A high BOD implies rapid digestion and conversion to microorganisms upon introduction to the pond (Pullin and Shehadeh, 1980).

THE WASTES TO WEALTH FISH PRODUCTION CYCLE

The mechanism of manure-fish recycling is as illustrated by Huet (1975). The chain or cycle of natural fish production includes the following links: (a) Mineral nutrients (b) plant production (c) intermediate animal consumption and production leading to the final product which is the fish and (d) reduction. The origin of this cycle lies in the mineral nutrients of water which come from soluble substances, carried to the water by exogenous detritus (animal waste) and also by rain-fall. By means of photosynthesis, the green vegetation transforms these inorganic substances into organic matter which forms vegetable tissue (higher and lower plants). Living or dead, the plants are consumed by numerous small animal organisms. These then serve as food for larger water animals (and also certain type of vegetation) which are in turn, both living and dead, eaten by fish.

The last stage is the reduction which is brought about by bacteria. Bacteria, by a mineralization mechanism, permits the return in solution of all dead components of organic matter-vegetable and animals and their re-integration into the biological cycle. A fish is the final result of the complex biological cycle. The productivity of

Table 4. The growth rate and cost of tilapia fish cultured in manured and pellet-fed ponds.

Pond treatment	Growth rate (kg/ha day^{-1})	Cost/kg ($)
Manured	16.0*	0.02 to 0.21
Pellet-fed	25.8*	0.41

*No significant difference (Source: Collis and Smitherman 1978).

a fish pond depends, in the final analysis, on the production of vegetation which in turn is dependent on the nutrients found in the pond. The vegetable growth of the fish pond can thus be increased by introducing animal manures.

THE IMPACT OF THE USE OF LIVESTOCK MANURE ON FISH PRODUCTION

Experiments conducted in open ponds, (the fish having access to the feed pellet decay products) gave results such that feeds containing as high as 30% manure produced fish growth equal to the growth obtained with conventional fish feed pellets. Nitrogenous manure inputs in ponds clearly influence the pond water productivity as it supplies the plankton with essential nutrients needed for the multiplication and growth of food organisms which are the natural food for the newly hatched baby fishes (Ovie, 1996). In the United States, Collis and Smitherman (1978) reported that the growth of tilapia cultured in manured ponds compared favourably with those fed with commercial pellet (Table 4). Although the yields from manured ponds are significantly lower than pellet-fed ponds, the profitability of the former was higher since manure is available at a nominal cost. In all cases, the use of such organic wastes resulted in large increases in the yield of fish per unit area of the pond and sharp decrease in the use of supplementary feeds, an indication that *Tilapia* can achieve reasonable growth under fish-cum-pig integration without addition of supplementary feeds.

FISH PATHOLOGY AND QUALITY

Research has shown that fish cultured under the integrated chicken-fish farming system are fit for human consumption. According to Pudadera et al. (1986), pathological examination of such fish prior to harvest showed that they are not infected by any micro-organism that could render them unfit for human consumption. Also, Yingxue et al. (1986) observed that the nutrient content of the fish fed on pelleted fish diet is not better than fish fed on chicken manure. Analysis of the fat content of approximately 100 carps grown on manure, grains and on fish meal-enriched pellets showed fat concentrations of 6, 20 and 15%, respectively (Kausar, 2009). There appears to be no significant difference in the taste and texture of flesh of fish grown in manured ponds and those fed on commercial diets. Allen and Hepher (1979) reported that fish from ponds receiving well-treated domestic wastes taste as good, or even better than fish grown in waste-free ponds. Similarly, Moav et al. (1977) reported good flesh colour and intramuscular fat-levels for fish grown in intensively manured ponds.

Poorly managed integrated systems however, usually have high nutrient loading, leading to deleterious effect of cyanobacterial bloom (Pearl and Turker, 1995). Cyanobacterial bloom is undesirable in aquatic ponds because they are relatively poor aquatic food base and poor oxygenators of pond waters with undesirable growth habits. Some species produce odorous metabolites and impact undesirable flavour to the cultured fish species while others produce compounds that are toxic to aquatic animals (Osuji et al., 2003).

POULTRY BY-PRODUCTS

Poultry by-products (livestock offals that is, chicken guts and other wastes products of meat processing such as bones and feather) can form part of fish feed ingredient. Poultry by-products and feather meal as dietary ingredients appear to be excellent protein and lipid sources containing 69% crude protein, 10 - 21% lipid and about 10% ash. The hydrolyzed feather meal is a slightly hydrolyzed product produced by cooking feathers in the presence of calcium hydroxide to increase its digestibility. Poultry by-products are lower in lysine than fishmeal, and trout diets containing over 75% poultry by-products would be deficient in the amino acid.

Feather meal has been evaluated in both fresh and salt water species to contain about 80 – 85% protein and is a relatively good source of sulphur-containing amino acids. Whether these amino acids are completely available has not been demonstrated however. Good results have been reported when it is used in catfish diets at the 15 percent level. That some of the sulphur-containing amino acids in hydrolyzed feather meal are available to salmonids was recently demonstrated in feeding tests at the University of Washington. In these experiements, trout grew much better on mixes of feather meal and yeast single cell protein (SCP) than when either of these commodities was used as the sole source of protein.

Chicken, pig and cattle manures are substrates for production of housefly (*Musca domestica*) maggots which are in turn used as fish feed, or as supplement to fish meal in fish feed formulation. Maggots are readily available and are accredited for its high nutrient value with an amino acid profile with biological value exceeding that of soybean and groundnut. This organism can be harvested, processed into a meal that can be used to substitute or replace fish meal like some other non conventional feedstuffs such as periwinkles, frog etc. Sogbesan et al. (2006) reported that 25% replacement of fishmeal in feed of hybrid catfish, culture with maggot gave comparative growth and profitability to that of fishmeal based diet.

OTHER BENEFITS OF INTEGRATION

Other benefits of integration of livestock with fish farming are efficient resource utilization including labour, feed, landspace, reduction on investment risk through diversification, income generation, family food source, employment opportunities and conservation of environment due to waste management (Lee, 1971; Otubusin, 1986). Livestock integrated culture system is quite compatible with the earthen pond culture, which in Nigeria, is the most economic fish farming system particularly in the rural areas. The fish farm supplies not only a large quantity of fish, but also produces meat, milk, eggs, vegetable, etc as it fully utilizes the water body, the water surface, the land and the pond silt to increase the food available for human consumption. The Asian world has been on integrated livestock cum fish and crop farming for many succeeding years (Azziz, 1978) because of their intensive fish culture techniques in which animal manure have been adopted as the only feed resources for fish in captivity.

CONCLUSION

It has been established that well treated animal manure can serve as organic fertilizer and feedstuff in fish ponds while maggots, livestock offals, bones and feather meal can form part of fish feed ingredient in earthen ponds without affecting the taste, meat quality of the fish and even increases the profitability of fish farming. Other benefits of integration of livestock with fish farming are efficient resource utilization and conservation of environment due to waste management.

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