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Formulating an Environmental Friendly Fish Feed for Sustainable Aquaculture Development in Nigeria

[1]O.A. Akinrotimi, [2]U.U. Gabriel, [1]N.K. Owhonda, [1]D.N. Onunkwo,
[1]J.Y. Opara, [1]P.E. Anyanwu and [1]P.T. Cliffe
[1]African Regional Aquaculture Centre, Nigerian Institute for Oceanography and Marine Research,
P.M.B. 5122, Aluu, Port Harcourt, Nigeria
[2]Department of Fisheries and Aquatic Environment,
Rivers State University of Science and Technology, P.M.B. 5080, Port Harcourt, Nigeria

Abstract: Over the last decade, aquaculture in Nigeria has witnessed a lot of growth. It is unequivocally agreed that aquaculture production will continue to increase. As aquaculture production becomes more intensive, fish feed will be a significant factor in increasing the productivity and profitability of aquaculture. Feed management accounts for at least 60% of the cost of production. Given that feed is the biggest source of nutrient loading in aquaculture production, clear understanding of its impact on the environment is highly essential for sustainable development. This will help to reduce negative impacts and improve predictability of environmental effects. Present knowledge and understanding of the environmental impacts of aqua feed among fish culturists and fish nutritionists is very low and needs further refinement, as much emphasis before now has been on the formulation of fish feed, that will enhance fast growth within a limited period of time without taking cognizance of its impact on the environment. Potential pollutants from aqua feed are Phosphorous and Nitrogenenous substances as well as organic matter and these are release to the environment majorly through excretion of faecal loss misuse of medicated feed and uneaten feed. This study however, reviewed the importance of formulating an environmental friendly fish feed for sustainable aquaculture. Inter relationship among various factors namely, fish feed production, feeding methods and regimes, influence of feed on water quality and environment are thoroughly discussed. Also, various strategies in dealing with aqua feed induced environmental pollution which include formulation of diets with reduced Food Conversion Ratio (FCR), balanced formulation of diet, utilization of high energy diets, reduction of nitrogen and phosphorus level and control of feeding regimes are critically analyzed.

Key words: Environmental, fish feed, nutrient loading, sustainable, aquaculture

INTRODUCTION

Aquaculture is aimed at increasing the production of fish basically for human consumption, its benefits also includes employment, income, food security and general improvement in the livelihoods of the people in remote and resource poor areas. For aquaculture to attain its full potential in contributing to human development and social empowerment, the aquaculture sector, requires new approaches that are realistic and achievable in the context of current environmental circumstances (Tacon and De Silva, 1997).

In Nigeria demand for fish consumption has been put at 1.875 million tones of fish per annum. National fish production is stagnating at some 450,000MT due to years of over fishing and lack of management (AIFP, 2004). To meet her demand for fish, Nigeria depends heavily on importation of frozen fish which presently is adjudged to be one of the largest importer in the whole world (AIFP, 2004). To reduce this heavy dependence on importation, aquaculture seems to be the only viable option in boosting the production of fish for teeming masses in the country.

As aquaculture production becomes more and more intensive in Nigeria, fish feed will be significant factor in determining the productivity and profitability of aquaculture as accounts for at least 60% of the total cost of production. The earliest fishmeal plant was installed and commissioned in the early eighties at the Nigerian Institute for Oceano-graphy and Marine Research (NIOMR), Lagos which was to be the base for the take-off of pelleted fish feed (Akande and Talabi, 1982).

Corresponding Author: O.A. Akinrotimi, African Regional Aquaculture Centre, Nigerian Institute for Oceanography and Marine Research, P.M.B. 5122, Aluu, Port Harcourt, Nigeria

But the evolution of fish feed since then till now is yet to match the enthusiasm of fish farmers, both in quality and quantity. This situation calls for a great increase in local production of fish feed to enhance the maximum productivity of aquaculture.

The production of animal's feed in the country is about 3.5 millions tons annually. Majority of this is for poultry while less than 1% of the total production (some 25,000 tons) are fish feed, which are poor in quality and inconsistent in production (AIFP, 2004). As at present fish feed manufactures are very few in comparison to the number of fish farms available in the country (Table 1).

Table 1: The number of fish farms and feed producers in the states of the Federation

No.	Geo political zones (States)	No. of dams and reservoirs	No. of fish farms	No. of feed producers
	South East zone			
1.	Abia	4	40	2
2.	Anambra	5	18	3
3.	Ebony	17	12	7
4.	Enugu	22	4	4
5.	Imo	9	40	16
6.	Sub total	57	114	32
1.	South South zone			
7.	Akwa Ibom	16	98	4
8.	Bayelsa	52	86	-
9.	Cross river	17	199	-
10.	Delta	30	420	6
11.	Edo	6	136	-
12.	Rivers	22	89	8
13.	Sub total	147	1,028	18
1.	South West zone			
14.	Ogun	24	173	35
15.	Ekiti	6	31	2
16.	Lagos	-	153	16
17.	Ondo	8	15	3
18.	Osun	7	300	26
19.	Oyo	29	234	9
20.	Sub total	74	906	91
1.	North central zone			
21.	Abuja	15	29	1
22.	Benue	45	198	5
23.	Kogi	35	32	-
24.	Kwara	21	121	18
25.	Plateau	85	18	9
26.	Nassarawa	16	16	2
27.	Niger	35	29	1
28.	Sub total	252	443	36
1.	North East zone			
29.	Adamawa	16	4	-
30.	Bauchi	49	-	-
31.	Borno	18	12	-
32.	Gombe	44	9	1
33.	Taraba	83	8	1
34.	Yobe	20	13	1
35.	Sub total	230	46	3
	North West zone			
1.	Jigawa	15	4	1
2.	Kaduna	20	10	9
3.	Kano	17	10	1
4.	Katsina	40	7	16
5.	Kebbi	30	56	-
6.	Sokoto	15	9	1
7.	Zamfara	40	9	7
	Sub total	177	105	35
	Grand total	937	2,642	215

Source: AIFP (2004)

This makes the aquaculture industry to be heavily dependent on importation. It is estimated that 4,000 tons of quality fish feed are imported yearly (AIFP, 2004). This calls for a rapid development of fish feed industry and production of feed in Nigeria.

Production of fish feed: Aquaculture practice in Nigeria involves both the intensive and semi-intensive systems of production. Either of the systems involves input of supplementary and complete feed (Mohanty and Dashim, 1995; Adikwu, 1999; Fagbero, 1999; Fasakin *et al*., 2003). Artificial feeds are well-compounded mixture of feed stuffs in mash form or pellets that could be fed to fish. Mash feeds are good for fry and pellets for fingerlings. Juveniles and adults depending on pellet size (Eyo, 2003).

For any aquaculture venture to be viable and profitable, it must have a regular and adequate supply of balanced artificial diets for the cultured fishes. This is so because the dissolved nutrients that promote primary and secondary production in the natural environment are seasonal and might be insufficient or may not occur in required proportion to meet the nutritional demand for culture fishes. Supplementary feeding satisfies this need and ensures that the fish gets the appropriate spectrum of its basis food requirement for maximum growth (Ugwumba and Ugwumba, 2003).

It is obvious that until very recently Nigeria depended largely on natural and locally available food to supply her fish culture establishments (Ayinla and Idoniboye-Obu, 1987). However, increasing demand for protein food, the resulting need to intensify production and the government keen interest to maximize judicious exploitation of the country's large water body have made it necessary to rely on pelleted feed for supplement or complete feeding (Ezenwa, 1979). The main aim of feed formulation is to provide cultured fish species with an acceptable diet that meet their nutrients requirements (Ibiyo and Olowo-Segun, 2004). Hastings (1976) observed that the combination of feed stuffs into a ration has greater nutritional value than if the feed stuff were fed separately. This forms the basis of formulation and feed manufacture, to provide high quality fish feed. The type of feed formulated depends on the age, species, production function and environmental conditions. High protein diets are essential for fry/fingerlings and juveniles, about 30-35%, while adult fish requires less (Lovell, 1989).

Materials that are cheap and available in large quantity are favoured for fish feed. Such materials include agricultural/industrial wastes for example, palm kernel cake, groundnut cake, millet/corn bran, wheat bran, blood meal, fish meal, soya bean meal (Table 2). The use of cheap ingredients without reduction in effectiveness is desirable in reducing overhead expenses (Moav *et al*., 1977; Falaye, 1992).

Table 2: Nutrients level of Readily available common feed ingredients with their current prices

Ingredients	Energy ME Kcal kg^{-1}	Crude protein %	Crude fiber %	Phosphorus (Available) %	*Cost/ton in naira
Maize	3434	9	2	0.09	38,000
Guinea corn	3300	11	2	0.32	25,000
Millet	2560	10	8	0.10	8,000
Cassava meal	3200	2.5	3.5	0.03	15,000
Corn offals	2500	11	12	0.09	8,000
Sorghum offals	2700	9	6	0.09	8,000
Wheat bran	1870	16	8.5	0.3	9,500
Palm/Kernel meal	2175	18	12	0.16	10,000
Rice bran	2860	12	12.5	0.46	-
Rice husk	1400	4	30	-	-
Brewers dry grains	1980	25	12	0.16	9,000
Groundnut cake	2640	45	5	0.6	60,000
Soyabean meal	2700	44	6.5	0.2	85,000
Fish meal	2860	65	1	3.0	150,000
Blood meal		81.5	0.7	2.5	100,000

Source: (Bekibele, 2002), *Subject to change from time to time

Table 3: Feeding frequencies in different species of fish

Fish species	Optimum feeding frequency (feeds day^{-1})	Initial fish size (g)
Cyprinus carpio	3	0.2
Hybridcat fish	2	0.5
Heterobranchus sp	1-2	0.8
Oreochromis niloticus	2	0.7
Clarias sp.	2	0.5
Mullet sp.	2	0.8
Sarotherodon melanotheron	2	0.7
Chrysythys nigrodigitatus	3	0.8
Tilapia guineensis	2	0.8

Source: (De Silva and Anderson, 1995)

MATERIALS AND METHODS

Data were generated from field observation, experimentation, review of literature and personal interviews in some states of the federation.

Feeding methods and frequency: How fish are fed is important as what a fish is fed with. Fish can be fed according to one of several methods, including feeding chart, percentage body weight or satiation. Although it has been recommended to feed according to percentage body weight (Masser, 1988). Production of high quality fish at least-cost depends on an effective feeding method. Various techniques exists from traditional hand feeding to the use of automatic control feeder. A reliable and least cost feeding system should ensure the effective distribution and spread of adequate feeds in agricultural ponds (Misra *et al*., 2003). The feeding rates and frequency depend on stocking density, age and size of the fish, production function and pond ecology (which varies considering with seasons). This also differs from one species to another (Table 3).

RESULTS

From the field and review of study, it was observed that the main sources of pollution in aquaculture induced

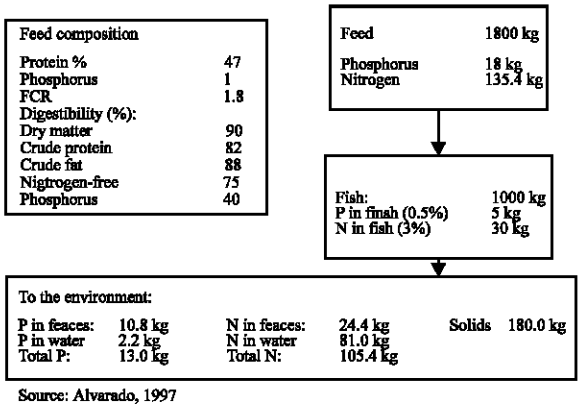

Fig. 1: Characteristics of extruded diet and nutrient loading (kg) per ton of fish produced

by aqua feed is through excretion of phosphorus and nitrogenous substance, faecal loss misuse of medicated feed are accumulation of uneaten feed. Nutrient loading which leads to pollution aqueous culture occur in three ways namely: Overfeeding of fish or feeding of fish at a time when it is not growing; Feeding unstable and highly soluble diets. Nutrient discharges in aquaculture can enter the environment in different forms (Fig. 1). This is because, the inter-relationship between feeding and water quality in aquaculture is a complex complicated interactions of environmental parameters such as temperature, dissolved oxygen, pH and salinity; all influence the feeding metabolism and growth of species under culture. By providing optimal species-specific requirements of these parameters and adequate feeding to satiation with proper metabolism, improved growth and survival can be ensured (Eyo, 2003). When water quality parameters fall below the optimum levels, feeding and growth will be impaired and the species under culture will be stressed. This also means that a greater portion of the feed offered is wasted leading to the release of potentially harmful organic and inorganic materials into the water (Chamberlain and Hopkins, 1994).

DISCUSSION

The various ways in which pollutants are release into environment in aquaculture include one or more of the followings:

Excretion of nitrogenous substances: The major product excreted by fish is Total Ammonia Nitrogen (TAN), which is formed in the liver and excreted across the gills (Ramdall and Wright, 1987; Rammarine *et al*., 1987; Kelly *et al*., 1994). Ammonia is an efficient route for nitrogen excretion (Lovell, 1989). Rate of ammonia production in fish culture system is dependent on

amount and quality of amino acid composition level of protein fed (Lovell, 1989; Dosdert *et al*., 1995). Ballastrazzi *et al.* (1994) and Lanari *et al*. (1995) reported that nitrogen excretion increases with increased protein level in the feed.

Faecal loss: The feacal loss in fish is directly proportional to the quality of food eaten by the fish. Kibria *et al.* (1998) observed a direct relationship between the nitrogen intake and feacal nitrogen losses in silver perch and carp. Kikiuch *et al.* (1995) reported higher feacal nitrogen and phosphorus loss at a higher protein feed intake in rainbow trout. The feacal loss from aquaculture is in the range of 0.5-15.7% of nitrogen intake (Porter *et al*., 1987; Beveridge and Phillips, 1993).

Uneaten feed: This is one of the paths for pollution in aquaculture (Pullin, 1989). Many farmers feed their fish indiscriminately or with the feed that are not appealing to the fish, while some increase the quantity of feed above the required level, thereby leaving much feed uneaten by the fish. The effect of pollution induced by uneaten feed is more pronounced in tank culture, than in earthen pond. This is because part of uneaten feed is lost in the pond sediments through the process of mineralization.

Phosphorous substances in feed ingredient: The phosphorus in the feed ingredient occurs in a number of forms. It occurs in the inorganic form as well as phosphate complexed protein, lipid and carbohydrate. These forms are available to the fish. Phosphorus present in most grain and seed by-products is generally unavailable to fin fish. Fish excrete phosphorus in soluble and particulate forms. The soluble forms, organic phosphorus and phosphate pollutes the water directly (Baruah *et al*., 2004).

Misuse of medicated feed: In addition to the potential for environmental degradation by waste aqua feed, therapeutant misuse should not be over looked. Medicated feeds are often indiscriminately used in some farms, during disease outbreak in hatcheries, nurseries and farms. Some of these are included in the diet (Hassan and Ahmed, 2001). Although some of these drugs are unstable in water and do not cause any major problems, others are very stable and can precipitate development of bacterial strains that are resistant to these drugs (Alvarado, 1997). Some of the drugs if not used properly can cause pollution in aquaculture.

Impacts of nutrients loading on the environment: The environmental impact assessment of aquaculture industry is getting increasing attention and rigorous restrictions is being set on this industry by government and environmentalists (Baruah *et al*., 2004). Although pollution from aquaculture is relatively low compared to agriculture and other point sources (Watanabe, 1991) Phosphorus is both present in feaces and water, in organic form and phosphates which pollute the water directly (Baruah *et al*., 2004). While nitrogen may occur in the form ammonia, total organic nitrogen, nitrites and nitrates (Erskine and Saynor, 1996). An abundance of these nutrients in aquatic systems may not only have a toxic effect on resident biota (Carr and Goulder, 1990; Foy and Rossel, 1991a) but it can also stimulate primary production (Makinen, 1991) resulting in harmful effects of eutrophication (Alvarado, 1997; Baruah *et al*., 2004). An abundance of nutrient loading encourages growth of epiphytic and toxic algae, making water slimy and emanating offensive odours (Lancelot *et al*., 1987).

Moreover, farm effluent have adverse effect on the land and water body receiving the discharge. This is a critical issue in management since the quality of water discharge from ponds can be linked directly with feed and feeding practices (Ajao, 2001). As farming systems intensify either in terms of increases stocking density and consequent nutrient input or in terms of number of farms per unit area, the need for development of environmentally cleaner strategies becomes more important. The net result of excess nutrient is obviously an economic loss to the farmer and a potentially deteriorating aquatic environment (Anderson and Desilva, 1997).

Strategies in dealing with pollution induced by aquafeed: In Nigeria, where fish farming is primarily dependent on supplied nutritionally complete formulated diet, mitigation of negative impacts of aqua-feed through development of more environmentally friendly feed is considered to be a major challenge facing fish farmers today. There are various strategies, that can be employed to tackle this problem, they are as follows:

Formulation of diets with reduced Food Conversion Ratio (FCR): To reduce nutrient loading in aquaculture, a better feed conversion is essential as has been observe in cat fish and tilapia (Kibria *et al*., 1998). A food conversion ratio of 1.0-12 is highly desirable (Fagbenro *et al*., 2003).

Balanced-formulation of feed: At present, most commercially available aqua-feed for aquaculture are either under or over formulated as nutritionally complete diets, with the aim of enhancing good growth, without

concern for environmental considerations. The important message here is for feed manufacture and on-farm feed compounds to tailor the feed to the intended farming system. It has been suggests that improvement in feed quality and feeding techniques can result in reduction of nitrogen pollution from aquaculture (Eikebrokchtal *et al*., 1991; Jensen, 1991).

Utilization of high energy diets: This place the onus on the feed manufacturers to use high quality and highly digestible raw materials by improving palatability of the feed. The precise requirement for protein, amino acid and energy for each species and stage of development need to be defined. High energy diets increase the utilization of nutrients and as a consequence reduce the solid waste and nutrient load in the waters (Johnson and Wandsvik, 1991).

Lowering the amount of nitrogen and phosphorus in feed: Feeds are used in aquaculture to increase aquatic animal production above that possible with fertilizers and manures. In most of the feed eaten by fish, only 10-30% of phosphorus and 20-40% of nitrogen applied in feed is retained by culture animals (Boyd and Tucker, 1998). The remainder of the nitrogen and phosphorus enters pond eco systems in feaces or other metabolic products, much of the nitrogenous wastes of fish and other aquatic animals is excreted as ammonia, which usually results in pollution of the water. Thus the amount nitrogen and phosphorus, though essential, should be reduced in fish diet. This can be done by careful, selection of ingredients when formulating fish diets.

Inclusion of dietary phytase in fish diet: This makes the chelated phosphorus available to fish and hence there is less faecal excretion, thereby reducing environmental pollution. This is available in powder form or in liquid. An example is Natuphos (Baruah *et al*., 2004).

Reduction in the utilization of fresh cattle blood in fish diet: The level of usage of fresh cattle blood should be minimized to a barest minimum possible both in pond culture and tank culture. Specifically, it should not even be used at all, when formulating diets for fish in tanks. It s high-level utilization, in feed formulation has resulted into serious alga bloom, thereby fouling the pond water.

Control of feeding regimes: Nutrient loading can also be minimized by controlling the feeding regimes. Control and restricted feeding reduces the nutrient load, as this gives a higher nutrients assimilation efficiency to fish (Usher *et al*., 1990).

CONCLUSION

Successful Aquaculture enterprise depends largely upon good environmental medium. Many of the problems retarding aquaculture today could be traced to poor environmental management, which in most cases is nutritionally induced. Concrete steps should be taken to tackle this problem. Several strategies have been discussed and should be adopted to suit specific practices to attain optimum and sustainable production from various culture systems with due consideration for the capacity of the environment, in particular the aquatic ecosystem. Future research, experimentation and application of proven effective approach, especially in the area of feed manufactures to formulate an environmentally friendly aqua feed with low pollution potential , which will ultimately lead to sustainable aquaculture in Nigeria and other developing countries.

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