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Waste Production in Aquaculture

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ABSTRACT

Due to rivalry resulting from the exploitation of natural resources such as soil and water by other production and development businesses, strengthening aquaculture has emerged as an alternative to boosting aquatic production. However, enhanced waste disposal from aquaculture production systems is required for resilience, as is extra inclusion, such as fish and food, in each cultural region. Polluted aquatic animal products have sparked public outrage and jeopardised the long-term viability of aquaculture operations. The need to boost aquatic product output cannot be overstated, and as a result, cultural systems must be developed that will increase fish production through effective waste management, reducing environmental deterioration caused by marine pollution and ensuring its sustainability. This paper examined the various aspects of waste production from aquaculture, including its sources, components, and management practises in various cultural systems, with a focus on waste production from food, feedstuffs, fertilisers, pesticides, herbicides, and other sources, as well as to identify waste sources, content, and potential hazards to both fish culture and the environment. To ensure the development of enhanced and sustainable aquatic animals, waste management proposals in diverse cultural systems were produced.

Keywords: *Aquaculture; Biostats; Natural Resources; Waste management*

INTRODUCTION

Aquaculture is gaining importance day by day as the study of crustacea, mollusca, and fishes has made much progress. It is required to know the background concentration of nutrients in receiving waters, as well as the emission of nutrients from the farm per unit of time and the water retention duration in a given area, in order to determine the environmental impact of aquaculture effluents. Though the forms of waste produced in aquaculture farms are essentially the same, the quality and quantity of the components vary based on the species cultured and the culture procedures used. Much of the material accessible is about extensive salmonoid culture systems, and to a significant extent, pens and cages in temperate climates. It was revealed that the poison is harmful to a variety of marine creatures and causes molluses to fail to reproduce or grow abnormally (Thain & Waldock,1986).

LITERATURE REVIEW

Aquaculture waste:

Farming of fish, crustaceans and bivalves generates waste in the form of particulate and soluble organic materials. The nature and amount of effluents vary with the design, species cultured and level of intensification. In general waste products (faces & excreta) and uneaten food (including pseudofaeces) are the major sources of inorganic and organic nutrients (predominantly organic carbon & nitrogen). The water column is the recipient for the dissolved material, while the largest proportion of solid wastes released settles to the seabed within the culture environment or in the immediate vicinity of the farm.

Classification of aquaculture waste products:

Aquaculture waste products are mainly of the following three types:

a. Residual food and faecal matter

b. Metabolic by-products

c. Residues of biocides and biostats

Other types of waste products:

1. Wastes can accumulate in land-based farms that use fertilisers to produce food organisms as a result of sedimentation, disintegration, and underutilization.

2. Tidal water fish ponds may receive additional organic matter in the form of suspended particles and dissolved nutrients as a result of inflows.

3. The use of therapeutically chemicals and hormones in aquaculture farms also yields waste.

Waste product composition:

The waste products contain organic carbon and nitrogen (carbohydrates, lipids, and protein), ammonia, urea, bicarbonate, phosphate, vitamins, therapeutants, and pigments.

The following are the components of aquaculture feed:

Feed comes in a variety of forms, including dry, moist, and wet. The content of commercially available feeds varies significantly, but all contain protein, carbs, and fat, as well as some supplements such as vitamins, therapeutants, and pigments. Håkanson (1988) gave typical values of composition of three types of typical salmon feeds in Nordic countries, which are shown in table 1.

Table 1: Composition of three types of typical salmon feeds in Nordic countries

Composition(g/Kg)	Moist Pellets	Dry Feed (Lower Energy)	Dry Feed (High Energy)
Dry Matter	325	900	900
Protein	170	500	450
Fat	60	120	240
Carbohydrates	50	150	100
Nitrogen	27	80	72
Phosphorous	4	15	10
Gross Energy (MCal/Kg)	1.3	4.6	5.2

Source: Pillay, 2004

Metabolic waste products derived from feed:

The production of faecal and excretory waste is obviously influenced by farm stock density. Experiments with rainbow trout have revealed that the amount of solid and dissolved organic metabolic products is proportional to the amount of food consumed (Pillay, 2004). Faecal output was estimated to be roughly 260g per kg of food ingested, or around 26% of total food consumption. Diets with fewer proteins and a larger percentage of carbohydrates have been found to be more digestible. It is estimated that 80 percent of shrimp feed is expelled as metabolites, surplus nutrients, faces, or used for maintenance (Primavera, 2006).

Only 27.2 kg of the 122.9 kg consumed nitrogen is retained, with the remaining 78 percent lost as faecal and excretory nitrogen (Pillay, 2004).If the nitrogen content of the faeces is 4%, 68 to 86 percent of the nitrogen consumed by fish is voided as soluble ammonium and urea, resulting in 32 kg of ammonium production per tonne of food supplied (Pillay, 2004).Ammonium excreted per tonne of fish in land-based trout farms is estimated to be 45 kg in Denmark and 55.5 kg in the UK (Pillay, 2004).

Effects

i. Bicarbonate is produced as a by-product of respiration and is expelled through the gills. Despite the fact that it is alkaline, it is unlikely to have a substantial impact on the pH of sea water due to the buffering effect of sea water.

ii. Phosphate produced on the farm is in particle form and has been shown to have no impact on the ecosystem in marine water.

iii. Eutrophication is caused by an increase in the amount of dissolved inorganic phosphates in fresh water.

Waste production from food and feedstuffs:

In a mussel farm, the build-up of faecal matter and debris under a raft might vary significantly. If a raft of mussels consumes 180 tonnes of organic matter, 100 tonnes is returned to the sea (Pillay, 2004), and the mussels add to the sediments to be digested at the sea bottom in the mussel bed.

In all types of Bivalvia cultivation, the accumulation of faeces and pseudofeces can be exceedingly high. The output of faeces and pseudofaeces from a typical oyster raft in Hiroshima Bay, Japan, housing 420000 oysters over a nine-month period was estimated to be 16 tonnes (Pillay, 2004).

Phaeopigments formed by the breakdown of chlorophyll as a result of the mussels feeding on phytoplankton were estimated to discharge 10 times more under the mussel than in area far away from the farm. The organic carbon produced by oyesters grown on rocks in France fluctuates periodically from 7.6 to 99 grammes per square metre per day, which is connected with phytoplankton seasonal change (Ottman & Sornin, 1985).

Effects

i. High rates of oxygen uptake come from the bacterial breakdown of organic materials.

ii. Bacterial breakdown frequently results in a reduced environment and the generation of hydrogen sulphide (H_2S), which is poisonous to oysters. (Ito & Imai, 1955; Pillay, 2004).

iii. It also increases Biological Oxygen Demand (BOD).

Feed loss:

In an aquaculture farm, feed generated wastes comprise not just faeces and other excretory products, but also unfinished feed. Feed loss is determined by a variety of factors, including the stock's feeding habits, feed water stability, feed distribution method, and feeding timing. The percentage of unconsumed feed in Danish trout farms is 10–30% waste fish, 5–10% moist pellets, and 1–5% dry feed (Drusano *et al.*, 1982; Pillay, 2004). These figures tend to be based on pond and trunk farm measurements. Feed losses are expected to be higher in marine or freshwater cage farms. Pillay (2004) determined a wastage of 27 percent and 31 percent for dry and moist meals in freshwater, respectively.

Fertilizer derived:

Pond farms, where the addition of organic or inorganic fertilisers is either the only or partial method of food generation for the cultured stocks, are an important aspect of aquaculture in tropical and subtropical locations.

The content of animal dung is highly diverse and is influenced by the animal's species, the type of food it eats, how the manure is handled and stored, and the weather. Organic matter ranges between 15% and 34%, total nitrogen between 0.3 and 1.7 percent, and phosphate (P_2O_5) between 1.25 and 2.96

percent (Pillay & Dill, 1976). Animal manure increases heterotrophic bacteria development in the water body.

Despite the fact that organic fertilisers are favoured in aquaculture, many farms utilise inorganic fertilisers alone or in conjunction with organics. The primary nutrients, nitrogen, phosphorous, and potassium (NPK) are all included in inorganic fertilizers. Nutrients including calcium, magnesium, and sulphur, as well as trace minerals like copper, zinc, boron, manganese, iron, and molybdenum, may be present. Fertilizer is sprayed in quantities that the ponds can quickly use to produce the desired food organisms. Dosage must be regulated according to feeding intensity to avoid the formation of an algal bloom, which might cause unfavourable conditions.

Residues of Biocides and Biostats:

Chemicals and other poisonous compounds are often employed to control predators, pests, and weeds on land-based farms, particularly pond farms, as part of pond preparation before stocking with larvae, fry or fingerlings.

Pesticides

To rid aquaculture water of pests and predators, tea seed cake, derris powder, and rotenone are commonly employed. Tea seed cakes have a saponin content ranging from 10–15%. After lowering water, a dose of 216 kg of tea seed cake and 144 kg of quick lime is placed at the pond bottom per hectare. Within 2-3 days, the toxicity is gone. Rotenone, in the form of derris powder, is used for the same purpose, and the toxicity lasts for around 48 hours (Wood *et al.*, 2005). Under tropical conditions, even at doses of up to 20 ppm, toxicity ceases after 8 to 12 days (Alikunhi, 1957; Jhingran, 1986).

DDT, endrin, aldrin, and 2,4-D are examples of non-selective poisons used as pesticides to eliminate pests and predators. Snails and polychaete worms are controlled with bayluscide and nicotine, while crabs infesting pond dikes are controlled with BHC and the insecticides 'sevin`.

Herbicides:

Various types of herbicides are used to eradicate emergent, floating, and submerged weeds in tropical areas. Herbicides like 2,4-D and Diquat are extensively used for controlling floating and emergent weeds. Copper sulphate and simazine are used to control submerged weeds and have a long-term impact on pond productivity. Anhydrous ammonia is used to kill densely growing underwater weeds and has a nutrient-like effect on the water.

Environmental Impact:

Even though the toxicity of all pesticides used to manage weeds, pests, and predators in tropical pond farms is unknown, the culture procedures make it unlikely that they will have a significant environmental impact. It is assumed that farm waste releases will have long-term consequences. Dipterex, an insecticide, has been discovered to be rapidly hydrolyzed in tropical pond conditions (Haque & Barua, 1988; Beveridge & Phillips, 1993).

Chemical use has a greater direct influence on the ecosystem in open-water aquaculture, such as mollusk farming in coastal areas and cage and pen finfish farming. Pesticides such as Neguvon and Nuvon have had deadly effects on crustaceans in the vicinity of farms in certain conditions, such as salmon net-pin farming in Norway, where pesticides such as Neguvon and Nuvon are used to eliminate fish lice (Egidius & Moster, 1987). Because of their high biological effectiveness, even in ultra-micro amounts, pesticidal compounds are among the most challenging to analyse. They are frequently beyond chemical detection limits, necessitating the use of a mix of bioassay and chemical approaches to investigate them (Walker 1976; Stickney 1979).

Tributyltin (TBT) is an antifoulant that has been investigated in terms of its environmental impact. Because of their high toxicity to fouling species, low toxicity to humans, and lengthy antifouling protection, tributyltin (TBT) compounds are commonly utilised on pleasure boats, harbour construction, and marine cages. TBT's toxicity was originally discovered on oyster beds in regions frequented by pleasure boats in France (Arcachon Bay). Poor spawn output, aberrant larvae, and shell deformity were detected, and tributyltin (TBT) was suspected of being the cause (Alzieu & Heral, 1984; Kan-atireklap *et al*, 1997). Following research, it was discovered that the toxin has a deleterious effect on various types of marine life, and that it causes reproductive failure or growth anomalies in molluses (Cardwell & Sheldon, 1986; Paul & Davies, 1986; Thain & Waldock,1986). Recent research has found that tributyltin (TBT) can kill caged fish and accumulate in their tissues.

How Production Dynamics Affect Aquaculture Waste Generation:

Aquaculture production is based primarily on three structural elements: the cultural elements, the cultural environment, and the cultural species and management practices. Production dynamics are defined as the way these structural elements change over time, how they are controlled and their inter-relationship. The functioning of the cultural environment involves chemical, biological, and physical processes influenced by external conditions (i. e., climatic factors & management practices).

Recent studies focusing on the dynamics of marine shrimp culture systems have shown that quality variables like dissolved oxygen (DO), pH, and temperature may change significantly over a 24-hour period due to respiration and photosynthesis. In addition, seasonal variations in rainfall may affect salinity, which decreases during the rainy season and increases during the dry season. Water transparency, pH, and dissolved oxygen concentration may also fluctuate over the growth cycle, exhibiting a decline pattern. This is mainly a result of an increased accumulation of uneaten food, which leads to higher bacterial growth. In semi-intensive shrimp ponds, polychaete populations may be drastically reduced by the end of the rearing period due to the shrimp's predation pressure.

The cultured animal may show changes in its feeding behaviour and physiology over the growth cycle. For example, some *Penaeus* species may change their diet over the rearing period, which often involves a shift from detritus-based sources to more animal-based sources at a larger body size.

DISCUSSION

Can aquaculture waste be reduced?

Several alternatives have been proposed for reducing aquaculture waste material entering coastal water. These include:

- The treatment of effluents through the construction of sedimentation ponds for decantation and biological oxidation of organic matter.
- Polyculture or integrated culture of filter-feeding organisms such as oysters, mussels, seaweed with fish or shrimp (Primavera, 2006).
- Feeds should be allocated according to the cultured animal's spatial distribution in the culture environment.
- The quantity of external feed inputs should be balanced with the biomass of naturally occurring food and the on-genic patterns in feed intake by the cultured animal (Dauda *et al.*, 2018).
- A uniform feed distribution favours a higher level of food intake among the cultured species that display homogenous spatial distribution patterns.
- Feed particle size should be increased in response to the handling efficiency of the cultured animal.
- Before being fed, the feed should be sieved to eliminate dust and broken pellets, and it should be provided effectively to guarantee that there is little or no waste from uneaten feed. (Dauda *et al.*, 2018).

Waste is processed in aquaculture and allied businesses, which is thought to constitute a substantial threat to the ecosystem. Appropriate technologies should be employed to reduce pollution. The conversion of these wastes, as well as the simultaneous collection of critical materials before disposal, has become the primary goal of fishery management. Fish wastes can be used to produce valuable products like biogas and biofertilizer (Pędziwiatr, 2017).

Evaluate the assessment approaches for local versus regional scenarios, for regions with varied farm density and hydrodynamic conditions, using modelling and satellite monitoring (Olsen, Holmer & Olsen, 2015).

Most solids may be removed with minimal labor in circular tanks with appropriately built inlets, drains, and filters. Filters such as drums, discs, beads, and sand catch etc remove particles as small as 60 microns from water. Artificial shallow wastewater treatment systems (ponds or canals) that have been planted with aquatic plants and rely on natural processes to clean wastewater are known as constructed wetlands. Constructed wetlands have an advantage over alternative treatment systems because they function with minimal energy (Miller & Semmens, 2002).

CONCLUSION

Many of the environmental issues relating to aquaculture waste production in the tropics are still speculative because definitive studies are not yet available. Research is required to define the sustainable carrying capacity of coastal areas in terms of supporting aquaculture production and assimilating wastes. It is argued that in some coastal areas of poor productivity, aquaculture effluents can actually be beneficial and that coastal environments have a high capacity to flush nutrients out into adjoining water. Such attributes, however, should not be over-emphasized. In many cases, effluents are discharged in small areas with limited water supplies, poor water exchange, and heavy farming. In general, mismanagement and intensification are recognized as the main causes of organic loading in the aquaculture system and in adjacent coastal areas.

The dynamic nature of tropical aquaculture systems has limited attempts to further improve farm management techniques associated with waste production. Alternatives, such as the treatment of waste through sedimentation ponds and polyculture with filter-feeding organisms, have not yet been widely accepted due to constraints related to the requirement of a large proportion of the farm area and problems associated with diversification of production. Therefore, the amount and effects of aquaculture waste discharged into coastal areas are highly dependent on the dynamics of the culture environment and the cultured species, which, on the other hand, can influence the effectiveness of management practices. This implies that in the short term, effective reduction of aquaculture waste can only be achieved after a detailed description and quantification of the cultured species' feeding patterns and their relationships with the culture environment have been made. This will allow the development of user-friendly simulation programs that combine the various components of the culture system, assisting farmers in the complex decision-making process of feed management.

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