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A REVIEW OF THE IMPACTS AND MITIGATIONS OF CATFISH EFFLUENT ON THE ENVIRONMENT

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Abstract

Effluents from fish ponds/tanks contain living and dead particulate, organic matter, ammonia, nitrite, nitrate, phosphate, suspended soil particles and other substances that can be considered potential pollutants. Agencies responsible for water pollution abatement considered the aquaculture industry that generates pond effluent as one of sources of environmental pollution. As a result of this, there is a need for proper treatment and disposal of pond effluents in order to ensure environmental preservation and maintenance of the aesthetic values of the environment. Studies have shown that of the two methods, wetland disposal and mechanical aerator, used for catfish effluent reduction, the use of mechanical aerator seemed to be more effective and it has several advantages over the wetland disposal method for effluent treatment. The impacts of aquaculture effluents on the environment were highlighted. Fish feed properties that could enhance catfish effluent treatment and disposal to overcome the impacts on the environment were highlighted, given that fish feed waste constitutes a major portion of pond effluents. Methods of reducing the impacts of fish ponds effluent on the environment and the best management practices for effluent control and reduction were discussed.

1.0 Introduction

Effluents from fish ponds/tanks contain living and dead particulate, organic matter ammonia, nitrite, nitrate, phosphate and suspended soil particles and other substances that can be considered potential pollutants [1]. The most significant of these pollutants are nutrients (nitrogen and phosphorus), suspended solids (SS), and organic matter [2]. Erosion of embankments, pond bottoms, and discharge ditches are the main sources of suspended solids in catfish pond effluents [3]. Therefore, agencies responsible for water pollution abatement consider the aquaculture industry as a polluter. The effects of pond effluents are highlighted by Boyd [4, 5] as follows: It produces offensive odour, impacts on aesthetic value of the environment, reduces dissolved oxygen, pollutes water body and introduces diseases. The need for proper disposal of pond effluents is paramount in order to ensure environmental preservation and maintenance of the aesthetic values of the environment. The effects of pond effluents are highlighted by [6, 7] as follows: It produces offensive odour,

impacts on aesthetic value of the environment, reduces dissolved oxygen, pollutes water body and introduces diseases. The primary concern was not the release of toxic substances, but that effluents may promote eutrophication. The potential effects of aquaculture effluents on receiving bodies of water are:

(i) an increase in organic matter loading, resulting greater oxygen demand
(ii) an increase in nitrogen and phosphorus concentrations, producing algal blooms
(iii) an increase in sedimentation and
(iv) toxicity following the discharge of hypolimnetic water (cold water region), leading to decrease metabolic rate of cultured fish.

The effects of high concentrated suspended solids were highlighted by [8, 9] which are as follows:

(i) It degrades aquatic ecosystems by increasing turbidity and reducing the depth to which sunlight can penetrate
(ii) It decreases photosynthetic activity and oxygen production by plants and phytoplankton
(iii) It decreases the growth of aquatic plants and also affects a variety of aquatic life that use the plants as habitat
(iv) It increases the temperature of surface water because the particles absorb heat from the sunlight
(v) It reduces the levels of dissolved oxygen

Pond effluents from catfish released during fish harvesting are highly polluted due to suspended of sediment by seining efforts [10]. The effects of continuous suspension catfish effluent on fresh water quality depends on methods of drainage, amounts of water drained during the harvesting and the concentration of pollutants in the effluents [11]. About 20 to 30 % of nitrogen and phosphorus applied during feeding are observed in fish at harvest [10]. About 70% of the nitrogen and phosphorus from feed and fertilizer in aquaculture are left in pond water and can potentially be discharged to the environment [11]. The effect on receiving waters will depend largely upon the volume and strength of effluents in relation to the volume of the receiving water body and the aquatic species present in the receiving water body [2]. Catfish Production is the largest segment of aquaculture in Nigeria. Most catfish are cultured in the southern part of Nigeria, and the industry is economically important to several other states. The most popular species that have been proven as desirable for culture in Nigeria are the *Clarias gariepinus*, *Heteroclarias*, and *Heterobranchus species* [12]. There are numerous publications on the catfish pond effluents [3, 6, 13, 14]. These studies were mostly conducted over short periods of time and in experimental ponds. It is difficult to draw logical conclusions from these studies because the quality of catfish pond effluents varies with location, season, farm management practice, amounts of overflow after rains, and amounts of water drained during harvest. Water in catfish ponds usually has higher concentrations of nitrogen, phosphorus, organic matter and biochemical oxygen demand than natural surface waters in the vicinity [3, 15] reported that catfish effluent affects both physical and chemical properties of the soil; it contains higher concentration of macro and micro nutrients than that of soil at the disposal sites. The quality of soils at the immediate discharge site appears to be favourable in respect of soil enhancement [15]. It has impact on soil quality in the immediate environment of the discharge site. Discharge of untreated wastewater pollutes the soil and surface water and this could be heightened during flooding which is still a menace in Lagos State [16]. Two natural features minimize the impact of pond discharges on the environment were

waste treatment processes within the ponds and the relatively low volume of water discharged at any one time [1]. Others are reuse of water for irrigation (integrated system) is another way to remove nitrogen and phosphorus from effluents and reclaim them for agricultural production. The uses of constructing wetlands [17] and sedimentation basins [3] as effluent treatment were highlighted; and sedimentation basins are easier to build than wetlands and can be as effective as wetlands in treating catfish farm effluents [18]. Some developed countries have developed standards and criteria for pond effluents; they require permits for discharging ponds effluents into natural water and effluents characteristics must comply with specifications set forth in the permit. The potential impact of fish farms effluents on water bodies (environment) is not well studied in Nigeria. Therefore, procedures for regulating, controlling and monitoring the environmental impact of fish farms are not well established. Lack of site-specific data on the effluent quality of farms and on their impact on receiving environment is a major constraint on the establishment of such regulating measures and adoption systems. The paper aims at reviewing the catfish pond effluents and its impacts and mitigation on environment.

2.0 Pond Effluents and Environment

In 2006, world aquaculture production was about 51.7 million tonnes, and almost 15 times greater than 1970 production of 3.6 million tons [19, 20]. Trends in modern aquaculture are shifting more toward intensive aquaculture. Feed, aeration, fertilizer, and chemical substances help farmers overcome limitations in natural aquaculture productivity and improve both quantity and quality of aquaculture production. On the other hand, the increasing intensity of production has caused a large impact on the environment. Environmental impacts resulting from aquaculture include:

(i) Destruction of mangrove and wetlands
(ii) Excessive use of chemicals
(iii) Inefficient utilization of fish meal
(iv) Salinization of land
(v) Excessive use of water
(vi) Spread of aquatic animal disease
(vii) It reduce of biodiversity
(viii) It promotes conflicts with other resource users
(ix) It causes water pollution

Of the above listed environmental impacts, water pollution is the most common concern for most nations [21, 22]. Effluents from ponds or tanks as culture units were influenced by feeding type and quality [1, 23]. Effluent quality depends on application rate and system of farming [21, 22]. The principal source of aquaculture waste is ultimately the manufactured feeds that are necessary to increase production beyond national levels [24]. Untreated wastewater usually contains among other contaminants, nutrients, mainly nitrogen and phosphorus that can stimulate the growth of aquatic plants, which in turn results in various environmental pollution related problems. The uneaten (leftover) portion of the food has high BOD and is the most direct source of waste while the excretory wastes are secondary derived from the food that is consumer but unassimilated by the fish. This can be minimized through distribute fish feed in a way that allows for the opportunity (sufficient time and space) for fish to consume all the feed and to achieve adequate growth while minimizing feed waste [23,25] makes the following recommendations for feeding and prevention of feed waste which are as follows:

(i) The potential performance of the diet must be known for the size and species of fish. This may require labeling food with information on digestibility and waste generation, such as quantity of solids, nitrogen, and

phosphorus. It could also provide information and feed conversion and growth rate obtained under controlled environmental conditions.

(ii) The biomass of fish in the system must be known.

(iii) The health and conditions of fish must be known (appetite)

(iv) Fish should be relatively uniform in size and capable of accepting a single-size pellet.

(v) Broken pellets and dust should be sifted out before feeding, and feed systems must not damage the pellets.

(vi) Feed should be applied in a manner to maximize its consumption by fish.

(vii) Feed should be applied at slightly below maximum ratio.

Quality of effluents influenced by type of feeding, method of harvesting and drained point;deep stratified ponds that are drained from the deepest point, initial discharge may be oxygen –depleted and contain high concentrations of reduced substances such as ferrous iron and hydrogen sulphide [22]

2.1 Pond Effluents on Environment

The effects of effluents on the environment depend on type of ponds in operation, volume of pond in relation to area, runoff producing features, the amount of rainfall, exchange and dilution and assimilation of receiving waters [1, 23]. Watershed pond overflows during the wetter parts of the years. While levee ponds usually are supplied by water from external sources and do not receive significant runoff. Therefore, they have much less overflow from storms than watershed ponds. Obviously, water exchange increases the amounts of effluents from ponds. There are no standard practices on water exchange. Water exchange decreases from nursery to holding pond. In brackish water ponds, water exchange is frequently used and exchange rates normally range from 2% to 5% per day in extensive aquaculture as high as 30% to 40% per day in intensive aquaculture [26].In flow-through aquaculture systems, like raceways and tanks, effluents are discharged to the environment with enhanced concentrations of nutrients and solids. Such effluents may have a serious negative impact on the quality of the receiving water when discharged untreated [27 - 29]. [30] compared older established fingerling pond effluents with those of newly established ponds and found that settleable solids, biochemical oxygen demand (BOD) and soluble reactive phosphorus were slightly, but significantly, higher in effluents of older ponds, characterized by a higher accumulation of organic matter. [6, 9, 14, 31 - 33] recommended the following measures for reducing the impacts of fish ponds effluent on environment which are as follows:

(i) Use high-quality feeds and efficient feeding practices.

(ii) Manage within a ponds assimilative capacity.

(iii) Provide adequate aeration and circulation of pond water

(iv) Position mechanical aeration to reduce erosion.

(v) Minimise water exchange

(vi) Operate food fish production ponds for several years without draining.

(vii) Capture rainfall to reduce pond overflow.

(viii) Allow solids to settle before discharging

(ix) Reuse water that is drained from ponds.

(x) Treat effluents by using constructed wetlands

(xi) Use effluents to irrigate terrestrial crops.

(xii) Divert excess run off from large watersheds away from ponds.

(xiii) Optimize the ratio of watershed to pond area.

(xiv) Construct ditches to minimize erosion and establish plant cover on banks.
(xv) Protect embankments in drainage ditches from erosion.
(xvi) Maintain plant cover on pond watersheds.
(xvii) Avoid leaving ponds drained in winter, and close valves once ponds are drained.
(xviii) Close drain values when renovating ponds.
(xix) Use sediments from within ponds to repair levees, rather than disposing it outside of ponds.
(xx) During pond renovation, excavate to increase operational depth (increased water storage will reduce volume of effluents).

3.0 Methods of pond Effluents treatment

The two common methods of catfish effluent reductions were wetland and mechanical aerator**.**

3.1 Wet land Method: The findings revealed that the cell planted with vertiver grass (wet land) removed 83.8% of the TN_2- N, 81.42% of the TSS, and 67.47% of the BOD, 73.6% of the $N0_2$- N and 3% TP [34]. That for a plant to be useful for agriculture and biological engineering and accepted as safe, it should have as many as possible of the following characteristics [35]:

(i) It should exhibit xerophytic characteristics if it is to survive the forces of nature.
(ii) It should have a deep penetrating root system, capable of withstanding tunneling and cracking characteristics of soils.
(iii) It should be capable of growing in extreme soil types, regardless of nutrient status, pH, acid sulphate or salinity and toxic minerals. This includes sands, shale, gravels, and even more toxic soils.
(iv) It should be capable of developing new roots from nodes buried by trapped sediments, and continue to grow with the new ground level, to eventually forming natural terraces.
(v) It should be totally free of pests and diseases and should not be an intermediate host for pests or diseases of any other plants.
(vi) It should be cheap and easy to establish as a hedge and easily maintained by the user at little cost.
(vii) It should be easily removed when no longer required

3.2 Mechanic Aerator: The findings revealed that paddlewheel aerator reduced TSS (24.4±1.5 %), TN_2-N (53.3±1.2 %) , TNH_3-N (65.2±1.2%) , NO_2-N(97.1±1.1 %) , TP (61.8±1.1%) and BOD_5 (54 ±1.5 %). compared with natural purification 33.9±1.6 % of TSS, 22.7±1.4 % of N_2-N, 29.3±1.6 % of NH_3-N, 53.9±1.2 % of NO_2-N, 21.6±1.5 % of TP and 15.4±1.6 % of BOD_5at the same dilution ratio [36]. Paddle-wheel aerator proved to be efficient alternative means of controlling catfish effluents to biological method which required large areas of cover crops [36].It has several advantages over wetland include: It occupies small land area, portable, effectiveness, simplicity, no need for a preliminary treatment before the effluent treated, more effective used for nutrient resources and it does not expose the odour of the waste stream as occurred in an improper designed and implemented wetland.

4.0 Mitigation of Impacts of Catfish Effluents on Environment

The [37] highlighted that there are several ways of regulating effluents include: discharge not allowed; discharge allowed

only if effluent quality is within specified limits (water quality restrictions also may apply); discharge allowed only if Best Management Practices (BMPs) are used; discharge is allowed but charges are applied to effluent pollution loads. The first option of no discharges in unsuitable for many types of aquaculture facilities because of overflow after rains, water exchange often is necessary to maintain suitable water quality, and ponds must be drained for harvest. Discharge permits with water quality criteria and water volume criteria require monitoring and reporting at regular, specified intervals to show compliance [37]. Much research has been conducted in order to find possible and efficient ways to improve the quality of aquaculture effluents as well as mitigation [3, 38] highlighted that the best management practices (BMPs) are considered the most practical approach to control effluent volume and quality from aquaculture farms because effluents from there are many guidelines for aquaculture effluents that producers may voluntarily adopt. They are as follows:

1. Reduce effluent volume.
   - Control the volume of inflow to lessen overflow.
   - Harvest fish without completely draining ponds.
   - Maintain storage capacity in ponds to store rainfall and avoid overflow.
2. Minimize suspended solids through erosion control.
   - Control erosion on watersheds by providing vegetative cover, eliminating gully erosion, and constructing terraces.
   - Eliminate steep slopes on roads and cover roads with gravel.
   - Provide grass cover on earthwork and position aerators to avoid water currents from impinging on earthwork.
3. Improve pond water quality.
   - Do not overfeed.
   - Use high quality feed that are not excessive in nitrogen and phosphorus content.
   - Use plenty of mechanical aeration.
4. Use therapeutic agents and other chemicals correctly.
   - Carefully follow instructions for use on labels of therapeutic agents and other chemicals.
   - Store chemicals under a roof to prevent them from washing into rainfall.
   - Diagnose diseases and obtain recommendations for treatment before applying therapeutic agents.
5. Build new farms or farm expansions correctly.
   - Construct new ponds according to Natural Resources Conservation Service (NRCS) standards.
   - New ponds should be located on watersheds that are not disturbed by subdivisions, industry, or row crops.

It should be stressed that BMPs are not fixed rules. BMPs change as knowledge, technology, and site location change, so they need to be reviewed and updated to reflect these changes

5 Conclusion

Catfish effluent has impacts on environment. The concentration of catfish effluent was influenced by feeding rate and quality. Wetland and mechanical aerator are two common methods used for catfish effluent treatment. Mechanical aerator was more effective in nutrient resources and it has several advantages over wetland for effluent treatment.

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