IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 13, Issue 1 Ver. IV(Jan. - Feb. 2016), PP 64-71www.iosrjournals.org

Performance Evaluation of a Developed Paddle Aerator on Catfish Effluent in Lagos State, Nigeria

Omofunmi O.E.[1],J.K[2]. Adewumi., A.F[2]. Adisa., and S.O[3] Alegbeleye
[1]*Department of Agricultural and Bio-Environmental Engineering, Yaba College of Technology, Yaba-Lagos, Nigeria*
[2]*Department of Agricultural Engineering, Federal University of Agriculture Abeokuta, Nigeria.*
[3]*Department of Fisheries and Aquaculture, Federal University of Agriculture, Abeokuta, Nigeria.*
Corresponding Author: Omofunmi, O.E. E-Mail Address: omofunmieric@yahoo.com

Abstract: *Catfish production is one of the largest segments of fish culture in Lagos State, Nigeria. However, catfish effluents, which usually deteriorate the environment, need to be controlled. The effect of paddle-wheel aerator in catfish effluent was evaluated. The volume of catfish effluent was collected into two basins and diluted at given ratios. The paddle-wheel aerator was installed in one basin, while another basin served as control in determining the impact of paddle wheel aerator on catfish effluents. Water qualities such as Total Suspended Solids (TSS), Total Nitrogen (TN), Total Phosphorus (TP), Total Ammonia (TNH_3) and Nitrite (NO_2-N) and Biochemical oxygen demand (BOD_5) examined and analysed. Results indicated that paddle-wheel 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_5 at the same dilution ratio There were significant different ($P \leq 0.05$) between paddle wheel aerator and natural purification in concentrations reduction. The paddle wheel aerator was found be relevant in the water quality improvement and thus recommend for small and medium scale fish farmers in controlling effluents.*

Key Word: *Catfish, Effluents, Lagos State, Paddle- wheel aerator, Performance evaluation, Water quality.*

I. Introduction

The catfish industry plays is very important role in the Nigeria aquaculture industry as the largest segment of aquaculture in the Nigeria (Adekoya et al, 2006). Most catfish are grown in the southern part of Nigeria, and the industry is economically important to several of these states. The most popular species that have proved desirable for culture in Nigeria are the Clarias gariepinus, Heteroclarias sp, and Heterobranchus species (Adekoya et al, 2006). The importance of Clarias geriepinus has no less than elsewhere in Nigeria based mainly in the farmers and consumer preferences. There are numerous publications on the subject of catfish pond effluents. These studies were mostly conducted over short periods of time and in experimental ponds It is difficult to draw conclusions from these studies because the quality of catfish pond effluents varies with location, season, farm management practice, amounts of overflow after rains, method of drained and amounts of water drained during harvest. Ozbay (2002) highlighted that the quality of catfish effluent can be judged from level of turbidity. Turbidity causes that affected quality of catfish effluent are as follow: Suspended clay particles, mechanical activities and channel catfish activities. Boyd, et al, 2000 reported that, water in catfish ponds usually has higher concentrations of nitrogen, phosphorus, total suspended solids, organic matter, and biochemical oxygen demand than natural surface waters in the vicinity. Boyd, (1990, 2001a, 2003) has earlier found that fishpond wastewater has offensive odour, which impacts on aesthetic value of the environment, reduces dissolved oxygen, pollutes water body and introduces diseases. The effects of effluents on the environment depend on type of ponds in operation, method of drained, in-system treatment processes, volume of pond in relation to area, runoff producing features, the amount of rainfall, exchange and dilution and assimilation of receiving waters. Natural bodies of water also have the capacity to assimilate organic matters and nutrients but, it depends on the volume of effluents and quality of effluents that enter the water body only when the self- purification capacity of water has not been exceeded, surface water disperse waste via transportation, sedimentation, dilution and diffusion. Researchers likes Boyd (2001a, 2001b, 2003); Tucker *et al*., (2002); Tucker and Hargreaves, (2008); and Tomasso, (2002) have suggested ways to improve the quality of aquaculture effluents which include: aeration and circulation, reuse of water for irrigation in integrated system, reuse of water for multiple fish crops, biological method such as natural nitration (grass strips and construction wetlands) and sedimentation basins. Ozbay (2002) reported that the cell planted with vertiver grass removed 81.42 % of Nitrogen, 46.2 % of TSS, and 67.5 % of BOD_5 from catfish effluents. Grate et.al (2000) findings indicated that the rice crops removed 32 % of total Nitrogen and 24 % of total Phosphorus from catfish effluents. Boyd and Tucker (2000) reported that coastal Bermios Dallis grass and Bahia grasses (grass strips) removed 62 % of TSS, 34% of BOD_5 and 22 % of Nitrogen. Schwartz and Boyd (2001) highlighted that constructed wetland to purify catfish pond effluents after two days, removed 92.6 % of BOD_5, 92.1 % of TSS, 60.7 % of Nitrogen and 55 % of total Phosphorus. Aeration has been used in increase the dissolved oxygen concentration in water, reduce taste and odour and remove certain volatile organic compounds. The most common aerators used in water treatment are: Gravity, Fountain, Injection or Diffused and Mechanical aerators. Catfish effluents, which usually deteriorate the environment, need to be controlled. The biological method earlier mentioned requires a large area of land for filtration by cover crops seems unsuitable. A viable alternative is the paddle-wheel aerator. Paddle-wheel aerator has not been used in catfish effluents reduction The objective of the present study was to evaluate the effects of paddle wheel aerator in catfish culture effluents in Lagos, Nigeria.

II. Materials And Methods

2.1 Source of Materials and Sample Preparation

Catfish effluents samples were collected from Fish Farms situated closely to Lagos State Polytechnics, Ikorodu in Lagos State, Nigeria. Figure.1 depicts the sampling site at Ikorodu. Plate .1 shows the paddle wheel aerator locally developed for wastewater quality improvement. The experiment made of two aerator test basins (A and B), each contained $1m^3$ volume of mixture of untreated catfish effluents and volume water at given dilution ratio (d_{r1}, d_{r2}, d_{r3}, d_{r4}, and d_{r5}) at 1:4 (05), 1:9 (10), 1:14 (15), 1:19 (20) and 1:24 (25) respectively.

2.2 Experimental Methods

Paddle wheel aerator machine was powered by one horse power motor (0.75 KW), with six paddles which was installed on the plastic tank A, while plastic tank B, served as control. The aerator was run for two hours. The required water qualities for both the tanks were determined and analyzed for two hours at thirty minutes interval for three days (designated as T_1, T_2, and T_3) respectively. Physical and chemical properties analysis which included Total Suspended Solids (TSS), Total Nitrogen (TN), Total Phosphorus (TP), Total Ammonia (TNH_3), Nitrite (NO_2) and BOD_5, which were analyzed in accordance to the APHA standard.

2.3 Measurements

2.3.1 Nitrogen, Nitrite, Nitrate and Ammonia: 100 ml of filtered water sample was collected in Kjeldahl flask fitted with distillation unit. 1g of Magnesium oxide (MgO) was added and distillation started; 25 ml of distilled was collected. 1g of devards alloy was added to the remaining volume of the flask and distillation started again. 25 ml of distilled was taken into two separate Nessler tubes and 0.5 ml Nessler reagent was added to each tube. The mixed solution started developing colour. This colour after 10-15 minutes was matched against colour discs of a Nesslenizer (BDH Nesslenizer). Nitrogen content (mg/l) is expressed as follows: N, NO_2, NO_3 and NH_3 (mg/l) = umber of matchng division of the standard dics × 100 × 0.01 (APHA, 2005).

2.3.2 Phosphorus (mg/l): 50ml of filtered water sample was put in a nessler tube. 2ml of sulphomolybdic acid and 5 drops of stannous chloride solution were added. The mixtures were mixed thoroughly. The developed blue colour after 3-4 minutes was compared with nesslenizer standard colour discs. The phosphate content (P_20_5) in mg/l is expressed as follows:

Phosphate (mg/l) = disc reading for 50mm × 2 × 0.01 (APHA, 2005).

2.3.3 Suspended solid (mg/l): 50 ml of samples through pre – weighted glass fibre paper dried for 30 minutes and weighed again. The suspended solid content of the sample is the difference in the weight of filters. For a given sample location, the experiments were repeated three times and average reading were taken (APHA, 2005).

2.3.4 Biochemical oxygen demand (BOD_5): The BOD was determined by Winkler's method. Water sample for BOD were collected at each location in 100 ml BOD bottles without agitating. The initial DO content is determined as stated; stopper was carefully removed. 1ml each of sodium iodide (Nal) solution and magnesium Sulphate ($MgSO_4$) solution were added with aid of 1ml pipette, the stopper was replaced and the content was thoroughly mixed, 2.0 ml of concentrated Sulphuric acid (H_2SO_4) was added mixture, 50ml of the solution was titrated with 0.025N of Sodium thiosulphate ($Na_2S_2O_3$) with starch solution as indicator of the colorless end point. After 5 days, incubated bottles, DO was determined using the above procedure

The BOD_5 (mg/l): Initial DO of sample – DO of sample after 5 day X 100 /ml of percentage of sample added (APHA, 2005).

2.4 Data Analysis

SPSS program version 17.0 was used for statistical analysis. Mean values of each parameter measured was compared using Duncan`s multiple range test. The statistical inference was made at 0.05 (5%) level of significance.

Fig 1: Map of Lagos State, Nigeria.

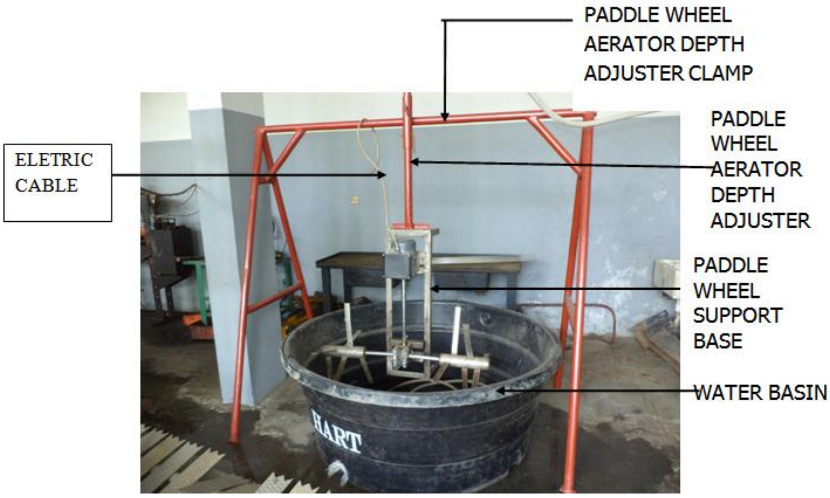

Plate 1: Mounted Paddle wheel aerator for operation

III. Results And Discussion

The impact of Paddle Wheel Aerator on Catfish Effluents

The paddle wheel aerator and dilution effects on the quality of catfish effluents were evaluated and the results were as presented in Figures 2, 3, 4, 5, 6, 7 and 8 respectively.

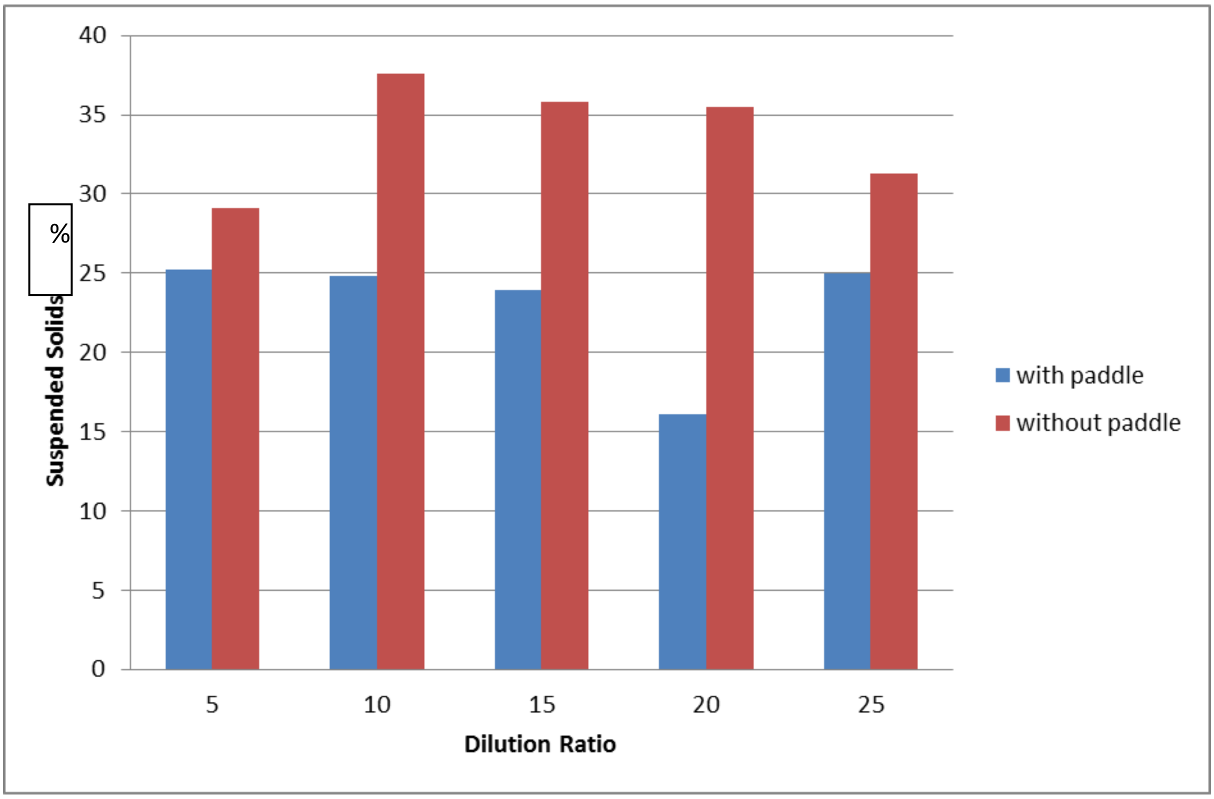

Fig.2: Bar Chart showing the percentage reduction in Suspended Solids (%) with and without paddle wheel aerator at given dilution ratios

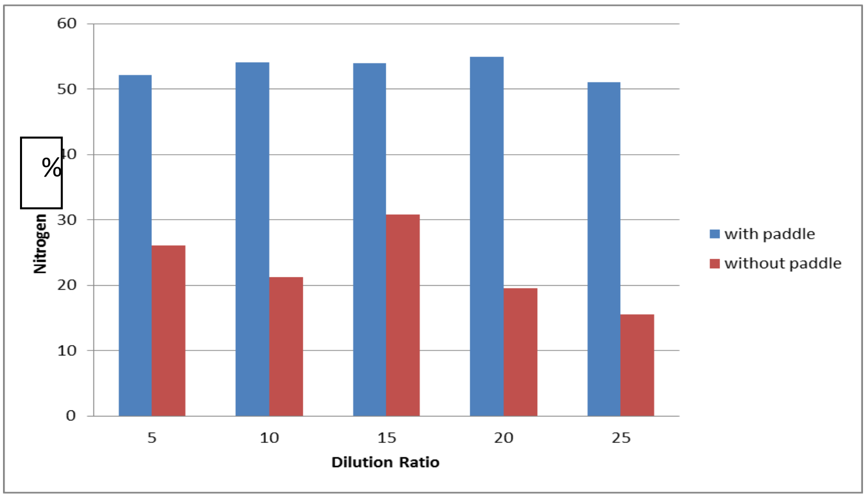

Fig 3: Bar Chart showing the percentage reduction in Nitrogen (%) with and without paddle wheel aerator at given dilution ratios

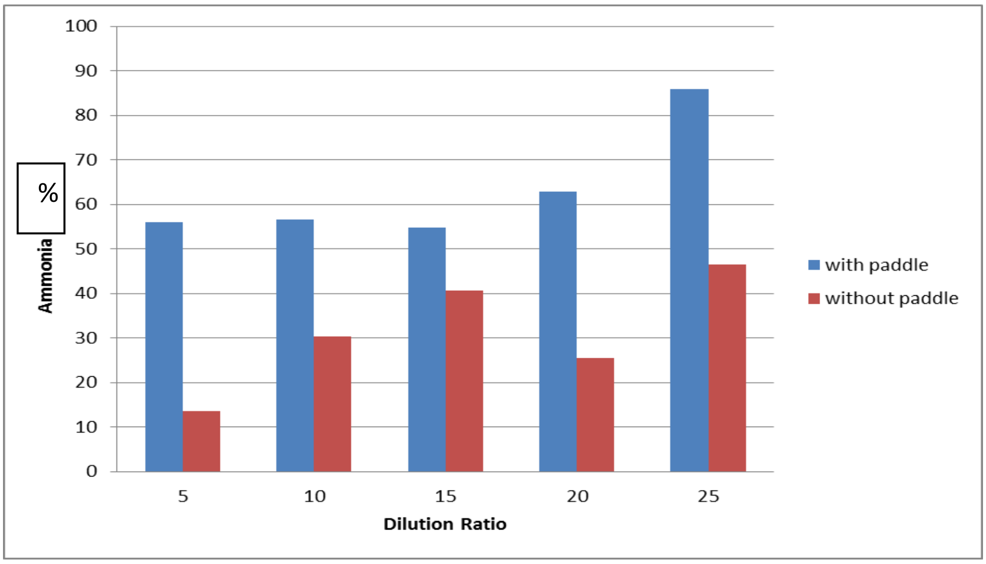

Fig 4: Bar Chart showing the percentage reduction in Ammonia (%) with and without paddle wheel aerator at given dilution ratios

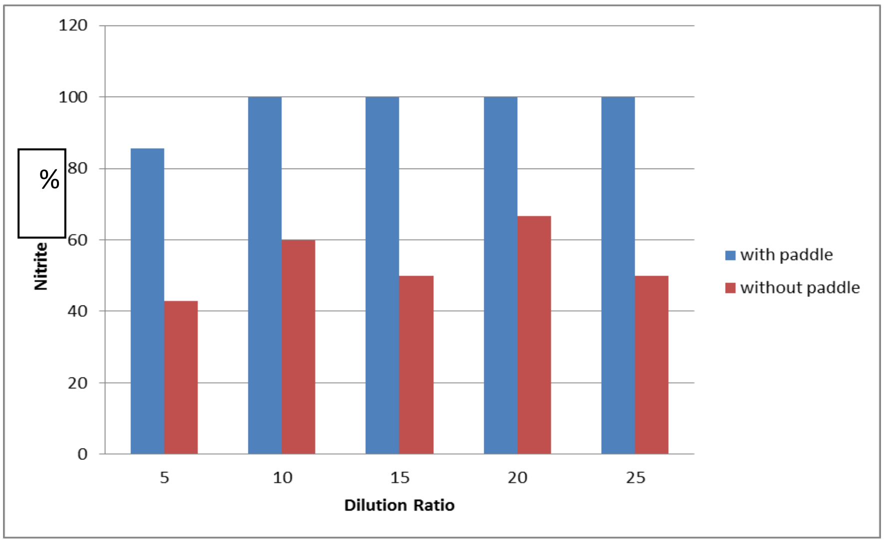

Fig 5: Bar Chart showing the percentage reduction in Nitrite (%) with and without paddle wheel aerator at given dilution ratios

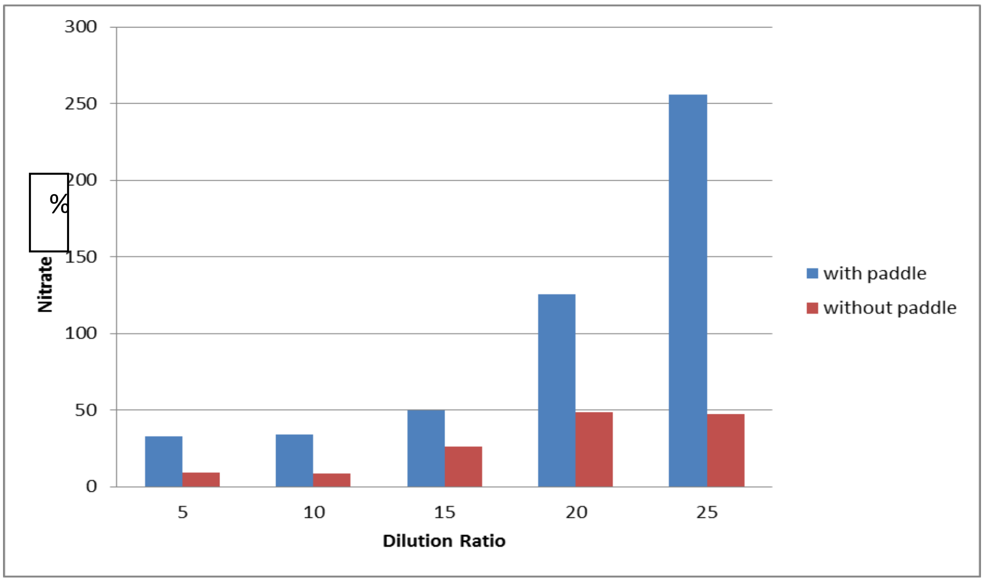

Fig 6: Bar Chart showing the percentage increase in Nitrate (%) with and without paddle wheel aerator at given dilution ratios

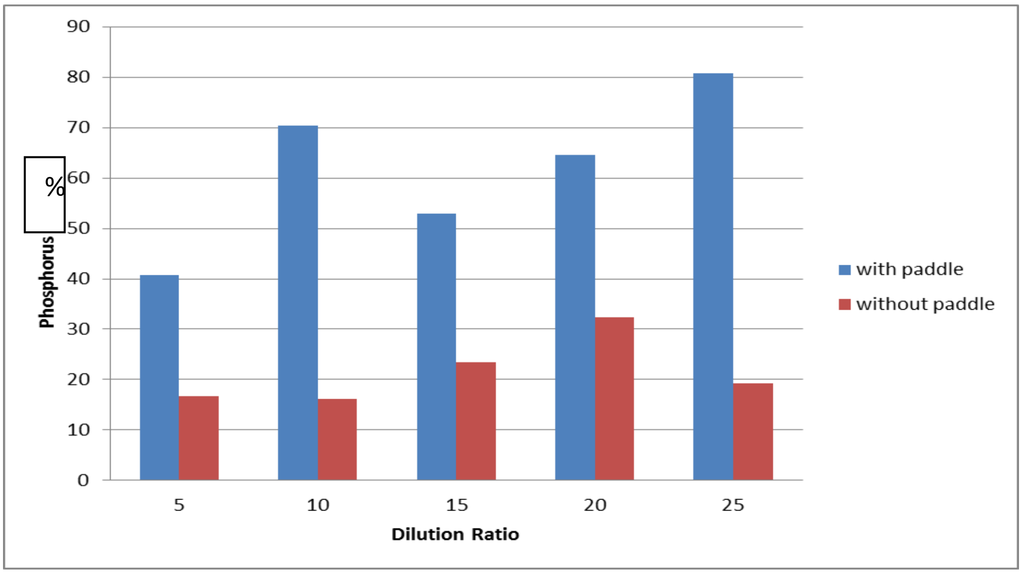

Fig 7: Bar Chart showing the percentage reduction in phosphorus (%) with and without paddle wheel aerator at given dilution ratios

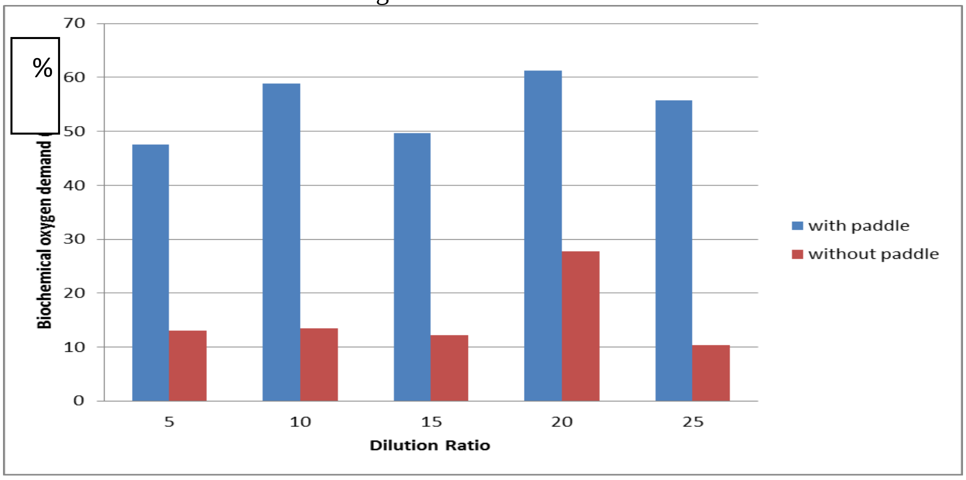

Fig 8: Bar Chart showing the percentage reduction in Biochemical oxygen demand (%) with and without paddle wheel aerator at given dilution ratios

3.1 Changes in the Total Suspended Solids (mg/l)

Percentage reduction in total suspended solids (TSS) with and without paddle wheel aerator were presented in Fig. 2. Percentage reduction in total concentration of TSS with and without paddle wheel aerator ranged from 23.1 – 25.2 % and 29.1 – 37.6 % respectively. Maximum reduction occurred at 05 and 25 dilution ratios. While minimum reduction occurred at 20 dilution ratio. The variations of percentage reduction in TSS concentration among the dilution ratios with paddle wheel aerator were attributed to:

(a) Volume of water
(b) Depth of the water in the pond
(c) Concentration of the effluent
(d) Level of clay particles / inorganic matter and
(e) Level of insoluble phosphorus and precipitates of calcium phosphates.
(f) Magnitude of micro-organisms.

The effect of dilution ratios was less significant in concentration of TSS with paddle wheel aerator compared to without paddle wheel aerator. The percentage reduction in the total suspended solids in fish pond was lower with the paddle wheel was in operation than that of without paddle wheel. The results show significant ($p \geq 0.05$) difference between percentage mean reduction in the total suspended solids with and without paddle wheel at all the level of dilution ratio. The difference between paddle-wheel and non-paddle-wheel may be attributed to: The paddle wheel aerator that caused the suspension of the particles (mostly clay). While circulation of water increases the suspension of insoluble nutrients and also the resuspension was enhanced by the turbulence action of paddle wheel aerator that brought inorganic matter and nutrients back into the water column.

3.2 Change in the total concentration of nitrogen (mg/l), ammonia (mg/l), nitrite (mg/l), nitrate (mg/l) and Phosphorus (mg/l)

Percentage reduction in Nitrogen, Ammonia and Nitrite with and without paddle wheel aerator at all level of dilution ratios were presented in Fig. 3, 4, 5 and 7 respectively. While percentage increase in Nitrate with and without paddle wheel aerator were presented in Fig.6. Reduction in concentration of Nitrogen, Ammonia, Nitrite and Phosphorus with and without paddle wheel aerator ranged from 51.1 – 54.9%, 25.6 – 30.8 %; 56.1 – 85.9 %, 13.5 – 46.5 %; 85.7 – 100.0 %, 42.9 – 66.7 % and 40.7 – 80.8 %, 16.3 – 32.3 % respectively. While increase in concentration of Nitrate with and without paddle wheel aerator ranged from 40.7 – 80.8 % and 16.7 - 32.3 % respectively. There are no significant different ($p \leq 0.05$) in concentration of nitrogen and most nitrogenous compounds (nitrite and nitrate) and phosphorus reduction with paddle wheel aerator at all level of dilution ratios except ammonia at 25 dilution ratio only. In ammonia, the maximum concentration reduction for both with and without paddle wheel occurred at 20 dilution ratio. This shows that it contained the most active ammonia reducing micro-organic (bacterial) at that dilution ratio. Without paddle wheel aerator, the distribution trend can be accounted for the fact that ammonia and nitrite are intermediate species. They are both rapidly produced and consumed through the water column. The variation in trends of percentage reduction in concentration of phosphorus at all level of dilution ratios with paddle wheel aerator are due to: dilution effects on the concentration of the catfish effluent and level of insoluble phosphorus (particulate matter) and precipitates of calcium phosphates. The percentage reduction in the total concentration of nitrogen, ammonia, nitrite and phosphorus and increase in the total concentration of nitrate were higher with the paddle wheel than the one without paddle wheel. The results show significant ($p \geq 0.05$) difference between percentage mean reduction in the total concentration of nitrogen, ammonia, nitrite and phosphorus with paddle wheel and that without paddle wheel at all the level of dilution ratio. Nitrogen and other nitrogenous compounds tend to escape from water when the water is agitated. The chemistry of this is straight forward, oxygen get into water with increase in turbulence, therefore ammonia is oxidised into oxides of nitrogen of different complexities and finally to nitrogen which their escapes from water being soluble in its gaseous form. The difference may be due to the amount of oxygen dissolved and proper mixing of the dilution which enables the micro-organisms come into intimate contact with the dissolved and suspended organic matter and the circulating water also increases the suspension of nutrients which can stimulate plankton growth and increase microbial activity.

3.3 Change in the total concentration of Biochemical oxygen demand (mg/l)

Percentage reduction in total concentration of Biochemical oxygen demand (BOD) with and without paddle wheel aerator ranged from 40.7 – 80.8 % and 16.3 – 32.3 % respectively. Variations in concentration of (BOD) reduction are due to different inorganic matter contents in each dilution ratio. The percentage reduction in the total concentration of biological oxygen demand was higher when paddled than when not paddled. The results show significant ($p \geq 0.05$) difference between percentage mean reduction in the total concentration of biological oxygen demand between with paddle wheel and without paddle wheel at all the level of dilution ratio. The result was as presented in Figure 8. The difference between paddle-wheel and non-paddle-wheel may be attributed to: increases in dissolved oxygen and circulation of water also increase the suspension of nutrients which can stimulate plankton growth and increase microbial activity that aided decomposition.

In summary, aquaculture waste water is heavily loaded with inorganic and organic matters. The cycling of inorganic and organic matters in the pond is influenced by sedimentation and resuspension processes. Resuspension was enhanced by the turbulent action of paddle wheel aerator that brought inorganic matter and nutrients back into the water oxygen rich water column where organic matter decomposition occur much more efficient, yielding less toxic components than in the sediment. Results indicated that paddle-wheel 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_5 at the same dilution ratio There were significant different ($P \leq 0.05$) between The findings support those of Tucker and Robinson (1990); Boyd (2001b, 2003) and Tucker (2000) that the paddle wheel aerator reduces the concentrations of ammonia, nitrite, nitrogen, phosphorus and biological oxygen demand. This finding differs slightly from observations made by some investigators such as Ozbay (2000); Grate et al (2000); Boyd and Tucker (2000), and Schwartz and Boyd (2001) based on biological method. These differences may be attributed to: different catfish effluents concentrations, location and different devices (materials) used.

IV. Conclusions

The effect of paddle-wheel aerator on catfish effluent was established. Results from the study indicate that:

- Reductions in the concentration of nitrogen, ammonia, nitrite, phosphorus and biological oxygen demand
- Reduction in the concentration did not depend on dilution ratio and purely aerobic process, while without paddle wheel aerator depended on dilution ratio and self- purification which involved oxic and anoxic processes.
- The results indicated that Ammonia oxidizing bacterial less dominant than that of Nitrite oxidizing bacterial at the same dilution ratio.
- Between ammonia, nitrite, and nitrate, nitrite has the fastest turnover rate.
- The paddle wheel aerator was found effective in the water quality improvement,
- Paddle-wheel aerator proved to be efficient alternative means of controlling catfish effluents to biological method which required large areas of cover crops
- Paddle wheel aerator is recommend for small and medium scale fish farmers in controlling effluents

Acknowledgements

I acknowledge the Nigerian Institute of Oceanography and Marine Research in water analyses. I also express my profound gratitude to Mr. T. O. Sanusi the secretary of Agricultural and Bio- Environmental Engineering Department,

References

[1]. Adekoya,B.B;T.O.Ayansanwo,A.A.Idowu,O.A.Kudoro andA.A. Salisu 2006). Inventory of Fish Hatcheries in Ogun State .Ogun State Agricultural development programme, Abeokuta.

[2]. American Public Health Association (APHA). 2005. Standard Methods for the water and wastewater, American Water Works Association, Water Control Federation. Examination of

[3]. Boyd,C.E,(1990) Water quality in ponds for agriculture.in Singh and Wheaton(CIGAR).Auburn University,Albama,Agricultural Experimental Station,Auburn.

[4]. Boyd C. E. 2001a. Aquaculture and water pollution. Pg.153-157.In:D.F.Hayes and. M.Mckee (editors).Decision support systems for water resources management. American Association, Middleburg Virginia, USA.

[5]. Boyd, C E 2001b. Water quality standards: total ammonia nitrogen. Global Aquaculture, Advocate 4(4):84-85.

[6]. Boyd, C. E., J. Queiroz, J. Lee, M. Rowan, G. N. Whitis, and A Gross. 2000. Environmental assessment of channel catfish farming in Alabama Journal of tile World Aquaculture Society (3);5: 1-544.

[7]. Boyd C. E. 2003. Guidelines for aquaculture effluent management at the farm level. Aquaculture 226:101-112.

[8]. Boyd, C. E. and C. S. Tucker. 2000. Rule-making for aquaculture effluents in the US. Global Aquaculture Advocate 3,81-82.

[9]. Ghate, S. R., G. J. Burtle, G. McIlidis and G. L. Newton. 2000. Effectiveness of grass to filter catfish (lctalurus punctatus) pond effluent. Aqua cultural Engineering, 16, /49-159.

[10]. Ozbay, G. 2002. Studies of channel catfish Iclalurus punctatus pond effluent characteristics and treatment options. Ph.D. dissertation, Auburn University, Alabama, USA. Aquaculture. 207- 221

[11]. Schwartz, M. F. and C. E. Boyd. 2001. Channel catfish pond effluents. Prog. Fish culture, 56:273-.281

[12]. Tomasso, J.R 2002.Aquaculture and the Environment in the United State. Aquaculture Society Lousiana center. Baton Rouge, Louisiana, USA.

[13]. Tucker, C. S. 2000. Characterization and management of effluents from aquaculture ponds in the southeastern United States. Southern Regional Aquaculture Center, Mississippi State University, Stoneville, Mississippi, USA.

[14]. Tucker, C. S., C. E. Boyd, J. A. Hargreaves. 2002. Characterization and management of effluents from warm water aquaculture ponds. The Environmental Impact of Aquaculture in the United States. United States. Aquaculture Society, Baton Rouge, LA.

[15]. Tucker, C. S. and J. A. Hargreaves. 2008. Environmental best management practices for aquaculture. Aquaculture International, 17,301-302.