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PERFORMANCE EVALUATION OF A DEVELOPED PADDLE AERATOR ON CATFISH EFFLUENTS IN LAGOS STATE, NIGERIA

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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 TN_2-N, 29.3±1.6 % of TNH_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 to be relevant in the water quality improvement and thus recommend for small and medium scale fish farmers in controlling effluents.

Keywords: Catfish, Effluents, Lagos State, Paddle- wheel aerator, Performance evaluation, Water quality

INTRODUCTION

The catfish industry plays a very important role in the Nigeria aquaculture industry as the largest segment of aquaculture in the Nigeria (Adekoya *et al.*, 2006). Most catfishes are grown in the southern part of Nigeria, and the industry is economically important to several of the states in this region. The most popular species that have proved desirable for culture in Nigeria are the Clarias gariepinus, and Heterobranchus species (Adekoya *et al,*, 2006). The importance of Clarias gariepinus in Nigeria is based mainly in the farmers and consumers Preferences.

There are numerous publications on the subject of catfish pond effluents. The 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 locations, seasons, farm management practices, amounts of overflow after rains, method of drained and amounts of water drained during harvest (Boyd, 2003). 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 within 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) reported that fishpond wastewater has offensive odour, which has 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 an area, runoff producing features, the amount of rainfalls, 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 bodies only when the self- purification capacity of water has not been exceeded, surface water disperse wastes 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 (2001b) reported 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 to increase the dissolved oxygen concentration in water, reduce 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 methods earlier mentioned require a large area of land for filtration by cover crops seem unsuitable. A viable alternative which may be the paddle-wheel aerator may be used. Paddle-wheel aerator has not been used in catfish effluents reduction The objective of the present study therefore, was to evaluate the effects of paddle wheel aerator in catfish culture effluents in Lagos

Nigeria.

MATERIALS AND METHODS

Source of Materials and Samples Preparation

Catfish effluents samples were collected from a Fish Farm 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 of water at given dilution ratio (d_{r1}, d_{r2}, d_{r3}, d_{r4}, and d_{r5}) at 1:4, 1:9, 1:14, 1:19 and 1:24 respectively.

Experimental Methods

Paddle wheel aerator machine was made by Omofunmi, (2014), 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 usually runs for two hours. The required water quality for both the tanks are determined and analyzed after every two hours at thirty minutes after the run of the machine 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 determined in accordance to the APHA, (2005) standard.

Measurements

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 the solution 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 and distributed into two separate Nessler tubes and 0.5 ml Nessler reagent added to each tube. The mixed solution started developing colour. This colour after 10-15 minutes was compared with the colour discs of a Nesslenizer (BDH Nesslenizer). The determination of nitrogen content (mg/l) of the solution is expressed as follows:

N, NO_2, NO_3 and NH_3 (mg/l) = Number of matchng division of the standard dics × 100 × 0.01 (APHA, 2005).

Phosphorus (mg/l): 50 ml of filtered water sample was put in a nessler tube. 2 ml 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 50 mm × 2 × 0.01 (APHA, 2005).

Suspended solid (mg/l): 50 ml of samples through pre – weighted glass fibre paper were dried for 30 minutes and re-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 thrice and average reading were taken (APHA, 2005).

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

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

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.

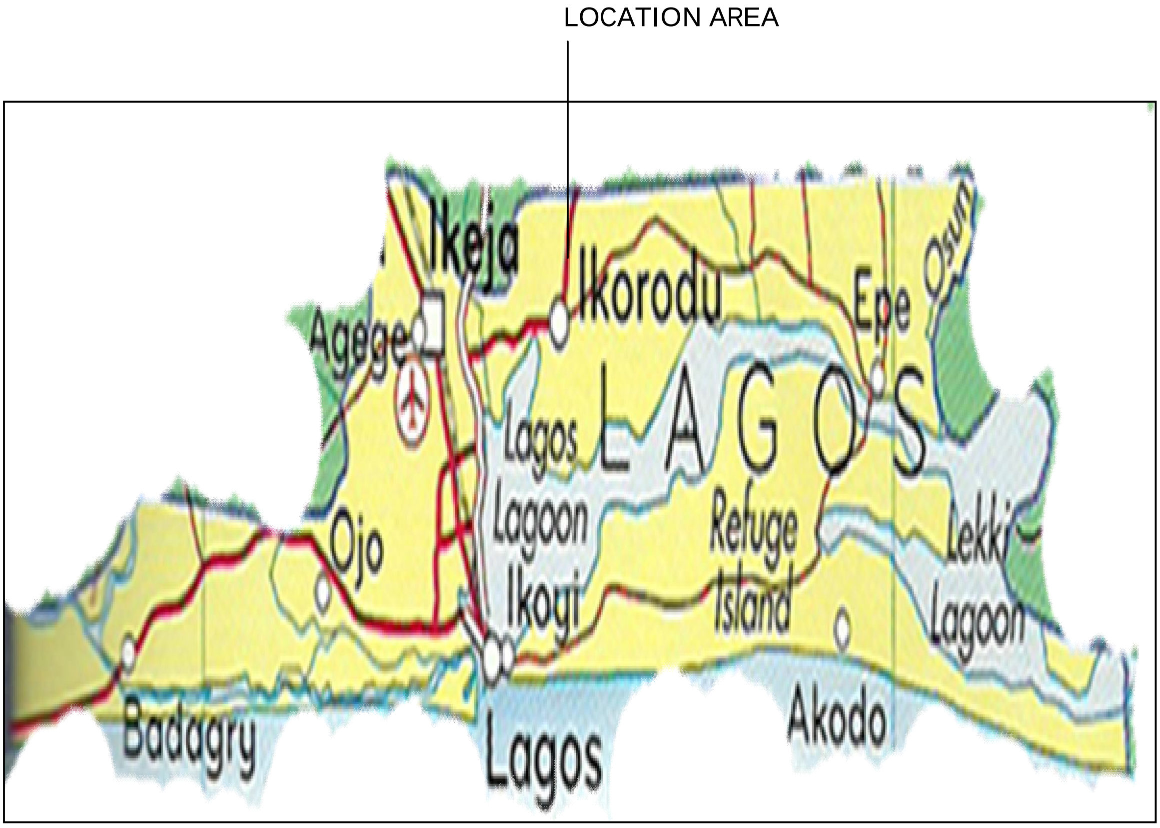

Fig 1: Map of Lagos State, Nigeria.

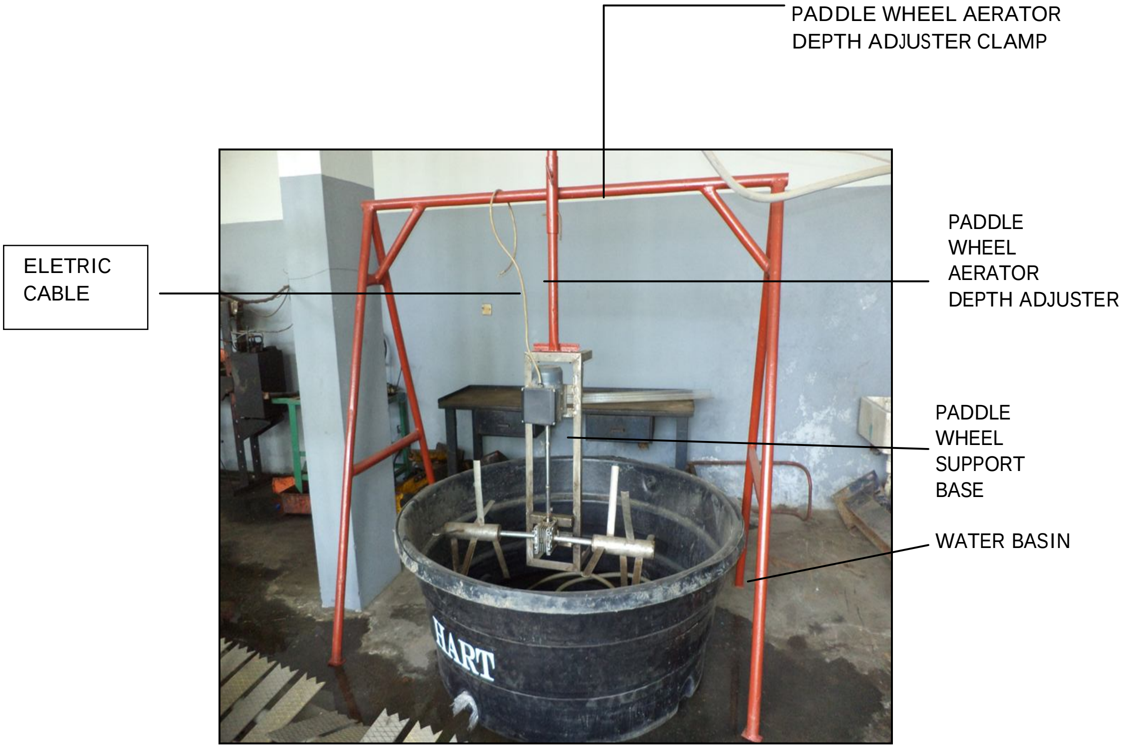

Plate 1: Mounted Paddle wheel aerator for operation

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 are presented in Figures 2, 3, 4, 5, 6, 7 and 8 respectively.

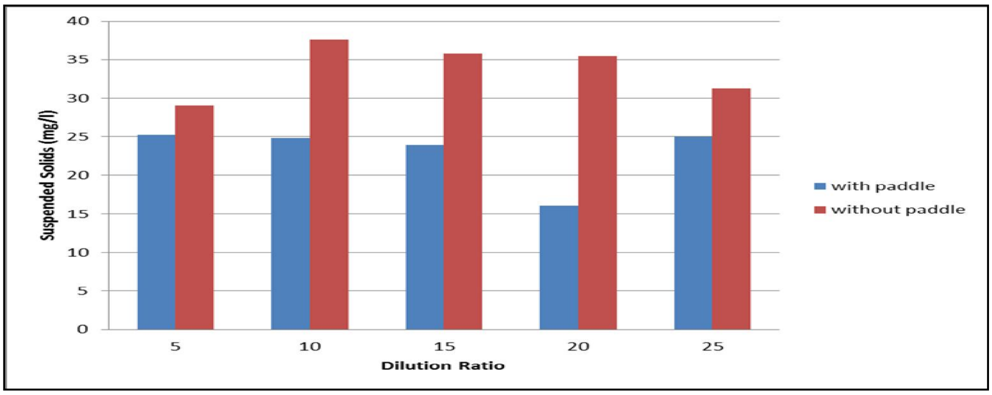

Fig.2: Bar Chart showing the percentage reduction Suspended Solids (%) with and with out paddle wheel aerator at given dilution ratios

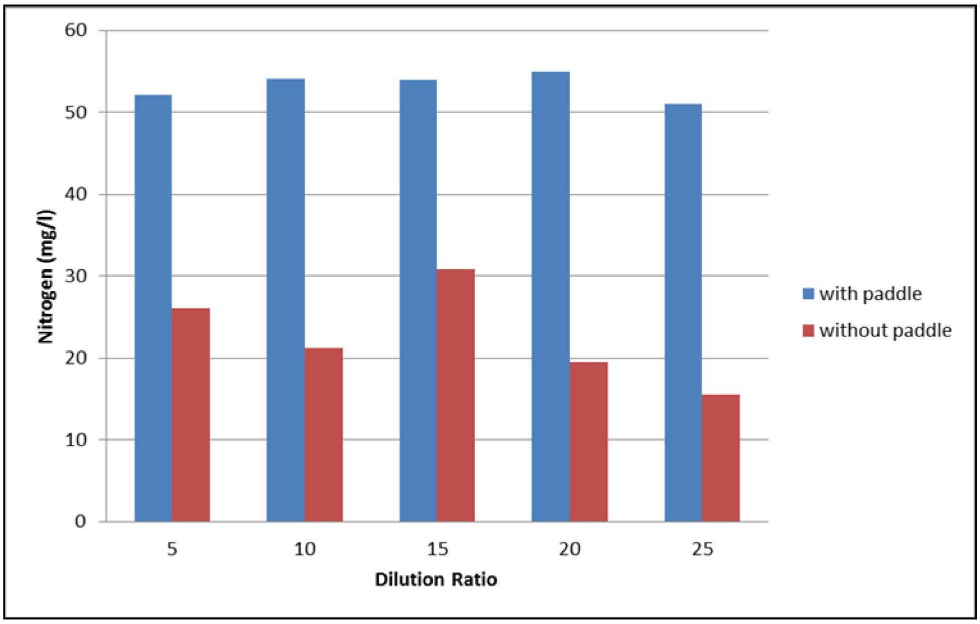

Fig 3: Bar Chart showing the percentage reduction Nitrogen (%) with and without paddle wheel aerator at given dilution ratios

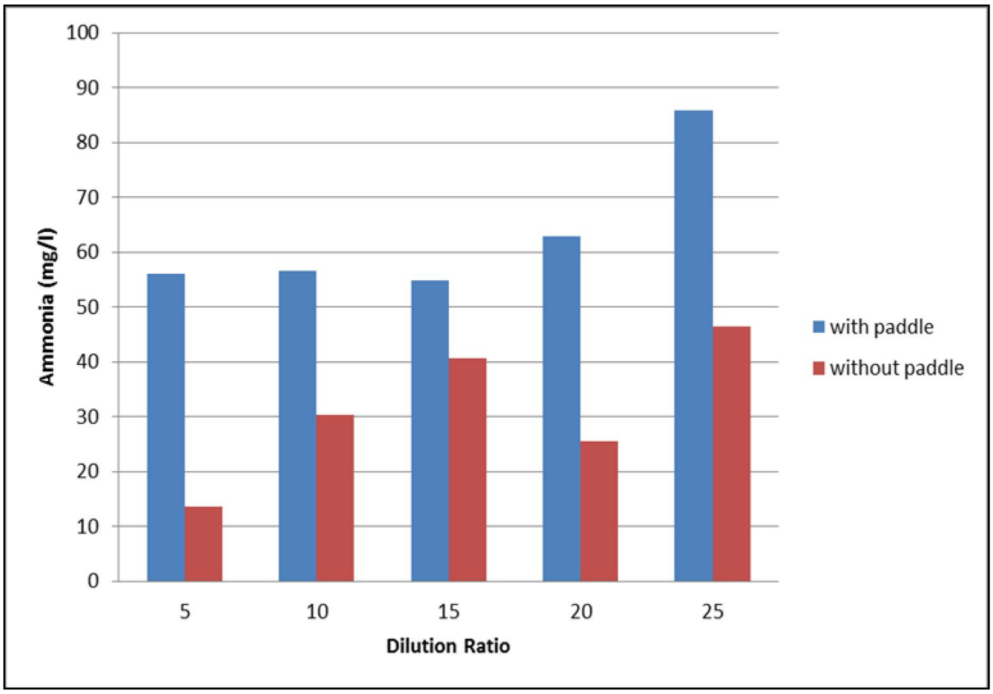

Fig 4: Bar Chart showing the percentage reduction Ammonia (%) with and without paddle wheel aerator at given dilution ratios

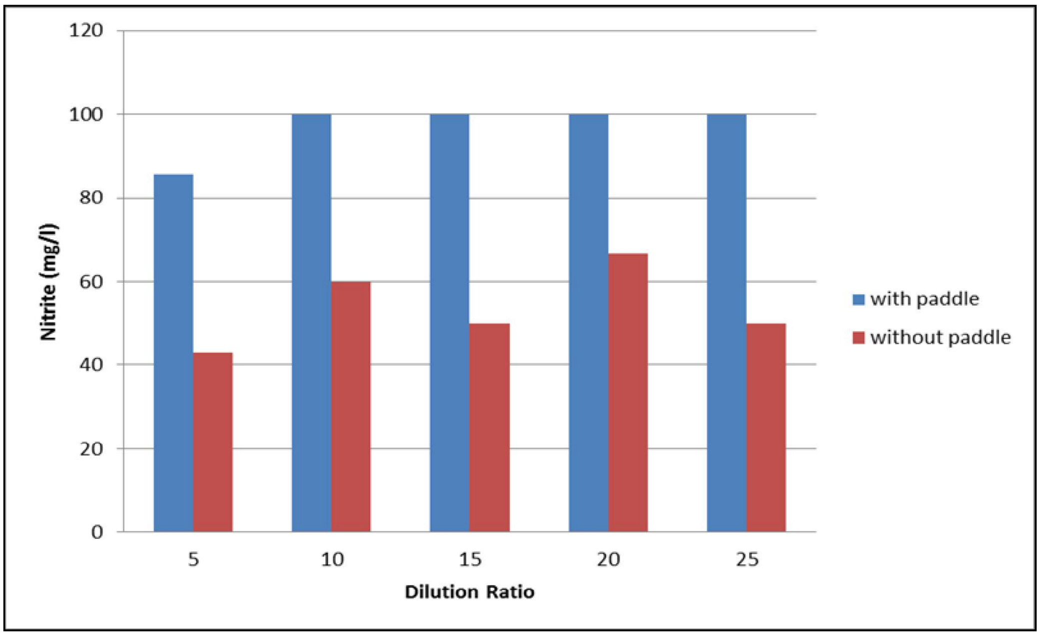

Fig 5: Bar Chart showing the percentage reduction Nitrite (%) with and without paddle wheel aerator at given dilution ratios

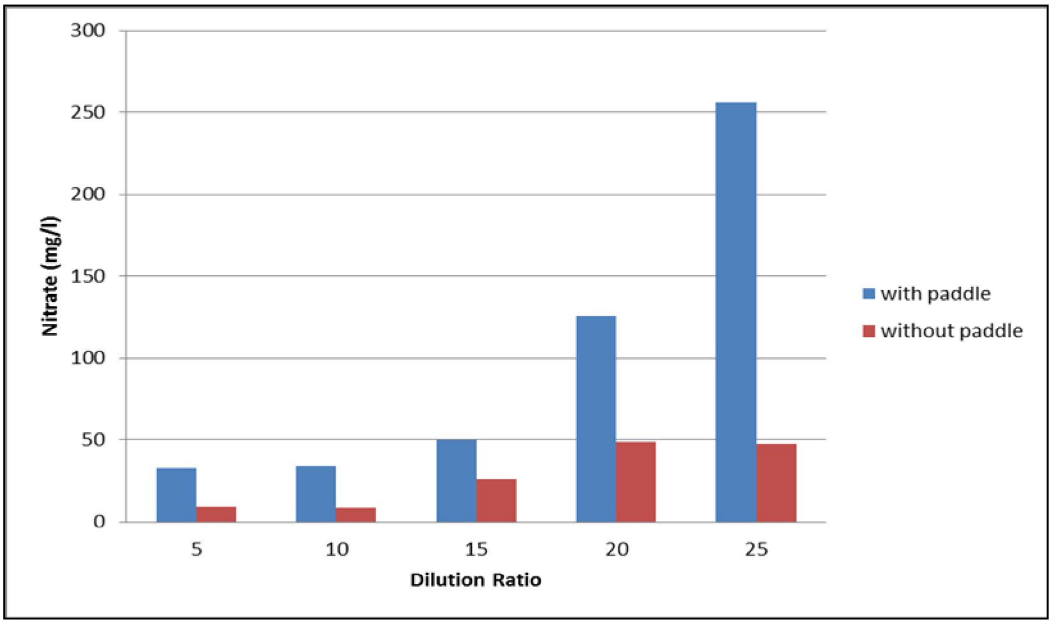

Fig 6: Bar Chart showing the percentage increase in Nitrate (%) with and without paddle wheel aerator at given dilution ratios

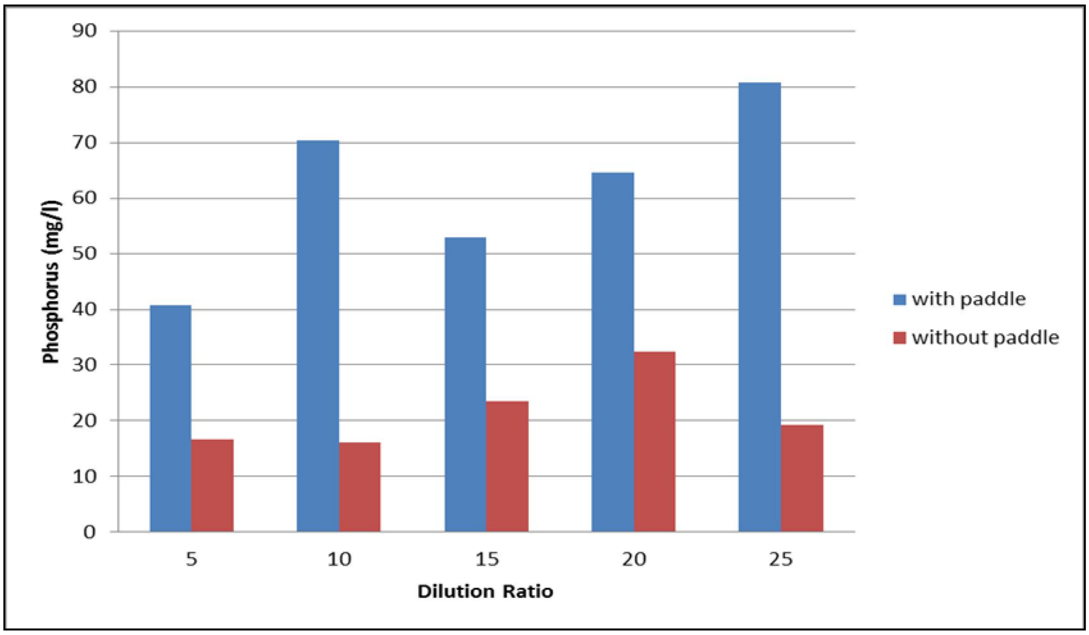

Fig 7: Bar Chart showing the percentage reduction phosphorus (%) with and without paddle wheel aerator at given dilution ratios

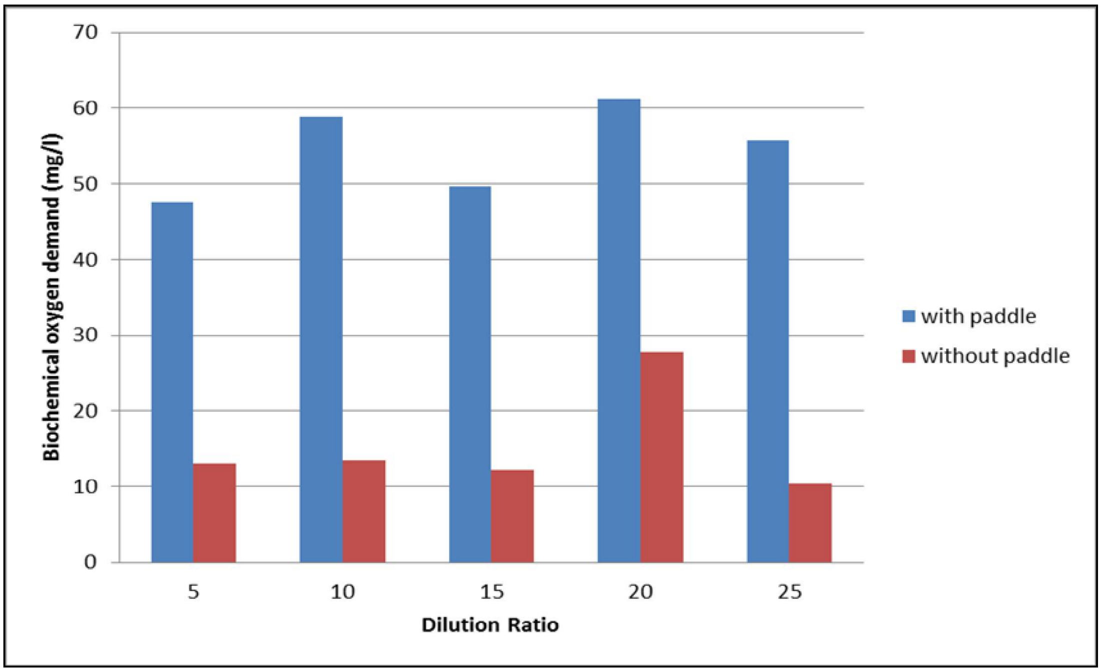

Fig 8: Bar Chart showing the percentage reduction Biochemical oxygen demand (%) with and without paddle wheel aerator at given dilution ratios

Changes in the Total Suspended Solids (%)

Percentage reduction in the total suspended solids (TSS) with and without paddle wheel aerator were presented in Fig. 2. 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 re-suspension that was enhanced by the turbulence action of paddle wheel aerator that brought inorganic matter and nutrients back into water column.

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 the total concentration of nitrogen, ammonia and nitrite and increase in the total concentration of nitrate were higher with the paddle wheel than without paddle wheel aerator at all level of dilution ratios. The results are presented in Fig. 3, 4, 5 and 7 respectively. 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 escape as gaseous nitrogen. 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.

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

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 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: the circulation of water which also increases the suspension of nutrients which can stimulate plankton growth and increase microbial activity that aided decomposition.

In general, 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 by 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 ≤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.

CONCLUSIONS

The effects of paddle-wheel aerator on catfish effluent assessed and itemised below. Results from the study indicate that:

- Reductions in the concentration of nitrogen, ammonia, nitrite, phosphorus and biological oxygen demand
- Reduction in the concentration not depended 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

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