Journal of Aquaculture
Research & Development

Akinwole et al., J Aquac Res Development 2016, 7:12
DOI: 10.4172/2155-9546.1000460

Research Article Open Access

Growth Performance of African Catfish (*Clarias gariepinus*) Juveniles Reared in Wastewater Treated with Alum and *Moringa oleifera* Seed

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Abstract

Growth performance of African catfish (*Clarias gariepinus*) juvenile cultured with wastewater treated by solid removal, using alum and *Moringa oleifera* seed as coagulants was examined. Wastewater from fish rearing pond was collected and treated with 120 mg L^{-1} of alum and *Moringa* seed and the supernatant water was decanted and used for fish culture. Ninety *Clarias gariepinus* juveniles with mean weight of 10 g were stocked at the rate of 5 kg m^{-3} per tank in triplicates for each treatment. Each tank contained 20 L of the respective treated wastewater, while the control contained freshwater from deep well. Water in the culture tanked was changed every 72 h and replaced with treated water from the experimental tanks. Growth and feed utilization parameters were assessed fortnightly for 12 weeks. Data obtained were analysed using one way analysis of variance and where significant difference was observed Tukey HSD test was used to establish the exact pairs with difference. The growth performance and feed efficiency of catfish cultured with *Moringa* seed treated water (MSTW) did not differ ($P>0.05$) from those cultured with deep well water but were higher ($P<0.05$) than those of catfish raised with alum treated water (ATW). The MSTW catfish had higher ($P<0.05$) survival rate of 93.33 ± 3.83% compared with the control (90.78 ± 30.64%) and ATW catfish (30.00 ± 26.40%). The MSTW catfish exhibited the best performance in terms of total production per cubic metre of water used, with a value of 2.64 ± 0.46 Kg m^{-3}, compared with 0.94 ± 0.02 Kg m^{-3} and 0.82 ± 0.61 Kg m^{-3} in the control and ATW catfish respectively. *M. oleifera* seed could be effectively used for wastewater treatment and water reuse in the culture of *Clarias gariepinus* without negative effect on the growth and feed utilization.

Keywords: African catfish; Fish culture effluent; Natural coagulant; Synthetic coagulant; Water reuse system

Introduction

Water reuse system plays an important role in aquaculture. It promotes the efficient use of scarce global water resources and decreases the deleterious effect of aquaculture wastewater on the receiving environment [1]. According to FSD [2], scarcity of water has been noticed as an emerging international challenge and the most efficient management technique suggested is recirculation. Several initiatives towards reusing fish culture wastewater have been established. These include biofiltration, which involves nitrification of aquaculture wastewater [3] and nitrification followed by denitrification [4]. Another method is integrated aquaculture system [5], where wastewater from fish culture which would have constituted nuisance to the environment is being used for crop production. Waste in aquaculture water are either solids (suspended solid or dissolved solids) from uneaten feeds and fecal droppings or dissolved nutrients (ammonia, nitrite, nitrate and phosphate) which are from metabolic activities of the fish or biodegraded products of the solid waste. Biofiltration is used for the removal of soluble gases especially the nitrogenous waste [4], even though sedimentation is used to remove suspended solid, the unaided method is not fast enough and it could lead to biodegradation of some of the solid waste and hence accumulation of toxicants in the water. The accumulation of toxicants in an aquatic environment can result in reduced reproductive capabilities, alter growth rates and reduce ability to withstand variations in pH, temperature and dissolved oxygen [6]. There is need for rapid removal of solid waste from culture water [7], in order to prevent the problems associated with solid wastes. In the production of drinking water from raw water resources, removal of solid particles is done by coagulation/flocculation process [8]. The process usually involved the use of inorganic coagulants and the most widely use are aluminum sulphate, and poly aluminum chloride [9]. According to Ebeling et al. [10] alum has the capacity to coagulate and trap solid matter, which may be floating, including algae and planktons, which may be beneficial to cultured fish. The amount of alum used for effectively coagulation is relatively high and its remnant in treated drinking water has raised public health issue [11]. The need for safe and effective coagulants has created the impetus to search for alternative natural coagulants. Ubuoh et al. [12], noted that some plants material have been found to be effective as coagulants in domestic water treatments and this includes *Moringa oleifera* seeds [13], maize and *Strychnos potatorum* seeds [14]. Solid waste from fish culture effluents has been effectively removed with *Moringa oleifera* [15] and maize [16]. However, the treated aquaculture effluents were not reused for fish culture. Alum remains the most commonly used coagulant for solid waste removal. Nonetheless, to our knowledge, there is dearth of information on the response of catfish to wastewater treated with alum or *Moringa* seed. Therefore, this study was conducted to examine the primary productivity of the aquaculture wastewater treated for solid removal with alum and *Moringa oleifera* seed power and the growth performance of *Clarias gariepinus* juvenile cultured with the treated water.

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Received November 18, 2016; **Accepted** December 05, 2016; **Published** December 07, 2016

Citation: Akinwole AO, Dauda AB, Ololade OA (2016) Growth Performance of African Catfish (*Clarias gariepinus*) Juveniles Reared in Wastewater Treated with Alum and *Moringa oleifera* Seed. J Aquac Res Development 7: 460. doi: 10.4172/2155-9546.1000460

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Materials and Methods

Source and processing of coagulation aids

The two coagulation aids used in the study were Aluminum tetraoxosulphate (VI) ($Al_2(SO_4)_3$) called Alum, a synthetic coagulating aid and *Moringa oleifera* seed, a plant based natural coagulating aid. The alum was obtained from University of Ibadan water treatment plant while *Moringa oleifera* seeds were handpicked from the *Moringa oleifera* tree in the Department of Forest Resources Management, University of Ibadan. Dried and matured *Moringa* seeds were collected, the seeds were removed from the pods and sun dried. The dried seeds were later crushed and grounded with mortar and pestle until a fine particle was obtained, and sieved using a 0.15 mm mesh size netting in order to obtain a fine powder. The alum was also crushed and grounded, and later sieved using a 0.15 mm mesh sized netting in order to obtain a fine powder.

Treatment of wastewater

Initial fish culture effluent water sample used was collected from an earthen pond stocked with African catfish (*Clarias gariepinus)* grow out system in the University of Ibadan fish farm. The wastewater (140 L) sample was obtained from the fish farm in the first week and subsequent wastewater was obtained from the culture experiment itself, in order to fulfill the primary objective of testing the reuse potential of the treated wastewater. The collected wastewater sample was treated with the two flocculation aids.

The flocculation process was in three stages. First, the coagulation aids were measured at the set dosages (120 mg L^{-1}) with the use of an electric weighing balance and added into the measured 70 L water sample in a plastic container for each flocculating aid. The water was then subjected to manual mixing of 100 revolutions with a turning stick.

The flocculated water was allowed to settle for 24 h. The supernatant was carefully decanted into another plastic container and then poured into the fish rearing tanks for each treatment. Circular plastic tanks of diameter of 45 cm, radius 22.5 cm, and depth of 29 cm were used for the experiment. The water was maintained at the depth of 15 cm, corresponding to a total culture water volume of 20 L per tank. Freshwater from the deep well was only added to complement the 20 L in each tank, where the volume was reduced due to splash, evaporation or sediment removal.

Stocking and management of catfish

Ninety *Clarias gariepinus* juveniles with individual mean weight of 10 g were stocked at 10 fish per tank in triplicates for each treatment, giving a total of nine tanks for the two treatments and one control (deep well water) where no coagulation aid was used. The fish stocked were fed at 5% body weight with 42% crude protein, of 2 mm commercial feed twice a day for the first four weeks, while for the remaining weeks the fish were fed 3 mm of the commercial feed (Table 1). Water quality parameters of the wastewater were measured before and after treatment with the coagulation aids, and this was carried out at 72 h interval. The water in the fish rearing tanks was drained and replaced with the newly treated water. The details of the water quality parameters is published in our article on Hematological response of *C. gariepinus* reared in treated wastewater after solids removal using Alum or *Moringa oleifera* seed [17].

Measurements of variables

The pH, ammonia, nitrite and nitrate were determined colourimetrically using API® fresh water test kit. The temperature in the culture tanks was measured every 72 h with the use of mercury in glass thermometer. The dissolved oxygen of the waster sample was determined with Labtech® dissolved oxygen meter. The Total dissolved solid (TDS) and Total suspended solid (TSS) were evaluated gravimetrically following the standard methods [18]. All the water quality parameters were within the recommended range for African catfish culture, though a low pH of 6.58 ± 0.03 was observed in alum treated wastewater but the pH is still within the limit. However, TSS and TDS were higher in the treated wastewater, alum treated wastewater had 360.75 ± 58.46 mg/L while moringa seed treated wastewater had 745.17 ± 38.86 mg L^{-1}. TDS was 441.75 ± 45.28 mg L^{-1} in alum treated wastewater and 870.75 ± 39.34 mg L^{-1} in moringa seed powder treated wastewater.

The plankton samples were collected in a 40 mL bottle and transferred to the laboratory immediately for analysis, 5 mL sub-sample was taken from each tank using pipette and gently delivered into a petri dish. This was then examined under light microscope and the different organisms in the sub-samples were identified using the standard identification method as described by Odium [19] and Needham and Needham [20]. Abundance of both phytoplankton and zooplankton were reported based on number of cells or individuals per 5 mL of the water sample. Any organism with more than 50 cells or individual is reported to be abundant and less than that is reported to be non-abundant.

Fish in each rearing tanks was sampled every two weeks for evaluation of growth, survival and feed utilization following the procedure of Akinwole et al., [5]. The selected growth indices are Total weight gained (TWG), Mean weight gained (MWG), Mean daily weight gain (MDWG), Specific growth rate (SGR), Feed conversion ratio (FCR) and Percentage survival.

Statistical analysis

The experiment followed a completely randomized design model. Data obtained for growth performance characteristics were subjected to analysis of variance using the IBMSPSS software version 21. Means were separated by Turkey's HSD test at significance level of $p<0.05$. Results were presented as mean± standard deviation.

Results

Abundance and diversity of planktons

All the zooplankton and phytoplankton that were found in the wastewater were also found in the *Moringa oleifera* seed treated water but none was found in the alum treated wastewater. As shown in Table

Nutrient Composition	2 mm Feed (Coppens Pre-grower-13EF	3 mm Feed (Coppens Select-13EF)
Crude protein (%)	42	42
Fat (%)	13	13
Crude fibre (%)	2.0	1.5
Ash	8.1	6.8
Gross energy (Mj Kg^{-1})	20.0	20.3
Digestible energy (Mj Kg^{-1})	18.1	18.4
Metabolizable energy (Mj Kg^{-1})	16.2	16.4
Vitamin A (IE Kg^{-1})	10000	10000
Vitamin D (IE Kg^{-1})	2000	200
Vitamin E (mg Kg^{-1})	200	200
Vitamin C (mg Kg^{-1})	150	150

Table 1: Nutrient composition of the diet.

Planktons	Waste-water before treatment	Alum powder treated waste-water*	Moringa seed powder treated waste-water
Zooplankton Abundance			
Daphnia magna	Abundant	Nil	Abundant
Sinocalanus dorri	Abundant	Nil	Abundant
Eucyclops macruroides	Abundant	Nil	Not abundant
Polyhemus pediculus	Not abundant	Nil	Not abundant
Moina micrura	Not abundant	Nil	Not abundant
Phytoplankton Abundance			
Pleurocapsa fuliginosa	Not abundant	Nil	Not abundant
Thalassionema spp	Abundant	Nil	Abundant
Chlorella spp	Abundant	Nil	Not abundant
Oscillarotia spp	Abundant	Nil	Abundant
Ceratium spp	Not abundant	Nil	Abundant
*Nil means Not found			

Table 2: Zooplankton and phytoplankton abundance in the wastewater before and after treatment.

2, for zooplankton, *Daphnia magna* and *Sinocalanus dorri* that were abundant in the wastewater before treatment were also abundant in the moringa seed treated water. Only *Eucyclops macruroides* had its composition changed from abundant to non-abundant in the moringa seed treated water. The result was also similar for the phytoplankton, none was found in alum treated wastewater, while all that were found in wastewater were also present in moringa seed treated water. The status was also the same except for *Chlorella spp* whose status was changed from abundant to non-abundant and *Ceratium spp* that changed from non-abundant to abundant.

Growth performance characteristics

The results of growth performance and feed utilization parameters of catfish cultured in alum treated wastewater, Moringa seed treated wastewater and deep well water were shown in Table 3. The average final body weight, feed utilization, specific growth rate, total weight gain, mean weight gain and mean daily weight gain of the MSTW catfish did not differ ($P>0.05$) from those cultured with deep well water. Both MSTW and control catfish had greater ($P<0.05$) average body weight, weight gain, specific growth rate, mean weight gain and mean daily weight gain compared with the ATW catfish. The MSTW catfish had higher ($P<0.05$) survival rate of 93.33 ± 3.83% compared with the control catfish (90.78 ± 30.64%) and ATW catfish (30.00 ± 26.40%). Fish cultured in moringa treated wastewater also exhibited the best performance in terms of total production per cubic metre of water used, with a value of 2.64 ± 0.46 Kg m^{-3}, compared with 0.94 ± 0.02 Kg $m^{-3}$and 0.82 ± 0.61 Kg m^{-3} in the control and alum treated wastewater respectively.

Discussion

The presence of plankton, their types and abundance in culture water are effective indicators of the water quality in the culture system and the health status of the ecosystem. This is because they retort very fast to alteration and nutrient changes in water bodies [21]. Thus, changes in water quality can rapidly affect their diversity and abundance. The absence of both phytoplankton and zooplankton in the alum treated water could be attributed to the changes in the water quality due to the reactions of alum with other compounds in the water. This observation concurs with the report of Ebeling et al. [10], who posited that alum has the capacity to coagulate and trap all the particulate matter in water, including the algae and planktons. The presence of diverse zooplankton and phytoplankton in the moringa seed treated water indicated a healthy ecosystem, which has potential to aid the growth performance of fish cultured with the water. Pace and Praire [22] asserted that phytoplankton being primary producers, are very important in aquatic food chain and all life forms in the ecosystem are directly or indirectly dependent on them. While zooplankton feed on phytoplankton, fishes feed on both phytoplankton and zooplankton.

Clarias gariepinus is an important fish species especially in Nigeria, where it remains the most cultured fish species. The wide culture of *C. gariepinus* is favoured by its characteristics among which is the ability to tolerate poor water quality. However, there is limit to poor water quality it can tolerate. The use of alum as a coagulant in this study led to a significant reduction in the pH in the water, while the pH in moringa treated water was not affected. Similarly, Ubuoh et al. [12] observed that wastewater treated with *Moringa oleifera* seed did not exhibit pH fluctuation irrespective of the dosages. Performance of catfish cultured in moringa treated water was similar to those raised in deep well water but better than those cultured in alum treated water. The improvement in the performance of MSTW catfish could be due to the ability of moringa seed to remove the solid waste without having negative impact on water quality [15]. This is evident in the similarities in the diversity and abundance of plankton in the wastewater before and after water treatment with *Moringa* seed. The poor growth performance in the ATW catfish could be due to the alum-induced reduction in the abundance and diversity of plankton and pH. In line with the current observation, Vijayasri et al., [23] observed that chemical coagulants removed all the algae in treated water and made the water unfit for use in shrimp culture.

The higher survival rate in the MSTW catfish could be due to the stable water quality [24]. Compared with MSTW catfish, the lower survival rate of the control catfish could be due to the temporary shock the fish were exposed to in the course of changing water regularly. The extremely low survival rate of ATW catfish could be due to the high alum remnants in the treated water. Alum remnants in drinking water could have negative impact on humans and had raised a public health concern [11]. Thus, it is probable that alum remnants can cause mortality in fish. Although there was reduction in fish mortality when dosage was reduced from 120 mg/L to 60 mg/L after the fifth week when the highest mortality was recorded, mortality was still recorded in alum treated wastewater till 12th week of culture.

The MSTW and control catfish had a higher feed efficiency compared with the ATW catfish. This could be due to the presence

Parameters	Control	Alum	Moringa seed
Average final weight (g)	49.57 ± 13.46^a	30.73 ± 27.54^b	46.48 ± 12.03^a
Weight gain (g)	351.17 ± 129.85^a	40.67 ± 133.67^b	333.67 ± 111.12^a
Mean weight gained (g)	37.31 ± 13.46^a	15.67 ± 16.56^b	36.07 ± 12.03^a
Mean Daily Weight Gain (g day^{-1})	0.44 ± 0.09^a	0.19 ± 0.20^b	0.42 ± 0.07^a
Specific Growth Rate (% day^{-1})	1.90 ± 0.19^a	1.20 ± 1.06^b	1.83 ± 0.11^a
Survival rate (%)	90.78 ± 30.64^a	30.00 ± 26.40^b	93.33 ± 3.83^c
Total biomass (g)	451.17 ± 129.88^a	140.67 ± 133.67^b	433.67 ± 109.93^a
Total feed consumed (g)	1016.9 ± 345.38^a	587.37 ± 56.09^b	969.83 ± 319.14^a
Feed Conversion Ratio	3.01 ± 0.56^a	3.19 ± 8.16^b	2.93 ± 0.27^a
Production (Kg m^{-3})	0.94 ± 0.02^a	0.82 ± 0.61^b	2.64 ± 0.46^c
Values (expressed as mean ± SD) with different superscripts are significantly different ($p<0.05$)			

Table 3: Growth and feed utilization performance of *C. gariepinus* reared in treated wastewater.

of zooplankton and phytoplankton that provided additional food in both the deep well and moringa seed treated water [21]. It could also be because of the good nutrient composition of moringa seed. Dienye and Olumuji, [25] reported that *Moringa oleifera* can be incorporated in fish feed without adverse effect on growth performance and health status, this is also corroborated by our research on the hematological response of *C. gariepinus* reared in treated wastewater [17], where the heamtological parameters of the *C. gariepinus* reared in moringa pointed towards healthy fish, while that of alum was contrary. The primary aim of water reuse system is to conserve water and to reduce the deleterious effect of aquaculture on the environment by limiting the amount of fish culture wastewater released into the environment [25]. The report of this experiment yielded a positive outcome in terms of water conservation, as production per cubic meter of water used was significantly higher in moringa seed treated wastewater, than that of the control.

Conclusion

The results obtained from this study showed that *M. oleifera* seed could be used effectively for wastewater treatment and water reuse in the culture of *Clarias gariepinus* juveniles without any negative effects on the growth and feed utilization. Alum had a negative effect on the growth and survival of catfish juveniles. Fish farmers should be encouraged to use *Moringa* seeds in water treatment plants instead of alum or other chemicals in order to promote wastewater reuse and water conservation.

References

1. Timmons MB, Ebeling JM, Wheaton FW, Summerfelt ST, Vinci BJ (2002) Recirculating aquaculture systems (2ndedn). Cayuga Aqua Ventures, Ithaca, NY 14850, USA.
2. Farming Systems Design (FSD) (2009) Methodologies for integrated analysis of farm production systems. Proceedings of an International symposium held August 23-26 2009 - Monterey, CA.
3. Van Rijn J, Tal Y, Barak Y (1996) Influence of volatile fatty acids on nitrite accumulation by a *Pseudomonas stutzeri* strain isolated from a denitrifying fluidized bed reactor. Applied and Environmental Microbiology 62: 2615-2620.
4. Dauda AB, Akinwole AO (2015) Evaluation of polypropylene and palm kernel shell as biofilter media for denitrification of fish culture wastewater. NSUK Journal of Science and Technology 5: 207-213.
5. Akinwole AO, Dauda AB, Nwolisa EC (2014) Influence of culture water draw-off on growth of the African catfish (*Clarias gariepinus,* Burchell 1822) cultured under integrated System. International Journal of Applied Agricultural and Apicultural Research 10: 139-147.
6. Adamu KM, Audu BS (2008) Haematological assessment of the Nile tilapia *Oreochromis niloticus* exposed to sub-lethal concentrations of Portland cement powder in solution. International Journal of Zoological Research 4: 48-52.
7. Timmons MB, Summerfelt ST (1997) Advances in circular culture tanks engineering hydraulics, solids removal and fish management. Recent advances in aqua-cultural engineering. North east regional Agricultural Engineering, Ithaca, New York.
8. Lee PC, Gau SH, Song CC (2007) Particle removal of high-turbidity reservoir water by electro-aggregation. J Environ Eng Manag 17: 371-375.
9. Seid AM, Mobarakian A, Taherkhani F, Asgari G (2014) Effect of chitosan as a coagulant aid combined with poly aluminum chloride, removing of turbidity from drinking water. Avicenna J Environ Health Eng 1: e187.
10. Ebeling JM, Ogden SR, Sibrelli PL, Rishel KL (2004) Application of chemical coagulation aids for the removal of suspended solids (TSS) and phosphorus from the micro screen effluent discharge of an intensive recirculating aquaculture system. North American Journal of Aquaculture 66: 198-207.
11. Zhao S, Gao B, Wang Y, Yang Z (2013) Influence of a new coagulant aid-Enteromorpha extract on coagulation performance and floc characteristics of aluminum sulfate coagulant in kaolin–humic acid solution treatment. Colloid Surface A, 417: 161-169.
12. Ubuoh EA, Akhionbare SMO, Onifade AO (2013) Potential of *Moringa oleifera* seed powder as a coagulation agent for refinery wastewater treatment in warri, delta State, Nigeria. International Journal of Advanced Biological Research (I.J.A.B.R) 3: 17-20.
13. Oluwalana SA, Bankole W, Bolaji GD, Martus D, Alegbeleye O (2004) Domestic water purification using *Moringa oleifera*. The Nigerian Journal of Forestry 29: 28-32.
14. Raghuwanshi PK, Meindloi MJ, Sharma AD, Malviya HS, Chaudhiri S (2002) Improving filtration quality using agro-based materials as coagulation aid. Water Quality Research of Canada, 37: 745-756.
15. Akinwole AO, Jioke II (2006) An investigation of the potential of *Moringa oliefera* seeds as a coagulant and for suspended solids removal in fish culture wastewater. The proceedings of the 31st Annual Conference, of the Forestry Association of Nigeria, Makurdi, Benue State.
16. Akinwole AO, Akinbebije TO, Dauda AB (2015) Performance of maize seed as coagulant in the treatment of fish culture effluent. In the book of Abstract: 30th Annual Conference of Fisheries Society of Nigeria held between 22nd – 27th November at ETF lecture Theater, Delta State University, Asaba Campus, Asaba Delta State, Nigeria.
17. Akinwole AO, Dauda AB, Ololade OA (2016) Haematological response of *Clarias gariepinus* juveniles reared in treated wastewater after waste solids removal using alum or *Moringa oleifera* seed powder. International Journal of Aquaculture 6: 1-8.
18. AOAC (2012) Official methods of analysis of AOAC International (19thedn), Association of Official Analytical Chemists, Gaithersburg, MD.
19. Odum EP (1971) Fundamentals of ecology. W.B. Saunders Ltd., Philadelphia.
20. Needham JG, Needham PR (1975) A guide to the study of freshwater biology. (5thedn), Holden Day Publisher, San Francisco.
21. Nasir AMS, Reshma JK, Mathew A, Aswathy Ashok JA (2015) Effect of water quality on phytoplankton abundance in selected ponds of Nedumangad Block Panchayat, Kerala. Emer Life Sci Res 1: 35-40.
22. Pace ML, Prairie YT (2005) Respiration in lakes. Respiration in aquatic ecosystems. Oxford University Press, New York.
23. Vijayasri KA, Dhanapal G, Sagar V, Reddy TF (2013) Evaluation of reuse of shrimp farm effluent after chemical and biological treatments. Indian J Fish 60: 91-98.
24. Boyd CE (2004) Water quality management for pond fish culture, Elsevier, New York.
25. Dienye HE, Olumuji OK (2014) Growth performance and haematological responses of African mud catfish *Clarias gariepinus* fed dietary levels of *Moringa oleifera* leaf meal. Net Journal of Agricultural Science 2: 79-88.