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Efficient Water Exchange System in Fish Ponds or Tanks for Improved Fish Productivity

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Abstract

In addition to providing foreign exchange to Uganda, fish is one of the commodities that can provide the best proteins to improve nutrition especially in children and pregnant women and hence support food security. Efforts have been made to enhance the production of fish by encouraging aquaculture to bridge the gap of the declining capture fisheries, targeting 1,000,000 tons of fish production from aquaculture. There is therefore need for technologies that aim at enhancing the production of fish in Uganda. The efficient method of water exchange is one of the innovations to increase the fish productivity in earthen ponds and tanks. This method is based on the principles of hydrostatic pressure and the water stratification. The results from the experiment gave improved water quality parameters. This enabled fish productivity to increase from 1.22 to 1.88 Kg per cubic meter. Adoption of this innovation can enable fish farmers increase the productivity by 54%.

Key words: hydrostatic pressure; water exchange; stratification

1.0 Introduction

Uganda is endowed with great potential for aquaculture development, especially in terms of the rich water resources, a diversity of fish species suitable for aquaculture, excellent temperatures suitable for fast fish growth and fertile soils for the production of fish feed ingredients. Fisheries contribute UGX 2 trillion to the national economy, 12% to agricultural GDP and 2.5% to National GDP (MAAIF 2017). With all these significant contributions, however, there are indications that production is not keeping pace with the increasing demand, amidst a growing fish supply deficit that urgently needs to be addressed. Increasing population, nationally, regionally and globally is the main cause of the increasing demand. This is coupled with the increasing awareness of the nutritional value of fish, being the most important source of the essential nutrients and micronutrients critically required for good health. However, the way of water exchange is limited to semi-intensive aquaculture production systems due to poor water quality management practices.

Most fish ponds and tanks are conventionally exchanging top layers of water which is rich in dissolved oxygen and retain the bottom layers that are dominated by left-over feeds and the excreta. This causes the bottom layers to accumulate ammonia beyond the allowable levels and hence retards the fish growth and at times causes fish death. This problem can been overcome by the innovation of the efficient water exchange technology that exchanges the bottom water layers as they become conventionally replaced by the top water layers that are rich in dissolved oxygen. The purpose of this innovation is to design a system that improves the water exchange in ponds and tanks production system so as to improve the stocking density of fish ponds or tanks production systems.

2.0 Methodology

The efficient water exchange system is mainly composed of PVC pipes that are strategically fixed to convey the water to the ponds or tanks and also drain out the excess or un-wanted water from the pond. The drainage system is made in such a way that allows hydrostatic pressure to push the bottom layers of water through a combination of pipes where one pipe is inserted into a bigger pipe with perforations at the bottom as shown on the set, Figure 1

Fig. 1; Pipes connection for the drainage systems

The upper sets of pipes in figure 1 show the arrangement of the drainage system using the new design innovation and the lower pipes show the conventional method of drainage.

The setup in figure 2 shows the cross-section of the combination of the PVC pipes that enhance the water exchange in the pond/ tank. During water exchange, more water is conveyed to the pond/tank through the inlet pipe and this causes the increase in the pressure along the water column. The increase in pressure is caused by the hydrostatic pressure given by ($h\rho g$); where h is the depth of the water, ρ is the density of water and g is the acceleration due to gravity. This pressure pushes the stratified water layers at the bottom and passes through the outer perforated pipe until it reaches the top of the inner pipe and starts to flow out by gravity.

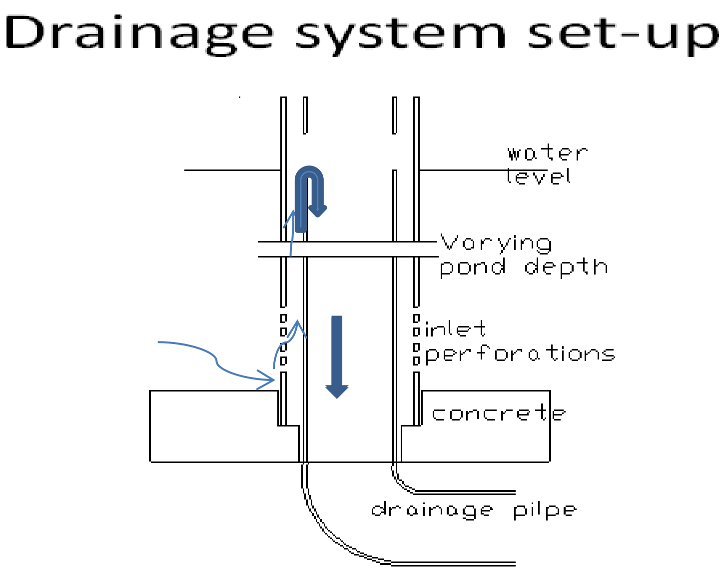

Fig. 2; Improved drainage system for efficient water exchange

The system was tested on station at the Aquaculture Research and Development Center (ARDC)-Kajjansi with 3 tanks using the old conventional system and 3 tanks using the innovated improved drainage system. The fish were fed on the same feeds at similar intervals.

2.1 Experimental Design

The innovation was also tested at farm level at Priority fish farm Located at Kihungye LC1, Kashenshero Town Council, Mitooma District.

Set-up involved 6 ponds each with capacity of 60 cubic metres.

The ponds were stocked with Nile Tilapia basing on the stocking density of 60 grams per cubic metre (4 fish @15g) for the conventional system.

The ponds using the new innovation were stocked with 90 grams per cubic metre (6 fish @15g).

3 ponds (labelled 1-3) used the conventional water exchange system and 3 other ponds (labelled 4-6) used the efficient water exchange system.

Data on the basic water quality parameters was collected twice in each week for eight months and analyzed using excel to get averages of the basic water quality parameter that include; dissolved oxygen, pH, Temperature and Ammonia.

3.0 Results and Discussion

3.1 Results

3.1.1 Improved design system for water quality parameters

The computed averages of the water quality parameter are shown in table 1

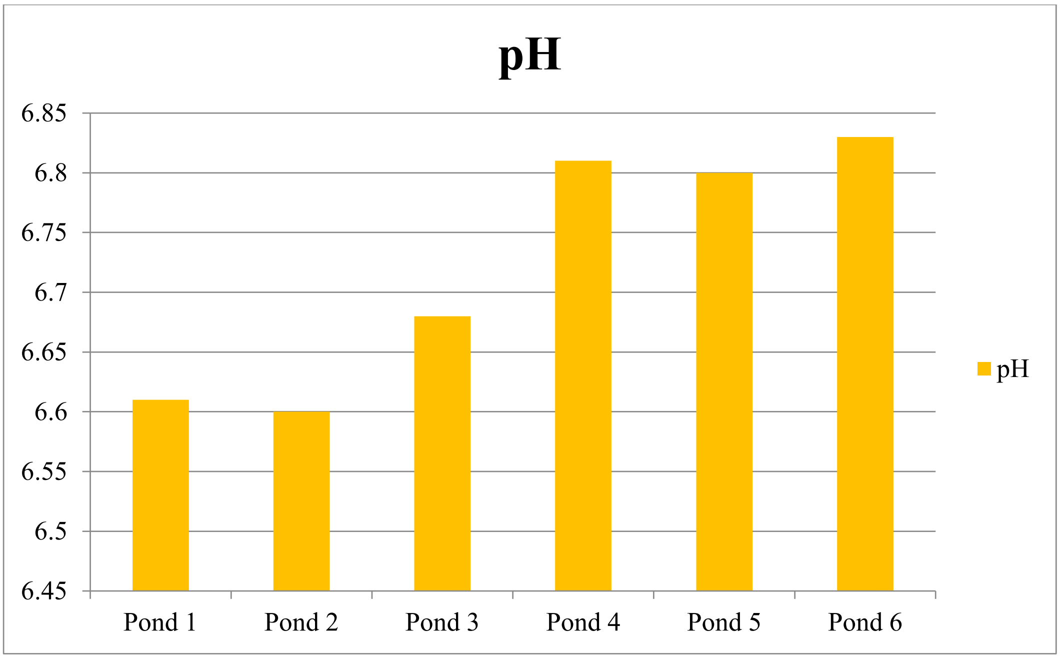

Fig. 3; Graph showing variations in pH

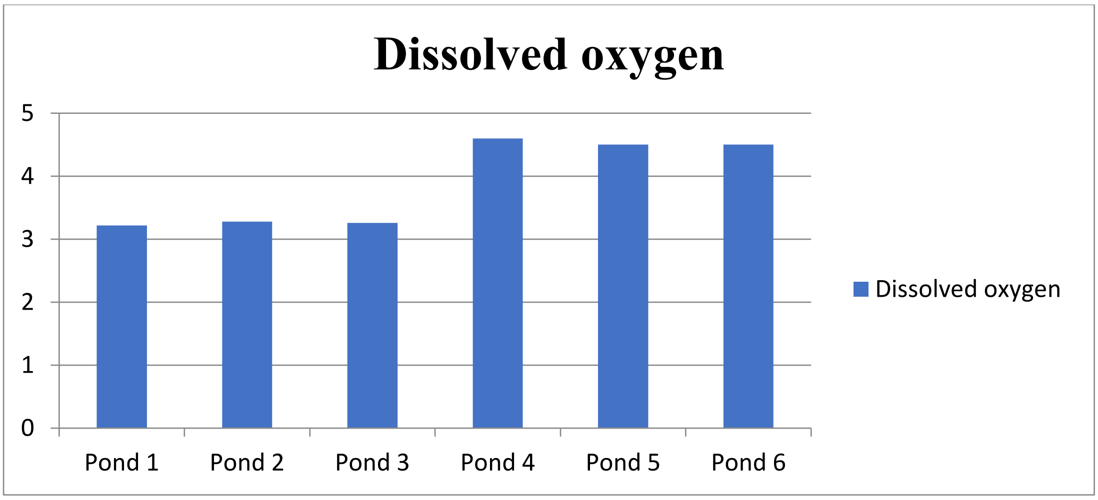

Fig. 4; Variations in dissolved oxygen

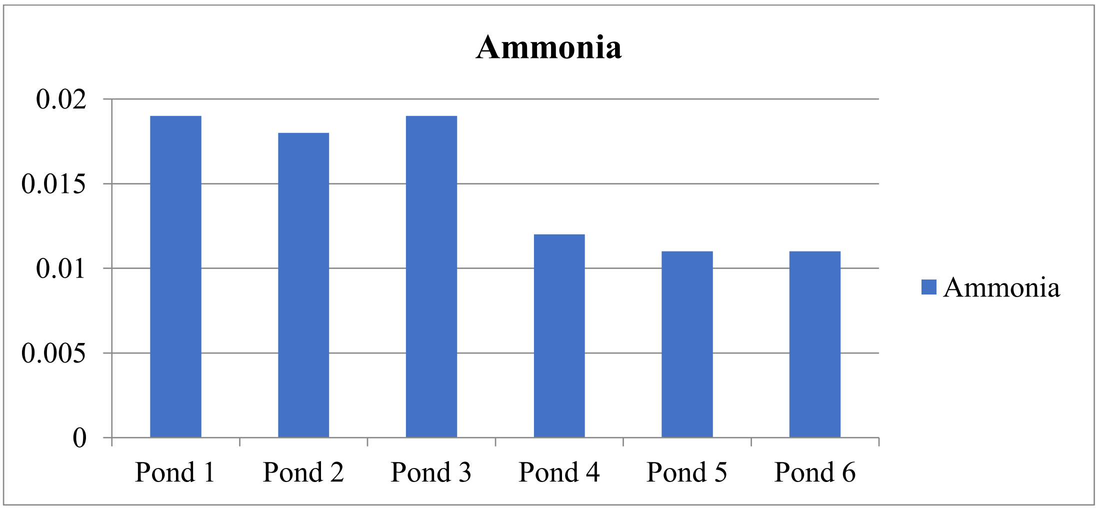

Fig. 5; Variations in Ammonia levels

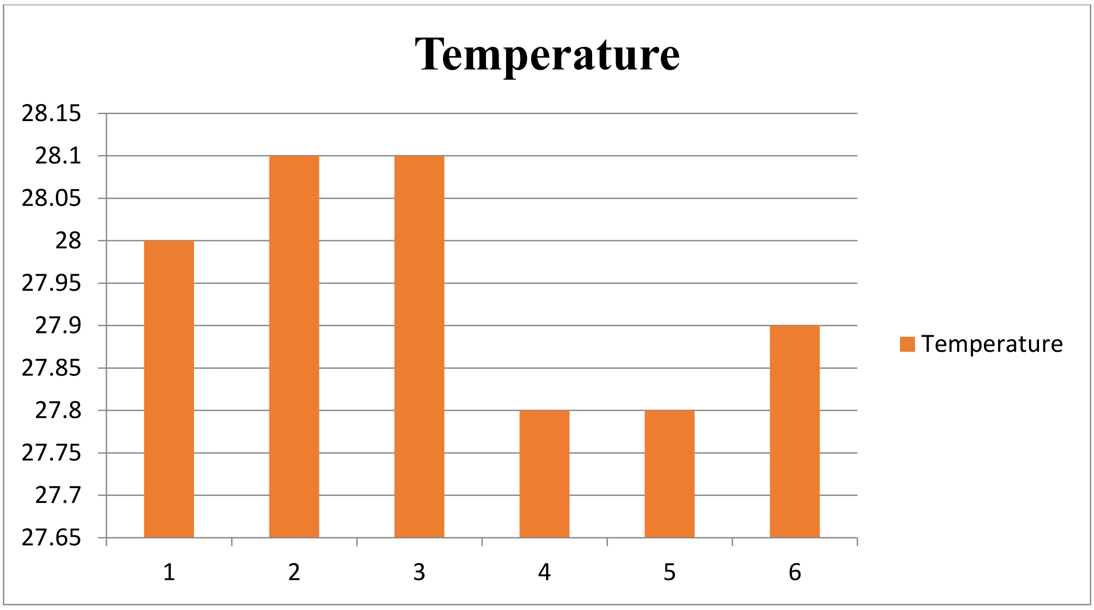

Fig. 6; Variations in water temperature

3.1.2 Improved stocking density and productivity of fish ponds /tanks

The experiment revealed the improved productivity using the improved water exchange system

Table 2; table showing stocking densities

	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5	Pond 6
Stocking density (number of fish per M^3)	4	4	4	6	6	6
Harvest (Kg/M^3) $*10^{-1}$	12	12	12.6	19.2	18.6	18.6

Table 3; Table showing productivity of ponds

	Ponds 1-3	Ponds 4-6
Average harvest (Kg/M^3)$*10^{-1}$	12.2	18.8

3.2 Discussion

Figure 2 shows the improvement of dissolved oxygen from 3 ppm to 4.5 ppm.

Figure 3 shows the reduction in ammonia levels within the pond/ tank water environment from 0.187 to 0.113 mg/l

Figure 1 shows a range of 6.6 to 6.83 which falls within the allowable range of 6.5 to 8.5.

Figure 4 shows the temperature range of 27.8 to 28.1 degrees centigrade which fall within the allowable range of 25 to 32 degrees centigrade.

From the above findings, it is evident that the innovation has improved the dissolved oxygen in fish pond and tank as production systems and this has resulted into increased carrying capacities of these structures. It has as well reduced the ammonia levels. The improved carrying capacities have resonated with the increased stocking densities which have eventually increased fish productivity by 54%.

4.0 Conclusion

The drained water that is rich in nutrients should be used to irrigate crops, to pave way for integrated aquaculture cum irrigated vegetable growing and aquaponics which are all environmentally friendly. Ultimately, this results in promotion of the circular economy in aquaculture and environmental sustainability. The innovation should be adopted by fish farmers who have selected aquaculture as an enterprise within the Parish Development Model (PDM), a government intervention intended to increase incomes of farmers. Also all fish hatchery operators should adopt this innovation to improve on fish fry survival rates. The adoption of this innovation can increase fish farmer's production and productivity. Upscaling the innovation can significantly increase aquaculture fish production in Uganda.

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