Developing and Assembling of Prototype Water Circulating System for Aquaculture in Ikorodu, Lagos, Nigeria

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Abstract

Nigeria has witnessed unprecedented interests in fish farming largely due to scarcity of fish in the local markets in addition to the huge export potentials of our local fin and shellfish species in international markets However, there are challenges associated with water availability, quality control and disposal of used water in aquaculture. Thus, prompted the need for development of a re-circulatory system that will put into consideration sustainability of required water. A Prototype of Re-circulatory Aquaculture System (PRAS) was constructed to check the challenge of sustainable quality water for improved production/yield in aquaculture and to determine the cost implication in the construction of the System. The constructed prototype re-circulatory system consisted of four bio-filter water treatment chambers (BWTC – 1, 2, 3 and 4) with different bio-filtering materials in each chamber to purify used water for recycling. The BWTC-1 is the sedimentation tank containing granite and sharp sand to remove or filter suspended solids from the used water. The BWTC-2 contained activated charcoal to adsorb or remove contaminants and impurities from the used water. The BWTC-3 contained oyster shell to remove nitrate, toxic ammonia and organic matter in the used water by degassing and to stabilize the water temperature and pH. The BWTC-4 contained plastic egg trays to remove impurities and also to degas the water in it. Results were presented as the line diagram and pictures of the constructed system. A total sum of ninety-four thousand seven hundred naira (₦94,700.00) was expended in the development of the system. The Prototype Re-circulatory Aquaculture System is capable of purifying used water for small-scale fish farming recycling system. Hence, it is hereby recommended for small-scale fish farming adoption and adaptation for a large-scale fish culture.

Keywords: water quality, Prototype Re-circulatory Aquaculture System (PRAS), cost.

Développement et assemblage du prototype Système de circulation de l'eau pour l'aquaculture à Ikorodu, Lagos, Nigéria

Résumé

Le Nigéria a connu des intérêts sans précédent dans les pisciculturesen grande partie en raison de la rareté des poissons sur les marchés locaux en plus des énormes potentiels d'exportation de nos espèces locales de nageoires et de crustacés sur les marchés internationaux Cependant, il existe des défis associés à la disponibilité en eau, au contrôle de la qualité et à la disposition d'utilisé de l'eau dans l'aquaculture. Ainsi, a suscité la nécessité de développer un système de re-circulatoire qui mettra en considération la durabilité de l'eau requise. Un prototype du système d'aquaculture re-circulatoire (PRA) a été construit pour vérifier le défi de l'eau de qualité durable pour une production / rendement amélioré en aquaculture et pour déterminer l'implication des coûts dans la construction du système. Le système de re-circulatoire du prototype construit était composé de quatre chambres de traitement de l'eau bio-filtre (CTEB - 1, 2, 3 et 4) avec différents matériaux bio-filtrants dans chaque chambre pour purifier l'eau utilisée pour le recyclage. Le CTEB-1 est le réservoir de sédimentation contenant du granit et du sable tranchant pour éliminer ou filtrer les solides en suspension de l'eau utilisée. Le CTEB-2 contenait du charbon activé pour adsorber ou éliminer les contaminants et les impuretés de l'eau utilisée. Le CTEB-3 contenait une coquille d'huîtres pour éliminer le nitrate, l'ammoniac toxique et la matière organique dans l'eau utilisée par dégazage et pour stabiliser la température de l'eau et le pH. Le CTEB-4 contenait des plateaux d'œufs en plastique pour éliminer les impuretés et également pour dégager l'eau. Les résultats ont été présentés comme le diagramme de ligne et les images du système construit. Une somme totale de quatre-vingt-quatre mille sept cents nairas (₦94 700,00 N a été dépensée dans le développement du système. Le prototype du système d'aquaculture re-circulatoire est capable de purifier l'eau d'occasion pour le système de recyclage des pisciculturesà petite échelle. Par conséquent, il est recommandé par les présentes pour l'adoption et l'adaptation des pisciculturesà petite échelle pour une culture du poisson à grande échelle.

Mots-clés: qualité de l'eau, prototype Système d'aquaculture re-circulatoire (PRA), coût.

شهدت نيجيريا اهتمامات غير مسبوقة في تربية الأسماك بسبب ندرة الأسماك إلى حد كبي في الأسواق المحلية بالإضافة إلى الإمكانات الهائلة لتصدير أنواع الزعانف والمحار المحلية لدينا في الأسواق العالمية ومع ذلك، هناك تحديات مرتبطة بتوافر المياه مراقبة نوعية المياه المستعملة والتخلص منها في تربية الأحياء المائية. وبالتالي، دفعت الحاجة إلى تطوير نظام إعادة الدورة الدمويةالتي ستضع في الاعتبار استدامة المياه المطلوبة. تم إنشاء نموذج أولي لنظام تربية الأحياء المائية المعاد تدويرهللتحقق من التحدي المتمثل في استدامة نوعية المياه لتحسين الإنتاج/الغلة في تربية الأحياء المائيةوتحديد الآثار المترتبة على التكاليف في تشييد النظام يتكون نظام إعادة الدورة الدموية النموذجي من أربع غرف لمعالجة المياه بمرشح بيولوج مع مواد تصفية بيولوجية مختلفة في كل غرفة لتنقية المياه هو خزان الترسيب يحتوي على الجرانيت والرمال الحادة لإزالة أو تصفية المواد الصلبة المعلقة من المياه BWTC-1 المستعملة لإعادة التدوير على قشرة محار لإزالة BWTC-3 على فحم منشطلامتزاز أو إزالة الملوثات والشوائب من المياه المستعملة. احتوى BWTC-2 المستعملةاحتوت على صواني بيض BWTC-4 احتوت .PH النترات والأمونيا السامة والمواد العضوية في المياه المستعملةعن طريق الشحوم وتثبيت درجة حرارة الماء و بلاستيكية لإزالة الشوائب وأيضًا على الماء الموجود فيها قُدمت النتائج على شكل مخطط سطري وصور للنظام المشيد.تم إنفاق ما مجموعه أربعة وتسعين ألف

في تطوير النظام النموذج الأولي لنظام إعادة تربية الأحياء المائية قادر على تنقية المياه المستعملةلنظام إعادة تدوير تربية (N94,700.00) وسبعمائة نايرا الأسماك على نطاق صغير. وبالتالي، يوصى بموجب هذا بتربية الأسماك على نطاق صغير اعتماد وتكييف ثقافة سمكية واسعة النطاق

Introduction

In recent times, Nigeria has witnessed unprecedented interests in fish farming largely due to scarcity of fish in the local markets in addition to the huge export potentials of our local fin and shellfish species in international markets (Anyanwu and Ezenwa, 2003). However, the aquaculture sector has not been able to attain its full potentials arising from problems associated with water supply and management. These problems varied in their manifestation in various ecological zones of Nigeria. In the arid region, it is associated with inadequate water supply due to low rainfall, high water evaporation rates, loose soil types and poor water retention characteristics of the soil, while in the humid region, the problem is mainly that of drainage of wastewater and unavailability of land due to intensive urban development. Hence, the traditional flow through system adopted by majority of fish farmers is increasingly becoming obsolete leading to the closure of most farms in urban and peri-urban communities. Hence, research effort must be geared towards a system that will minimize water wastage by encouraging the treatment and reuse of wastewater in fish production.

Re-circulating Aquaculture Systems (RAS) are intensive, usually indoor tank-based systems that achieve high rates of water re-use by mechanical, biological, chemical filtration and other treatment steps (Bregnballe, 2015). Re-circulatory aquaculture systems (RAS) are designed to minimize water consumption, control culture conditions, and allow waste streams to be fully managed (Libey, 1993; Ebeling *et al*., 1995: Bebak-Williams *et al*., 2002; Jared *et al*., 2006). They can also provide some degree of biosecurity since they provide means of isolating the stock from the external environment (Anon, 2013). However, the high cost of procurement and installation of RAS arising from the fact that majority of its components are imported place it out of reach of average Nigerian fish farmer, thereby making its adoption extremely difficult. This project was therefore aimed at designing and constructing a Prototype RAS using locally available materials as well as determining the cost of construction to enhance its adoption among fish farmers in Nigeria.

Materials and Methods

Construction Site

The Prototype Re-circulatory Aquaculture System (PRAS) was constructed in the nursery and hatchery unit of the Department of Fisheries Technology, Lagos State Polytechnic, Ikorodu, located on latitude 6º37'N, longitude 3º31'E.

Procedure for Design and Construction

The design was conceived by the team, sketch on A3plain sheet of paper and thereafter, drawn to scale of 1:10 using autocad® 2015 software. The materials used for the construction are as presented in Table 1. The woods and carpentry materials were obtained from Fadama market in Ikorodu, whilethe pipes and other plumbing materials were sourced from dealers within Lagos State Polytechnic. Again, the activated carbon and oyster shell were obtained from accredited sellers in Ojota market, Lagos. The bio-tower was made from a cylindrical plastic frustum of dimension 58cm x 45cm x 70cm. Two holes of 12mm diameter were drilled towards the base of the tower tank and at the top edge opposite the first hole. The holes were fitted with a back knot each and silicon sealant was used to seal the back knot to the plastic.

Plastic Egg trays were arranged inside the tower to serve as bio-filter.

The rearing tanks comprise five (5) cylindrical plastic frustum of dimension 60cm x 33cm x 32cm. A hole was bored at the base of each rearing tank and each was fitted with a back knot which was sealed with silicon sealant, a 9mm pipe of 70cm length was attached to the back knot and each pipe was connected to a 12mm pipe via an adaptor. The 12mm pipe of 370cm length was connected to the sedimentary tank. 12mm air valve was connected at the point of connection to the sedimentary tank. The sedimentation tank, carbon filtration tank and purification tank were made from a cylindrical plastic frustum of 60cm x 33cm x 32cm dimension. Two holes of 12mm diameter were drilled towards the base of each of the tanks and a hole of 12mm diameter at the top edge of each tank opposite the first hole. The holes were fitted with a back knot each and silicon sealant was used to seal the back knot to the plastic. Granite of 25kg was poured into the sedimentation tank followed by 25kg of sharp sand to serve as the sedimentary water filter. The sedimentary tank was connected to the rearing tanks through 12mm pipe that was connected from the rearing tanks was fitted into the back knot at the top edge while another 12mm pipe of 40cm length was connected from the back knot towards the base of the sedimentation tank into the carbon filtration tank, while another 12mm pipe of length 40cm was connected from the back knot towards the base of the carbon filtration tank into the purification tank. Activated charcoal of 5kg was poured into a sieve bag and then placed at the base of the carbon filtration tank to serve as carbon water filter. A 12mm pipe that was connected from the carbon filtration tank was fitted into the back knot at the top edge while another 12mm pipe of 22cm length was connected from the back knot towards the base of the purification tank into the pumping machine. Oyster shell of 25kg was poured into the purification tank to serve as water purifier. The pumping machine (0.5hp) was connected to the system by attaching the water inlet to the purification tank and the water outlet to a pipe connected to the bio-tower. Wooden platforms were constructed to hold all the structures in place.

Cost Determinants

The costs of procurement of the materials were recorded at the point of purchase. The total hours expended per person in the construction process was also recorded and multiply by a factor of ₦400/man hour to estimate the workmanship.

Presentation of Results

The results of the construction were presented in form of diagram, photographs and table of the cost incurred during construction.

Result and Discussion

The design of the Prototype Re-circulatory Aquaculture System (PRAS) is shown in Figure 1, while the photograph of the Constructed prototype re-circulatory system and subcomponents of the prototype re-circulatory system are depicted in Plates 1 to 8.

The System was entirely made up of locally available raw materials and it covers an Area of 141276cm^2. Each container has an inlet and outlet lines. The inlet line to the rearing tank has a diameter of 9mm with a spray bar with a T shape that is 0.2m away from the rearing tank to promote the water distribution in the tank as well as the introduction of oxygen. The outlet was equipped with a 9mm drainpipe at the bottom, which emptied water/effluents to a larger 12mm flow line that empties into the sedimentation tank. A 12mm line takes water from the borehole to the overhead tank, while a 9mm pipe brings the water from the overhead tank to a distributing point to the tanks. A 0.5hp pumping machine was installed to pump

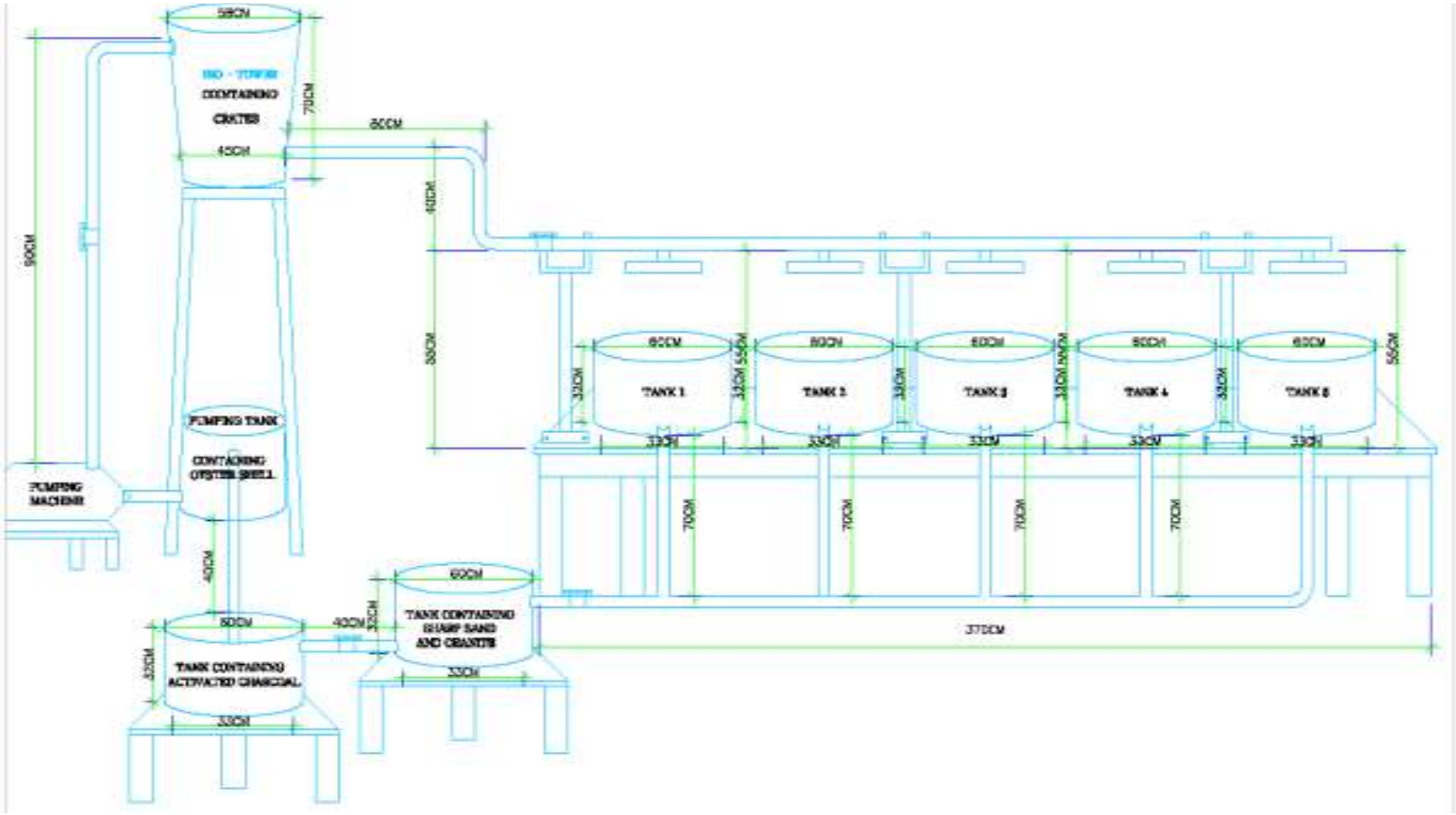

Figure 1: Design of Prototype Recirculatory Aquacultural System

Plate 1. Cross section of the rearing tanks

Plate 2: Cross section of the bio-tower connected to the purification tank

Plate 4: Arrangement of egg tray in the bio-filter water treatment tank

Plate 5: Cross section of the sedimentation and bio-filter water treatment tank

Plate 6: Connection of water pump to the water treatment tank

Plate 7: Side View of the constructed prototype re-circulatory System

Plate 8: Front view of the constructed prototype re-circulatory System

water from the submerged tank to the bio-filter tank that flows gradually through a series of filtration points and degassing point to the overhead tank to continue the re-circulation. There were different methods of filtration units adopted in this system; the sedimentation tanks which aid in the removal of solid wastes as it served in the purification process, the bio-bed which contains graded levels of granite, sharp sands, oyster shell, and activated carbon which helps in the break-down of toxic ammonia.

The cost of construction of the Prototype Re-circulatory Aquaculture System is shown in Table 2 below. A total sum of ninety-four thousand seven hundred naira (N94,700.00) was expended in the cause of the project. An amount that should be affordable to small scale aqua culturist and is relatively lower than the cost associated with procurement of water, water management and wastewater disposal in aquaculture.

Table 1: Cost of construction of the prototype Re-circulatory System

MATERIALS	QUANTITY	PRICE PER UNIT (₦)	TOTAL PRICE (₦)
9mm pipes	7	1,400.00	9,800.00
9mm tee	4	200.00	800.00
9mm elbow	16	150.00	2,400.00
12mm air valves	5	1,000.00	5,000.00
Tank back knot	12	1,000.00	12,000.00
Silicon sealant	1	1,700.00	1,700.00
6mm plug	10	100.00	1,000.00
12mm adaptor	14	200.00	2,800.00
6mm pipe	2	1,200.00	2,400.00
12mm pipe	3	1,700.00	5,100.00
12mm by 9mm sockets	14	200.00	2,800.00
12mm by 9mm tee	6	300.00	1,800.00
12mm by 9mm elbow	2	300.00	600.00
0.5 hp pumping machine	1	3,000.00	3,000.00
50L plastic bowls	8	700.00	5,600.00
100L plastic tower tank	1	2,000.00	2,000.00
Granite	25kg		1,500.00
Sharp sand	25kg		1,500.00
Oyster shell	25kg		1,500.00
Activated Charcoal	5kg		1,500.00
Wood and Nails			15,000.00
Plastic egg trays	1 dozen	200.00	2,400.00
Workmanship			10,000.00
Top Git®	1 can.	2,500.00	2,500.00
Total			94,700.00

Conclusion

A four- bio-filter water treatment chambered Prototype of Re-circulatory Aquaculture System (PRAS) of 14.13m^2 costing ₦94,700 was developed to mitigate problems of water availability and quality in the study area at a relatively cheap cost. This is capable of purifying used water for a recycling system in small-scale fish farming. It is hereby recommended for small-scale fish farming and can further be adapted for large-scale use.

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