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ORIGINAL RESEARCH

Design and construction of a collapsible tarpaulin-lined pond for aquaculture production

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Abstract
Aquaculture basically refers to the technique of growing fish in tanks or cages to supplement or replace wild fisheries. Despite many advances in culture system development, traditional aquaculture systems do not allow for both flexibility of use and water re-circulating. With the aim of promoting sustainable aquaculture through simple and flexible re-circulating aquaculture systems, a collapsible tarpaulin-lined pond was developed to provide culturing space for 1000 pieces of African Catfish (*Clarias gariepinus*) or 500 pieces of Nile Tilapia (*Oreochromis niloticus*) assuming a survival rate of 100 %. A circular geometry was selected for the pond with diameter and height of 4.3 m and 0.9 m, respectively. A pentadecagon framework assembly consisting of connecting rods, angle connectors and stands was designed and constructed of galvanised steel pipes to support the high-grade canvas tarpaulin tank. The tank can safely withstand water and fish load at full capacity without failure at maximum stresses of 0.11 MPa, 0.17 MPa, 0.13 MPa, and 6.26 MPa, representing stress at the tarpaulin's base, shear stress on connecting pipes, compressive axial stress on the leg, and bending stress, respectively. A biological filtration unit was installed on the tank to culture African Catfish at a stocking density of 78 fish/m^3 or 39 fish/m^3 for Nile tilapia. This novel aquaculture technique offers a more sustainable and controlled means of producing food and other aquatic products to meet the increasing global demand.

Keywords: Aquaculture, Stocking Density, Tarpaulin, Pentadecagon, Clarias Gariepinus, Tilapia

Introduction
Aquaculture involves the breeding, rearing and harvesting of plants and animals in all types of water environments including ponds, rivers, lakes and oceans (Umanah and Dapa, 2017). Constituting one of the world's largest sources of animal protein, fish production is crucial to global food security and nutrition (Shah and Mraz, 2020). According to FAO (2020), 46 % of estimated total fish production was derived from aquaculture in 2018, with fish food sources accounting for 17 % of the global population's intake of animal proteins and 7 % of all protein consumed globally. Aquaculture plays a key role in the prosperity of many sub-Saharan African countries including Ghana and Nigeria. It contributes to food security by augmenting domestic fish production as well as creating jobs for people (Oyedeji, 2016). The Nile tilapia (*Oreochromis niloticus*), bony tongue (*Heterotis niloticus*) and African catfish (*Clarias gariepinus*) are the primary species for fish cultured in the Ghanaian aquaculture space. These species are relatively easy to culture, grow faster and have the ability to withstand and grow in harsh environmental conditions (Agyakwah et al., 2020).

Demand for fish is significantly increasing as a result of the ever-increasing rate of global fish consumption and world population growth (Lekang, 2007). According to FAO (2020), the average annual growth rate of total fish consumption and population growth over the past 60 years is 3.1 % and 1.6 % respectively. Global fish consumption rate in recent years, together with the increasing population growth rate when juxtaposed with global fish production rate, raises supply sustainability concerns (Shah and Mraz, 2020). The rate at which demand for fish is increasing outpaces the rate at which production of fish is advancing. In the case of Ghana, local production has not kept up to meet demand, creating a fish deficiency of 151,541.25 metric tonnes according to FAO (2020). Pervasive challenges have historically plagued the sector and hindered growth as a result of low technical know-how, lack of quality inputs and technology (Agyakwah *et al*., 2020). Ghana needs to advance in fish production technologies to close its fish production deficit.

To ensure sustainability of food fish commodity, FAO (2020) proposed the intensification of the quota which aquaculture contributes to global fish production. Raising aquaculture output means production systems must be made easy-to-manage to whip the appetite of many to venture into the field. In the face of global pandemics like the novel Covid-19 and the need for enhanced food and nutrition security, it is vital that innovations on production technologies that introduces options of flexibility, portability and easy operability to aquaculture production are developed. Unfortunately, design flaws and lack of scientific basis plague most locally built, flexible fish holding units. This makes it tough to scale up such designs. As a result, after a season or two of use, most owners stop using these tanks due to a variety of technical issues, such as leaks, instability, and bulging.

Despite the development of novel tank designs based on varied geometrical forms and sizes (Amponsah, 2018; Amponsah *et al*., 2021), the dream of completely exploiting the benefits of flexible culturing systems has not been fully realized. Many prospective aquaculture producers are discouraged by the high amount of water used in current fish culturing systems. Effective waste management techniques are required to salvage high water usage levels associated with current culturing systems (Schuenhoff *et al*., 2003). Introduction of improved water re-circulation systems that allow waste to be filtered out and water conserved is required (Martins *et al*., 2010). Traditional tank holding systems such as the earthen and elevated ponds satisfy only farmers looking for more permanent holding systems for production over a long period of time. It does not come in handy for people who are interested in backyard fish culture and are looking for a more temporal tank holding systems (Agyakwah *et al*., 2020). Much advanced solutions has been explored by the European aquaculture giant AKVA group but they are expensive for small-holder farming applications (AKVA Group, 2017). For small-holder production applications, collapsible ponds are a

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better choice for persons with less starting capital, because earthen ponds require more labour and have higher maintenance costs. Collapsible ponds are also made from locally available materials. In scholarly works, not much is said about collapsible tarpaulin-lined ponds though the concept is emerging on the market in mostly rectangular shapes. Currently, existing collapsible tarpaulin lined ponds on the market does not have biological filtration units and hence does not allow for water conservation.

The objective of the study is to design a collapsible tarpaulin-lined fishpond system which allows for both flexibility of use and water re-circulation, for aquaculture production. The study used a pentadecagon framework as the skeletal framework to achieve a circular pond geometry. This is because ponds of circular geometry allow for effective waste removal for better pond water quality management. It helps to achieve desirable levels of dissolved oxygen (DO), pH and total suspended solids (TSS) (Amponsah et al., 2021).

Materials and Methods

Pond design methodology

The tank's design and construction were carried out at the Agricultural Engineering and Transport Division Workshop, located at the CSIR-Crops Research Institute in Fumesua, Kumasi. The design methodology for collapsible tarpaulin-lined ponds follows the engineering design process as shown in Figure 1. Pond capacity (load) was determined at the design stage using established stocking densities for species and desired number of fish to be stocked. Design decisions were made on the geometry of the pond based on research and observation. Components were then designed for construction, assembly, testing and evaluation.

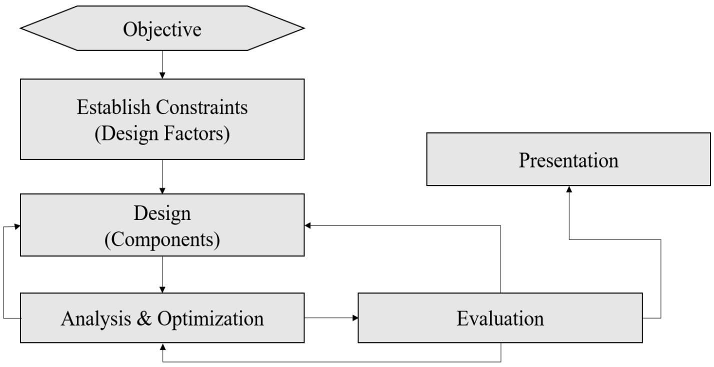

Figure 1 Pond design process

Pond design factors

The pond system was designed to achieve key functional goals. Parameters considered in design stage of the system include tank volumetric capacity, stocking density, pond geometry, number of stands or legs, capacity of biological filtration (bio-filter) setup and tank material type. Other important design factors include portability, flexibility, ease of assembly and ease of operation.

Design concept and description

The collapsible tarpaulin-lined pond is composed of two major components, namely the tank (holding facility) and the biological filtration (bio-filter) setup. The tank or holding facility is made of canvas tarpaulin material. The tarpaulin tank is developed and mounted on a metal framework consisting of connecting rods, angle connectors and legs/stands made from galvanised steel pipes. Each part of the framework is constructed separately and can be assembled or disassembled. Fasteners (bolts and nuts) at respective joint of the frame have been provided to allow easy assembly and disassembly of the tank, making it portable. A belt is provided to guard against bulging of the tarpaulin when under water pressure. A circular geometry was selected for the tank design and the pentadecagon framework sets the stage for a circular tank geometry.

The biological filtration (biofilter) setup is the single most important component of the pond system as far as waste management is concerned. Bio-filters use natural processes and organism (bacteria) through the nitrogen cycle to break down ammonia into less harmful components. It also helps remove faecal waste and leftover feed from the pond water to ensure that the water is conducive for fish culture. A standard bio-filter is composed of submersible pumps, water hoses, nylon mesh-stuffed bucket on a stand, nylon meshed-stuffed basket inside the waste tank, sedimentation tank with its accompanied plumbing components. A detailed list of materials used for their construction is provided in Table 1.

Table 1 List of construction materials, specifications, and functions

Material	Specification	Function
Steel pipe	2” galvanized round pipe	Used for constructing the skeletal pentadecagon framework
PVC pipe	1” pipe (26.6mm); ½” & 2” pipe (50mm); ¾” pipe (60mm)	For making the in-tank bio-filter stand
PVC-coated canvas tarpaulin sheet	High density Polyvinyl chloride (PVC) coated fabric/canvas material with minimum density of 200 g/m^2, 100% moisture resistance rating	Used in constructing the main tank and tank belt
Hardwood		Used for making the electric stand
Bucket	25-litre plastic bucket	Used as mesh-stuffed bucket for the in-tank bio-filter component
Basin	Plastic basin (12" diameter)	Used as mesh-stuffed basin for the external bio-filter component
Waste bucket	Plastic drum with lid (120 litres)	Used as main waste tank
Water hoses	¾ garden hose	For water transportation within the bio-filtration set-up

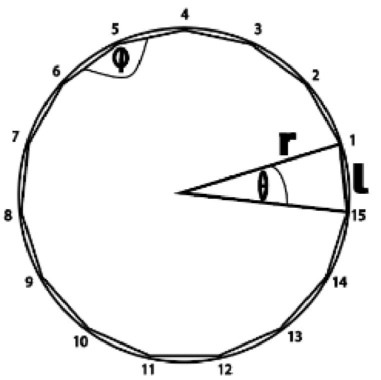

Figure 2 Mensuration of circular pond design

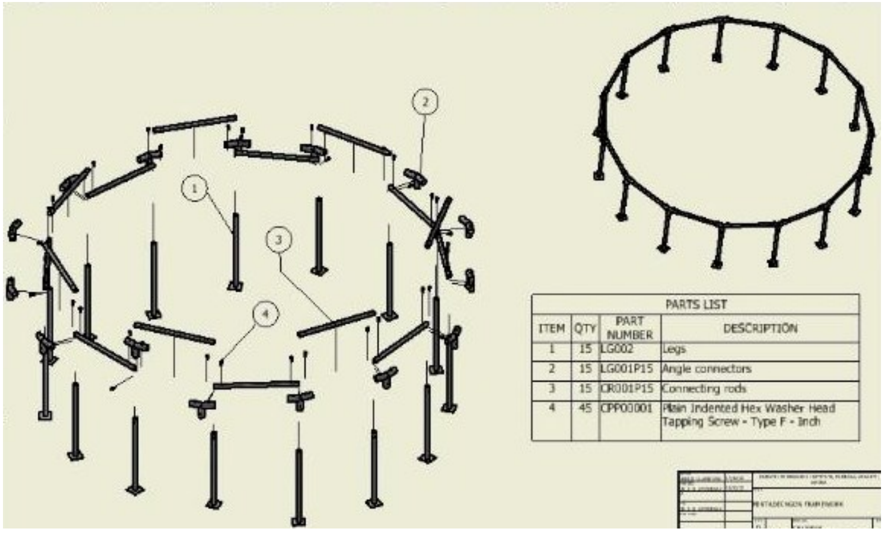

Figure 3 Pentadecagon framework of pond

Design calculations

Stocking density

Stocking density is a major determining factor for fish production and farm profitability because it directly affects fish survival, growth, behaviour, health, water quality, and feeding (Oké and Goosen, 2019). Stocking density was determined using Equation 1 following Umanah and Dapa (2017).

$$\text{Stocking density} = \frac{\textit{Number of fish stocked}}{\textit{Volume of pond } (\text{m}^2)} \quad (1)$$

Mensuration of pond

The skeletal framework of the tank was designed as a pentadecagon (regular polygon of 15 sides/angles as shown in Figure 2), having leg/stand support at each interior angle. The interior angle of the pond skeletal framework was calculated using Equation 2 as follows:

$$\varphi = \frac{n - 2}{n} \times 180^{o} \quad (2)$$

Where n = *number of sides, angles or legs*

Stocking capacity

The tank is expected to optimally hold a total of 1000 pieces of African Catfish (*Clarias gariepinus*) or 500 pieces of Nile Tilapia (*Oreochromis niloticus*).

Tank frame components

The framework components are made of galvanized steel pipes, which are structurally durable, lighter and corrosion resistant. The pipes were cut according to dimension and arc welded using butt welds. Welded joints were carefully grinded using a hand-held grinder. These grinded joints were sprayed with red-oxide and later with silver paint to prevent corrosion. An assembly of the tank framework is provided in Figure 3.

The stands were designed to provide support to the pond system. The number of stands or legs was determined by the number of sides or angles of the polygon.

The length of each connecting pipe was determined as the length of the chord that the internal angle, Θ makes with the circumference (Fig. 2). It was given by Equation (3).

$$\text{Length of a chord , L} = 2r\sin\frac{\Theta}{2} \quad (3)$$

Where r = *radius of circle (m)*

Angle connector (Fig. 4) is an important component of the framework which serves as the converging point for the connecting rods and their respective legs/stands at each interior angle of the pentadecagon framework. The component has two butt-welded flanges designed to mate with two connecting rods at angle φ apart from each other in the horizontal plane. The angle connector also has a flange which stands in the vertical plane designed to mate with the leg of the framework.

Bio-filter system and installation

The size of the biological filtration setup is based on the volumetric capacity and expected load in terms of waste generation of the pond system. A standard bio-filter is composed of submersible pumps, water hoses, nylon mesh-stuffed bucket on a stand, nylon meshed-stuffed basket inside the waste tank, sedimentation tank with its accompanied plumbing components (Fig. 5). The two submersible pumps are for recirculating/aeration and return. The sedimentation tank

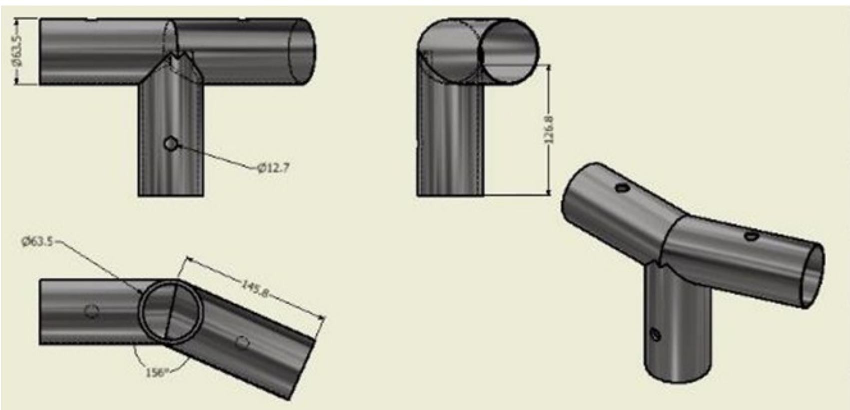

Figure 4 Detailed drawing of angle connectors

has holes at the base to receive plumbing components and a wastewater tap outlet for waste discharge. Another hole at midway of waste/sedimentation tank returns filtered water for recirculation into the pond. Water hoses were used as different hydraulic conduits on the bio-filter set-up.

Most components of the biofilter setup are made of pre-existing containers which have been serviced to achieve characteristics suitable to the design. The nylon mesh is the filtration sieve in the assembly. By using a copper wire and a pair of pliers, the nylon mesh was stuffed into the mesh bowl and the mesh bucket to complete the double-stage sieving components. The waste tank receives wastewater for sedimentation and filtration. Two holes were drilled at both the base and midway to receive plumbing components. An *h-shaped* external plumbing loop was constructed to create pathways for filtered water to return while keeping the waste out. Water hoses were used as conduits for water transportation in and out of the pond. Two submersible pumps were used, among which one is for circulation/aeration and the other for returning of water into the pond after filtration. The two submersible pumps are powered by an electric stand placed close to the pond. The complete biofilter setup with various components is exploded in Figure 5.

Tarpaulin tank development and construction

The tarpaulin holding facility was constructed using the development of cylinders as shown in Fig. 6. The various parts of the tarpaulin tank were heat welded using a heat gun to form the complete holding facility. A belt was added to prevent bulging of pond due to pressure of water on the walls of the tank. The length of the belt was determined as πd in IV of Fig. 6 where d is diameter of pond and t is width of belt. AutoCAD version 2020 (Autodesk, 2020) was used for the computer-aided design (CAD) drawings of the tank and all other relevant components.

Operating principle of pond setup

The pond is filled with water and stocked with fingerlings. Waste accumulation from feed and faeces is concentrated at the centre by centrifugal action produced by circulatory pump placed on a pump stand inside the pond. Water hoses placed at the centre of the pond collect wastewater by capillary action and transport the waste to the sedimentation tank for filtration and further treatment. Filtered water is recirculated by a returning pump while the waste is ejected as effluent.

Stress analysis

The volume of the pond (v) was estimated by Equation (4) given as:

$$v = A \times h \ (m^3) \qquad (4)$$

Where $A = \pi r^2$, *and* h = *height of pond*

The mass of water in pond (m_w) was estimated by Equation (5) given as:

$$mw = pw \times v \ \ (g) \qquad (5)$$

Where pw = density of water (gm^{-3})

The cross-sectional area (A_c) of galvanised steel pipes was

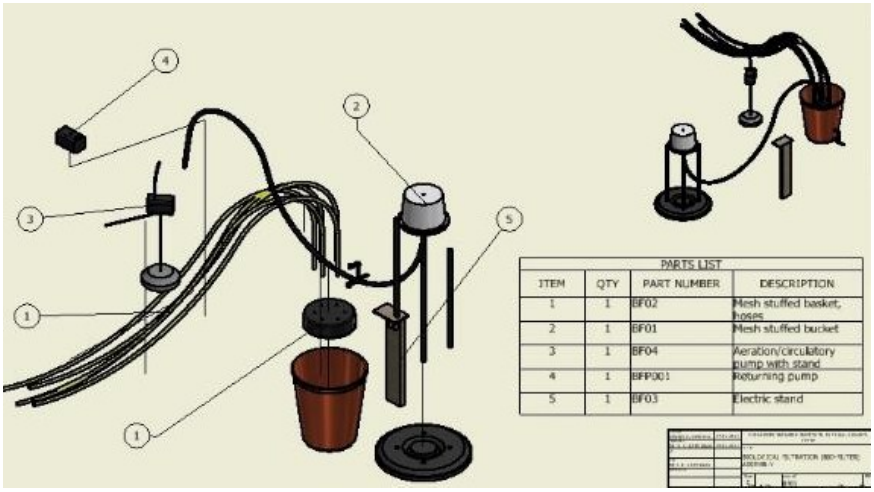

Figure 5 Biological filtration (Biofilter) assembly

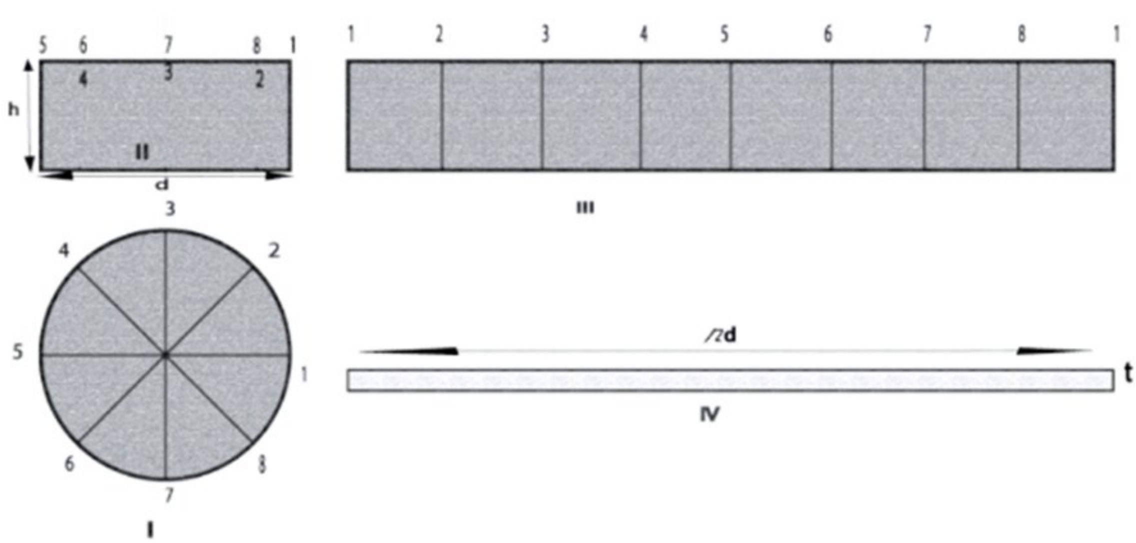

Figure 6 Development of tarpaulin tank

given by Equation (6) as follows (Gere, 2004):

$$A_c = \pi \frac{(d_o^2 - d_i^2)}{4} \ (m^2) \quad (6)$$

Where d_o = *outer diameter of cross - section (m)*
di = *inner diameter of cross - section (m)*

The maximum shear stress in connecting pipes was determined by Equation (7) as follows (Pytel and Kiusalaas, 2012):

$$б_s = \frac{4V}{3A_c} \ (Pa) \quad (7)$$

Where *V = maximum shear load on connecting pipes (N), and A_c= Cross-sectional area of connecting pipes (m^2)*

The maximum bending stress on connecting pipes was determined by Equation (8) as follows (Pytel and Kiusalaas, 2012):

$$\text{Maximum bending stress } б_s = \frac{32M}{\pi(D^3 - d^3)} \ (Pa) \quad (8)$$

Where *M = maximum bending moment (Nm), d = inner diameter of cross-section (m), D = outer diameter of cross-section (m)*

Following Gere (2004), the maximum compressive axial stress on leg/stand was computed as:

$$б_c = \frac{R_A}{A_c} \ (Pa) \quad (9)$$

Where A_c = cross sectional of strand or legs (m^2), and R_A = Reaction at support (N)

Total mass of fish in pond at maturity was computed as:

$$m_{Tf} = M_f x \ N_s \ x \ Sr \ \ (kg) \quad (10)$$

Where M_f = Average mass of fish at maturity (kg), N_s = Number of fish at stocking, S_r = Fish survival rate (%)

The stress/pressure at the tarpaulin base of pond was given by:

$$P_b = P_{atm} + \frac{W_b}{A} \ (kPa) \quad (11)$$

Where A= base area of tarpaulin tank, P_{atm} = Atmospheric pressure (101.325 kPa), W_b = weight or load at base of tank (N)

Results and Discussion

Pond mensuration calculations

The respective pond design parameters were calculated as follows:

Interior angle of the pond is from Equation (2):

$$\varphi = \frac{(15 - 2)}{15} \times 180^o = 156^o$$

Using desired number of fingerlings at stocking as 1000, total base area desired for pond A is 14.3 m^2. This implies that the radius of the pond will be 2133.5 mm. The internal angle extended by the pentadecagon at its circular arc is computed as:

$$\Theta = \frac{360}{n} = \frac{360}{15} = 24^o$$

From Equation (3), length of connecting pipe, l is 887.2 m. A height of 0.9 m pond was selected for the tank to make it easier for an average adult to work on the fish tank with ease. The summary of results from design calculations is given in Table 2. Figure 7 shows the complete assembly of the various components of the collapsible tarpaulin-lined pond.

Table 2 Summary of results from design calculations

Name of part dimension	Value
Interior angle of angle connectors	156^o
Length of connecting pipes	887.2 mm
Radius of tarpaulin base	2133.5 *mm*
Area of circular base of tarpaulin	14.300000.0 m^2
Circumference of tarpaulin	13112.4 *mm*
Height of tarpaulin	900.0 mm
Height of legs	900.0 mm
Volumetric capacity	12.87 m^3

Stocking density

From Equation 1:

The stocking density for Catfish and Tilapia were respectively determined as follows:

$$\text{Stocking density}_{catfish} = \frac{1000}{12.87 \ m^3} = 78 \ fish/m^3$$

$$\text{Stocking density}_{Tilapia} = \frac{500 \ Tilapia}{12.87 \ m^3} = 39 \ fish/m^3$$

Figure 7 Collapsible tarpaulin lined pond assembly

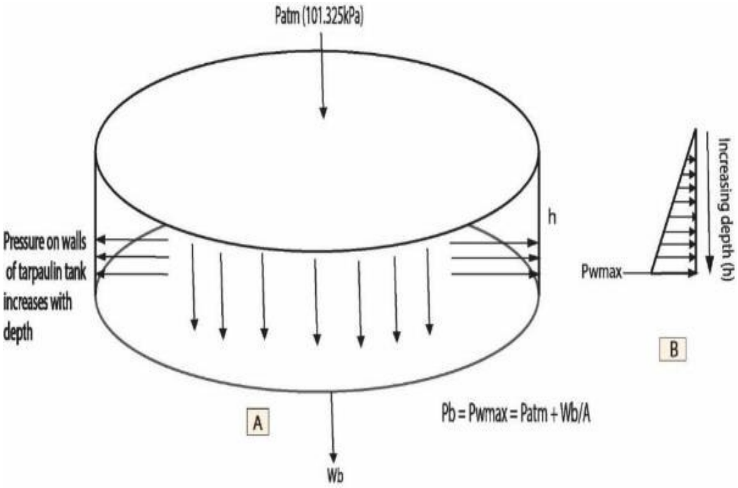

Figure 8 Stresses on walls of tarpaulin tank

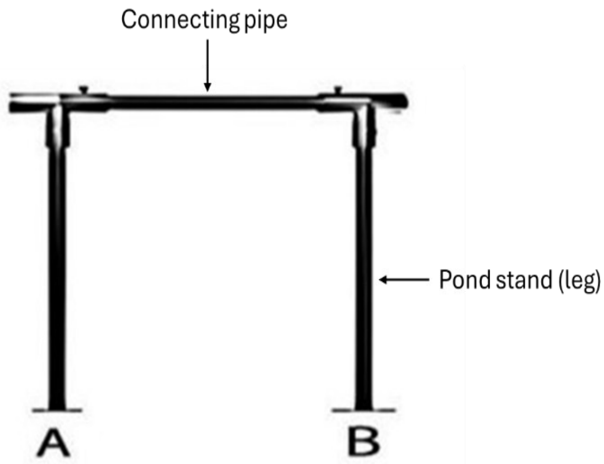

Figure 9 Pond framework components

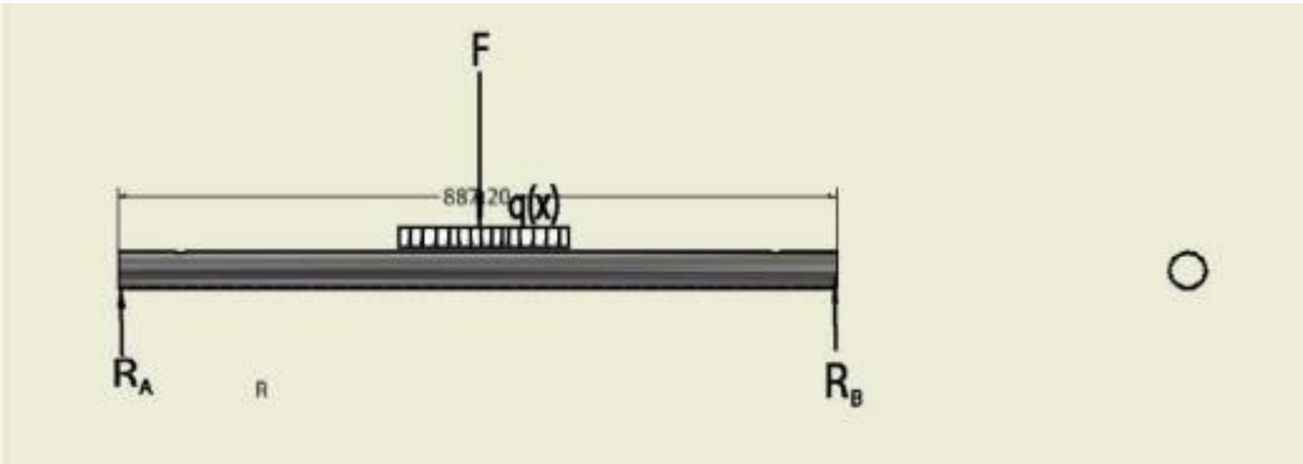

Figure 10 Free body diagram of connecting pipe

Stress analysis of pond design

Stresses on tarpaulin

Volume of pond, $v = A.h = 14{,}300{,}000\ mm^2 \times 900\ mm = 12.78 m^3$

Mass of water in pond,
$m_w = p_w \times v = 1000\ kg/m^3 \times 12.87\ m^3 = 12870\ kg$

In analysis of maximum possible loading of pond, combined load of water and fish were treated as a solid mass and the total weight was determined. The average unit mass of Catfish at maturity was assumed to be 2 kg. Fish survival rate of 100 % after production was assumed. A static condition was also assumed. From Equation (10), total mass of fish in pond at maturity is:
$m_{rf} = M_f \times N_s \times S_r = 2\ kg \times 1000\ fish \times 100\% = 2000\ kg$

Total mass of both fish and water in pond:
$m = m_w + m_{rf} = 12870 + 2000 = 14870\ kg$

Load acting on base of pond,
$W_b = mg = 14870\ kg \times 9.81\ m/s^2 = 145{,}874.7\ N$
Stress or pressure at the tarpaulin base of pond,

$$P_b = P_{wmax} = P_{atm} + \frac{W_b}{A} = 0.111325 MPa$$

Stress is maximum at the base since pressure in fluid increases with depth (Fig. 8A). In the same way, distribution of pressure on walls of tarpaulin tank intensifies with increasing depth (Fig. 8B) (Cengel and Cimbala, 2006). Critical point on the tarpaulin walls is at a small offset point from the base of tarpaulin tank. Bulging of tarpaulin due to water pressure is intense at offset distance from the base of tarpaulin tank. To prevent failure of the wall due to bulging, a belt made from high grade canvass tarpaulin material was provided to further increase the strength properties of the tank at that point.

Stresses on framework components

The anticipated stress points in the pond framework are depicted in Figure 9. Compression, bending, and shear loads will act on the pond stand/legs (points A and B), in addition to axial, torsional, and bending forces on the connecting pipes.

Stresses on connecting pipes

Figure 10 illustrates a free body diagram of the connecting pipe, displaying the distribution of stresses. Pressure on connecting rod is distributed over length x, where x is the length of load distribution from attached edge of tarpaulin.

Cross sectional area of galvanised steel pipes used were determined from Equation (6) as:

$$A_c = \pi \frac{(d_o^2 - d_i^2)}{4} = \frac{\pi}{4} (0.0508^2 - 0.0457^2) = 0.000387\ m^2$$

Distributed load, $q(x) = 111.325\ kN/m$
Converting to point load,

$$F = \frac{111.325\ kN}{m} \times 0.8872\ m = 98.77 N$$

$$\text{Support loads, } R_A = R_B = \frac{98.77\ N}{2} = 49.38\ N$$

Table 3 Maximum stresses on pond components

Nature of stress	Value (MPa)
Maximum pressure or stress at base of tarpaulin, P_b	0.11
Maximum shear stress on connecting pipe, $б_s$	0.17
Maximum compressive axial stress on leg, $б_c$	0.13
Maximum bending stress, $б_b$	6.26

Table 4 Pond material properties

Material type	Grade	Mechanical properties	
		Yield strength (Re) Min (MPa)	Tensile strength (Rm) Min (MPa)
Galvanised steel (Podbrezova, 2008)	11353	235	340
Tarpaulin (PVC-coated fabric)	High grade canvas; 0.78 mm thick, waterproof	Average tensile strength (kN/m) 112.39	

Figure 11 The collapsible tarpaulin fish tanks in use

Maximum shear force induced in connecting rod, v = 49.38 *N*
Maximum shear stress in connecting rod:

$$\tau_s = \frac{4(49.38\ \text{N})}{3(387\ \text{mm}^2)} = 0.1701292\ MPa$$

Maximum bending moment occurs at midpoint of connecting rod,

$$M = 49.38\ \text{N} \times \frac{887.2}{2}\ mm = 21904.97\ N.\ mm$$

Maximum bending stress,

$$б_b = \frac{32M}{\pi(D^3 - d^3)} = \frac{32\ (21904.97\ N.mm)}{\pi\ (50.8^3 - 45.7^3)\ \text{mm}} = 6.26\ MPa$$

Safety of pond design
The maximum compressive axial stress on leg/stand is:

$$б_c = \frac{R_A}{A_c} = \frac{49.38N}{387\ mm^2} = 0.13\ MPa$$

Table 3 provides a summary of respective stresses on pond components. Mechanical properties of main pond materials are presented in Table 4.

Material properties for PVC-coated fabric of thickness 0.78 mm and surface weight 1050 g/mm^2 are provided in Table 4 (Zhang et al., 2012). Since yield strength, Re>>$б_b$ and R_e>>$б_c$ (Table 3), the connecting pipe and stand will optimally withstand the loading of pond. Also, maximum stress at base of tarpaulin, P_b << average tensile strength of tarpaulin (Table 4). This suggests that the pond can resist failure due to bulging. Moreover, the belt provided on outer tarpaulin walls offers extra strength and resistance to failure. The total maximum loading of pond is not only far less than the strength of materials used for construction, but also at a durable safe factor.

Pond assessment
Results produced a collapsible tarpaulin-lined pond of circular geometry which allows for effective waste removal and water re-circulation through its bio-filtration technology. The pond elevation (0.9m) allows for ease of operation. The final design also allows for flexibility of use such that it is easily mounted and unmounted due to ease of assembly. Users can easily mount this pond system at their backyards and in open spaces at home (Figure 11). Currently, collapsible tarpaulin-lined ponds are not much explored in scholarly literature. However, design versions are emerging on the market. A significant proportion of contemporary tank designs lack the inclusion of biological filtration, thereby precluding the possibility of water recirculation. Moreover, the current designs assume a rectangular geometry rather than a circular one. Additionally, these collapsible tanks lined with tarpaulin fail to address the issue of bulging that commonly occurs at the lower sections of the tarpaulin walls. The tank design presented herein effectively addresses the limitations, thereby enabling the efficient culture of African Catfish (*Clarias gariepinus*) or Nile Tilapia (*Oreochromis niloticus*).

Amponsah *et al*. (2022) evaluated the performance of the fishpond setup for producing 1000 pieces of African catfish (Clarias gariepinus) with an initial weight of 10 g. The results showed a survival rate of at least 92%, a specific growth rate of

1.30 g/d, a feed conversion ratio of at least 1.40, and offering a benefit-cost ratio of 1.2 in a production period of 6 months.

Conclusions

Designed at a height of 0.9 m for ease of maintenance and diameter of 4.3 m, the galvanised pipe framed tarpaulin-lined tank has a volumetric capacity of approximately 12.87 m^3. The tank is designed to optimally culture African Catfish (*Clarias gariepinus*) at a stocking density of 78 fish/m^3 or Nile Tilapia (*Oreochromis niloticus*) at a stocking density of 39 fish/m^3. As a continuous recirculating aquaculture system (RAS), the tank has a biological filtration unit installed for waste removal, aeration and water re-circulation.

Angle connectors, connecting pipes and stands are the key components of the pentadecagon framework. Galvanised steel pipes were cut, welded and carefully grinded to form framework components. Stress analysis of pond frame and materials proved that the design could safely hold fish at full production and capacity without failure.

Performance and economic assessment of the pond setup is recommended to promote its adoption. Future research should also focus on the biofilter design optimisation, as it forms a critical part of the recirculating aquaculture system (RAS).

Conflict of Interest Declarations

The authors have no conflicts to declare.

References

Agyakwah, S. K., Asmah, R., Mensah, E. T. D., Ragasa, C., Amewu, S., Tran, N., and, M. O., and Ziddah, P. (2020). Farmers ' Manual on Small-Scale Tilapia Pond Farming (K. Abban, L. Awity, W. Sowah, J. Anchirina, O. Gyinae, & P. Safo (eds.); First edit, p. 37 pp). CSIR- Water Research Institute, Accra Ghana. Available online at https://ebrary.ifpri.org/digital/collection/p15738coll5/id/7164

AKVA Group. (2017). Land Based Aquaculture Catalogue.

Amponsah, S. K. (2018). Yali Voices: Making Aquaculture Possible With Simple Fish Tanks. Young African Leaders Initiative (YALI) Network. https://yali.state.gov/yali-voices-making-aquaculture-possible-using-simple-raised-fish-tanks/

Amponsah, S.K, Bessah, E., Agodzo, S., Asare, H., Agyemang, S. M., and Azumah, D. D. (2022). Performance assessment of recirculating aquaculture system(RAS) designs for culture of African catfish(clarias gariepinus). J Aquacult Eng Fish Res, 8(9), 1–7. https://doi.org/10.3153/JAEFR.22.8.002

Amponsah, S. K., Agodzo, S., Agbeko, E., and Osei, E. A. (2021). Impact of tank geometry on production of African Catfish (Clarias gariepinus). African Journal of Agricultural Research, 17(1), pp. 165–172.

Autodesk. (2020). AutoCAD (No. 2020). Autodesk. Available at https://www.autodesk.com/products/autocad/overview

Cengel, Y. A., and Cimbala, J. M. (2006). Fluid mechanics: fundamentals and applications (S. Jeans & D. D. Matteson (eds.), First ed.). McGraw-Hill.

FAO. (2020). The state of world fisheries and aquaculture 2020: sustainability in action (M. Barange, V. Agostini, M. C. de Souza, N. Franz, K. Friedman, G. Mair, J. Plummer, M. Tacoet, R. van Anrooy, K. Viparthi, and Main (eds.)). OCCP publishing group.

Gere, J. M. (2004). Mechanics of Materials (S. Ko (ed.)). Bill Stenquist.

Lekang, O.-I. (2007). Aquaculture engineering. In Aquacultural Engineering, 38 (16). Blackwell Publishing Ltd. https://doi.org/10.1111/j.1365-2109.2007.01844.x

Martins, M., Eding, H., Verdegem, J., Heinsbroek, N., Schneider, O., Blancheton, P., Roque, E., Verreth, J., Group, F., Yerseke, N. T., Exp, A., Piscicole, R., and Abbreviations, D. (2010). New developments in recirculating aquaculture systems in Europe: a perspective on environmental sustainability. Archimer Aquacultural Engineering, 43(3), pp. 83–93.

Oké, V., and Goosen, N. J. (2019). The effect of stocking density on profitability of African catfish (Clarias gariepinus) culture in extensive pond systems. Aquaculture, https://doi.org/10.1016/j.aquaculture.2019.04.043

Oyedeji, F. N. (2016). Assessment of the effects of fish density on growth rate of african catfish (clarias gariepinus). International Journal of Scientific and Research Publications, 6(5), pp. 567–570.

Podbrezova, Z. (2008). Steel tube and pipe handbook (5th . repl). Železiarne Podbrezová.

Pytel, A., and Kiusalaas, J. (2012). Mechanics of materials (R. Adams, G. Hilda, & T. Altleri (eds.), Second ed.). Global Engineering.

Schuenhoff, A., Shpigel, M., Lupatsch, I., Ashkenazi, A., Msuya, F. E., and Neori, A. (2003). A semi-recirculating, integrated system for the culture of fish and seaweed. Aquaculture, 221(1–4), pp. 167–181. https://doi.org/10.1016/S0044-8486(02)00527-6

Shah, B. R., and Mraz, J. (2020). Advances in nanotechnology for sustainable aquaculture and fisheries. Reviews in Aquaculture, 12(2), pp. 925–942. https://doi.org/10.1111/raq.12356

Umanah, S. I., and Dapa, T. (2017). The effect of stocking density on the growth performance and feed utility of albino clarias gariepinus reared in collapsible tarpaulin tanks. American Journal of Innovative Research and Applied Sciences, pp. 138–144. Available online at https://american-jiras.com/Saviour-ManuscriptRef.2-ajira090717.pdf

Zhang, Y., Zhang, Q., and Lv, H. (2012). Mechanical properties of polyvinylchloride-coated fabrics processed with Precontraint® technology. Journal of Reinforced Plastics and Composites, 31(23), pp. 1670–1684. https://doi.org/10.1177/0731684412459898