EFFECT OF 3 MM GLASS THICKNESS ON WATER HOLDING CAPACITY OF TOWER-SHAPED AQUARIUM

OLAYIMIKA, S. O. A
Water Resources, Aquaculture, and Fisheries Technology Department,
Federal University of Technology, Minna; Niger State.
solo.olayimika@futminna.edu.ng, seideolayimika@gmail.com, olayimikasolo@gmail.com
+234(0)8060361100, 08055531823

ABSTRACT
The research determines the volume of water a 3 mm glass thickness of Tower-shaped aquaria can hold. Aquaria volumes of 20, 30, 40, 50, and 60 litres (L) aquaria were designed and constructed in triplicates, cured, and tested for leakages. The aquaria were monitored under room condition (Mean Temperature of 23.9 ºC (22 – 27.5 ºC)) for 49 days after the introduction of water. Tower-shaped glass of 3 mm thickness failed to hold water of volumes 40, 50, and 60 Litres, but held 20 and 30 Litres of water. The aquaria that failed had different patterns of crack. The 3 mm thickness glass is recommended for 30 Litres and a lesser volume of water for a Tower-shaped aquarium to prevent economic loss, waste of time for clean-up and mopping stress, loss of interest in aquarium keeping, and injury from broken glass. A durable aquarium which is a product of this research will increase fish survival, improve the wellbeing and health of aquarium fish viewers and fanciers, therefore resulting in the prevention of brain fatigue and related health issues. It will also, aid brain recovery and restoration from stress caused by thinking and depression; increase good mood, reduce vices, beautify and create a conducive environment, job and wealth for the people as well as encourage foreign exchange.

Keywords: Durable, Failed, Volume, Leakages, Design, Constructed

INTRODUCTION

Ornamental fisheries as an upcoming aspect of fisheries referred to as recreational fisheries in some cases and limited to aquarium fisheries on some occasions and sport fisheries on few occasions. Ecotourism is also an aspect of Ornamental fisheries. Ornamental fisheries involve the study and production of special featured aquatic animals and plants (with special: colour, shapes, movement, emission, and activity among others), housing, marketing, and managing them and their environment. They can be for these purposes: beautification, recreation, health benefits, research, foreign exchange, international relationship, job, and wealth creation. Ornamental fish can be shellfish or finfish with a higher value per unit weight compared to other aquatic animals of the same size due to the special feature(s) possessed for aesthetic purposes (beautification and endearment), recreation, and health implication (natural therapy). Ornamental fish is also referred to as the highest valued fish. They are usually small in size compared to table fishes except for sport fishes (Olayimika, 2001). Salt and freshwater ornamental fishes are the two major classes. They are mostly kept alive in enclosures, those in the aquarium are therefore referred to as aquarium fishes, while the sport fishes are mostly in the ponds, pools, lakes, streams, dams, reservoirs, and recreational centres (Olayimika and Lamai, 2008, 2010). Fishes, invertebrates (corals, crustaceans, molluscs), and live rock are kept by aquarium hobbies (Livengood and Chapman, 2017).

The importance of Ornamental fisheries to the human race is enormous, and is based on these roles it performs among others:

1.) Aesthetic purposes (beautification and endearment) of homes, offices, and other places;
2.) Recreational purposes (relaxation, picnic and tourism centres for people),
3.) Health purposes (prevent and control sicknesses caused by stress and brain fatigue such as Stroke, Hypertension, Depression, and High blood pressure),
4.) Minimization of vices in the society and family (gives opportunity to young people to spend their times in viewing instead of being engaged in evil activities),
5) Creation of jobs and wealth for aquarium builders, breeders, marketers, feed and accessories manufacturers; and a means of foreign exchange for nations,
6.) Research and learning at various levels,
7.) Environmental balancing (Help in improving the humidity of homes, offices, and other locations, thus reduce health challenges that would have arisen as a result of dryness).

Ornamental fish culture worldwide is becoming a major branch of aquaculture. Entrepreneurship in Aquarium is a fast-growing economic opening. The world ornamental fish trade is around US$6 billion (Fossa, 2004). Export of ornamental fish from Nigeria as a trade has been on for over 40 years (Areola, 2004). It was started by some Americans who had a heavy investment in species identification and locations in water bodies, and are still making demands to date for such fishes. Nigeria`s earnings from ornamental fisheries are over $1.5 million in its export trade, with about 100 identified species (Areola, 2004; Koroye, 2010 and Ukaonu *et al*., 2011). Ecotourism involves fisheries for other areas of human satisfaction apart from consumption (Fadipe, 2007; Yusuf and Ogundana, 2016), but according to Chukwura (2008), it has witnessed long neglect, possibly due to lack of awareness of its huge benefits. Lack of awareness, technical know-how, scarcity of information, low interest in tourism are part of the challenges facing Ornamental fishery (Yusuf and Ogundana, 2016) Keeping fish as a hobby has been embraced by man to appreciate the grace and beauty of one of nature's creatures (Odunaiya, 1986). The gains accruable from Ornamental fisheries cannot be attained without proper and stable habitat that is achievable in an aquarium.

Small compartments used in homes and offices to keep ornamental fishes as an artificial home for viewing, and mostly termed aquarium. It is an artificial enclosure that is designed and made to house aquatic organisms with at least a transparent side for viewing. Glass is mostly used for the transparent side(s) although other materials like Acrylic and Perplex can be used, however, permanent impressions, stains and lines on the materials with distortion of view is a major challenge for using non-glass materials. Glass can be classified into Annealed, Tempered or Toughened, Laminated, Heat-strengthened, and Reflective (Ledbetter *et al.*, 2006). Annealed glass is the commonest, cheapest, and most used in aquarium construction. Aquascaping (Aquarium designing) is the major challenging part of ornamental fisheries but exciting to the hobbyist. Ornamental fishes often kept in aquaria in homes arefor aesthetics and those mostly in public aquaria dedicated mainly to the scientific study of plants and animals, being a simulation of the natural environment (Poluvin, 1996). A mini model of the natural habitat of the fish. Aquaria require care in designing, preparing to maintain the elements and ecosystem in it. An aquarium is a home in which ornamental fishes and other aquatic organisms are kept healthy while sport fishes are kept in larger compartments in most cases, in tourism and recreational centres.

Customers' aesthetic demand for various shapes and volumes of aquaria, designed to provide conducive habitation where water is kept intact for organisms is essential (Paranjayap, *et al.*, 2014). Aquarium design involves conceiving and picturing a concept, sketching it, and developing the drawing; considering the organisms to be put into it, its location, management techniques, and the consumer's interest. The functionality of the aquarium may be affected by the walls': size, shape, and thickness. Aquarium walls function as a barrier against pressure from air, water, and weather, however, it performs excellently at room temperature, attracts customers' interest in aquatic organisms and provides a healthy environment for the organisms' survival.

Glass is also a material used for aquarium construction, it is brittle and prone to sudden failure (Warren, 2001) and this can be dangerous. Glass has a much lower coefficient of linear expansion compared to most metals. The physical characteristics of glass are shown in table 5.

The demand for different shapes and sizes of aquaria by people of various incomes, social status, and ideas for aesthetics, healing, and other reasons is on the increase. The quality and cost implication of meeting such demand has been a major challenge due to failure experienced based on strength of glass. Most aquaria builders make use of 3 and 4 mm glass thicknesses for the construction of home and office aquaria without adequate information on the water holding capacity of the glass thickness, the roles of the shape, and the size. Financial losses that will be incurred as a result of damages on properties affected by water spill, fish and equipment loss due to cracks and breakages have been a major problem facing aquarium producers and customers, especially in underdeveloped and developing nations. The time required for rearrangement of things and odor generated from wet rugs falls from slippery floors etc are also discouraging. The demand for ornamental fish everywhere in the world is on increase (Fossa, 2004; Ploeg, 2017), hence the demand for a good stable-quality, water-tightaquaria to house them. The suitability of 3 mm annealed glass thickness required for construction ofTower-shape aquaria for various volumes will be determined**.**

MATERIALS AND METHODS

The following materials were used: pencil, ruler, absorbent, sealant, marker, water, reservoir (water tank), silicon gun, plump, angle, bisector, a sheet of paper, eraser, blade, sharp knife, protractor, solvent, glass cutter, cello-tape, glass sheets, office pins, thermometer, hand gloves, and wooden cases during transportation, construction, testing, curing and experiment under room condition. Tower-shaped aquaria with a water capacity of volumes: 20, 30, 40, 50, and 60 litres were sketched and designed (Sketches of the design were drawn to scale using bisector, protractor, angles, ruler, pencil, paper, and eraser). Fifteen Tower-shaped aquaria of five different volumes were then constructed in triplicate using 3 mm glass thickness, tested for leakages, and kept for use under room condition. Annealed glass sheets of 3 mm thickness were bought and packed in wooden cases (to prevent cracks and breakages), then transported to the project site; hand gloves were worn for protection. Glass sheets placed on the absorbent table were marked into required sizes based on design. The marked points were inverted, then points of intersections were joined with a long ruler, then the solvent was applied after which a gentle pressure was applied to the glass cutter running on the required line. The glass was softly tapped at the cut section using a diamond head then gentle pressure was applied to detach it from the sheet while pulled out a little. Dulling stone was used on the sharp cut sections and particles clean off the glass with a hand towel. The nozzle tip of the sealant was cut in a slanting form at 45 º with an opening of 4-5 mm using a razor blade and the sealant's tip was cut using a sharp knife, then the nozzle was screwed to it. The sealant was inserted into the sealant gun cartridge, and trigged with gentle pressure for overflow of 4-5 mm, to prevent coagulation in the nozzle. Assembling of different volumes was done according to the specifications in triplicate (Table 1). Cello-tape was cut into 10-15 cm length and attached externally in pairs to all sides of the basement glass sheet, likewise a set at a side of the wall to serve as a means of attachment for formwork formation, locating the glass sheets at their potential positions. Each of the side glass sheets was lifted and stationed in its rightful positionusing the cello tape to brace it until all the sides wereerected and positioned in their places. The nozzle ofthe sealant was pointed at glass sheets meeting points starting from the base and moving upward, with gentle pressure applied to the trigger to releasesealant to areas required to be joined and moving thegun in a steady form for even distribution. Gentle pressure was then applied to eliminate air bubbles and create a good bond using a finger to run on the sealant shortly after application, before setting or coagulation. The aquaria were cured under room condition. The first curing took 45 - 60 minutes after construction, after which the aquarium was relocated from the workshop table for a pre-test using water of 1-2 litres to test for leakages along thejoints. A further cure of 24 hours was done before the aquaria were fully tested for leakages. Water wasintroduced into each aquarium gradually to determine the water holding capacity for different sizes and observed for forty-nine days.

RESULTS

The experiment was conducted under an average room temperature of 23.9 ºC (22 – 27.5 ºC) and an average water temperature of 18.6ºC (17.5 – 22.0 ºC). The Tower-shaped aquaria of various volumes only differed in-depth, ranging from 15 – 75 cm (Table 1). Tower-shaped 3 mm thickness glass failed for 40, 50, and 60 litres of water (Table 2). The failure patterns for 40 – 60 litres ranged from 1 -15 (Table 3). The failures occurred within 0 – 168 hours post introduction of water (Table 4). Water was held in the 20 and 30 litres aquaria within the experimental period of 49 days.

DISCUSSION

The recorded water and room temperatures were within the acceptable range for fish survival. The failure in retention of water in 40 litres and above for tower-shaped aquarium of 3 mm glass thickness proved that it had water holding capacity lesser than 40 litres which may be influenced by the area covered by the depth of water column that the water force acted upon (Table 1). This shows that only lower volumes of water, of not more than 30 litres can be retained in Tower-shaped 3 mm thickness glass aquarium (Table 2). Glass of 3 mm thickness had various levels and grades of failures based on the pressure exacted on the glass sheet by varied volumes of water (Table 3), thus glasses of higher thicknesses may have better ability to retain water, these agree with Aquarium Fish Tank (2015) that with enough braces, an unattractive and undesirable enormous glass tank can be constructed from very thin material hypothetically, resulting from vertical braces within few centimeters. To achieve a reasonable seeing area, there is a need to consider the thickness and nature of the material for the work. The failures occurred during and shortly after filling with water for various volumes. The duration of glass failure also varied with the water volumes, from shortly after the introduction of water to 168 hours before breakage took place (Table 4). Thus, results from Tables 2, 3, and 4 confirmed Aquarium Fish Tank (2015) concept that the choice of the right glass is critical in such applications because, it is a brittle material and is weak in tension due to its non-crystalline molecular structure, and Warren (2001), that glass has a much lower coefficient of linear expansion than most metals. **Failures occurred because it has only a little ability to bend before failing; this aligns with** Morgan (2010) that glass is a brittle substance that has a little degree of bending within, it cannot deform like most metals; it only bends to a point and breaks...

CONCLUSION AND RECOMMENDATION

Aquaria builders have the opportunity to offer economical quality 3 mm thickness tower-shaped glass aquaria of 30 litres and below to customers without the fear of failures that will cause: economic loss, wastage of time, the stress of cleanup and mopping, discouragement from keeping an aquarium and injuries that may occur from the broken glass aquarium among others; and for creation of the healthy nation, job and wealth for the people which are attainable based on this research outcome. This assertion will increase the wellbeing and healthiness of people through the viewing of ornamental fish in a stable aquarium that restores the brain from stress and provide a good mood, minimize vice, add aesthetic values to places, and provides a more conducive environment. Further researches should be carried out on other glass thicknesses, shapes, and volumes.

REFERENCES

Areola, F. O. (2004). Export potential of ornamental live fish in Nigeria. *Fisheries Society of Nigeria Conference Proceedings*, Calabar p.589

Aquarium Fish Tank (2015). Retrieved from Build aquarium: http://www.info.com

Chukwura, D. I. (2008). Ornamental fish industry, scope and project for future development in Nigeria, Newsletter of the Federal College of Fisheries and Marine Technology, Victoria Island, Lagos

Fadipe, A. S. (2007). *Basic principles and practice of tourism media*, ACE, Lagos

Froese, R and Pauly D, (2015). *Fish base* Retrieved from http://www.fishbase.org/search.php

Fishlore Aquarium Fish information (2015). *The footprint of tank*, Retrieved from http://www.fishlore.com

Fossa, S.A. (2004). Man-made fish: Domesticated fishes and their place in aquatic trade and hobby. *Ornamental Fish International Journal*, 44, 1-23

Koroye, E. (2010). *Export ornamental fish is big business*, African Aquaculture, and Fisheries Digest 3 (8) 11.

Ledbetter, S. K., Andrew R.W., Alan, P. K. (2006). ASCE, Structural Use of Glass, *Journal of Architectural Engineering*, 4:12;137-149

Livengood, E. J. and Chapman, F. A. (20017). *The ornamental fish trade: An introduction with perspectives for responsible aquarium fish ownership*. UF/FAS Extention, University of Florida Retrieved from http://edis.ifas.uft.edu. October 2017

Morgan, T. (2010). *Aspect of Structural Glass*. Institute of Structural Engineers, SE Counties ranch 1-81

Odunaiya, O. (1986). Investment Opportunity in Aquarium Technology - Export Marketing of Tropical Aquarium Fishes *Proceedings of the 5th Annual Conference of Fisheries Society of Nigeria* held at Ilorin, 261-269

Olayimika, S.O (2001). Appraisal on the survival of the *Poeciliareticulata*(Guppy) as an ornamental fish in Northern Nigeria (Acase study of Minna, Niger State). A Master's degree thesis submitted to Postgraduate School, Federal University ofTechnology, Minna, Niger State; Nigeria.

Olayimika, S.O (2008). Appraisal on the survival of the *Xiphophorus maculatus* (Platy) as an ornamental fish in Northern Nigeria (Acase study of Minna, Niger State). *Proceedings of Annual Conference of International Research and Development Institute, Research and Development Network* held June 24-27, 2008 at Institute for Development Research Hall, Ahmadu Bello University, Zaria, Nigeria 3:8; 121

Olayimika, S. O. (2009). Effect of sex combination ratio on the breeding of *Poecilia reticulate* (Guppy) for ornamental purpose. *Proceeding of Annual Conference of International Research and Development Institute* held at University of Port Harcourt, September 2-3, 2009, 5: 5; 48-51

Olayimika, S. O. and Lamai, S. L. (2010). Effect of parental sex and breed on phenotypical expression (colouration) in progeny of *Peocilia reticulate* (Guppy) forOrnamental Purpose. *Journal of Applied Agricultural Research* 2:1;127-132

Paranjayap, P., Martyn, P., Maluniu, O., Lettyb, B. (2014). *How to make an aquarium*, Retrieved from http.//www.glassfiles.com.

Ploeg, A. (2017). The Indian ornamental fish industry. Ornamental Fish International. Retrieved from http://www.ofish.org.

Poluvin, N. V. C. (1996). Reef fisheries. Chapman and Hall, London 7-47 adapted from Onuoha, P. C. (2008). A Preliminary Survey of Marine Ornamental Fishes in the Catches of Fishing Trawlers Operating Within the Nigerian Continental Shelf. *International Journal of Emerging Technology and Advance Engineering*. 4 (9) 2250-2459, September 2014) p.1 Retrieved from www.ijetae.com

Umarani, G., Premalatha, E. and Aruna, M.T.P. (2010). Facades of Tall Buildings-State of Art, *Modern Applied Science, Canadian Center of Science and Education* 4, 12. Retrieved from http.//www.ccsenet.org/mas

Yusuf, O. I. S and Ogundana, F. O. (2016). Ornamental Fish Tourism and Economic Development, *Journal of Ornamental and Recreational Industry* 14 (1) 1-5. Retrieved from www.transcampus.org/journal; www.ajol.info/journal,jorind

Table 1: Glass sizes used in the construction of various dimensions of glass Aquaria

Volume (L)	Depth (cm)	Length (cm)	Breadth (cm)
20	15	30	30
30	30	30	30
40	45	30	30
50	60	30	30
60	75	30	30

Table 2: Water volumes at which failures occurred in 3 mm glass thickness of tower-shaped aquaria

Replicate	20	30	40	50	60
Wi	No Failure	No Failure	No Failure	50	60
Wii	No Failure	No Failure	40	50	60
Wiii	No Failure	No Failure	40	40	60

KEYS: Wi = Replicate 1, Wii = Replicate 2, Wiii = Replicate 3

Table 3: Failure grades of glasses in various volumes in 3 mm glass thickness tower-shaped aquaria

Replicate	20	30	40	50	60
Wi	0	0	0	11	15
Wii	0	0	1	12	15
Wiii	0	0	15	15	15

KEYS: 0 = No failure, Failure range: 1 = least failure to 15 = Highest failure, Wi = Replicate 1, Wii = Replicate 2, Wiii = Replicate 3

Table 4: Time is taken (hours) before failures occurred in various Dimensions for 3 mm glass thickness for tower-shaped glass aquaria

Replicate	20	30	40	50	60
Wi	No Failure	No Failure	0	0	0
Wii	No Failure	No Failure	168	0.583	0.001
Wiii	No Failure	No Failure	0.5	0	0.014

KEYS: Wi = Replicate 1, Wii = Replicate 2, Wiii = Replicate 3

Table 5: Physical Characteristics of Glass

The Glass Physical Characteristics	**Values**
Density:	approx. 2.5 at 21°C
Coefficient of linear expansion:	86 x 10^{-7}m/°C
Softening Point:	730°C
Modulus of Elasticity:	69GPa (69 x 109 Pa)
Poisson's ratio:	Float Glass 0.22 to 0.23
Compressive Strength:	25mm Cube: 248MPa (248 x 106 Pa)
Tensile Strength:	19.3 to 28.4MPa for sustained loading
Tensile Strength (toughened glass):	175MPa. (Warren, 2001)