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THE EFFECT OF GLASS THICKNESS ON THE WATER HOLDING CAPACITY OF A CUBOID-SHAPED AQUARIUM

[1]OLAYIMIKA, S. O. A, [1]S. L., LAMAI, [2]O. A. OLUGBOJI, and [3]A. D. GARKIDA
[1]Department of Water Resources, Aquaculture and Fisheries Technology, Federal University of Technology, Minna, Niger State.
[2] Department of Mechanical Engineering, Federal University of Technology, Minna, Niger State.
[3]Department of Glass Technology, Ahmadu Bello University, Zaria, Kaduna State.
Corresponding author: solo.olayimika@futminna.edu.ng,
+ (234)-08060361100, 08055531823

Abstract

The volumes of water a 3mm glass thickness Cuboid-shaped aquaria can hold was determined. Aquaria of volumes 30, 40, 50, and 60litres were designed and constructed in triplicates, cured and tested for leakages, monitored under room condition (mean temperature of 23.9 ºC and mean water temperature of 18.1 ºC for 49days after the introduction of water. The cuboid-shaped glass of 3mm thickness failed to hold water of volumes 50 and 60litres, but held 30 and 40Litres of water. The aquaria that failed were not so much at variance in patterns. The 3mm thickness glass is recommended for 40litres and lesser volumes of water in the cuboid-shaped aquarium to prevent possible economic loss, time wastage and stress from clean-up, loss of interest in aquarium keeping, and injury from broken glass. Such durable aquaria can increase fish survival ex-situ, and the wellbeing of aquarium fish enthusiasts thereby boosting good mood while enhancing aesthetic values of environments besides facilitating job and wealth creation for the people involved as well as, earn and foreign exchange through exports.

Keywords: Volumes, room condition, failed, patterns, temperature.

Introduction

Ornamental fisheries is 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 a few occasions. Aqua-tourism is also an aspect of ornamental fisheries. Ornamental fisheries involve the study and production of special featured aquatic animals and plants (colours, shapes, movements, emissions, and activities amonsgt others), housing, marketing, and managing them and their environment for non-food purposes. They can be for these purposes: beautification, recreation, health benefits, researches, foreign exchange, international relationship, job, and wealth creation. Ornamental fish can be a shellfish or finfish with a higher value per unit weight when 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). They are usually small in size compared to table size fishes except for sports fishes (Olayimika, 2001). Salt and freshwater ornamental fishes are the two major groups. They are mostly kept alive in enclosures, those in aquarium are referred to as aquarium fishes, while the sport fishes are mostly in ponds, pools, lakes, streams, dams, reservoirs, and recreational centres (Olayimika, 2008,; Olayimika, 2009; Olayimika and Lamai, 2010). Aquatic animals kept as aquarium hobbies, include fishes, invertebrates such as, corals, crustaceans (examples, crabs and shrimps), molluscs (snails, clams, scallops), and also rock (Livengood and Chapman, 2017).

The importance of ornamental fisheries is enormous. It is used for aesthetic purposes (beautification and endearment) of homes, offices, and other places; also for unique lively recreational purposes (picnic), relaxation, as well as, play a major role in tourism and sport fishing. It is unique in its role in health performance and improvement, especially in the prevention and healing of ailments caused by stress and brain fatigue such as, stroke, hypertension, depression, and high blood pressure. It minimizes vices in the society where people spend their leisure time viewing ornamental and sport fishes instead of being engaged in evil activities. Jobs and wealth are being created for aquarium builders, breeders, marketers, feed and accessories producers, and a means of foreign exchange while providing the opportunity for research and learning at various levels. It promotes environment that reduces infections caused by dryness by increasing the humidity levels of homes, offices, and other locations where available (Olayimika, 2021).

Ornamental fish culture is on the increase worldwide and aquarium production is a fast-growing business. The global wholesale value of live ornamental fish in the year 2000 was estimated by the Food and Agriculture Organisation (FAO) to be US$ 900 million with a retail value of US$ 3 billion (Whittington and Ohong, 2007). Ornamental fishes have been exported from Nigeria before 1964 (Areola, 2004). Americans with heavy investment in species identification and locations in water bodies started the business in Nigeria. Nigeria earned over $1.5 million from ornamental fisheries in its export trade, with about 100 identified species (Areola, 2004; Koroye, 2010). The demand for ornamental fish across the world is on the increase (Ploeg, 2017). 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. Yusuf and Ogundana (2016), reported that, "ornamental fishery production has not been fully taken into consideration due to some reasons which include: lack of awareness about the probable use of ornamental fishes as an element of attraction, lack of technical know-how in the area of culturing ornamental fishes, scarcity of information on the available sources of ornamental fishes, and non-interest of private individuals in breaking a truce in the area of making ornamental fishes an element of tourist attractions." 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 achievement expected in ornamental fisheries cannot be attained without proper and stable habitat that is achievable in an aquarium.

Small compartment used in homes and offices to keep ornamental fish as an artificial home for viewing, and mostly termed aquarium, 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), though, other materials like Acrylic and Perplex can be used, but 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 are for aesthetics and those mostly in public aquaria are dedicated mainly to the scientific study of plants and animals, being 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.

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, perform excellently at room temperature yet, attract customers' interest in a good environment (water) for aquatic organisms' survival.

Glass is a material used for aquarium construction, it is brittle and prone to sudden failure (Warren, 2001) and this is dangerous. Glass has a much lower coefficient of linear expansion compared to most metals (Table 1).

Table 1: 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)

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 implications of meeting such demands have been ~~a~~ major challenges due to failure experienced based on strength of glass. Most aquaria builders make use of 3mm and 4mm glass thicknesses for the construction of the home and office aquaria without adequate information on the water holding capacity of the glass thickness, the roles of the shape, and the sizes. Financial losses that will be incurred as a result of damages on properties affected by water spills, fish and equipment loss due to cracks and breakages have been ~~a~~ major problems facing aquaria 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, hence, the demand for good, stable quality, water-tight aquaria.

The suitability of the 3mm annealed glass thickness required for the construction of Tower-shape aquaria for various volumes will be determined in this work.

Materials and Methods

Materials used: pencil, ruler, absorbent, sealant, marker, water, reservoir (water tank), silicon gun, plump, angle, bisector, a sheet of paper, eraser, razor blade, sharp knife, protractor, solvent, glass cutter, cello-tape, glass sheets, office pins, thermometer, hand gloves, and wooden cases during design; construction, testing, curing and experimentation under room condition. Cuboid-shaped aquaria with a water capacity of volumes: 30, 40, 50, and 60litres were sketched and designed Annealed glass sheets of 3mm 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 the 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 cutter, 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 cleaned off the glass with a hand towel. Nozzle tip of sealant was cut in a slanting form at 45^o with an opening of 4-5mm using a razor 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 4-5mm to prevent coagulation in the nozzle. Assembling of different volumes was done according to the specifications in triplicates (Table 2).

Table 2: Glass dimensions used in the construction of various volumes of Aquaria

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

Cellotape was cut into 10-15cm 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 framework formation, locating the glass sheets at their potential positions. Each of the side glass sheets was lifted and stationed in its rightful position using the cellotape to brace it until all the sides were erected and positioned in their places. The nozzle of the sealant was pointed at glass sheets meeting points starting from the base and moving upward, with gentle pressure applied to the trigger to release sealant to areas required to be joined and moving the gun 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 - 60minutes after construction, after which the aquarium was relocated from the workshop table for a pre-test using water of 1-2litres of water to test for leakages along the joints. A further cure of 24hours was done before the aquaria were fully tested for leakages. Twelve Cuboid-shaped aquaria of four different volumes were thus constructed in triplicates using 3mm glass thickness, tested for leakages, and kept for use under room condition. Water was introduced into each aquarium gradually to determine the water holding capacity for the different volumes.

Results

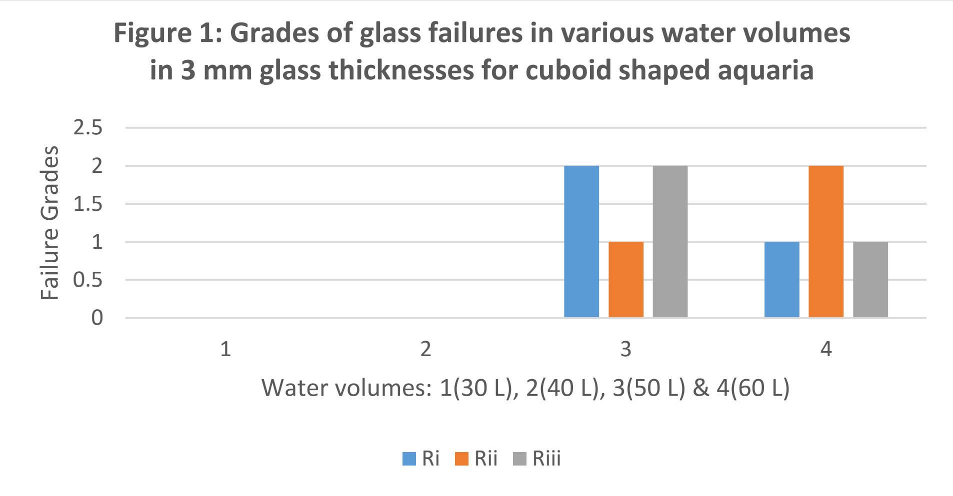
The experiment was conducted under an average room temperature of 23.9 ^{o}C (22.0 – 27.5^{o}C) and an average water temperature of 18.1^{o}C (17.0 – 21.0^{o}C). The Cuboid-shaped aquaria of various volumes only differed in length, ranging from 30 – 75cm (Table 2). Cuboid-shaped 3mm thickness glass failed with a mean water volume of 46.67litres and all 50 and 60litres 3mm glass aquaria failed (Table 3).

Table 3: Water volume at which failures occurred in 3mm glass thicknesses of cuboid-shaped aquaria

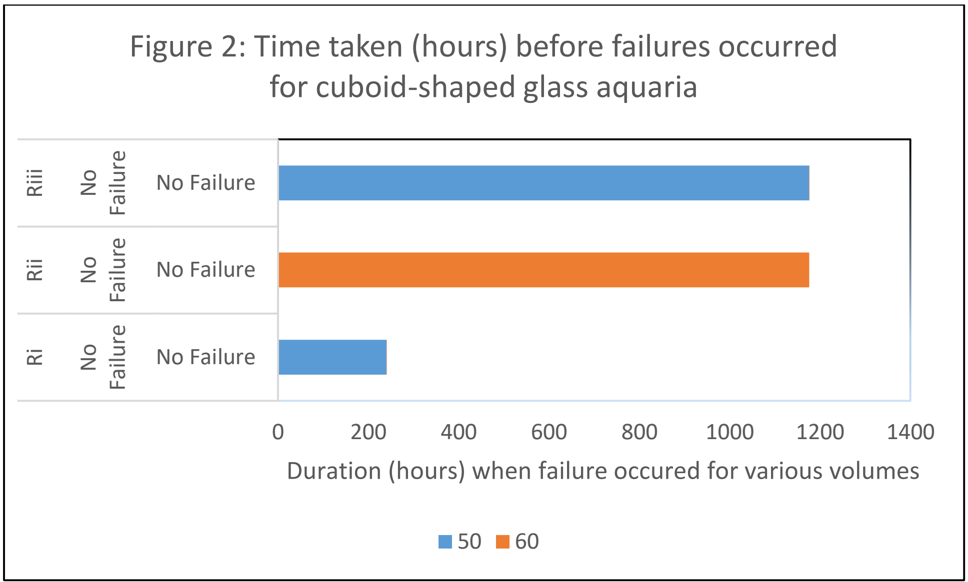
Replicate	30	40	50	60
Ri	No Failure	No Failure	50	60
Rii	No Failure	No Failure	40	60
Riii	No Failure	No Failure	50	60
Mean	No Failure	No Failure	46.67	60

Keys: Ri = Replicate 1, Rii = Replicate 2, Riii = Replicate 3

The failure patterns for 50 – 60litres ranged from 1 -2, that is, with minor cracks (Figure 1). The failures occurred within 0 – 1176hours post introduction of water (Figure 2).



Keys: 0 = No failure, Failure range: 1 = least failure to 15 = Highest failure, Ri = Replicate 1, Rii = Replicate 2, Riii = Replicate 3



Keys: Ri = Replicate 1, Rii = Replicate 2, Riii = Replicate 3

Water was held in the 30 and 40litres aquaria within the experimental period of 49days for which the ability to retain water was determined. The failure commenced at 46.667 litres (mean volume) of water.

Discussion

The recorded water and room temperatures were within the acceptable range for fish survival. The failure in retention of water in 50litres and above for Cuboid-shaped aquarium of 3mm glass thickness proved that, it had a water holding capacity of less than 50litres which may be influenced by the area covered by the length of the water column that the water force acted upon, and the pressure generated by the water (Table 2). This showed that, 40litres of water can be held in a 3mm Cuboid shaped glass aquarium (Table 3). Glass of 3mm thickness had similar levels and grades of failures based on the pressure exacted on the glass sheet by varied volumes of water at the same depth, this was proven with a 60litres glass aquarium that showed sign of stress for a long period before the failure occurred (Figure 1). This agreed with work of Aquarium Fish Tank (2015), that, considered thickness and nature of the material to be of importance in aquarium construction. The failures occurred during and shortly after filling with water volume of 50 and 60litres. Duration of glass failures also varied with the water volumes, from shortly after the introduction of water to 1176hours before failure took place (Figure 2). Thus, results from Tables 3 and Figures 1 and 2 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), who stated that, glass has a much lower coefficient of linear expansion than most metals leading to

failures due to its little ability to bend before failing; which was also in consonance with Morgan (2010), who opined that, glass is a brittle substance that has a little degree of bending within, it cannot deform like most metals but it only bends to a point and breaks.

Conclusion

From the findings of this work on the shape, thickness of glass material and volume for aquaria construction, 40litres of water can be held in a 3mm Cuboid shaped glass aquarium. Aquaria builders have the opportunity to offer economical quality 3mm thickness Cuboid-shaped glass aquaria of 40litres and below to customers without the fear of failures that will lead to losses. Further research should be conducted on other shapes and thicknesses.

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