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A Low-Cost Recirculation System Using Disposable Beverage Containers

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Abstract.—A tank system with recirculating water designed for use with disposable plastic 3-L beverage bottles is described. The system consisted of 100 culture units (2-L working volume in each), five 40-L tanks, and an upwelling biofilter. The 40-L tanks were used to increase the total volume of the system, to allow operation of the filter when bottles were not occupied, and for temporary storage of fish when treatments were pooled following screening. Each bottle received water from a common distribution manifold, and flow was adjustable from 0 to 1 L/min (0–30 water changes per hour). Bottles could be removed easily for replacement or to facilitate study of fish. The system was designed to allow separation of treatments for genetic studies, but would be useful for experiments requiring replication of treatments or experimental units with minimal environmental variation.

Experiments that include multiple treatments with replication often require the maintenance of small fish in separate containers. The expense of building multiple-tank systems with commercially available containers (e.g., glass aquaria) can be difficult to justify, especially if the system will be in use for only part of the year. Culture systems constructed from disposable beverage bottles are inexpensive and can be tailored to a variety of applications. For example, beverage bottles have been modified for use as hatching jars (Rottman and Shireman 1988) and disposable test chambers (Goodfellow et al. 1985). The system described in this note used 3-L, clear, plastic beverage bottles as culture units to raise channel catfish (*Ictalurus punctatus*) from hatchout to a total length of 5 cm. The single-piece bottles were self-standing and had five molded feet in the base. Some bottling companies use a two-piece, round-bottom bottle with a removable plastic base. Either type of bottle is suitable for this application. The bottles were inexpensive, sturdy, and easy to modify.

Construction of culture units.—All pipe and fittings used for construction of the culture units were of schedule 40 polyvinyl chloride (PVC), unless noted otherwise. The final components are shown in Figure 1. For construction, the neck of a 3-L plastic bottle was removed (2.54 cm from the top) with a bench-mounted radial saw, and the base was removed (5 cm from the bottom) with a utility knife. A 2.54-cm × 1.27-cm female, normal pipe thread (NPT) reducer bushing was inserted into the bottle so that the 1.27-cm fitting was inside the bottle and the 2.54-cm fitting projected through the neck. Placement of the bushing in the bottle neck immediately after sawing allowed contraction of the cooling plastic to produce a tight fit around the bushing. Clear silicone sealant (Dow Corning, Inc., Midland, Michigan) was spread around the 2.54-cm fitting already in the bottle and a 2.54-cm coupler was forced onto the bushing in the bottle. Clear silicone sealant was spread around the inside of the bottle neck to completely seal between the bottle and the bushing. A 1.27-cm male NPT × 0.95-cm barbed polycarbonate plastic fitting (Aquatic Ecosystems Inc., Apopka, Florida) was placed into the 1.27-cm hole in the bushing. A 19-cm length of 1.27-cm, clear, rigid tubing was attached over the barbed end of the polycarbonate plastic fitting and sealed with clear silicone sealant. A 7.62-cm length of 2.54-cm-diameter pipe was fitted into the 2.54-cm coupler on the bottom of the culture unit to drain water from the bottle. A venturi drain was constructed by placing a 21.5-cm length of 2.54-cm-diameter pipe with four vertical slits (2.54 cm high × 0.95 cm wide) cut in the bottom to allow water to drain from the bottom of the culture bottle. A removable screen was made by cutting plastic window screen to a size that wrapped around the inner standpipe. The screen was sealed with clear hot melt glue (Thermogrip, Black and Decker, Inc., Hunt Valley, Maryland) along the side and the top. Construction of tops for the culture units depended on the type of bottle used. For the one-piece bottle (the type used for this system), two beverage bottles were used to build a single culture unit. The base was removed (5.5 cm from the bottom) from a second bottle, and a 2.54-cm hole saw was used to drill a hole in one of the five molded feet. This hole allowed feeding of fish without the removal of the top. A 0.95-cm drill bit was used to drill holes for air and

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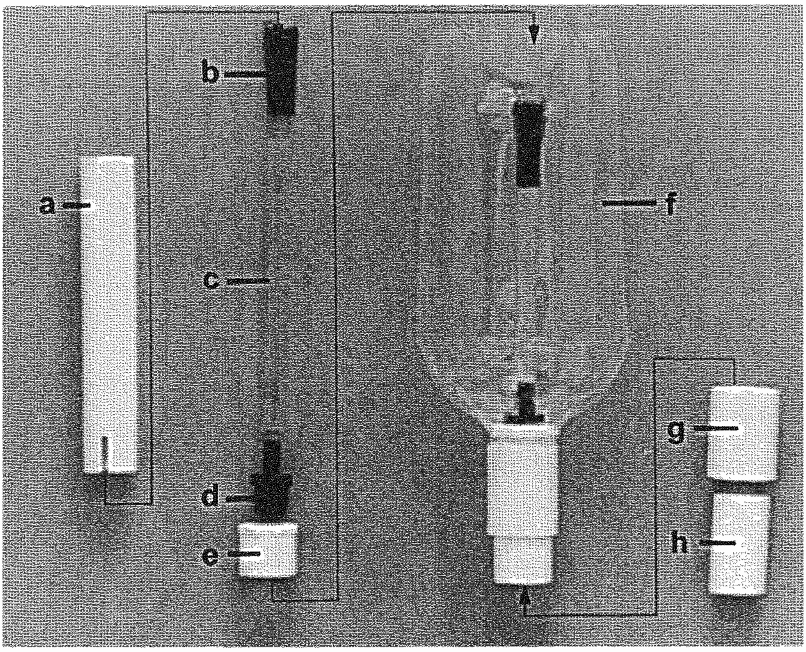

FIGURE 1.—Components and assembled culture unit: 21.5-cm length of 2.54-cm polyvinyl chloride (PVC) pipe with slits (a); removable drain screen (b); 19-cm length of 1.27-cm clear rigid tubing (c); 1.27-cm normal pipe thread × 0.95-cm barbed polycarbonate fitting (d); 2.54-cm × 1.27-cm female normal pipe thread reducer bushing (e); assembled culture unit (f); 2.54-cm coupler (g); and 7.62-cm length of 2.54-cm PVC pipe (h).

water lines in two other feet. This modified bottom was placed on top of the culture unit. If the two-piece bottles were available, the removable plastic base, when modified as described above, served as a top for the culture bottle.

System description.—The culture units were placed on a two-tier wooden shelf, with two rows of 25 units per tier (Figure 2). The discharge pipe from each unit was mounted to fit through a 3.5-cm hole in the shelf and the overflow drained through 3.8-cm holes drilled in a pipe (7.62 cm diameter) mounted below each row of bottles. There was no permanent attachment made between the culture units and the 7.62-cm drain pipe. The

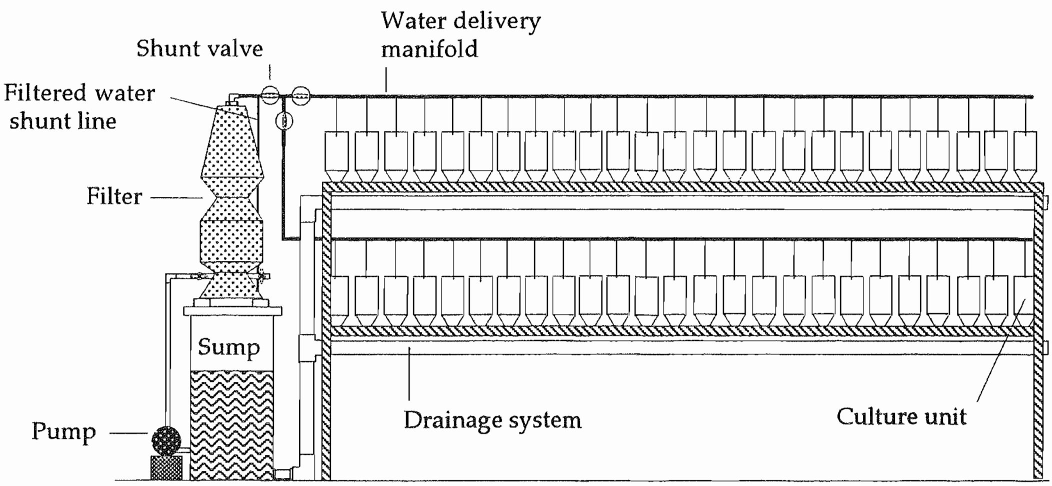

FIGURE 2.—Schematic diagram of the culture system (40-L tanks not shown).

two upper-tier drain pipes were plumbed downward through 90° elbow fittings to connect with the lower-tier drain pipes by "T" fittings. The two lower-tier drain pipes were plumbed downward with one 90° elbow fitting and one "T" fitting to lead into a single 7.62-cm line leading to the floor. The drain line was routed into another 90° elbow, and a 7.62-cm × 5.08-cm reducer bushing was used to connect to a 5.08-cm pipe leading to a 100-L plastic sump with a 5.08-cm bulkhead fitting. Five 40-L, circular, plastic tanks were connected in-line between the filter and the culture unit rack (not shown). The 40-L tanks were included to increase total volume of the system, to allow operation of the filter when bottles were not occupied, and for temporary storage of fish when treatments were pooled following screening. A 93-W centrifugal pump (Little Giant Pump Co., Inc., Tulsa, Oklahoma) was plumbed to the sump tank with a 2.54-cm bulkhead fitting and 2.54-cm pipe for the intake. Water was pumped into a 0.30-m^3 upwelling biofilter (Armant Aquaculture, Inc., Vacherie, Louisiana; Malone et al. 1993) through 1.27-cm-diameter pipe. Filtered water exited the biofilter through a 2.54-cm-diameter manifold that delivered water to the upper and lower tiers of the system. A valved return line allowed shunting of some of the filtered water back to the sump tank to reduce pressure in the water delivery manifold if needed. Twenty-five 1.27-cm-diameter holes were drilled and tapped for NPT fittings in each tier of the water delivery manifold. A 1.27-cm NPT male × 0.95-cm barbed polycarbonate plastic fitting (Aquatic Ecosystems) was screwed into each tapped hole. A tubing assembly was prepared for each fitting in the water manifold. The assembly consisted of one 20-cm length of clear 0.95-cm aquarium tubing and two 12-cm lengths of 0.95-cm tubing joined by a plastic "Y" fitting. The 20-cm tubing was attached to the plastic fitting in the water manifold. This assembly allowed two units to receive water from each outlet in the delivery manifold. A Dura-clamp tubing flow valve (Aquatic Ecosystems) was placed on each water delivery tube. Air was supplied by a 746-W Sweetwater regenerative air blower (Aquatic Ecosystems), already in place for the aeration of existing culture systems. An air-delivery manifold, similar in construction to the water manifold, supplied air to the two tiers (not shown). Each air manifold was drilled and tapped for twenty-five, 0.635-cm plastic needle valves (Aquatic Ecosystems). An aquarium air stone in each unit was connected to the air manifold with a tubing assembly constructed as described for the water manifold.

System operation.—Water flow rate to the culture units was adjustable from 0 to 1 L/min (0–30 water changes per hour) either by changing the overall flow through the system with the return line shunt valve or by adjusting the individual tubing valve at each unit. The maintenance required was backwashing of the biofilter every other day, cleaning solids from standpipe screens, and transferring fish to clean culture units when the sides became fouled with surface-growing organisms. Culture units were cleaned with a stiff-bristled round brush and rinsed with freshwater.

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