TECHNICAL NOTE

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A Simple Apparatus for Conducting In-Stream Toxicity Tests

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ABSTRACT: Because of the increasing importance of evaluating the actual impact of chemical discharges on fish in receiving waters the need for a suitable apparatus for conducting in situ toxicity tests has arisen. This paper describes a simple, inexpensive, easily handled fish cage that has proven to be quite suitable for conducting in situ toxicity tests with small fish. The cages are constructed of 10-cm plastic pipe.

KEYWORDS: field tests, fish cages, toxicity tests

As efforts continue toward achieving the goals set by PL 92-500, the 1972 Amendments of the Federal Water Pollution Control Act, of attaining "fishable, swimmable" waters by 1983 and "zero pollutant discharge" by 1985, increasing emphasis is being placed on determining the actual effects of chemical discharges on aquatic organisms in the receiving waters. One method used by the authors with success employs in situ toxicity testing techniques. While fairly sophisticated methods have been developed and widely applied for assessing the effects of contaminants on aquatic organisms in the laboratory, little emphasis has been placed on developing standard techniques for making similar types of measurements in the field.

Mount [*1*] discussed some of the factors that cause the results of aquatic toxicity tests in laboratories to differ from those obtained in natural streams, noting that laboratory tests typically overestimate the effects of contaminants that will be observed in natural systems. This overestimation arises, in part, from the reduced availability to organisms of contaminants in natural systems as compared with the availability of these contaminants under laboratory test conditions. Further, it is rare that the laboratory systems properly reproduce the variability in the concentration of available forms of contaminants that normally occur in the environment. These and other factors influencing the toxicity of contaminants to aquatic organisms have been discussed by Lee [*2*] and Newbry [*3*].

Toxicity tests conducted in the laboratory can, in general, be used to determine "nominally safe" contaminant concentrations (that is, those concentrations which, if not exceeded, will guarantee that aquatic organisms will not be adversely affected by the contaminants). The safety factors on these nominally safe contaminant concentrations are known in few, if any, cases at present. It is very likely that in the future water quality managers will need to know these safety factors so that water quality management strategies can be established to provide specified levels of protection to desired beneficial uses of bodies of water. Only in this way will it be possible to utilize effectively the limited economic and natural resources available for water pollution control.

In order to estimate these safety factors it will be necessary to develop simple, reliable methods for making in situ measurements of the effects of contaminants on aquatic organisms. This paper describes a simple toxicity testing cage that has been found to be suitable for measuring the in-stream responses of aquatic organisms (fish) to contaminants. The cage was designed by the authors and has been successfully used in a number of field studies [*4–6*].

Background

Several studies have been reported in the literature in which some type of cage was used to hold test organisms, usually fish, during toxicity tests. The Michigan Department of Natural Resources [*7*], in a series of studies on the toxicity of chlorinated municipal wastewater effluents to fish, used cages constructed of exterior-grade plywood to hold rainbow trout and fathead minnows. There was an excessive mortality of fish in the control cages, possibly because toxicants, such as wood preservatives, leached from the cage materials.

Skea et al [*8*] used cages constructed of hemlock and wire mesh (unspecified wire type) to conduct a short-term (14-day) bioaccumulation study in the Hudson River. No problems were noted; however, the cage size (2 by 1 by 0.8 m) suggests that handling may have been difficult.

Davies and Woodling [*9*] used cages constructed of chicken wire in a study of the acute lethal toxicity to trout of metals present in a mountain stream. The possible effect of high velocity was a concern, and it was necessary to carefully select protected areas for the placement of the cages. The necessity of placing this cage in relatively quiescent areas would very likely limit its general utility.

Falk [*10*] described the construction of a toxicity test cage used by the Canada Department of the Environment. It consisted of aluminum angle frames fastened with stainless steel bolts (approximately 56 per cage) and a braided nylon mesh bag. This cage apparently functioned well, but was very likely both relatively expensive and time-consuming to construct.

Prior to the initiation of a series of intensive field studies by the authors and co-workers it was determined that a toxicity testing

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cage would be required that would be light, durable, easily fabricated, nontoxic, and otherwise protective of the fish to be used in conducting in-stream toxicity tests. None of the designs reported in the literature appeared suitable, so a new type of cage was designed.

Cage Construction and Use

Details of the construction of the toxicity test cage are shown in Fig. 1. The cage is fabricated from standard 10-cm (4-in.) diameter polyvinyl chloride (PVC) pipe, schedule 40, and pipe fittings that are readily available commercially. The pipe wall thickness was 0.64 cm (0.25 in.). This type of pipe is routinely used in individual household septic tank wastewater disposal systems as well as in other applications. The body of the cage consists of a 40-cm (16-in.) section of pipe with a slot 25 cm (10 in.) in length and one third the circumference of pipe cut midway in the section. The cover is a section of pipe 33 cm (13 in.) long with one third if its circumference removed. This cover will snap over the body of the cage and will not slip under normal conditions when the cage is in use, but may be easily turned or removed manually.

The two end caps that form the ends of the cage are attached to the body of the cage with a small amount of PVC solvent cement. The solvent contained tetrahydrofuran, methyl ethyl ketone, cyclohexanone, and dimethylformamide. No toxicity problems owing to leaching of solvent components were encountered. Holes 0.3 cm (⅛ in.) in diameter are drilled in the upper half of each end cap and in the cover. A hole 0.6 cm (¼ in.) in diameter is drilled in the center of one end cap to accept a 1.5-m (5-ft) section of nylon rope, which is then knotted on the inside of the cage.

This cage can be conveniently placed in streams by driving a metal fence post into the river bed at each selected toxicity test station and then securing the cage to this post. Each cage can then be positioned at any vertical point in the flow stream by tying it to the fence post at the desired depth. For deeper water systems the cage may be attached to a buoy at the desired depth in the water. With holes drilled only in the upper half of the cage, the cage can be removed from the water periodically during the toxicity test without undue stress on the test fish. This greatly simplifies visual observation of the organisms, an essential part of any toxicity test.

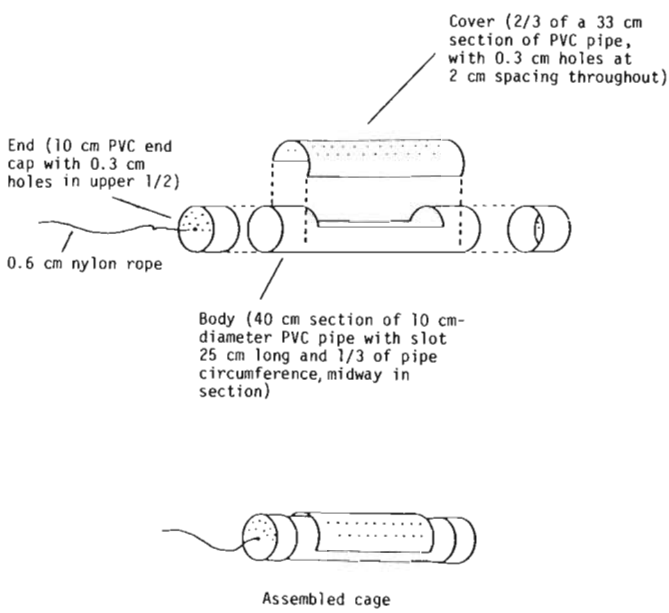

FIG. 1—*Exploded view of fish cage.*

At some locations, especially in very shallow water, problems of excessive silt accumulation within the cage were encountered when the cage was placed too close to the bottom. These problems were usually solved by raising the cage position in the water column. For some situations it may be necessary to add a Styrofoam® float to the downstream end of the cage to prevent that part of the cage from accumulating excessive silt as a result of being too close to the bottom.

Studies were conducted with dyes to examine the water exchange rate between the water in the cage and the surrounding water. Equilibration occurred in about one minute.

The toxicity testing cage described above has been found to be exceptionally well suited to field use [*3–6,11*]. In the numerous field studies in which cages of this type have been used by the authors, no mortality has occurred in the cages placed at clean water control stations, indicating that the cages adequately protect the test organisms (3- to 5-cm-long fathead minnows, *Pimephales promelas*). While these cages have been typically used for acute toxicity testing for about one week's duration, a six-month toxicity test using fathead minnows (ten fish, 3 to 5 cm in length) showed 100% survival at the clean water control stations. These fish were not fed during the test. Adequate food entered the cages through the holes. The light weight, durability, and ease and low cost of construction of these cages make them practical pieces of field equipment.

Acknowledgments

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