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Responsibility

LC50 calculations help predict toxicity

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Safe concentration of a toxicant is called the maximum allowable toxicant concentration

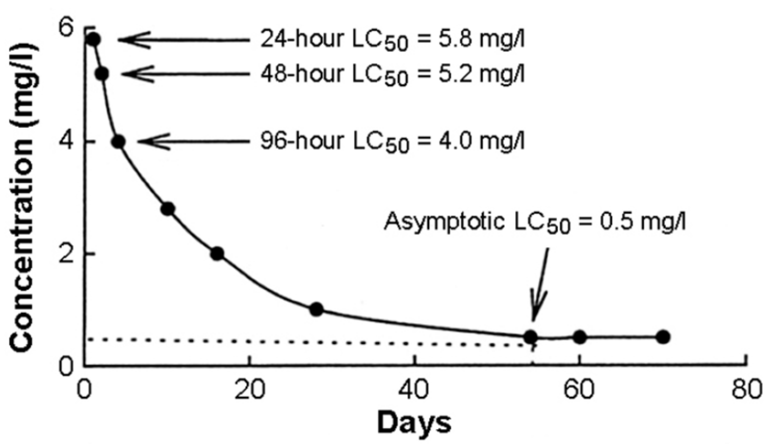

Fig. 1: Illustration of the asymptotic LC_{50}.

Aquaculturists sometimes are confronted with the toxicity of natural or man-made substances to fish, shrimp, or other culture species. Naturally occurring toxicity can result from low dissolved-oxygen concentrations and high concentrations of ammonia, carbon dioxide, nitrite, or hydrogen sulfide. Toxicity also can result from contamination of culture systems by pesticides, heavy metals, or industrial chemicals.

Lethal concentration

The potential toxicity of chemical substances often is presented as their LC_{50}. LC_{50} is the concentration of a substance that is lethal to 50 percent of the organisms in a toxicity test. LC_{50} can be determined for any exposure time, but the most common exposure period is 96 hours. Other common durations are 24, 48, and 72 hours.

As a general rule, the longer the exposure, the lower the LC_{50}. If the exposure is long enough, an asymptotic LC_{50} value can be obtained (Fig. 1). The asymptotic LC_{50} is not time-dependent.

Toxicity testing

Toxicity tests usually are conducted in glass containers that hold 1 liter or more of toxicant-treated water and several individuals of the test species. Typical tests use a range of toxicant concentrations and a control with no toxicant.

In static tests, water exchange is not used and wastes may accumulate. Moreover, the concentration of the toxicant can decline through absorption by the test animals, or chemical or biological degradation. Thus, flow-through tests (Fig. 2) in which the treated water is continuously renewed to rid the system of wastes and maintain a constant toxicant concentration are more reliable.

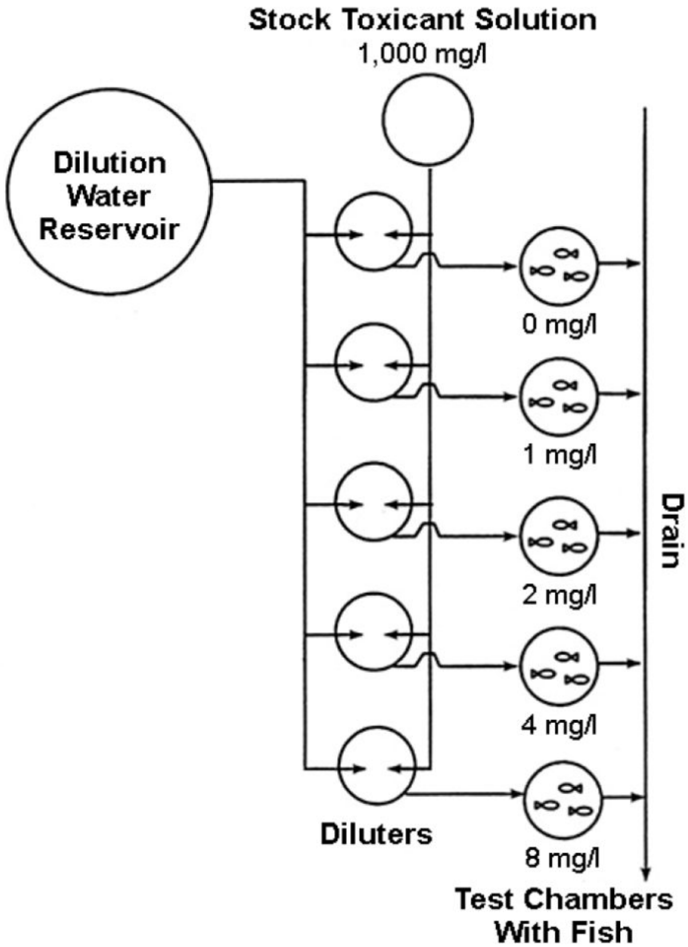

Fig. 2: Example of a flow-through toxicity test.

Specific guidelines for conducting toxicity tests include procedures for the acclimation of test organisms and limits on organism size and weight per volume of water, temperature range, light intensity, and other factors. Mortality must be checked frequently with dead test organisms removed promptly. *Standard Methods for the Examination of Water and Wastewater*, published by the American Public Health Association, is an excellent reference on toxicity testing.

When tests terminate, the mortality for each toxicant concentration is adjusted for mortality in the control. The mortality percentage is plotted on semi-log paper versus the toxicant concentration, and the concentration that killed 50 percent of the test organisms is calculated graphically or by statistical techniques (Fig. 3).

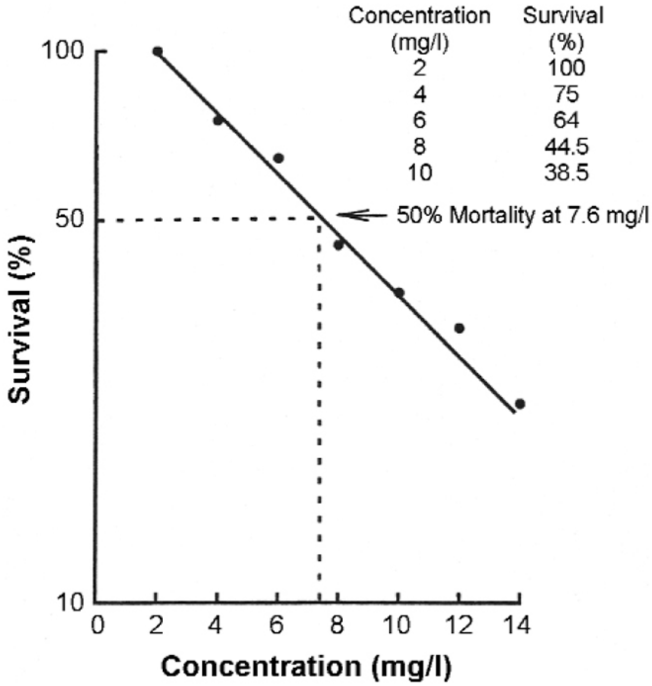

Fig. 3: Graphical estimation of LC_{50}.

Variability

There can be great variation in LC_{50} among toxicity tests conducted in different laboratories. This results from differences in water quality in the test containers, temperature, species and source of test organisms, and other factors.

For example, the toxicity of most substances increases with increasing temperature. Water quality variables such as pH and total alkalinity also can have large effects on toxicity. Copper and most other metals are much less toxic at total alkalinities of 100 milligrams per liter or greater than at lower alkalinities. The concentration of total ammonia nitrogen necessary to kill 50 percent of test organisms is greater at a pH of 7 or below than at higher pH.

Aquaculture uses

In evaluating the cause of mortality in aquaculture animals, one may find in scientific literature a range of LC_{50} values for a particular toxicant. The LC_{50} value most appropriate for reference is the one obtained in a toxicity test in which conditions were similar to those of the aquaculture system at the time of mortality.

Fig. 4. Formula to relate MATC to LC_{50}.

In aquaculture, the concentration of potential toxicants should be below that which causes mortality or adverse effects on growth and reproduction. This information is directly available from toxicity tests with a duration equal to the entire life cycle of the test species.

The safe concentration of a toxicant is called the maximum allowable toxicant concentration or MATC. There is much less life cycle toxicity data available than 96-hour LC_{50} data. However, it is possible to relate a 96-hour LC_{50} to the MATC by an application factor by applying the formula in Fig. 4.

Application factors typically range 0.01-0.1, but for some toxicants, the factor may be 0.001. Application factors tend to be smaller for highly toxic compounds than less-toxic ones. In aquaculture, an application factor of 0.05 is suitable for most natural toxins, while a factor of 0.01 should be used for industrial chemicals or pesticides.

Factor example

To illustrate the use of application factors, suppose the 96-hour LC_{50} to the culture species for unionized ammonia (NH_3) is 1.2 milligrams per liter. The MATC would be 1.2 milligrams per liter x 0.05 = 0.06 milligrams per liter. Thus, if the NH_3 concentration remains below 0.06 milligrams per liter, the culture species should suffer no adverse effects.

Of course, toxicity might occur at concentrations of NH_3 below 1.2 milligrams per liter, for that value represents the concentration necessary to kill half of the test organisms. A much lower concentration could be expected to cause incipient mortality (Fig. 3).

Sometimes it is not possible to find LC_{50} data for a desired temperature. Toxicity usually doubles with a 10 degrees C increase in temperature. Thus, if 2 milligrams per liter is the 96-hour LC_{50} of a substance at 20 degrees-C, the corresponding values at 25 and 30 degrees-C could be estimated as 1.5 milligrams per liter and 1 milligrams per liter, respectively.

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