A Method for Intermittent Chlorine Dosing in Continuous-Flow Toxicity Tests

by BENTLEY C. GREGG
and ALAN G. HEATH
Dept. of Biology and Center for Environmental Studies
Virginia Polytechnic Institute and State University
Blacksburg, Va. 24061

The cooling lines through the condensers in steam electric generating plants frequently become fouled with attached organisms which reduce cooling efficiency and decrease water flow rate. In many plants a chlorine solution is fed for several short periods each day to treat problem areas and then is discharged as condenser blow-down. To study the toxic effects of these discharges on the organisms in the receiving water, there is a need for an intermittent delivery system to simulate the down-stream conditions, such as the chlorine pulses (DICKSON, et al., 1974). We here describe the composition and operation of an intermittent delivery system used to perform chlorine toxicity tests on macroinvertebrates.

Description of the System

Stainless steel oval tanks simulate the receiving streams and rotating stainless steel paddles add current. Blacksburg tap water, dechlorinated by passage through an activated charcoal filter, is added to the streams by means of a modified BRUNGS AND MOUNT (1970) proportional diluter. Instead of the usual Marriotte bottle for toxicant delivery to the dipping chamber, there is a 1/2 in. dia. Tygon tube from a submersible pump (Little Giant Pump Co., Oklahoma City) inside a 5-gal. jug (painted black to retard photoreactions of the chlorine solution) (Fig. 1). The submersible pump is plugged into a Variac-type voltage regulator (Standard Electric Co., Dayton, Ohio) to control the rate of flow up the delivery line. The Variac is plugged into a twenty-four hour timer with a fifteen minute switching potential (Paragon Electric Co., Two Rivers, Wisc.). The timer turns on the system for forty-five minutes at three equally spaced intervals during the day (similar to the chlorination schedule of many steam electric-generating plants).

Each time the diluter cycles, dilution water fills the cup at one end of the dipping bird and pivots the hollow dipping bird into the dipping chamber. When the timer switches on, the submersible pump delivers chlorine solution to the dipping chamber. The next time the diluter cycles, there is chlorine solution in the dipping bird and it is pivoted into the mixing chamber and it continues to be added each cycle until the timer

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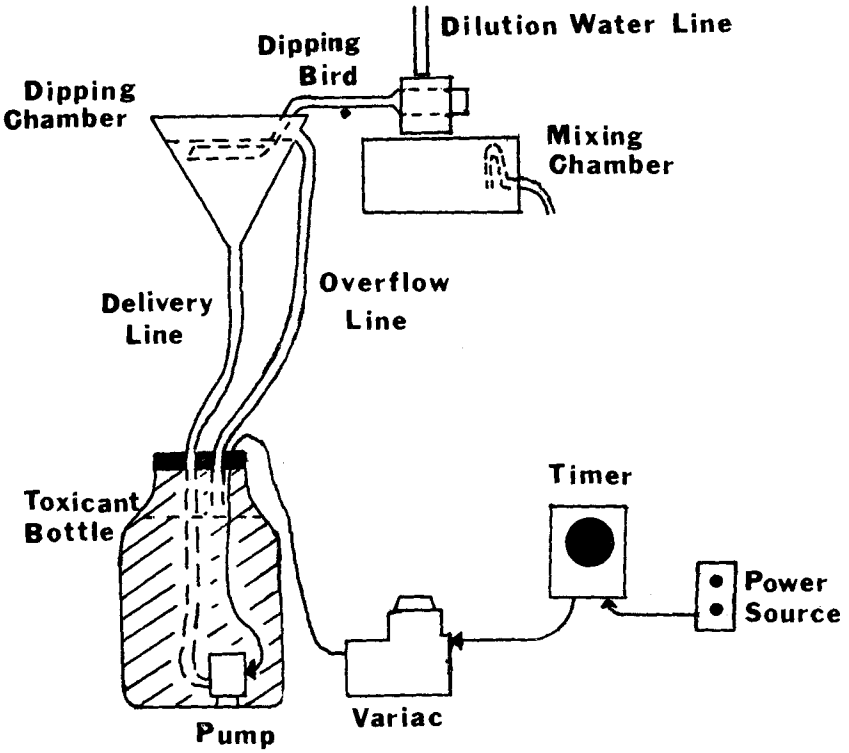

Figure 1. Line drawing of the intermittent delivery system with critical parts of BRUNGS AND MOUNT (1970) diluter (not drawn to scale).

switches off 45 min. later. The diluter cycles approximately every 4 min. and delivers 500 ml to each 12-l stream. When the timer trips off, the chlorine solution descends back into the toxicant bottle, and only dechlorinated dilution water is delivered to the streams for the remaining of 7 hr. & 15 min. of the cycle.

Description of the Chlorine Cycle

Figure 2 shows two different pluses of the system with different stock concentrations. Residual chlorine measurements were made using an amperometric titrator (Wallace and Tierman, Belleville, N.J.) by the technique in Standard Methods (p. 112; 1971). Measurements were performed every four minutes, the turnover time of the diluter, for at least nine

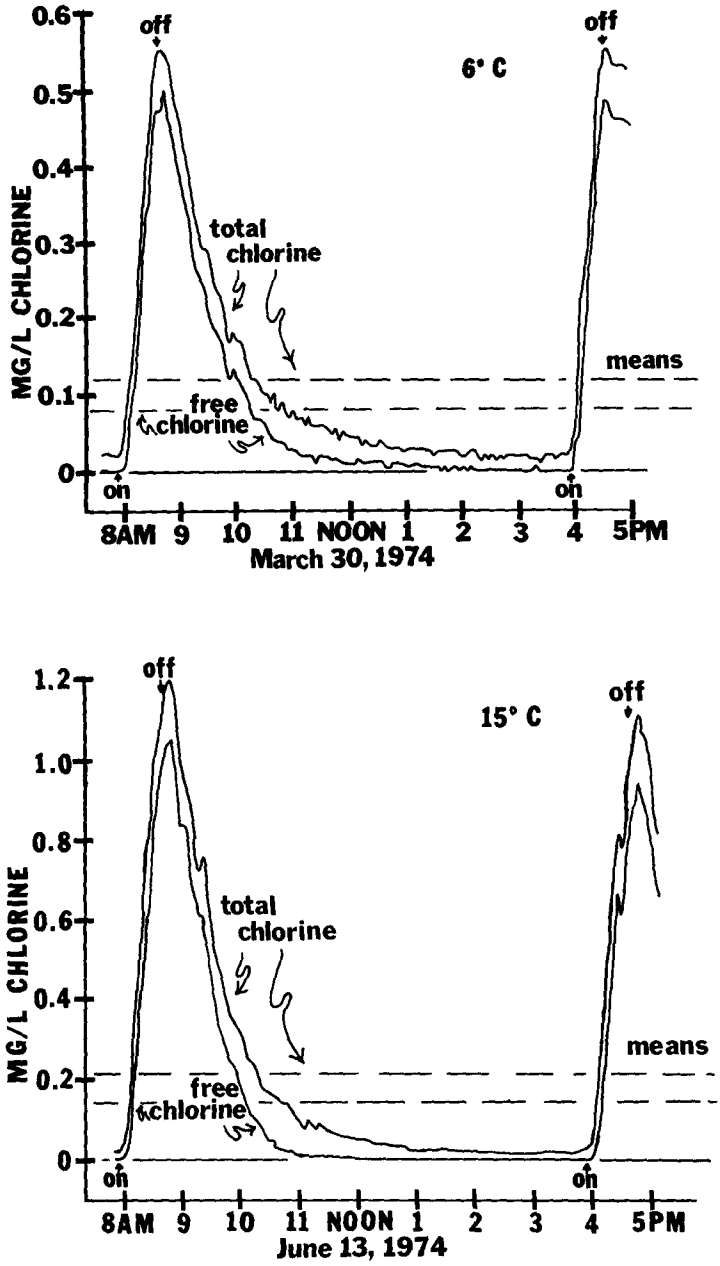

Figure 2. Representative chlorine pulses with different stock solutions for Test 1 (March 30, 1974) and Test 2 (June 13, 1974).

TABLE I

Statistical Analyses of Measured Peaks during Test 1 and Test 2, with Means, 95% Confidence Limits, and Ranges, in mg/l of Total Residual Chlorine.

Test 1	Mean	No.	95% Conf. Limit	Range	Coeff. of Var.
high	0.531	16	0.501-0.561	0.40-0.60	10.74%
2nd	0.265	17	0.246-0.284	0.17-0.32	13.74%
3rd	0.151	17	0.135-0.167	0.10-0.22	20.84%
4th	0.0771	17	0.0699-0.0843	0.05-0.10	18.22%
low	0.0418	17	0.0373-0.0463	0.03-0.06	21.14%
Test 2					
high	1.144	17	1.098-1.198	0.98-1.36	7.80%
2nd	0.512	15	0.496-0.528	0.45-0.56	5.53%
3rd	0.320	14	0.286-0.354	0.27-0.515	18.51%
4th	0.175	15	0.148-0.202	0.13-0.33	27.70%
low	0.0350	15	0.030-0.040	0.02-0.05	24.74%

hours to illustrate a complete cycle and the peak of the next cycle. Because of the inflow volume : holding volume ratio of each tank, the removal of chlorinated water from the streams is progressively more gradual until first all free chlorine is removed and then all combined chlorine - except the background concentration from the charcoal filtered source.

Mean chlorine concentrations during the chlorine cycles (Figure 2) were computed by obtaining the mean concentration for each four-minute measurement during the eight hour cycle. The means and peak concentrations can then be compared with continuous chlorine-dosing toxicity tests in which a Marriotte bottle is connected to the dipping chamber.

Table I shows statistics on numerous measurements of the chlorine peaks during both tests to illustrate that each of the continuously measured cycles were representative of the usual operation of the system.

Discussion and Conclusion

The system can be used for intermittent-dosing or continuous-dosing tests with only the minor modification of attachment of the respective delivery line to the dipping chamber. The system has proven efficient and reliable as shown by the representative data from two tests. Though other types of delivery systems are available such as peristaltic pumps, the solenoid-utilizing diluter of ESVELT AND CONNERS (1972), manual addition of toxi-

cant to the dipping chamber, or the peristaltic pump-driven centrifuge tube-siphon diluter of CHANDLER et al. (1974), this system seemed as inexpensive and trouble-free as any other. The chlorine cycles observed in our artificial streams were very representative of the concentrations below a power plant on the Clinch River as reported by DICKSON et al. (1974). The system described was used with a somewhat volatile and reactive toxicant, yet still functioned with good replication for eight day tests so it should also be applicable for more stable toxicants in long-term tests.

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