Methods to Test Chlorine Solution Concentrations in Ebola Emergencies

Chlorine solution is widely used for disinfection in emergency response activities. In Ebola response, 0.5% chlorine solution is recommended for cleaning non-living things and surfaces and 0.05% chlorine solution is recommended for cleaning living things. The conversion factor between percent and ppm or mg/L of chlorine solutions is: 1.0% = 10,000 ppm = 10,000 mg/L. The recommended chlorine solutions concentrations in Ebola response are thus 5000 ppm (or mg/L) (0.5%) and 500 ppm (or mg/L) (0.05%). These concentrations are too high to test with commonly used free chlorine residual (FCR) and total chlorine residual (TCR) test kits, which have a maximum reading of about 4 mg/L. Thus, alternate test methods are needed. Three alternate methods are described herein: 1) portable iodimetric titration kits; 2) dilution followed by testing with FCR/TCR test kits; and, 3) calculation based on manufacturing.

Method 1: Portable Iodimetric Titration Kits

Iodimetric titration is the most accurate way to test chlorine solutions, and is commonly used in laboratory settings. Hach Company (USA) manufactures a portable titrator that can be used with cartridges and pre-packaged chemicals to accurately test chlorine solution concentration in the field. The method appropriate for 0.05% and 0.5% solution is Hach Method 8209 (20-70,000 mg/L). To use this method, you select the appropriate titration cartridge for the concentration anticipated (0.113N for 0.05%, 2.0N for 0.5%), add 2mL (for 0.05%) or 4mL (for 0.5%) of the solution to 50 mL of clean (bottled) water in a plastic flask, mix in two pre-packaged chemicals, titrate until light yellow, add in starch, and titrate until clear. The chlorine solution concentration is then calculated by multiplying the reading on the digital titrator by the appropriate digit multiplier (1 for 0.05% solution, 22.2 for 0.5% solution). To use this method you will need: clean unchlorinated (bottled) water, a digital titrator; cartridges and disposable dispensing plastics; 2 pre-packaged chemicals; liquid starch; a pipette; pipette tips; and a plastic flask. This kit can be used in the field, but is not appropriate for untrained personnel. Please see attached Hach 8209 directions for ordering information and instructions. The cost of this kit is ~500 USD for equipment, and then 2.50 USD per test.

Method 2: Dilution Followed by Testing with FCR or TCR test kit

A simpler method is to dilute the chlorine solution with clean (bottled) water to a range that can be tested using widely available FCR or TCR test kits. For the 0.05% solution (500 ppm / mg/L) one dilution is needed: adding 1 mL of the 0.05% solution to 250 mL of clean (bottled) water. The diluted water is then tested using a FCR or TCR test kit, and the result from the test kit is multiplied by 250 to obtain the ppm / mg/L of the original solution. Ideally, using this dilution factor, a 0.05% solution will read 2.0 mg/L on a FCR or TCR test kit.

A double dilution series is needed for the 0.5% solution (5,000 mg/L or ppm). First, add 1 mL of the 0.5% solution to 50 mL of clean (bottled) water, then add 1 mL of that diluted concentration to a second 50 mL of clean (bottled) water. Test the second dilution solution with a FCR or TCR test kit, and multiply the result by 2,500 to obtain the ppm / mg/L of the original sodium chlorine solution. Ideally, using this dilution series, a 0.5% solution will read 2.0 mg/L on a FCR or TCR test kit. For this method, you will need clean unchlorinated (bottled) water, a pipettor, plastic beakers delineated at 50 mL increments, and a FCR or TCR test kit. Please note that FCR and TCR test kits vary greatly in accuracy, precision, ease-of-use, and cost (see attached paper titled Murray-2014 for information on selecting the best method to test FCR or TCR in your context).

Method 3: Estimated Calculation Based on Manufacturing

If powdered HTH or NaDCC is used, the concentration can be estimated using the following equation:

$$\frac{\text{mg}}{\text{L}} = \frac{\text{mg HTH/NaDCC} \times \frac{\text{Percent Chlorine of HTH/NaDCC}}{100}}{\text{Liters}_{\text{water}}}$$

For example, if 1,000 mg (1 gram) of 65% strength HTH was added to 1 Liter of water, the resulting hypochlorite concentration is estimated at 1000*65/100/1 = 650 mg/L or 0.065%.

If quality-controlled liquid sodium chlorine solution (bleach) is used (i.e. purchased from a known reputable source who tests their solution and can provide those results to you and stored out of sunlight and heat) the concentration can be estimated using the following equation:

$$\frac{\text{mg}}{\text{L}} = \frac{\text{\% Chlorine} \times 10{,}000 \frac{\text{mg/L}}{\%} \times \frac{1 \text{ Liter}}{1{,}000 \text{ mL}} \times \text{mL Chlorine}}{\text{Liters}_{\text{water}}}$$

For examples, if 50 mL of 5.25% sodium chlorine solution (bleach) is added to 5 Liters of water, the resulting hypochlorite concentration is estimated at 5.25*10000/1000*50/10 = 525 mg/L or 0.0525%.

Expiry and Stabilization

Sodium chlorine solutions degrade quickly when exposed to heat and UV light. At 1%, a solution will lose half its concentration in 4-6 weeks if not stabilized. The expiry time can be extended by empirically determining the amount of sodium hydroxide (lye) to add to the solution to raise the pH of the solution to greater than 11.9. Simple pH test strips can be used to test the pH of the chlorine solution; ColorpHast brands are recommended because the color does not degrade as quickly in the presence of chlorine. However, chlorine efficacy is highest at lowest pH, so while it is recommended to stabilize concentrated solutions for transport and storage, it is not recommended to stabilize the 500 mg/L and 5,000 mg/L solutions used for cleaning in Ebola emergencies. In Ebola emergencies, it is recommended that chlorine solutions be made fresh (and tested) daily to ensure effective disinfection.

Other Options

There are test strips (Indigo, others) and simple meters (Hanna) than can be used to test chlorine concentrations. The accuracy of these methods is low as the test strips have six color ranges from concentrations of 0-10,000 mg/L; and the Hanna meters maximum reading is 500 mg/L, which is lower than needed. These options could be used for a 'rough check' but should not be considered accurate.

If you have any questions on the information in this fact sheet, or comments for edits, please email Daniele Lantagne at daniele.lantagne@tufts.edu.

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