Agriculture and Agri-Food Canada
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Water Quality Matters

COAGULATION BEAKER TEST

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COAGULATION

Coagulation is a chemical water treatment designed to remove suspended particles and dissolved compounds from a water source. A chemical coagulant, such as aluminum sulphate, is added to the water in a volume determined by pre-testing the water. This pre-test is called a '**beaker test**.'

A beaker test determines the amount of chemical required to treat a dugout or cell, and also indicates the expected results. The coagulant is diluted to a 1% solution and gradually added to a 1 L sample of the water to be treated, until a desired pH level of approximately 6.0, or alkalinity concentration of 40 mg/L is reached. This test determines the amount of 1% chemical solution required for each litre of water to be treated. If the volume of water in the dugout is known, the amount of chemical needed to treat the entire water body can be estimated.

MATERIALS REQUIRED

To perform a beaker test, the following materials are required:

- 2 L measuring container
- 10 mL to 60 mL syringe
- rubber spatula for mixing
- pH meter or pH test strips
- 1% coagulation chemical solution
- distilled water
- alkalinity test strips
- rubber gloves
- eye protection

A beaker test is an important first step before treating your dugout or cell

PREPARATION OF SOLUTION

A dilute coagulant solution must be used in order to obtain useful results. For simplicity sake, usually a 1% solution consisting of undiluted liquid coagulant and distilled water is used. The solution is prepared as follows:

1. Measure 495 mL of distilled water with a measuring container
2. Pour this into a clean, plastic bottle
3. Use a syringe to measure 5 mL of undiluted, liquid coagulant into the bottle
4. Replace lid on bottle and shake vigorously for 30 seconds
5. Rinse the syringe 3 times with distilled water so that it can be reused

A 1% coagulant solution is now ready for use in a beaker test.

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ESTIMATING DOSAGE

A successful coagulation treatment requires proper chemical **dosage** - the amount of coagulant necessary to effectively and safely treat the water. The proper dosage for a particular water source can be obtained from the beaker test. To approximate the coagulant dose (in mL) for use with the beaker test, determine the raw water alkalinity (in mg/L) and consult **Table 1**. Higher alkalinity requires a higher coagulant dose. The lower coagulant dose in the dose ranges listed should be used when starting the beaker test.

Table 1

Alkalinity (mg/L)	Approximate 1% Ferric Chloride Dose (mL)	Approximate 1% Aluminum Sulphate Dose (mL)
60	6.4 to 9.6	7.6 to 17.6
80	10.6 to 16.0	12.6 to 29.2
100	15.0 to 22.4	17.6 to 41.0
120	19.2 to 28.8	22.6 to 52.6
140	23.6 to 35.2	27.6 to 64.4
160	27.8 to 41.6	32.6 to 76.0
180	32.0 to 48.0 >40 mL not recommended	37.6 to 92.6 >60 mL not recommended
>180	not recommended	not recommended

STEP-BY-STEP

1. Measure 1 L of dugout water into the 2 L measuring container
2. Add the minimum volume of 1% coagulant solution (from Table 1) to the container
3. Stir vigorously for 10 seconds
4. Immediately measure and record the pH and alkalinity
5. If the pH is greater than 6.0, and the alkalinity is 40 or greater, add more 1% solution in reasonable increments (i.e. 2.5 or 5 mL at a time)
6. Stir gently for another 10 seconds, and then measure and record the pH and alkalinity
7. Repeat steps 5 and 6 until the pH is 6.0, or the alkalinity is approximately 40 mg/L
8. Record the amount of 1% solution (in mL) necessary to drop the pH or alkalinity to the desired level (6.0 pH units or 40 mg/L respectively)

DETERMINING DUGOUT SIZE

There are several formulas available to calculate the size of your dugout. Some of these are very accurate, but they tend to rely on overly complex math calculations. For easy, step-by-step calculations, visit the following website:

www.agric.gov.ab.ca/calculator/dugout.html

Here you can enter your dugout measurements and the formula will instantly produce your dugout water volume in several different units. If you don't have access to the Internet, you can estimate the water volume of the dugout by using **Figure 1** (back page). Only the length and width of the **water surface** are required to use the graph. This method assumes standard dugout end slopes of 4:1 and side slopes of 1.5:1, and is accurate to within 15% over the given range of depths. The following example calculation is illustrated by the bold dashed lines on Figure 1:

- Measured length: 50 m (164 ft)
- Measured width: 25 m (82 ft)

Plotting these values on Figure 1 estimates a volume about one-half way between 2000 and 3000 cubic meters (m^3), or approximately 2500 m^3.

CONVERSIONS

- To convert from m^3 to L, multiply by 1000:
  2500 m^3 x 1000 = 2,500,000 L
- To convert from m^3 to Imp gal, multiply by 220:
  2,500 m^3 x 220 = 555,000 Imp gal
- To convert from ft to m, multiply by 0.305:
  164 ft x 0.305 = 50 m

CALCULATING COAGULANT VOLUME

Once the beaker test is complete and you've calculated the size of your dugout or cell, it is possible to calculate how much undiluted liquid coagulant is needed to treat your water source. This process involves inserting the volume of the coagulant previously determined in the beaker test, and the water volume in the dugout or cell into the formula in **Figure 2** (top of page 3).

Figure 2

coagulant volume (mL) = $\frac{\text{beaker test volume (mL/L)} \times \text{volume of dugout or cell (L)}}{100}$

As an example, when the dugout water volume is 2,500,000 L, and the optimum dose of 1% coagulant from a beaker test is determined to be 20 mL per L of raw water, the amount of coagulant necessary to treat the dugout would be:

coagulant volume = $\frac{20 \text{ mL/L} \times 2{,}500{,}000 \text{ L}}{100}$ = 500,000 mL or 500 L

This means it will require approximately 500 L of undiluted liquid coagulant to properly treat this dugout.

IMPORTANT TIPS

- When stirring the coagulant into the container for the beaker test, do not stir for longer than suggested. Over stirring can have an adverse effect on results.
- The amount of coagulant calculated in Figure 2 should only be used as a guideline. This helps to ensure that enough coagulant is on hand to perform the treatment.
- The pH and alkalinity should be constantly monitored throughout the treatment to ensure that the pH does not drop below 6.0, and the alkalinity does not drop below 40 mg/L.
- If for any reason the pH drops below 6.0, or the alkalinity drops below 40 mg/L during the beaker test, the coagulant dose is too high. This is considered to be an overdose and should never be applied to a dugout or cell. Repeat the beaker test to calculate a proper dose.
- To improve the accuracy of the coagulant volume calculation, the actual measurements of the water surface must be taken prior to treatment. Guessing at your water volume may provide a close estimate, but an incorrect guess can result in an improper dose of coagulant being applied.
- If the raw water alkalinity is initially low (< 40 mg/L), coagulation treatment may be more complicated. Contact your local PFRA office for assistance.

THE BIG PICTURE

Coagulation can be successful on most surface water sources. Poor results are usually related to an improper dose, excessive aquatic animal activity, or the presence of algae blooms prior to treatment. Although coagulation removes a large percentage of particles and dissolved matter, it may still contain pathogens; therefore further treatment and disinfection is required if the water is used for domestic and drinking water purposes.

Proper equipment and procedures are necessary for effective coagulation treatment. For the first coagulation, PFRA recommends working with someone who has experience. Contact the PFRA district office nearest you for more information and technical advice.

For further information on rural prairie water quality and treatment technology:

- see the following **Water Quality Matters** publications: "On-Farm Coagulation", "How to Coagulate Your Dugout or Cell", and Chemicals for On-Farm Coagulation";
- visit the PFRA website at www.agr.gc.ca/pfra;
- read Prairie Water News available from PFRA, or on the internet at www.quantumlynx.com/water; or
- **contact your local Prairie Farm Rehabilitation Administration Office** (PFRA is a branch of Agriculture and Agri-Food Canada).

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Figure 1 - Dugout Water Volume