



CHEMICALS FOR ON-FARM COAGULATION

May 2001

WHAT IS COAGULATION?

Coagulation is a safe and effective method of treating water, which improves its quality by reducing levels of organic compounds, dissolved phosphorus, colour, iron and suspended particles.

This publication provides information on the chemicals available for coagulation treatment.

Coagulation can be performed in dugouts, coagulation cells or by using commercial in-house coagulation systems. Four coagulation chemicals and one coagulant aid are commonly used in water treatment plants. Selection of the right chemical depends on which coagulation method is used.

A coagulation cell is a small, constructed reservoir that treats and stores water. It is sized to provide sufficient water for the farmstead during the winter. Another option is a commercially available in-house coagulation system, which uses a tank in a batch treatment process.

For more information about coagulation water treatment see the **Water Quality Matters** publications "On-Farm Coagulation", "How to Coagulate your Dugout or Cell" and "Coagulation Beaker Test."

WHAT CHEMICALS ARE USED FOR COAGULATION?

Aluminum sulphate, ferric chloride, ferric sulphate and polyaluminum chloride are the primary chemicals used to treat drinking water. These chemicals work by using the positive charge of aluminum or iron to neutralize the negative charge on the dissolved compounds and

suspended particles in the water. This causes the formation of large particles, which settle quickly.

Powdered activated carbon (PAC), a coagulation aid, can be used in coagulation cells to enhance the removal of taste and odour compounds, and remove some organic carbon.

In water treatment plants, aluminum sulphate is a commonly used coagulation chemical, followed closely by ferric chloride. Polyaluminum chloride is used for specific applications, such as extremely turbid water and in-house treatment systems, because it is less sensitive to variations in water quality.



Coagulation cells make more efficient use of coagulation chemicals because all the treated water is used

WHICH CHEMICAL IS BEST?

By comparing the three coagulant chemicals, you will find that each has strengths and weaknesses. The most important considerations when choosing a chemical are how the water will be treated and how it will be used afterwards.





The in-house coagulation system commonly uses polyaluminum chloride

Which chemical is best for dugout treatment?

If a large dugout is being treated, aluminum sulphate is recommended for coagulation. Ferric chloride or ferric sulphate will result in a build-up of iron at the bottom of the dugout. This iron without an oxygen supply will dissolve and disperse in the water. Aluminum is more stable than iron, making the risk of it re-entering the water minimal.

Which chemical is best for a commercial in-house treatment system?

For a commercial in-house treatment system, polyaluminum chloride is the recommended chemical. Although polyaluminum chloride is expensive, it works well and is unaffected by seasonal alkalinity fluctuations. Aluminum sulphate, ferric chloride and ferric sulphate are more sensitive to alkalinity fluctuations. Frequent dosage adjustments are required to ensure good water treatment results.

Which chemical is best for coagulation cell treatment?

All three chemicals can be used to treat a coagulation cell; however, the specific use of the water determines which chemical will be most suitable (for this process).

If the coagulation cell is used primarily for domestic purposes, including drinking water, each of the three chemicals have their advantages and disadvantages. Selection is then based on the type of treatment system that will follow coagulation (e.g. reverse osmosis) and the relative importance the user places on health, aesthetics and cost.

Powdered activated carbon (PAC) is often used as a coagulation aid to enhance the removal of taste and odour compounds in cells. Research shows that coal-based PAC performs better than wood-based PAC.

What problems are associated with residuals?

All coagulation chemicals add specific elements to the water. With proper doses and application, chemical residuals generally pose no problem. This can be confirmed by testing the water after treatment.

Ferric sulphate, when used, adds iron and sulphate to water. Ferric chloride adds iron and chloride; aluminum sulphate adds aluminum and sulphate; and polyaluminum chloride adds aluminum and chloride.

HOW MUCH DOES COAGULATION COST?

Ferric chloride, ferric sulphate and aluminum sulphate are very similar in cost.

Polyaluminum chloride, to perform at the same level as the other chemicals, generally costs about three times as much. However, with turbid water it may be similar in cost.

All four chemicals are available as liquid solutions from distributors in 205 L (45 gallon) drums or at select companies in 20 L (4.5 gallon) pails. In addition to the chemical cost, a deposit of \$60 for the 205 L gallon drum is charged and refunded when the empty container is returned. The cost of chemical in 20 L pails is double when compared to purchasing the chemical by the drum.



The various coagulant chemicals are aluminum or iron dissolved in sulphuric or hydrochloric acid

Prior to settling:



Following settling:



Left to right: Raw, Aluminum Sulphate, Ferric Sulphate, Ferric Chloride, Polyaluminum Chloride.

The iron-based coagulants have a brown floc and the aluminum-based coagulants have a white floc.

Following settling, the water clarity and colour are similar.

Ferric chloride and ferric sulphate are slightly more expensive than the same volume of aluminum sulphate; however, the iron-based coagulants are more concentrated, therefore the cost to treat water is similar.

The volume of chemical required to perform a successful coagulation can vary greatly and is directly related to the water's alkalinity level. When treating water with high alkalinity, more chemical is necessary, which increases the cost.

The chemical cost to coagulate an average-sized dugout (2.2 million litres or one-half million gallons) with aluminum sulphate is between \$200 and \$500.

The chemical cost of coagulating a typical coagulation cell (300,000 litres or 65,000 gallons) with aluminum sulphate or ferric chloride is between \$30 and \$100.

Commercial in-house coagulation systems commonly use polyaluminum chloride at a typical annual cost of \$200 to \$400.

Table 1: Advantages and Disadvantages of Various Coagulation Chemicals

CHEMICAL	ADVANTAGES	DISADVANTAGES
ferric chloride or ferric sulphate	<ul style="list-style-type: none"> - best removal of organics - low cost - doesn't add aluminum to water - high iron residual is easy to detect 	<ul style="list-style-type: none"> - improper doses cause reddish colour and high iron residual - high iron residuals can plug filters and stain laundry - very acidic (full protective gear should be worn) - aesthetically unpleasing sludge (brown)
aluminum sulphate	<ul style="list-style-type: none"> - relatively low cost - less acidic (protective gear is still recommended) 	<ul style="list-style-type: none"> - lower DOC removal - improper doses cause high aluminum residuals and may pose a health risk
polyaluminum chloride	<ul style="list-style-type: none"> - lower aluminum residual than aluminum sulphate - less impact on pH and alkalinity 	<ul style="list-style-type: none"> - cost is three times greater than that of other coagulants
PAC (coagulant aid)	<ul style="list-style-type: none"> - improves removal of DOC - improves taste and odour 	<ul style="list-style-type: none"> - should only be used in coagulation cells - costly



Powdered activated carbon (PAC) is a fine powder that is difficult to mix into a slurry but will enhance taste and colour of the water

PAC is available as a powder in 22.7 kg (50 lb) bags for approximately \$100. It is usually applied at 10 to 30 mg/L, or about one-tenth to one-third of a bag for a typical 300,000 litre coagulation cell.

WHAT ABOUT SAFETY?

Safety is a concern when using ferric chloride because the pH is less than one. Full protective gear, including a face shield, is recommended when handling the product.

Aluminum sulphate and polyaluminum chloride, with a pH of 2.0 to 2.5, are less acidic, but protective gear is still recommended. Working with PAC requires breathing filters to protect from inhalation of the fine carbon dust. Always follow the protective measures in the Material Safety Data Sheets for all chemicals.

Transportation of chemicals falls under the regulations of the *Transportation of Dangerous Goods Act*. These coagulants require placards to be posted on the vehicle and a certificate for transportation of dangerous goods. Farmers are exempt from the required training but are required to post placards on any vehicle transporting more than 500 kg of coagulant.

AUTHORED BY: L. Brault and A. Leader, PFRA

FUNDING: Strategic support and funding for this project has been provided by the Canada-Saskatchewan Agri-Food Innovation Fund (AFIF).

ENDORSEMENT: This report should not be taken as an endorsement by PFRA or Agriculture and Agri-Food Canada of any of the products or services mentioned herein.

THE BIG PICTURE

Dugouts represent an important water source on the Prairies. Following good land use practices around the dugout improves and maintains good water quality. Coagulation will work better with higher quality raw water.

Coagulation will improve water quality, but does not make water safe for domestic use. Additional treatment depends on how else the water is used. For livestock watering or crop spraying, additional treatment may not be required. For human consumption, additional treatment and disinfection is required.

For more information about coagulation, see the following **Water Quality Matters** publications: “On-Farm Coagulation”, “Chemicals for On-Farm Coagulation” and “Coagulation Beaker Test”.

For further information on rural Prairie water quality issues:

- read the other publications in PFRA’s **Water Quality Matters** series;
- visit the PFRA Web site 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)