Water Quality Matters

Evaluation of Treatment Systems

December 1997

WHY IS IN-HOUSE WATER TREATMENT NECESSARY?

Water used for drinking and household use, especially water from a surface water supply, must be treated before it is used so it is safe and aesthetically pleasing. Some existing in-house water treatment systems currently in use on Saskatchewan farms were monitored to determine their effectiveness as part of the research conducted under the Canada-Saskatchewan Agriculture Green Plan Agreement. This part of the research focused on existing in-house filtration and disinfection systems, and their ability to remove dissolved organic carbon (DOC), colour and turbidity from the water. This publication provides:

- general information on in-house water treatment systems, including their cost and operation; and
- specific results from monitoring existing in-house systems.

Farm water supplies on the Prairies may have high concentrations of organic matter, high turbidity and be highly coloured. These conditions may degrade water quality so that the water is not safe or aesthetically pleasing for household use, including drinking. The Water Quality Matters information sheets describe how these factors affect water quality and drinking water safety.

WHAT TYPES OF IN-HOUSE TREATMENT SYSTEMS ARE COMMONLY USED?

In-house water treatment refers to any treatment technology that is used by individuals within their homes. Common in-house systems used on farms in the Prairies for treating surface water supplies include:

- sand filtration;
- granular activated carbon (GAC) filtration;
- chlorine disinfection; and
- softeners.

Other systems include:

- membrane processes such as reverse osmosis (RO), nanofiltration (NF), and ultrafiltration (UF);
- distillation;
- ozonation; and
- ultraviolet light disinfection.

Two common types of in-house treatment systems were studied:

- primary treatment systems that supplied enough water for all household uses. The primary treatment systems that were studied were granular activated carbon (GAC) systems used in combination with chlorination and water softeners.

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- add-on components to the primary treatment system supplied small quantities of high quality water for drinking and cooking. These add-on components included kitchen sink RO and distillation units.

HOW WELL DID THE IN-HOUSE SYSTEMS WORK?

Primary Treatment System: GAC, and Softener/Chlorine Disinfection

Randomly-selected in-house water treatment systems that consisted of sand filters and granular activated carbon (GAC) filters (along with water softeners and chlorine disinfection units) were monitored. Results (Table 1) showed they did not adequately treat water to produce safe and acceptable drinking or bathing water. The primary treatment systems were not effective in reducing DOC, colour or turbidity. This ineffectiveness was largely due to the fact that the systems were not maintained appropriately. In particular, the carbon in the GAC filters was not replaced when it was exhausted.

The concentrations of DOC and turbidity were not reduced to target levels specified in the study for safe drinking water (<5 mg/L for DOC, and <1 NTU for turbidity). Only in one household did the treatment system reduce the colour of the water enough to meet the target (<15 TCU), probably because the source water was not highly coloured. The effectiveness of the water treatment systems could have been improved if the carbon media was replaced frequently.

A common primary water treatment system for Prairie farms is a chlorinator, carbon filter and softener

Table 1: Performance of Primary Treatment Systems in Reducing DOC, Colour and Turbidity

Treatment System (Primary Systems)	Goals	Granulated Activated Carbon (GAC) + Softener		Chlorine + GAC		Chlorine + GAC + Softener	
		Dugout Water	After Treatment	Dugout Water	After Treatment	Dugout Water	After Treatment
DOC	<5.0	11.2	9.9	7.9	8.1	15.7	13.2
Colour (TCU)	<15	29.5	27.3	15.2	14.0	32.2	21.2
Turbidity	<1.0	4.2	3.2	9.1	6.8	8.5	5.6

Note: shaded values are within the desired goals

Add-on Components To Primary Treatment Systems: (RO and Distillation)

Add-on components to primary treatment systems, including RO and distillation units, are used on farms to produce high quality cooking and drinking water at the kitchen tap. Both kitchen sink processes that were studied, including reverse osmosis (RO) and distillation, supplied high quality and safe drinking water that met the objectives set for DOC, colour and turbidity (Table 2). The add-on systems removed 89% to 100% of the DOC, colour and turbidity from the water. When properly operated and maintained, these units are also designed to produce water free of microbial contamination.

A distiller is sometimes used as an add-on component to p ovide safe drinking and cooking water

Table 2: Performance of Add-on Components in Reducing DOC, Colour, and Turbidity

Parameter	Goals	Reverse Osmosis		Distillation	
		Before	After	Before	After
DOC (mg/L)	<5.0	20.6	0.0	8.3	0.0
Colour (TCU)	<15	24.8	1.0	15.2	1.6
Turbidity (NTU)	<1.0	4.2	0.3	9.4	0.4

NOTE: shaded values are within the desired goals

HOW MUCH DO IN-HOUSE SYSTEMS COST?

The cost of a typical primary treatment system component, (sand filter, GAC filter, chlorinator, softener) is about $500 to $1000 each. Similarly, kitchen sink RO or distillation units cost about $500 to $1000 each. While the primary treatment systems are designed to supply enough water for an entire household's needs, the kitchen sink units are designed to produce only 25 to 45 L (6 to 10 gallons) per day.

WHAT OPERATION & MAINTENANCE IS REQUIRED FOR IN-HOUSE SYSTEMS?

Equipment Use

- All in-house water treatment systems require specific operation and maintenance, which includes replacement of critical components. Systems must be operated in accordance with the manufacturer's instructions.
- Sand and carbon filters as well as softeners require regular backwashing.
- Membrane pre-filters (which include depth cartridges or pleated filters) and membranes must be replaced periodically. Pre-filters generally require replacement about four times per year, and membranes may need to be replaced every two to three years.
- The carbon inside GAC filters needs to be completely replaced as its ability to remove organic matter from the water will decrease over time. GAC should be replaced at least once per year (approximately four weeks after spring runoff). For optimum water treatment of a coloured water source (which includes most dugouts), the GAC may need to be replaced two to three times per year, or even more often to ensure high quality water.

- Chlorinators should be monitored weekly by testing for safe residual chlorine levels in the water. Chlorine doses should be set to achieve adequate residual chlorine levels (total chlorine equal to or greater than 0.5 mg/L and free chlorine equal to or greater than 0.1 mg/L). The system must also be operated to ensure there is adequate contact time between the chlorine and the water.
- Distillers must be cleaned regularly.
- A water softener may be needed as part of the treatment system to make the water more acceptable for bathing and washing by reducing the hardness of the water. Although hardness may be a problem with ground water supplies, most Prairie surface water sources do not require softening. (For more information on water softening, please see the article entitled "*To Soften or Not to Soften"* in Prairie Water News, Vol. 5, No. 1.)

Water Quality Testing

- All treated water should be tested regularly to ensure the systems are delivering water that is safe as well as aesthetically pleasing.
- Water should be tested seasonly by a certified laboratory (at least two to four times per year) to ensure it is safe from microbiological contaminants (coliforms) and for other suspected contaminants such as nitrates or arsenic.

ARE THERE ANY LIMITATIONS TO USING IN-HOUSE TREATMENT SYSTEMS?

- No single, universal water treatment process exists to treat all possible water quality problems. Each treatment process is sold for specific purposes, and if properly designed and maintained, will perform those tasks well. For example, RO units are designed primarily to remove inorganic matter commonly found in groundwater, and carbon filters are primarily designed to reduce the concentrations of organic compounds found in surface water.
- In-house treatment systems must be designed and installed to treat the available source water.
- Owners must maintain in-house systems adequately, for example by replacing carbon or monitoring chlorine levels, to ensure the system continues to function as designed.
- Systems that are not properly maintained or that are operated outside their limits can actually create water quality problems such as increased turbidity.
- Water should be treated to reduce organic matter *BEFORE* the water is chlorinated to prevent the formation of trihalomethanes (see the **Water Quality Matters** information sheet "Prairie Water Quality Problems").
- Kitchen sink RO units produce *"reject"* water in volumes anywhere from seven to 20 times the volume of treated water. This means that for every litre of drinking water produced, the RO unit will generate seven to 20 litres of reject or waste water. These ratios may increase with inadequate pre-treatment or decreases in water temperature.
- Add-on components such as RO or distillation units work better when the water has undergone primary treatment.

These bottles show algae passing through the primary GAC treatment system. Fortunately, the add-on RO unit delivered better water to the kitchen tap

THE BIGGER PICTURE

The best way to produce safe drinking water is to use a MULTIPLE BARRIER APPROACH where a number of different stages of treatment, or "barriers", are used to improve water quality. Ideally, a multiple barrier system will reduce particulate and dissolved matter before the

water is disinfected. One example of a multiple barrier system would include sand filtration, followed by carbon filtration and chlorination, followed in turn by a kitchen tap unit to produce drinking and cooking water. Such units include a chlorine tolerant kitchen sink RO or nanofilter (NF) membrane, or a distiller. (For more information on the multiple barrier approach, please refer to the **Water Quality Matters** publication "Approaches to Water Treatment".)

The limited studies conducted on randomly-selected farms as part of this research showed that GAC systems used alone or in combination with softeners or chlorinators were not effective in treating organic-rich surface water to produce safe and aesthetically pleasing drinking water. The systems were ineffective largely because they were not maintained properly. Increased replacement of carbon media would have improved the effectiveness of the primary treatment system. (The ability of GAC systems to reduce levels of DOC is addressed in the **Water Quality Matters** publication "Water Treatment Trailer.") However, RO and distillation units, designed to provide small amounts of water at the kitchen tap, were capable of producing high quality drinking water.

Further research and development is needed:

- to find effective techniques to treat organic-rich surface water sources, which would include most dugouts;
- to determine pre-treatment techniques for in-house membrane processes; and
- to compare in-house RO units with other membranes such as nanofiltration, ultrafiltration and microfiltration.

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

- contact your local Prairie Farm Rehabilitation Administration office (PFRA is a branch of Agriculture and Agri-Food Canada);
- read the other publications in PFRA's **Water Quality Matters** series;
- get a copy of "Rural Prairie Water Quality: Searching for Solutions for On-farm Users" available from PFRA; or
- read Prairie Water News, available from PFRA, or on the Internet at www.quantumlynx.com / water

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