



BIOLOGICAL TREATMENT OF SURFACE WATER

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WHAT IS BIOLOGICAL TREATMENT OF WATER?

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. One innovative method of water treatment is biological water treatment. Biological treatment has been used in Europe since the early 1900s and is now receiving more interest in North America.

Biological water treatment involves the use of naturally occurring micro-organisms in the surface water to improve water quality. Under optimum conditions, including enough oxygen, the organisms break down material in the water such as dissolved organic carbon (DOC) and thus improve water quality. Sand or carbon filters are used to provide a place on which these micro-organisms grow.

One type of in-house biological system for treating surface water was studied in three households in Saskatchewan as part of research conducted under the Canada-Saskatchewan Agriculture Green Plan Agreement.

WHY USE BIOLOGICAL TREATMENT?

Biological water treatment processes are ideally suited to treat water that is highly coloured and has high DOC and nutrient levels. Surface water supplies used on farms in the Canadian Prairie are typically rich in organic matter. Dugouts (small on-farm reservoirs) have particularly

high levels of DOC (see the **Water Quality Matters** information sheet "Prairie Water Quality Problems").

Conventional granular activated carbon (GAC) systems are quickly exhausted under these high organic loads and require frequent replacement of carbon (see the **Water Quality Matters** publications "In-House Water Treatment Systems" and "Water Treatment Trailer").

Research showed that the biological treatment system, including a slow sand filter and biological activated carbon (BAC) filter, effectively reduced DOC, turbidity and colour in surface water supplies from dugouts, improving the quality of water used in homes. This was accomplished without the need to replace the carbon.

HOW WILL BIOLOGICAL TREATMENT IMPROVE WATER QUALITY?

Biological treatment improves water quality by reducing organic matter, DOC, colour and turbidity. DOC can cause health problems in chlorinated water. Reduced DOC levels can also improve the taste and odour of the water, and can reduce the amount of chlorine needed for disinfection.



WHAT WERE THE SYSTEM COMPONENTS?

The biological treatment system has three parts:

- a slow sand filter where water flows by gravity; it is designed to remove suspended matter;
- a biological activated carbon (BAC) filter to reduce dissolved organic matter; and
- a 1000 L storage tank to meet peak household demands.

The system was designed to operate continuously, providing high quality non-potable water to the entire household by filtering particulate matter and biodegrading dissolved organic matter. For drinking and cooking water, a reverse osmosis (RO) membrane was installed as an additional protective barrier at the kitchen sink. The RO unit will remove micro-organisms from the water including bacteria, viruses and parasites, providing it is properly operated and maintained. It also reduces some parameters like total dissolved solids that are not reduced by the biological system, although this is not usually a problem associated with surface water sources on the Prairies.



The source water for this biological treatment system is a typical Prairie dugout

HOW WELL DID THE BIOLOGICAL TREATMENT SYSTEMS PERFORM ON SURFACE WATER SUPPLIES?

The biological treatment system successfully reduced the levels of DOC, colour, turbidity and chlorophyll *a* (algae) in the water to within specified guidelines in each trial. The BAC filter improved the water quality by removing:

- 75% to 92% of DOC;
- more than 80% of the colour;
- 73% to 96% of the turbidity; and
- more than 90% of the chlorophyll *a*.

The results of the sampling conducted on one of the three surface water systems are shown in Table 1.



This initial prototype for a surface water biological treatment system was installed for a farmer in December, 1993

Table 1: Performance of Each Successive Stage of Biological Treatment System at One Site

PARAMETER	GOAL	BEFORE SAND FILTER	AFTER SAND FILTER	AFTER BAC FILTER	AFTER RO
Dissolved Organic Carbon, DOC (mg/L)	<5.0	13.0	6.3	3.2	0.3
Colour (TCU)	<15	16.0	6.9	2.0	2.0
Turbidity (NTU)	<1.0	3.0	1.2	0.9	0.1
Chlorophyll <i>a</i> (mg/L)	<0.01	0.015	0.001	0.001	0.001

NOTE: shaded areas indicate results met goal

The reverse osmosis unit was installed primarily to remove micro-organisms from drinking water, and it effectively achieved this objective. Tests indicated that micro-organisms were virtually non-detectable after RO treatment. The RO unit further reduced DOC and turbidity levels, had minor effects on further colour and chlorophyll *a* reduction, and reduced levels of inorganic matter such as hardness and calcium.

WHAT DID IT COST AND HOW LONG DID IT LAST?

Each biological treatment system was capable of supplying about 700 L/day (160 gallons per day), which is sufficient to meet all household demands in one dwelling. The cost was about \$6,000, which included the sand and BAC filters, storage tank and kitchen sink RO unit, as well as miscellaneous components such as an air pump.

At one site that has been studied for three years, performance has been sustained and no media replacement has been required. The biological treatment system may be able to last for many years without media replacement.

WHAT OPERATION & MAINTENANCE IS REQUIRED FOR BIOLOGICAL SYSTEMS?

- The biological treatment system is easy to operate and has a long life expectancy, compared to the more common GAC system. Good operation and maintenance is essential to ensure it works well.
- An appropriate air supply system is needed to supply oxygen to the microbes in the BAC filter.
- The slow sand filter must be backwashed manually using air and water to remove the accumulated material and prevent loss of productivity. Backwashing is required about once a month, or after about 15,000 to 20,000 L of water (3,000 to 4,000 gallons).
- Backwashing of the BAC filter with air and water is required about every four to six months, or after about 50,000 to 80,000 L (10,000 to 18,000 gallons) of water. More frequent backwashing may be needed if water quality begins to deteriorate.

ARE THERE ANY LIMITATIONS TO USING BIOLOGICAL WATER TREATMENT?

- Biological treatment converts ammonium to nitrate. If the source water is high in nitrates, then biological treatment may increase nitrates to a level that exceeds Canadian Drinking Water Quality Guidelines. It should be noted that an RO unit would reduce nitrates to a safe level.
- Biological treatment of water is not designed to reduce levels of total dissolved solids, hardness, calcium, magnesium, sodium, sulphate or other types of inorganic matter.
- As with other water treatment systems, the treated water must be disinfected (through methods such as chlorination, membrane filtration, or other processes such as distillation) before the water is used for drinking and cooking.

THE BIGGER PICTURE

The biological treatment systems that were studied were effective multiple-barrier treatment systems for surface water supplies with high levels of organic matter. In combination with a kitchen sink reverse osmosis unit, the systems delivered high quality domestic water for all household demands and safe drinking and cooking water for individual farms. All three producers involved in the study were satisfied with the treatment provided by the biological system.

Further study of biological treatment systems is however needed:

- to determine how much treated water the system is capable of delivering (flow rates) and
- to determine the long-term performance of the systems.

Biological treatment processes may prove to be valuable in treating surface water supplies for both individuals and communities.

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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