Water Used To Wash Milk Contact Surfaces

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Developed for Dairy Farmers of Ontario by the University of Guelph in collaboration with the University of Ottawa.

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The information presented in this brochure is intended as a reference/ educational tool and it is not sufficiently detailed to allow its use as a technical document. Local conditions may affect the efficiency of any management or treatment efforts. Consult a specialist before considering modification to the water treatment systems on your farm.

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Part I: Introduction

Purity of milk is a vital principle on which the Ontario dairy industry bases its daily activities and reputation. Milk pasteurization does not kill all organisms that may be present in milk. Clean milk can be maintained only if milk comes into contact with clean surfaces throughout the entire milking and storage system. Therefore, the water that is used to wash milk contact surfaces must also be clean. Only water that contains zero Escherichia coli (E. coli) and zero coliforms should be used to wash milk contact surfaces.

Providing water of potable quality to milking systems may require a multibarrier approach. Reliance on a single barrier (i.e., farm management practices, well design and construction, or in-barn water treatment) to maintain water quality puts the water quality at risk if that single barrier fails. One needs to understand the advantages and limitations of each of these barriers and monitor to ensure that each of the barriers is functioning properly. Together these barriers constitute the highest level of protection that can reasonably and practically be provided to ensure the cleaning of the milking equipment with clean water.

The microbial quality of water is usually evaluated by testing for the presence of E. coli and total coliforms. It is required that water, as it is used, contains zero E. coli and zero coliforms. This means the water source and water handling mechanisms must be free of contaminants.

This booklet will help you to understand the possible risks that may be associated with water used to clean milk contact surfaces and also present you with possible management and treatment options that can reduce the risk of water contamination.

Part 2: Complying with Ontario regulations and legislation

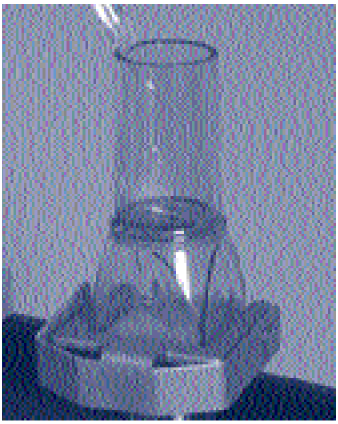
Applicable Legislation, Acts, recommendations
The milk marketed in Ontario has to conform to the regulations of The Ontario Milk Act. The producer requirements are outlined in Regulation 761 of The Milk Act. All components of the milking and storage systems must be clean. This includes the water used to wash these milk contact surfaces. The Canadian Milk Quality Assurance Program also specifies that water must meet provincial standards. In Ontario, water requirements were established under The Safe Drinking Water Act. The guidelines are outlined in the Canadian Drinking Water Quality Guidelines at http://www.epa.gov/safewater/sdwa/sdwa.html and http://www.hc-sc.gc.ca/hecs-sesc/water/dwgsup.htm

Role of Dairy Farmers of Ontario
Dairy Farmers of Ontario (DFO) administers the provincial Raw Milk Quality Program for the provincial government and is responsible for the enforcement of provincial standards, including the provision of clean water to wash milking equipment. Quality criteria for the water used for cleaning surfaces in contact with milk is also covered under Best Management Practices in the Canadian Milk Quality Assurance Program. It is the responsibility of DFO to ensure that each dairy operation meets the provincial requirements.

Part 3: Water analysis process

Description of the microbial testing

The microbial quality of water is currently assessed by testing water samples for the presence of E. coli and total coliforms. A minimum sample volume of 100mL is required. A 250mL water sample is taken as an additional 100mL is needed if Clostridium perfringens testing is done. A Clostridium perfringens test is done if E. coli is present. The water is collected at the point of use which may be a tap or water hose inside the milkhouse. Samples are collected in sterilized bottles immediately after turning on the tap to parallel how water would be used. Water in the lines over the sink in the milkhouse are used regularly and should not contain microbiological contaminants. The quality of the water from a good well can be easily compromised at the tap by manure residuals, so these taps and hoses need to be maintained in a clean state at all times.



Significance of the tested parameters

Test results will indicate the presence of E. coli and total coliforms. These organisms are not allowed to be present in potable water. The growth medium contains chemicals that change colour when coliforms or E. coli are present.

Test results report

E. coli

The presence of E. coli in water is an indicator that faecal matter is present in the respective water sample. **This suggests that other potentially pathogenic micro-organisms may have entered the water also.** The contamination can be caused by on or off farm sources including manure from farm animals, feces of pets and wildlife, or leaking or improperly functioning septic systems. The contamination could be stemming from the source of the water (well or surface water body), or can enter the water at any point where the water system is compromised. This includes fissured pipes, improper pipe fittings or even a dirty tap or water hose. Leaks may also not be readily apparent unless the system is subjected to high or low pressure.

Total coliforms
Presence of total coliforms in the water most commonly indicates that the water source is contaminated by surface water. This may include lake, pond, or stream water that may infiltrate a well located close to surface waters, or the well may be located in a sensitive geological formation (e.g., karst geology, moraine deposits, etc.). Surface water from rain may also acquire coliforms from contact with soils and these can enter wells by direct runoff, or by infiltration along cracked well casings.

Part 4: Interpretation of results

The water test results for bacteria will show the number of colony forming units (CFU)[1] for E. coli and total coliforms in one hundred millilitres of water. Any recorded number greater than zero indicates contamination. The laboratory report may not report zero values but rather indicates that there was less than 1 (<1) or less even than 3 (<3) bacteria present. This is done because it is difficult to say with certainty that no bacteria are present.

There are situations where it is not possible to determine the numbers of E. coli or coliforms present because water samples may:

- contain so many of these test organisms that the CFU

[1] *Colony forming unit or CFU - This measurement is based on the assumption that, during testing, each bacteria present in the water sample is able to multiply and form one colony. However, two or more bacteria that are clumped together or located very close to each other can lead to the formation of only one colony. Therefore, this method of counting bacteria generally underestimates the actual number present in the sample.*

merge together and cover the whole of the growth medium;
- contain some of the test organisms but also many other bacteria that merge together;
- contain none of the test organisms but many other bacteria covering the growth medium; and
- contain too many bacterial colonies which are generally separated but for which counting is very difficult.

These scenarios, where accurate counting is not possible, are not usually distinguished from one another in reporting the results, and may be variously reported as overgrown (og), or too numerous to count (tntc), or 300 plus (+). Regardless of how the result is coded, the water sample is considered to be contaminated. Water should be immediately retested in these areas.

Repeated tests that give results that indicate large numbers of bacteria suggest a problem and the need for corrective action. Consult an expert on these issues.

Part 5: Review of potential contamination sources

Well water versus surface water
Well water is generally cleaner than surface water. It is easiest to provide clean water from a drilled well. However, if you are using a surface water source (pond, lake, streams) from any agricultural area in Ontario, you need to filter and treat the water before use. Surface water sources can rarely meet requirements even if the proper management is employed around the surface body of water. It is strongly recommended that you consult a specialist before considering any water treatment measures.

Was sampling done correctly?
A test result is only as good as the sample that was analysed.

Collect the water in the milkhouse from the tap that is regularly used as follows:

- Before collecting the sample, wash and thoroughly dry your hands.
- Take the water sample from a line that is regularly used immediately after turning on the tap.

- Using clean hands and sterile bottles (supplied by DFO or the local health unit), remove the cap and hold it in your fingers without touching the lip or cap interior. Do not place the cap on an adjacent surface as the surface may be contaminated.
- Without touching the mouth of the bottle; hold the bottle under the running water until it is at the required mark, or nearly but not completely full if there is no mark. Replace the cap and tighten it immediately after sampling and put the sample bottle in a clean plastic bag. If the sample is to be collected or there will be a delay in delivering the sample to the laboratory, place the sample in the refrigerator or in a cooler with ice pack(s). Ensure delivery to the laboratory for analysis within 24 hours.

Where did the contaminants enter the water?

The water that is used in the milkhouse is the water that comes out of the tap or the hose. If the water sampled here is contaminated, this means that the milk may become contaminated. However, this does not tell us where the water became contaminated. It may be that the water was contaminated in the well or surface water source or during the travel through the piping and filtering and softening apparatus. However, it could be that the water was contaminated at the point of use by dirty water outlets or improper handling.

Start to keep a file or record of all your test results. When you receive the results of each new test, compare it with previous ones. This will build up a history of your water quality test results and allow you to see the history over time and over different seasons. It is possible for sample results to vary depending on the time of year if the well is under the influence of surface water, but generally well water from a deep underground aquifer should remain relatively constant in quality. **However, it is important to remember that sample results can vary slightly because bacteria are not evenly distributed in water samples.**

Table 1 provides some examples for you to consider.
To determine whether the sample is contaminated at the source or in the piping:

- Take a sample close to the water source and another from the tap over the milkhouse sink immediately after turning on the tap; or
- Take a sample immediately after turning on the tap and another about three to five minutes after turning on the tap.

Either method will help you determine if the water source and/or water handling system is contaminated.

Part 6: Reviewing risk factors associated with the quality of your well water

Well water can be put at risk by natural features of the soil and geology of the well location, by well construction and maintenance, by the management of manure on the farm and around the well, as well as by faulty septic systems or nearby off-farm contamination sources. An interactive Excel spreadsheet to help evaluate the risks associated with your water source is available from DFO on a CD.

The information in tables 2, 3 and 4 that follow will allow you to compare the situation of your well with what is considered a risk factor by current Ontario regulations.

Table 1 – Reviewing bacterial test results

Sample Series #	Test results taken: Immediately after turning on tap	Three to five minutes	Possible point of contamination
1	a) No bacteria	b) No bacteria	Neither the water source nor the piping are contaminated.
2	a) Bacteria present	b) Bacteria present	The water may be contaminated at the source or in the distribution system (piping). If the pipes are new, then the contamination is very likely occurring at the source (in the well or surface water body).
3	a) Bacteria present	b) No bacteria	The contamination may occur at the point of sampling or be due to a low level of contamination where numbers vary. Clean the tap and hose and resample periodically to give a sample history.
4	a) No bacteria	b) Bacteria present	The contamination may occur at the point of sampling or be due to a low level of contamination where numbers vary. The water source may have been recently contaminated and/or may be reflective of a failure in the water treatment system. Clean the tap and hose and resample periodically to give a sample history. Check water treatment system (eg. power failure, filter problems, no sanitizing agents, burned bulb, etc.).

Assessment of soil and geological risk factors
If any of the soil and geological parameters fall in a high-risk level, then your well is in a risk situation. Not too much can be done about the soil and bedrock type short of drilling a deeper new well.

A raised grassed cover around your well to act as a filter strip for any surface run-off is always a good management practice.

If you are in a risk situation, monitor carefully the quality of your water, build up a history of your water quality and take steps to treat the water if necessary.

Assessment of management risk factors
The good part about the risks associated with the management is that some of them can be corrected. Currently, some of these management practices, such as distances from well to land where manure or biosolids are applied, are legal requirements under the Nutrient Management and The Safe Drinking Water Act. Even if your well is not used for human consumption and, therefore, you are not required to legally respect all these distances, it is still advisable to follow them as an indication of due diligence on your farm. This will help maintain the quality of the well water and minimize treatment costs.

Manure around the well is not a good idea. Microbes can infiltrate into the groundwater at significant distances from the well and be transported to the well through porous bedrock or through sand or gravel. **Drawing large volumes of water from the well over a short time period accelerates the movement of groundwater,** and this can facilitate the transport of microbes underground over surprisingly long distances.

Ideally the well should be far enough from any possible sources of contamination such as feedlots, barns, manure storage structures, septic systems and plots where manure is land applied. It is very likely that a well, especially an older one, is quite close to barns and yards. If this is true, then the water must be closely monitored and the well must be maintained. If the well is chronically contaminated, consult a specialist.

Storage and application of liquid manure is more hazardous than the use of solid manure, especially when they are land applied when the soil is not sufficiently dry. Obviously, you should not store manure or biosolids up-slope from the well and should maintain a distance between the well and fields where manure or biosolids are applied.

Assessment of risk factors associated with construction and maintenance of the well

A properly installed and maintained well is most often the best insurance against water contamination. If you do not know much about your well, its age, depth and information can be obtained from provincial well water records held by the Ontario Ministry of the Environment.

Correct all the high-risk factors that are related to the well construction and maintenance. For example, if your well is older you would need to check the well casing for obvious cracks or traces of water seeping inside the well and seal them.

It is surprising how contamination can be often reduced just by mounding earth around the casing, making sure that the well cover is properly installed and ensuring that the opening in the casing for the water pipe is sealed.

Part 7: Surface water

Wells under the influence of surface waters

Particular attention needs to be paid to wells that are under the influence of surface water. It may be difficult to determine whether your well fits into this category but continuous and seasonal variation in water quality may suggest that it is. These waters are very easily contaminated with bacteria as well as with protozoan parasites such as Cryptosporidium and Giardia. Under current regulations, such waters are to be treated as surface waters and cannot be deemed potable under the current regulations unless they are treated and the treatment system is able to remove 99.9 per cent of Cryptosporidium and 99.99 per cent of Giardia. Use table 5 on page 15 to see if your well falls under this description.

Table 2- Soil and geological risk factors

Soil and geological parameters		Level of risk
Soil type (permeability)	Permeability class A (sandy soils – fine sand)	Lower
	Permeability classes B, C & D (silt, loam, clay)	Higher
Bedrock type	Fractured bedrock (karst), gravel or coarse sand	High
	Compact clay layers, non-fractured bedrock	Low
Depth to bedrock	Under 1m	Very High
	1m to 3m	High
	3m to 6m	Medium
	Over 6m	Low
Soil cover within 10m around the well	Grass cover	Lower
	Bare soil or sparse grass cover	Higher
Depth to groundwater	Under 6m	High
	Between 6m and 30m	Medium
	Over 30m	Low
Is the well reaching into overburden only or into bedrock	Overburden	High
	Bedrock	Low (depending on the bedrock type)

Table 3 – Management risk factors

Management parameters		Level of risk
Manure management (manure spread on land)	No manure application	Very low
	Manure land applied at less than 30m from well	High
	Manure land applied at less than 100m but more than 30m from well	Medium
	Manure land applied at more than 100m from well	Low
Type of manure applied (risk is low if no manure applied)	Liquid	High
	Solid	Low
Tillage (risk is very low if no manure applied)	No-till	Medium
	Regular till	Low
On-farm manure storage capacity	Less than 240 days	High
	More than 240 days	Low
Distance from well to feedlots, yards and barns	Less than 15m for wells with a 6m deep steel casing or less than 30m for any other well	High
	Less than 100m	Medium
	Over 100m	Low
Separation distance between septic system(s) and well	Less than 30m	High
	Less than 100m but more than 30m	Medium
	More than 100m	Low
Elevation of the well relative to the barns, feedlots, yards, manured fields	Upslope from sources of contamination (manure storages or field application, septic systems)	Low
	Downslope from sources of contamination (manure storages or field application, septic systems)	High

Table 4 – Well construction and maintenance risk factors

Well parameters					Level of risk
Well casing	Steel casing			6m and over	Low
				Less than 6m	Medium
	No steel casing				High
Well type	Drilled	Annular seal	Seal material	Concrete	Medium
				Clay slurry or bentonite	Low
			Depth of seal	Less than 6m	High
				6m or more	Low
	OR				
	Dug	Casing seal	Seal Material	Concrete	Medium/ high
				Clay slurry or bentonite	Medium
			Depth of seal	Less than 2.5m	Very high
				Over 2.5m	Medium
Well age	More than 60 years				Very high
	40 to 60 years				High
	20 to 39 years				Medium
	Less than 20 years				Low
Well mainten-ance	Height above surface			Less than 40cm (16in)	High
				More than 40cm(16in)	Low
	Well cover			Yes	Low
				No	Very high
	Mounded earth (earth mound around the well casing sloping away from the well)				Low
	No mounded earth or well in a depression				Medium/ High
Free live-stock, wild-life and pet access to the well	Yes				High
	No (e.g., fenced well)				Low

Table 5 – Water systems under the influence of surface water (from The Safe Drinking Water Act)

- A water system that obtains water from a well that is not a drilled well or that does not have a watertight casing that extends to a depth of at least six metres below ground level.
- A water system that obtains water from an infiltration gallery (an infiltration gallery may consist of a ditch, filled with coarse sand, gravel and stones of variable sizes, that allows infiltration of surface water into a well).
- A water system that is not capable of producing water at a rate greater than 0.58 litres per second and that obtains water from a well, any part of which is within 15 metres of surface water.
- A water system that is capable of producing water at a rate greater than 0.58 litres per second (35 litres or 9.2 gallons per minute) and that obtains water from an overburden well, any part of which is within 100 metres of surface water.
- A water system that is capable of producing water at a rate greater than 0.58 litres per second (35 litres or 9.2 gallons per minute) and that obtains water from a bedrock well, any part of which is within 500 metres of surface water.
- A water system that exhibits evidence of contamination by surface water.
- A water system in respect of which a written report has been prepared by a professional engineer or professional hydrogeologist that concludes that the system's raw water supply is ground water under the direct influence of surface water and that includes a statement of his or her reasons for reaching that conclusion.

As already mentioned, surface water sources are not deemed sufficiently safe to provide potable water. Such water, and water obtained from systems that are deemed to be under the influence of surface water (Table 5), needs to be treated before use. The treatment system usually includes a filtration unit capable of retaining any particulates larger than one micron, followed by at least one type of disinfection system.

Water Treatment Options

Advantages and Disadvantages of various treatment options:

1. Chlorination

How does it work	• Addition of liquid chlorine to water. • Chlorine can be bought or produced on-site by use of electrolytic salt chlorinators.
Recommended use	• Microbial disinfection of untreated ground water that is not under the influence of surface waters (where protozoa contamination is less likely).
Advantages	• Most common disinfection system. • Good disinfectant for removal of E. coli-like bacteria. • Reduces unpleasant smells but may add smell of chlorine. • Relatively inexpensive.
Shortcomings	• Does not kill protozoa or some viruses. • Formation of unwanted by-products and residuals. • Readily made ineffective by interaction with pipes and residuals. • Corrosive.
Special considerations	• High concentrations of organic matter considerations in water require increased chlorine dosage but the levels of chlorine permitted in contact with food contact surfaces are limited. The solution might be to modify the chlorine level added but this is difficult to achieve at the farm level. • Interaction between chlorine and organic matter and particulates in water leads to formation of toxic

by-products and potential residuals in milk. Organic matter can be reduced before chlorination by filtration but filter maintenance and regular replacement are essential if that is to be effective. Flocculation with the addition of polymers could also be used but is difficult to achieve at the farm level. Use of activated carbon filters or reverse osmosis systems after chlorination at the point of use to reduce the chlorine and potentially dangerous and carcinogenic organic compounds which may be present in water as a result of chlorination.

- High ammonia or organic material concentration in water leads to formation of chloramines reducing disinfection efficiency. Chlorine dose has to be modified to achieve appropriate levels of free chlorine but this is difficult to achieve at the farm level.

It should be noted that the main disadvantage of chlorine use is that the higher the chlorine level used, the greater the concentration of the toxic by-products and the greater its corrosivity.

2. UV-light

How does it work	• Transmission of UV-light produced by an UV-light tube at specified wavelengths through a column of flowing water.
Recommended use	• Under appropriate conditions and sufficient flux is good disinfectant for most waters.

Advantages	• Inactivation of bacteria, protozoa and viruses in untreated or pre-filtered water. (These organisms may not be necessarily be killed but they cannot infect and grow after UV treatment.) • No known toxic by-products.
Shortcomings	• Does not eliminate bad smells or taste. • Not effective against all toxins in water.
Special considerations	• High turbidity (water cloudiness) interferes with transmission of UV-light. Solution: Filtration or flocculation before the UV treatment. • High salt concentrations, particularly iron and magnesium ions, can interfere with the efficacy of UV treatment. Solution: Use water softeners/resin exchange systems before the UV-light treatment. • Spectrum and intensity of UV lamp changes with lamp age and needs monitoring and regular replacement to maintain process effectiveness.

3. Ozonation

How does it work	• Bubbling through water of ozone gas produced on-site by using air and UV-light systems or electric discharges.
Recommended use	• Microbial disinfection of untreated or pre-filtered water.
Advantages	• Improves the overall quality of water. • Good disinfectant for removal of bacteria, protozoa and viruses

	(better for virus inactivation than UV-light). • Improves the taste and smell of water. • Reduces concentration of unwanted and possibly toxic organic compounds.
Shortcomings	• No residual disinfectant left in the water to avoid bacterial re-growth in the distribution system.
Special considerations	• Ozonation results in large quantities of available organic matter that can lead to bacterial re-growth after treatment. Solution: filtration using active carbon filters necessary immediately after ozonator. • Ozonation can lead to the formation of toxic bromate when bromide is present in water. Solution: Increase the amount of ammonia in water before ozonation or increase acidity (lower the pH). OR Use a different treatment system.

4. Filtration and Flocculation

Treatment equipment	• Filtration pre-treatment. • Active carbon filtration. • Reverse osmosis. • Flocculation (used to remove fine material in suspension).
Recommended use	• Pre-treatment filtration and flocculation clarifies water and enhances the effectiveness of disinfection. • Post-treatment filtration removes unwanted organic compounds (e.g., after ozonation).

Advantages

- Increases the efficiency of disinfection.
- Reduces the amount of by-products during chlorination.
- Reduces the risk of microbial re-growth after ozonation.
- Eliminates unwanted chemical contaminants (reverse osmosis and active carbon filters).

Shortcomings

- Needs to be used in conjunction with a disinfection system.
- Filter life is limited; need to be changed at intervals depending on the quality of the incoming water.
- Adequate flocculation difficult to achieve routinely especially at low temperatures.

Special considerations

- Active carbon filters cannot be used before disinfection as they favour bacterial growth.

5. Hydrogen Peroxide (H_20_2)

How does it work

- Hydrogen peroxide is injected directly into the water stream. Commercial formulations used for disinfection are mixed with low level of acids that may act as stabilizers (i.e., acetic acid).
- Presence of acetic acid will allow formation of some levels of peracetic acid which is a far better disinfectant.

Recommended use

- Plain hydrogen peroxide is a weak disinfectant - to be used as disinfectant only for process waters (not drinking water).
- In combination with ozonation or UV-light treatment it can eliminate most water contaminants.
- However, no regulatory agency in

	U.S. or Canada recommends it for disinfection of drinking water.
Advantages	• Can be used to remove a series of organic contaminants from various sources (e.g., oils, humic compounds, phenols, pesticides) and microorganisms or various types. It can also remove odours and smells. • Breaks down to water and oxygen without toxic by-products.
Shortcomings	• Hydrogen peroxide by itself may not be able to effectively disinfect waters at low contact times; needs to be mixed with reaction enhancing solutions or powders (catalysts) at the point of use or acetic acid may be added in the formulation. • The concentration and formulation of hydrogen peroxide compounds vary. The quality of incoming water can affect the rate of formation of peracetic acid and therefore may affect efficiency of disinfection. • Hydrogen peroxide may decompose in storage and thus affect its efficiency (commercial formulations contain stabilizers such as acids, that slow down decomposition).
Special considerations	• Corrosivity of hydrogen peroxide is usually lower than that of brine. However, hydrogen peroxide is very corrosive if it comes in contact with iron (from the water or piping systems). Solution: Use only in stainless or coated containers. • Concentrated hydrogen peroxide (as found in the commercial formulations) is very corrosive. This problem is

amplified when peracetic acid is present. **Handle with care.**
- When used for drinking water, overdosage of hydrogen peroxide may impact health.

Note that other treatment options are also available on the market. However they need to be tested for your specific conditions and proven that they work before they can be safely employed.