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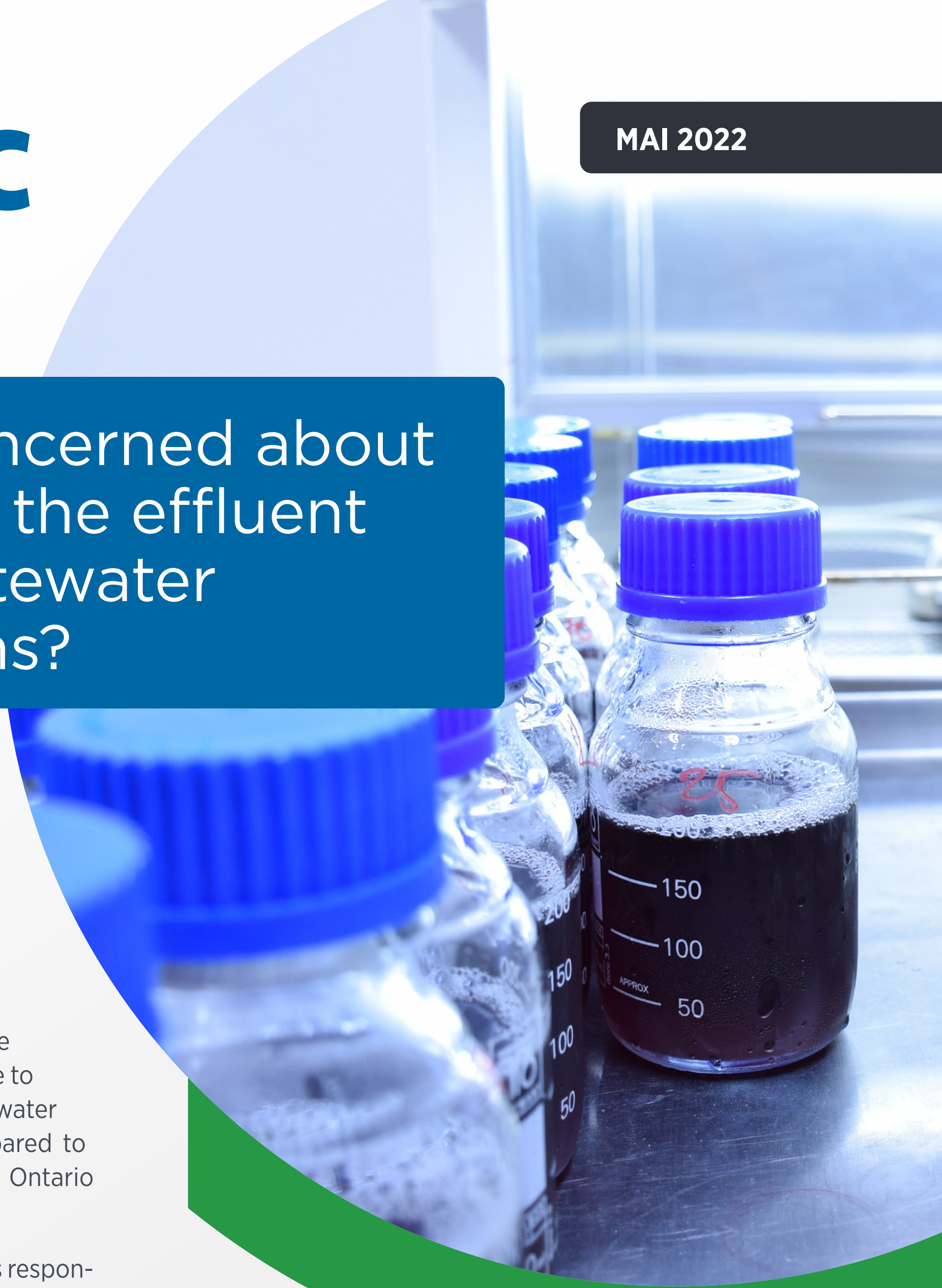
Should we be concerned about fecal coliforms in the effluent from on-site wastewater treatment systems?



According to statistics, 86% of the population is served by municipal wastewater systems in Canada. This rate has remained stable over the past few years. Of the remaining 14%, about 12% had their own on-site wastewater treatment system and about 2% were served by systems that discharge untreated wastewater (Environment and Climate Change Canada, 2020). These indicators vary from province to province, with 46% unrelated to municipal wastewater treatment systems in Prince Edward Island compared to 10% in British Columbia, and approximately 11% in Ontario and in Quebec (*ibid.*).

These statistics provide arguments to organizations responsible for river basin management and other environmental groups to accuse owners of on-site wastewater treatment systems of contaminating waterways. Particularly, we often talk about high levels of fecal coliforms in the lakes and rivers due to the presence of non-compliant septic systems. Should we be concerned about fecal coliforms in the effluent from such systems? Let's talk about it.

WHAT IS A FECAL COLIFORM?

From a scientific point of view, fecal coliforms, also called thermotolerant, are a subgroup of total coliforms capable of fermenting lactose at a temperature of 44.5°C. The species most frequently associated with thermotolerant coliforms is *Escherichia coli* (*E. coli*) and, to a lesser extent, certain species of the genera *Citrobacter*, *Enterobacter* and *Klebsiella* (INSPQ, 2003). In turn, total coliforms are enterobacteriaceae that include bacterial species that live in the gut of warm-blooded animals. They are rod-shaped, aerobic or facultative anaerobic bacteria possessing the enzyme ß-galactosidase, which releases a chromogenic agent used in culture medium to identify them (INSPQ, 2017a). They are also frequently found in the environment, for example in soil or vegetation (Verhille, 2013).

It may seem surprising, but many fecal coliforms are not really of fecal origin. Yes, they are naturally present in the human or animal intestinal tract, but survive and multiply equally well in soil, water and on plants. They are also common in foods. These bacteria sometimes also come from water enriched with organic matter, such as industrial effluents from the pulp and paper industry or food processing. For this reason, the generic term "thermotolerant coliforms" is gradually replacing that of fecal coliforms (INSPQ, 2003; Verhille, 2013).

On the other hand, *E. coli* is certainly of human or animal fecal origin, because it does not exist in the natural environment. It can, however, survive for a few months in water, soil or on plants, although it rarely multiplies in these environments (INSPQ, 2017b). The *E. coli* bacteria represent 80 to 90% of the thermotolerant coliforms detected (INSPQ, 2003). And this is not surprising, since it makes up about 80% of our aerobic gut microbiota.

Only certain strains of thermotolerant coliforms can cause illness and only under certain conditions, leading to gastroenteritis, urinary tract infections, meningitis or sepsis (Rogers et al., 2016, Verhille, 2013, Kus, 2014; Chart, 2012). The most dangerous strain is probably *E. coli* O157:H7 that is responsible for several pathologies, including ulcerative colitis, hemolytic-uremic syndrome (sometimes called hamburger disease) and others.

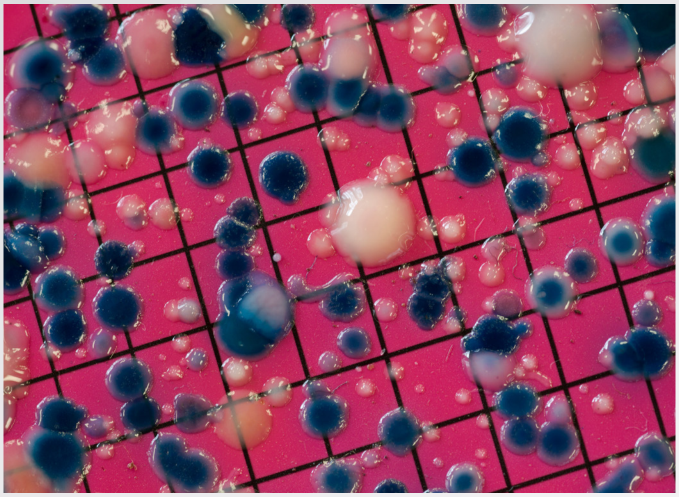
You probably remember that romaine lettuce, spinach and salad are regularly the subject of warnings by the Public Health Agency of Canada and by U.S. health officials because of outbreaks of *E. coli* bacteria, in particular the *Escherichia coli O157:H7* serotype. This same strain is responsible for food poisoning transmitted by ground meat.

INTEREST OF DETECTING

For the fecal coliform indicator, Quebec laboratories usually use the membrane filtration (FM) technique on m-FC agar medium. The APHA 9222 D standard for this method is described by the American Public Health Association.

The unit of measurement for these indicators is the number of colony forming units per 100 milliliters (CFU/100 ml).

Systematic screening for all these pathogenic microorganisms would be difficult, if not impracticable (significant cost and time). **The interest of detecting fecal coliforms in wastewater, as indicator organisms, lies in the fact that their survival in the environment is generally equivalent to that of pathogenic bacteria and that their density is generally proportional to the degree of pollution produced by fecal matter.**



Escherichia coli colonies isolated in the Petri dish

The detection of *E. coli*, used as the indicator for drinking water, is however incontestable proof of the occurrence of **recent** fecal contamination and indicates the **potential** presence of enteric pathogens. Therefore, the maximum acceptable concentration of *E. coli* in drinking water has been established as "no detectable microorganisms per 100 ml volume" (Health Canada, 2020a).

The fecal coliform indicator is no longer used for the quality of drinking water, because it lacks specificity (Verhille, 2013). In contrast, total coliforms are used as a tool to determine the effectiveness of the water treatment system and to indicate changes in water quality in the distribution system. So, it is an **operational indicator** (Health Canada, 2020b). The presence of total coliforms indicates a serious failure in the treatment or infiltration of surface water into the distribution network.

And it is relevant to point out that the absence of detection of *E. coli* in the water does not guarantee 100% good sanitary quality of the water, because this bacterium and other coliforms are generally more sensitive to disinfection than more chlorine-resistant pathogens such as viruses and protozoa parasites such as *Cryptosporidium* (Verhille, 2013; Health Canada, 2020a).

WASTEWATER FROM ISOLATED DWELLINGS

In the domestic wastewater, 10^6-10^{10} CFU/100ml are detected, depending on the sources.

In Canada, the standards most often encountered are CAN/BNQ 3680-600, NQ 3680-910 and NSF/ANSI 40. In these standards, there are two important disinfection thresholds: 50,000 CFU/100 ml for a treatment referred to as basic (attributed for example to advanced secondary treatment in Quebec) and 200 CFU/100 ml for disinfection.

To make these disinfection thresholds more understandable, let's do a little comparison that is not at all obvious. For example, in Canada, bacteriological water quality criteria for bathing are also based on fecal coliforms. In fresh water, a water quality criterion for fecal coliforms of 200 CFU/100 ml is adopted for the protection of activities in direct contact with water, such as swimming, water skiing and windsurfing. In addition, a criterion of 1,000 CFU/100 ml has been adopted for the protection of so-called indirect water contact activities such as sport fishing, sailing and boating (Health Canada, 2012; MELCC, 2022b). So, if we relied on this indicator alone, the effluents from tertiary treatment systems with disinfection are quite acceptable for bathing.

To compare, here are the results of the annual sampling campaigns carried out by the BNQ since 2014, in Quebec, on our actual systems. On a sample size of 75 installations, the System O)) in advanced secondary treatment met the performances shown in the table below. Remember that this type of system must reach < 50,000 CFU/100 ml.

Fecal coliforms in effluent (CFU/100 ml)	Frequency
Between 10 and 200	24 %
< 10	53 %

Table 1. System O)) effluent results in AST since 2014

These sampling campaigns on real systems therefore demonstrate that the System O)) advanced secondary treatment systems ensure a degree of **passive disinfection** - without mechanical or electrical means such as a UV lamp - which is often superior to the requirements of the regulations and the standard to which it is subject.

OTHER SOURCES OF CONTAMINATION

The image that we retain of modern agriculture is the spreading of fertilizing organic matter in large quantities. Using different techniques, manure and farm slurry (liquid manure) are dispersed on the surface or incorporated into the soil. These materials, although necessary to maintain soil quality, are obviously a source of contamination of surface and groundwater. Traditional agriculture, characterized by small herds scattered across the territory, had relatively little impact on water quality. Modern intensive agriculture, on the other hand, tends to concentrate livestock farming, particularly for pig production, which accentuates the problems of agricultural pollution (MELCC, 2022a; OMAFRA, 2008).

In general, process water effluents, runoff or leaching from the agri-food industry, in particular slaughterhouses and dairies, pulp and paper mills and landfill sites contribute, among other things, to fecal coliform intake in waterways and other bodies of water (MELCC, 2020).

And, speaking of municipal sewage treatment plants, it is easy to see that they are another major source of contamination. For example, in Quebec, 60% of treated municipal wastewater is discharged without disinfection. In addition, combined or combined sewer overflows occur frequently, thus channeling stormwater contaminated with untreated wastewater into nature (MDDEFP, 2013). It is estimated that across Canada, 4.4% of the volume of municipal wastewater discharged has not been treated (MELCC, 2022a, Environment and Climate Change Canada, 2020).

CONCLUSION

Overall, fecal coliforms are used as an indicator of the **performance** of the wastewater treatment system. All this with a view to preventing pollution at the source and in the multi-barrier approach to reduce the **probability** of contamination of the environment, drinking water and to reduce the dangers for other uses. Thus, our answer to the question “Should we be concerned about fecal coliforms in the effluent from on-site wastewater treatment systems” will obviously be Yes. But it is inconsistent to suggest that the onus lies solely on onsite wastewater treatment systems for isolated dwellings.

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