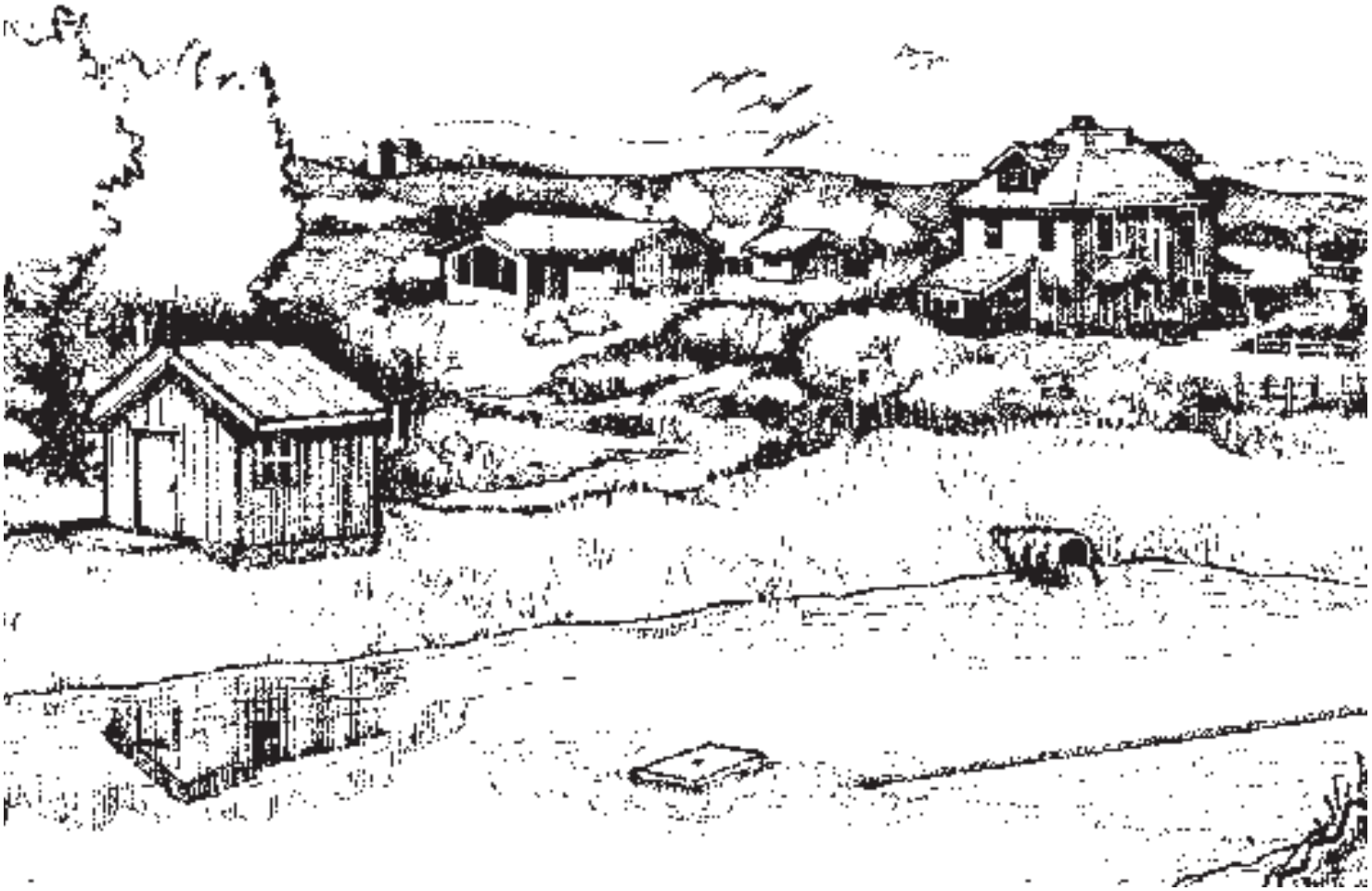
Water Quality for Domestic and Human Drinking Water Supplies



Domestic and drinking water supplies have higher quality requirements than most other uses. Water that appears to be acceptable based on visual appearance, taste, odour, and colour may contain contaminants that affect human health. Risks can be chemical or microbiological. It should be remembered that water that has been successfully treated for human consumption might become re-contaminated and present real health risks. Re-contamination sometimes occurs in the distribution system.

On the other hand, water that is otherwise harmless may have such objectionable appearance, taste, and odour that it is unacceptable for household use.

Health Risks and Water Quality

On first appearance, water would appear to be a relatively simple liquid. It is, however, a powerful solvent that is capable of containing a very complex mixture of chemical substances. Water also provides a suitable medium in which a diverse range of microbiological organisms can exist. The presence of various chemical constituents and microscopic organisms in water may impact upon human health.

Microbiological Factors

Waterborne microbiological diseases are caused by bacteria, protozoa, and viruses.

There are three major groups of microbiological organisms that cause waterborne diseases:

- bacteria
- protozoa
- viruses.

Examples of each of these three groups of pathogenic organisms are given in Appendix 2, Water Quality Guide in Table 1, Causes and Symptoms of Some Waterborne Diseases, page 125, along with the symptoms of the resulting disease. All of the symptoms listed for a particular disease are not always observed. It should also be noted that this list is not exhaustive but contains examples of microscopic organisms that have been linked with waterborne diseases in the past.

In many cases, the association of a disease outbreak with exposure to contaminated water is not recognized. Many of the symptoms that are exhibited in some of these diseases are attributed to other factors such as the “flu” or food poisoning. As such, many cases related to waterborne disease are

never reported to health officials and therefore available statistical data are understated. The number of people contracting diseases from the consumption of contaminated drinking water is conservatively estimated to be between 900,000 and 3,000,000 each year in the United States.

In Canada, notifiable disease statistics are the responsibility of each province and considerable variation exists in the manner and completeness with which this information is collected. Consequently, the number of individuals affected by waterborne diseases is not known in Canada. If one assumes a similar rate of occurrence for waterborne diseases in Canada, between 90,000 and 300,000 Canadians may be affected annually by water contaminated with microbiological organisms.

In many cases where disease outbreaks have been linked to drinking water, the cause is never determined. In the U.S. from 1991 to 1998, the identity of the agent causing waterborne disease outbreaks was not determined in 40 per cent of these cases.

Bacteria

Most bacteria found in water do not cause diseases in humans. Types of bacteria that do cause disease are found in the intestinal tract of warm-blooded mammals, including humans. These bacteria are excreted in waste matter and may be carried into water supplies.

Seepage from septic tanks and sewage lagoons, plus runoff from livestock feedlots, pastures, and cropland to which manure has been applied may contain bacterial contaminants. Similarly, fecal matter may also be introduced from rodents, birds, and other wildlife. Surface water supplies are therefore highly susceptible to bacterial contamination.

Once bacteria have entered a water supply, they may continue to reproduce, thereby maintaining or even increasing the degree of contamination. Surface water supplies that are largely immobile, like dugouts, provide an excellent breeding ground for bacteria.

Floodwater usually contains high levels of bacteria.

Protozoa

Protozoa are a group of microscopic parasites that are frequently present in surface waters. Some protozoa, notably giardia and cryptosporidia, exist in the form of cysts. The protective covering of the cyst permits the parasite to survive in harsh environmental conditions. The cyst also protects the parasite against disinfectants such as chlorine. Once ingested, the parasite germinates and reproduces. Encysted parasites may subsequently be evacuated from the animal or human host through the feces.

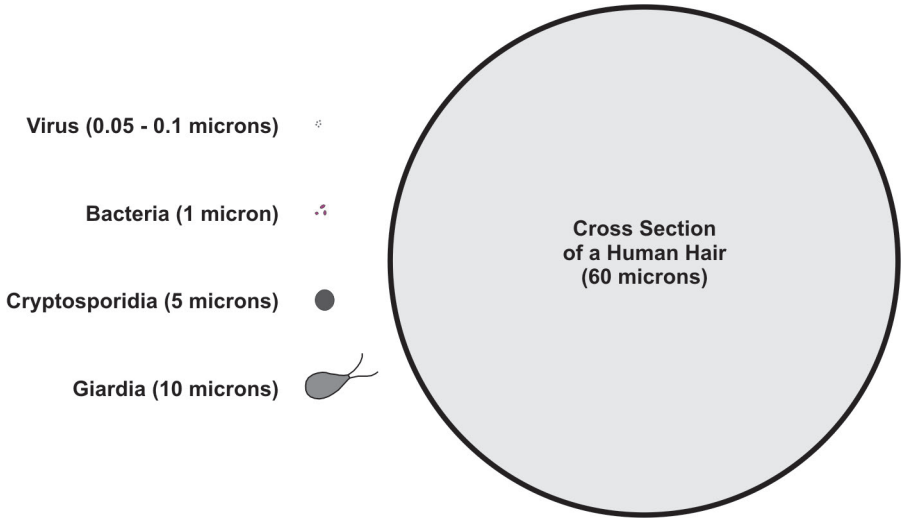
Cryptosporidia and giardia have been suggested as the causative agent in approximately 60 per cent of reported waterborne disease outbreaks in the U.S. between 1991 to 1998. Giardia are found in feces from humans, beavers, muskrats, and dogs. Cryptosporidia have been found mainly in fecal matter from cattle, sheep, and pigs. However, they have also been detected in the feces of humans and other mammals. Contamination of water supplies occurs when fecal matter containing the parasites is deposited or washed into the water.

Viruses

Relatively little is known regarding the incidence of diseases resulting from waterborne viruses. However, a number of different waterborne viral agents have been found in contaminated water supplies and linked to disease including hepatitis A, rotavirus, Norwalk agent, over 30 types of adenoviruses, and over 70 types of enteroviruses.

Figure 6-1 Relative Sizes of Pathogenic Organisms illustrates why pathogenic organisms are not visible to the human eye.

Figure 6-1 Relative Sizes of Pathogenic Organisms



Chemical Factors

There are a number of chemicals that can pose a human health risk. In some cases, these materials are naturally present in water through weathering and erosion. In other cases, human activities result in the introduction of these chemicals into water.

Chemicals that potentially have an adverse effect upon human health include naturally occurring minerals, metals, and toxins as well as a variety of synthetic, organic chemicals including many different types of pesticides. A list of the various chemicals, their source, and their adverse health effects are listed in Appendix 2, Water Quality Guide, in Table 2, Chemicals and Their Associated Risk to Human Health, page 126.

Contact your regional health authority to obtain contact information for water-testing laboratories.

If you suspect that your water contains elevated levels of naturally occurring chemicals, or if you believe that your water has become contaminated, specific tests may be performed in a laboratory. There are numerous laboratories with a diverse range of analytical testing capabilities located in each province.

Aesthetics and Water Quality

Numerous chemical compounds and microbiological species affect the aesthetic quality of water. Certain compounds and species impart an objectionable taste or odour to water while others may cause staining or leave behind a residue or solid precipitate. These chemical agents and microbiological species are generally regarded as nuisances that typically do not pose a risk to human health. The most commonly encountered nuisance water problems are summarized in Appendix 2, Water Quality Guide, Table 3, Chemical Agents and Microbiological Species Affecting Aesthetic Quality of Water, page 127. The source of the nuisance impurities and organisms are listed along with the symptoms typically observed as a result of their presence in water. The presence of these impurities and organisms can be confirmed by laboratory tests. Once their presence has been determined, appropriate steps may be taken to eliminate or minimize the associated problems.

Standard Testing of Drinking Water

*"**The Rural Water Quality Information Tool**" provides an abundance of information on water quality, water sampling, and testing. The tool allows you to input your own water test results, and it then provides a detailed interpretation of the test results.*

The tool can be found on the Alberta Agriculture and Forestry website located at:

http://www.agric.gov.ab.ca

Click on the search Button and then in the search box type in

*"**Rural Water Quality Information Tool**".*

Regular testing of water is necessary to monitor the effectiveness of a treatment system. From the point of view of health and safety, microbiological testing of water is of prime importance.

Figure 6-2 Saskatchewan Health Provincial Lab

Testing for Coliforms

Coliform bacteria are commonly found in the environment. While most of these organisms are not harmful, their presence is an indicator that other harmful or pathogenic microorganisms may be present. An assumption is made that if coliform bacteria are absent, then pathogenic bacteria are also probably absent. If coliform bacteria are present, pathogenic organisms may also be present and caution needs to be exercised due to the risk to human health. Therefore, in public water supplies, the presence of coliform bacteria indicates a problem with the water treatment system. It could also indicate inadequate disinfection within the distribution system, or a break in the water pipes. Similarly, the presence of coliform bacteria in private water supplies may be indicative of a contaminated water source or a faulty treatment system.

Most water-testing laboratories in Canada, and for that matter many other countries, perform what is known as the analysis for total coliforms. This test is used to indicate the presence of a diverse group of bacterial organisms. In some test procedures, an estimation of the quantity of bacteria present is determined, and listed as the number of colony forming units per millilitre of water tested. However, other tests simply indicate the presence or absence of coliform bacteria.

If a water sample is found to contain coliform bacteria, the next step is to determine whether any of these bacteria are due to fecal contamination. This is generally done by testing the water for fecal coliforms or specifically for *E. coli*. The presence of fecal coliforms or *E. coli* indicates that the water is contaminated by either human or animal waste. Microorganisms from these wastes can cause diseases.

It must be emphasized that if a water sample is positive for total coliforms but does not contain fecal coliforms or *E. coli*, the sanitary quality of this water is still considered unacceptable. If coliform bacteria can survive, there is the potential for pathogenic microorganisms to exist in the future.

Suspended particles or cloudiness in water is a potential indicator of water contamination and may indicate problems with treatment processes. Highly turbid water also reduces the efficiency of disinfection processes such as chlorination and UV treatment. The amount of suspended particles or cloudiness may be measured as a turbidity test. Municipal and community water supplies typically monitor turbidity on a routine or continuing basis.

In 1989, the Mistahia Health Unit, formerly South Peace Health Unit, located in Grande Prairie, Alberta conducted a survey of bacteria levels found in local farm dugouts. Health Unit staff reviewed the results of bacteriological analysis conducted on raw (untreated) dugout water samples from the 1960s to 1989.

Bacteria Found	Samples Containing Bacteria
Total coliform	31.5%
Fecal coliform	23.7%
Total bacteria population (>500)	1.2%
Confluent growth (unidentified bacteria)	1.7%
Meets Canadian Drinking Water Guidelines (1989)	41.9%
Total water samples tested	578
Note: Information provided by Elmer Spilchen, Public Health Inspector, Grande Prairie, Alberta.	

Water testing is done for indicator bacteria rather than a number of individual species.

The survey results indicate that dugouts are at risk of contamination with bacteria, and confirm the need for effective treatment of dugout water to be used for household purposes.

Pitfalls of Standard Water Testing Techniques

If a treated municipal drinking water supply is found free of coliform bacteria, it is generally assumed that the water treatment process is working adequately and that the distribution system is functioning properly. While most pathogenic bacteria and viruses are destroyed by disinfection, some organisms such as cryptosporidia and giardia may not be inactivated. Therefore, an acceptable result for coliform bacteria does not guarantee that all pathogenic organisms have been eliminated. Furthermore, an acceptable result for coliform bacteria on an untreated water supply such as a private well or dugout does not indicate anything regarding the presence or absence of protozoa or viruses.

Non-routine Testing of Drinking Water

While there are many laboratories that have the capability to test for coliform bacteria, total and fecal, as well as *E. coli*, relatively few have the capability to test for specific pathogens such as cryptosporidia, giardia, and various viruses. Many environment and health officials do not recommend routine monitoring of drinking water supplies for cryptosporidia and giardia due to the complex and expensive testing methods and the widespread existence of these protozoans in surface water. Instead of monitoring for protozoans, many agencies have preferred to focus on ensuring that adequate treatment procedures are in place for public and private water supplies and that best management practices are observed in the watershed.

Very few laboratories have the capability to test water routinely for viruses. This is mainly due to the lack of established testing procedures for many viral organisms. A second factor is that most laboratories perform microbiological testing on a very large number of samples. Testing all of these samples for even a small number of viruses would be practically impossible. This type of testing is normally only performed on the drinking water supplies of larger municipalities.

General Testing Recommendations

Test drinking water from a well or dugout at least twice a year, or more if there is a problem.

It is impossible to test a water sample for all known pathogens. It is also very expensive to test for a large number of different pathogens. Many health agencies have designated total coliforms as a standard indicator test to determine the bacteriological safety of drinking water. Test drinking water derived from a privately operated source such as a well or dugout at least twice a year for bacterial safety. More frequent testing may be necessary if contamination is suspected or unexplained illness occurs. If continuing illness is observed, discontinue use of the water until a sample has been tested.