Water—the 21st-century obsession

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Project summary

A farmer noticed his cows' milking rate decrease after the cows drank from a water source contaminated with fecal coliform and *E. coli* bacteria.

Project report

The aim of our project is to understand the issues surrounding the contamination of a stream that affected the health of a herd of cows. We would also like to propose solutions to the problem. The main purpose of our work is to demonstrate the importance of ensuring that this precious natural resource remains fit for consumption.

It was important to identify the variables involved: a family that had lived on a dairy farm for at least 50 years noticed a decrease in their cows' milking rate, resulting in a drop in income of nearly $5000. Apparently, samples taken by two companies revealed the presence of pathogenic *E. coli* bacteria in their drinking water.

A similar situation—the Walkerton tragedy—occurred one year ago, though on a much larger scale. This incident also involved contaminated drinking water. Before we go any further, let's examine the important role that water plays.

The importance of clean drinking water

"In its pure form, water is the source of life. When polluted, it is a vector for disease and death. This seemingly renewable resource that flows from our taps is rare and even non-existent in many parts of the world, especially in poor countries. When it comes to this blue gold, much like black gold, rarity and unfair distribution result in competitiveness, conflict and war. Pollution, waste, drought, floods, epidemics, the risk of war: at the dawn of the 21st century, humanity has to make a choice. It has to make water, and the preservation and sharing of this resource, one of its priorities. Water has to become an obsession."[1] This is how Claude Masson, joint editor of the newspaper *La Presse*, described the importance of water in May 1992. How far have we come ten years later?

[1]This citation is a free translation.

Consider the following statistics. Some people say that we have nothing to worry about when we look at the entire globe, which is covered by approximately 1.36 km^3 of water. But 97 percent is salt water, which is undrinkable. Only the remaining three percent is freshwater. Some of this remaining three percent is trapped in polar ice caps and underground pools, however, leaving only 0.58 percent!

Did you also know that Canadians consume—or rather waste—an average of 350 L of water per person per day. An astounding figure when you consider that the average person consumes 80 L of water per day. Canadians and Americans are the two largest consumers of water worldwide. At the other end of the spectrum, a resident of Madagascar consumes only 4.5 L of water per day!

We also have to wonder about the quality of the water that we consume. Poor water quality is the main cause of death worldwide, killing an average of 4.6 million children in developing countries. Why? Because these countries do not have adequate sanitation facilities and inhabitants drink water containing human or animal fecal matter, which results in disease and death.

Level of water pollution

We examined three series of water samples taken by three different groups: 1) Stantec Experts Conseils, representing the municipality of Montebello; 2) the farmer's association (UPA), representing the Pesant family; 3) our research group. Our samples were taken at the Outaouais Urban Community (OUC). In all three cases, the presence of fecal coliform bacteria was detected, although at different concentrations. This is of little importance, since the standard for drinking water is 0 colony forming units (CFUs) per 100 mL of water. None of the results were in compliance with the standard in this case. Other standards include 200 CFUs per 100 mL for swimming and 1000 CFUs per 100 mL for such activities as fishing, etc.

What is pathogenic bacteria?

The bacteria discussed in our project are fecal coliform and *E. coli* bacteria. Where there is a presence of fecal coliform bacteria, there is usually *E. coli*. Coliform bacteria are members of the Enterobacteriaceae family. These gram-negative, aerobic and facultative anaerobic, non spore-forming, oxidase-negative bacilli are capable of fermenting lactose following a 24-hour incubation period at 44.5°C and producing blue colonies in an m-Fc culture medium. These bacteria are found in the intestines and excrement of warm-blooded animals. If found in water, they are an indicator that the water has been contaminated by excrement and probably other microbes that cause such diseases as typhoid fever and hepatitis, as well as diarrhea.

As for *Escherichia coli*, more commonly known as *E. coli*, although it is found in our intestines and those of healthy animals, it can cause infant gastroenteritis, urinary infections and even death. This is exactly what happened in Walkerton. Negligence on the part of the managers of the public utilities and various other individuals resulted in many people becoming ill and seven others dying from *E. coli* in the tiny municipality's drinking water. The bacteria is also found in raw, contaminated ground beef. It lives in the soil, which explains why it is transmitted through the digestive system, and spreads through the consumption of contaminated foods. The symptoms exhibited by someone who has been contaminated with *E. coli* are diarrhea (sometimes bloody), dehydration and pain.

Considering the potential seriousness of the situation in Montebello—cows contaminated by drinking from a source that leads right into the municipality—it was important to take action and conduct analyses as soon as possible.

Testing

The Pesant family had tests conducted last July and August after realizing that their cows were sick. A representative from the Quebec Department of Agriculture warned them that their cows should no longer drink from this water source, having concluded that it was no longer fit for consumption because of the presence of fecal coliform bacteria, which came from the treatment plant located upstream. After this warning was issued, the Pesant family asked the municipality to provide them with drinking water for their cows while they waited for the problem to be resolved. After conducting his own analysis, the municipal representative—a consultant with the company Stantec Expert Conseils—insisted that the contamination did not come from the treatment plant. The municipality therefore refused to provide the Pesant family with a supply of drinking water. This is why we decided to do our own analyses. Which of the two parties was right: the Pesant family or the municipality?

The municipal testing was conducted on September 24 and 27, 2001, while we conducted our tests only on December 6 and 16. Although no snow had fallen yet, we had to take the cold temperatures into account. This affected our test results. We proceeded as follows. First, we used our own test tubes, which we had to sterilize before use. We placed all the test tubes in our autoclave and boiled them at very high temperatures for one hour. Then, we accompanied a member of the Pesant family to the site to take samples. We took ten samples in very specific areas, using a pole and a safety clamp. Later that day, we visited the OUC. Under Benoît Paquin's supervision, we conducted our analyses using the membrane filter method, which can be summarized as follows: a given volume of water from the sample is filtered through a membrane that has a porosity of 0.45 µm. The membrane is then placed in an m-Fc selective culture medium to incubate for 24 hours at approximately 44.5°C. We used a special product to test the sterility of our test tubes.

We then had to wait until the next day to interpret our results.

Results

The colonies of fecal coliform bacteria were to appear in colours ranging from dark blue to light blue. The count is expressed as the number of coliform bacteria in 100 mL of water.

Our results

Concentration of fecal coliform bacteria per sample

Series no. 1 (taken Dec. 6, 2001)

No. 1	> 2655/100 mL	No. 6	78/100 mL
No. 2	2655/100 mL	No. 7	0
No. 3	0	No. 8	Control
No. 4	control	No. 9	12/100 mL
No. 5	1101/mL	No. 10	72/100 mL

*The controls represent test tube sterilization tests and the 0 indicates only suspended matter.

Series no. 2 (taken Dec. 16, 2001)

No. 11	9/100 mL	No. 16	< 10/100 mL
No. 12	60/100 mL	No. 17	< 10/100 mL
No. 13	< 10/100 mL	No. 18	< 10/100 mL
No. 14	10/100 mL	No. 19	10/100 mL
No. 15	< 10/100 mL	No. 20	150/100 mL

Analysis

Before analyzing our results, we considered the following three hypotheses: 1) the fecal coliform bacteria were the result of a leak at the treatment plant; 2) the cows had contaminated themselves, aided by other factors; 3) some other external factor, such as manure spreading, was responsible. We then used the process of elimination.
The hypothesis regarding external factors such as manure spreading (bio-solids)* was impossible, since the information provided by the municipality indicated that this type of activity had never occurred.

The second hypothesis that the fecal coliform bacteria came from a leak in the storage tanks was also impossible. The bottom of the tanks are lined with 200 mm of sand, the sides are lined with a Texel-type geotextile membrane and the top is covered with 56 mm of crushed stone. The core of the dike is made of compacted earth free from topsoil and large rocks over more than 100 mm. There are also layers of concrete and other erosion-resistant materials beneath the tanks. It is therefore improbable that a leak from the storage tanks could have contaminated the stream.

Our final hypothesis was that the cows had contaminated themselves. Employees hired by the municipality to dig up the earth for the storage tanks broke the drain pipes running below the Pesant family's land. The pipes should therefore have been stopped with soil. When we visited, however, we noticed that water continued to pass through the drains. Cows deposit their manure on the land and, according to our resources, the soil is composed mainly of clay. This prevents water from penetrating the soil, causing it to remain at the surface. By examining the contour lines on a topographical map of the area, we noticed that the manure could have been washed into the stream that the cows

drank from, which would explain how the cows had became contaminated with fecal coliform bacteria.

Sources of error

The time of the year at which we conducted our tests is the most probable source of error. Since it was December, the temperatures had fallen and the concentration of fecal coliform bacteria had decreased since the test performed in July. The short period of time allocated for our research was another factor that greatly affected our results, since we were unable to do an in-depth study of the situation. The amount of precipitation during the summer of 2001 was also a factor.

Solutions

Our research points to a single cause: the water passing through the broken drain pipes and emptying directly into the stream. One possible solution would be to redirect the water and filter it through some sand or other porous material. The resulting organic decomposition would decontaminate the water. A more costly alternative would be to decontaminate the surface water using a miniature treatment plant for farmers.

Conclusion

Our project helped us better understand a problem that affects all of humanity: the preservation of our drinking water. Although our project had a limited scope, it could have more global applications as far as raising awareness of the importance of managing this precious resource is concerned.

***Bio-solids: DEPOSITS FROM WASTEWATER TREATMENT PLANTS (ORGANIC MATTER).**