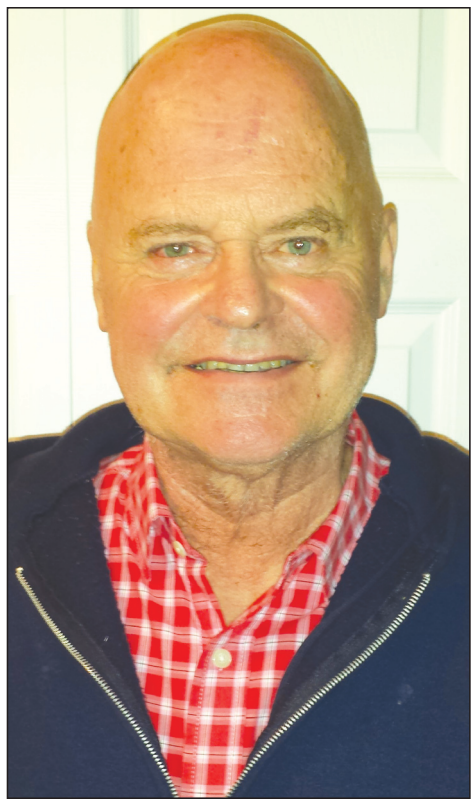
First Nations Deserve Safe and Good Tasting Tap Water



Dr. Hans Peterson

PHOTO COURTESY OF HANS PETERSON

By Dr. Hans Peterson

Background

For decades the federal government has constructed water treatment plants according to the Low Cost Rule. This has resulted in poor quality engineering, poor quality workmanship, poor quality equipment, and poor quality treated water. Across Canada. More than 90% of Canada's First Nations' water treatment plants cannot meet the full complement of the Guidelines for Canadian Drinking Water Quality. Clearly, safe and good tasting water has not been achieved. As long as the Low Cost Rule is the rule that is followed Canada's First Nations are bound to just get more of the same. Bad tasting and unsafe tap water.

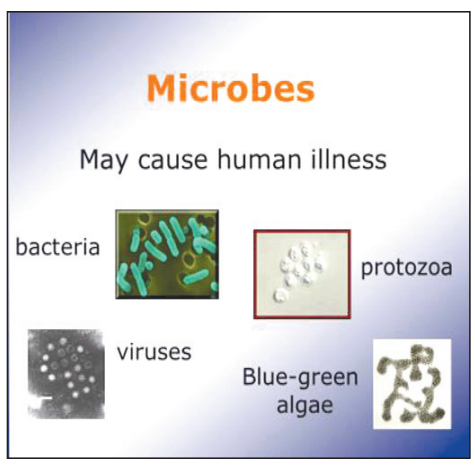
I started to write articles in the PAGC Tribune in May 2015. I have tried to cover important aspects of drinking water quality in First Nations communities. I have told you about the 13 different and difficult problems that need to be resolved that we have found in Saskatchewan groundwater sources. Similar to this there are at least 10 problems in surface water sources such as from lakes and rivers. But, there is more – much more. You are sitting down for a meal with your family and what do many people drink? Tap water. It is a healthy drink, or is it not? In most cities in Canada we really don't need to worry about drinking water safety. High quality raw water is treated with chemicals and the tap water quality is generally pretty good.

Water Quality outside of Canada

But, if you venture outside of Canada you may start to doubt the quality of the tap water. I just got an email from a friend of mine who is currently visiting the capital of Uganda, Kampala. Here is what he writes: "In Kampala it is not recommended to drink the water from the tap although they have a massive water source, Lake Victoria. But, still it seems what comes at the tap is not so good." In many places around the world not even large cities can say that their water is consistently safe to drink.

Microbes in water

This is really not about if the water tastes okay; it is more about, "Are you going to get sick if you drink the water?" In taking a trip to Mexico you may fret about drinking water safety. It is not an insignificant question and I want you to consider a few facts. I will talk about microbes and with that I mean viruses, bacteria, protozoan parasites and cyanobacteria. The last name you may know more as blue-green algae, but they are actually bacteria and the current name is cyanobacteria.



Two Types of bacteria

We have millions of bacteria in the human body and they are "friendly" except on the odd occasion when a different type of bacteria invades our bodies. These bacteria can cause disease so they are called disease-causing bacteria or pathogenic bacteria. There are two major problems with bacteria: 1) Pathogenic bacteria can cause diseases, and 2) many bacteria including ones that don't cause disease can produce organic compounds that are released into water. Combinations of bacteria and dissolved compounds released into the water are the most likely culprits of skin rashes and other skin irritations.

Conventional water treatment

Conventional water treatment processes can vary quite a bit, but they all have one thing in common: Chemicals are added at the front of the water treatment process. They employ filtration processes based on a granular material (which can be sand, manganese greensand, granular activated carbon, and many others) and they *cannot* filter out most microbes. Microbes will flow through these granular filters and end up in the treated water unless they can be trapped somehow. Coagulation can trap them and get them to clump together after which the granular filter will be able to remove at least *some* of them.

The "trapping" processes, however, can also damage the cell integrity of microbes and what is inside the microbes (this is the cytoplasm, in a way the blood inside a microbe) will come out into the water. Some of these compounds are dissolved and will move through most filters although some, such as granular or powdered activated carbon, may successfully absorb some of these organic compounds.

In contrast in the IBROM process we treat bacteria with "kids' gloves," we put the bacteria on life support (oxygen) and we do not use any chemicals. This amounts to "happy" bacteria that are only concerned with purifying the water.

Chlorination of Drinking Water

In the conventional water treatment process the water contains dissolved organic material, bacteria, viruses and at times protozoan parasites. Before the water reaches the treated water reservoirs the water is chlorinated. Microbes that have come as far as the chlorination process will likely die, and release their "innards (cytoplasm)" into the water. In typical conventional water treatment *ten times more chlorine* is required than in the IBROM process (I have written about the IBROM process in previous articles in the Tribune). So, in conventional treatment, a lot of chlorine is added. What do we get at the consumer's tap from conventional water treatment? We get dead microbes, chlorinated organics, and a high level of total chlorine. The key in chlorination is to get a free chlorine level of 0.20 mg/L (Health Canada requirement). If you just add low levels of chlorine you will not reach this level of free chlorine.

Contrast this to the IBROM process, there are no microbes, no organics, no chlorine-consuming inorganics (like ammonium) and we only use 0.30 mg/L of chlorine, which will result in more than 0.20 mg/L of chlorine anywhere in the distribution system.

The Bad Water of Neskantaga First Nation

During the federal election campaign the plight of the Neskantaga First Nation, in northern Ontario, was again raised. Chief Peter Moonias told CBC News that a water treatment plant was built in Neskantaga in 1993, but there were problems almost immediately. Chief Moonias continued that the majority of children in Neskantaga have sores on their bodies, such as in the photo provided. The "new" water treatment plant failed to produce proper drinking water since around 1994. That was 21 years ago and the water treatment plant has still not been fixed. What to do? I will address this question a bit later on.

But, it does raise the question of the lowest bid yet again to win the construction contract. Canada's First Nations have been plagued by this policy as it has been leading our country towards the ultimate low in water treatment. Indigenous and Northern Affairs Canada needs to stop acting as a straight banker where the only thing that counts is the lowest bid. The lowest bid is resulting in poorly constructed water treatment plants that produce bad tap water. Water being so bad that it results in sores on community members' bodies is not even expected in a Third World city and country like Kampala, Uganda, even if the water is undrinkable there. If INAC has a fiduciary responsibility toward First Nations it cannot discharge all its responsibilities simply by looking at only the lowest bid. What good is a water treatment plant if the product coming out of it is toxic?

The Plight of Yellow Quill First Nation

When I first went to Yellow Quill the concerns of Carla Plotnikoff, environmental health officer with the Saskatoon Tribal Council were all about potential diseases caused by the tap water in this community. This included skin rashes that were quite common.

Yellow Quill Councillor Verna Cachene thinking about what changed at Yellow Quill with the new IBROM system put it like this: "Skin rashes, which were so common at Yellow Quill, disappeared when the new IBROM treatment plant was taken into service. I am certain there were other health benefits in individuals which were not as apparent as a direct result of clean drinking water."

Skin Problems and Bad Quality Tap Water

When the quality of the tap water is really bad a community may be under a boil water advisory as even adding chlorine to the water cannot kill E. coli and coliform bacteria. This is a really bad sign because both E. coli and total coliform bacteria are usually killed long before other disease-causing viruses, such as Hepatitis A, bacteria such as Campylobacter, and protozoan parasites such as Cryptosporidium, are killed. If a community has raised its chlorine levels and coliform bacteria persist you know that you have major problems in your water. It could be a host of different things, but most likely you will have high dissolved organic carbon (DOC) levels. DOC interferes with chlorination as chlorine reacts with the DOC instead of killing microbes. The only likely solution is that a new and better water treatment process is urgently required for your community.

Back to Basics

When we look at the magnitude of water quality problems that faced Yellow Quill in 1999 and Neskantaga now in 2015 we've really got to take a step back and say, "How can we find sustainable solutions for communities with such poor raw water sources?"

"This is not as easy as Indigenous Affairs originally thought." This comment is actually a direct quote from a very talented INAC engineer in Ottawa. My question to this engineer was, "Why did Indigenous and Northern Affairs Canada hire you?" When I was in Ottawa one time I had a discussion with a top level civil servant. Like someone in the 21st Century still impressed with a fax machine when we have email and other means of instant communications, he dwelled on the simplicity and virtues of granular filtration (particle filtration) and he thought that this was the path of the future for water treatment in Canada's First Nations [!!Gasp!] I simply had no words for this. This is the road the federal government has taken for decades and this is the road that has got us into the current pickle with few First Nations being able to produce safe and drinkable distributed water. It is the wrong road. But, how can we convince the federal government to get on the right road? I am going to try.

Removal of Particles in Water Treatment

There are three major issues in water treatment: 1) Removing particles (including microbes), 2) removing dissolved organic compounds, and 3) removing dissolved inorganic compounds. I will discuss these processes and evaluate their effectiveness to treat poor quality water sources.

The first issue that I am going to tackle is how to remove particles in a water treatment plant. What we need to know is that when it comes to particles, size matters. Big particles are removed more easily than small particles.

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In the table to the right in the first data line the size of a particle is given in micrometres. There are 1,000 millimetres in one metre. There are 1,000,000 (one million) micrometres in one metre. So, when you look at the table provided, at the top line at the very right you see the number 1,000. That is a thousand micrometres or one millimetre. You can see such a particle with the naked eye. Sand grains of various sizes are around 1,000 micrometres. Then go down to the bottom left where you see "Separation Process." You will notice that Particle Filtration (granular filtration talked about above) will remove sand, some big yeasts, pollen, human hairs and red blood cells (hopefully not present in the water supply). So Particle Filtration removes big stuff that you can see. For particle filtration to remove smaller stuff, the smaller stuff needs to be bunched together to form bigger clumps. In conventional treatment we rely entirely on this to remove protozoan parasites like Cryptosporidium, Giardia, bacteria, and viruses. Without bunching together in bigger clumps *all of these particles will simply go right through the filters.*

These are the wrong kind of filters that the federal government appears to admire and is fixated on. These are the kind of filters that generated the problems in both Neskantaga and Yellow Quill.

We Need Membranes

Most cities in Canada including Calgary, Saskatoon, and Toronto use particle filters and are able to produce pretty decent tap water, because their source waters are already pure. But, what about Saddle Lake, Yellow Quill and Neskantaga? Saddle Lake has 25 times poorer raw water than Calgary.

This brings up an interesting point: What water treatment processes do we need to enable the removal of smaller particles than Particle Filtration can remove? We need membranes. The coarsest membrane is called *microfiltration* and it removes particles to around 0.1 micrometre. Many bacteria are around 1 micrometre and Giardia and Crypto are around 5 micrometres so we remove them by straight filtration using microfiltration membranes. This is good.

Then there is a jump to the next technology, *ultrafiltration*, as it can remove down to 0.01 micrometres. This is better. Now we can certainly remove bacteria and all parasites while we even have some margin to do so.

The next jump is to *nanofiltration* and now we see even more particle removals down to 0.001 micrometres. This is right in virus territory as they can be as small as 0.001 micrometre. The tightest (has the smallest holes that we need to push water through) of all membranes are Reverse Osmosis (RO) membranes. RO membranes can remove even the smallest virus as there are no viruses as small as 0.0001 micrometres! This is best.

At 0.0001 micrometres the holes in an RO membrane are 30,000 times smaller than the width of a human hair. This is what the IBROM process contains – extremely tight RO membranes. So First Nations have a choice to either go with a treatment technology that can remove hairs from the water, or go with a water treatment technology that can remove even the tiniest of viruses. As Homer Stokes, said in the 2000 movie *O Brother, Where are Thou?* 'The choice is clear.'

This has been resolved in the IBROM process. We have IBROM plants that have now run for more than 10 years without having to clean its membranes. This is unheard of globally. And, this is on really poor quality source waters.

Removal of Dissolved Organic Compounds

DOCs can alter the taste, odour, and colour of the treated water. In addition DOCs react with chlorine to form chlorinated organic compounds. Included among many chlorinated compounds are the trihalomethanes (THMs) that both Health Canada and Indigenous Affairs have started to pay attention to lately.

THMs were discovered in the 1970s and rose to prominence in the late 20th century when they were linked as a cause of cancer. However, there are many more chlorinated organics, such as the haloacetic acids (HAAs), and this is followed by a long list of other compounds. In fact, we only know what around 50% of those chlorinated organics are. Would it not be better to just remove all of the organics like the IBROM does? *There are no THMs, HAAs, or any other chlorinated organics in IBROM treated water! None*. Dissolved Organics are below detection.

With no organics to react with there are no chlorinated organics generated. That is why in every IBROM plant we add 0.30 mg/L of free chlorine and it stays the same throughout the distribution system. Free and total are the same. When you get a higher total chlorine than your free you know that the free chlorine has most likely reacted with organic material in the treated water. If there is ammonium in the water then chlorine will react with it as well. In comparison, the City of Saskatoon adds 3.0 mg/L of free chlorine. This is ten times more chlorine than is needed in the IBROM process! Most of Saskatoon's chlorine ends up as total chlorine as they also add ammonium in their final treatment.

Particle filtration, microfiltration, and ultrafiltration cannot directly remove DOC, but needs a trapping mechanism before removal. This is typically the addition of iron- and aluminum-based coagulants. But, there is a hitch with this. DOC in ground water, lakes and rivers can be divided into fat-loving (lipophilic) and water-loving (hydrophilic) compounds. Coagulation can only trap fat-loving compounds. In most water sources fat-loving and water-loving compounds are about equal in quantities.

So, if an engineering company, counting on your ignorance, suggests that advanced coagulation (adding lots of coagulation chemicals) followed by ultrafiltration will remove more than 90% of the DOC in a raw water source you now know that this is impossible. That didn't prevent one engineering company from stating that they could do so. Not even the manufacturer of the ultrafiltration water treatment process made claims like that. But, the engineering company did and the former Indian Affairs, your fiduciary, didn't realize that what the engineering company claimed they could do was, in fact, impossible both in theory and in practice.

After having spent millions of dollars on a full-scale ultrafiltration plant this community had to change its process to something that worked – the IBROM. Even the engineering company's pilot didn't work, which forces me to think that – moving to the present – Indigenous Affairs' technical review abilities are lacking. Why the engineering company, after an unsuccessful pilot with DOC removals around 50%, would recommend this process for full-scale implementation is difficult to understand. But, a full-scale water treatment plant for more than 5,000 people was built. It, like the pilot, removed around 50% of the DOC. The community wanted more than 90% removal. The IBROM removes 100% of the DOC.

Health Canada stopped the high level chemical additions ahead of the ultrafilter because aluminum levels in the distribution system were ten times higher than Health Canada's operational standard for aluminum. In addition, of course, the community had to add 25 times more chlorine to this water than the IBROM process requires. And the chlorine residuals disappeared in the distribution system! Now, with the IBROM, 0.30 mg/L of free chlorine is added and it remains stable in the distribution system. Health Canada is now very happy. I am still expecting a hug though.

The two lone contenders for removing most types of DOC from the water are nanofiltration and reverse osmosis membranes. For Saskatchewan water sources there is a crucial difference between these two membrane types which is discussed in the next section.

Removal of Dissolved Inorganic Compounds

So, what is the crucial difference between nanofiltration and reverse osmosis? To find out, look at the picture above. Dissolved inorganic compounds are the same as salts. Here you will find compounds such as: sodium, chloride, calcium, magnesium, sulphate, arsenic, ammonium, nitrate, and phosphate. Therefore, the crucial difference is that nanofiltration will allow some of these compounds to pass through the filter, but reverse osmosis will not. Even nanofiltration removes calcium and magnesium, the two ions we would like to retain in the water. So, why opt for nanofiltration? We get a higher Total Dissolved Solids (TDS) content, but unfortunately, that TDS is made up of ions like sodium and chloride (table salt) and who wants those ions in their drinking water? Certainly not Health Canada. So, no matter. If you use nano or RO membranes, magnesium and calcium needs to be added after membrane treatment. In the IBROM we run the RO treated water through a magnesium and calcium mineral contactor, which is exactly what the World Health Organization recommends.

First Nations Choice

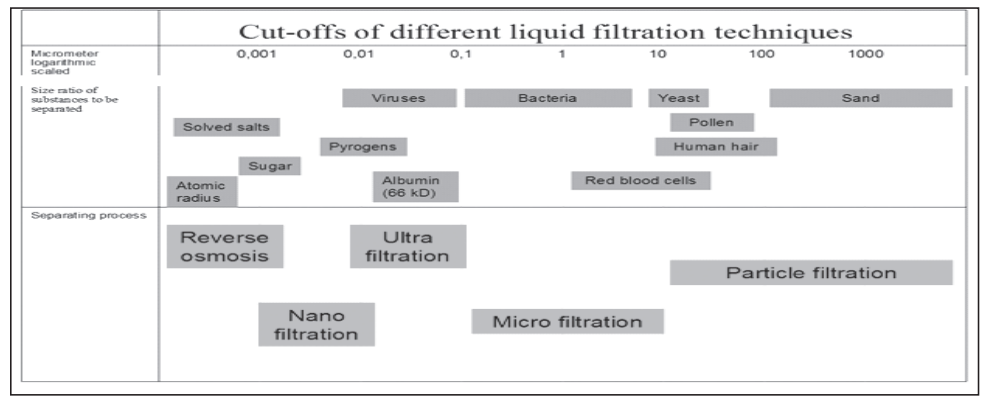
First Nations need to make some choices to get closer to safe and palatable drinking water in their communities.

The first thing that needs to happen is that buying decisions for water treatment plants need to move from Indigenous Affairs and the engineering companies to the First Nations communities. If this doesn't happen we are likely to be faced with the same kind of problems that Yellow Quill and Neskantaga have had – problems that have plagued First Nations across Canada for decades. Continuing with the "status quo" would be insanity. As Albert Einstein said, "Insanity is doing the same thing over and over again and expecting different results." Keeping the status quo is to disregard the needs of community members: safe and good tasting drinking water at every tap.

The second thing a First Nation needs to do is to decide what kind of particles the community's water treatment plant should remove. The choice is straightforward: Hair or disease-causing microbes that could be close to 30,000 times smaller than the width of a human hair.

The third thing that needs to be discussed is how many cancer-causing substances, and what level of chlorine should be allowed in the treated water? For particle (granular) filtration the answer is "lots," and for the IBROM process the answer is no cancer causing substances and very low levels of chlorine. Again, Stokes would have something to say about this.

Some five years ago a principled Saskatchewan engineering company wrote to then Indian Affairs telling them that they were no longer going to entertain doing a water treatment plant retrofit or new construction that could not meet the full complement of the Guidelines for Canadian Drinking Water Quality! Indian Affairs' Jouko Kurkiniemi phoned me and complained about that, "Damn Company X all they want to do is to install IBROM systems." I answered, "Jouko, what is wrong with that?" Nothing wrong and everything right.



Attending the James Smith Cree Nation IBROM water treatment plant Open House on November 19 were, from left: Nelson Burns, Spiritual Advisor; Councillor Brian Head, Peter Chapman Band; John Moostoos, JSCN Land Manager; and JSCN Councillor, Gerald McKay (who is now a board member of Northern Lights Community Development Corporation). *RON MERASTY PHOTO*

The Equality Rule Did Exist

With all the superior metrics that the IBROM process has garnered why would Indigenous Affairs not shout from the rooftops that we have been a part of formulating a solution to First Nations drinking water problems? Well, during the Conservative Party's time in government top level civil servants in the then Aboriginal Affairs and Northern Development Canada (AANDC) lived by an obscure rule that was termed the "Equality Rule." This rule directed top level AANDC civil servants not to construct water treatment plants in First Nations communities that produced better quality tap water than what neighboring non-native communities had. For the IBROM this was guilty as charged. I fully expect that the new Liberal government will find this unacceptable as they are actually interested in improving the quality of life for First Nations, which the previous government was absolutely not. I was in a meeting at AANDC headquarters in Gatineau, Quebec, when the "Equality Rule" was explained to me and an AANDC engineer. The AANDC engineer exclaimed, "That's ridiculous!"

I could not agree more!

A "Treat"ise on Getting Good Drinking Water

By Dr. Hans Peterson

In the last issue, Ron Merasty, writing about the James Smith Cree Nation IBROM water treatment plant "Open House" said that when I was at Yellow Quill that I wanted to be anywhere but there. Let me explain.

In 2002 the Yellow Quill project started out straight forward. I was to do, at the most, a 3-4 month pilot project testing a multitude of different water treatment technologies, conventional and advanced. I never expected to invest 22 months of my life there.

There were difficulties to overcome (and that's putting it mildly). First, none of the conventional technologies produced acceptable quality water and some of the advanced technologies, such as ozone, generated hundreds of millions of particles per liter. Who wants particles in their water?

The only technology that showed some promise was biological filtration, but the power of biological filtration needed to be increased ten-fold to be useful for treating Yellow Quill's groundwater.

Remember, INAC – bearing in mind that these good people are not scientists – had deemed Yellow Quill's groundwater UNTREATABLE. To them it was impossible to make the water drinkable. My mindset at the start was to think of it as "untreatable" as opposed to UNTREATABLE water. What I was aiming for was small, rather than capital letters, "untreatable."

With biological treatment during the first couple of months I managed to get the last E in UNTREATABLe sorted out. Then followed a frustrating time where it seemed I was banging my head against the trailer walls, where I was living, with little progress. What to do? That's when it really hit home to me – nobody had done what we tried to do before. Several experts told me it could not be done.

I wrote to some of the most prominent scientists in the world working on biological treatment. I read scientific journals. My First Nations operators carried out dozens of experiments. Then, bingo! In one fell swoop we got to UNTREATable. Little by little the capitals fell down, as it were, and at some point the water, finally, was only "untreatable."

Now our efforts became focused on getting rid of the "un" to end up with *treatable water.*

Eighteen months later we achieved treatable; 20 months later we reached eminently treatable. Then followed two months of making sure the process could take some hits and still stand (that it was robust, durable). That's when the Integrated Biological and Reverse Osmosis Membrane (IBROM) treatment was born. The IBROM water treatment plant was running well and the nine-year boil water advisory by Indian Affairs was lifted. Twenty-two months later I left my friends at Yellow Quill. I thought I would be happy to leave and get on with my "normal" life and surroundings – my milieu – but, to me Yellow Quill people had now a part of my family, and they still are.

I often think about my time at Yellow Quill and am very happy to see that as of now 17 First Nations communities have embraced the IBROM process. It was, and remains, a labor of love. The promise of safe and affordable tap water is now rapidly becoming a reality in First Nations communities.