WATER R_x

A prescription for keeping our water systems drug-free

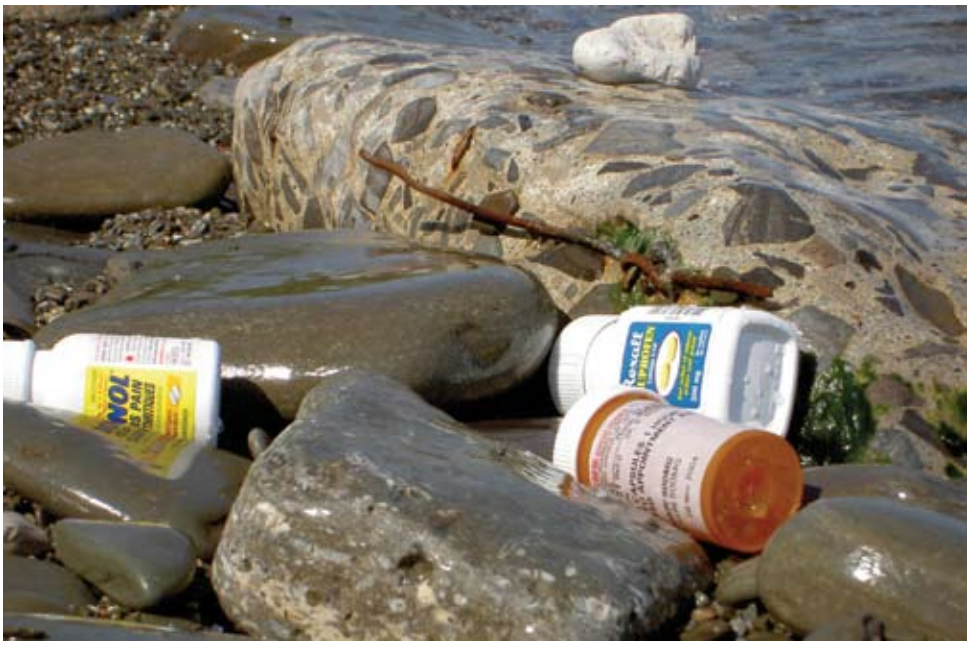
by Zoe Cormier

Dozens of pharmaceutical drugs, from Aspirin to Zoloft, are turning up in Canadian streams, rivers, lakes, and even our tap water. Most people from both academia and industry assure us that we have nothing to fear. But some new research suggests that these compounds might pose a real and ubiquitous threat to our environment, and possibly to ourselves.

When you take any drug, your body absorbs only a small fraction; most of it passes through the body and is excreted in human waste. Drugs that are not taken end up flushed down the toilet or in landfills, from which they eventually leach into the environment. Sooner or later, all 24,000 drug products that are registered for human and veterinary use in Canada, end up in the water.

In 2004, Canadians filed over 382 million prescriptions, worth an estimated $17.3 billion. Most of these drugs are water-soluble and break down in the environment. But a few are more persisent, such as clofibric acid (a form of Clofibrate, a cholesterol lowering drug once widely used in the EU); it is estimated that Europe's North Sea contains about 96 tons of clofibric acid. And here in Canada, pharmaceuticals are even turning up in the massive bodies of the Great Lakes.

Acetylsalicylic acid (found in Aspirin), Ibuprofen (in Advil), Naproxen (an antacid), Bezafibrate and Gemfibrozil (blood lipid regulators), Carbamazepine (an anti-psychotic, also known as Tegratol and Epitol), ethinyl estradiol (the active ingredient in most birth control pills), and Diclofenac (an anti-inflammatory) are some of the most commonly found drugs in the Canadian environment. A handful of those have even been found in tap water (Carbamazepine for example was found in Montreal and Hamilton tap water). Worldwide, close to a hundred different pharmaceutical compounds have been found in surface waters and sixteen different drugs have been found in drinking water.



A bad way to 'enrich' water

Pharmaceutical compounds find a way to leak into your tap water and other water systems—and the water purification safeguards are powerless to stop them. We put fluoride in the water on purpose. Aspirin and Prozac get there on their own.

"The public has always thought of contaminant issues as being related to some chemical plant, that's pouring nasties into the environment, but in this case it's us; we are the source," says Dr. Chris Metcalfe, a Trent University environmental chemist and internationally recognized authority on pharmaceuticals in the environment. Although some of the pharmaceuticals come from runoff from drug manufacturing plants, the vast majority come from us, the consumers.

BE AFRAID?

Every pharmaceutical ingredient thus far detected has been found at levels far below what would be considered toxic. Pharmaceuticals are usually found at the part per trillion level, or lower, equivalent to about one cent in one billion dollars. "However, this issue could become significant as fresh water supplies diminish," says Dr. Christian Daughton, Chief of Environmental Chemistry for the US Environmental Protection Agency.

Dr. Virginia Cunningham, Director of Environment, Health and Safety Product Stewardship for GlaxoSmithKline for 25 years, says that from what she can tell, there

is no immediate danger. "I have not identified [GSK] compounds that I would say pose any significant risk to the environment or to people—however, I say that based on current methodology. So I won't say that there is no risk, but I have not been able to identify any." Nor have scientists at Health Canada or researchers in academia found any evidence yet for a risk to human health.

But just because we don't know about any risks, say many environmentalists and scientists, does not mean that risks aren't necessarily there, especially considering that these molecules have all been designed to have potent, specific biological effects. Many of these environmentalists and scientists are concerned about subtle effects that may result from chronic, long-term exposure. Effects that may be very difficult to detect.

"One of the things that is so interesting and disturbing at the same time is that, when you go to a pharmacist and you get your prescription, you get a long list of things not to take with it," says Dr. Gail Krantzberg, an environmental toxicologist with the International Joint Commission, an independent binational organization that monitors the Great Lakes. "Certain drugs are contraindicative—but the mixture is out there, you're taking it all in... that in my mind is cause for serious concern."

One thing that all the experts agree on: we really do not know yet what the effects of pharmaceuticals are on human health at this point in time.

ANTIBIOTIC RESISTANCE

Although there appears to be no short term risk from the direct consumption of pharmaceuticals in tap water, there may be an immediate, indirect risk posed to human health: antibiotic resistant bacteria. Antimicrobials are found in Canadian and international waters, and evidence is mounting that they can foster the spread of dangerous pathogens in our waterways.

Around the world, levels of resistant bacteria have been increasing steadily for the past few decades. Antibiotic resistance levels for human diseases in Canada can be as high as 40 per cent (such as for E. coli resistance to amphicillin), but in other countries (including the US) the rates can be much higher. According to the Canadian Committee for Antimicrobial Resistance (CCAR), in Taiwan and Hong Kong resistance rates can be as high as 90 per cent for some strains. In general, rates of resistance in most strains of bacteria appear to be increasing at about 2.5 per cent a year.

Antibiotics kill bacteria—but some bacteria are naturally resistant to the drugs, just as some humans are naturally resistant to a few diseases. Sometimes, an antibiotic treatment kills all the normal bacteria, leaving resistant ones behind to spread in their wake.

It is widely recognized by experts around the world that antibiotics are being needlessly prescribed. According to Dr. John Conly, Director for the CCAR, between 50 and 80 per cent of the time that an antibiotic is prescribed, the actual cause of illness is a virus, which cannot be treated with antibiotics.

In addition to this is the substantial use of antibiotics in livestock. On dense factory farms these drugs are given to animals for the treatment and prevention of illness and as 'growth promoters.' It is estimated that in North America about 25 million pounds of antibiotics are given to livestock—but in Canada there is no system for tracking the purchase of veterinary drugs so we have no hard data on livestock use. "But a conservative estimate would be a 100 fold greater use for animals," compared to what is given to our human population, says Conly.

The waste from the 70 million chicken, swine and cattle in Canada is either drained directly away, or is used as fertilizer in agriculture—again, either way, the antibiotics and the pathogens leach into the water eventually (about 75 per cent of antibiotics fed to livestock is excreted).

It is known that resistant microbes from animal feces can spread through the ecosystem through our waterways—in some US rivers, up to 50 per cent of the bacteria were found to be antibiotic resistant.

Now some evidence suggests that antibiotics excreted from the animals are also a problem because they can help maintain the populations of antibiotic resistant bacteria in the water. "I would hypothesize that the answer would be unequivocally yes, but the level of evidence required [to prove this is] difficult," said Conly.

THREAT TO WILDLIFE

Although Cunningham says that her research indicates no "risk to the environment," a number of toxicologists and biologists suspect otherwise.

Antidepressants for example have been the target of a number of studies looking at environmental risks. Fluoxetine (Prozac) has been found in the brains, livers and muscles of fish living downstream from a sewage treatment plant near Dallas, Texas. It is not known yet what effect this has on the fish, or the humans that may consume the fish.

Controlled lab studies have shown that, albeit at concentrations higher than what is found in the environment, common antidepressants such as Luvox, Prozac, and Paxil can induce premature spawning in shellfish; Luvox, in fact, was found to be even more potent than natural serotonin. Although these studies do not necessarily prove any impact seen in the wild, they highlight an important point: we cannot predict how pharmaceuticals tested on and designed for mammals will affect other kinds of life; chemicals work in different ways in different animals. Hence, unless you know what you're looking for, we might already be seeing impacts of pharmaceuticals on the environment and not know it.

But while most research provides only weak support for an environmental threat, one pharmaceutical has been quite strongly implicated as a threat to wildlife (somehow appropriately, the one designed to prevent the creation of unwanted life): ethinyl estradiol.

SOMETHING FISHY IN THE WATER

For more than a decade scientists have found that, in some rivers and for some species, the numbers of male fish have been dwindling, and scores of research point to one answer: hormonal disruptors.

If exposed to enough "female" hormones (like estrogen) early in life, male fish can switch gender and develop into females. If exposed to only small amounts of female hormones, male fish will only partially "feminize" and end up as "intersexuals," with testicles that contain vitellogenin (a protein found in eggs), or even fully developed eggs and ovarian ducts inside the testicles (known as an "ovitestis").

Feminized and intersexual fish were first identified in ponds downstream from sewage treatment plants in England in the early 1990s. Since then, wildlife biologists in that country have found very high numbers of intersexual fish throughout the UK. "In some rivers [such as the Aire river in Northern England], 100 per cent of the male [roach] fish have some degree of feminization," says Dr. John Sumpter, an environmental scientist at Brunel University in London, England. Although not quite as common, feminized fish are also found in Canada, such as in the Great Lakes.

Even though many non-pharmaceuticals, such as PCBs, heavy metals, and pesticides (including the infamous DDT) can mimic estrogen, ethinyl estradiol, a synthetic form of estrogen and the most commonly prescribed oral contraceptive in particular has been the focus of a great deal of research.

Ethinyl estradiol is one of the most potent

What you can do

1. Never flush pharmaceuticals down the drain, return them to your pharmacy. British Columbia, Alberta and PEI all have take-back programs for residents to return unused drugs to pharmacies for proper disposal, free of charge. In 2001, the province of Alberta collected more than 48 metric tons of unused drugs in a province of only 9 million people. In the rest of Canada, Shoppers Drug Mart has now implemented a take-back scheme.

2. Eat less meat. Seems to be one solution to almost everything these days. Tropical deforestation, greenhouse gases, world hunger and antibiotic resistance are all linked to our over consumption of meat. When you do eat meat, try to eat organic; it's farmed without antibiotics that can make their way into our water systems.

3. Minimize your use of antibiotics. Ninety per cent of all cold and flu symptoms are caused by viruses, not bacteria.

4. Avoid contraceptive patches and rings. Contraceptive patches, like Evra, manufactured by Janssen-Ortho, and rings, such as Organon's NuvaRing, although convenient, contain up to six times more synthetic estrogen than conventional pills.

"female" hormones in the world—after all, that is exactly what it was designed for. As Dr. Dana Kolpin, an environmental chemist with the US Geological Survey puts it: "It's one thing to mimic a hormone, it's quite another to actually be a hormone." Many researchers have found that at the part per trillion level—a level deemed inconsequential for most chemicals—ethinyl estradiol can feminize male fish.

Dr. Joanne Parrot, a research scientist with Environment Canada's National Water Research Institute, has been doing controlled lab experiments with fathead minnows for several life cycles (i.e. over several generations of fish) to examine the effects of birth control pills on the sustainability of populations. At one part per trillion, the contraceptive partially feminized the male fish and lowered their reproductive success; at three parts per trillion, "it was completely feminizing" she said.

Although this seems persuasive, Parrott, like most scientists, is hesitant to conclude that ethinyl estradiol is the true culprit; there are hundreds of estrogenic chemicals in the environment, so it is difficult to tell what is really causing the problem in the wild outside of a controlled lab setting. With current scientific evidence, all Sumpter can really say is that "ethinyl estradiol probably plays a reasonably major role."

Nevertheless, the UK's Environment Agency, "believes that there is now sufficient evidence of harm to fish that a risk management strategy is required for synthetic and natural estrogens entering the environment via sewage effluent."

Most scientists are now starting to think that if pharmaceuticals are having an effect on wildlife (and possibly on humans), it is through their action in combination with other pollutants. Sometimes chemicals can work together (like different estrogen mimics), sometimes they can oppose each other's actions (like, in some respects, estrogen and testosterone mimics). Widespread feminization of fish may in fact be a result of the vast numbers of estrogenic compounds that wildlife are exposed to. Similarly, it may be a combination of pollutants working together that are responsible for many of the biological phenomena we've been observing over the last fifty years, such as population crashes in amphibians, the dramatic decline in human sperm counts, and a wide variety of cancers.

"We really need to understand the responses of organisms to highly complex mixtures in order to understand what is really happening," says Sumpter.

DENIAL IS NOT A RIVER

Drugs in our water do not appear to be as pressing a health threat as other environmental issues, but most policy makers and scientists agree that research and planning are necessary to make sure it doesn't become a more serious problem.

To remove most of the pharmaceuticals from our drinking water, municipal water treatment plants would have to upgrade to newer, more expensive technologies, such as membrane filtration or ozonation. Most think this would be extremely costly, but Dr. Saad Jasim, CEO of the Walkerton Clean Water Centre and former Director of Water Quality and Production for the Windsor Utilities Commission, says that upgrading the WH Weeks plant in Windsor to ozonation resulted in a net savings of $247,000 a year, as the plant no longer had to purchase disinfecting chemicals.

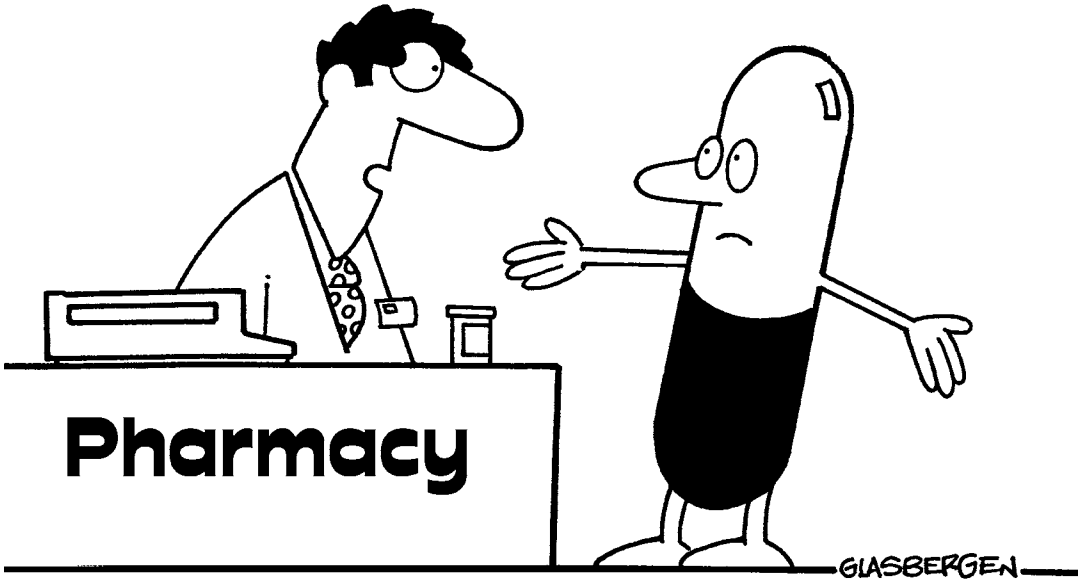
But upgrading our drinking water techniques doesn't help our wildlife exposed to sewage effluent coming out of wastewater treatment plants. "The take home message for us in Canada is that we don't do a particularly good job on our sewage," says Metcalfe. "In northern Europe tertiary treatment is the norm, here in Canada the norm is secondary sewage treatment, and many of our major cities like Montreal, St. John's, Halifax, and Victoria only have primary sewage treatment. Municipalities do have the capacity to upgrade their facilities, it's just that some of them don't."

Many environmentalists have suggested that pharmaceutical (and other chemical) companies be responsible for covering some of the costs of treatment upgrading, comparing it to holding packaging manufacturers responsible for paying for the proper disposal of their products. All the pharmaceutical companies interviewed for this story disagreed, arguing that if any private industry were to be held accountable, it would be one that produces considerably more contaminants.

To address the release of these substances in the first place, the Canadian government placed all drugs and cosmetics under the Canadian Environmental Protection Act in 1999 (prior to this they were covered by the Food and Drug Act, and hence exempt from environmental risk assessments for their approval). Now all new drugs slated for release into Canada must be evaluated for their environmental risk, and Health Canada and Environment Canada are currently reexamining the 22,000 or so chemicals previously approved for any environmental risk.

But Health and Environment Canada conduct environmental risk assessments on each compound in isolation, not in combination as most scientists believe they ought to in order to really see an effect. "So there's just a huge question mark hanging over the impacts of those chemical mixtures," says Kathleen Cooper, a senior researcher for the Canadian Environmental Law Association. "It's amazing actually that we don't know, we're flying blind full speed ahead."

Unfortunately, creating sound environmental policy for pharmaceuticals is extremely challenging. "Because most industry and business see environmental actions as having a cost, they are asking for greater



"Well there's a side effect I haven't seen before."

scientific certainty if there are going to be regulations," says environmental consultant Chris Hilkene.

MEA CULPA

Although Canadian wildlife (and Canadian people, some would argue) have been in better health, the pharmaceutical industry is doing quite well. Last year the sector grew 5.6 per cent and banked $17.3 billion (their largest profits to date) in prescription sales in Canada, and global sales grew 7 per cent to $550 billion. Are they investing any of their profits into researching this issue, looking at creating drugs that are more efficiently metabolized, investigating new water treatment techniques, or creating take-back programs for unused drugs?

In most cases, the answer to the question is no. "This is just not an issue that a pharmaceutical company would handle," said Rhonda O'Gallagher, Senior Manager of Corporate Affairs for Pfizer Canada, Canada's largest drug company. However, Canada's Researched-Based Pharmaceutical Companies, the Canadian Drug Manufacturing Association, the Non-Prescription Drug Manufacturers of Canada have all provided funding for drug take-back programs in BC.

But some companies are putting time and money into this issue outside of Canada. GlaxoSmithKline began 25 years ago when it developed "an environmental function" in its research and development area, said Virginia Cunningham, based in the US They have conducted environmental risk assessments, looked at toxicological effects, created mathematical models to estimate concentrations in the environment, and engaged in scientific dialogue by publishing their work. They have not found any risks to human or wildlife health, but it should be noted that they have not been doing targeted research on chemical mixtures.

AstraZeneca, Canada's second largest drug company, began working on environmental risks fifty years ago at the Brixham Environmental Laboratory in the UK. Collaboration takes place at the Laboratory with other pharmaceutical companies (including with Pfizer, Unilever and GlaxoSmithKline), academics and government, with AstraZeneca providing "$4 out of every $5" in funding.

Researchers at Brixham have conducted research on the persistence of drugs in the environment, more efficient treatment plants, possible uses of green technology and green chemistry in manufacturing, and how to create drugs that are less easily excreted (a very difficult task). They are also investing $36 million in the creation of a new biological wastewater treatment facility to minimize the release of pharmaceuticals from their Bristol, UK, manufacturing plant.

They have also done research on mixtures of chemicals on wildlife, and have concluded that the cause of fish feminization in the UK is a "a combination of birth control pills and hormone replacement therapy, and ordinary natural steroids excreted by females," says Dr David Taylor, of Brixham Environmental Laboratories.

"We think risk [from pharmaceuticals] is unlikely," says Taylor, "but we wouldn't go so far as to say there isn't any. We're interested in knowing whether there's a problem or not."

Cunningham said that her real concern is that the media are "sometimes alarmist." News reports might "make people afraid to take their medicine," she continued, "that's why there's concern about things like labeling [of pharmaceuticals with environmental precautions], you don't necessarily want to cause people to feel reluctant to take the medicine that they need, and we've actually had conversations with the [US] FDA on this, their concern is to make sure that people get the medication that they need."

WHAT CAN YOU DO?

Anything you flush down the drain will end up in your rivers, lakes, oceans—and eventually, your drinking water.

The detection of these compounds at such small, frequent rates at the very least underscores just how contaminated our fresh water is by our activities. Plasticizers, pesticides, herbicides, nitrogen fertilizers, mercury, and a slew of industrial chemicals are entering our environment at increasingly higher rates, and resulting in environmental and health effects that are undisputable. CK

Zoe Cormier is a Toronto-based science writer