Muskoka
WATERSHED COUNCIL

Emerging Issues in Watershed Health

Pharmaceuticals and Personal Care Products in Water

Over the past fifteen years, scientists have been researching a type of pollution that was not previously recognized. Pharmaceuticals, drug residuals and personal care products have been documented in surface, ground and drinking water and there is mounting evidence that these chemicals may pose some serious health and environmental risks. Recent advances in chemical analysis have facilitated the detection of these compounds. Since they were never given consideration in the past, our understanding of the impacts of these chemicals in the environment is extremely limited. The United States National Research Council has recently listed pharmaceuticals as a major class of water pollutant that requires more research and consideration for drinking water legislation (Daughton, 2001).

There are over nine thousand different types of drugs and personal care products registered for use in Canada (Servos, 2005). Most pharmaceuticals are organic in nature and serve a variety of therapeutic uses. They are bioactive and are typically designed to dissolve, but are not readily digested, which contributes to their ability to persist in the environment. While we have a good understanding of how each of these products works in mammals, it is difficult to predict the possible effects they may have in the natural ecosystem, especially when they are combined with other drugs and chemicals in the environment.

Research has found prescription and non-prescription pharmaceuticals in Canadian sewage treatment plant effluent (Metcalfe et al, 2003). It has also found evidence of a variety of drugs including antibiotics, anticancer agents, blood lipid regulators, anticonvulsants, analgesics, psychiatric drugs and anti-inflammatory compounds in the natural environment (Metcalfe et al, 2003). While most pharmaceuticals and their metabolites are not considered to be persistent in nature, their continual release into the ecosystem creates a similar effect to persistance (Daughton, 2001).

Drugs and personal care products enter the environment in a variety of ways including sewage, landfills, runoff and wind-borne drift. Most drugs or their metabolites are excreted or discarded into sewage treatment systems or septic systems, which are the primary sources of release into the natural ecosystem. Many products are degraded by the conventional sewage treatment process; however some are very persistent and remain unaffected or are only partly removed (Servos, 2005). The level of these compounds released from sewage varies by season, the type and quantity of sewage, the retention time, the treatment type and the method of disinfection (Metcalfe et al, 2003). Other forms of drug pollution can occur when unwanted pharmaceuticals or personal care products are discarded into landfill sites or from the excrement of domestic animals that have been fed steroids and antibiotics. These drug compounds can leach into the soil and contaminate both surface and ground water. The concentration of any given drug in the environment is directly related to its physical, chemical and biological properties as well as to the level of use, metabolism and excretion patterns (Ongerth & Kahn, 2004).

There is very little research into how humans and other non-target organisms are affected by a low- dose exposure to drugs over extended periods of time,

especially when the drugs are in combination with other compounds in the environment. Assessing the consequences of drug exposure to an individual organism cannot be accurately determined without considering the influences of all of the chemicals to which the organism is simultaneously exposed. Some effects may be very subtle and occur over long periods of time, leaving the cause undetermined or unnoticed all together. Other effects may cause indirect consequences in that they may leave an organism unable to deal with other stressors. Therapeutic drugs can have unintended effects on non-target organisms at much lower concentrations than prescribed levels, especially with continuous exposure (Daughton, 2001).

Most of the research into pharmaceuticals and personal care products in the environment focuses on aquatic organisms because of their continuous exposure to the chemicals from cradle to grave. Studies have shown that fish living downstream from municipal treatment plants can demonstrate altered physiology, changed behaviour, reproductive abnormalities and evidence of endocrine system disruption (Metcalfe et al, 2003). Biologically specific substances such as endocrine disrupters (e.g., the birth control pill) are not broken down by the sewage treatment process and are active at low doses. Researchers have discovered male fish with reduced reproduction levels, reduced growth, changes in mating behaviour and feminization. These changes in physiology and behaviour are attributed to the exposure of the male fish to female hormones (Jobling et al, 2006). Some drug compounds have been found to settle into the aquatic sediment where they are taken up by plant life and pose the risk of becoming bioaccumulative in the food chain (Daughton, 2001).

As surface and groundwater are the sources for drinking water, it is no surprise that traces of some compounds have been found in very low levels in treated drinking water (Servos, 2005). Most of these drugs are removed by activated carbon or ozonation; however, others can persist. Untreated drinking water such as that from a personal well is more vulnerable to contamination unless household treatment mechanisms are in place. Most potential health effects associated with the long-term chronic ingestion of low concentrations of drugs through drinking water remain speculative. Drug-resistant pathogens may arise from the presence of antibiotics in the environment, or the exposure to even low-level doses of one compound could limit the effectiveness of another drug prescribed for therapeutic use (e.g., Ibuprofen interferes with the cardio-protective properties of aspirin). Both male and female infertility has been linked to chronic exposure to a variety of drugs. Humans may experience long-term effects from drug exposure, which are difficult to attribute to a specific cause (Daughton, 2001).

The removal of pharmaceuticals, residuals and personal care products from sewage is extremely costly and therefore not a common practice in sewage treatment. While most pharmaceuticals found in intake water are extremely minimal, it is the interactions between the many compounds and the continuous exposure that is cause for concern. The removal of pharmaceuticals will require significant upgrades to existing sewage treatment plants and the development of improved engineering controls (Servos, 2005). It is an area that is generally unregulated.

The effects of pharmaceuticals, drug metabolites and personal care products on the natural ecosystem is an emerging area of study and the implications of these findings are not well understood. What is clear is that this is one area of environmental toxicology that needs a great deal of further research. In the meantime, the proper disposal of drugs and personal care products to minimize their potential for reaching the natural ecosystem is crucial and consideration will have to be given to developing regulations and changing how our water and sewage is treated.

What You Can Do

While pharmaceuticals and personal care products are likely not an issue in Muskoka's water, prevention is the first line of defence to keep it from becoming so.

- ✓ Eliminate any unnecessary use of toiletries, cosmetics and drugs.
- ✓ Eat organic foods to reduce your intake of hormones and antibiotics.
- ✓ Never dispose of medications in the sink, toilet or garbage. Instead, return unused and expired prescription and over-the-counter drugs to your pharmacy for proper disposal.
- ✓ Pharmaceuticals may also be taken to a Household Hazardous Waste Depot for proper disposal. Visit www.muskoka.on.ca for the depot nearest you.

Bibliography

Daughton, Christian G. 2001. Pharmaceuticals and Personal Care Products in the Environment: Overarching Issues and Overview. http://www.epa.gov/esd/chemistry/pharma/book-summary.htm.

Jobling S., Williams, R., Johnson, A., Gross-Sorokin M., Nolan, M., Tyler, C.R., VanAerle, R., Santos, E., and Brighty, G. 2006. Predicted Exposures to Steroid Estrogen in U.K. Rivers Correlate With Widespread Sexual Disruption in Wild Fish Populations. Environmental Health Perspectives Vol 114, No. S-1.

Metcalfe, C.D., Koenig, B.G., Bennie, D.T., Servos, M, Ternes, T.A., and Hirsch, R. 2003. Occurrence of Neutral and Acidic Drugs in the Effluents of Canadian Sewage Treatment Plants. Environmental Toxicology and Chemistry, Vol. 22, No. 12, pp. 2872-2880.

Metcalfe, C.D., Moon, T., Vance, T. and Struger, J. 2004. Pharmaceutical Drugs in Canadian Surface Waters: Distribution and Effe3cts on Fish. Health Canada – Science & Research. http://www.hc-sc.gc.ca/sr-sr/finance/tsri-irst/proj/cumul-eff/tsri-337_e.html.

Oliver, A.J., Lester, J.N. and Voulvoulis, N. 2005. Pharmaceuticals: A Threat To Drinking Water? Trends in Biotechnology, Vol.23 No. 4, pp. 163-167.

Ongerth, Jerry and Khan, Stuart. 2004. Drug Residuals: How Xenobiotics Can Affect Water Supply Sources. Journal American Water Works Association. Vol. 96 Iss 5, Page(s) 94-101.

Raloff, Janet. 2000. More Waters Test Positive For Drugs. Science News Online, week of April 1, 2000; Vol.157. No. 14. http://www.sciencenews.org/articles/20000401/fob1.asp.

Servos, Mark R. 2005. Characterizing the Effects and Causative Agent in Municipal Treatment Plant Effluents Related To Reproductive Responses in Fish: The Role Of Emerging Contaminant Of Concern. Department of Biology, University of Waterloo.

MWC would like to thank Janette Sutey for her invaluable work in drafting this document.