Pharmaceutical Disposal and Water Quality

This article explains the issue of pharmaceuticals in water and how to properly dispose of these products to prevent water quality contamination.

Unused and unwanted medicines being collected.

For purposes of water quality discussions, pharmaceuticals are usually grouped with other chemicals found in water supplies and called pharmaceuticals and personal care products (PPCPs). PPCPs are a diverse group of chemicals that include;

- products we ingest (or give to our pets and domesticated animals) to improve health, which include over-the-counter (OTC) drugs, pharmaceuticals (prescription medicines, nutritional supplements, and veterinary drugs,
- products we use to adorn and clean ourselves, which include fragrances, lotions, shampoos, antibacterial soaps, detergents, sunscreens, cosmetics, and,
- other chemicals used in various important applications, which include pesticides, plasticizers, and brominated flame retardants.

All of these chemicals are used by humans or given to animals and are finding their way into our water supplies. The purpose of this fact sheet is to explain the source of these chemicals, how they are getting into our water supplies, and how each person should properly dispose of unwanted or no-longer-needed PPCPs.

Ingested Health Care Products

Medicines are produced and used in very large volumes. Fifty percent of the population uses at least one prescription drug daily and four out of five patients leave the doctor's office with a prescription. Almost 800 million prescription items were dispensed in 2007, 59.2 % more than in 1997.

Worldwide, between 200 and 400 million pounds of antibiotics are taken annually. Of this total over 50 million pounds of antibiotics are taken in the United States annually with half of these going to animals. It is estimated that hospitals and long-term care facilities intentionally discard 250 million pounds of unused or unwanted medicines each year. These PPCPs enter the environment by excretion by humans and domestic animals and by flushing unneeded or expired PPCPs down a toilet or drain. These PPCPs in the waste stream go to the local municipal wastewater treatment plant or to your private on-lot sewage system. Many people are surprised to learn that today's municipal water and wastewater treatment systems do not intentionally remove these chemicals from the water and wastewater they treat, although a considerable portion of these chemicals are removed in the treatment processes. On-lot sewage systems, likewise do not intentionally remove these chemicals though

some PPCPs are adsorbed onto the soil receiving the absorption field's wastewater.

Adorning and Cleaning Products

Little is reported about the quantities of fragrances, lotions, shampoos, antibacterial soaps, detergents, sunscreens, and cosmetics used by the population. What we do know is that every time you take a shower, you wash whatever of these products you use down the drain where they enter the wastewater treatment or private on-lot sewage systems. As with health care PPCPs, only limited quantities of these chemicals are removed by today's treatment systems. When you go swimming, these products are washed directly into the surface waters.

Other Chemicals

Pesticides, plasticizers, brominated flame retardants, and other similar products enter the environment by various pathways including being placed in the soil, volatilizing into the atmosphere, and being discharged into streams. In few cases is there any quality control or deliberate treatment of these chemicals.

Why the Concern Now?

Until very recently chemical diagnostic technology was not able to detect these chemicals in water because the concentrations were below detectable limits. Now that it is possible to detect parts-per-trillion (ppt) or nanograms per liter, we are frequently finding one or more of these chemicals in our water. Even though these concentrations seem very small and insignificant there are an extremely large number of molecules of these products in the water we drink. The Box on this page may help you understand this concept.

What are the Current Conditions?

A USGS reconnaissance study (Kolpin et al. (2002) in 1999-2000, the first of its kind, evaluated the presence of pharmaceuticals, hormones and other organic contaminates in 139 streams in 30 states. They found 82 of 95 antibiotics, non-prescription drugs, steroids, and hormones in at least one sample. Eighty percent of streams sampled had more than one contaminant. Seventy-five percent had two or more. Fifty-four percent had more than five, 34% had more than 10 contaminants, and 13% of streams tested positive for more than 20 targeted contaminants.

In a study (Velicu and Suri, 2008) that sampled 21 Chester County streams, seven different estrogen compounds were detected in at least 10% of the streams sampled and two of these compounds were found in more than 86% of the streams sampled. The two estrogen compounds found in the highest concentrations were estriol (0.33 to 19.7 ng/L) and progesterone (7.35 to 11.8 ng/L).

Acetaminophen, commonly known as Tylenol, is a much used over-the-counter drug. A common dose of Tylenol is 500 milligrams (mg). Acetaminophen has been detected in drinking water at concentrations of 0.00000005 mg/L. This concentration is equal to 0.00005 µg/L or 0.05 ng/L or 50 pg/L. 50 pg/L is equivalent to 50 grams of acetaminophen in one trillion liters of water. This is also equivalent to finding 48 billion (48,000,000,000) molecules of acetaminophen in a cup of water. So the next time you have your morning cup of coffee, consider what else is in that cup.

There is no doubt these chemicals are beginning to show up in our drinking water supplies. The important question is "So what?" "Are they really harmful to us?"

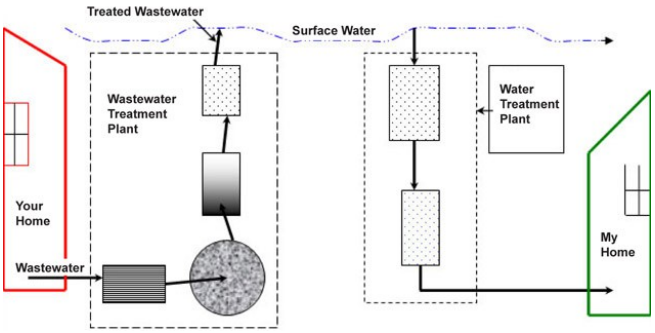
There is not a great deal of credible information to show that we humans are being affected, health wise, by these very low concentrations of chemicals in our drinking water. There is, however, growing evidence that some of these chemicals disrupt the endocrine balance in various ecological species (endocrine disruptors) and can adversely affect fish and other aquatic species living in the contaminated waters.

Some of these chemicals interfere with or mimic natural hormones and disrupt reproduction, development, and behavior of fish and other organisms. Feminization of male fish has been observed in waters with estrogen concentrations in the 0.1 to 10 ng/L range. No one knows at what concentrations similar impacts will be detected in humans (the research has not been done).

How do Medicines and Drugs get into Our Water?

In the United States, most unused or unwanted medicines are either flushed down the toilet (35%) or placed in the trash (54%). Many pharmacies have appropriate drug disposal programs and procedures, but less than 2% of unwanted medicines are returned to the pharmacy where they were obtained. Over 7% of the population leaves unwanted medicines in a cabinet for someone else to deal with later.

It is relatively easy to understand how drugs that have been flushed down a toilet could get into the water supply (Note the flow path from "your home" to "my home".)



Wastewater and Water Treatment Systems

A major portion of these chemicals are removed (some as high as 99.9%) by traditional wastewater treatment plant processes but the accumulated effect of the chemicals that remain in the effluent and are discharged into the receiving waters is troublesome. Chimchirian et al. (2007) found that 41 to 99% of estrogen compounds were removed from three traditional wastewater treatment plants, with activated sludge plants showing the best removal.

However, estrogen compounds found in the treatment plant effluent were still above the detectable limits, leaving daily estrogen loads (predominately estrone) in the effluent ranging from 2 to 167 mg/d. Data from a wastewater treatment plant that applies microfiltration followed by reverse osmosis advanced treatment to a portion of their treated water still shows detectable concentrations of many PPCPs in the effluent. Treated wastewaters are usually discharged to local streams and flow downstream to the next town where the water is treated before being piped to your home.

Drugs that are disposed of in the trash should be expected to be retained in a landfill where the trash is deposited. However, much of the waste deposited in landfills is organic and, over time, organic waste decomposes and produces leachate. In modern, properly designed and operated landfills, the landfill leachate is collected and treated; but the treatment processes do not completely remove the PPCPs in the leachate before being discharged to local surface waters.

PPCPs in treated wastewater that is irrigated onto forest or cropland will generally be captured in the soil profile where soil microbes and soil chemical reactions will breakdown the PPCPs into quite harmless products.

There is a far more subtle and maybe more important pathway from a PPCP user to the water supply. When a doctor prescribes medicine(s), you ingest these drugs. Your body uses some of the prescribed drug for its designed purpose, but a majority of each drug is excreted. So a large portion of prescribed and properly used medications are automatically returned to the wastewater and then to our receiving streams. Adorning and cleaning products enter our drinking water by being washed into the wastewater and then into the receiving streams.

Keep these Chemicals Out of the Water

Keeping PPCPs from our water supplies is almost impossible. Reducing the use of these products is the only way to reduce the volume of these products that reach our water supply. At this point, the technology does not exist that will completely remove PPCPs from water.

Keeping unused and unwanted health care products from our water supplies is something each of us should give careful consideration. The only truly safe way to dispose of these drugs is by high-temperature incineration. These incineration sites are usually under the control of law enforcement and all of the disposal suggestions below should eventually lead to proper incineration.

The ONDCP (2007) prescription drug disposal guidelines advise you to:

- Flush prescription drugs down the toilet **only** if the label specifically instructs doing so.
- Dispose of unused prescription drugs through pharmaceutical take-back programs if available.

If these methods are not available or appropriate:

- Take unused, unneeded, or expired prescription drugs out of their original containers.
- Mix the drugs with an undesirable substance, such as kitty litter.
- Put the drugs in sturdy, opaque, non-descript containers.
- Throw these containers in the trash.

The American Pharmacists Association, the U.S. Fish and Wildlife Service, and the Pennsylvania Department of State (DOS, 2009) all recommend the following:

- Do not flush unused medications.
- Ask your pharmacist about take-back programs.

When tossing unused medications, protect children and pets from the potentially negative effects by:

1. Crush or dissolve solid medications.
2. Mix with kitty litter or a solid kitchen substance.
3. Place in a sealed plastic bag to reduce the poisoning risk.
4. Remove and destroy **all** identifying personal information.
5. Check for approved state or local collection programs or with area hazardous waste facilities.

Summary

Proper management and disposal of pharmaceuticals and personal care products (PPCPs) requires that each of us to take precautions to make sure that these unused and unwanted products do not reach and enter the waters that become our drinking water. Because it is impossible to detect these chemicals until the water contains billions of molecules, it is imperative that every possible action be taken to keep these chemicals out of our drinking water.

References

- Chimchirian, R. F., R. P. S. Suri, and H. X. Fu. 2007. Free synthetic and natural estrogen hormones in influent and effluent of three municipal wastewater treatment plants. Water Environment Research 79(9):969-974.
- Kolpin, D. W. et al. 2002. Pharmaceuticals, hormones, and other organic wastewater contaminants in U.S. streams, 1999-2000: A National reconnaissance.

Environmental Science and Technology 36(6):1202-1211.

- PA Department of State (DOS). 2009. Pennsylvania State Board of Pharmacy Newsletter. Last accessed January 2010.
- Velicu, M and R. Suri. 2009. Presence of steroid hormones and antibiotics in surface water of agriculture, suburban, and mixed-use areas. Environ. Monit. Assess. 154(1-4):349.
- White House Office of National Drug Control Policy (ONDCP). 2007. Last accessed January 2010.

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