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# Xenobiotic Danger in Recreational Water: What's in Your Water?

**Robert W. Lowry**

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What in the world is “xenobiotic,” and why should I be worried about it? This will be from the “You heard about it here first” file. No, it is not some new kind of disease, bacteria, parasite, or organism. It is a term that is used as a catchall for a number of things. *Xeno* is Greek for “foreign,” and *biotic* is from *bios*, which means “life,” and together they mean “biologically active.”

Household products such as window, countertop and floor cleaners; dishwashing and laundry compounds; and heavy-duty potent chemicals such as degreasers, drain cleaners, and oven cleaners are now all going down the drain and through the sewer system. Septic tanks do not destroy these chemical wastes, and they cause local pollution. Newer cleaners with antimicrobial ingredients are also part of household wastewater.

One of the concerns in providing high-quality drinking water is that the sources may be getting scarce or contaminated as a result of droughts, expanding population, well closings, pesticide contamination, MTBE, perchlorate, agricultural runoff, and chemical-manufacturing and industrial pollution, to name a few causes. Drinking-water quality has gotten better over the past few decades in large part because of better analytical techniques. Things have been found in water we never knew were there. We identified them and then established standards and procedures to remove the harmful ones. Who would have heard about chemicals such as PCBs, (polychlorinated biphenyl), THMs (trihalomethanes), TCE (trichloroethylene), or MTBE (methyl t-butyl ether) or organisms like crypto (*Cryptosporidium parvum*) or giardia (*Giardia lamblia*) 25 years ago? Today, practically everyone in the field of recreational water has heard of most of these.

The lack of fresh, uncontaminated source water has caused municipalities to consider and implement water-recycling practices. It might be easier to remove the contaminants from household wastewater and recycle it rather than removing contaminants from industrially or agriculturally polluted source or groundwater. This has caused a shift in the water-quality focus from natural elements and traditional waterborne pathogens (disease-causing organisms) to known individual synthetic chemicals and newer, harder-to-kill pathogens. We only recently have become concerned with the impact of phosphates and nitrates on recreational-water quality.

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There are no guidelines for them yet, but we will probably have to focus on THMs in recreational water soon. THMs are disinfectant by-products formed when chlorine or bromine reacts with certain natural organic matter in water. These halogenated organics are named as derivatives of methane and include suspected carcinogens. They are any of various derivatives  $\text{CHX}_3$  of methane (such as chloroform or bromoform) that have three halogen atoms per molecule. THMs are not allowed in drinking water. To comply with federal regulations, water-treatment methods changed at drinking-water-treatment facilities so that THMs would not be produced.

The next shift of focus in water quality will probably be toward synthetic contaminants such as pharmaceuticals and “natural” contaminants such as hormones. These contaminants will be found in much lower concentrations than any other contaminants. They will also have biological effects that might occur at concentrations below the current detection levels.

Each time a new drinking-water contaminant is identified and becomes a concern, recreational-water concerns are not far behind. Then the new contaminant has to be added to some catchall category or collective term that describes what it is, such as pesticides, synthetic organic chemicals (SOCs), volatile organic chemicals (VOCs), inorganics, metals, and radionuclides.

## Xenobiotics

Xenobiotics include pharmaceutically active compounds (PhACs) and endocrine-disrupting chemicals (EDCs). Exogenous hormones (hormones that are produced outside the body) and one’s own hormones are definitely biotic (caused or produced by living beings). Xenobiotics also include drugs, both the legal kind that you get with a physician’s prescription and the illegal type such as cocaine, heroin, marijuana, methamphetamines, “ice,” “speed,” and “crank.”

Perchlorate is an example of both a xenobiotic and an endocrine disruptor. It is a chemical used as the primary ingredient of solid rocket propellant and in munitions beginning in the 1950s. Perchlorate is also used in the production of explosives and fireworks. It adds the blue color to fireworks displays. For disposal, perchlorate has often been dissolved in water and poured on the ground. Perchlorate dissolves easily and moves quickly in underground and surface water, but it breaks down very slowly in the environment. Wastes from the manufacture and improper disposal of perchlorate-containing chemicals are increasingly being discovered in soil and water. Traces of perchlorate have been found in groundwater in virtually every state in the United States. It has been detected in many rivers, and low levels have been found in some lettuce samples and milk.

Perchlorates include ammonium perchlorate, potassium perchlorate, sodium perchlorate, and perchloric acid. Perchlorate interferes with iodide uptake into the thyroid gland. Because iodide is an essential component of thyroid hormones, perchlorate disrupts the function of the thyroid. The thyroid helps regulate metabolism. In children, it also plays a major role in proper development. Impairment of thyroid function in expectant mothers can affect the fetus and newborn and result in effects including changes in behavior, delayed development, and decreased learning capability. Changes in thyroid hormone levels can also result in thyroid-gland tumors. Although the range of health effects for these xenobiotics is broad, all of

these compounds are foreign to the living organism in which the health effect is observed, which makes them xenobiotic.

Pharmaceuticals (prescription medications) are formulated to be highly soluble and not readily degradable in the human digestive system. These properties make them persistent in water and not readily degraded by sunlight. Pharmaceutical residuals appear in urine and sweat as a product of their use and subsequent excretion. Other prescription preparations such as topical ointments and lotions that are used for dermal conditions are easily shed into the water on immersion.

A test published by the U.S. Geological Survey in March 2002 states that tiny amounts of everyday products such as soap and prescription drugs were found in 80% of the water sources sampled. The study tested streams in 30 states. Streams showed 95 different chemicals, from antibiotics to perfumes. Most of these chemicals were in the ppb (parts per billion) range. If municipalities are going to recycle sewage and mix it with source water to meet demands, they are going to have to consider monitoring and treating xenobiotics as part of their program.

Many of the PhACs are active in the microgram-per-liter to picogram-per-liter range. No one knows what the potential adverse health effects are of consuming xenobiotics in drinking water. The ultimate recycling of water is a commercial recreational water facility (a public swimming pool, spa, or hot tub). The water is sometimes used for years before complete draining or significant dilution.

In a study done by J. Alan Beech in 1981, it was determined that the average person entering the water leaves behind 200 ml of sweat and 50 ml of urine. No reliable studies have been done on which to base the amount of urine voided in the water by swimmers. Warren and Ridgeway, from Water Research Laboratory, Marlow, England, estimated it to be 25–50 ml per swimmer in 1978. Beech estimated it to be much higher for children under 10 years of age. He adopted a value of 50 ml per swimmer.

Kuno, from C.C. Thomas in Springfield, IL, reported that an active swimmer in water at 24 °C (75 °F), when the air temperature was 38 °C (100 °F) lost approximately 1 L (1.06 quart) of sweat per hour. For his calculation he assumed 10% of the volume, or 100 ml/hr. The average time spent in a pool is 2 hr. The EPA estimates that child swimmers age 5–9 years spend 3 hr in pools at a time, teenagers spend 6 hr, and adults, 1 hr. Beech used an average of 2 hr, which resulted in 200 mL of sweat.

We know that drugs appear in sewage. Therefore, it is not a quantum leap to understand that xenobiotic drugs, household cleaners, and personal-care preparations are present in recreational water. When sewage was tested for the top 50 prescription medications in recent studies in Australia, all 50 drugs were present. A partial list of prescription- and over-the-counter-drug residuals found in sewage in Australia appears in the appendix.

Of primary concern is the potential for adverse health effects. Drug-residual concentrations reported in sewage to date are an order of magnitude (two or more times) below those at which an effective therapeutic dose would result from ingesting the water. That is in sewage, not in recycled, recreational water that may be years old. The concentrations will be much higher in old recreational water. Multiple drugs in the water raise the possibility of drug interactions that might cause health effects not otherwise observed. No one has ever put that many drugs into one body of water with continuous additions made over many months or even years and then exposed swimmers to it.

Then there is the idea of continuous, multiple, or repeated exposure to low levels of these drugs. Swimming every day in a drug soup could have untold consequences. It could take one or many exposures over months or years for any symptoms or adverse health effects to appear. This could make finding that xenobiotics in recreational water are the culprit nearly impossible. Doctors might not even be able to diagnose the problem, much less the cause.

Some evidence suggests that dose-response curves for some drugs are actually U shaped, having an unexpected range of increased significance or beneficial effect at very low concentrations. This is of such concern that there is even a program and advisory committee devoted to this called BELLE—**biological effects of low-level exposure**—and it has a multi-institutional advisory committee ([www.belleonline.com/](http://www.belleonline.com/)).

Because little is known about the potential environmental effects of xenobiotics in drinking water, the U.S. EPA National Exposure Research Laboratory is planning further research into drinking-water sources. One area of concern is the impact of natural and synthetic sex steroids on the endocrine system of aquatic life such as fish. The potential growth of antibiotic-resistant bacteria and other pathogens is another area of concern. The EPA needs more data to understand and determine the risks posed by xenobiotics in source water.

Human and environmental exposure to xenobiotics is of a concern when

- A small amount of sewage is recycled and mixed with source water for drinking.
- Small amounts of municipally treated sewage are returned to the environment, where it can contaminate source water.
- Septic-tank wastewater is returned to the land through leach fields, where it can run off and contaminate source water.

Imagine, if you will, what might be in swimming-pool, spa, hot-tub, whirlpool, waterslide, water-park, lazy-river, or other recreational water. What and how much might be in the water of a recreational facility that has a daily bather load of 9,000 people and has used the same water for 100 days? What about the spa that has 25 people in it all day long and the water is a month old? If you swallow some pool water, are you ingesting some or all of the 50 prescription drugs listed in the appendix? It is estimated that 25–30% of all people over the age of 18 years have tried illegal drugs. You might be ingesting some pot, cocaine, heroin, methadone, crack, or other drugs just by swimming in your local pool. You could be getting some extra hormones, amino acids, vitamins, or minerals. You could even be getting some extra caffeine or nicotine. Maybe you never thought about it. Maybe you didn't want to know. Maybe you will never go swimming in a public facility again. . . . Maybe you will.

## Recommendations

Xenobiotic material has been in the water since the very first pool was ever built. We have just recently been able to analyze it. We are just now talking about it. You might start to hear about it from your patrons. You will soon be doing something about it.

There are test methods for drugs. They are the same ones used to test Olympic athletes, some felons, and homicide victims for drugs. They are very expensive and very sophisticated. There are no easy or inexpensive tests for xenobiotics or drugs. They are insignificant on a total dissolved-solids (TDS) test. We also do not know what any common water sanitizers will do to xenobiotics. They might destroy them. They might do nothing to them. They might chlorinate them, brominate them, or oxidize them to unknown by-products that might be harmful or harmless. At present for recreational water, the only defense we have against xenobiotics is draining. One draining method used in England and Europe is to drain 30 L (~8 gallons) of water per bather per day. This might also reduce the need to superchlorinate to avoid the buildup of combined chlorines.

Another recommendation is to use water from an approved potable municipal water-treatment facility. In the United States, this water must meet the requirements of the Safe Drinking Water Act. Some 100+ known contaminants are below the level determined safe. Do not use groundwater, well water, or surface water in a recreational water facility unless the water has been tested by the local health authority and approved for drinking. There is no way of knowing what is in that water without extensive and expensive testing.

## Summary

Now you have another concern for the safety of your patrons or swimmers, and you have a valid reason for keeping the water fresh. The fresher the water, the less chance there is for xenobiotics to be present or build up. It is a hot topic in drinking water right now. It will not be long before recreational water comes under scrutiny. Will you be ready when your customers or patrons start asking about this?

## Appendix: Prescription-Drug Residuals Found in Sewage Water in Australia

Allopurinol	Dicloxacillin	Ketoprofen	Roxithromycin
Amoxicillin	Diltiazem	Lactulose	Salicylic acid
Aspirin	Dothiepin	Metformin (HCl)	Sertraline
Atenolol	Doxycycline	Metoprolol	Simvastatin
Captopril	Erythromycin	Metronidazole	Sotalol
Carbamazepine	Flucloxacillin	Moclobemide	Sulphamethoxazole
Cefaclor	Frusamide	Nizatidine	Sulphasalazine
Cephalexin	Gemfibrozil	Oxipurinol	Tiaprofenic acid
Chlorothiazide	Gliclazide	Paracetamol	Trimethoprim
Cimetidine	Hydrochlorothiazide	Phenoxyethylpenicillin	Valproate
Clavulanic acid	Ibuprofen	Phenytoin	Verapamil
Codeine	Irbesartan	Quinine	
Diclofenac	Isosorbide	Ranitidine (HCl)	