# There is Medicine in These Waters

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*We drank of every variety of water excepting pure water—sometimes iron, sometimes sulphur; and, indeed, every kind of chalybeate, for every rill was impregnated in some way or another. At last, it occurred to me that there were such things as chemical affinities, and that there was no saying what changes might take place by the admixture of such a variety of metals and gasses, so I drank no more. I did not like, however, to interfere with the happiness of others, so I did not communicate my ideas to my fellow-passengers, who continued drinking during the whole day; and as I afterwards found out, did not sleep very well that night; they were, moreover, very sparing in the use of them the next day.*

— Captain Frederick Marryat. (1839)[1] *A Diary in America, with Remarks on Its Institutions.*

The medicinal effects of mineral water have been touted for millennia. Famed healing springs include Baden-Baden in Germany, Vichy in France, Piestany in Slovakia, and Saratoga in upstate New York—all places where the sick sought relief from chronic illness and pain. Today we can stay at home; there is medicine in the water. Persistent concentrations of hormones, antidepressants, and antibiotics end up in our waterways and our drinking water according to the U.S. Geological Survey.[2,3] Perhaps this is a cheap public health measure for keeping everyone healthy! Unfortunately, a recent study[4] found that a mixture of 13 common medications found in drinking water inhibits cell growth and causes negative changes to human embryonic cells. Simply put, by-products of industrial society are not the only endocrine disruptors; medications for humans and livestock have negative consequences on our health as well. Casual disposal of medicinal hormones creates water-borne pollution. Proper disposal of pharmaceutical medications is a must.

Today, in the U.S. and Europe, municipal drinking water typically has 100 or so pharmaceutical medicines and personal care products in significant concentrations.[5] Various hormones, antidepressants, and antibiotics end up in our waterways, the most common being aspirin, statins, hypertension medications, and hormones of women.[6] In fact, 80% of the waterways sampled included such common medicines as acetaminophen (24%), the hormone estradiol (16%), Ditiazem, a blood pressure medication (13%), Codeine (11%), and antibiotics (10%). The risks of this chemical pollution go relatively unrecognized and certainly unanticipated. Nevertheless, the Strategy Plan 2000 for the U.S. EPA Office of Research and Development makes identifying the risks of pharmaceutical and personal care products (PPCPs) one of top five goals for protecting human and ecological health.[7]

Ecosystem changes through human activities occur primarily via three routes: habitat fragmentation, alteration of community structure, and chemical pollution. Since the work of Rachel Carson, scientist and author of *Silent Spring*, the impact of chemical pollution has centered on the conventional "priority" pollutants due to their

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long-term persistence in the environment. Little attention has been given to the active ingredients of pharmaceuticals and personal care products (PPCPs) because they break down more quickly in the environment compared to more traditional chemicals, such as PCBs and dioxin. However, since the exponential growth of pharmaceutical use by consumers, the quantities of PPCPs being disposed of are on par with agricultural chemicals. The ecological consequences of most of (PPCPs) are poorly understood. Since most of these substances are disposed of continually via the sewage system, PPCPs are essentially persistent in the environment. The transformation/removal rates for these substances are compensated by their replacement through continuous consumer use—they are present, at significant concentrations, all the time.

Due to various routes of discharge, PPCPs occur as complex mixtures in the environment. These discharge routes include treated domestic and industrial wastewater, commercial animal feeding operations, and surface applications of manure. However, the two largest sources of PPCPs discharge into the sewer system are residential and hospital waste streams. Depending on the medicine, a significant percentage of the bioactive ingredients may pass through the body unchanged while others are partially metabolized into other bioactive metabolites. This results in the direct excretion of metabolites into the sewer system, where they go largely untreated. Without proper education, patients dispose of pharmaceutical drugs, further contaminating the water system.

Attempting to understand the effects of pharmacological agents on aquatic life isn't particularly easy. Research on pharmaceuticals primarily focuses on the individual effect of each medicine. However, drugs are typically found in complex combinations in the environment. The recently published study on 'Effects of a Complex

## Reducing Pharmaceutical Pollution

**WHAT PHYSICIANS CAN DO:**

- Always take cost-effectiveness and environmental impact into account when comparing medications that are equally safe and suitable for the purpose.
- Prescribe starter packs.
- Prescribe refill packs if available.
- Encourage patients to return unused medications to the pharmacy.
- Inform patients of the importance of even returning used estrogen patches to the pharmacy and avoid flushing them down the toilet, since most of the estrogen remains in the patch after use.
- Do not prescribe more medications than can be used; if in doubt, repeating the prescription is preferable.
- Review and regularly reassess the patient's total consumption of medication in order to reduce waste.
- Learn more about which drugs have large environmental impacts by using this website (see below) and by asking for information from the pharmaceutical companies' representatives.

From Janus: Environment and pharmaceuticals http://www.janusinfo.se/imcms/servlet/GetDoc?meta_id=7240

**The two largest sources of these products entering the sewer system are residential and hospital waste.**

Mixture of Therapeutic Drugs at Environmental Levels on Human Embryonic Cells' in *Environmental Science Technology*[8] investigated the effects of 13 drugs at low concentrations. The purpose of this study was to mimic the association and concentration of various drugs found in the natural environment. In the study, the drug cocktail showed a 30% decrease in cell proliferation compared to controls, as well as cellular activated stress response and morphological changes. The studies concluded that "water-borne pharmaceuticals can be potential effectors on aquatic life."[9]

Public agencies are beginning to consider the problem seriously. In fact, the Stockholm County Council in Sweden has identified the presence of medicinal products in the ground water and air as one of the five most important environmental issues.[10] Several solutions are underway, including prioritizing medications that are less harmful to the environment. To do this the Swedish Association of the Pharmaceuticals Industry has begun an environmental risk assessment of all medications marketed in Sweden. The primary evaluation occurs on a scale of insignificant (0), low (1), moderate (2) and high (3) for three of the areas under consideration: *persistence*—the ability to resist degradation in the aquatic environment, *bioaccumulation* (accumulation in adipose tissue of aquatic organisms), and *toxicity*—the potential to poison aquatic organisms.[11] The published report also considers the volume of daily doses delivered. Estradiol, a female hormone, scored a high risk for persistence, bioaccumulation and toxicity, giving it a total score of 9 on a scale from 0-9. In Sweden, there were 25 million doses of Estradiol delivered daily, making it the fourth most common medicine on the list after aspirin, Simvastatin (cholesterol-lowering) and Furosemide (an antihypertensive).

The Stockholm County Council created recommendations for physicians to participate in the safe disposal of medications (see page 5). One of the most important is: "Inform patients of the importance of even returning used estrogen patches to the pharmacy and avoid flushing them down the toilet, since most of the estrogen remains in the patch after use."[12] The environmental impact of pharmaceutical medicines designed to treat human female reproductive issues include endocrine disruption on an ecological level—the life cycle of aquatic life. Though there is not well designed evidence to date, this may also affect human endocrine activity as well. Consequences may include the steady decline in the age of puberty onset over time.[13] Simply put, human pharmacological hormones can act as endocrine disruptors in the environment!

The first principle of the Stockholm County Council states "Always take cost-effectiveness and environmental impact into account when comparing medications that are equally safe and suitable for purpose."[14] This is reminiscent of the 'Principles of Ecological Healing: "All healing has ecological consequences."[15] In California, the Emerging Contaminants Workgroup of the Santa Clara Basin Watershed Management Initiative published a white paper discussing the environmental impact of pharmaceutical disposal.[16] In it they summarize the potential actions we can take to reduce this serious problem. For example, unused residential and expired pharmaceuticals should not be disposed of in toilets and sinks. To inculcate this practice, we should encourage proper disposal through organized "take-back" events at local senior centers, pharmacies, and police and fire departments. Ultimately, legislation and funding is required to most effectively promote these programs.

From a professional perspective, it is our responsibility to understand the ecological consequences of the practices we use every day in our work. With rising

**Environmental Risk Assessment for medications includes:**

- **persistence**
- **bioaccumulation**
- **toxicity**

populations of modern cities and states, pharmacological agents will continue to emerge as unsuspected chemical pollutants. It is our job as health professionals to create 'clean medicine,' a part of Green Health Care. Green Health Care requires not only a workplace that is healthy for its occupants; it involves medical practices that do no harm to ourselves or the environment. While current medicinal practices generate significant pollution, we do have health care options that generate little if any waste. We can and must choose these more enlightened practices.

Our health depends on the health of the environment in which we live. As well, it depends on the medicines we use for illness, meant for returning us to wellness. Precaution is essential for human health as well as the health of the environment. Due to people living longer and an increasing population, ecosystems are continuously contaminated by medicines and personal care products. Low concentrations of modern medicines can and do act as endocrine disruptors in our ecosystems and may potentially damage human health. Our medical system has the technology and the know how to make significant changes that will be good for people and the environment. The time to act is now!

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