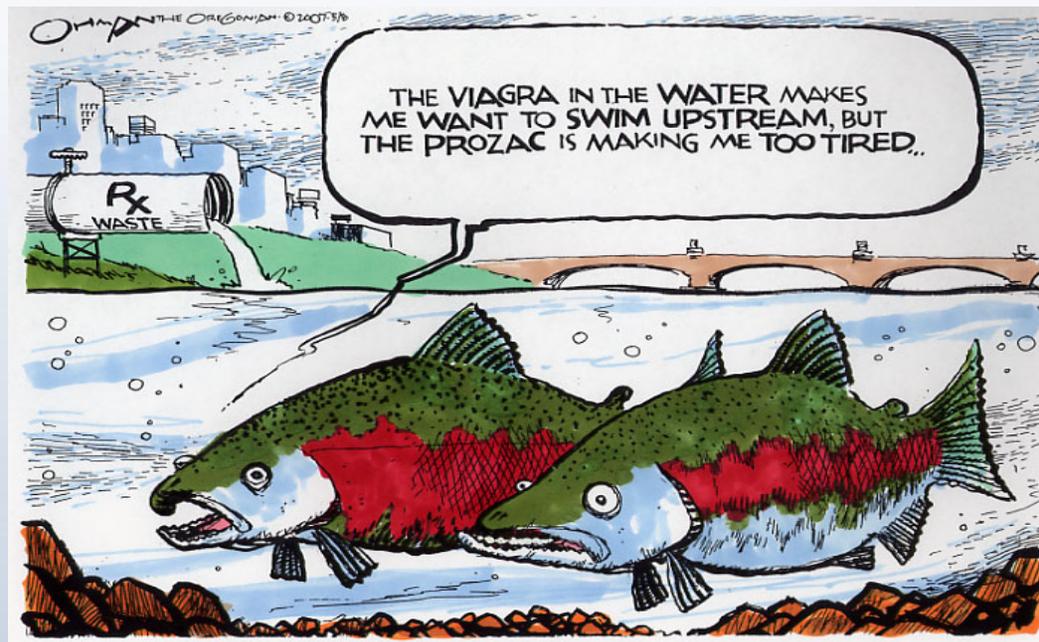


Pharmaceutical Waste Management: Environmental Impacts



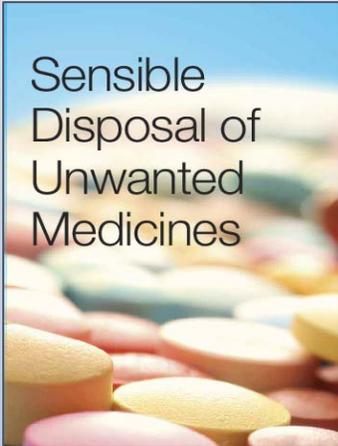
HealthCare Pharmaceutical Waste Management Workshop
26 January 2012



Laura Kammin, Pollution Prevention Program Specialist, Illinois-Indiana Sea Grant

Outline

- Things to Know About Pharmaceuticals
- Origin of Pharmaceuticals in the Environment
- Examples of Environmental Impacts
- Potential Impacts on People
- Understanding the Regulations



Sensible
Disposal of
Unwanted
Medicines

Things to Know About Pharmaceuticals

- What are the main risks of improper storage and disposal?
- Issues and Barriers
- Disposal: Individual vs. Health Care Facility



Main Risks of Improper Disposal Practices

1. Accidental ingestion

- Between 2001-2008, > 430,000 children \leq 5 yrs were seen in EDs due to poisonings from self-ingested prescription and OTC medicines.



- In 2010, the ASPCA Animal Poison Control Center received more than 41,700 calls related to pets consuming human medications.



Main Risks of Improper Disposal Practices

2. Environmental impacts

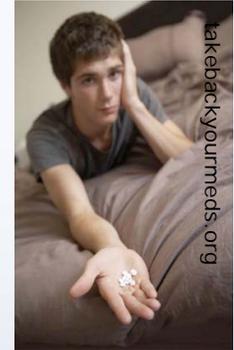
- Accumulation in waterways leads to concern about continuous, multigenerational exposure to wildlife.
- Impacts to terrestrial species.



Main Risks of Improper Disposal Practices

3. Illegal use or theft

- A survey of teens found that 62% who abused prescription pain relievers said they were easily accessible through parents' medicine cabinets.



4. Unnecessary waste of healthcare dollars



Pharmaceutical Waste Management: Issues and Barriers

- Communicating the issue
- Lack of conclusive research
- Controlled Substances Act
- Funding for staff, disposal & publicity
- Privacy of medical information
- Misinformation
- Convenience



Disposal: Individuals vs. Health Care Facilities

- Federal agencies that regulate handling and disposal of prescription meds include:
 - Drug Enforcement Administration (DEA)
 - Environmental Protection Agency (EPA)
 - Dept. of Health & Human Services (DHHS)
 - Dept. of Transportation (DOT)
- In addition, there are state laws regulating prescription meds, solid waste and hazardous waste.
- U.S. Resource Conservation and Recovery Act
 - Regulates transportation, treatment, and disposal of HW



Origin of Pharmaceuticals in the Environment



- What pharmaceuticals have been found?
- How do they reach the environment?
- Where have pharmaceuticals been found?
- What about treatment techniques?

Pharmaceuticals in the Environment

Types of human and animal pharmaceutical chemicals identified in water bodies (Daughton and Ternes 1999):

- Hormones
- Antibiotics
- Blood Lipid regulators
- Analgesics and anti-inflammatories
- Beta-blockers
- Antidepressants
- Antiepileptics
- Antineoplastics (used in chemotherapy)
- Tranquilizers
- Retinoids
- X-ray contrast media



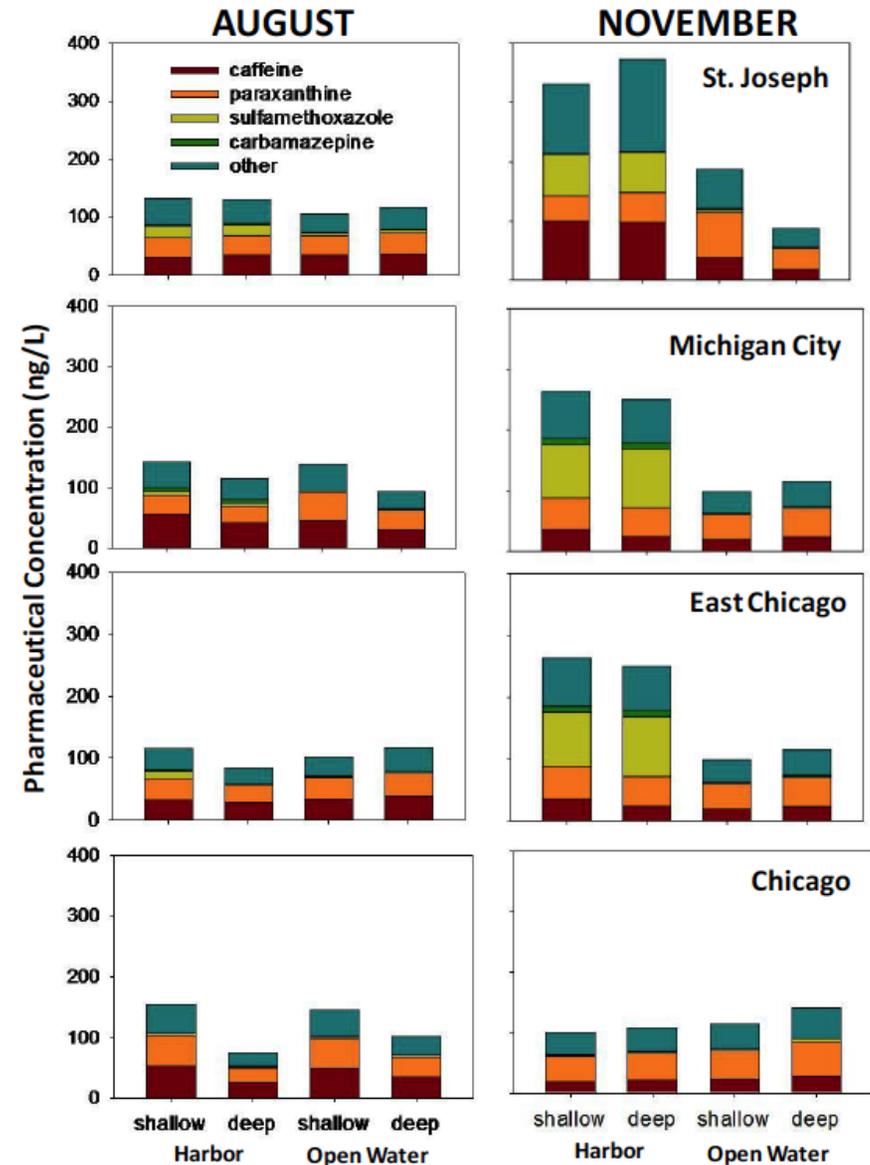
Pharmaceuticals in the Environment

Trace organics in Lake Michigan: Concentration and detection frequency of pharmaceuticals in the near-shore water column

Ball State University, Dr. Melody Bernot

Table 1. Concentrations of pharmaceuticals detected denoted as “other” in Figure 1. Values are ranges of concentrations detected across sites separated by sampling period (August, November 2011).

Compound	Concentration Range (ng/L)	
	August	November
Acetaminophen	2.5 - 5.1	3.5 - 13.0
Cotinine	1.5 - 4.7	2.8 - 6.3
Gemfibrozil	1.0 - 10.0	1.4 - 49
Ibuprofen	1.7 - 6.9	3.5 - 30
Lincomycin	1.5 - 3.1	3.5 - 7.9
Naproxen	5.0 - 10.0	3.5 - 30
Sulfadimethoxine	0.5 - 1.0	0.7 - 1.6
Sulfamerazine	0.5 - 1.0	0.7 - 1.6
Sulfamethazine	0.5 - 1.0	0.7 - 1.6
Sulfathiazole	0.5 - 1.0	0.7 - 1.6
Triclocarban	2.5 - 10.0	3.5 - 7.9
Trimethoprim	1.5 - 3.1	3.5 - 10.0
Tylosin	1.5 - 6.7	2.8 - 6.3



How do pharmaceuticals reach the environment?

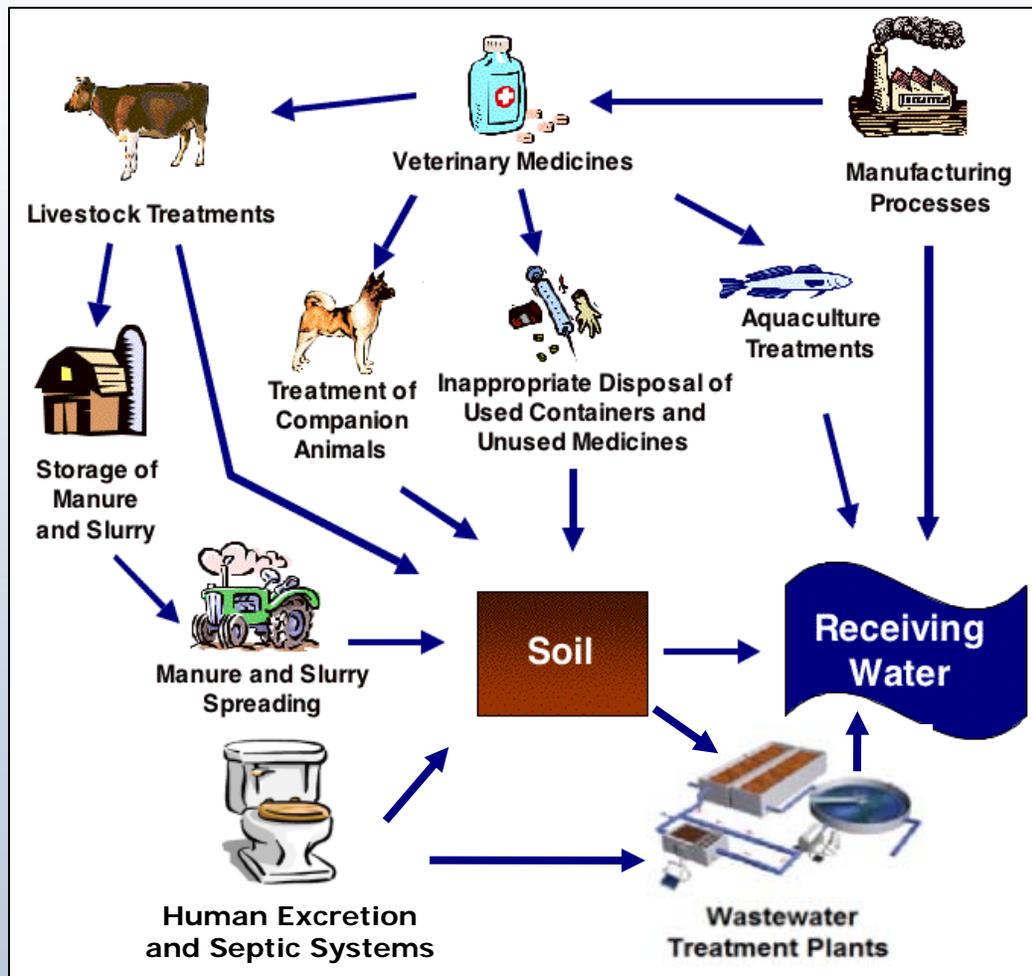


Figure adapted from A. Boxall, EMBO reports Vol. 5, No. 12, 2004

- Effluent from wastewater treatment plants
- Surface application of manure and biosolids
- Commercial animal feeding operations and aquaculture
- Landfill leachate (direct/wastewater treatment)
- Septic systems

Where are pharmaceuticals found?

In 1999-2000, the USGS surveyed 139 streams in 30 states for pharmaceuticals, hormones, and other organic contaminants. (Kolpin *et al.* 2002)



- They found medications in 80% of the sampled streams.

Since then, pharmaceuticals have been found just about everywhere:

- **rivers, ponds, lakes, groundwater, wastewater effluent, treated drinking water, sediment, plant and animal tissue** (www.epa.gov/ppcp/lit.html)

Where are pharmaceuticals found?

In 2001, the USGS and CDCP conducted a study at a drinking water facility to determine if 106 contaminants could survive the treatment process (Stackleberg *et al.* 2004).

- Sampled stream water as well as raw, settled, filtered, and finished water.
- 40 contaminants detected in one or more samples of stream water or raw-water
- Several prescription and OTC drugs were detected in the finished drinking water

In 2008, an AP investigation found pharmaceuticals in 24 major metropolitan areas.



Pharmaceuticals in the News

Drug control on a bad trip with the environment



Julie Deardorff
Toxics health and fitness reporter

If you're loading into or expired prescription drugs, the kind that some might want to chew or use to get high, the federal government has some advice. ■ Remove the pills from their original containers. ■ Mix them with an unpalatable substance, such as kitty litter or coffee grounds and put them in a sturdy or sealed bag so they are not eaten by children, pets or dumpsite scavengers. ■ Then, throw them in the trash.

If the drugs are particularly powerful addictive painkillers or stimulants, flush them the better, instead of depositing them in the trash. This may sound like a lot of trouble, but for a good reason. Accidental poisoning, a prescription drug abuse epidemic, and misuse is increasingly prevalent among teens and young adults. ■ It's now the second most common illegal drug problem in the nation behind marijuana, and the federal government is taking steps to curb it. More than 90 percent of the drug abusers say they get their drugs from a friend or relative for free, and Andrea Vastano, spokeswoman for the White House Office of National Drug Control Policy.

But the guidelines, issued earlier this year, are not as strict as several other federal agencies, including the Environmental Protection Agency, have a downside: They're not as environmentally friendly as some would like.

The best way to dispose unwanted medications is to toss them in a secure container with the proper controls, but this requires a mail or take-back program, something that isn't uniformly available in the U.S.

Some pharmacies will take unwanted medicine off your hands, and municipalities offer one-day collection events. You also can ship them to the nearby over-seas, but "there's no long-term solution to this growing and potentially dangerous waste stream," said Susan Hachino, a coastal settlement specialist with the Illinois-Indiana Sea Grant (IISG).

Throwing drugs in the trash means they have the potential to reach streams, lakes and other waterways through runoff and leachate if they don't make it in lined landfills.

DISPATCHES



TECHNOLOGY Pipe Dreams

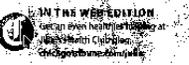
THE QUEST FOR PURIFYING WATER IN AN IMPROPER WORLD
By Julie Deardorff

THE AEROBIC COMPLAINING W.C. Field offered this rationale for not drinking tap water: "I feel bad in it." Clearly, Field's proposed fix, but there are reasons less likely to worry about the fluid flowing from our faucets these days. One, a water filtration cycle, lead from corroding pipes, a slew of herbicides and other chemicals that people expose down to toilet and shower water supply. An Associated Press investigation last year revealed that trace amounts of pharmaceuticals make their way into the drinking water of a least 41 million Americans. These chemicals (for example, antidepressants, cholesterol, epilepsy) can accumulate in the body, a process that scientists don't fully understand. Fish may be sensitive in our water sources, but thanks to mercury-like endocrine disruptors that have built up in water bodies such as Washington, D.C.'s Potomac River, some male fish have been found with immature eggs in their testes. Fish in Texas have been found with the active ingredients of Prozac in their brains. Only an ecologic researcher would think this funny.

36 WASH. POST THE ATLANTIC

letter way than only dealing with waste at the end of its life cycle."

■ **F. Smith, Julie Deardorff** at www.washingtonpost.com. Send health and fitness news to write@npr.org.



IN THE WOODS
Last year when he got a job at a...
...the...
...the...

that scapes on a broad range of alternatives than a carbon fiber alone. But reverse osmosis concentrations can be slow and cost-intensive, if not thousands of dollars. Most also come with pumpkin-sized storage tanks. One exception is General Electric's Aquia filter system, an elegant tankless device that can process more than 700 gallons a...

Drugging the Waters

HOW AN AGING POPULATION AND OUR GROWING ADDICTION TO PHARMACEUTICALS MAY BE POISONING OUR RIVERS

by Elizabeth Royte

norman Leonard moved to Heritage Village, a sprawling retirement community in western Connecticut, 11 years ago. Its green-gabled condominiums and Capes were well maintained, and the landscapers hadn't skimped on the rhododendrons. A retired CPA, Leonard considers himself, at age 80, to be in pretty decent shape. He plays platform tennis on the grounds and hikes often in nearby forests and reserves. But still, he takes five different drugs a day to manage his blood pressure, acid reflux, and high cholesterol. Heritage Village is home to about 4,000 residents with similar medical profiles, who take an average of six drugs a day.



And that's a healthy population. In a convalescent home a few miles away, Patricia Reilly, age 88, wheels herself each morning toward a low shelf. With a glass of water and small cups of applesauce at the ready, she prepares to take her morning medicines: nine different types that treat heart disease, acid reflux, renal stones, a chronic urinary-tract infection, chronic constipation, migraine headaches, depression, allergic rhinitis, degenerative arthritis, and intermittent vertigo. The 120 residents of River Glen Health Care Center, where the average age is 90, take an average of eight drugs a day, the most common among them target high cholesterol, high blood pressure, depression, and diabetes. Once swallowed, Reilly's medications will bring her some relief, but their biological activity won't stop once they leave her body.

When residents of Heritage Village and two other nearby retirement communities flush their toilets, wastewater laden with traces of prescription drugs rushes through a series of

pipes into the Heritage Village treatment system, which pumps water with radiation, to Kerley's Ultraviolet Series of portable systems that use iodine, among other things, and look like space bottles. Most filters, however, take the form of a device on the wall, which is attached to a water line. Water flows through the bag, leaving organic material and heavy metals behind, along with that briny chlorine taste. These devices—Erics is a subsidiary, Inertec of Chicago—and "not being the best known—are inexpensive and perform well. But carbon filters catch drugs in a jarwater. If the filters overload, they can dump excess contaminants, making your water less clean, too.

Dietering drinkers may care to investigate once a plant or two has been built to reverse osmosis. This technology is used to desalinate seawater, for example, and is used with your tap water, forcing it through a semipermeable membrane.

photographs by Masood Kamandy

26 **enr** FALL 2005



Hormones and Hormone Mimics in the Aquatic Environment

By Karen Kidd

Over a decade ago, fishermen first reported developmental abnormalities in fish from rivers in the United Kingdom. Follow-up investigations revealed that up to 100% of the males in reaches of the rivers had become feminized (lacking testis and gonads), and in the worst cases, had developed eggs. In the United Kingdom, the fish were also producing precursors of egg yolk (proteins called vitellogenin) when fed to the river water for only short periods of time. These fish are produced by the liver in response to estrogen in food stream and are used to mature eggs in the ovaries to spawning.

Endocrine system impacts

male fish normally only produce vitellogenin during the reproductive season in response to a rise in food stream estrogen levels—the appearance of vitellogenin in males is a sign that these fish were being exposed to something in the water was mimicking an estrogen. It



pletely broken down in the wastewater treatment process. As a result, effluent from these plants can contain complex and ill-defined mixtures of detergents, pesticides, antimicrobial agents, perfumes, plasticizers and pharmaceuticals. Some of these chemicals can interfere with or modulate the activity of sex hormones in the body, and produce biological responses that are similar to natural processes or that are in conflict with normal development. Laboratory studies have been conducted to determine the substances responsible for the feminization of male fish in rivers in the United Kingdom. It is now accepted that the estrogens produced naturally by women and the synthetic estrogen women consume in birth control and hormone replacement therapies are mainly responsible for the feminization of male fish (Desbrow et al. 1998). The hormones that control reproduction and development in humans are very similar or identical to the hormones used by you and

AN AP INVESTIGATION : Pharmaceuticals Found in Drinking Water

DAY 1	DAY 2	DAY 3
<p>PharmaWater I PharmaWater-NYC Water PharmaWater-Research PharmaWater-Matros-A to Z PharmaWater-Small Cities PharmaWater-WaterSheds PharmaWater-Metabolism</p>	<p>PharmaWater II PharmaWater-Secrecy</p>	<p>PharmaWater III PharmaWater-Philadelphia Drugs PharmaWater-Treatments PharmaWater-Bottled Water</p>

Drugs in the drinking water

Tests have detected minute concentrations of pharmaceuticals in the drinking water supplies of at least 46 million people in two dozen major American metropolitan areas, an Associated Press investigation has found. The federal government does not regulate prescription drugs in water.

Treatment Techniques

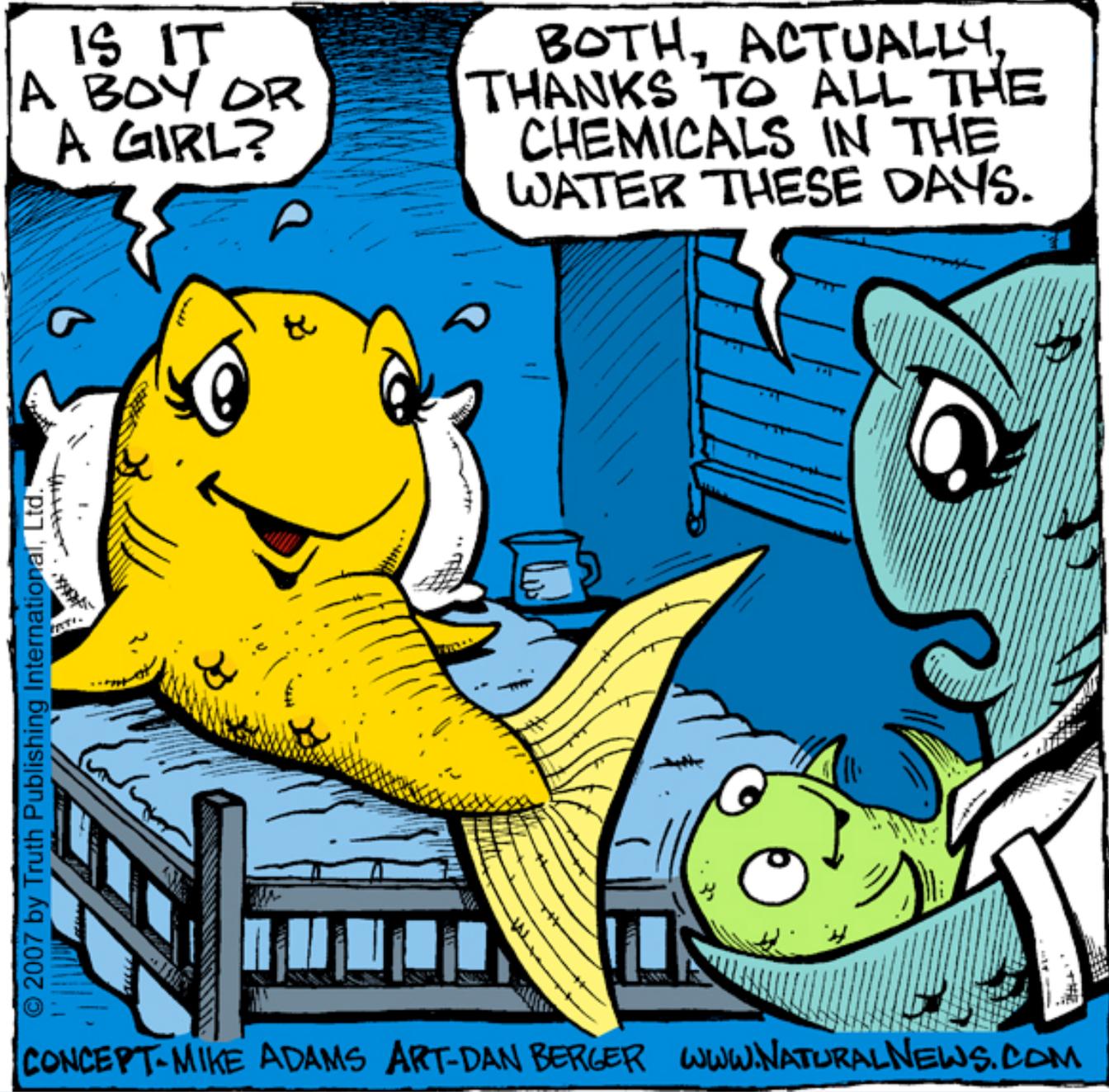
Septic systems and most wastewater treatment facilities were not designed to remove pharmaceuticals.

There are several techniques that can be used to remove pharmaceuticals from water:

- Longer solids retention (SRTs) (5-15 days)
- Filters and disinfectants (Chlorine) (Work best in combination)
- Bacteria
- Reverse Osmosis (Expensive and produces brine)
(Zuehlke 2006)
- Ultrasound (Xiao and Weaver, The Ohio State University 2011)

Examples of Environmental Impacts

- Steroid Compounds
- Anti-depressants (SSRIs)
- Non-steroidal anti-inflammatories (NSAIs)



IS IT
A BOY OR
A GIRL?

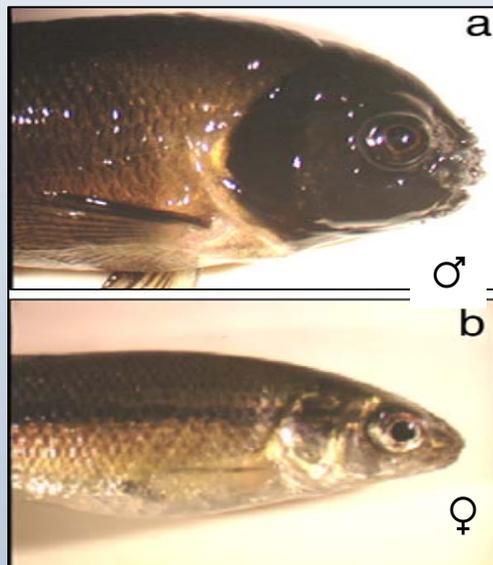
BOTH, ACTUALLY,
THANKS TO ALL THE
CHEMICALS IN THE
WATER THESE DAYS.

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CONCEPT-MIKE ADAMS ART-DAN BERGER WWW.NATURALNEWS.COM

Steroid Compounds

- Estrogens can have feminization effects on male fish
(Nash et al. 2004, Jobling et al. 1998)
- Androgens can have masculinization effects on female fish (Ankley et al. 2003; Morthorst et al. 2010)



Steroid Compounds

- Population effects (Kidd 2007)
 - 7 year, whole lake experiment in Ontario, Canada
 - Added ppt of oestrogen 3Xs week
 - Male fathead minnows became feminized
 - After the second season, the population crashed



Serotonin Reuptake Inhibitors (SSRIs)

- Changes in fish and shrimp behavior
(Fluoxetine)
- Metamorphosis delays in frogs
(Fluoxetine)
- Induce mussel spawning
(Norfluoxetine/ Fluvoxamine)



Serotonin Reuptake Inhibitors (SSRIs)

African frog tadpoles were raised in clean water and in tanks of water mixed with 38 ppb fluoxetine (Prozac)

- Days after the tadpoles hatched, the control group had begun to develop legs, but the “treated” tadpoles had no legs.



African frog (*Xenopus laevis*)
tadpole in clean water



African frog (*Xenopus laevis*)
tadpole in treated water

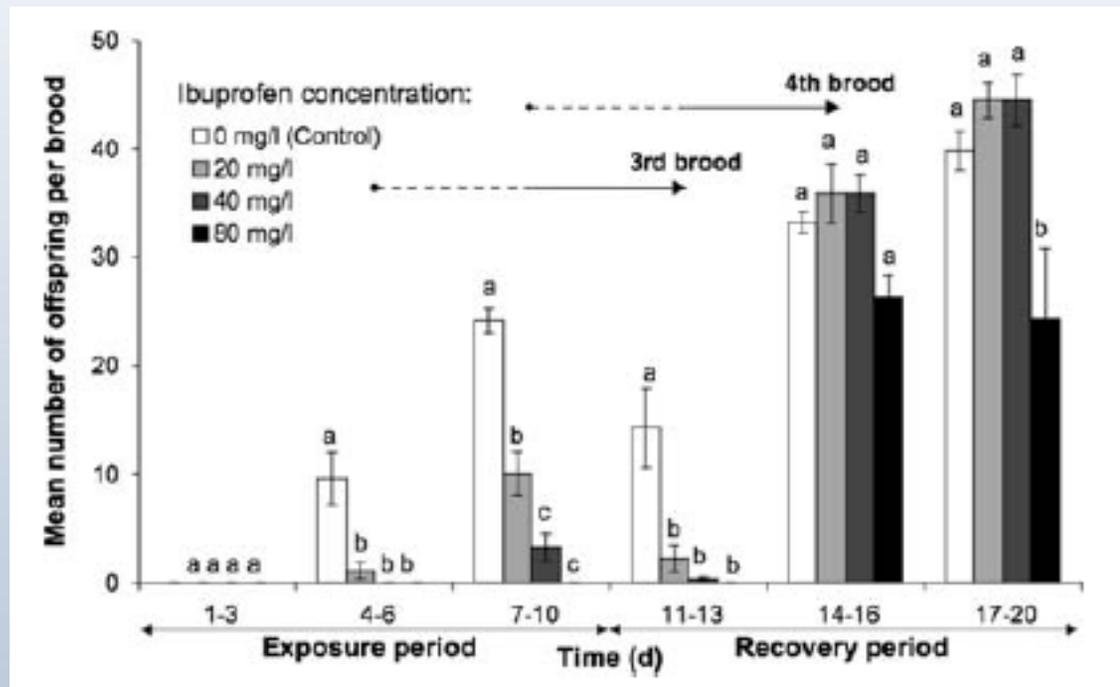
Non-steroidal anti-inflammatory (NSAIs)

Ibuprofen

10-day exposure to Ibuprofen followed by 10-day recovery period in clean water



Daphnia magna



Exposure
decreased
number of
young
produced

Non-steroidal anti-inflammatory (NSAIs)

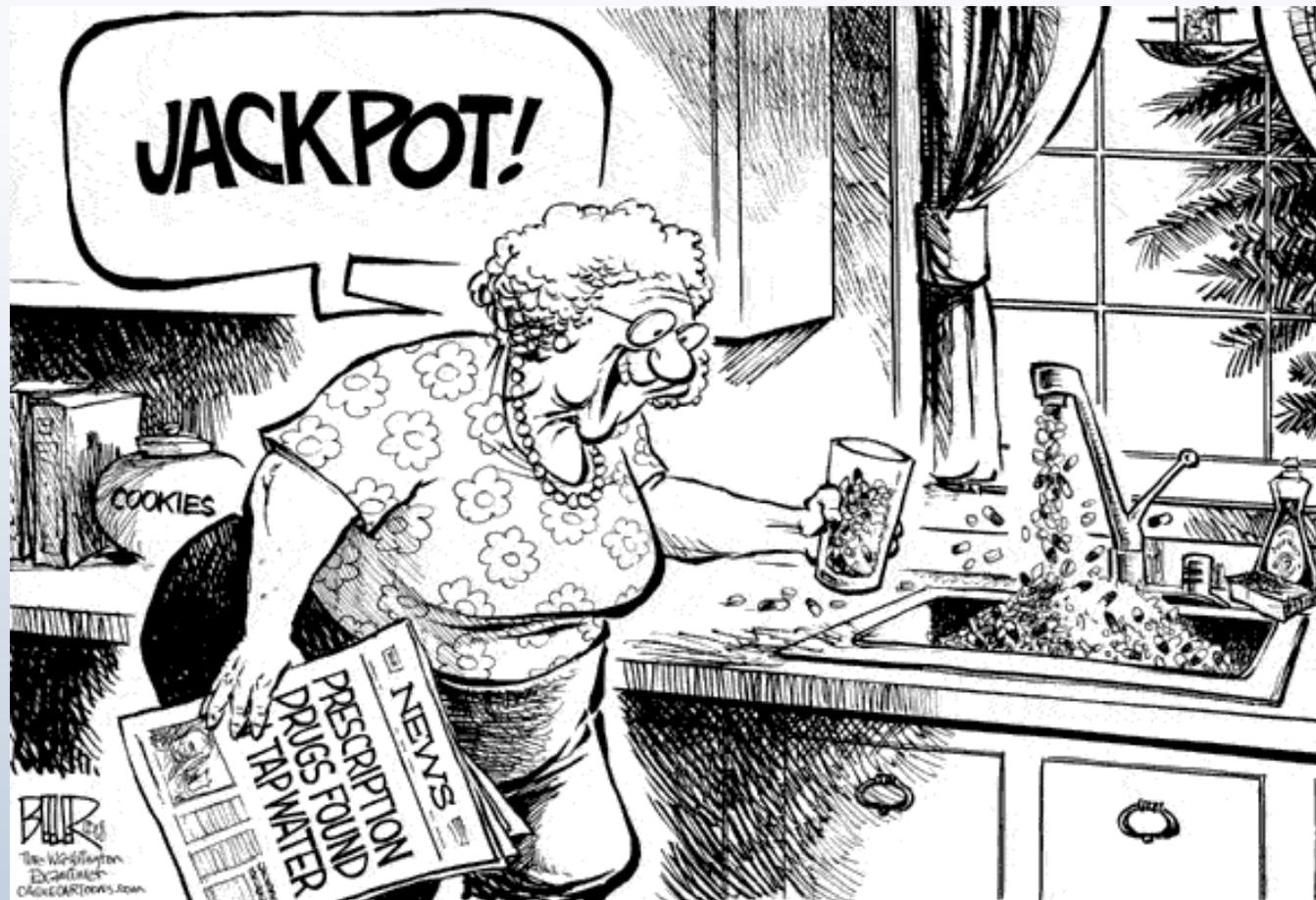
- In the early 1990s, white-backed vultures experienced dramatic population declines (~95%) in India, Pakistan and Nepal
- Diclofenac (Voltaren®, Cataflam®) was heavily used in cattle
- And the cattle carcasses were a major food source for the vultures
- Birds died of acute renal failure



Take-home Messages

- Some pharmaceutical chemicals (e.g., anti-epileptics) persist
- Others are “pseudo-persistent”– They break down but are continually replaced
- Greatest concern is population-level effects: the multi-generation exposure to low-dose for small aquatic organisms





Potential Impacts on People

- Chemicals found in the environment are several orders of magnitude lower than concentrations known to exert effects on humans.
- Using animals as sentinels
- Direct human toxicity unlikely, but subtle long-term effects? (antibiotic resistance)
- Concerns about fetal exposure (ex. Diethylstilbestrol)
- Adverse effects from meds in drinking water is not expected (Bruce et al. 2010, WHO 2011)

Understanding Regulations

Pharmaceutical wastes can be classified as hazardous waste, medical waste, or non-hazardous waste depending on the chemical, physical, and toxicological properties.

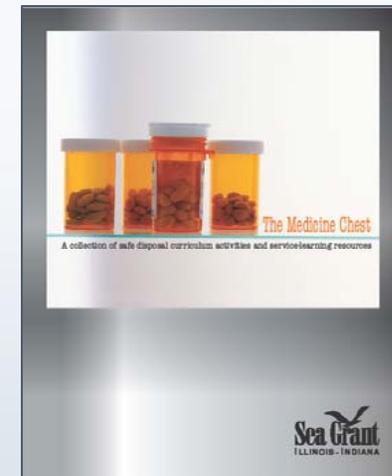
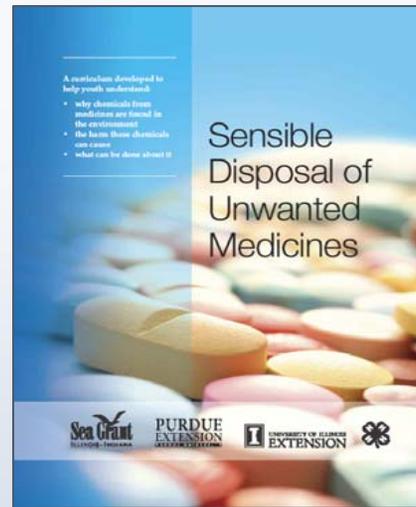
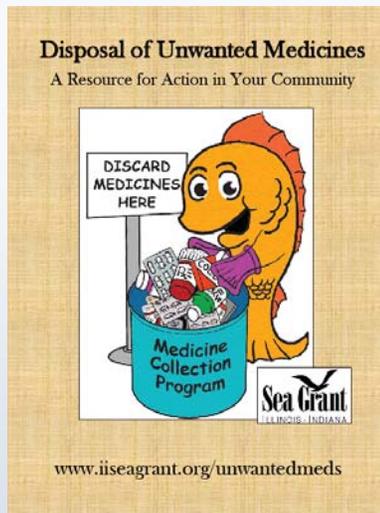
Hazardous Waste characteristics:

- Ignitability
- Corrosivity
- Reactivity
- Toxicity

P-listed (acutely hazardous) and U-listed wastes



Resources



EPA Database of Published Literature (~ 13,000 references)

<http://www.epa.gov/ppcp/lit.html>

Pharmwaste email listserve – national group of health care professionals, waste management officials, government

<http://lists.dep.state.fl.us/cgi-bin/mailman/listinfo/pharmwaste>

DON'T FLUSH MEDICINE



Laura Kammin

Pollution Prevention Specialist

Illinois-Indiana Sea Grant

lkammin@illinois.edu

217-333-1115

www.unwantedmeds.org