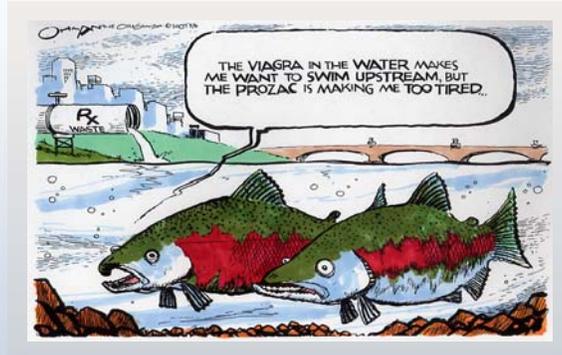


Pharmaceutical Waste Management: Environmental Impacts



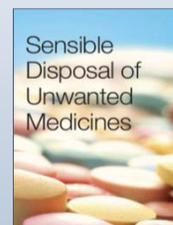
HealthCare Pharmaceutical Waste Management Workshop
26 January 2012



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



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

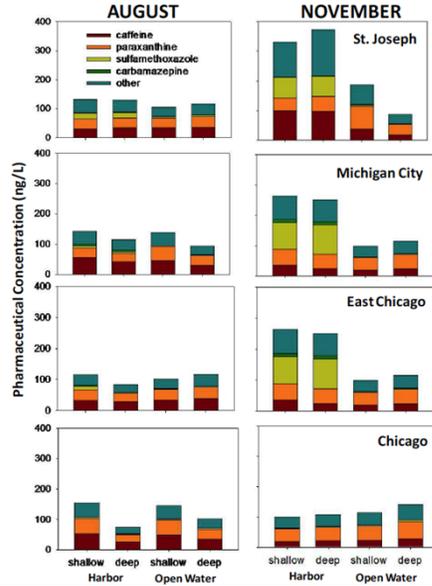


Pharmaceuticals in the Environment

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

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

Drug control on a bad trip with the environment

ECO-JOURNAL
January/February 2011
Hormones and Hormone Mimics in the Aquatic Environment

AN AP INVESTIGATION: Pharmaceuticals Found in Drinking Water

Drugs in the drinking water
Tests have detected minute concentrations of pharmaceuticals in the drinking water supplies of at least 48 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

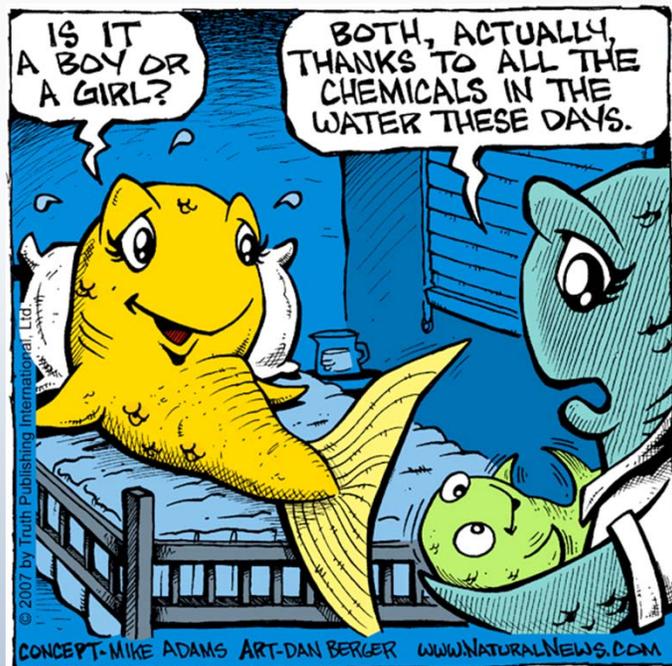
Septic systems and most wastewater treatment facilities were not designed to remove pharmaceuticals.

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)

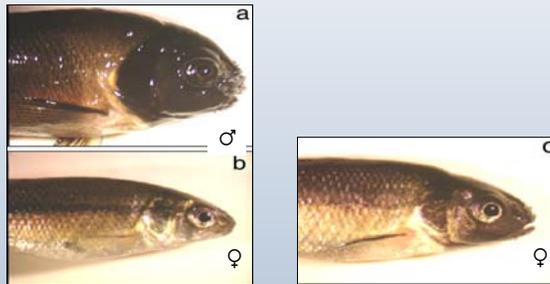
Examples of Environmental Impacts

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



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

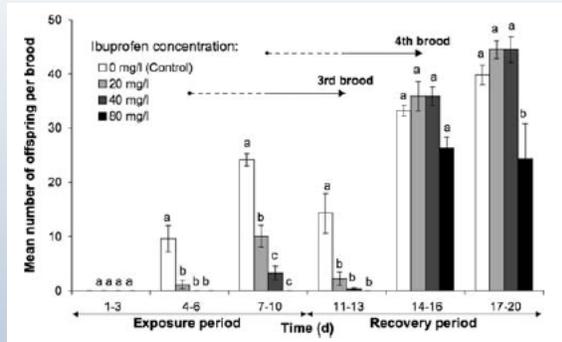
Non-steroidal anti-inflammatory (NSAIs)

Ibuprofen

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



Daphnia magna



Exposure
decreased
number of
young
produced

Hayashi et al. 2008. *Ecotoxicology*. 17:246-251.

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



Oaks et al. 2004. *Nature* 427:596-598

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.

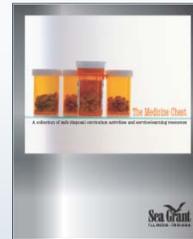
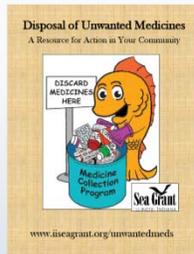
Hazardous Waste characteristics:

- 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**



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