

# Source Control for Pharmaceuticals in Wastewater

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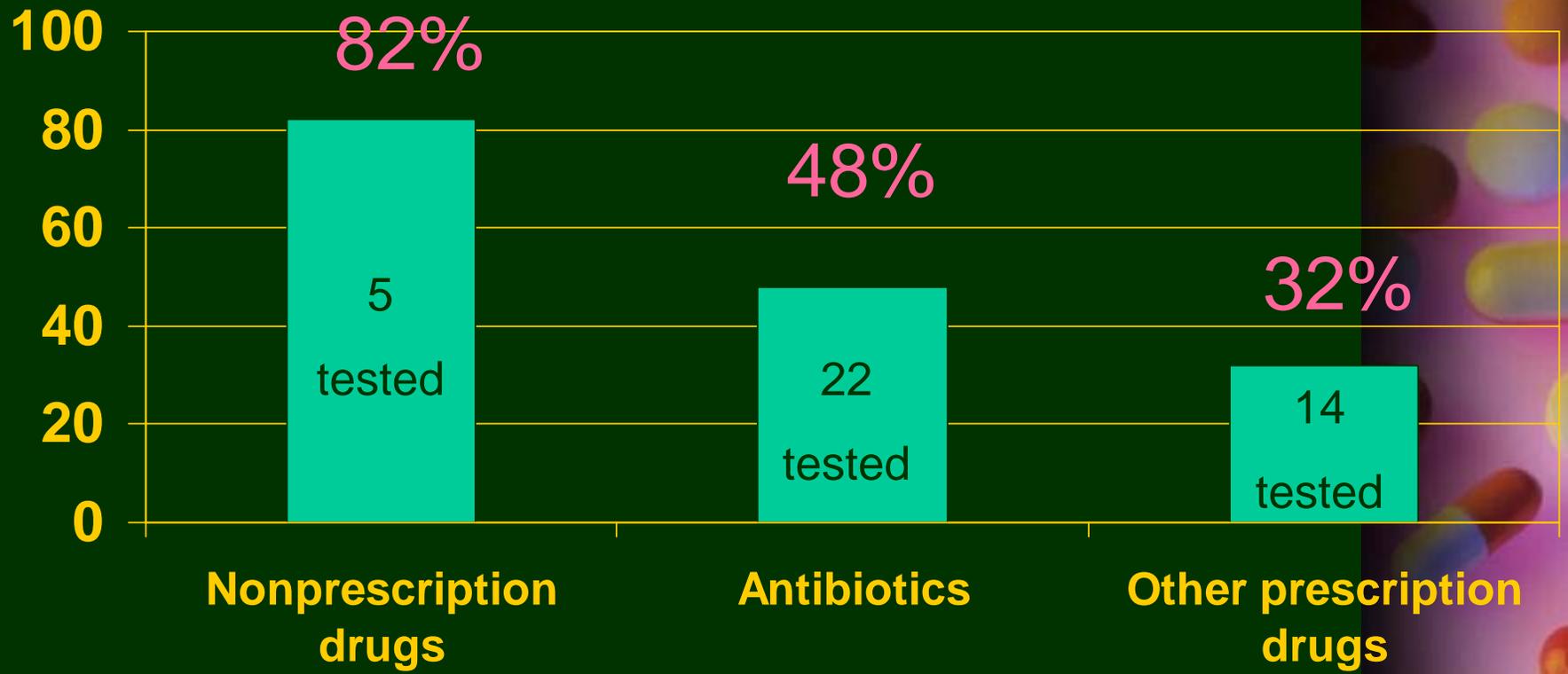
# US Waterways are Impacted!

- USGS Analyzed 139 streams- 80% of samples analyzed one or more of pharmaceuticals
  - Acetaminophen (24%)
  - Steroids and hormones (16%)
  - Diltiazem (blood pressure medication) (13%)
  - Codeine (11%)
  - Antibiotics and antimicrobials (10%)
  - Ibuprofen (10%)



# USGS Stream Survey

## Frequency of Detection by Drug Class



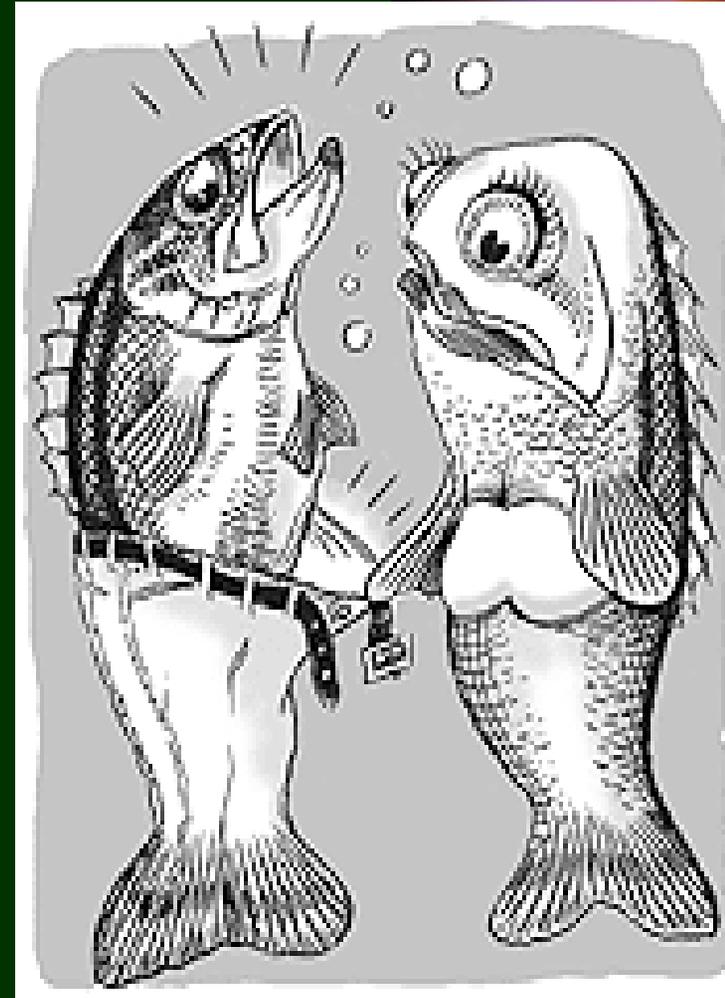
# Why do we care?

- Potential effects to organisms
  - Endocrine disruption
  - Synergistic effects
  - Possible toxicity
- Precautionary Principle
  - Pharmaceuticals should not be in the aquatic environment
  - Limited toxicological information on pharmaceuticals less than 1% of active ingredient products
- Creation of “superbugs”



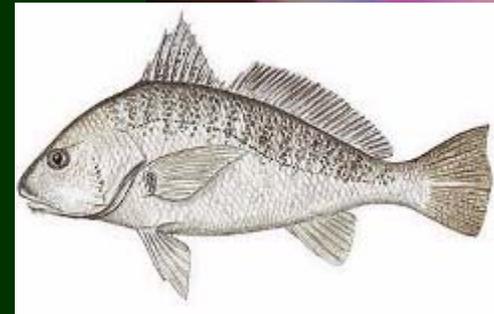
# 17alpha ethynyl estradiol

- Synthetic estrogen
- Present in 16% of rivers in USGS study
- Median concentration 73 ng/l
- Vitellogenin production (feminization) in male fish
- Effects at concentrations as low as 1 ng/l
- Feminization of male fish in Lake Mead & UK linked to estrogens



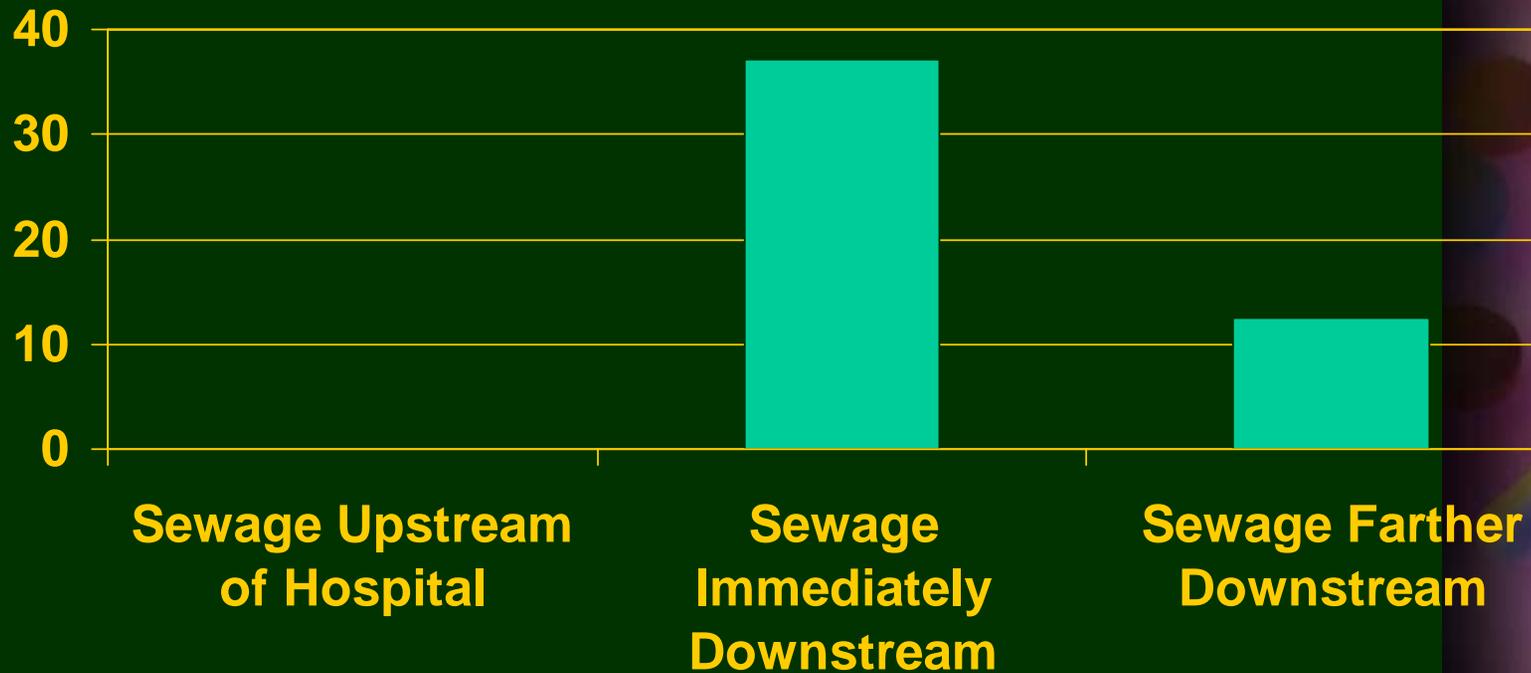
# Other Endocrine Disruptors

- SSRIs (antidepressants) induce spawning in shellfish
- Calcium channel blockers (used to lower blood pressure) dramatically inhibit sperm activity in Atlantic croaker
- Clofibrate (used to lower cholesterol) caused high production of estrogen in juvenile zebra fish at concentrations present in Chesapeake Bay



# Antibiotic Resistance

Percent of Resistance to Oxytetracycline in Acinetobacter Isolates, Danish Study



# Antibiotic Resistance

- Ampicillin-resistant bacteria found in every U.S. river tested in a 1999 study
  - 4 - 59% of population resistant
  - Significant numbers contained plasmids, which may be transferable to other organisms
- All samples of Ohio River water and two tributaries, contained E. coli with some degree of resistance to penicillin, tetracycline, and vancomycin in a 2000 study
  - Samples containing the highest levels of antibiotics also contained bacteria with greatest resistance



# Persistence of Pharmaceuticals

- B-blocker nadolol and antibiotic amoxicillin 80-90% excreted unchanged
- Persistence in environment due to constant discharge
  - Antiepileptic drug carbamazepine
  - 50% breaks down after 82 days under semi-field conditions (Lam et al 2003)



# How Pharmaceuticals get into the Environment

- Wastewater treatment plants that treat household, industrial, and business
- Industrial dischargers
- Commercial animal feeding operations
- Surface application of biosolids

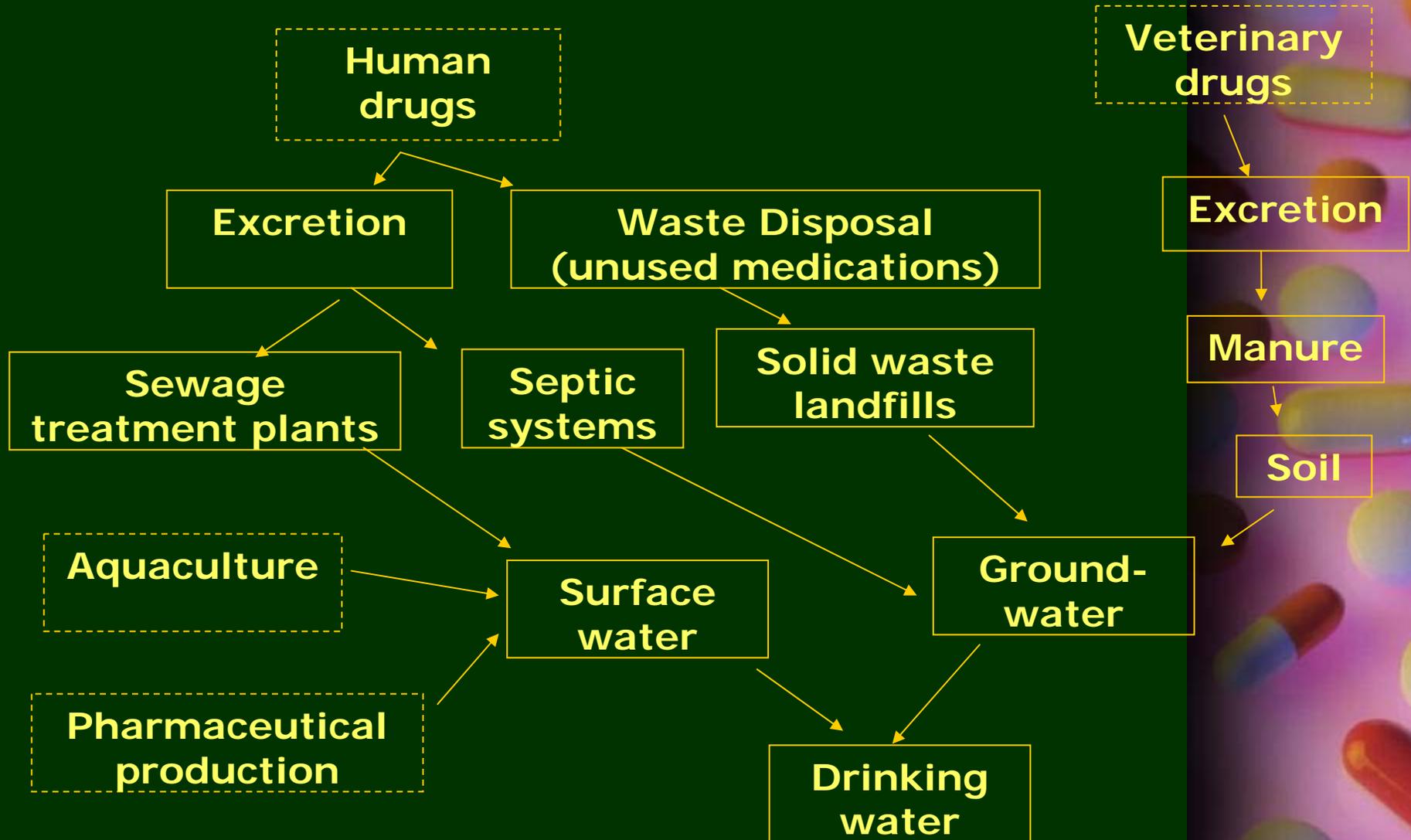


# Drug Portal to the World



adapted by Daughton from Ternes (April 20)

# Sources and Pathways



# Excretion Percentages – Top 10 US Pharmaceuticals in 2003

- Lipitor - cholesterol reduction – < 2% excreted
- Zocor – cholesterol reduction – < 0.5% excreted
- Prevacid – ulcers - < 1% excreted
- Procrit – anemia – < 5% excreted
- Zyprexa – antipsychotic – 7% excreted
- Epogen – anemia – < 5% excreted
- Nexium – acid reflux - < 1% excreted
- Zoloft – antidepressant – 14% excreted
- Celebrex – anti-inflammatory - < 3% excreted
- Neurontin – antiseizure – 100% excreted
- Leading OTC drug: Ibuprofen – 10% excreted



# Removal Rate at WWTPs

- Sex hormones reduced by 68%
- Natural steroids and synthetic hormones are removed at 38-83%
- The majority of compounds are predicted to be removed via the sludge phase



# Major Sources of Pharmaceutical Waste

- Regulated
  - Hospitals
  - Pharmacies
  - Assisted living facilities
  - Veterinary hospitals
  - Dentists
- Unregulated
  - Residents
  - Hospice patients



# Residential Pharmaceutical Waste



# Who regulates residential pharmaceutical waste?

- Department of Health Services
  - Do not regulate residential pharmaceuticals, have no jurisdiction over residential medical care
- Department of Toxic Substances
  - Do not regulate residential pharmaceutical waste, even if it is classified as a hazardous waste
- Drug Enforcement Agency
  - Out of the closed loop system no longer regulated
- U.S. Food and Drug Administration
  - Approve drugs, do not care about end of life



# Residential Disposal of Pharmaceutical Waste

- Unregulated
- Pharmacies are not required to take-back unused/ expired medications
- Traditionally, two disposal options
  - Down the drain
  - Trash
- Now have other options
  - Household Hazardous Waste Events
  - Working on other options for residents



# Other Programs

- Return unwanted medicine (RUM) program in Australia
  - > 30 tons collected in 2004
  - 20 million people
  - Since 1998 – funded by government with approximate cost of 1 million per year
- California ~ population 35 million
  - Implies that we have greater than 30 tons of pharmaceuticals being disposed of incorrectly every year!



# Current Pilot Programs

- Palo Alto hosts take back at Senior Centers
  - Collected 75 lbs of pharmaceuticals during 3 day event
  - Only advertised at Senior Centers
- County of Marin
  - Take back at 5 pharmacies
  - 2 months one 8 gallon container of waste pharmaceuticals
- State of Maine – one Saturday collected at pharmacy
  - 52 people approximately 50 gallons one day event
  - USEPA collaborated with Police, Northeast Recycling Council, Maine EPA and Pharmacy



# Return of Medications (survey at pharmacies in UK)

- Majority of items returned from people over 60 years old
- Reasons for return
  - Medication stopped
  - Patient died
  - Excess supply or clear out
  - Medication stopped by patient
  - Adverse effect from drug
  - Most returns within a year of being prescribed



# Residential Pharmaceuticals

Potential Actions	Anticipated Challenges	Next Steps
Discourage disposal in toilets or sinks	Funding; prioritization amongst other clean water agencies	NGOs encouraged to educate residents on this topic
Encourage disposal at HHW events	Funding for HHW programs prior to region-wide campaign	Local HHW and POTWs are encouraged to communicate about local funding constraints
Take-back programs at pharmacies	Buy-in from pharmacies, HMO pharmacies, and drug store chains/businesses; funding	Local pilot programs are encouraged
Take back events at senior centers	Coordinate with HHW programs or haulers	Educate seniors and provide take-back options
Take back events or programs with Fire/Police	Buy-in from fire or police department; funding	Local agencies may wish to collaborate with Fire/ Police to pilot a take-back event

# Next Steps

- Wastewater agencies work with HHW programs to develop an easy drop-off alternative for residents
- Further Research
  - Hospice Patients
  - Drug Enforcement Agency
- Future Legislation Options



# Contact Information

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