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Pipeline

NESC

Small Community Wastewater Issues Explained to the Public

Pharmaceuticals and Personal Care Products: An Overview

It just makes sense to want clean, safe water. The thought of drinking polluted water or bathing in a murky mess is very distasteful. Because our desire to have safe water sources is so strong, we have developed increasingly sophisticated methods for monitoring and detecting pollutants in the water.

Having these improved tests means that groundwater and surface water contamination can be detected at lower and lower levels—even down to nanograms per liter. And that has led to an emerging public awareness about pollutants. Pharmaceuticals and personal care products (PPCPs) are some of these emerging contaminants.

Lately new information about PPCPs turning up in the environment has been making headlines and raising questions about potential human health risks. And all of this attention has led scientists to realize that they don't know much about the kinds of impacts PPCPs may have.

According to the U.S. Environmental Protection Agency (EPA), two classes of PPCPs are considered therapeutics: antibiotics and steroidal hormones. Antibiotics may cause resistance among pathogens, making some bugs difficult to kill. Steroidal hormones overlap with another

Watersheds supply our drinking water, provide habitat for plants and animals, and serve as sources for recreation and relaxation. Researchers are examining the possible impact of pharmaceuticals and personal care products (PPCPs) on water quality.

class, known as endocrine disruptors. Not much is known about any other class of PPCPs. And PPCP levels are not regulated in drinking water.

Researchers have detected PPCPs in quantifiable amounts in samples collected from U.S. waterways. PPCPs that have been found include medications for pain, depression, and colds; birth control pills; caffeine; hair products; cleaning supplies and pesticides. Some of these products contain endocrine disrupting compounds and other contaminants that researchers fear may harm aquatic life. However, research has only just begun and little evidence exists about the consequences on human or aquatic life.

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Significant sources of PPCPs include pharmaceutical and chemical manufacturing facilities, hospitals, nursing homes, long-term care facilities, pharmacies, veterinary operations, landfill leachate, septage tank haulers, meat processors, and runoff from animal feeding operations where large quantities of antibiotics and other drugs are used.

Surprisingly, however, one of the largest sources of PPCPs is the typical household where PPCPs enter wastewater treatment plants through human excrement, flushing unused medications, and washing chemicals down the drain. And as we use more and better deodorants, disinfectants, birth control products, and pesticides, the amount of PPCPs found in the environment will become greater. No one knows what, if anything, PPCPs may be doing to septic systems performance.

While there is no certainty, antibacterial soaps and cleansers may have an effect on the bacteriological requirements of the treatment system. Without the proper balance of bacteria in the system, waste may not break down as it should, and the result could be early system failure.

What are the possible health effects?

There are more questions about the possible health effects of PPCPs on humans and aquatic life than there are answers. Most of the research to date has only proven that various PPCPs are present in the environment.

Because such a broad mix of compounds have been found, the U.S. Geological Survey thinks it is impossible to predict what any possible health effects might be. Researchers will have to take this complex mixture into account before they can say that this compound or these sets of compounds are causing an observed effect.

Most of the research on the effects of PPCPs involves antibiotic and hormone drugs. Research has shown that sex steroids from oral contraceptives and other similar chemicals can feminize male fish and change behaviors of either sex. A three-year study by a research team at Brunel University in the United Kingdom found that many final sewage effluents contain estrogenic hormones believed to originate from women's urine. The research began after the discovery that male fish in the lagoons of a United Kingdom wastewater treatment plant had become partly feminized. In Europe, researchers have tied a decline in human male sperm count to low levels of birth control hormones in the environment.

Antibiotics are viewed as "wonder drugs" with their ability to treat infectious diseases that were often killers. However, widespread use of antibiotics by both humans and in livestock has led to antibiotic resistant bacteria. Traces of antibiotics in watersheds may only magnify this problem.

Studies within the U.S. indicate that groundwater that is down gradient from hospital and veterinary clinic waste may contain varying amounts of antibiotics, i.e. sulfonamides and trimethoprim. One Wisconsin study found antibiotics in wastewater effluent as well as adjacent groundwater monitoring wells. According to this study, however, samples contained only minute amounts of antibiotics (<10 micrograms per liter [ug/L]), and the size of the treatment facility had no effect on whether antibiotics were found.

What are endocrine disruptors?

Some chemicals, both natural and man-made, can interfere with the hormonal systems of humans, animals, and aquatic

life. Endocrine disrupting chemicals (EDCs) can act in a number of ways in different parts of the body. They may:

- reduce the production of hormones in endocrine glands,
- affect the release of hormones from endocrine glands,
- copy or counteract the action of hormones at target tissues, or
- speed up the metabolism of hormones and so reduce their action.

In many cases, it is not yet clear exactly how EDCs act, even in some cases where a link has been shown between EDC exposure and an adverse effect.

According to the National Institute of Environmental Health Sciences (NIEHS), endocrine disruptors may be responsible for emerging cases of breast and other cancers, as well as endometriosis and subfertility or infertility. Some suspected endocrine disruptors come from chlorinated organic chemicals, such as DDT, toxaphene, and kepone. They also come from herbicides, such as 2,4-D; mercury; styrene; dioxin; and polychlorinated biphenols.

Preventing PPCPs from Entering the Environment

One key to limiting the amount of PPCPs that enter the environment is direct disposal of unused drugs. But, because this country doesn't have a cohesive set of regulations or even guidance for proper disposal of unused drugs, a consistent guide needs to be created about the safest way to dispose of drugs.

Another aspect that could limit the introduction of PPCPs into the environment has to do with their intended use. Although not much can be done about chemicals that are considered human medicine, according to EPA, there are a wide number of things that can be done with respect to drug design and delivery that can actually lower doses of drugs or make drugs more environmentally friendly. Also, users can change their habits regarding antibacterial soaps, disinfectants, and other PPCPs used around the home.

PPCPs and Water Reuse

EPA researchers note that one of the largest reasons people have fears about PPCPs is they can come from excrement. The agency notes that also may be the reason that some water reuse projects fail, such as various toilet-to-tap programs, which propose to reclaim wastewater for drinking.

Water reuse is common in Hawaii since nearly all of the state's drinking water supply is obtained from unconfined groundwater aquifiers. Drinking water for the one million residents of Oahu Island in Hawaii is obtained from groundwater. In Oahu, treated wastewater is used to irrigate some agricultural lands and some of the 35 golf courses on the island. Therefore, protecting this groundwater from possible contamination is important.

Roger Babcock, Ph.D., associate professor of civil and environmental engineering at the University of Hawaii, is currently involved with a study on Hawaii's Oahu Island to screen groundwater, wastewater, and reclaimed water for PPCPs. In addition to PPCP detection, the study also determines soil sorption characteristics of selected pharmaceutical compounds and the fate and transport of PPCPs in recycled water during percolation through soil in field-test plots.

"What we are trying to do is figure out what the fate of these compounds is when they are discharged into the environment," Babcock said.

Currently, recycled water cannot be used over an aquifer and this was the catalyst for the study, Babcock said. "Recycled water is generally only approved for use in areas where it's not over a drinking water supply, but there is a proposal for fairly large-scale reuse over a potable aquifer. This study is aimed at finding out if that's okay," he said.

Results of the study so far indicate PPCPs were found in treated and untreated wastewater, but no PPCPs were detected in the groundwater samples taken.

Unanswered Questions

It will probably take many years to solve the mystery of PPCPs. Currently, more questions are generated than answers about the potential effects of PPCPs, but one thing is certain—detection of PPCPs does have an emotional impact on all levels of society.

Researchers have speculated that people have a far stronger reaction to the detection of PPCPs verses the detection of pesticides in the environment because

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Reprint Info

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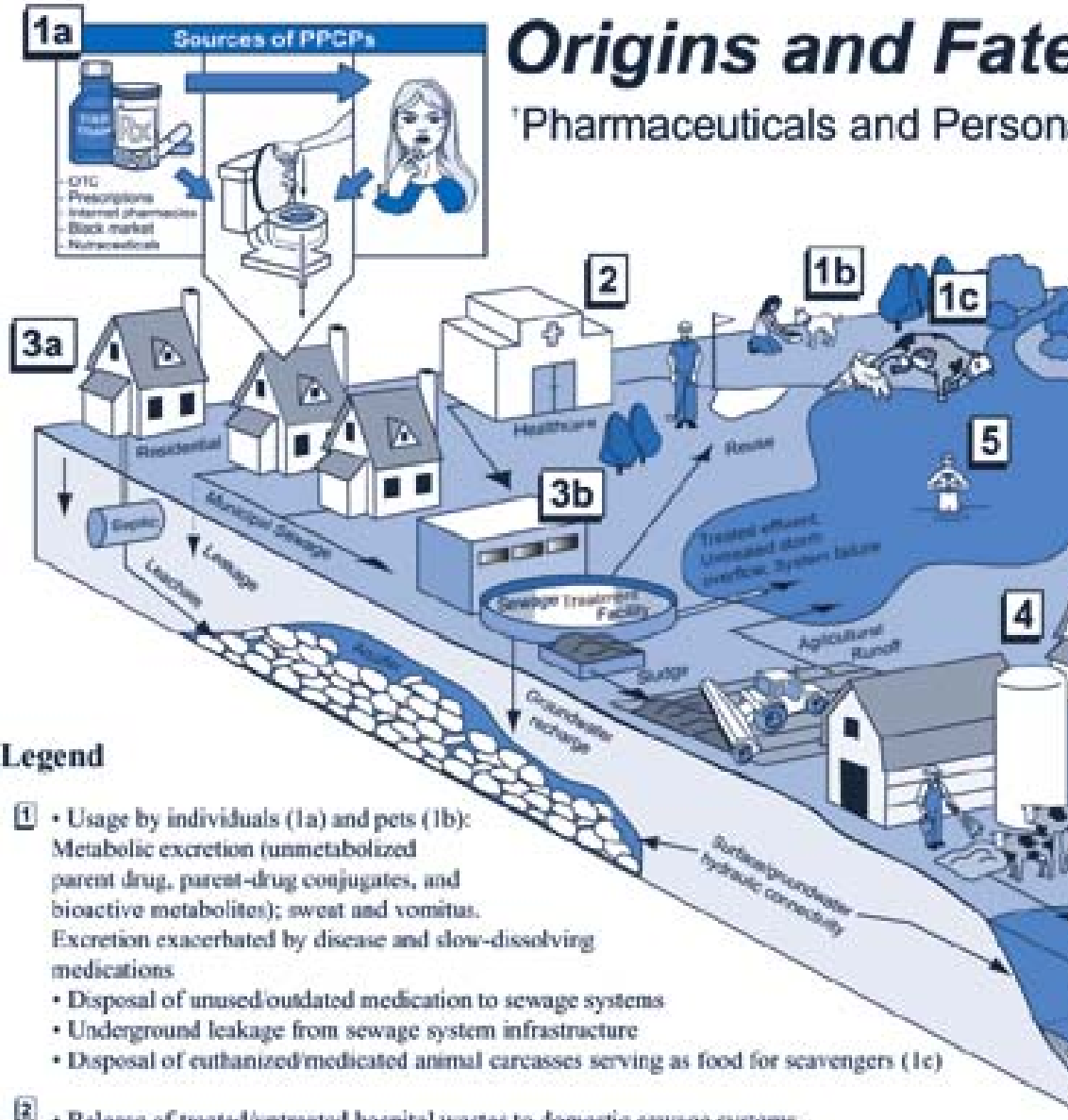

Origins and Fate

Pharmaceuticals and Person

Legend

1 • Usage by individuals (1a) and pets (1b): Metabolic excretion (unmetabolized parent drug, parent-drug conjugates, and bioactive metabolites); sweat and vomitus. Excretion exacerbated by disease and slow-dissolving medications
• Disposal of unused/outdated medication to sewage systems
• Underground leakage from sewage system infrastructure
• Disposal of euthanized/medicated animal carcasses serving as food for scavengers (1c)

2 • Release of treated/untreated hospital wastes to domestic sewage systems (weighted toward acutely toxic drugs and diagnostic agents, as opposed to long-term medications); also disposal by pharmacies, physicians, humanitarian drug surplus

3 • Release to private septic/leach fields (3a)
• Treated effluent from domestic sewage treatment plants discharged to surface waters, re-injected into aquifers (recharge), recycled/reused (irrigation or domestic uses) (3b)
• Overflow of untreated sewage from storm events and system failures directly to surface waters (3b)

4 • Transfer of sewage solids ("biosolids") to land (e.g., soil amendment/fertilization)
• "Straight-piping" from homes (untreated sewage discharged directly to surface waters)
• Release from agriculture: spray drift from tree crops (e.g., antibiotics)
• Dung from medicated domestic animals (e.g., feed) - CAFOs (confined animal feeding operations)

5 • Direct release to open waters via washing/bathing/swimming

6 • Discharge of regulated/controlled industrial manufacturing waste streams
• Disposal/release from clandestine drug labs and illicit drug usage

Christian G. Daughton, U.S. EPA-Las Vegas

March
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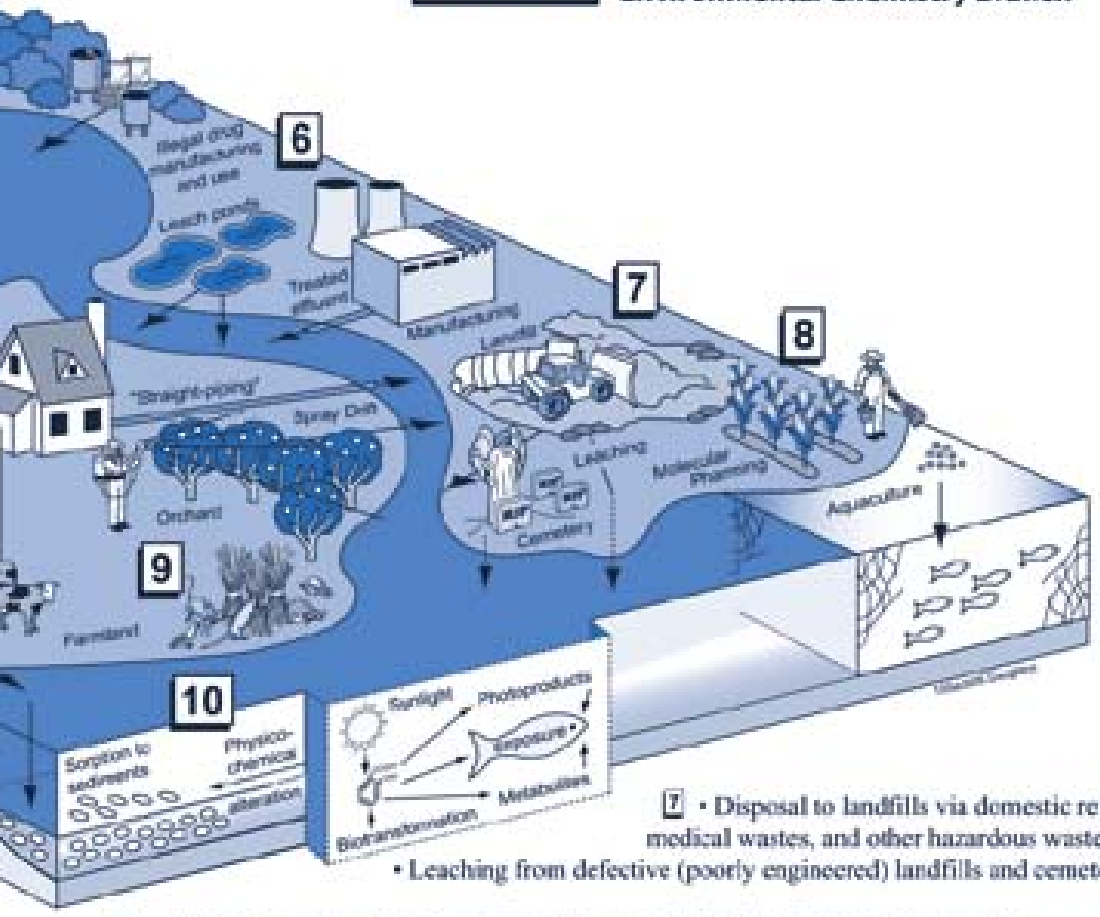
e of PPCPs† in the Environment

al Care Products

U.S. Environmental Protection Agency
Office of Research and Development
National Exposure Research Laboratory
Environmental Sciences Division
Environmental Chemistry Branch



7 • Disposal to landfills via domestic refuse, medical wastes, and other hazardous wastes
• Leaching from defective (poorly engineered) landfills and cemeteries

8 • Release to open waters from aquaculture (medicated feed and resulting excreta)
• Future potential for release from molecular pharming (production of therapeutics in crops)

9 • Release of drugs that serve double duty as pest control agents:
examples: 4-aminopyridine, experimental multiple sclerosis drug → used as avicide; warfarin, anticoagulant → rat poison; azacholesterol, antilipidemics → avian/rodent reproductive inhibitors; certain antibiotics → used for orchard pathogens; acetaminophen, analgesic → brown tree snake control; caffeine, stimulant → *coqui* frog control

10 Ultimate environmental transport/fate:
- most PPCPs eventually transported from terrestrial domain to aqueous domain
- phototransformation (both direct and indirect reactions via UV light)
- physicochemical alteration, degradation, and ultimate mineralization
- volatilization (mainly certain anesthetics, fragrances)
- some uptake by plants
- respirable particulates containing sorbed drugs (e.g., medicated-feed dusts)

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ruary 2001)

http://epa.gov/nerlesd1/chemistry/pharma/images/drawing.pdf
from: http://epa.gov/nerlesd1/chemistry/pharma/

continued from page 6

ibuprofen and caffeine are drugs that the public uses. Now that we know these compounds are out there, the big question is—how much of an impact do PPCPs have on the environment and what do we do about it?

For more information on PPCPs contact Daughton at (702) 798-2207 or daughton.christian@epa.gov, *Kolpin at (319) 358-3614* or dwkolpin@usgs.gov, *Babcock at (808) 956-7298 or* rbabcock@hawaii.edu *or visit EPA's Web Site on PPCPs at* www.epa.gov/nerlesd1/chemistry/pharma/index.htm

Additional information may be found in the National Environmental Services Center's magazines. *The Small Flows Quarterly* Winter 2004 contains an article titled, "The Mystery Behind PPCPs." *On Tap* magazine Winter 2003 contains an article titled "Endocrine Disruptors: What are they doing to you?" These articles are available online at www.nesc.wvu.edu or by calling 1-800-624-8301 or 1-304-293-4191.

Chemicals May Play Role in Rise in Obesity

According to an article that appeared in the March 12, 2007, Washington Post, "too many calories and too little exercise are undeniably the major factors contributing to the obesity epidemic, but several recent animal studies suggest that environmental exposure to widely used chemicals may also help make people fat."

Preliminary evidence suggests that through a process scientists call adipogenesis, chemicals, which have been shown to cause abnormal changes in animals' sexual development, can also trigger fat-cell activity.

Marine paints, pesticides, and certain food and beverage containers are made up of some of the chemicals under investigation. The Centers for Disease Control and Prevention found one chemical, bisphenol A, in 95 percent of the people tested, at levels at or above those that affected development in animals.

Jerry Heindel, a top official of the National Institute of Environmental Health Sciences (NIEHS), said the suspected link between obesity and exposure to "endocrine disrupters," as the chemicals are called because of their hormone-like effects, is "plausible and possible."

Bruce Blumberg, a developmental and cell biologist at the University of California at Irvine, called the chemicals "obesogens"—chemicals that promote obesity.

The World Health Organization estimates that more than a billion adults worldwide are overweight and 300 million are obese. Scientists have begun examining a wide range of possible causes beyond eating too much and exercising too little—including possible chemical exposures.

Blumberg began to suspect a link while trying to pinpoint how one endocrine disrupter, tributyltin, affects genetic mechanisms in the reproductive system. Tributyltin is used as a marine and agricultural fungicide, an antimicrobial agent in industrial water systems, and in plastics; it can cause serious sexual abnormalities in marine animals.

"What we discovered," Blumberg said, is that tributyltin disrupted genetic interactions that regulate fat-cell activity in animals. "Exposure to tributyltin is increasing the number of fat cells, so the individual will get fatter faster as these cells produce more of the hormones that say 'feed me,'" Blumberg said. The exposed animals, he added, remain predisposed to obesity for life.

Retha R. Newbold, a developmental biologist at the NIEHS, has seen similar lifetime effects in her work with diethylstilbestrol (DES), a potent synthetic estrogen she has studied for 30 years.

Newbold's research has shown that mice exposed to DES during early development produced more fat cells, larger fat cells, and more abdominal fat than those not exposed. Exposed mice became obese adults and remained obese even on reduced calorie and increased exercise regimes. Like tributyltin, DES appeared to permanently disrupt the hormonal mechanisms regulating body weight."Once these genetic changes happen in utero, they are irreversible and are with the individual for life," Newbold said.

Bisphenol A is another compound that has captured researchers attention. Bisphenol A, is an ingredient in polycarbonate plastics that are used in many products, including refillable water containers and baby bottles, and epoxy resins that line the inside of food cans and also used as dental sealants. In 2003, U.S. industry consumed about two billion pounds of bisphenol A.

Researchers have studied bisphenol A's effects on estrogen function for more than a decade and have found indications that developmental exposure to low doses of bisphenol A activates genetic mechanisms that promote fat-cell activity.

Research into the impact of endocrine-disrupting chemicals on obesity has been done only in laboratory animals, but the genetic receptors that control fat cell activity are functionally identical across species.

For more information about this article, visit the Washington Post's Web site at *www.washingtonpost.com/wpdyn/content/article/2007/03/11/AR2007031100918.html.*

Don't

Those Old Meds!

Today, new medications are being manufactured constantly. And with this increased production comes increased usage. Regardless of how medications make their way into the wastewater stream, inadvertently by excretion or purposefully by disposal, increased usage means increased amounts in the environment.

There is no best answer for what to do with unused or expired medications, but one thing is for sure, it is no longer recommended to flush them down the sink or toilet. Sewage treatment plants weren't designed to remove these chemicals, and many drugs are showing up in our surface and groundwater.

Surprisingly, no specific government guidelines exist for the disposal of drugs by the consumer. The U.S. Food and Drug Administration and the U.S. Environmental Protection Agency (EPA) regulate the disposal of pharmaceuticals at the manufacturers' level. However, there are few good recommendations for consumers.

Some state and local agencies have come up with their own drug disposal legislation. The California Waste Prevention Information Exchange recommends the return of drugs to pharmacies via take-back programs, but these programs are not present in all communities. In Maine, a state mail-back program has been proposed where patients will be provided with prepaid mailers to be sent to a secure address where only Drug Enforcement Agency (DEA) officers will handle the unwanted medications.

Although details vary from state to state, at least 26 states have created some sort of program that allows the return of prescription drugs in original packaging from state programs, nursing homes, or other medical facilities to be redistributed to needy residents. Be sure and check with your local health department or EPA office for any special rules that apply to your area.

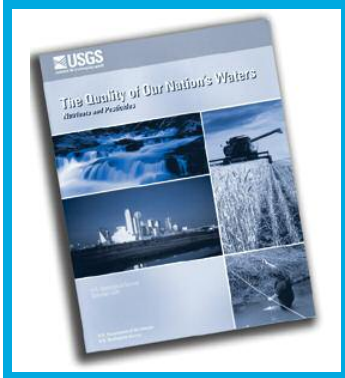
Some communities have household hazardous waste programs, the same ones that accept old motor oil and batteries, that accept unwanted medications, however the incineration costs are often prohibitive and the legality issues of working with controlled substances are problematic.

Pharmacy take-back programs are a great idea but they are not widely available and here too the legalities involved make them difficult to set up. For private citizens, one option is to throw drugs into the trash. This is not preferable, but it is less harmful to the environment than disposal into the wastewater stream. To do this safely and reduce potential for abuse:

1. Keep drugs in the original container (with safety lids).
2. Scratch out patient information on labels.
3. Place liquids in glass bottles in plastic re-sealable bags to contain leakage.
4. Add some water to dry tablets or capsules to dissolve them slightly.
5. Place in the trash as close to garbage pick up time as possible.

Source: www.epa.gov/nerlesd1/chemistry/ppcp/images/pharmacist.pdf (Accessed March 8, 2007)

Related Resources



"The Quality of Our Nation's Waters: Nutrients and Pesticides"
U.S. Geological Survey (USGS) and U.S. Department of the Interior

This report is the first in a series of nontechnical publications, The Quality of Our Nation's Waters,that describes the National Water-Quality Assessment (NAWQA) Program's major findings on water-quality issues of regional and national concern.

As part of the NAWQA Program, the USGS works with other federal, state, and local agencies to understand the spatial extent of water quality, how water quality changes with time, and how human activities and natural factors affect water quality across the nation. This first report discusses nutrients and pesticides in water and pesticides in bed sediment and fish tissue. It is intended primarily for those involved in resource management, conservation, regulation, and policy making at regional and national levels. (local and state officials, general public, state regulatory agencies, and public health officials)
GNBKGN16/Book: 84 pp. (1999). $0.00

Animal Agriculture: Waste Management Practices
U.S. General Accounting Office Resources, Community, and Economic Development Division

This booklet discusses the growing concern over pollution from intensive livestock and poultry production. It examines waste management practices used in the U.S. and other countries, as well as potential new practices based on technologies transferred from other industries.

The booklet identifies the federal financial and technical assistance available for waste management and how to obtain this assistance and summarizes federal agencies' roles in conducting and/or supporting research to develop new waste management practices. The booklet includes four appendices with information about the USDA, EPA, and other federal financial and technical assistance programs. (state officials, public health officials, finance officers, contractors, developers, and general public)
GNBLGN17/Booklet: 44 pp. (1999). $2.55

Organic Wastewater Compounds, Pharmaceuticals, and Coliphage in Groundwater Impacted by Onsite Wastewater - ***WWCDMG47*** $0.00

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