

**STRATEGIES FOR SUSTAINABLE UNWANTED MEDICINE COLLECTION  
PROGRAMS: IN COMMUNITIES, IN THE CLASSROOM, AND BEYOND**

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## ABSTRACT

Medicines are produced in increasing volumes every year and the rate of development of new medicines also continues to grow. With this growth comes concern regarding the environmental fate of unwanted medicines. Recent studies have identified pharmaceutical compounds in fresh and marine waters nationwide, and several of these bioactive compounds are potentially harmful to aquatic organisms, even in small quantities. Additionally, improper medicines disposal poses poisoning risks to children, the elderly and pets and can lead to medicine and/or identity theft. Unused medicines may accumulate in homes or be flushed, placed in the trash, or given to others, all of which have significant disadvantages. One approach for decreasing amounts of unwanted medicines reaching the environment is the organization of collection programs that ensure safer methods of disposal. Illinois-Indiana Sea Grant has developed a toolkit, *Disposal of Unwanted Medicines: A Resource for Action in Your Community*, to establish safe, legal collection programs in communities. We focus on collection events for the public as a partial solution to the problem. Our new educational initiative provides tools for youth and their families to play an active role in this issue through education and outreach strategies for best practices for safe disposal of unwanted medicines. Unwanted medicine disposal information is being disseminated through the creation of programming and activities for 4-H youth, scouts, and after-school youth clubs. Youth in these non-formal education programs will serve as an important agent for change to help protect and improve the quality of our waters. Our partnership with the innovative and successful Prescription Pill and Drug Disposal Program (P<sup>2</sup>D<sup>2</sup>) Network will also be presented.

## INTRODUCTION

The fate of unused medicines is a rapidly emerging concern that spans a broad range of issues including human and environmental health, water quality, solid waste management, law enforcement, and the health care industry. Substances of concern include both prescription and non-prescription medicines, and this category is sometimes expanded to include cleansing agents, cosmetics, nutritional supplements, and skin care products. A common term used for this suite of compounds is pharmaceuticals and personal care products (PPCPs). There are thousands of products that fall into this classification; all of these substances are specifically designed to interact with biological processes and are widely used around the world. They can enter the environment when people dispose of medicines via trash or toilet, or after use when they are excreted in their original or metabolized form or rinsed off the skin in the case of topical applications (Daughton and Ternes 1999).

### The Issue

Medicines are produced and prescribed in increasing volumes every year. In the United States, sales of over-the-counter medicines have increased by 60% since the 1990s<sup>1</sup>. In 2008, total sales for prescription medicines in the United States reached \$291.5 billion, a 1.4 percent increase from 2007 (Ruiz 2009). With these increases comes concern about the fate and effects of these compounds in the environment. Recent studies have identified a wide range of pharmaceutical chemicals in rivers, streams, and groundwater nationwide (Kolpin *et al.* 2002, Barnes *et al.* 2008), and it has also been shown that some of these compounds are potentially harmful to aquatic organisms, affecting reproduction and development even at very low concentrations in some cases (cited in Daughton and Ternes 1999). The fate of pharmaceutical chemicals in sewage sludge is also of concern (Kolpin *et al.* 2002), as sludge from wastewater treatment is often applied to agricultural land as a fertilizer. The long-term impacts of medicine disposal on our

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<sup>1</sup> Pistell, Anne. Maine Department of Environmental Protection. Presentation at Northeast Water Science Forum, August 9, 2007.

health and the health of the environment are not fully known. However, unless action is taken, the quantity of these chemicals reaching our waterways will continue to increase as pharmaceutical usage increases. Thus, Illinois-Indiana Sea Grant recommends a precautionary approach to this issue.

So what can be done? The issues surrounding medicine disposal are complex. Improper disposal of unwanted medicines can pose a risk to children and pets. For example, medicines placed in the trash without taking precautions to secure the container, make the medication unpalatable, or disguise the content are potentially accessible to children and pets, sometimes resulting in unintentional poisonings. Medicines disposed with their original labels intact can result in identity theft and medicine theft. This is an especially important issue for the elderly, who are the biggest consumers of prescribed medicines.

In early 2007, the Office of National Drug Control Policy issued guidelines for proper disposal of prescription drugs, following on the heels of several states providing advice to their citizens. This guidance was most recently updated in October 2009 and is available at [http://www.whitehousedrugpolicy.gov/publications/pdf/prescrip\\_disposal.pdf](http://www.whitehousedrugpolicy.gov/publications/pdf/prescrip_disposal.pdf). The three main components of the national guidelines are:

1. Don't flush medications down the toilet unless the label specifically instructs you to do so and instead,
2. Take advantage of community take-back programs or other programs that collect medicines at a central location for proper disposal. If a take-back or collection program is not available, then
3. Remove labeling from packaging and dissolve solid medications, mix with unpalatable items (kitty litter, coffee grounds, etc.) and seal in a bag before placing in the trash.

Several states have adapted these suggested guidelines and issued state-specific advice to ensure compliance with specific state hazardous waste and household waste regulations. These strategies include the opportunity to mail or bring unused medications to various collection points, such as pharmacies and community collection events, for eventual destruction. Options such as mixing with plaster, crushing the pills, and locking up medication if it can be done safely until the next community collection have also been suggested. All of these approaches to medication disposal play roles in reducing the introduction of pharmaceuticals to the environment. A summary of current disposal practices for unwanted residential medications in the United States is provided in a review by Glassmeyer *et al.* (2008).

Disposal to trash is considered to be an interim solution because medicines placed in landfills are likely to slow the transport of the chemical to waterways or sludge, but landfill leachate can ultimately reach wastewater treatment plants and local streams and rivers (Barnes *et al.* 2004). Illinois-Indiana Sea Grant believes that currently, the best disposal solution is incineration of medications in a regulated incinerator. There is, however, a very long list of hurdles to overcome before a national disposal plan can be implemented that is protective of humans, wildlife and pets and their shared environment. These hurdles include identifying safe and convenient medicine collection pathways, determining who will pay for this service, and minimizing the need for disposal through smarter prescribing and smarter consumer choices to save healthcare dollars and resources.

The Illinois-Indiana Sea Grant resource kit, *Disposal of Unwanted Medicines: A Resource for Action in Your Community* was created to help communities design, establish and implement safe and legal unwanted medicines collection programs. One component of a successful program is identifying the best way to engage the community and let them know when the collection will occur and what can be brought to the event. Included in the kit are several examples of pamphlets, fact sheets and education materials that have been developed by communities and states as they wrestle with this complicated issue. The recommendations and advice vary because jurisdictions are finding different ways to deal with the fact that only interim solutions are

available currently. These outreach materials can be adapted and used by other communities to save time and funds.

The good news about this issue is that it touches upon so many different aspects of our lives that there is no end of partners to join with to educate and reach out to the public. This issue impacts the elderly through medicine and identity theft issues, accidental poisoning, and health care costs. It matters to the police because prescription drug abuse by teenagers is on the rise. In 2008, 15.4% of 12th-graders reported using a prescription drug nonmedically within the past year (Johnston *et al.* 2009). Concerns for the safety of children and pets also can drive behavioral change. Furthermore, medications that go unused are a significant waste of health care dollars. And for all of us, our health depends on the health of our environment, including rivers and streams and the creatures that live in them.

## **BACKGROUND: DISPOSAL OF UNWANTED MEDICINES**

For many reasons, medicines are not always entirely used and therefore remain and may eventually expire in the hands of consumers or health care facilities. Some reasons for this include:

- Improvement of the patient's medical condition
- Patient or doctor decides to discontinue use of the medication due to side effects or lack of therapeutic effect
- Patient death
- Packaging contains more medication than the patient needs, e.g. with over-the-counter or prescription medicines bought in bulk

Disposal of unwanted medicines is an issue both for households and healthcare business such as hospitals, hospices, rehab centers, assisted living facilities, clinics, and pharmacies. Health care businesses' disposal practices are regulated at the state and federal level. Some medications are classified as hazardous waste because they contain or are preserved with hazardous chemicals (e.g. mercury, radioactive components) and therefore most states have specific regulations surrounding pharmaceutical disposal. The U.S. Environmental Protection Agency is currently considering including pharmaceuticals in the federal Universal Waste Rule set forth in 40 CFR part 273 which, if adopted by individual states, would allow for easier management of household medicine waste.

### **Current Disposal Patterns by Individuals**

A 1996 survey (Kuspis and Krenzlok 1996) examined the expired medicine disposal habits in 100 pharmacies and 500 patients. The survey found:

Pharmacies:

- 97% had established policies regarding the disposal of undispensed, expired medicines
- However, only 5% had consistent recommendations for customers on medicine disposal

Patients:

- 54.0% disposed of medicines in the trash
- 35.4% flushed medicines down the toilet or sink
- 7.2% did not dispose of medicines
- 2.0% used all medicines prior to expiration
- 1.4% returned medicines to the pharmacy

### **Risks of Unsafe Medicine Storage and Disposal**

1. Accidental poisoning: Medicines are the most common poison exposure category in the United States, and unsecured storage or disposal via the trash is a significant source of accidental poisoning. In the United States, approximately 30 children under age 5 years of age die as the result of unintentional poisoning annually (U.S. Consumer Product Safety Commission 2005).

Furthermore, data from the National Electronic Injury Surveillance System also indicate that in 2003, an estimated 78,000 children under age 5 were treated for poisonings in U.S. hospital emergency rooms (U.S. Consumer Product Safety Commission 2005). Additionally, as the biggest consumers of prescription medicines, it is possible for senior citizens to misuse and self-prescribe medicines, using out-of-date medicines from past ailments to treat new, undiagnosed symptoms. Having a large number of medicines in the home can contribute to confusion over proper dosages and which pills to take when.

2. Diversion and drug abuse: Medicines are sometimes misappropriated for consumption or sale by family members and friends, workers in homes, and by burglars. Storing numerous medicines in the home or throwing excess medicines in the trash without first securing them can lead to this type of misuse. The National Survey on Drug Use and Health found in a nationwide study that 12% of young adults (ages 18-25) used prescription pain relievers non-medically in 2005 (Office of Applied Studies, Substance Abuse and Mental Health Services Administration 2006). Of these users, 67% obtained them from a friend or relative, as compared to 14% who had the medicines prescribed to them by a doctor. The 2006 “Monitoring the Future” Survey conducted by the University of Michigan reported that although illegal drug use by American teens dropped more than 23% from 2001-2006, their abuse of medicines, both over-the-counter and prescription, was rising (Johnston *et al.* 2007).

3. Economic waste: Medicines thrown in the trash or flushed down the drain represent wasted health care dollars. Studies identifying the types and quantities of medicines that go unused could lead to better-informed prescription practices and better advice to patients on how to properly take prescriptions.

4. Improper medicine donations: In response to humanitarian crises, large quantities of medicines are sometimes donated internationally. If the donations do not match the need, or if the donated medicines are expired or otherwise unusable, significant disposal problems can arise overseas, as the receiving areas may have impaired waste treatment systems. Because there have been several cases where unusable medicines have been donated, in most cases with the best intentions, to international relief organizations during crises, the World Health Organization discourages donation of unwanted medicines from collection events (World Health Organization 1999). This is especially important as environmental safeguards for proper disposal of unusual medicines may not be available in these countries.

5. Environmental impact: Waste discharged through sewage systems can contaminate water resources in the surrounding environment. Pharmaceutical chemicals in waterways pose a potential for deleterious effects on wildlife. Wastewater treatment plants (WWTPs) are not designed to treat chemicals in medicines. Therefore, when flushed down the toilet or sink, some pharmaceutical chemicals pass through the WWTP altered or unaltered and can enter rivers, lakes, living organisms, and groundwater (Daughton and Ternes 1999). Additionally, some of these chemicals remain in the sewage treatment plant’s sludge, which is frequently applied to agricultural land as a fertilizer (Daughton and Ternes 1999).

Research is currently underway to develop treatment technologies at WWTPs because excreted medicines as well as unaltered parent compounds reach the treatment facilities (Daughton and Ternes 1999). This suggests that wastewater treatment at the WWTP will ultimately be very expensive, require a mixture of technologies, and may be a many years into the future. Removing purposeful disposal of unwanted medicines from the wastewater stream will decrease the amount of these chemicals entering the environment while technologies are being developed for the WWTP.

Trash disposal is recommended when collection programs are not available, however this pathway also has several significant disadvantages and may cause the same impacts as flushing. Most medicines are soluble in order to enter the blood stream or to reach other tissue. Thus when placed in landfills where water is moving through the waste, these chemicals can still reach waterways or be collected as part of leachate collection systems and end up in WWTPs.

Some pharmaceutical chemicals (e.g. anti-epileptics) persist in the environment; others are “pseudo-persistent”, in that they break down quickly but are continually replaced because of continual inputs. The concentrations of individual pharmaceutical chemicals detected in the influent of sewage treatment plants are typically in the range of a few parts per billion, while concentrations in treated effluent are usually lower, in the range of several hundred parts per trillion up to several parts per billion, depending on the chemical. As the effluent is diluted when it discharges into a river, the concentrations in waterways tend to range from undetectable to a few hundred parts per trillion. In sewage sludge, concentrations are sometimes much higher as the sludge is compacted.

Researchers have found that chronic exposure to low levels of pharmaceutical chemicals, within the same range of concentrations as has been observed in some waterways, can have significant effects on aquatic animals including fish (Palace *et al.* 2002, 2006) and lobsters. At present, the greatest concern regarding pharmaceutical chemicals in the environment is their potential effects on small aquatic organisms. This is mainly because these organisms have short generation times, hence multiple generations are easily exposed. Because of this, there is a greater likelihood that effects will not be restricted to individual organisms but instead will accumulate over time to result in population-level effects.

Pharmaceutical chemicals identified in the environment are generally present in concentrations several orders of magnitude lower than the concentrations known to exert effects on humans. This makes direct human toxicity seem unlikely but does not rule out the possibility of subtler long-term effects that are harder to detect and the exposure is to a vast mixture of compounds that we are unable to measure. Some scientists believe that low-level exposures to numerous drugs with the same or similar methods of action may add up to larger effects on aquatic organisms, that certain combinations of medicines may act synergistically to produce disproportionately large effects, or that other unpredictable interactions between chemicals may occur. It is possible that there were other substances of potential concern in the water that were unobserved in these studies simply because researchers did not sample for them, or because there are currently no analytical techniques capable of identifying them. Much research remains to be done in this area.

### **How do Pharmaceutical Chemicals Enter the Environment?**

Residential, commercial, and agricultural pharmaceutical chemicals follow two primary pathways to wastewater treatment systems:

- **Metabolic excretion:** Many pharmaceutical chemicals are biotransformed in the body. Biodegradation alters the chemical structure of their active molecules, which, in turn, often results in a change in their physical and chemical properties. Metabolism is frequently incomplete, and excretion rates range from 0 to 100% (Kummerer 2004, Bound and Voulvoulis 2005). As a result, sometimes a significant fraction of the medicine is not absorbed into the patient’s body and instead is excreted. In some cases, metabolic processes alter the medicine, creating a different chemical that may be more or less toxic than the parent compound and may revert back to the parent form in the sewage treatment plant or in the environment. This same process is true for livestock or pets being administered medicines.

- Direct disposal: Disposing of unwanted or expired medicines can be a challenge for households. In the United States, few formal guidelines are available for individual consumers on medicine disposal, and, consequently, most of their unused medicines enter septic tanks, sewers, or landfills.

Once they have been discarded or excreted, pharmaceutical chemicals enter surface waters and groundwater through several pathways:

- Effluent from plants that treat household, industrial, and hospital wastewater
- Septic systems
- Runoff and groundwater from uncontrolled landfills or landfill leachate sent to WWTPs
- Controlled industrial discharges
- Commercial animal feeding operations and aquaculture
- Surface application of manure and biosolids
- Runoff from dog parks

In general, wastewater treatment plants were not designed to remove dissolved medicines from water. They were designed to remove solids, organic materials, and some nutrients such as phosphorus and nitrogen. At wastewater treatment plants, water goes through one, two or three stages of treatment, depending on the sophistication of the plant and the needs of the community served.

Septic systems represent another source of unwanted medicines to surface and groundwater, as they are also not equipped to break down pharmaceutical chemicals (Swartz *et al.* 2006). Researchers have discovered some estrogenic chemicals in groundwater down-gradient of residential septic systems, and new research indicates higher levels of these chemicals in ponds near areas of higher residential density<sup>2</sup>.

## **RESIDENTIAL UNWANTED MEDICINE COLLECTION PROGRAMS IN ILLINOIS**

The Illinois Environmental Protection Agency (IEPA) has launched an initiative in collaboration with partners in both the private and public sector to promote environmentally responsible disposal of unwanted and expired medications. Under a pilot program, IEPA has worked with several communities across the state, including county health departments, other local governments and pharmacies to provide expanded opportunities for collecting or dropping off unwanted medicines and personal care products. For additional information and a map of Illinois counties with medicine disposal locations highlighted, visit the IEPA website <http://www.epa.state.il.us/medication-disposal>. Four medicine take-back program case studies from Illinois are also profiled in the Illinois-Indiana Sea Grant *Disposal of Unwanted Medicines: A Resource for Action in Your Community* toolkit, available online at <http://www.iisgcp.org/unwantedmeds/index.html>.

## **PRESCRIPTION PILL AND DRUG DISPOSAL (P<sup>2</sup>D<sup>2</sup>) NETWORK**

The P<sup>2</sup>D<sup>2</sup> program developed out of a research project undertaken by students in ecology and Illinois studies classes at Pontiac Township High School about the disposal of unwanted medicines. The students partnered with local pharmacies in Livingston County, Illinois, and undertook a multi-faceted campaign to provide their community with safe medicine disposal

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<sup>2</sup> Standley, L. Presentation “Contamination of Surface Ponds on Cape Cod, MA, by EDCs and Pharmaceuticals from Septic-Contaminated Groundwater” at Northeast Water Science Forum, August 8, 2007.

options. The program adapted and evolved as they looked for sustainable approaches for their community. The program has since grown to include pharmacies in 25 Illinois counties, Washington, Texas, Wisconsin, and Michigan. The students developed collection bins, billboards, press releases, and contacted many federal, state, and local officials to help encourage local communities to reduce the amount of unwanted medicines being thrown away inappropriately and ending up in Illinois waterways. Illinois-Indiana Sea Grant works with communities that want to join the P<sup>2</sup>D<sup>2</sup> network by providing information needed to undertake safe and legal medicine collection programs and by providing funding for program advertisements and purchase of safe medicine collection bins for police stations. Pharmaceuticals that are collected by the P<sup>2</sup>D<sup>2</sup> program are sent for incineration in a regulated hazardous waste incinerator. Incineration is currently the most environmentally safe technology for the disposal of medicines. The process is highly regulated by the U.S. Environmental Protection Agency and significantly minimizes contamination of air particles compared with other medication destruction methods that could end up in Illinois waters.

The P<sup>2</sup>D<sup>2</sup> network also works with the state of Illinois to identify and coordinate collection programs state-wide. The state of Illinois provides funding for disposal and transportation of unwanted medicines through state contracts with hazardous waste haulers. Illinois is committed to the prevention of improper disposal of pharmaceuticals, environmental protection, and resource conservation efforts that have been established by Illinois-Indiana Sea Grant and the P<sup>2</sup>D<sup>2</sup> network. These efforts are driven and sustained by communities that are highly motivated to collect unwanted medicines.

### **STUDENTS AS AGENTS FOR CHANGE: INFORMING COMMUNITIES ABOUT PROPER DISPOSAL OF UNWANTED MEDICINES**

In response to a growing national concern about improper disposal of unused or expired medicine and medicine misuse, educators from the University of Illinois Extension/Illinois-Indiana Sea Grant are creating two pilot education projects. Illinois-Indiana Sea Grant extension educators identified two target youth audiences to receive this information: high school students and 4-H youth. Two curriculum-based publications are in development for these youth audiences. The first is *The Medicine Chest: A collection of safe disposal curriculum activities and service-learning resources* (<http://www.iisgcp.org/education/MedicineChest.pdf>), a compilation of multidisciplinary, standards-based classroom lessons, sample stewardship activities, and background information for teachers and high school students. Activities included demonstrate how the improper disposal of unwanted medicines can be harmful to people, pets, and our waterways.

As they engage in these community stewardship activities, students will serve as “agents for change” in people’s habits to improve the quality of our waters. Students will develop lifelong skills as they provide useful information about medicine disposal to family members and various community sectors. Students who actively take part in *The Medicine Chest* activities will be equipped to deliver resource protection and health and safety messages to help people make conscientious decisions when disposing of medications and other household chemical products.

An important component of *The Medicine Chest* is the sample P<sup>2</sup>D<sup>2</sup> Project lesson plans developed by ecology, civics, language arts, music and art teachers at Pontiac Township High School (aligned with Indiana’s Academic Standards and National Science Standards). High school teachers will also be provided with numerous multidisciplinary approaches on how to engage students in successful service-learning projects and how to gather data from research-based background information, including Illinois-Indiana Sea Grant’s *Disposal of Unwanted Medicines* toolkit.

The second publication targeted to 4-H leaders and youth members is the 4-H Guide, *Disposal of Unwanted Medications*. Illinois-Indiana Sea Grant is collaborating with authors

Natalie Carroll Purdue Extension Specialist and Professor of Youth Development and Ag Education and Whitney Siegfried, Graduate Student, Purdue University Extension to create this guide aimed at high school-aged 4-H'ers. Through experiments, simulations, research, and discussion activities, youth will understand why chemicals from medications are being found in the environment; the harm these chemicals can cause; and what can be done about it.

Five inquiry-based lessons are included:

- **So, what's the big deal?** A filtration experiment that teaches about wastewater disposal.
- **What are the issues?** Conducting research to learn about the history of disposal of unused and expired medicine; Taking a poll of citizens' disposal activities.
- **What should I be concerned about?** Using online resources to acquire the latest data and to learn about the medications of primary concern; Preparing a report that describes contaminants found in local waterways.
- **What are my options?** Act upon the better alternatives and work to reduce flushing of medicines in their communities by investigating alternatives for proper disposal of expired and unused medicine and brainstorming ways to provide community education.
- **How can I let other people know about these issues?** Suggestions for how youth can share their knowledge through projects such as speeches, displays, demonstrations, mentoring a younger 4-H member, and outreach to older adults.

Our strategic collaborations with scientists, outreach specialists, educators, and curriculum specialists have yielded many benefits. Illinois-Indiana Sea Grant is well positioned to deliver education resources; conduct professional development training for both formal and non-formal educators, with the ultimate goal of providing youth with the necessary skills to take action, engage and inform others, and create awareness about an important topic that will help improve people's health and safety, as well as the sustainability of our living aquatic resources.

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