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Pharmaceutical Residues in the Water

The improper disposal of pharmaceutical waste products has caused several harmful effects on the environment. Studies performed on *Acinetobactor* samples revealed that bacteria exposed to increased concentrations of pharmaceutical waste are more likely to become anti-biotic resistant (Guardabassi et al, 2008.). In Canada, male minnows exposed to low levels of estrogen experienced feminization and became inter-sexed, producing both sperm and eggs (Kidd, 2007). Similarly, a Florida alligator population exposed to pharmaceutical waste experienced hormonal abnormalities that affected their reproductive development (Guillette *et al*, 1994). Similar effects could cause long-term damage to Vermont's ecological resources; however, the Environmental Protection Agency and Food and Drug Administration have found no evidence of any human health concerns related to pharmaceutical waste residues (see US Food and Drug Administration and US Environmental Protection Agency in "Works Cited" below).

Waste Accumulation

Waste effluents enter water sources through several pathways. When a medication is not completely absorbed in the body, it is released by a patient in his/her waste (Christenson, 2008). It then enters the sewer system; however, modern sewer systems do not possess the technology needed to breakdown organic waste, including pharmaceutical products. Additionally, many individuals are left with excess medications either because they no longer feel they need to take them, or because their doctor prescribed a dose that was more than they needed. In this situation, individuals have historically been instructed to flush the medications in the toilet to avoid the accidental poisoning of children or contributing to the illegal drug market. Current federal guidelines maintain that flushing is an improper disposal technique; however, the public has not been made properly aware of this change (US Office of National Drug Control Policy, 2007).

How Pharmaceuticals Enter the Water

Habits of the General Population

Most intentional human pharmaceutical waste likely comes from either the failure from patients to finish their prescribed medication, or from physicians over-prescribing medication. A survey done in 2009 found that as little as 2% of people finish any prescriptions prescribed by their physicians, with levels varying depending on what type of medication was prescribed (Glassmeyer, 2009). Another survey, conducted in 1996, took data from 500 of the callers of a poison information center (Kuspis, 1996). The survey aimed at finding the most common practices for people disposing medication. What they found was that 54% of people simply discarded the medication in the trash, 35.4% reported either rinsing the medication down the sink or flushing it down the toilet, 7.2% simply stored the medication in their home, and only 1.4% reported having returned the medication to a pharmacy or hospital (Kuspis, 1996). A more recent survey done in 2006 showed that 54% of respondents had stored medication in their home, 35% had disposed of medication in a sink or toilet at some point, and only 22.9% had ever returned medication to a pharmacy or hospital (Seehusen, 2006). The survey also pointed out that less than 20% of respondents had ever been given advice about disposing medication by their health care provider (Seehusen, 2006).

Unused Pharmaceuticals Belonging to the Deceased

According to research done by Ruhoy and Daugton (2007), a particular cause of Pharmaceutical and Personal Care Product (PPCP) accumulation results from drugs that become "orphaned" by the death of their consumer. Many coroner offices document the quantity and type of medication found at sites visited for investigation and acquisition of decedents. After collecting data of this kind over a thirteen-month period in Nevada, Ruhoy and Daughton found an average of 3 active pharmaceutical ingredients (APIs) per decedent. These results excluded inhalers, syringes, and patches. Over 92 percent of medications found at the site of death were flushed. Seven percent were thrown away in household trash. Law enforcement services incinerated less than one percent of medication that was found. Ruhoy and Daughton found that over the course of their 13-month study at least 325,000 doses of a range of medications were disposed of into the sewage system, representing over 102,000,000 milligrams of APIs. Given similarities between the U.S. and Nevada death rates, Ruhoy and Daughton extrapolated these findings to obtain an estimate of “at least 17.9 billion milligrams (17.9 metric tons) of APIs disposed of annually into the national sewage systems by the deceased population alone (mass disposed by Clark County Coroner’s Office multiplied by the ratio of the U.S. population to the Clark County population)”(Ruhoy & Daughton, 2007).

Institutional Pharmaceutical Waste

In addition to hospitals, long term care facilities (LTCF) and other institutions including “assisted living facilities, nursing homes, coroners, hospice, veterinary practices, dental offices, public housing, schools, daycare, correctional facilities, cruise ships, pet keepers, and hobby farms,

have to deal with issues separate from households and hospitals (Wu, 2009)." One example of a unique challenge to disposing of pharmaceutical waste lies in nursing home mobility. If a nursing home resident changes homes or passes away, to "avoid liability issues, most facilities will not transfer medications." The protocol for these facilities left with large quantities of unused medications has previously been to flush them (EPA, 2008). A survey in Washington State found "over 65 percent of pharmaceutical waste was coming from 'specialty outpatient' facilities, over 20 percent from hospitals, and about five percent coming from nursing homes, boarding homes, and retail pharmacies (Oliver, 2003)." It is clear that institutional facilities have much larger quantities of pharmaceutical waste to dispose of than households, but unclear is the extent to which these facilities contribute to pharmaceuticals in the human waste stream (Wu, 2009).

Unintentional Agricultural Releases

Much of the unintentional pharmaceutical waste is due to unintentional releases from agricultural production. Confined Animal Feeding Operations (CAFOs) are one of the primary culprits, and states are already taking action through regulations and requiring permits for CAFOs (Bauman, 2010). Even on more organic farms, animal manure used as fertilizer saturates crops with Nitrogen and Phosphorus, but the excess is released into waterways, affecting ecosystems, animals and potentially humans. Overflowing storage lagoons, spray fields and contaminated groundwater are the primary sanctuaries of animal waste polluting U.S. waterways (Sanderson, 2003). The impact of pharmaceuticals given to animals could be detrimental; one study found antibiotic-resistant bacteria in groundwater underneath a swine waste lagoon (Barlett, 2004).

Federal Guidelines

Hospital disposal of pharmaceutical waste is controlled by strict guidelines outlined in the federal Resource Conservation and Recovery Act of 1976 (RCRA). These guidelines divide pharmaceutical waste into several classifications, based on ignitability, toxicity, corrosivity, and reactivity (Smith, 2002). The P-list contains the most hazardous medications, including nicotine, epinephrine, and warfarin. These medications must be taken off-site to a certified hazardous waste incinerator for disposal. The U-list contains less hazardous medications that can be incinerated on-site at a lower temperature before transfer to a landfill. These guidelines, although somewhat confusing, appear to be in line with current recommendations for environmental concerns. Enforcement of RCRA guidelines, however, has been a problem in recent years (Christenson, 2008).

Vermont Policy

Vermont has a handful of small collection services that allow for residents to dispose of their unwanted prescription medications. Starting in May 2008 the St. Alban's City Police Department, authorized by the city, established a Prescription Drug Repository program. Since May the SACPD has collected more than 8,500 unwanted and unused prescription pills from

residents (Thompson, 2008). The pills were to be incinerated through the Northwestern Medical Center; however the chief of police refused to hand the pills over after discovering that the waste disposal contractor that the hospital uses, National Waste Management, hauls the waste out of state, compromising the integrity of appropriate disposal. The pills are currently locked away in SACPD's evidence vault. The program has inspired other towns to take similar action. Burlington created their own drug repository program in October 2008 to deal with unwanted prescription drugs (Burlington Police Department, 2008).

Northeast Recycling Council

The Northeast Recycling Council (NERC), a non-profit organization, took interest in proper drug disposal and collection within the state. In 2006 they conducted, with funding from the EPA, several pilot collections in the northeast, including one in Rutland, VT. Following the collections the Council disposed of the collected materials through Stericycle, a private company, which incinerates the substances in a federally licensed waste incinerator (Rubinstein, 2006).

Table 1 shows the results of the NERC's pilot projects. The amount collected was consistent across locations with each person bringing in approximately one gallon of uncontrolled substances. The percentage of controlled substances collected averaged 4% of the total waste collected at each event ranging from a low of 1% to a high of 17%. The turnout for these pilot programs, however, was relatively low. If looked at separately, collections held in conjunction with health and hazardous waste (HHW) events collected a significant amount more than stand alone collections. This can be attributed to the public's familiarity with HHW events as opposed to the NERC's relatively unknown collections. Table 1 displays that collections held in conjunction with HHW events collected nearly 1.25 gallons per person of uncontrolled substances compared to .7 gallons per person collected at stand alone events (NERC, 2006).

Table 1: Results of the Northeast Recycling Pilot Projects

Pilot Location	Number of Participants	Average Volume (Gallons) per Participant Non-Controlled Substance	Average Cost per Gallon Destruction of Non-Controlled Substance	Hazardous Waste Transportation Fee
Montague, MA*	6	0.8	$30	$350
S. Portland, ME*	51	0.7	$24	$250
Northampton, MA*	14	0.4	$20	$350
South Hadley, MA**	22	1.4	$13	$0
Wilbraham, MA**	18	1.4	$12	$0
Buckland, MA**	6	1.3	$14	$350
Rutland, VT*	28	1.1	$17	$225
Wolfeboro, NH**	27	0.7	$7	$0
AVERAGE	**21.5**	**0.97**	**$17**	**$191**
Stand-alone collection* With HHW event**				

Source: Rubinstein, Lynn. Operating Unwanted Medication Collections-. Rep. Northeast Recycling Center 2006

Types of Collection Programs

Standards for safe pharmaceutical waste disposal in other states have focused on consumers' actions as well as procedural standards in hospitals, nursing homes, and other health care facilities. Other states have implemented programs for safe and environmentally friendly disposal alternatives to flushing of medications in the home. These include continuous drop off, single day, and mail-back programs.

Continuous drop off

Fourteen states, including Arizona, Maryland, and New Jersey, have implemented programs that allow consumers to dispose of unwanted, expired or unused non-controlled substance medications—prescription or over the counter—to pharmacies, health clinics and other county facilities. Controlled substances cannot be collected at pharmacies or hospitals, but can be collected at local law enforcement agencies. Pharmaceuticals collected that are unopened, unused and are not expired can be donated to charitable organizations, healthcare facilities or patients who meet specific guidelines (Cauchi, 2008). The pharmaceuticals collected that are not eligible for reuse are eventually shipped to a hazardous waste facility where they are incinerated. citation

Take-away programs are limited to small-scale and part-time operations in the United States. Local Environmental Protection Departments, health departments, pharmacies, sheriff's offices, Drug Enforcement Administrations, and health care facilities have been involved in organizing and funding programs for the collection of pharmaceuticals (Hinchey-Mallory, 2007). Regional and national operations have been initiated in Canada and Europe to allow all patients to have full-time access to a take-away site. In Canada, take-away programs have allowed physicians to determine which patients are most likely to follow dosing instructions, and has allowed for the reevaluation of initial prescription levels. This has reduced the amount of consumer waste produced (Christenson, 2008).

Single Day Collections

Similar to continuous drop off programs, Utah and Nebraska have designated certain days for the collecting of unused, unwanted or unneeded medications. These days are publicized in the local media and drop off sites are supervised by local law enforcement officials to prevent the misuse or illegal sale of drugs. On the collection day, medications are collected at pharmacies, shipped to a hazardous waste facility and incinerated. In 2005, South Portland, Maine had a one day take back event sponsored by the North East Recycling Council. On this day, 50 gallons of medications from 52 people from 17 Maine communities, which was credited with preventing more than 55,000 pills from entering the waters and helped educate consumers about the importance for proper disposal of medical waste (Hinchey-Mallory, 2007).

Mail-back Program

In 2004, Maine House Representative Bromley, of South Portland, Maine proposed House bill L.D. 1826 entitled "An Act to Ensure the Proper Disposal of Expired Pharmaceuticals". This bill created the Unused Pharmaceutical Disposal Program to allow residents to mail unused or expired medications to the Maine Drug Enforcement Agency. The bill stated that pre-paid envelopes addressed to the Maine DEA be made available at local pharmacies, physicians' offices and post offices. The DEA would collect the medications, which were then sent to incineration plants. The bill allowed for the director Maine's DEA to accept funding for private sources for the program, but public funding was not authorized (Northwest Product Stewardship Council, 2009). L.D. 1826 was passed in the Maine house and senate and signed by Governor Baldacci but has not gone into effect due to a lack of funding from private sources.

Conclusion

The research conducted for this report suggests that a comprehensive solution to the pharmaceutical waste problem would involve increasing the pressure on hospitals and pharmacies to conform to current federal guidelines and increasing patient awareness of the growing problem of water contamination from pharmaceutical waste, in addition to an organized program for proper disposal, such as a take-away or reuse program.

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Originally Compiled at the request of Representative Peter Fagan by Lindsay Cyr, Timothy Douglas and Mikaela Frissell on February 12, 2009, and updated by Luke Martin, Julie Seger, and Kristen Skager on February 3, 2011, under the supervision of Professor Anthony Gierzynski

Disclaimer: This report has been prepared by undergraduate students at the University of Vermont under the supervision of Professor Anthony Gierzynski. The material contained in the report does not reflect the official policy of the University of Vermont.