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Review Article

Greener Itinerary to Thwart Pharmacy - Effluence

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ABSTRACT

The use of PPCPs is on the rise on the globe. PPCPs enter into the environment through individual human activity and as residues from manufacturing, agribusiness, veterinary use, and hospital and community use. Individuals may add PPCPs to the environment through waste excretion and bathing as well as by directly disposing of unused medications to septic tanks, sewers, or trash. Because PPCPs tend to dissolve relatively easily and don't evaporate at normal temperatures, they often end up in soil and water bodies. Some PPCPs are broken down or processed easily by a human or animal body and/or degrade quickly in the environment. However, others do not break down or degrade easily. The likelihood or ease with which an individual substance will break down depends on its chemical makeup and the metabolic pathway of the compound. Varying concentrations of drugs found in water sources can have ill effect on the aquatic life and human health. For pharmaceutical pollution, the solution calls upon all health care sectors to participate in preventing pharmaceutical pollution. Green Pharmacy aims at zero pharmaceutical waste in our environment. It offers an opportunity for social action that will greatly benefit our environment at all levels of our society. It encourages health providers and clients to focus on healthy lifestyle and prevention to ensure their well-being through regular wellness practices. It provides education and opportunity for everyone involved with the life cycle of medicine to participate in reducing pharmaceutical pollution. With relatively simple yet firm commitments to change our habits, becoming stewards of medicine rather than consumers of medicine we effectively become part of the solution. This review paper delineates about the powerful approaches of green pharmacy that provides comprehensive solution to pharmaceutical pollution affecting much of well being on globe. Research to date points to the ubiquity of PPCPs in aquatic environments. Existing wastewater treatment facilities are inadequate and aren't designed to remove them from the waste stream. Our current system of quantifying their toxicological effects is inadequate. Now is the time to prevent further harm to living organisms and the environment.

Keywords: RCRA; SDCP; Biomagnification; Endocrine disruptors; Green pharmacy; Ecopharmacology; Engineered landfills; Ecotoxic acivities; Management practices; Environmental impacts

INTRODUCTION

The discovery of a variety of pharmaceuticals in surface, ground, and drinking waters around the country is raising concerns about the potentially adverse environmental consequences of these contaminants. Minute concentrations pharmaceuticals can impose detrimental effects on aquatic species and possibly on human health and development. The consistent increase in the use of potent pharmaceuticals, driven by both drug development and our aging population, is creating a corresponding increase in the amount of pharmaceutical waste generated. Pharmaceutical waste is not one single waste stream, but many distinct waste streams that reflect the complexity and diversity of the chemicals that comprise pharmaceuticals. Pharmaceutical waste is potentially generated through a wide variety of activities in a health

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care facility, including but not limited to intravenous (IV) preparation, general compounding, spills/breakage, partially used vials, syringes, and IVs, discontinued, unused preparations, unused unit dose repacks, patients' personal medications and outdated pharmaceuticals.

In hospitals, pharmaceutical waste is generally discarded down the drain or landfilled, except chemotherapy agents, which are often sent to a regulated medical waste incinerator. These practices were developed at a time when knowledge was not available about the potential adverse effects of introducing waste pharmaceuticals into the environment. Proper pharmaceutical waste management is a highly complex new frontier in environmental management for health care facilities. A hospital pharmacy generally stocks between 2,000 and 4,000 different items, each of which must be evaluated against state and federal hazardous waste regulations. Pharmacists and nurses generally do not receive training on hazardous waste management during their academic studies, and safety and environmental services managers may not be familiar with the active ingredients and formulations of pharmaceutical products. Frequently used pharmaceuticals, such as epinephrine, warfarin, and 9 chemotherapeutic agents, are regulated as hazardous waste under the RCRA. Failure to comply with hazardous waste regulations by improperly managing and disposing of such waste can result in potentially serious violations and large penalties[1-3]

Pharmaceutical Products in Puget Sound

When unwanted or expired pharmaceutical products are rinsed down the drain or flushed down the toilet, they may end up in fresh and marine waters. While very low levels may not pose a risk to humans, they have been found to affect aquatic ecosystems. Scientists have linked pharmaceutical pollution in surface waters to endocrine effects in freshwater and marine species. A survey conducted by the WCRC found that 72% of Seattle-area households dispose of unwanted pharmaceuticals each year by flushing them down the toilet, rinsing them down the sink, or tossing them into the garbage. That same survey also found that 80% of households would return unwanted pharmaceutical products to their local pharmacy if a secure location was set up for that purpose. To address this problem in the Northwest Straits, Snohomish County MRC is partnering with WCRC and others to create a simple, low cost and secure system to collect unwanted medications from households and small quantity sources. Snohomish County MRC will play an important role educating citizens on the potential impact of pharmaceuticals in surface waters. Citizens will be encouraged to drop off unwanted products at local pharmacies where they can be collected for incineration.

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LINE OF ATTACK OF DRUGS TO WATER BODIES

Pharmaceutical pollution is an emerging concern worldwide. Drugs enter water bodies in many ways which include industrial dischargers, commercial animal feeding operations, surface applications of manure and bio solids and wastewater treatment plants that treat residential, commercial and industrial wastewater. Pharmaceuticals enter wastewater treatment plants from excretion by the human body and due to disposal of unused or expired medications down the toilet or drain. The drugs that we take are not entirely absorbed by our bodies and are excreted without being fully metabolized. Drug components leach out and seep into groundwater and find their way into local wastewater treatment plants. Hospitals and long-term care facilities annually flush millions of pounds of unused pills down the drain and account for the majority of pharmaceuticals entering municipal wastewater treatment plants. Drugs and cosmetics may contain mercury, selenium and other heavy metals. These persistent, bioaccumulative and toxic substances pollute the air, land and both surface water and groundwater. Drugs do not necessarily remain in the environment for long period of time, but continual input in a water body can cause the concentration to be relatively constant. This may lead to interference with growth and reproduction in water organisms. There have been several well-documented cases of endocrine-disrupting effects on aquatic animals due to drugs entering waterways (Fig. 1 & Fig. 2). Estrogens have caused male fish to become female. Antidepressants have caused lobsters to be more aggressive. Prozac has induced reproduction in shellfish. Even extremely diluted concentrations of drug residues harm the reproductive systems of fish, frogs and other aquatic species. Tadpoles have gone smaller by 40% in size when exposed to water from the treatment plant[4].

Fig 1 Stream stressed by pharmaceutical pollution

The pollutants have ill effect on human health too. In accordance with a report, researchers have found out that human cells fail to grow normally in the laboratory when exposed to trace concentrations of certain pharmaceuticals. Some drugs found in water have promoted antibiotic-resistant germs. When the bacteria is exposed to a drug, there are chances that bacteria will mutate in such a way that would render the drug ineffective .A survey in US has shown that 80% samples from various waterways have been detected with one or more pharmaceuticals in low concentrations. Examples of medications found included acetaminophen, steroids, hormones, codeine, antibiotics, antimicrobials and ibuprofen. In India, according to a news source at Patancheru, water samples from a stream have shown presence of 21 different drugs, which ranged in purpose from hypertension , heart disease, chronic liver ailments, depression, gonorrhea to ulcers.

The above alarming reports have created an opportunity for all health sectors involved in health care pharmaceutical developers and manufacturers, hospitals, individual physicians and all those involved in the health care system, law enforcement agencies, pharmacies, waste management agencies, consumers, environmental protection organizations, and governmental agencies to take action and reduce potential harm to the environment. The recent increase in awareness of environmental issues is creating an opportunity for sectors involved in health care—pharmaceutical developers and manufacturers, hospitals, individual

physicians and all those involved in the health care system, law enforcement agencies, pharmacies, waste management agencies, consumers, environmental protection organizations, and governmental agencies—to take action and reduce potential harm[5]. Residential, commercial, and agricultural pharmaceuticals can follow two primary pathways to the environment:

● **Excretion:** Human and livestock excretion of drugs and metabolites following consumption (which ultimately follows sewage, septic or surface runoff pathways to wastewater or to biosolids).

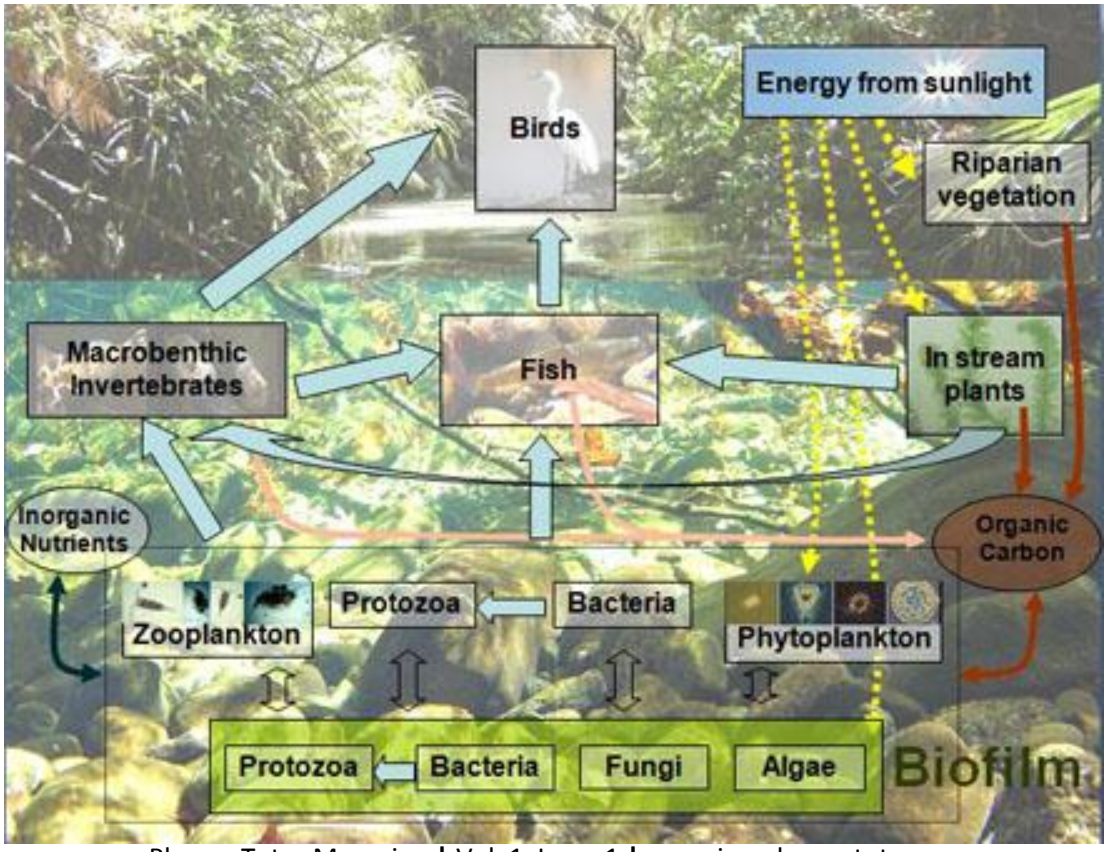
● **Direct Disposal**: Disposal of unused pharmaceuticals to the septic tank, sewer or landfill.

Fig. 2 Bioaccumulation of pharmaceuticals in aquatic organisms (below)

If disposed of or excreted to the sewer, pharmaceuticals are sent to wastewater treatment plants that offer primary, secondary or tertiary treatment levels. Regardless of the level of treatment, most conventional wastewater treatment cannot effectively eliminate pharmaceutical compounds. Landfill leachate can contain trace amounts of pharmaceuticals as well. Often this leachate is sent to the same wastewater treatment systems that receive residential wastewater. Pharmaceuticals have been detected in landfill leachate, so disposal of pharmaceuticals at engineered landfills may merely postpone pollution of surface water and ground water. As a result, incineration is currently the best method for destruction of unwanted pharmaceuticals (Fig. 2).

Many cities, counties and states are struggling to prevent and remove pharmaceuticals in both wastewater and solid waste.

Protecting the integrity of our water resources is one of the most essential issues and Green Pharmacy provides a basis for putting our beliefs into action. This will have a positive effect of the health and vitality of our world. The purpose of Green Pharmacy is to reduce pharmaceutical pollution and provide safe disposal options for unwanted and expired medications. People rely heavily on pharmaceuticals in the current medical



system. All of us are medication consumers at some point of time in our lives. A large variety of drugs including prescription drugs, over-the-counter medicines and veterinary medicines in varying concentrations have been found in various waterways.

PPCPs refers, in general, to any product used by individuals for personal health or cosmetic reasons or used by agribusiness to enhance growth or health of livestock. PPCPs comprise a diverse collection of thousands of chemical substances, including prescription and over-the-counter therapeutic drugs, veterinary drugs, fragrances, and cosmetics. Studies have shown that pharmaceuticals are present in our nation's waterbodies. Further research suggests that certain drugs may cause ecological harm. The EPA is committed to investigating this topic and developing strategies to help protect the health of both the environment and the public. To date, scientists have found no evidence of adverse human health effects from PPCPs in the environment. PPCPs have probably been present in water and the environment for as long as humans have been using them. The drugs that we take are not entirely absorbed by our bodies, and are excreted and passed into wastewater and surface water. With advances in technology that improved the ability to detect and quantify these chemicals, we can now begin to identify what effects, if any, these chemicals have on human and environmental health. Pharmaceuticals and personal care products were first called "PPCPs" only a few years ago, but these bioactive chemicals (substances that have an effect on living tissue) have been around for decades. Their effect on the environment is now recognized as an important area of research.

PPCPs include:

- Prescription and over-the counter therapeutic drugs
- Veterinary drugs
- Fragrances
- Cosmetics
- Sun-screen products
- Diagnostic agents
- Nutraceuticals (e.g., vitamins)

Sources of PPCPs:

- Human activity
- Residues from pharmaceutical manufacturing (well defined and controlled)
- Residues from hospitals
- Illicit drugs
- Veterinary drug use, especially antibiotics and steroids
- Agribusiness

The importance of individuals directly contributing to the combined load of chemicals in the environment has been largely unrecognized. PPCPs in the environment illustrate the immediate connection of the actions/activities of individuals with their environment. Individuals add PPCPs to the environment through excretion (the elimination of waste material from the body) and bathing, and disposal of unwanted medications to sewers and trash. In February 2007, the White House Office of National Drug Control Policy issued the first consumer guidance for the PDPD. (Proper Disposal of Prescription Drugs) Proper disposal of drugs is a straightforward way for individuals to prevent pollution. Some PPCPs are easily broken down and processed by the human body or degrade quickly in the environment, but others are not easily broken down and processed, so they enter domestic sewers. Excretion of biologically unused and unprocessed drugs depends on:

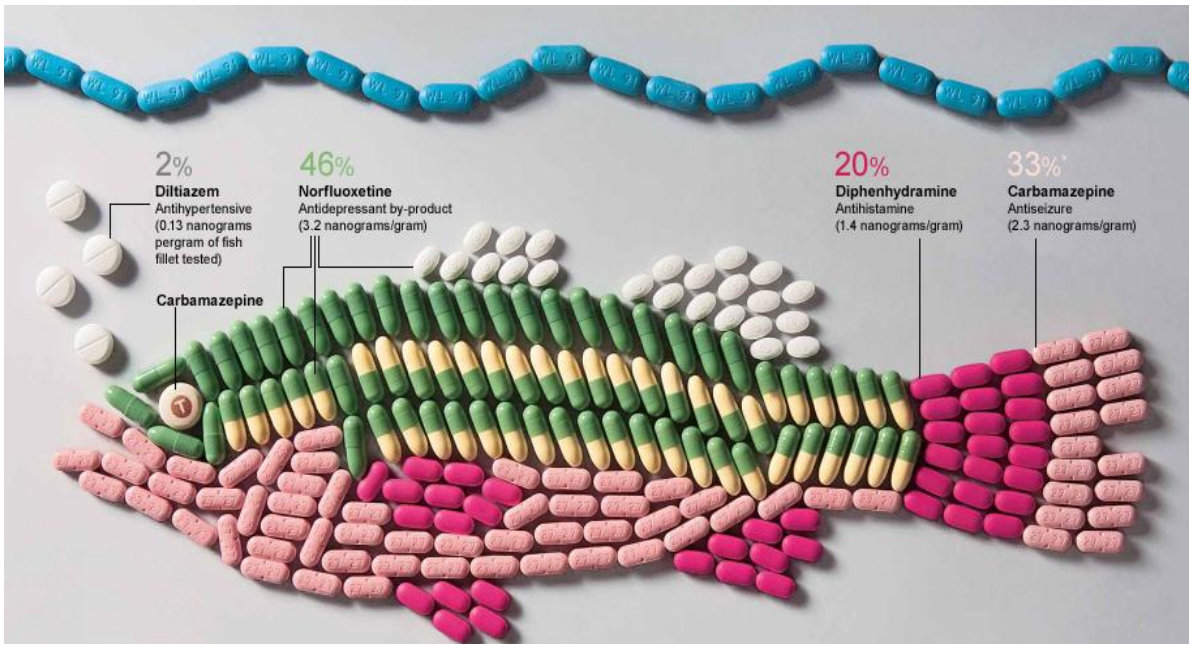
- individual drug composition (certain excipients -- i.e., inert ingredients -- can minimize absorption and therefore maximize excretion)
- ability of individual bodies to break down drugs (this ability depends on

age, sex, health, and individual idiosyncrasies)

Because they dissolve easily and don't evaporate at normal temperatures or pressure, PPCPs make their way into the soil and into aquatic environments via sewage, treated sewage sludge (biosolids), and irrigation with reclaimed water.

The EPA - US considers the presence of pharmaceuticals and personal care products in the environment as one of the most significant emerging threats of the 21st century. Pharmaceuticals and personal care products refers in general, to any product used by individuals for personal health or cosmetic reasons or used by agribusiness to enhance growth or health of livestock. PPCPs comprise a diverse collection of thousands of chemical substances, including prescription and over-the-counter therapeutic drugs, veterinary drugs, fragrances, and cosmetics. These products are found to be pseudo-persistent because they enter the environment faster than they can be removed. Hence arises the need for protecting the environment where Green Pharmacy can play an important role. Green Pharmacy tries to engage all sectors involved in the production, distribution, sales and consumption of medicines in environmentally preferable practices[6-8].

Fig. 3 Relative amount of 4 pharmaceutical drugs found in fish pulled from Chicago's North Shore Channel



The manufacturing sector should opt for innovative drug design that can improve delivery systems to require lower doses for efficacy. They can use recyclable materials for packaging or package size can be reduced to minimize the unused portion of prescriptions. Complete and direct information about proper disposal techniques can be added to packaging. The pharmaceutical industry can provide more information directly to physicians. They can grade their medicines for persistence, bioaccumulation, and toxicity. Pharmaceutical industry can provide funding for the proper disposal of unused or expired medicines. This would help in promoting advanced recycling strategies.

Pharmaceutical industry could also devote a portion of its huge advertising campaign to educate both physicians and consumers about the environmental and health issues associated with drug

products and cosmetics. For manufacturers, "reverse distribution," which allows pharmacists to return unsold drugs back to the manufacturer, could be enlarged to include unused medication and expired medication. Hospitals for a healthy environment should enhance their focus on hazardous waste and pharmaceutical waste and develop best management practices for disposing pharmaceutical waste .Some of the pharmaceuticals may be passed into the sewer line. This includes solutions in IV bags containing only saline, lactate or nutrients such as glucose, vitamins, salts and other electrolytes. Hazardous waste may be sent to hazardous waste incineration agencies.

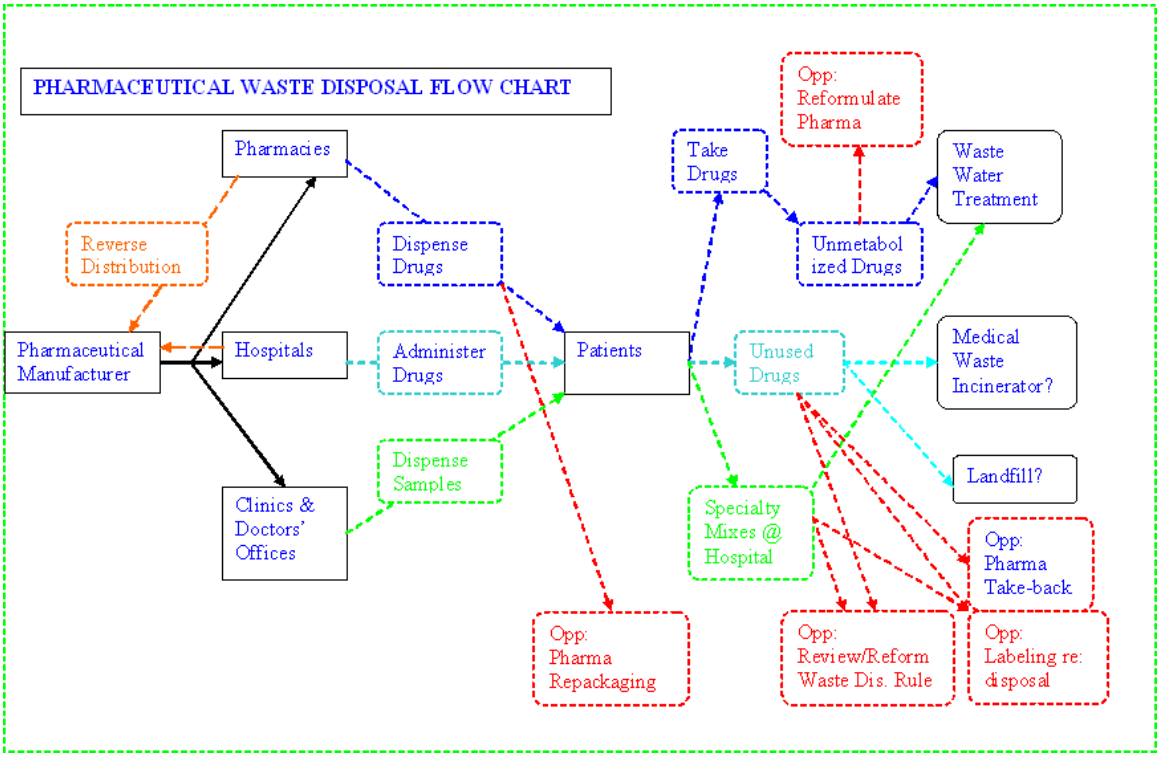


Fig. 4 Flow chart of pharmaceutical waste disposal

Non-hazardous drugs may be segregated into a non-red, non-yellow container, such as beige or white with blue label "non-hazardous pharmaceutical waste– incinerate only" or may be disposed at a regulated medical waste or municipal incinerator that is permitted to accept non-hazardous pharmaceutical waste[9-14].

Physicians, veterinarians and dentists should also participate in the solution. The time when a medical practitioner is prescribing a medication is an ideal moment to educate patients about proper disposal habits. The physician should not prescribe more medication than required. They can prescribe starter packs and refill packs. Environmental impact of the medications should be considered when prescribing. Pharmacists can keep a record of patient's medication consumption and regularly review them. He can learn which drugs have the highest eco-toxicity and can educate patients, consumers, and colleagues about the importance of proper disposal of pharmaceutical waste. SDCP have been started by the American Pharmacist Association to raise awareness amongst consumers about potential environmental and societal impacts of improperly disposed of medicines. It helps to promote environmental friendly consumer behavior through different communication networks[15].

Pharmacies should serve as take-back sites for proper pharmaceutical disposal. They can have recycle bins, which allow consumers to bring their unused and expired medicines back whenever they shop. As certain medications find their way into an illicit drug market, law enforcement agencies can participate in take-back programs to ensure that these substances are handled only by a pharmacist or a physician. Such take back pharmacies have been established in many countries. All prescription drugs except controlled drugs , all over the counter drugs, medication samples, vitamins and supplements, medicated ointments, lotions, creams, oils, liquid medicines in leak proof containers, homeopathic remedies, pet medications, suppositories etc. are easily accepted at the take back pharmacy. However, controlled prescriptions like narcotics, valium and codeine are not taken back. Further, IV bags, bloody and infectious waste, personal care products, empty containers, thermometers , hydrogen peroxide ,aerosol cans, inhalers are not accepted by the pharmacies[16].

Pharmaceutical contamination: An emerging concern worldwide

In was traumatized when samples of treated wastewater taken from a plant where about 90 Indian drug factories dump their residues, were analyzed. Enough of a single, powerful antibiotic was being spewed into one stream each day to treat every person in a city of 90,000. And it wasn't just ciprofloxacin being detected. The supposedly cleaned water was a floating medicine cabinet _ a soup of 21 different active pharmaceutical ingredients, used in generics for treatment of hypertension, heart disease, chronic liver ailments, depression, gonorrhea, ulcers and other ailments. Half of the drugs measured at the highest levels of pharmaceuticals ever detected in the environment, researchers say. Those Indian factories produce drugs for much of the world, including many Americans. The result: Some of India's poor are unwittingly consuming an array of chemicals that may be harmful, and could lead to the proliferation of drug-resistant bacteria. "If you just swallow a few gasps of water, you're treated for everything. The question is for how long?" Last year, The AP reported that trace concentrations of pharmaceuticals had been found in drinking water provided to at least 46 million Americans. But the wastewater downstream from the Indian plants contained 150x the highest levels detected in the US. Ciprofloxacin, the antibiotic, and the popular antihistamine cetirizine had the highest levels in the wells of six villages tested. Both drugs measured far below a human dose, but the results were still alarming. In its series of articles, AP documented the commonplace presence of minute concentrations of pharmaceuticals in US. drinking water supplies. The AP also found that trace concentrations of pharmaceuticals were almost ubiquitous in rivers, lakes and streams.

The medicines are excreted without being fully metabolized by people who take them, while hospitals and long-term care facilities annually flush millions of pounds of unused pills down the

drain. he consequences of the India studies are worrisome. As the AP reported last year, researchers are finding that human cells fail to grow normally in the laboratory when exposed to trace concentrations of certain pharmaceuticals. Some waterborne drugs also promote antibiotic-resistant germs, especially when _ as in India _ they are mixed with bacteria in human sewage. Even extremely diluted concentrations of drug residues harm the reproductive systems of fish, frogs and other aquatic species in the wild. In the India research, tadpoles exposed to water from the treatment plant that had been diluted 500x were nonetheless 40% smaller than those growing in clean water.

The discovery of this contamination raises two key issues for researchers and policy makers: the amount of pollution and its source. Experts say one of the biggest concerns for humans is whether the discharge from the wastewater treatment facility is spawning drug resistance. "Not only is there the danger of antibiotic-resistant bacteria evolving; the entire biological food web could be affected," said Stan Cox, senior scientist at the Land Institute, a nonprofit ARC in Salina, Kan. Cox has studied and written about pharmaceutical pollution in Patancheru (Andhra Pradesh), India.. "If Cipro is so widespread, it is likely that other drugs are out in the environment and getting into people's bodies." Before Larsson's team tested the water at PETL plant, researchers largely attributed the source of drugs in water to their use, rather than their manufacture. In the US, the EPA says there are "well defined and controlled" limits to the amount of pharmaceutical waste emitted by drug makers. India's environmental protections are being met at Patancheru. Factories in the US report on releases of 22 active pharmaceutical ingredients, the AP found by analyzing EPA data. But many more drugs have been discovered in domestic drinking water. Possibly complicating the situation.

The more bacteria is exposed to a drug, the more likely that bacteria will mutate in a way that renders the drug ineffective. Such resistant bacteria can then possibly infect others who spread the bugs as they travel. Ciprofloxacin was once considered a powerful antibiotic of last resort, used to treat especially tenacious infections. But in recent years many bacteria have developed resistance to the drug, leaving it significantly less effective.

People might say, 'Oh sure, that's just a dirty river in India,' but we live on a small planet, everything is connected. The water in a river in India could be the rain coming down in your town in a few weeks. Patancheru became a hub for largely unregulated chemical and drug factories in the 1980s, creating what one local newspaper has termed an "ecological sacrifice zone" with its waste. Since then, India has become one of the world's leading exporters of pharmaceuticals, and the US _ which spent $1.4 billion on Indian-made drugs in 2007 _ is its largest customer.

A spokesman for the PRMA, representing major US drug makers, said they could not comment about the Indian pollution because the Patancheru plants are making generic drugs and their members are branded. A spokesman for the GPA said the issues of Indian factory pollution are "not within the scope of the activities" of their group. Drug factories in the US and Europe have strictly enforced waste treatment processes. At the Patancheru water treatment plant, the process is outdated, with wastewater from the 90 bulk drug makers trucked to the plant and poured into a cistern. Solids are filtered out, then raw sewage is added to biologically break down the chemicals. The wastewater, which has been clarified but is still contaminated, is dumped into the Isakavagu stream that runs into the Nakkavagu and Manjira, and eventually into the Godawari River. In India, villagers near this treatment plant have a long history of fighting pollution from various industries and allege their air, water and crops have been poisoned for decades by factories making everything from tires to paints and textiles. Some lakes brim with filmy, acrid water that burns the nostrils when inhaled and causes the eyes to tear.

The US - EPA's RCRA regulate the disposal of solid waste and define various categories of waste. The EPA defines solid waste as garbage, refuse, sludge or other discarded material. RCRA hazardous wastes are a subcategory of solid waste. "F" List Wastes are waste produced during common industrial or manufacturing processes such as degreasing. Examples include solvents like trichloroethylene and carbon tetrachloride. "K" List Wastes, or source-specific, wastes are waste streams generated by specific industrial sectors, such as ink formulators, petroleum refineries and producers of veterinary pharmaceuticals, explosives, pesticides and inorganic pigments. "P" and "U" List Wastes involve discarded commercial chemical products, or unused pure or commercial-grade chemical products. Chemicals on the "P" list are fatal or irreversibly damaging to humans and animals at low doses. Those on the "U" list pose a hazard to human or environment health when improperly managed. Compounds appearing on these lists include pesticides and pharmaceuticals. Characteristic Wastes are not on the lists above but qualify as hazardous if they exhibit the characteristics of ignitability, corrosivity, reactivity or toxicity. US - EPA has been involved in giving grants to hospitals to develop best management practices for disposing pharmaceutical waste. US EPA maintains an active program called the contaminant candidate list to identify the contaminants in public drinking water. Such practices should be encouraged worldwide[17].

Municipal water agencies should develop policies that maintain proper water quality. Strict regulations should be proposed for preventing hospitals from disposing medicines directly into the municipal water system. Environmental organizations should support take-back programs and follow approaches to recycle drugs and spread awareness and educate the masses. Each of us has a responsibility to keep our environment clean when discarding unused medication. The consumer should ensure that they protect children and pets from potentially negative effects of drugs while discarding. Consumers should not throw the medicines down the toilet or in the garbage, but take the drugs to a take back site or hazardous waste facility. They should buy smaller containers of medicines. Preference should be given to products with recyclable packaging. They can ask their medical practitioner bout environmental impact of their medication and whether a more sustainable alternative exists. They should always choose the smallest prescription amount or refill option unless the medication is for a chronic condition. Unused medications may be donated to nonprofit organizations that redistribute medicines to charitable organizations in non-industrial countries that need basic medications. The patients should keep the medication in their original containers, fill the medicine return form and bring the medication to the take back pharmacy. They should remove all personal information from all medication containers before bringing it to take back sites. Moreover, in order to reduce pharmaceutical contamination in drinking water, the consumers should take all necessary measures to keep water sources clean[18-23].

ECOPHARMACOLOGY

Ecopharmacology concerns the entry of chemicals or drugs into the environment through any route and at any concentration disturbing the balance of ecology (ecosystem), as a consequence. Ecopharmacology is a broad term that includes studies of "PPCPs" irrespective of doses and route of entry into environment. Pharmacceutical residues may reach the environment by a number of different routes. It is generally assumed (albeit hardly verified) that the production of pharmaceuticals in industrialized countries is well controlled and unharmful to the environment, due to the local

legal restrictions usually required to permit production. However, a substantial fraction of the global production of pharmaceuticals takes place in low-cost production countries like India and China. Recent reports from India demonstrate that such production sites may emit very large quantities of e.g. antibiotics, yielding levels of the drugs in local surface waters higher than those found in the blood of patients under treatment. The major route for pharmaceutical residues to reach the aquatic environment is most probably by excretion from patients undergoing pharma treatment. Since many pharmaceutical substances are not metabolized in the body they may be excreted in biologically active form, usually via the urine. Furthermore, many pharmaceutical substances are not fully taken up from the intestine (following oral administration in patients) into their blood stream. The fraction not taken up into the blood stream will remain in the gut and eventually be excreted via the faeces. Hence, both urine and faeces from treated patients contain pharmaceutical residues.

An additional source to environmental pollution with pharmaceuticals is improper disposal of unused or expired drug residues. In European countries take-back systems for such residues are usually in place (although not always utilized to full extent) while in e.g. the US only voluntary initiatives on a local basis exist. Proper destruction of pharma residues should yield rest products without any pharmaceutical or ecotoxic activity. Furthermore, the residues should not act as components in the environmental formation of new such products. Incineration at a high temperature (>1000^{o}C) is considered to fulfill the requirements, but even following such incineration residual ashes from the incineration should be properly taken care of. Pharmaceuticals used in veterinary medicine, or as additives to animal food, pose a different problem, since they are excreted into soil or possibly open surface waters. It is well known that such excretions may affect terrestrial organisms directly, leading to extinction of exposed species (e.g. dung-beetles). Lipid-soluble pharma residues from veterinary use may bind strongly to soil particles, with little tendency to leak out to ground water or to local surface waters. More water-soluble residues may be washed out with rain or melting snow and reach both ground water and surface water streams[23-33].

Few options to help dispose of expired or unwanted prescription or over-the-counter medications safely

Collection sites for household pharmaceuticals

Take advantage of a community drug take-back program. Because of concerns of drug abuse and that some medications are highly regulated controlled substances, drug take-back programs are managed through law enforcement agencies.

A number of counties hold regularly scheduled drug-take back events, and many police and sheriff facilities have permanent drop boxes. These programs typically accept all medicines from households, including prescription, over-the-counter, and pet medicines.

Contact your county sheriff's office or city police office to find out if there is a permanent collection site near you. Or call your city or county to see what options are available in your community.

Disposing of medications at home

Your unwanted medications may be disposed of in your trash. Follow these precautions to prevent accidental or intentional ingestion.

Keep the medication in its original container. The labels may contain safety information and the caps are typically childproof. Leaving the content information clearly visible, cover the patient's name with permanent maker.

Modify the contents to discourage consumption. **Solid medications**: add a small amount of vinegar to pills or capsules to at least partially dissolve them.

Liquid medications: add enough table salt, flour, or nontoxic powdered spice, such as mustard to make a pungent, unsightly mixture that discourages anyone from eating it.
Blister packs: wrap packages containing pills in opaque tape like duct tape.
Seal and conceal. Tape the medication container lid shut with packing or duct tape and put it inside a non-transparent bag or container such as an empty yogurt or margarine tub to ensure that the contents cannot be seen. Do not conceal medicines in food products because they could be inadvertently consumed by wildlife scavengers.

Discard the container in your garbage can—do **not** place in the recycling bin.
Incineration is the preferred method for destruction of household pharmaceuticals. If you know your garbage goes to an incinerator, you can safely dispose of your medications using these instructions. If your garbage goes to a landfill and you would prefer not to wait until a collection option is available, it is still better to follow these instructions than to flush any medications.

Unused ampoules, vials, and IV bags should not be opened. Wrap the container with tape to minimize breakage, then place in an opaque plastic container (such as an empty yogurt or margarine tub). Wrap the outside of the container or bag with additional duct or shipping tape to prevent leakage and further obscure the contents. Dispose of the container in the trash.
Chemotherapy drugs may require special handling. Work with your healthcare provider on proper disposal options for this type of medication.
Mercury thermometers: When you are checking through your medicine cabinet for outdated pharmaceuticals, please also be on the lookout for mercury thermometers. However, household pharmaceutical collection sites do not collect any mercury-containing devices or needles and syringes. It is very important for your family's safety for you to take mercury thermometers to your local household hazardous waste collection sites. Please also check for cooking thermometers. Mercury cooking thermometers are especially dangerous because if they break in a pan of hot liquid the vapors are extremely toxic. Be very careful when handling thermometers. Keep them in their cases if they came with one, and remove them from the house as soon as you can.

CONCLUSION

Green Pharmacy aims at zero waste and offers an opportunity for social action that will greatly benefit our environment at all levels of our society. It requires consumers not to dispose of any medication down the toilet or in the trash, to purchase drugs in small amounts, limiting expired medications, use medications with low environmental impact, disposed of unused or unwanted medications at take-back sites only. Unused and unexpired medications can be donated to non-profit organizations that redistribute medications. Manufacturers should design drugs that are more ecologically sensitive and medicines that biodegrade more quickly and yield end products that are less harmful. The pharmaceutical industry could also devote a portion of its huge advertising campaign to educate both physicians and consumers about the environmental and health issues. Hospitals should develop methods for proper disposal of waste. Physicians, veterinarians and dentists should also participate in the solution. The time when a medical practitioner is prescribing a medication is an ideal moment to educate patients about proper disposal. Pharmacies should serve as take-back sites for proper pharmaceutical disposal. They can have recycle bins, which allow consumers to bring their unused/expired

medicines back whenever they shop. Our contribution towards safe and healthy environment by adopting Green Pharmacy can prove to be a powerful approach that provides a comprehensive solution to an issue which has the potential to affect much of life on Earth.

ABBREVIATIONS

Pharmaceuticals and Personal Care Product (PPCP); Smart Disposal Campaign Programs (SDCP); Environmental Protection Agency (EPA); Resource Conservation and Recovery Act (RCRA); Washington Citizens for Resource Conservation (WCRC); National Drug Control Policy (NDCP); Proper Disposal of Prescription Drug (PDPD); Associated Press; Agriculture Research Centre (ARC); Patancheru Enviro Tech Ltd (PETL); Pharmaceutical Research and Manufacturers of America (PRMA); Generic Pharmaceutical Association (GPA)

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