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MANAGEMENT OF GREEN PHARMACEUTICALS

Shiraz Mehdi *, Tabrez Uz Zaman and Syed Saif Imam

Department of Hospital Management and Hospice Studies, Jamia Millia Islamia, Jamia Nagar - 110025, Delhi, India.

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Correspondence to Author:
Shiraz Mehdi

Research Scholar,
Department of Hospital Management and Hospice Studies, Jamia Millia Islamia, Jamia Nagar - 110025, Delhi, India.

E-mail: shiraz.kazmi1.sk@gmail.com

ABSTRACT: Green Pharmacy represents a holistic approach to healthcare that emphasizes the importance of controlling the environmental contamination caused by pharmaceuticals. Also, Green Pharmacy prevents environmental contamination due to the API (active pharmaceutical ingredient) present in the medicines. Contamination of the environment by Active pharmaceutical ingredients can occur through various pathways, such as improper disposal, wastewater from pharmaceutical manufacturing industries, and even through excretion by patients. These contaminants adversely affect aquatic ecosystems and potentially impact human health if they enter the food chain supply by any means. Proper disposal and wastewater treatment are crucial to mitigate this environmental risk. This abstract explores the potential benefits of the Green Pharmacy, including reduced adverse effects, sustainability, and cultural preservation. It also addresses the challenges associated with standardization, quality control, and regulatory approval. Additionally, it also provides some new ideas about how to stop or prevent the uncontrolled contamination of API in the environment due to the improper disposal of drugs from pharmaceutical manufacturing industries, hospitals, and also from houses. The Green pharmacy concept encourages a shift towards a more sustainable and nature-centric approach to healthcare, aligning with the growing global interest in holistic well-being and environmental conservation.

INTRODUCTION: The concept of 'Green pharmacy' in the context of pharmaceuticals refers to the practices and principles aimed at reducing the environmental impact of pharmaceutical products, particularly Active pharmaceutical ingredients. It addresses contamination from APIs and focuses on sustainability in the pharmaceutical industry [1].

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The history of the green pharmacy concept to prevent contamination of Active pharmaceutical ingredients in the environment has evolved in response to growing environmental concerns. Some brief overviews of its development are:

In the late 20th century, increased awareness of environmental issues, such as water pollution, led to concerns about the presence of pharmaceutical residues in the environment. Researchers began detecting APIs in the water bodies and raising alarms about their potential impacts [2]. In 1980-1990 scientists started research to find pharmaceutical ingredients in the environment and their effects on aquatic ecosystems and humans.

The research revealed that the APIs from human and veterinary sources could persist in water and soil, potentially harming wildlife, and the ecosystem and if come in contact with the water treatment plant it can harm human health too [3].

In late 2000's Regulatory agencies, particularly in Europe, began to take action. In 2001, the European Medicines Agency (EMA) issued guidelines for assessing the environmental impact of human pharmaceuticals. These guidelines required pharmaceutical companies to consider the potential environmental risks of their products during development [4, 5]. In 2000, Green pharmacy principles and practices started gaining momentum. These principles emphasize sustainable drug design, responsible manufacturing, improved wastewater treatment, proper disposal, and education about proper disposal.

In 2010, various countries and regions introduced legislation and policies to address API contamination. For example, the European Union's Environmental Risk Assessment (ERA) process became mandatory for all new human and veterinary medicines. Also, The U.S. Environmental Protection Agency (EPA) initiated efforts to evaluate the environmental impacts of API's [6]. Presently international organizations, such as the World Health Organization (WHO), have recognized the importance of addressing pharmaceutical pollution. Collaborative efforts between governments, the pharmaceutical industry, and environmental organizations aim to develop sustainable solutions [7].

Effects of API Induced Pollution on Living Organism:

Contributing Factors: Medicinal products and pharmaceutical ingredients can be considered as environmental contaminants when they enter the environment in amounts that can have adverse effects on the ecosystem and human health[8]. This can happen through various routes such as:

1. Wastewater discharge.
2. Improper disposal.
3. Excretion.
4. Animal agriculture (veterinary).
5. Bioaccumulation.

Wastewater Discharge: Pharmaceutical residues can enter the environment when pharmaceutical manufacturing facilities release wastewater containing active pharmaceutical ingredients into rivers or sewage systems. Even after wastewater treatment, trace amounts may persist. API is of particular concern because even a small amount of it can have biological effects. Many countries have regulations and guidelines in place to limit the discharge of pharmaceutical wastewater into the environment [9, 10]. These regulations aim to control the quality of discharge wastewater and set limits on specific pollutants. Pharmaceutical Wastewater may contain active pharmaceutical ingredients, which can be harmful to aquatic life and may lead to antibiotic resistance when released into water bodies. In addition to this many chemicals, solvents, excipients, and additives used in pharmaceutical production can contaminate water sources, affecting aquatic ecosystems and potentially entering the food chain. APIs can disrupt aquatic ecosystems and harm aquatic organisms, even at low concentrations, by affecting their growth, reproduction, and behavior. Inadequate treatment of pharmaceutical wastewater can result in the presence of trace pharmaceutical residues in drinking water, potentially affecting human health [11].

Improper Disposal: Improper disposal of medicines in the environment can promote contamination in many ways:

When medicines are flushed down through toilets or thrown in the trash, they can leach into the groundwater or end up in the rivers and lakes, contaminating water sources. Also, disposing of medication in landfills can lead to the release of chemicals into the soil, potentially affecting plants and wildlife [12].

Excretion: API can also be excreted in urine and then enter wastewater treatment systems. These systems may not always effectively remove pharmaceutical compounds, leading to the presence of APIs in treated wastewater that is discharged into the rivers and ocean and from there to tap waters harming human health [13]. According to some previous research and after some tests it is

found that the concentration of APIs ranges from ng/Lt or microgram/Lt or even mg/Lt of the APIs found mostly in the wastewater.

Animal Agriculture: Animal agriculture can have significant environmental impacts and contribute to contamination in various ways, runoff from animal farms can carry manure, nutrients, and pathogens into nearby water bodies, leading to water pollution. Excess nutrients like nitrogen and phosphorus can cause harmful algal blooms which leads to oxygen depletion and harm the aquatic ecosystem and aquatic life. Also, the use of antibiotics and hormones in animals can result in residues entering the environment through manure and potentially contribute to antibiotic resistance and hormone disruption in wildlife and the ecosystem [14, 15].

Bioaccumulation: Bioaccumulation is a process by which certain chemicals or pollutants accumulate in the tissues of organisms at higher concentrations than those found in their surrounding environment. This can have significant environmental and human health implications.

Bioaccumulation of harmful substances can lead to toxic effects in wildlife, including reduced reproductive success, behavioral changes, and even population declines. In marine environments, bioaccumulation is a concern for seafood consumers. Species like large predatory fish (e.g., tuna, shark) can contain high levels of mercury or other contaminants, posing a risk to human health if consumed in excess [16].

Bioaccumulation is also harmful to Humans, humans can be exposed to bioaccumulated pollutants through the consumption of contaminated food, inhalation of air pollutants, or contact with contaminated soil and water. Chronic exposure to these substances can lead to various health problems, including neurological, developmental, and reproductive issues [17].

Adverse Effects of APIS on Environment: The effects of medications have long been underrated, yet they require just as much attention as the effects of other chemicals, such as pesticides, biocides, or industrial chemicals, which are known to have adverse effects on the environment and human health. Increased interest in the topic of pharmaceuticals in the environment resulted from the finding of estrogens in sewage effluents as a cause of fish feminization in the late 1990s [18, 19]. The German Advisory Council on Environment SRU, 2007) suggested in 2007 that it be investigated whether pharmaceuticals might be added to the Water Framework Directive's list of priority dangerous chemicals. However, after being suggested by the Expert Group on Review (SG-R) of the Priority Substances in 2009, no medication is still listed as a priority substance in 2018. Some medications are currently listed on or intended to be listed on a Watch List alongside other recognized relevant compounds to get further monitoring data. The majority of these drugs are antibiotics and hormonally active compounds. This is not shocking considering that medications contain active components that are intended to be biologically active in order to have a therapeutic impact and thus may have effects on other living species. Excipients are also acknowledged to be harmful [20].

An excipient is a component included in the formulation of a medication's active ingredient in order to enhance certain aspects of the pharmaceutical ingredient, such as its physical qualities. Many oral medicinal formulations utilize functional excipients like phthalates among other things. These compounds may be endocrine disruptors and have negative effects on development and/or reproduction.

In terms of market presence, there are currently around 3,000 active pharmaceutical ingredients (APIs) authorized on the EU market as a whole, even though the APIs authorized at the national level vary significantly (B10 Intelligence Service, 2013). Human and veterinary medicinal products are consumed for preventive, diagnostic, nutritional, and/or treatment purposes.

It is expected that 1,00,000 tonnes of APIs are consumed annually in the entire world (KNAPPE, 2008). The EU consumes 24% of all human pharmaceuticals globally, coming in second position to the US (55%), with Japan taking up the third spot with 14% (BIO Intelligence Service, 2013) [21, 22]. Examining the impact of drugs on wildlife, including endocrine disruption and behavioral alterations in land and marine animals.

For instance, the presence of endocrine-disrupting chemicals (EDCs) in aquatic habitats and water pollution both pose serious concerns for fish reproductive abnormalities brought on by estrogens. Estrogens, whether they are natural or manufactured, can harm fish reproductive systems. Estrogens, which include estradiol and ethinyl-estradiol, are hormones that are essential for the growth and operation of the reproductive system in both fish and humans. These estrogens or estrogen-like substances can interfere with fish's endocrine systems when they are present in water bodies. Additionally, exposure to high estrogen levels can cause male fish to become female. This may show up as the emergence of secondary female sexual traits in women, such as the creation of egg proteins, modifications to the gonadal morphology, and a decline in sperm production [23].

Improved wastewater treatment techniques to eliminate EDCs, legislative restrictions on the dispersal of such chemicals into the environment, and continuous study to better comprehend the impacts of EDCs on aquatic creatures are some of the ways that estrogens affect fish populations. To counteract the negative effects of estrogenic chemicals on aquatic habitats and the organisms that live there, it is crucial to monitor and manage water quality.

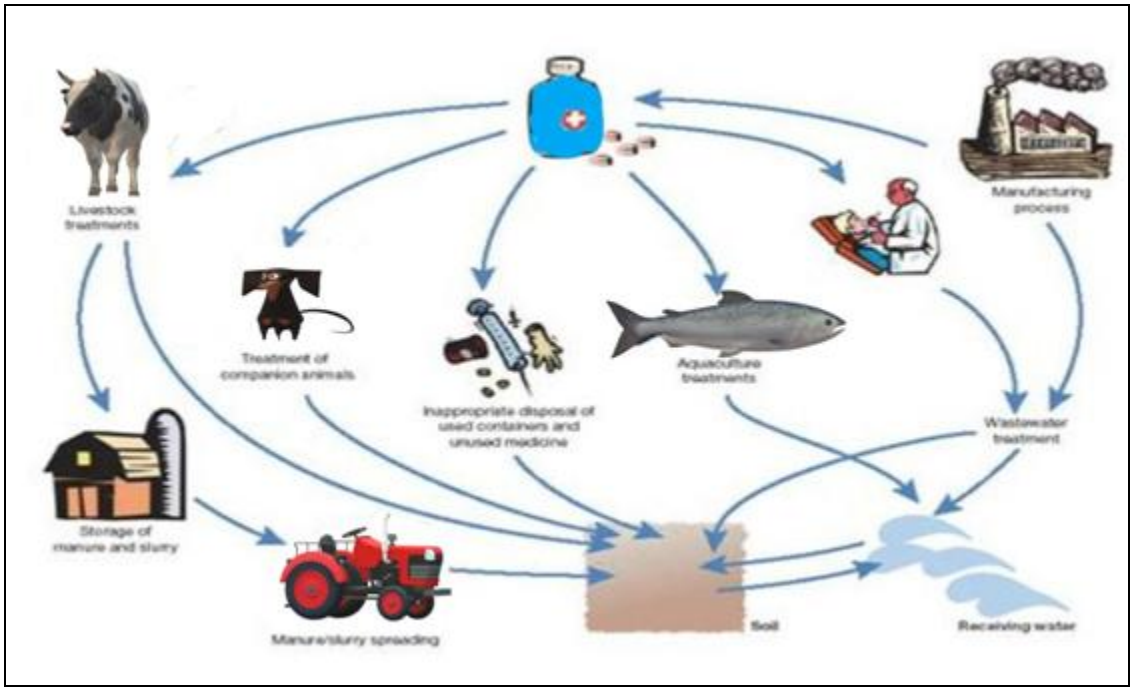

FIG. 1: CONSEQUENCES OF PHARMACEUTICAL POLLUTANTS

Concerns over environmental pollution are also greatly heightened by the use of veterinary medications. Antibiotic resistance and hormone disruption in wildlife and the ecosystem may be caused by residues from antibiotic and hormone use in animals that enter the environment through manure.

For instance, Diclofenac-related vulture deaths are a well-known environmental problem. Diclofenac is a non-steroidal anti-inflammatory drug (NSAID) that is frequently prescribed for treating animals in veterinary medicine. The consumption of diclofenac-treated animal corpses by vultures, on the other hand, can be fatal for these birds. Diclofenac is toxic to vultures and can also lead to kidney failure in them. Kidney failure in vultures can be fatal since vultures rely heavily on their kidneys to keep their water and electrolyte balances, especially in hot and arid climates. In South Asia, the number of vulture species has drastically decreased as a result of the widespread use of diclofenac in veterinary medications. Vulture populations have dropped by nearly 90% in some places.

Drugs Harming the Environment:

Human Drugs: Aminophylline, Beclametasone, theophylline, Paracetamol, Norethisterone, codeine, furosemide, Atenolol, Bendroflumethiazide,

chlorphenamine, lofepramine, Dextro-propoxyphene, Procyclidene, Tramadol, Clotrimazole, Thiridazine, Mebeverine, Terbinafine, tamoxifen, Trimethoprim, Sulfamethoxazole, Fenofibrate, diclofenac.

Veterinary: Amitraz, Amoxicillin, Amprolium, Baquiloprim, Cephalexin, Procaine, Clopidol, Tylosin, Tetracycline, Neomycin, *etc*. Numerous subtle effects, such as those on oocyte and testicular maturation, impacts on insect physiology and behavior, impacts on the decomposition of animal waste, inhibition or stimulation of aquatic plant and algal species' growth, and the emergence of antibacterial resistance in soil microbes, have all been documented. It is quite likely that the fertility and development of fish, reptiles, and aquatic invertebrates are impacted by the steroids found in contraceptives. Algae and soil bacteria are both impacted by antibiotic use in humans and animals. Earthworms seem to be sensitive to the parasiticides used in veterinary treatment, and plants may be sensitive to several antibiotics. Macrocyclic lactones can damage invertebrate larvae in dung at quite low quantities.

Additionally, it has been demonstrated that macrocyclic lactones cause a variety of sub-lethal reactions in dung invertebrates, including decreased eating, upset water balances, slowed growth, inhibition of pupation, and disturbance of mating. Macrocyclic lactones may therefore indirectly influence other species by reducing the quality and quantity of their food source, as cattle excrement contains a diverse fauna and serves as a productive foraging habitat for other species. Pharmaceuticals linked to sediment have also been taken into account for their effects. Nentwig *et al.* demonstrated *via* life-cycle research that carbamazepine impacts the emergence of chironomids, an aquatic midge species. While many of these observations have been made at concentrations that are environmentally appropriate, their importance for environmental health has not yet been determined; in fact, determining this significance will be one of the difficulties in the years to come [24, 25].

Methods to Minimize the Contamination:

Environmental Research on Medicines: API (active pharmaceutical ingredients), according to the European Union, APIs defined as "any substance or mixture of substances intended to be used in the manufacturing of a medicinal product (pharmaceutical product) and that, when used in the production of a medicinal product, becomes an active ingredient of the medicinal product, intended to furnish pharmacological activity or other direct effect in the diagnosis, cure, mitigation, treatment, or prevention of disease or to affect the structure and function of the body."

There are more than 3000 APIs authorized on the European market and the consumption of this much of the APIs by the population results as the main source of environmental contamination by any means, like through excretion and inappropriate disposal of unused or expired medicines (through toilets, sink, or litter).

Environmental research on medicines primarily focuses on studying the environmental impact of pharmaceuticals, including their manufacturing use, and disposal. Key areas of research include:

Investigating the presence of "pharmaceutical residues" in water bodies and their potential effects on aquatic ecosystems and human health [15]. In recent years, the researchers found that the concentration of APIs found in the wastewater is ng/Lt or microgram/Lt or even mg/Lt, this concentration of APIs in wastewater can harm the aquatic ecosystem and human health also. Improper medicinal disposal is also a very big concern of the presence of pharmaceutical ingredients in the environment, many organizations (e.g WHO) started educating the proper disposal methods for unused or expired medications to prevent the contamination of water and soil [16].

Researchers conducted studies on the environment (mainly on soil and water), and found molecules unchanged (parent compound). The concentration of APIs found in the wastewaters is already high and has negative effects reported (for example: reproductive system disorders in fishes caused by estrogens, the emergence of resistant bacteria caused by antibiotics, or even the death vultures caused by the use of diclofenac as veterinary medicine). "Ecotoxicity", refers to the capability of a compound or any physical agent to show the harmful effects on both the environment and

organisms. Analyzing the effects of pharmaceuticals on wildlife, including endocrine disruption and behavioral changes in aquatic organisms and terrestrial animals. For example, reproductive disorders in fishes caused by estrogens are a significant concern related to water pollution and the presence of endocrine-disrupting chemicals (EDCs) in aquatic environments [17].

Estrogens, both natural and synthetic, can have adverse effects on fish reproductive systems. Estrogens, such as estradiol and ethinyl-estradiol, are hormones that play a crucial role in the development and functioning of the reproductive system in both humans and animals, including fish. When these estrogens or estrogen-like compounds are present in water bodies, they can disrupt the endocrine system of fish. Also, exposure to elevated estrogen levels can lead to the Feminization of male fish. This can manifest as the development of female secondary sexual characteristics, including the production of egg proteins, changes in gonadal morphology, and reduced sperm production [17].

The impact of estrogens on fish populations includes improved wastewater treatment methods to remove EDCs, regulatory measures to limit the release of such chemicals into the environment, and ongoing research to better understand the effects of EDCs on aquatic organisms. Monitoring and managing water quality is essential to protect aquatic ecosystems and their inhabitants from the detrimental effects of estrogenic compounds.

Veterinary Medicines are also a very big concern related to the contamination of the environment. The use of antibiotics and hormones in animals can result in residues entering the environment through manure and potentially contribute to antibiotic resistance and hormone disruption in wildlife and the ecosystem. For example, the death of vultures caused by Diclofenac is a well-documented environmental issue. Diclofenac is a non-steroidal anti-inflammatory drug (NSAID) commonly used in veterinary medicines to treat livestock. However, when vultures consume carcasses of animals that were treated with diclofenac, it can have deadly consequences for these birds [18]. Diclofenac is toxic to vultures, it can also cause kidney failure in vultures, this can be fatal as vultures are highly dependent on their kidneys for maintaining their water and electrolyte balances, especially in hot and arid regions. The widespread use of diclofenac in veterinary medicines led to a sharp decline in vulture populations in South Asia [19]. In some areas, vulture populations have decreased by over 90%.

To mitigate the environmental impacts of pharmaceutical ingredients which can have adverse effects on the ecosystem when they enter water bodies through various routes, such as wastewater discharge and improper disposal of medicines, it's crucial to improve pharmaceutical waste management, enhance treatment processes to remove pharmaceutical residues from wastewater, and raise awareness about proper medication disposal methods. Additionally, further research and regulatory measures are needed to address this growing environmental concern.

Prescribing medicinal products (a major cause of the contamination in the environment):

1. Prescribing to minimize their environmental impact is an important consideration in modern healthcare. Prescribing should be rational, optimal, and efficacious.

2. When possible, doctors should prescribe medications with formulations that have a reduced environmental impact. For example, extended-release formulations may require less frequent dosing, reducing overall drug use.

3. Considering generic drugs often have a smaller environmental footprint compared to brand-name counterparts. Prioritize essential medications that provide substantial clinical benefits to avoid unnecessary prescriptions.

4. Educating patients on the proper use and disposal of medications. Encourage them to return unused medications to the pharmacists for safe disposal instead of flushing them down the toilet or throwing them in the trash.

5. Prescribing antibiotics when their use is not needed such as in the common cold, should be stopped.

6. Overprescribing/over-the-counter drugs is also a big concern for example, doctors prescribe a

medicine to his/her patient for seven days once a day tablet but the pharmacist gives the whole strip to the patient containing 10 tablets, so the rest 3 are going to be disposed improperly by patients and cause contamination in the environment).

Dispensing of medicinal products may increase the environmental contamination caused by API. Dispensing of free or low-cost medicines may also lead to the accumulation of unused medicines using Excretion and improper disposal of drugs. Patients are also responsible for environmental contamination, for example, many patients treat themselves using self-medication and end up in the improper disposal of unused drugs, Patients also store excessive drug stocks which also end up in the improper disposal of the drugs.

Future Prospectives to Treat Contamination of APIs:

Water Disposal Management: Managing water disposal contaminated with APIs (active pharmaceutical ingredients) is a critical environmental concern. First, we have to see the process of how the APIs come in contact with the environment with the help of a flow chart:

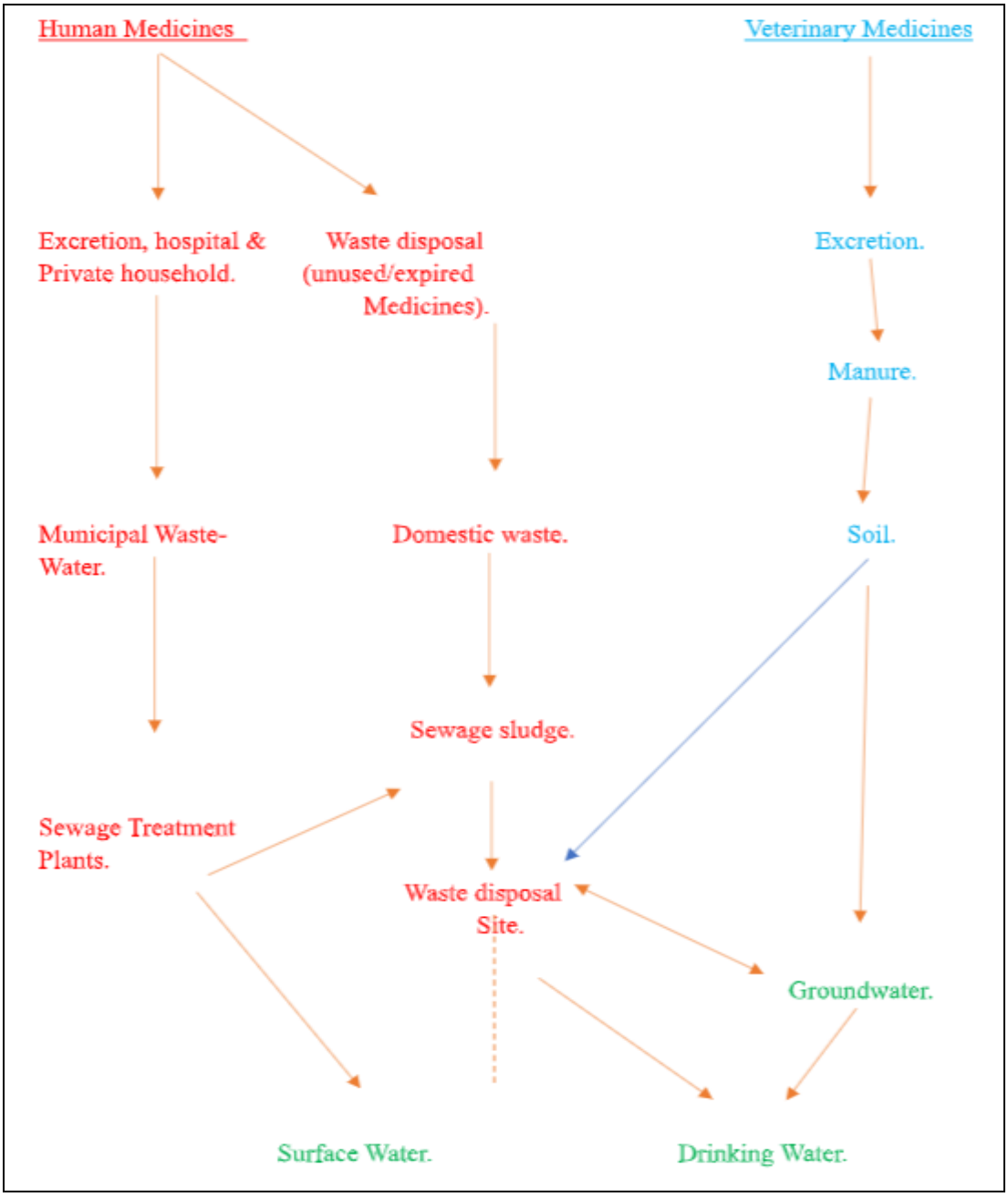

FIG. 2: FLOW CHART OF HOW API'S CONTAMINATING WATER

As we can see in the flow chart there are two ways from where the APIs can come in contact with the environment: From human medicines and on the other hand from veterinary medicines. Human medicines can cause contamination by improper disposal. When pharmaceuticals are flushed down in toilets or discarded inappropriately, they can end up in water systems, potentially affecting aquatic life and ecosystems [16]. If it comes in contact with ground water as shown in the flow chart it can also be harmful to human health. Proper disposal methods and responsible use of medications are important to minimize this environmental impact. On the other hand, veterinary medicines can also contribute to environmental contamination. When these medicines are administered to animals or improperly disposed of, they can enter the environment through animal waste, runoff from agriculture areas, or the disposal of unused medications. This can potentially impact soil, water, and ecosystems, highlighting the importance of responsible use and disposal of veterinary medicines to mitigate environmental harm [26, 27]. To solve these problems we can also see the process of the water treatment plant and make some changes in the water treatment plant to make sure that no APIs should pass through the plant.

Water Treatment Plant: Water treatment plants are facilities designed to treat and purify water from various sources to make it safe for human consumption and other purposes. The process typically involves several stages [20].

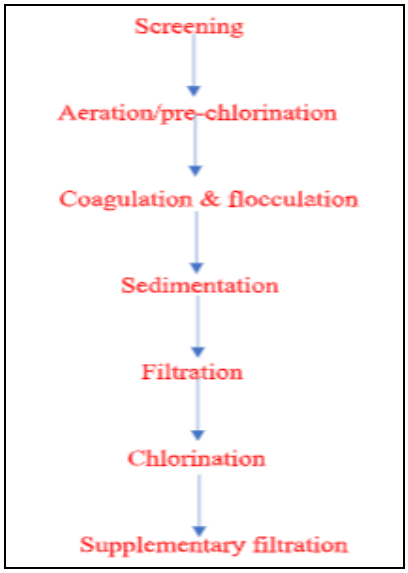

FIG. 3: FLOW CHART OF WATER TREATMENT PROCESS

Screening is an essential process in water treatment plants designed to remove large objects and debris from the incoming water before it undergoes further treatment. This helps protect downstream equipment and processes, such as pumps and filters, from damage or clogging. The screened water then proceeds through the treatment process.

Aeration is a critical process in water treatment plants that involves the introduction of air into water. This is done for several purposes:

1. Oxygenation: Aeration adds oxygen to the water, which is essential for the survival of aerobic microorganisms used in biological treatment processes.
2. Removal of gases: Aeration can help remove unwanted gases, such as hydrogen sulfide and carbon dioxide, which can cause odor and taste issues in drinking water.
3. Mixing: Aeration helps to mix chemicals and substances in the water, ensuring uniform distribution. This is crucial when adding chemicals like coagulants or disinfectants.
4. Oxidation: Aeration promotes the oxidation of dissolved iron and manganese, causing them to precipitate and be removed during subsequent treatment processes.

Coagulation and Flocculation, Coagulation is the first step, where a coagulant chemical, often aluminum sulfate (alum) or ferric chloride, is added to the water. These coagulants destabilize the colloidal particles by neutralizing their electrical charges. This causes the fine particles to come together and form larger, heavier particles called “flocs”. After coagulation, the water enters a flocculation basin, where gentle mixing or stirring is applied[21]. This promotes the collision and aggregation of the destabilized particles (flocs) formed during coagulation. The flocculation process helps these flocs grow larger and heavier [28].

The sedimentation process in water treatment plants often follows coagulation and flocculation. It involves allowing water to rest in a large tank or basin, typically referred to as a sedimentation basin or clarifier. During this period of rest, suspended

particles and flocs created during coagulation and flocculation settle to the bottom of the basin due to gravity. Filtration in water treatment plants that follows sedimentation. Its primary purpose is to remove the remaining suspended particles, fine colloids, microorganisms, and any other impurities that might have escaped previous treatment steps [29]. Chlorination is a widely used disinfection method in water treatment plants to ensure the safety of drinking water by destroying or deactivating harmful microorganisms, such as bacteria, viruses, and parasites. Supplementary filtration in a water treatment plant refers to an additional filtration process that may be employed to further enhance water quality beyond the primary filtration step. This supplementary filtration is used when specific water quality goals or regulations require further treatment [30].

Biggest Water Plant SBR: The biggest water treatment plant in India is the Sequential Batch Reactor, it is a wastewater treatment process that operates in a sequence of fill, react, settle, and decant phases within a single reactor tank. It's a cyclic biological treatment plant. SBRs offer flexibility and efficiency in treating wastewater while minimizing the need for additional tanks [22]. They can remove organic matter, nutrients, and suspended solids from wastewater through biological and physical processes. Even after processing through these SBRs the active pharmaceutical ingredient still passes and harms the aquatic ecosystem and human health.

How we can Solve this Problem: Well in the U.K. the problem related to the water treatment plant that after the whole process the APIs still pass through the plant is solved, A company named "ARIA" known for its innovation made a machine that fits into the water treatment plant and its main aim is to remove the APIs (active pharmaceutical ingredient) by totally deactivating the active compound.

When the wastewater passes through the machine or the plant made only to remove the pharmaceutical ingredient, the ions of the active ingredient get separated in the machine and settle down as flocs and are removed in the next processes. But if we see from the price point of view the machine is quite expensive, other method to resolve this problem is only a new idea or future prospective.

Electrophoresis: Electrophoresis is a laboratory technique used to separate and analyze molecules, such as DNA, RNA, and proteins, based on their size and charge. It involves applying an electric field to a gel or other medium through which the molecules move. Smaller, negatively charged molecules migrate faster toward the positive electrode, while larger or positively charged molecules move more slowly [23].

This process is widely used in molecular biology and biochemistry for various applications, including DNA fingerprinting, protein analysis, and DNA fragment sizing.

Electrophoresis Tank:

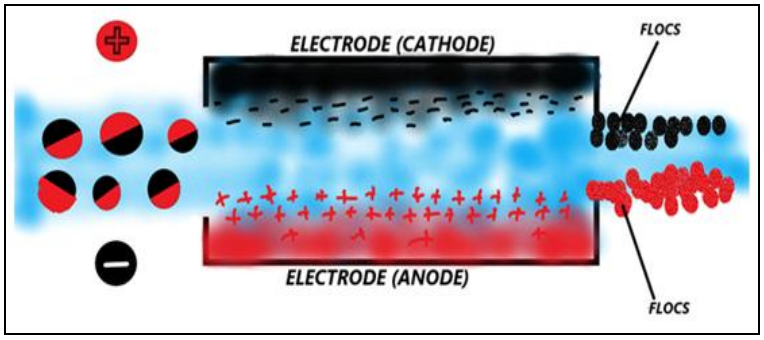

FIG. 4: ELECTROPHORESIS TANK

The above diagram is Electrophoresis tank, as we know Electrophoresis is used to separate compounds based on their size and charge, so, if we can somehow use the electrophoresis technique in the water treatment plant, based on the charge of the compound the active pharmaceutical ingredient will easily be deactivated by passes through the electrophoresis sheet the ions of the active pharmaceutical ingredient (APIs) get separated and it got deactivated as in the ARIA machine. In

addition, this technique will also not be expensive in comparison with the ARIA machine. In the diagram it is shown that, if the APIs passes through the electrophoresis tank, due to the presence of electrodes the APIs got separated into ions and the positive ions got attached to anode electrode and the negative ions attached to the cathode electrode and flocs created with time and due to the pressure of the water flow the flocs passes out from the electrophoresis tank and got separated in the further process of the water treatment plant.

A Greener Perspective for Expired Drugs: Pharmacies might collect unwanted or expired medications from clients as one of their strategies for reducing the environmental impact of pharmaceuticals. FIP offers some advice to neighborhood pharmacies regarding the collection and disposal of pharmaceutical waste in the document titled "Green Pharmacy Practice" [31, 32]. Pharmacies can choose to be accredited for their waste management operations, but the procedure is very pricey. The collection of unused and expired medications from patients as well as the disposal of pharmaceutical waste should be handled according to standard operating procedures, even if pharmacies are not required to get accreditation. Community pharmacies can also enter into a number of different types of agreements, including those with pharmaceutical waste collection companies for proper disposal, local governments for better management of collection programs and information campaigns, pharmaceutical product manufacturers for proper waste collection, and organizations that assist pharmacists in organizing their waste management activities [33, 34].

Pharmacists are best suited to tell patients about medical drugs, including any environmental risks, when it comes to patient communication. Through counselling, pharmacists should also educate patients on how to properly discard outdated or expired medications by enticing them to bring these medications back to a neighborhood pharmacy. Before returning medications to the pharmacy, pharmacists should also educate patients about the appropriate packing of medications. Additionally, all information regarding how to properly dispose of unneeded or expired medications should be made available in writing [35]. Participating in collection programs is a good approach for community pharmacy to reduce the amount of drugs in the environment. For instance, pharmacies in Switzerland gather 237g of unwanted medications per inhabitant each year, followed by those in France, Luxembourg, Ireland, and Sweden. The typical amount of pharmaceutical waste gathered from patients in Europe varies between 10g and 100g per person per year. As a whole, South-Eastern nations collect less unused or outdated medication than their European counterparts do [36].

Researchers in Romania carried out a study to determine whether Romanian patients return their unused or expired medications to aneighborhood pharmacy. Less than 1% of the patients surveyed claimed to have in fact returned these medications to a pharmacy, while the rest disposed of them as trash. The geographical distribution of community pharmacies (patients ought to be able to return their unused or expired medications to the closest pharmacy), the lack of patient privacy when disposing of pharmaceutical waste, and the lack of specific containers in the pharmacy all contribute to the poor collection service [37, 38].

Regarding the relationship between pharmacists and other medical professionals, FIP promotes interaction with doctors so that medications with a low risk of environmental contamination can be correctly assessed and prescribed. For instance, the Drug Therapeutic Committee and the Health and Medical Care Administration of the Stockholm County Council in Sweden have developed a website with information about pharmaceuticals, where the goods are categorized based on both their environmental danger and risk. Persistence, bioaccumulation, and toxicity (PBT) are the three factors that define an environmental danger of a pharmaceutical substance. Based on the findings of the environmental hazard assessment, a numerical value between 0 and 3 is assigned to each of these features. For any pharmaceutical product, the sum of these values can range from 0 to 9, with a high PBT index indicating a significant environmental impact. The danger to the environment is based on the potential toxicity of any therapeutic product to aquatic systems, which might be negligible, low, moderate, or severe. When prescribing and/or dispensing a pharmaceutical substance, several

considerations may be taken into consideration [39, 40].

CONCLUSION: The issue of pharmaceutical contaminants in the environment is a growing concern for both public health and ecosystems. Green pharmacy initiatives aim to address this problem by promoting sustainable and environmentally friendly practices in the pharmaceutical industry. Green pharmacy initiatives are essential in mitigating the contamination of the environment by active pharmaceutical ingredients (APIs). By promoting responsible drug manufacturing, disposal, and consumption, these initiatives seek to reduce the reduce the release of harmful substances into our ecosystems. APIs are known to have adverse effects on aquatic life and can potentially impact human health through contaminated water sources. Green pharmacy practices, such as proper disposal methods and also eco-friendly drug design, can help to minimize these risks. To address the issue effectively, collaboration between governments, pharmaceutical companies, healthcare providers, and consumers is crucial. Continued research and innovation are also necessary to develop cleaner pharmaceutical production processes and safer drug compounds. Green pharmacy initiatives play a vital role in safeguarding the environment and public health by addressing the contamination of ecosystems with pharmaceutical contaminants, particularly APIs, that how they are harming the aquatic life and the ecosystem. The abovementioned future prospectives are integral to a sustainable and healthier future.

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