Challenges and Current Perspectives of Medical Pharmaceutical Waste Management

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ABSTRACT

Medicinal and Pharmaceutical waste is any waste products that contains wastes generated in hospital care unit, medicinal drugs that are expired, unused, contaminated damaged or no longer needed and disposable items. In a healthcare facility, pharmaceutical waste can result from a variety of activities and locations. There is generation of drug waste at site of compound pharmacies. It is not uncommon for medicines to spill over, unused as well as bottles and vials containing residual drugs and household wastes of pharmaceutical products. In this review we illustrate the types medical and pharmaceutical waste like biomedical waste, infectious waste, pathological waste, chemical waste, cytotoxic waste, pharmaceutical waste etc. Most drugs and their metabolites, remain active in the environment for a long time after they have been excreted out that can have harmful and hazardous effects to the ecosystem. The most effective pharmaceutical waste management strategies include proper prescription and dispensing in unit dosage form as per the requirement of the patient, followed by redispersing and recycling medication that remains unused throughout the supply chain. The only medication that can be redispersed is one that still has a good qualities and stability. The review also covers the waste disposal techniques for both solid and liquid formulations such as incineration, autoclaving, encapsulation, burial etc and overall roles of pharmacist to address the global issues of waste management.

KEYWORDS: *Pharmaceutical Waste, incineration, Environmental Pollution, encapsulation, Pharmaceutical and Personal Care Products (PPCPs).*

INTRODUCTION

A person's lifestyle is linked to their health. If people do not improve their lifestyle choices, these lifestyle diseases will increase throughout the years. The issue of diseases associated with longevity is sometimes compared with diseases associated with civilization or affluence, according to some commenters. Sedentary habits and unhealthy eating are common causes of obesity and other associated ailments. There is the need of new pharmaceutical dosage forms to address those issues and automatically that result in tons of pharmaceuticals waste globally that result in environment pollutions, indirectly affect human health and entire ecosystem.[1]

As a general term, "waste" describes anything after its primary use that is no longer useful or is discarded after it has been used. It is important to understand that waste can come from a variety of sources, such as household waste, sewage sludge, packaging items, industrial chemicals, medical waste, garden waste, and so on. The pharmaceutical waste stream cannot be categorised as one waste stream. Expired products, drugs that have been discontinued or unused dispensed product to the patients, and industrial contamination and hospital wastes. Sewage and drainage system of pharmaceutical industries which are directly poured to river and lakes may also lead to environmental contamination.

Active pharmaceutical ingredients (APIs) and healthcare products have been detected in aquatic environments for the past two decades. APIs enter the environment in a variety of ways. Many are obstinate, which means that a waste water treatment plant (WWTP) cannot effectively remove them.

During the waste treatment process, complete degradation of Active Pharmaceutical Ingredient is not possible. For example, around ten percent of Atenolol and Carbamazepine reach the environment after waste treatment protocol and polluted the environment. There was a large discharge of powerful antibiotics across the lake, including Ciprofloxacin, Ofloxacin, Norfloxacin, etc. Environmental studies statistical data of 2020 showed that toxic level of Lomefloxacin was found in environmental samples.

According to the Central Pollution Control Board report of….., approximately 40057 tons of pharmaceutical wastes were generated daily and this study was carried out by Registered Health Care Facilities in India. In most cases, pharmaceutical waste is disposed through human activities and enters the sewer system. Pharmaceutical contaminants are not taken into consideration by most government level sewage and waste treatment facilities, so these wastes cannot properly managed and disposed. [2]

It is important to handle, treat, dispose of, and segregate waste properly in order to minimize improper waste management and also consider the quantity of waste generated so that overall waste management can be achieved. Having fewer wastes means fewer waste disposal burdens. It is therefore imperative for healthcare providers to minimize waste generation during their daily work in clinics or hospitals.[3]

According to health care wastes

- About 85% of the health-care wastes are non-hazardous. However, remaining 15% of the waste material is categorized as hazardous, which includes infectious, toxic, and radioactive materials.

- Globally, 16 billion injections are administered annually, but not all needles and syringes and vials are disposed properly.
- It is crucial to protect the health of patients, health workers, and the general public by ensuring the safe and environmentally responsible management of health care wastes. This includes preventing the unintended release of chemical and biological hazards into the environment.
- Under certain circumstances, open burning and incineration can emit dioxins, furans, and particulates that are hazardous and special techniques have to be adopted to neutralize them

Fig.1 Bio medical waste disposals.

This list illustrates the variety of materials found in waste and by-products:

1. **Infectious waste**: During Covid-19 outbreaks in Indonesia, infectious medical waste management was highly complicated due to the presence of blood and other body fluids (including leftover diagnostic samples), cultures and stocks of infectious agents from laboratory work , autopsies sample, patient related wastes (swabs, bandages, and disposable medical devices).As part of the regulations for the management of infectious waste in Indonesia, several guidelines have been modified from WHO [7] and United Nations Environment Programme(UNEP) [8] in terms of the collection, storage, transportation, and disposal of infectious waste (Fig. 1). Cleaning procedures and personal protective equipment ensure the safety of waste workers. A yellow leak-proof plastic bag marked with a biohazard symbol collects infectious waste from Covid-19 intensive care hospitals for up to 12 hours or ¾ filled bags. For hazardous short-term storage, yellow bags were treated with 0.50% chlorine for 30 minutes and stored for 48-hours (2 days); 168-hours (7 days); or 2,160-hours (90 days) at room temperature, 3.00-8.00C, or 0.00C [9].

2. **Biomedical waste:** There is considerable concern about biomedical waste (BMW) in modern times. It has been estimated that 15 to 25% of hospital waste is hazardous and dangerous to the health of the patient [10]. Used Needles and syringes can transmit Hepatitis B, Hepatitis C, and HIV to other patient. They are found to be responsible for 32% of all new Hepatitis B infections, 40% of all new Hepatitis C infections, and 5% of all new HIV infections. Waste generated from the health care sector consists of solid, liquid, and gaseous in nature. Mostly,

Liquids and solids that are contaminated with organic and inorganic substances, pathogenic radionuclides, microbial contaminations are common. According to the World Health Organization (1999), about 85% of health hazards from environmental and hospital waste were found to be non-hazardous, 10% were infectious, and 5% were associated with flora on the area which was not generally infectious but hazardous. A notification issued by the Government of India (1998) specifies that Hospital Waste Management is an essential part of the maintenance and hygiene of hospitals. Basically, this involves managing activities, which are mainly engineering functions, such as collecting, transporting, operating, treating, and disposing of waste. Biomedical waste disposal is shown in figure 1.

Medical waste has been classified into eight categories by the World Health Organization (WHO): [11]

I. General Waste
II. Pathological
III. Radioactive
IV. Chemical
V. Infectious to potentially infectious waste
VI. Sharps
VII. Pharmaceuticals
VIII. Pressurized containers

Biomedical waste flow chart management is depicted in Fig 2.

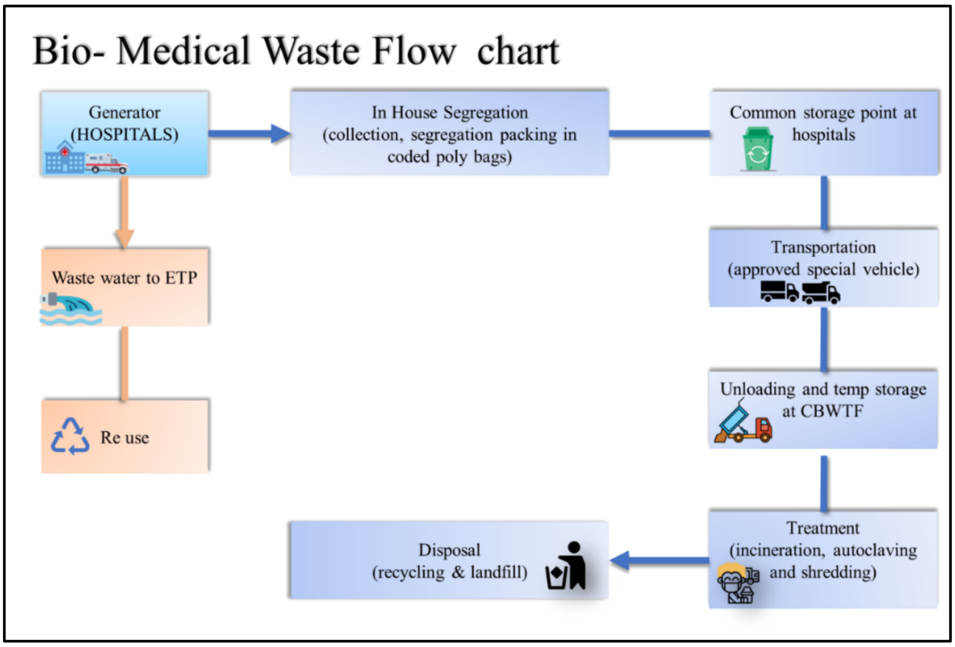

Fig 2. Bio medical flow chart

3. **Pathological waste:** Surgical or microbiological specimens from animal or human bodies can be turned into pathological waste, which is a small portion, part, or slice of tissue, organ, or body part [12]. Typically, this type of waste is generated during the examination and/or analysis of tissues in a laboratory to diagnose or study abnormalities or diseases. The current pandemic involves careful handling of this type of waste, which is similar to infectious waste. As the

tissue samples contain infective viral particles, they spread infection similarly to infectious waste [13,14].

4. **Chemical waste:** Among the chemicals used in laboratories are solvents and reagents, disinfectants, sterilizes, and heavy metals present in medical devices (e.g., mercury found in broken thermometers) and batteries. The acronym PET refers to polyethylene terephthalate, a long-chain polymer belonging to the polyester family [1]. Petrochemicals such as terephthalic acid (TPA) and ethylene glycol (EG) are used to produce PET. Other polyesters are formed by polymerizing acid and alcohol together, but they all come from different intermediates [15]. As a result of recycling, the polymer backbone is degraded into monomers (depolymerization) or randomly ruptured into chain fragments (random chain scission), producing gaseous products. Solvolysis and pyrolysis are two methods of chemical recycling; the former involves degradation by solvents, including water, and the latter by heat in absence of oxygen or air.[16]

5. **Pharmaceutical waste**: Medications disposal is an urgent issue today, one that is gaining more and more attention from healthcare professionals as well as consumers. As health care professionals, pharmacists have an admirable opportunity to educate patients about safe drug disposal as part of this movement. The proper counselling of patients on safe medication disposal can have a significant impact on public health and the environment [17]. This important issue needs to be incorporated into the curriculum in a practical way. It is also necessary to establish an effective and acceptable system of government-run collection and disposal. Disposal of medications with care and proper guidelines can help to reduce environmental mental load.[18] Multidisciplinary stakeholders, including government, NGOs, physicians, pharmacists, patients, and the public should work together to reduce the burden of unused and expired medicine on ecosystems. Health and environmental safety can be ensured through a proper waste management strategy [19].

6. **Cytotoxic waste**: Chemical waste that contains genotoxic problems (i.e., mutagenic, teratogenic, or carcinogenic compounds) such as antibiotics and cytotoxic drugs used in cancer treatment. There are approximately 77.5% of dentists who discard outdated and contaminated medicines into the common waste stream. A secure landfill is the best place to dispose of these wastes since they are considered as cytotoxic wastes [20]. Extractions of teeth are disposed of in common bins by 81.2%. The Office of Safety and Health Administration (OSHA) considers extracted teeth to be potentially infectious material that should be disposed of in a medical waste container. It is recommended that extracted teeth that have been sent to the dental laboratory for comparisons of shade or size be cleaned and disinfected with a hospital disinfectant solution. For preclinical exercises, extracted teeth should be autoclaved prior to use because liquid chemical germicides fail to reliably disinfect both the external surface and the interior pulp tissue [21]. There were 15.6% of dentists who used colour-coded bags for waste disposal in their clinics and only 8.1% returned their dental waste to certified collectors. About 33% are handled by certified agencies. Surveys that use questionnaires can be valid and reliable depending on the design, question content, and analysis as well as the response rates. Data collection using a questionnaire had the advantage of obtaining responses quickly and inexpensively [22,23]. Cytotoxic waste disposal is shown in figure 3.

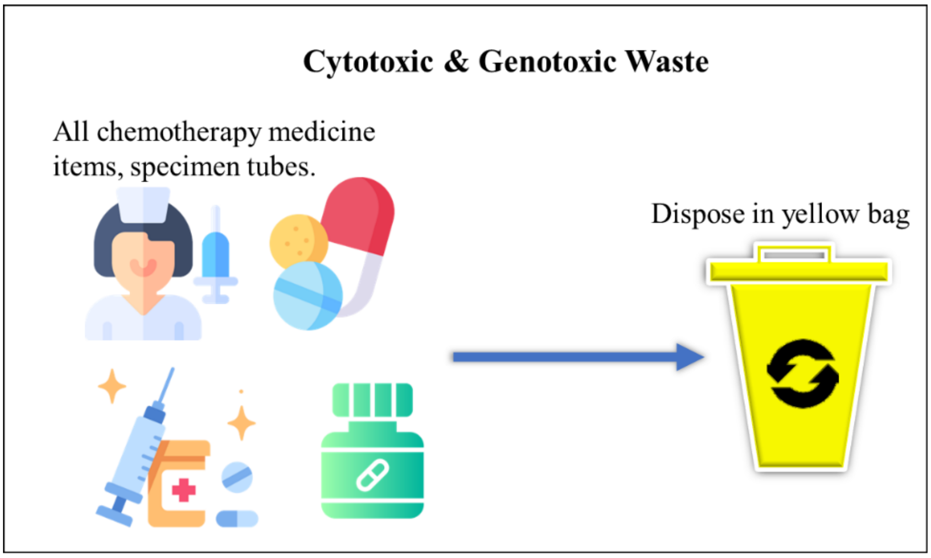

Fig 3. Cytotoxic waste

7. **Radioactive waste:** includes products that have been contaminated by radionuclides such as diagnostic or therapeutic materials contaminated by radionuclides. In the case of radioactive wastes, there are radioactive elements present within them (radionuclides) that are capable of causing radiation damage to biological life forms and posing a potential risk to their environment. Flow of high- level Radioactive waste shown in figure 4.

From highest to lowest radioactivity level, radioactive wastes are classified into the following six categories by the IAEA: [24-26]

1. High Level Waste (HLW)
2. Intermediate Level Waste (ILW)
3. Low Level Waste (LLW)
4. Very Low-Level Waste (VLLW)
5. Very Short-Lived Waste (VSLW)
6. Exempt Waste (EW)

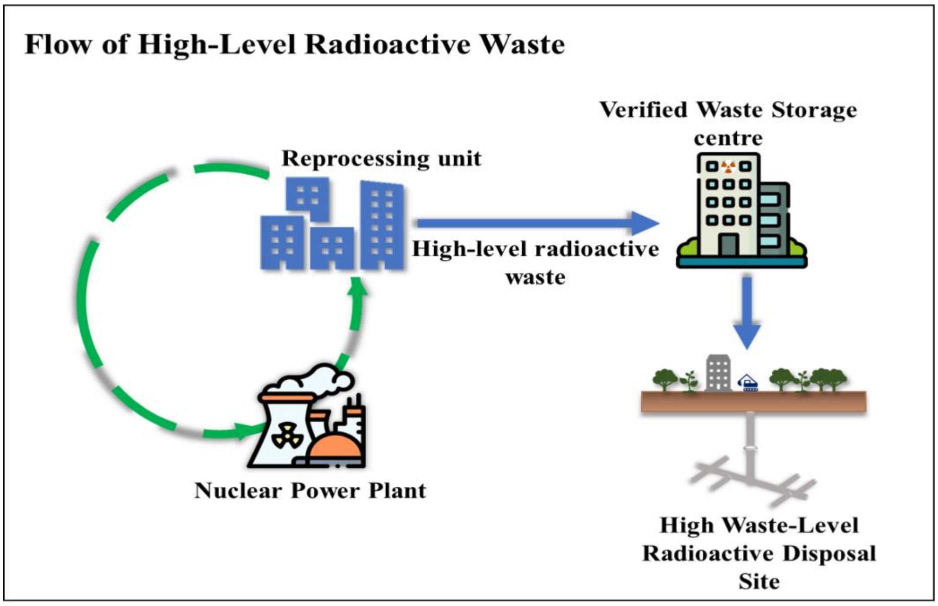

Fig 4. Flow of high- level Radioactive waste

8. **Non-hazardous or general waste**: waste that does not pose any particular biological, chemical, radioactive or physical hazard. The term "non-hazardous waste" refers to any waste which does not cause harm to people or the environment, and which is subject to regulations for its safe disposal. Non-hazardous waste comes under solid waste. It is divides into;[27]
   1 Municipal solid waste
   2.Refuse
   3.Garbage

   The EU hazardous waste regulations impose conditions on the disposal, transport and receipt of hazardous waste, these regulations do not apply to the disposal of mixed waste from domestic households and they do not place any obligations on householders.[28]

Regulatory bodies that administer pharmaceutical waste management

Regulatory bodies provide the guidelines for proper management, disposal and recycling of hospital acquired waste and pharmaceutical wastes. Hospital and industries should adhere to the norms and guidelines of respective bodies to ensure the environmental safety. Following are important regulatory agencies: [29]

I. Environmental Protection Agency (EPA)
II. Department of Transportation (DOT)
III. Drug Enforcement Administration (DEA)
IV. Occupational Safety and Health Administration (OSHA)
V. State Environmental Protection Agencies
VI. State Pharmacy Boards
VII. Local Publicly Owned Treatment Works (POTW)

EFFECT OF PHARMACEUTICAL WASTE ON ENVIRONMENT AND HUMANS –

There has been a notable rise in the use of medicinal pharmaceuticals to for the prevention and treatment of diseases. It is globally estimated that over half of all the medicines which are recommended, suggested, dispensed or sold are inappropriate, and half of the patients fail to follow the dose schedule. Pharmaceuticals can have significant adverse effects on wildlife and ecosystems, when unused medicines are improperly disposed.[30]

Pharmaceutical industries are releasing very harmful waste in the environment directly or indirectly or after chemical mitigation.[31] It has been found that the pharmaceutical combinations reach the environment and can be considered as environmental pollutants. Several pharmaceutical manufacturing facilities were found to be the provenance of much higher environmental concentrations than those caused by drug alone. A huge amount of waste is being generated by the pharmaceutical industries during production activities and maintenance operations. Trace amount of pharmaceuticals in drinking water for longer period of time may cause substantial unfavourable consequence to human livelihood and aquatic life, and are detected in drinking water (in nano gram per liter range). [32]

Sources of Entry of Pharmaceuticals into Environment

Pharmaceuticals wastes reached into the environment by human use and veterinary medical practices and personal care are among the issues that environmental scientists began addressing in the late 1990s. [33, 34] Sources of Entry of Pharmaceuticals into Environment shown in figure 5.

There are multiple pathways through which pharmaceutical chemicals enter the environment, including

1) Low-cost pharmaceutical production industries in developing countries such as India (production sites in India showed elevated antibiotics concentration from the surface waters) and China; [35]
2) Direct and improper disposal by patients/humans by unused or expired medications in to the trash and through the excretion of urine or faeces.
3) Release from hospital waste/trash.[36]
4) Disposal by pharmacies;
5) Veterinary use as medicine as well as additives to animal food; which is excreted into soil or surface waters (such exposure may affect terrestrial organisms directly, which endanger an exposed animal/ species);
6) Dairy waste disposal;
7) Household water/sewage, solid garbage mix with drug surplus;
8) Leaching from defective landfills;
9) Release from aquaculture which has medicated feed as well as excretion from the aquaculture;
10) Release from molecular farming/pest control drugs;
11) Disposal of euthanized/medicated animal carcasses, etc., [37]

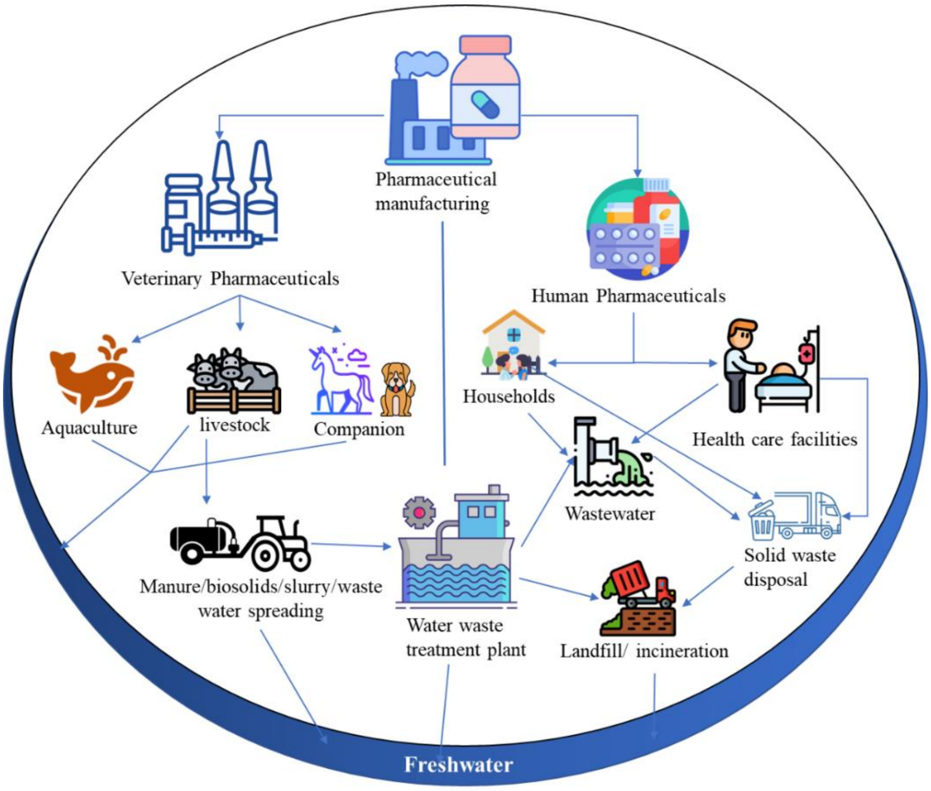

Fig 5. Sources of Entry of Pharmaceuticals into Environment

PHARMACEUTICAL WASTE

Various activities in the health-care system may lead to the generation of pharmaceutical wastes. The term pharmaceutical waste generally refers to [38,39]

- ✓ expired medicine,
- ✓ personal medication discarded by patients,
- ✓ waste materials containing chemotherapeutics,
- ✓ excess pharmaceuticals (e.g., IV bags and syringes),
- ✓ containers containing hazardous pharmaceuticals and discarded drugs,
- ✓ spill clean-up equipment, contaminated absorbents and protective gear.

A further classification of pharmaceutical waste consists of three categories:

- Hazardous waste
- Non-hazardous waste
- Chemo waste

a) Hazardous waste

Hazardous waste poses a significant risk to the environment and public health, and constitutes a significant warning sign. These can be liquids, solids, contained gases, or sludge. [40]

Hazardous wastes are divided into two categories:

(1) Listed wastes,

(2) Characteristic wastes

Listed wastes

According to Resource Conservation and Recovery Act, the listed wastes are divided into five categories (F, K, P, and U).

F-list represents to the non-specific source type wastes which commonly come from any commercial or industrial source such as solvents or any cleaning agents. While K-list represents to source specific type wastes which come from specific source such as petroleum refining or pesticide manufacturing. Similarly, P and U-list contains discarded commercial waste products including pharmaceutical wastes which are only discarded not used.[41]

Hazardous wastes are defined by the EPA according to four characteristics

Hazardous wastes are very harmful and have very low concentrations of their toxic effects. New EPA Hazardous Pharmaceutical waste rule shown in figure 6.

Characteristics wastes are those materials that tend to exhibit at least one of all four dangerous characteristics listed below.

1. **Ignitability**: It has a property of Ignitability. The large amount of waste is set on fire and is converted into ashes and the energy liberated is used as electricity. Many Pharmaceutical industries can handle this type of hazardous waste because they are ignitable.[42]
2. **Corrosivity**, it has a property of corrosion. Metal and other materials will corrode when exposed to corrosive waste, and burns on contact. It can be strong bases and acids. [43]
3. **Reactivity** Reactive wastes are unstable to environment in normal condition. They can cause eruption of harmful substance, poisonous gases, fumes, vapours' when burnt, compressed or mixed with water. [36]

4. **Toxicity** A waste comes under toxicity if they contain toxic metals like: lead, mercury, cadmium and organic chemicals. This waste mainly comes under D-Listed toxic chemicals. These chemicals are also overlooked by RCRA*. [44]

Fig 6. New EPA Hazardous Pharmaceutical waste rule.

b) **Non-hazardous waste**

The materials in this category do not exhibit any significant hazardous properties. Any industrial waste that cannot be disposed of in a dumpster or sewage line falls under the category of non-hazardous waste. Examples include unexploited or relatively used vials, syringes, ampoules, inhalers or bottles; unused or partially used intravenous bags or tubing containing medications; discontinued medications that cannot be reused; and tablets and capsules that have been unhandled or expectorated out by the patient. This category also includes expired drugs that are being thrown away. Discontinued medications that patients have brought from home and left are also considered pharmaceutical waste and should be disposed of according to EPA, state, and Drug Enforcement Administration regulations [45].

Non-hazardous pharmaceuticals should not be expelled out directly to water bodies like drainage pipes, foul sewer, sanitary sewer or septic tank. Non-hazardous pharmaceutical waste should always be incinerated to minimize the environmental pollution. [46-48]

c) **Chemo Waste** As name indicates these are the waste which can cause cancer to the cells. Regulated Medical Waste Incinerators (RMWI) is used for the incineration of pharmaceutical chemo wastes

These are of 2 types: [49]

1. **Trace Chemotherapy waste** as name indicates trace means in very small quantity. These are the waste materials which contain less than 3% of the material by weight and come in contact with or may contain a few drops of a chemotherapy drug. Empty receptacles, ampoules, IV's and tubing, personal protection equipment (PPE) such as surgical gowns, surgical caps, gloves, wipes, eye protection, high visibility clothing, safety footwear and safety harnesses. [50]

2. **Bulk Chemotherapy waste** as name indicates bulk means in large quantities, these are the waste materials which contain more than 3% of the material by weight or are saturated with

chemotherapy drugs. Therefore, non-empty spectacles, ampoules, IV's, and tubing are considered as bulk chemotherapy waste and must be managed as hazardous waste because the toxicity is increased.[51] Contaminated Personal protective equipment's (PPE) like gloves, foot wears etc. and materials used to sterilize spilled chemotherapy drugs (rags, towels, pads, etc.) also must be managed as hazardous waste. Syringes which are used to distribute chemotherapeutic drugs, that contain bulk chemotherapy waste, are considered as dual waste. [52]

Methodology

Pharmaceutical Waste Treatment and Disposal Technologies Specified in India's Pharmaceutical Waste

Integrated Approach for sustained solid waste management shown in figure 7.

Rules which describe various tools for effective management of wastes as follows; [53]

Fig 7. Integrated Approach for sustained solid waste management.

a) **Incineration**

In incineration, solid organic wastes are converted into residue and gaseous products by burning them. This is an efficient way of disposing of wastes. Both solid waste management residues and solid waste water management residues can be disposed of using this method [54]. Solid waste volumes can be reduced by up to 30% using this process. As a result of incinerating waste materials, heat, gas, steam, and ash are produced. It is common for individuals and industries to burn materials at a small and large scale [55]. The container can be used for disposing of solid waste, liquid waste, and gaseous waste. This method is recognized for its practicality as a method of disposing of many hazardous waste materials (such as biological medical waste). The term "thermal treatment" is sometimes used to describe incineration and other high-temperature waste treatment systems [56].

b) **Autoclaving**

In autoclaving, saturated steam is directly applied to the BMW in a pressure vessel for a period of time and temperature sufficient for the pathogens to be killed. [57] For autoclaves to be safe to disinfect, minimum temperatures, pressures, and residence times are specified in the

Biomedical Waste Rules. It is not recommended that human anatomical, animal, chemical, or pharmaceutical waste be autoclaved. In order to operate an autoclave, technicians must be qualified. Investment and operating costs are moderate. BMWs must be shred to an acceptable size before they can be autoclaved, which is a labour-intensive operation that would require frequent breakdowns. The waste produced by autoclaving is suitable for land filling [58].

c) **Microwaving**

Electromagnetic fields are applied over the BMW, causing the liquid to oscillate and heat up, killing the infectious components through conduction. [59] UV light can effectively remove waste materials from a waste site if it reaches the material. BMWs must be shredded and humidified before being microwavable. Large metal parts, anatomical wastes, animal wastes, and chemical or pharmaceutical waste cannot be microwaved. Waste produced by microwaving can be landfilled with municipal waste. It has the advantage of not requiring any steam, as well as requiring little electricity. There are some disadvantages, such as the need for qualified technicians and the frequent breakdown of shredders. There are medium investment and operating costs associated with this technology. [60] (figure 8)

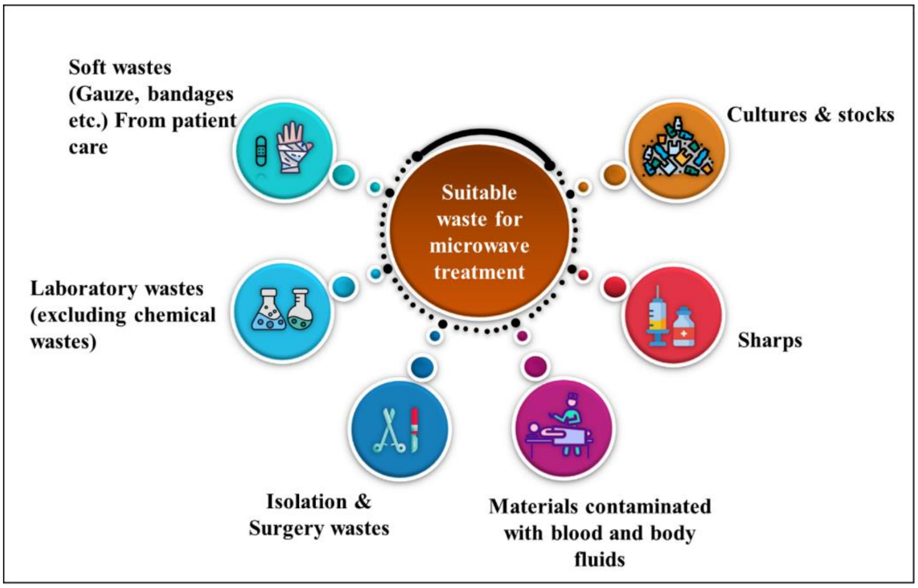

Fig 8. Suitable waste for microwave treatment.

d) **Deep burial**

A biomedical waste rule requires that human anatomical waste and animal waste disposed of in cities with fewer than 500,000 people and in rural areas be buried deep.[61] Consequently, the deep burial site should be prepared by digging a pit or trench about 2 meters deep in an area that does not flood or erode, where the soil is relatively impermeable, where there are no inhabitants or shallow wells in the area, and where there is little risk of surface water contamination..[62] Half-filled pits should be filled with BMW and lime within 50 cm of the surface, followed by soil filling the rest. A layer of 10 cm of soil should be added every time BMW is added to the pit to cover the waste.[63]

e) **Secure land filling**

Secure land filling is the most convenient method for disposal of discarded medicine, cytotoxic drug, solid chemical waste and incineration ash but the land which is selected for filling the waste should be highly secured. Secure land filling involves disposal of solid BMWs at a landfill designed and operated to receive hazardous wastes. Disposing of waste in a landfill involves burying the waste, and this remains a common practice in most countries [64]. A landfill should be hygienic, well managed, properly designed and comparatively cost-effective method for disposing of waste material. Many adverse impacts on environment are created such as wind-blown litter, attraction of vermin, and generation of liquid leachate due to improperly designed or improperly managed landfill earlier. Due to anaerobic conditions, organic waste breaks down into methane and carbon dioxide as the by-products of landfill. This gas creates problems like foul smell; surface vegetation is destroyed and causes evolution of greenhouse gas. Deposited waste increases vermin in the land such as mice or rats. So the land should be covered to prevent these vermin. Many modern landfills also have gas extraction system. Gas is pumped out by perforated pipes and flared of to generate electricity. [65]

f) Waste immobilization: encapsulation

An encapsulation process involves immobilizing pharmaceuticals in a solid block inside a plastic or steel drum. It is recommended that drums are cleaned before use, and that they have never previously contained explosives or hazardous materials. Solid and semisolid pharmaceuticals fill 75% of the tank, while cement, cement/lime mixtures, plastic foam or bituminous sand are poured into the remaining space. You should cut off the drum lids and bend them back to ease and speed up the filling process. When placing pharmaceuticals in drums, take care to avoid cuts to the hands. Lime, cement, and water are mixed with 75% capacity in drums, and then the drums are filled to capacity using 15:15:5 (by weight) lime, cement, and water. The consistency of a liquid may require more water in some cases. It is recommended that the steel drum lids are bent back and sealed, preferably by spot welding or seam welding. Cover the sealed drums with fresh municipal solid waste and place them at the bottom of a landfill. In order to facilitate movement, drums may be placed on pallets that can then be transported by pallet transporters. [66]

g) **Waste immobilization: Inertization**

Inertization is a process that removes the packaging materials from pharmaceuticals, such as paper, cardboard, and plastic. Blister packs must be removed from pills. A homogenous paste is then formed by grinding the pharmaceuticals and adding water, cement, and lime. [67] In order to protect workers from dust hazards, protective clothing and masks are required. In a landfill, the liquid paste is decanted into the normal urban waste by concrete mixer trucks. As a result, the paste solidifies into a solid mass dispersed among municipal solid wastes. Unsophisticated equipment can be used to perform the process, which is relatively inexpensive. Among the basic requirements are a grinder or road roller for crushing pharmaceuticals, a concrete mixer, and supply of cement, lime, and water. [68]

MANAGEMENT OF LIQUID WASTE:

a) **Sewer**

In small quantities, some liquid pharmaceuticals, such as syrups or intravenous (IV) fluids, can be flushed into sewers without causing serious health or environmental effects if diluted with water and flushed for a period of time. Liquid pharmaceuticals or antiseptics may also be flushed through fast-flowing watercourses [69]. Sewers that are in disrepair or have been damaged by war may require the assistance of a hydrogeologist or sanitary engineer. [70]

b) **Chemical disinfection**

Chemical disinfection is most appropriate for treating liquid wastes such as blood, urine, and stools. It is possible to kill or inactivate pathogens in the BMW by adding strong oxidants such as chlorine compounds, ammonium salts, aldehydes, or phenol compounds. [71] A chemical disinfection method can also be used to treat microbiological cultures, mutilated sharps, or solids that have been shredded. It is important to consider factors such as type and amount of chemical used, and extent and duration of contact between the disinfectant and the BMW when disinfecting. [72]

Prevention of water contamination by Pharmaceuticals:

To prevent pharmaceutical waste water from contaminating water, treatment plants are established if disposed of or secreted into drains. It is possible for waste water treatment to incorporate physical, chemical, or biological processes, depending on the type of pollutant in the water. [73]

Waste Water Treatment:

Polluted and toxic water can also be considered waste since it is a necessity for all biological and abiotic factors. [74] Therefore, it is our duty to bring awareness to the issue of waste water treatment as it raises the risk of water-borne diseases. Industry is the main source of waste water released today, causing the underlying areas to be disturbed. [75] STPs treat sewage before disposal, so it is less polluting before disposal [76].

Waste water treatment involves the following steps:

I. **Primary treatment levels**
II. **Secondary treatment levels**
III. **Tertiary treatment levels**

Primary treatment levels: Primarily**, physical processes** are used in primary treatment. There are two steps to the filtration process; the first is filtration, and the second is sedimentation of the large and small particles from the sewage. The secondary treatment of the primary settling tank is carried out on the supernatant or effluents. [77]

Secondary treatment levels: The majority of secondary treatment is carried out **by biological processes**. As effluents are released from the primary tank, they are placed in large aeration tanks, where they are constantly agitated mechanically while air is pumped through them. [78] As a result, aerobic bacteria can grow vigorously and form flocs (masses of bacteria associated with fungal filaments to form mesh-like structures). While growing, the microbes consume a large portion of the organic matter in the effluent. The effluent BOD (Biological oxygen demand) is significantly reduced as a result. Wastewater with a high BOD (the amount of oxygen consumed if all the organic matter in 1 liter of water were oxidized by bacteria) is more likely to cause pollution. In settling tanks, water is allowed to sediment once the BOD of sewage or wastewater has been significantly reduced. As a result, activated sludge is formed. Inoculum is made by pumping a small part of activated sludge back into the aeration tank. Anaerobic sludge digesters are used to dispose of the remaining sludge.

Sludge is digested by other kinds of bacteria, which grow anaerobically. In this process, bacteria produce hydrogen sulfide, methane, and carbon dioxide. Due to them in flammability, these gases can be used as fuel. [80]

Tertiary treatment levels: In the final cleaning process, waste water is improved in quality before it is reused, re-cycled, or discharged to the environment. [81] Examples include using alum, chlorine, etc. As well as reducing parameter values below the national standards, it is also used for further parameter reduction [Bruce 2010]. These days, effluent is generally released into natural water bodies such as rivers and streams. Almost all parts of the world have been using this methodology for more than a century now. There has been no man-made technology that has been able to rival microbial sewage treatment.[82]

STRATEGY FOR MINIMIZING THE PHARMACEUTICAL WASTE

The aim of waste minimization is to reduce the amount of waste generated. The waste cannot be eliminated completely, but the toxicity emitted can be decreased, and then the waste can be discarded. [83] The primary objective of waste minimization is to use raw materials, water and energy as efficiently as possible. The following three methods are used to minimize use: [84] (figure 9)

Fig 9. **Strategy for minimizing the pharmaceutical waste**

I. **Reduce**
II. **Reuse**
III. **Recycling**

I. **Reduce**

Reducing waste material is one of the most important methods of waste management. There are several ways to avoid waste, including reusing second-hand products, repairing broken items instead of purchasing new products, designing products that can be refilled or reused (such as cotton shopping bags instead of plastic bags), encouraging consumers to use reusable products (such as disposable cutlery), removing any food/liquid remains from cans, packaging, and designing products that use less material to accomplish the same goal (such as light weighting beverage cans). [85]

II. **Reuse**

Re-use refers to using a product more than once, either for the same or a different purpose, without reprocessing.[86] It is preferable to reuse the same product in the same state, e.g. returning plastic pallets, using empty glass jars for storage, and using second-hand clothes. [87] In general, reuse is preferable to recycling because it does not require the material to go through a detailed treatment process, so it can save on energy and material. [88]

III. **Recycling**

A recyclable material is reprocessed or treated so that it can be reused for its original purpose or for another. It includes organic waste recycling, but excludes energy recovery. Recyclable materials reduce the use of raw materials, which is beneficial to the environment. Recycling today is said to make tomorrow better. [89, 90]

BENEFITS OF WASTE MINIMIZATION PRACTICE

Waste minimization refers to the use of source reduction and/or environmentally sound recycling methods before energy, recovery, treatment, or disposal of wastes in accordance with the EPA (Environmental Protection Agency.[91] Waste treatment means the process of altering a waste stream's physical, chemical, or biological composition.

1. Increasing manufacturing, but minimizing the waste production.
2. Promotes good public image on environmental protection
3. Reduce potential environmental liabilities.
4. Sufficient amount of usage of resources (like water)
5. Intensify public and worker's health and welfare.

It is essential to keep in mind the company's waste policy in order to minimize waste. It is very important for companies to implement waste management programs on time, to motivate and instruct staff, to set goals, and to report results on a regular basis. It is necessary to know the sources, quantities, and sources of contaminants in waste by-products in order to manage waste efficiently.92]

ROLE OF PHARMACIST

There is no one better than a pharmacist to know the worthlessness of most medicines. Pharmacists should be responsible for changing the medication process, finding a cure, and minimizing toxic effects of pharmaceuticals. Pharmacist is involved with the entire process of prescribing, advising, dispensing, pharmaceutical care, disposal of expired medicines and ultimately reduction in metabolic waste discharge into the environment.[93] As well as ensuring patient safety, pharmacists advise patients about possible adverse reactions and interactions with other medications, foods, and alcohol. This would raise awareness about medicine misuse and disposal, and as a result, lower environmental and well-being risks. Since pharmacists are the most trusted, respected, and accessible resources for drug information, they are able to empower learners of all ages to acquire medical knowledge. [94] The pharmacist has a leading role in addressing issues related to pharmaceutical disposal methods for end-users of drugs. It is essential for pharmacists to understand the drug disposal activities in their region and to recommend them to patients. The indiscriminate disposal of unused/expired pharmaceutical products poses an environmental hazard that requires continuing training and education at every level.[95] Pharmacy professionals are medication experts and experts in health care, which can assist people in disposing of unwanted waste in an efficient way. In addition to opening a pharmacy, pharmacists are able to sell medicines at low prices to the poor. Besides providing a way for people to dispose of their unwanted or unused medications safely, drug disposal programs and pharmaceutical collection events also serve as a platform for examining the causes of medication waste. Drug abuse, accidental overdoses, and prescription drug abuse pose great threats to our society and threaten the environment. It is possible for pharmacists to be involved in several environmental organizations and provide information about the proper disposal of medicines and drug abuse. [96, 97]

CONCLUSION

In today's scenario with the growing life style, the need of pharmaceutical compounds is also increasing and they are with environment in extremely large quantity and the system present is not able to control the untreated or partially pharmaceutical waste. Pharmaceutical waste management continues to be new frontier for health care facilities. New waste classification is observed which is increasing the complexity of management of waste, so the new techniques of disposal are developing regularly to make surrounding eco-friendly. But one thing we should keep in mind that technique also should be cost-effective with better treatment facilities. In order to reduce the burden of unused and expired medicine on ecosystems, all stake holders, including government, NGO's, physicians, pharmacists, patients, and the public, need to work together. It is as important as taking care of our own mothers to take care of the environment as it is the only source of power, oxygen, and water. Protect the environment by consuming less, emitting less, conserving more, and conserving more.

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