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Role of Pharmacist in Pharmaceutical Waste Management

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ABSTRACT

The pharmaceutical industry is strengthening its progressing techniques to treat the waste product day by day and minimize the use of reagents that are dangerous to the environment by scheming alternate synthesis pathways. Pharmaceuticals and personal care products (PPCPS) are being used worldwide in large quantity each year and it is a matter of great concern to control the generation and treatment of waste because of it. Pharmaceutical waste is a form of medical waste that includes unexploited drugs, personal care products, such as cleansing pads, cotton pads, razors, and other supplies, exhibiting harmful effect to human and environmental health. As the pharmaceutical waste contains drugs, they are very reactive and cannot be disposed of like conventional waste and require special handling, whether it comes from a hospital, clinic, pharmacy or private household. So, knowledge of method of disposal of unused medicines should also equally be mandatory, similar to the knowledge of consumption of medicines. In past few years, it has been observed that several of pharmaceutical compounds like antidepressants; antibiotics, steroids, hormones, analgesics, antihypertensive, contraceptive etc. have been analyzed in water samples from ng/l to µg/l range. Humans, animals and aquatic life are highly affected by these pharmaceutical compounds though these are present in very small quantity but bear a highly toxic effect. Environment and health are directly or indirectly affected by pharmaceutical effluents especially in the vicinity of pharmaceutical industrial zones.
The present review has mainly focused on the P and U listed waste according to environmental protection agency i.e. hazardous waste, their effect on environment as well as various techniques used for their management to reduce environmental toxicity. Moreover, we have also discussed about the admirable position of pharmacist to play a vital role to educate people about public health and environment.

Keywords: *Pharmaceutical waste, Hazardous waste, Environmental health, Pharmacist*

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INTRODUCTION

As our society is moving towards modernization by changing life style and fooding habits, we are also on the verge of various diseases and inviting them with open hands. For the treatment of these diseases, we are using a lot of drugs and their combinations dosage forms of these drugs are prepared in pharmaceutical industries by using active pharmaceutical ingredients and excipients. Various pharmaceutical wastes (Hazardous wastes) are produced during the development of these pharmaceutical dosage form and by entering in the environment without any treatment, it can adversely affect directly to our environment and indirectly to the life of living organisms (Parasuraman, 2015). These pharmaceutical wastes can adversely affect the life of living organisms present in the soil, water and air leading to major destruction to the nature. Earthworms are one of the best example which increases the fertility of soil by processing of it but the pharmaceutical waste may destroy metabolic activity of earthworms and so the fertility of the soil by reaching inside the earthworms during the normal uptake (Dawson & Smith, 2007; Carter et al. 2014; De Souza Lira et al., 2017).

Pharmacy and Pharmacists can play an essential part of the well-being and health care system to make the environment free from such pollution and make them physically fit (Daughton & Ternes 1999). So it is mandatory to supervise the hazardous waste that comes out from the health care agencies and pharmaceutical industries (Medhi & Sewal 2012).
Pharmaceuticals are the single fastest-growing part of our health care budget but it is compulsory to outlook the waste released by these industries and as a pharmacist, it is our duty to control all this pollution by awaking people about the harmful impact of this waste in our surroundings (Ellis, J. B., 2006).
Except the broader category of pharmaceutical waste, Sreekanth et al. have described several types of waste which may greatly have effect on the environment and ultimately on the human health such as sedimented wastes from mining activities, particulate waste matters due to construction items,

Material exhausted from automobiles, materials belonging to electrical and electronics industry, garden waste, waste of pain industry etc. (Sreekanth et al., 2014).

Current review mainly focuses on pharmaceutical waste, their impact on environment and techniques used for their management. Waste belonging to health sector and pharmaceutical sector is originated through the different ways in a health care system such as spills, breakage, damaged, infected syringes, unused preparations, patient's personal medications, outdated pharmaceuticals, expired drugs etc. It may also be accumulated in other sectors such as patient's room, operating room, nursing stations, emergency rooms etc. (Kummerer, 2010). The another's major source of such waste is pharmaceutical manufacturing industries.

These pharmaceutical wastes find their way into the surrounding by different paths such as, sewer lines, discharge of treated wastewater and seepage from landfills sites, run off from animal wastes etc. Due to this extensive amount of waste being created lacking significant importance that it should be treated in such a way that it does not cause any harm to either human health or to the environment. There are different alternatives being available for the treatment, discharge and management of waste including prevention, elimination, precaution, minimization, re-use, recycling, energy recovery, ejection and disposal (Williams, 2005).

Pharmaceutical waste is not a single point waste, but many different point and non-point waste streams that can affect the unification and consistency of the chemicals that involve pharmaceuticals. These wastes can adversely affect our environment and health of living population (Sreekanth et al. 2014).

All the pharmaceutical waste can be broadly classified into three major categories, such as- (Kadam et al. 2016):

1) Hazardous waste
2) Non-Hazardous waste
3) Chemo waste

FIGURE 1. CLASSIFICATION OF PHARMACEUTICAL WASTE

According to various environmentalists, these pharmaceutical wastes are called as pollutants because they pollute the environment and leave their various toxic effects.

Some of these pollutants belonging to pharmaceutical wastes include expired solids, semi-solids and powders dosage forms, liquids, ampoules, anti-infective drugs, anti-neoplastic drugs, Propellants, aerosol container etc. (Priya, 2017).

Hazardous waste

Hazardous waste constitutes significant warning and has the capacity to develop threats to environment and public health. It can be liquids, solids, volatile substances or sediments including Asbestos, chemicals (brake fluid or print toner), batteries, solvents, pesticides, oils (except edible ones), e.g. car oil, Equipment containing ozone depleting substances, e.g. fridges, propellants, hazardous waste containers etc. (Kummerer, 2009) Several pharmaceutical products such as all antineoplastic, all antibiotics, all immunosuppressants, all endocrine disruptors, adrenaline, physiostigmine, nitroglycerine, warfarin, disulfiram, phenol, lindane, chloral hydrate, chloroform, ethyl ether, formaldehyde, selenium, pharmaceuticals containing heavy metals (Barium, mercury,cadmium, thiomersal), resorcinol, products containing nicotine, mercureochrome, hydrogen peroxide, potassium permanagate, alcohol based products etc may also be kept in the similar category. Focazio has devided these hazardous into two sub categories including (Focazio, 2008)-

i. Characteristic wastes
ii. Listed wastes.

Characteristics wastes- Characteristics hazardous wastes are those matters that have the tendency to exhibit one or more all four hazardous characteristics given in the following table (Minnesota Pollution Control Agency 2011).

Table 1: Characteristics of hazardous wastes

CHARACTERISTICS	MEANING
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.
Corrosivity	It has a property of corrosion. Corrosive waste corrodes metal or other material, can even burn the skin. It can be strong bases and acids.
Reactivity	Reactive wastes are unstable to environment in normal condition. They can cause eruption of harmful substance, poisonous gases, fumes, vapors' when burnt, compressed or mixed with water.
Toxicity	A waste comes under toxicity if they contain toxic metals like: lead, mercury, cadmium and organic chemicals. These waste mainly comes under D-Listed toxic chemicals. These chemicals are also overlooked by RCRA*.

***Resource Conservation and Recovery Act** (RCRA) is about the management, storage and discard action of hazardous waste which is having a harmful impact on our livelihood and causes pollution (Tong, 2011).

Characteristics hazardous wastes are very harmful and left their toxic effect in very less concentration. Examples of few pharmaceutical contaminants with their maximum toxic concentration are given below:

Table 2: Examples of few pharmaceutical contaminants with their maximum toxic concentration.

S.NO.	HAZARDOUS WASTE CODE	CONTAMINANT	MAXIMUM CONCENTRATION mg/l
1.	D004	ARSENIC	5
2.	D005	BARIUM	100
3.	D006	CADMIUM	1
4.	D018	BENZENE	0.5
5.	D019	CARBON TERACHLORIDE	0.5
6.	D020	CHLORDANE	0.03
7.	D021	CHLOROBENZENE	100
8.	D022	CHLOROFROM	6
9.	D007	CHROMIUM	5
10.	D023	o-CRESOL	200
11.	D024	p-CRESOL	200
12.	D025	m-CRESOL	200
13.	D026	CRESOL	200
14.	D012	ENDRIN	0.02
15.	D027	1,4 DICHLOROBENZENE	7.5
16.	D028	1,2 DICHLOROETHANE	0.5
17.	D029	1,1 DICHLOROETHYLENE	0.7
18.	D030	2,4 DINITROTOLUENE	0.13
19.	D031	HEPTACHLOR (AND ITS EPOXIDE)	0.008
20.	D032	HEXACHLOROBENZENE	0.13
21.	D033	HEXACHLOROBUTADIENE	0.5
22.	D034	HEXACHLOROETHANE	3
23.	D008	LEAD	5
24.	D013	LINDANE	0.4
25.	D009	MERCURY	0.2
26.	D014	METHOXYCHLOR	10
27.	D035	METHY ETHLY KETONE	200
28.	D036	NITROBENZENE	2
29.	D037	PENTACHLOROPHENOL	100
30.	D038	PYRIDINE	5
31.	D010	SELENIUM	1
32.	D011	SILVER	5

Listed Wastes-Listed wastes are mainly classified into five lists and these five are organized into four (F, K, P, and U) categories according to Resource Conservation and Recovery Act (RCRA).

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 (Kadam 2016). As in this review we are mainly concerned with the waste material related to Pharmaceutical and healthcare sector which are included in the P list containing the trade synthetic drugs, manufacturing chemical intermediates or out-dated trade chemical products referred and identified as severe hazardous waste (H) under RCRA. These are very dangerous materials because illness caused by them cannot be reversible even at low doses and also leads to demise or death.

For the benefit of RCRA, they have made some foremost Hazardous resources of these materials which can be demonstrated by the letters T (Toxicity) and R (Reactivity). Few P-Listed drugs with their waste code are shown in the table 3. (Kadam 2016).

Table 3: P- Listed drugs with waste code

S.NO.	WASTE CODE	P- LISTED DRUGS
1.	P003	ACROLEIN
2.	P070	ALDICARB
3.	P004	ALDRIN
4.	P011	ARSENIC PENTOXIDE
5.	P009	AMMONIUM PICRATE
6.	P013	ARSENIC OXIDE
7.	P038	ARSINE
8.	P099	ARGENTATE
9.	P119	AMMONIUM VANADATE
10.	P037	DIELDRIN
11.	P031	CYANOGEN
12.	P029	COPPER CYANIDE
13.	P050	ENDOSULFAN
14.	P088	ENDOTHALL
15.	P051	ENDRIN
16.	P101	ETHYL CYANIDE
17.	P194	OXAMYL
18.	P089	PARATHION
19.	P087	OSMIUM TETRAOXIDE
20.	P078	NITROGEN DIOXIDE
21.	P076	NITRIC OXIDE
22.	P074	NICKLE CYANIDE
23.	P075	NICOTINE AND SALTS
24.	P078	NITROGEN OXIDE
25.	P042	EPINEPHRINE
26.	P020	DINOSEB
27.	P013	BARIUM CYANIDE
28.	P054	AZIRIDINE
29.	P205	ZIRAM
30.	P185	TIRPATE
31.	P123	TOXAPHENE
32.	P014	THIOPHENOL
33.	P121	ZINC CYANIDE
34.	P120	VANADIUM OXIDE
35.	P113	THALLIC OXIDE
36.	P045	THIOFANOX
37.	P116	THIOSEMICARBAZIDE
38.	P103	SELENOUREA
39.	P115	SULPHURIC ACID
40.	P105	SODIUM AZIDE
41.	P104	SILVER CYANIDE
42.	P110	TETRAETHYL LEAD
43.	P199	METHIOCARB
44.	P066	METHOMYL
45.	P190	METOLCARB
46.	P128	MEXACARBATE
47.	P073	NICKEL CARBONYL
48.	P192	ISOLAN

There are certain products which become waste due to any of the reason such as expiry date, contamination, and degradation. These products are also known as Sole Vital Ingredient or Active Pharmaceutical Product and categorized in U list. This could be easily understood by the example of Hydrofluoric acid, which is the sole vital ingredient in some glass etching compounds. So it would be listed in U List as U134 hazardous wastes if disposed of without being used (Jaseem, 2017). Few U-Listed drugs with their waste code are shown in the following:

Table 4: U- Listed drugs with waste code

S.NO.	WASTE CODE	U- LISTED DRUGS (GENERIC NAME)
1.	U394	A2213
2.	U001	ACETALDEHYDE
3.	U034	ACETALDEHYDE , TRICHOLORO
4.	U187	ACETAMIDE , N-(-4ETHOXYPHENYL)
5.	U005	ACETAMIDE, N-9H-FLUOREN-2-YL
6.	U240	ACETIC ACID
7.	U002	ACETONE
8.	U003	ACETONITRIL
9.	U006	ACETYL CHLORIDE
10.	U007	ACRYLAMIDE
11.	U008	ACRYLIC ACID
12.	U009	ACRYLONITRILE
13.	U011	AMITROLE
14.	U012	ANILINE
15.	U136	ARSINIC ACID
16.	U014	AURAMINE
17.	U015	AZASERINE
18.	U280	BARBAN
19.	U278	BENDIOCARB
20.	U271	BENOMYL
21.	U031	1-BUTANOL
22.	U159	2-BUTANONE
23.	U160	2-BUTANONE, PEROXIDE
24.	U053	2-BUTENAL
25.	U074	2-BUTENE, 1,4-DICHLORO
26.	U215	CARBONIC ACID
27.	U033	CARBONIC DIFLUORIDE
28.	U156	CARBONOCHLORIDIC ACID
29.	U033	CARBON OXYFLUORIDE
30.	U211	CARBON TERTACHLORIDE
31.	U034	CHLORAL
32.	U035	CHLORAMBUCIL
33.	U044	CHLOROFORM
34.	U037	CHLOROBENZENE
35.	U012	BENZENAMINE
36.	U125	FURFURAL
37.	U213	FURAN
38.	U123	FORMIC ACID
39.	U120	FLUROETHENE
40.	U115	ETHYLENE OXIDE
41.	U118	ETHYL METHACRYLATE
42.	U163	MNNG
43.	U147	MALEIC ANHYDRIDE
44.	U151	MERCURY
45.	U046	METHANE
46.	U029	METHANE, BROMO
47.	U045	METHANE, CHLORO
48.	U077	ETHYLENE DICHLORIDE

Mercury containing discarded products has been scheduled in M-list. This list contains only those waste materials which contain mercury like fluorescent lamps, mercury switches etc.

Determination of Hazardous Waste (Focazio, 2008)

Only the initiator who has the knowledge of the products and processes, testing procedure of the waste can determine the hazardous waste like pharmacist, doctors, researchers, environmentalist etc. and can aware the people about the use and misuse of products.

Various ways to present and determine hazardous wastes:

1. Material Safety Data Sheet (MSDS) - Each product should have an MSDS. The MSDS may comprise data to serve in determining the pharmaceutical product when dispose of as hazardous waste.

2. Testing -Anyone can send the waste to a commercial laboratory to examine the waste using the toxicity characteristic leaching procedure (TCLP).

3. Generator Knowledge - Talk to your distributor, merchant, manufacturer and other sources to collect the knowledge about the status of your pharmaceutical product.

MANAGEMENT OF HAZARDOUS WASTE: (Minnesota Pollution Control Agency, 2011**)**

Management of hazardous waste is possible by following the given steps:

STEP-1) Separation of waste products:

1. Separate and store expired pharmaceuticals from where that can be sent for reverse distribution (distributors → pharmacies → industries).

2. Mixing of hazardous pharmaceutical waste should be avoided with regulated infectious waste for disposal.
3. Antagonistic waste should not be kept in the same container.
4. Separation of Hazardous waste under these categories:
    - P- or U-listed
    - Toxicity
    - Ignitability
    - Corrosivity
    - Reactivity

STEP-2 Storage of waste in separate containers

1. Label each container as "Hazardous waste".
2. The accumulation start date is the date in which the waste is first placed (accumulated) in

the container. So, now clearly mark the container as accumulation start date.

3. While adding or removing waste the containers must be closed.
4. The storage area must maintain access to communication or alarm system for investigation and urgent response.
5. Inspection log must be kept and the items kept in the container must be supervised

weekly.

"Satellite accumulation" [Ohio Administrative Code (OAC) rule, 2017**]** is another way of storage of hazardous waste materials**.** These are large and small quantity generators for longer accumulation of waste where the generation rate is so slow that a fully drum may not be accumulated within 90 or 180 days.

The Regulation specifies: (Technical Information Memorandum, 2003)

1. That a generator may accumulate waste in containers at or near point of generation where waste initially accumulates, which is under control of the operator of the process generating the waste.
2. The container is marked with the words "Hazardous Waste" or other words that identify the contents of the container.
3. The container should be in good condition and should be compatible with the accumulated waste.
4. The container is kept closed, except when it is necessary to add or remove waste.
5. Generators are relieved from the weekly inspection and log requirement for satellite container accumulation and to ensure that the proper condition are maintained.

STEP-3 Disposal of waste: Hazardous pharmaceutical waste must be transported to the offsite for the hazardous waste treatment, storage or disposal Facility (TSDF) for proper discharge.

2) Non-hazardous Pharmaceutical Waste:

It is believed that once the producers wrapping is opened, any unutilized or partly used product can be assumed as non-hazardous pharmaceutical waste. Examples include unexploited or relatively used vials, syringes, ampoules, inhalers or bottles; unused or partially used intravenous bags and tubing containing drugs; discontinued medications that cannot be reused; and tablets and capsules that have been unhand or expectorate out by patient. Drugs which are expired and being discarded also comes under this category. The leftovers that patient have brought from home and are not properly used are also considered as pharmaceutical waste and that should be discarded in such a way that it should not release any toxic effect to our surrounding. These disposal methods are under the guidelines with Environment Protection Agency (EPA) and Drug Enforcement Administration Regulations (DEAR) (Jaseem et al., 2017).

Management of Non-Hazardous Waste

The category of regulated Non-Hazardous Pharmaceutical covers the vast majority of pharmaceutical in the market. These are considered as special medical waste and must be managed in accordance with State Medical Waste Regulation. Non-hazardous pharmaceuticals should not be expelled out directly to water bodies like drainage pipes, foul sewer, sanitary sewer or septic tank.

There are certain substances which do not cause any toxic effect to our environment like solution from intravenous bags such as saline solution, glucose solution, dextrose solution, lactate, vitamins, potassium, and other salts and electrolytes can be safely discharged to the sewer.

Non-hazardous pharmaceutical waste should always be incinerated to minimize the environmental pollution. This would avoid diversion of the pharmaceuticals and management of contaminated leachate from the landfill.

Non-hazardous pharmaceuticals can be discarded at a legitimate municipal solid waste landfill with approval from the government. Liquid waste must be solidified with some type of substance which accumulates on surface before disposal (Pratyusha et al., 2012).

NOTE: Non-hazardous pharmaceuticals should never be autoclaved.

3) 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:

1. Trace Chemotherapy waste
2. Bulk Chemotherapy waste

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 comes in contact with or may contain a few drops of a chemotherapy drug (Kuhler et al., 2009).

E.g.- 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. These should be put into vessels and disposed of (Kuhler et al. 2009).

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. 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 (Kuhler et al., 2009).

MANAGEMENT OF CHEMO WASTE:

Disposal of Trace and Bulk Chemotherapy:

The Department advocates that all trace chemotherapy wastes must be incinerated (at high temperatures between 1,800 and 2,200 degrees Fahrenheit) for destroying waste. Autoclaving method should be avoided because these chemicals will not destroy at the temperature of autoclave. Bulk chemotherapy waste behaves as hazardous waste so must be managed as a

hazardous waste and shipped to a treatment, storage or safety disposal facility (WHO Guidelines 1999).

SOURCES OF ENTRY OF PHARMACEUTICAL WASTE:

Pharmaceutical wastes affect our environment by polluting air, water and soil if they are thrown untreated to the environment. As all three will pollute our food and ultimately affect the living organisms badly.

As per our perception, pharmaceutical waste mainly affects the surface waters such as lakes and rivers, but it is mandatory to note that it also reaches the groundwater, soil, manure and even drinking water and contaminate it. It adversely affects our environment and surroundings, microbes and other organisms in soil, aquatic life in rivers, lakes etc. So, it is necessary to clean the pharmaceutical waste water before mixing with the clean water (World Health Organization Guidelines, 1999).

Pharmaceuticals find their way in waste water treatment plants through either defecation or discard of un-needed medications. These pharmaceutical compounds may not be completely degraded at the wastewater treatment plant, some of the particulate matter is still present which create toxic effect before being released into the environment.

Entry of pharmaceutical waste into the environment

Residential, commercial, and agricultural pharmaceuticals can follow two primary pathways to enter the environment:

1) Defecation: Human and animal excretion of drugs and metabolites following consumption (which ultimately follows sewage, septic or surface run off pathways to wastewater or to biosolids and contaminate our water bodies and create water pollution) (Bernot and Justice 2014, Ramadas et al. 2013).

2) Direct Disposal: Disposal of unexploited pharmaceuticals to a septic tank, sewer, or landfill without reducing the toxicity (Daughton 2004, Murray et al. 2010, Heberer et al. 2004).

Some other Sources of Entry of Pharmaceuticals into Environment are:

1) Veterinary use as therapeutics as well as supplements which is added to animal food; is excreted into soil or surface waters.

2) Dairy waste disposal.

3) Medicated feed which is present and is released in aquaculture as well as excretion from the rearing of aquatic animals.

4) Discharge from molecular farming/ pest control drugs, cultivation, sowing etc.

5) Disposal of euthanized/medicated animal carcasses etc.

VARIOUS COMMON TECHNIQUES USED FOR TREATMENT OF PHARMACEUTICAL SOLID WASTES: (Kelessidis 2012, Burke, 2006**).**

MANAGEMENT OF ORGANIC PHARMACEUTICAL SOLID WASTE:

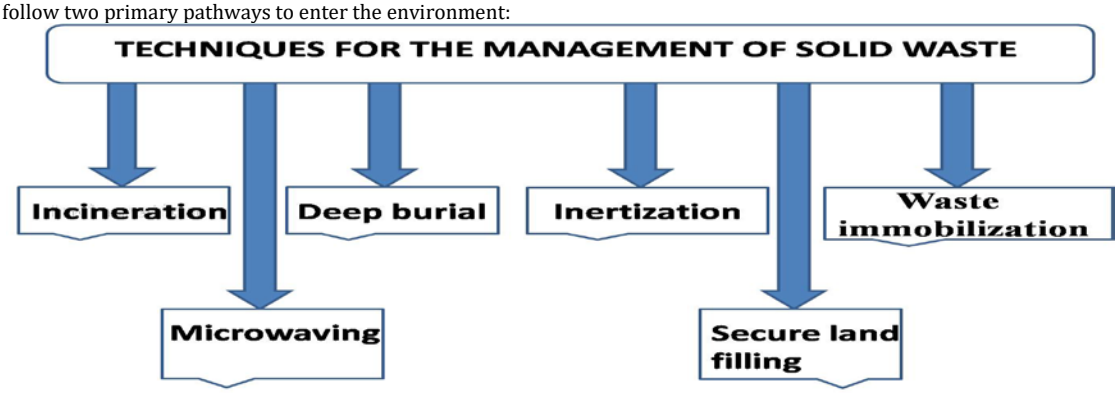

FIGURE 2: MANAGEMENT OF PHARMACEUTICAL SOLID WASTE

Incineration: Gaseous products and the residue is evolved in this disposal method in which the solid organic wastes is exposed to combustion. The residue of solid waste management and solid residue from waste water management is disposed off by this method efficiently. This process converts the large volume of solid into ashes which reduces 20-30 percent of the original volume. Incineration can also be described as thermal treatment because it requires very high temperature. Waste materials are converted into heat, gas, steam, etc by Incinerators. This method is not only carried out by industries but it is also carried on small scale by individuals. Practically, Hazardous waste materials like biomedical waste can be disposed of by this method (Singhet at al., 2007). There is a disadvantage of this method of waste disposal due to harmful emission of gaseous pollutants, but these gases can be used in generating the electricity, if used properly (Adgate et al., 2014). Incineration is not suitable for inorganic and metal compound waste like health care wastes as pressurized gas containers, large amounts of reactive chemical wastes, wastes treated with halogenated chemicals, halogenated plastics such as polyvinyl chloride, wastes with mercury or cadmium (such as broken thermometers, used lead or mercury batteries), or radiographic wastes. Incinerators must be designed with proper equipment to control air pollution. Ash from these incinerators must be disposed of in a secure landfill. Such incinerators are linked with highly skilled operating personnel with high investment and operating costs (Jafri 2010).

MANAGEMENT OF OTHER PHARMACEUTICAL SOLID WASTE: (Sharma et al. 2010, Chatsiwa et al., 2016**)**

Microwaving

Electromagnetic field is generated over the waste which excites the liquid in the waste to heat up, oscillate, and destroy the infectious components by conduction. If the ultraviolet radiation reaches the waste material, then this technology is productive. Waste require humidification and tearing into an appropriable size before microwaving. Microwaving method is not suitable for large metal parts, chemical, animals and human anatomical waste. The waste which is generated by microwaving can be land filled with municipal waste. Small electrical energy and no steam is required for this treatment technology. The controversy includes frequent breakdown of shredders and qualified technicians. Medium investment and operating costs is required for this method.

Deep burial

There are many different pharmaceutical wastes which require method of deep burial. The deep burial site should be prepared by digging a trench or pit which should be approximately 2.5 meters deep that is not vulnerable to flooding or erosion, and

where the soil is comparatively repellent, no settlers should be there and the area should be remote for surface water contamination. The trench should be half-filled with the waste, and then covered with lime within 50 cm of the surface, before filling the rest of the trench with soil. 10cm of soil should be added to cover the waste after each occasion when waste is added to the trench.

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. Landfill is also designed and operated to receive hazardous waste. Landfill is a common practice is most of the countries for disposing of waste which involves burying the waste in a landfill. Abandoned or unused quarries, mining voids or borrow pits are used for the establishment of landfill. 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 byproducts of landfill. This gas creates problems like foul smell, surface vegetation is destroyed and causes evolution of greenhouse gas. Design characteristics of a modern landfill include methods to contain leachate such as clay or plastic lining material. 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.

Waste immobilization: encapsulation

Pharmaceuticals are made inactive by Encapsulation in a solid block within steel drum or a plastic. Before usage drums should be cleaned and we should check that it does not contain hazardous materials or explosive materials previously. The drums are filled to 75% capacity with pharmaceuticals; solid and semi-solid, and the 25% space left is filled by pouring in a medium such as cement or cement/lime mixture, plastic foam or bituminous sand. The drum lids should be cut open and bent back for easy and speed filling. When placing of pharmaceuticals is done in the drums care should be taken to avoid cuts to hands. The ratio of lime, cement and water in the proportion of 15:15:5 by mass is added after the capacity of drum is filled to 75%. Liquid consistency is maintained up to satisfaction which requires larger quantity of water. By spot welding or seam the drum lids should be sealed and then bent back. The sealed drums should be covered with fresh municipal solid waste and should be placed beneath the landfill. The drums may be placed on pallets which can then be put on a pallet transporter for ease of movement.

Inertization

Inertization is an alternative of encapsulation which involves the mobilization of packaging materials, cardboard, plastic and paper from the pharmaceuticals. Pills need to be removed from their blister packs. A homogenous paste is formed with cement, lime, water and pharmaceuticals. Masks and protective cloth should be used by workers for protection from dust hazard. Concrete mixer trucks are used to transport the paste in liquid form and then the truck is taken to landfill and pour out into the normal urban waste. The paste then converts into dispersed solid mass within the municipal solid waste. This method is comparatively inexpensive and can be carried out with unsophisticated equipment. The equipment mainly required are road roller to crush the pharmaceuticals or grinder, a concrete mixer, and mixture of cement, lime and water.

MANAGEMENT OF LIQUID WASTE: (Fram and Kenneth 2011**) -**Two main techniques are used for the management of liquid waste.

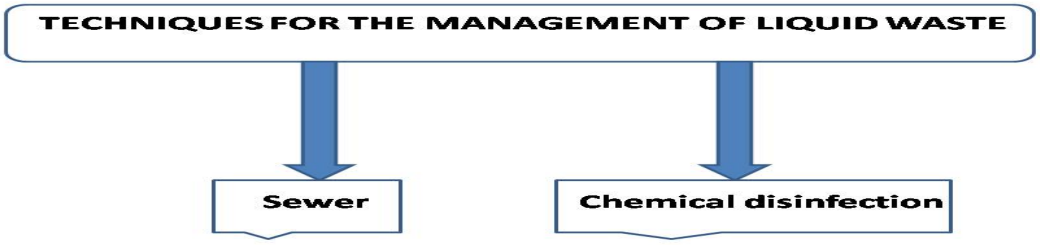

FIGURE-3MANAGEMENT OF PHARMACEUTICAL LIQUID WASTE

Sewer

Many liquid pharmaceuticals such as syrups and intravenous (IV) fluids, are flushed into the sewers after being diluted with water in small amount within different time intervals which will not cause any serious public health or environmental affect. Well-diluted liquid pharmaceuticals or antiseptics can be likely disposed in fast flowing water to flush small quantity. In this method, we need assistance of sanitary engineer or hydro-geologist if in case sewers get damaged or are disrepair (Glassmeyer et al., 2005).

Chemical disinfection

Chemical disinfection is perfectly used for treating liquid wastes such as urine, stools, blood, or health care facility sewage. We add inactive pathogens or strong oxidants-like chlorine compounds, ammonium salts, aldehydes, or phenol compounds in the waste. Chemical disinfection can also treat mutilated sharps, or shredded solids and microbiological cultures. Efficiency of disinfectants depends on factors such as the amount of chemical used, type of chemical, the extent and duration of contact between the disinfectant and the waste. Users should wear protective clothes as chemical disinfectants are hazardous (Mompelat et al. 2009, Fick et al., 2009).

Prevention of water contamination by Pharmaceuticals: (Miege et al., 2009, Fram and Kenneth, 2011**)**

If disposed of or secreted to the drain, to prevent water contamination by pharmaceutical waste water, treatment

plants are established. Depending upon the type of pollutant in water, waste water treatment can involve physical, chemical, or biological processes or combination of these processes.

Waste Water Treatment:

Water which is a necessity for all biotic as well as abiotic factor can also be present in the form of waste, if the water is polluted and contain some toxicity, it will also be considered as waste. So, it is our duty to put light on the management of waste water treatment as it increases water- borne diseases. Nowadays, industries are the main source of releasing waste water and due to this the underlying areas are getting disturbed. Before disposal, hence the sewage is treated in sewage treatment plants (STPs) to make it less polluting (Standley et al. 2008, Fairbairn et al. 2015).

Main steps followed in waste water treatment are:

i. **Primary treatment levels:** Primary treatment is mainly done by **Physical process**. It involves basically two steps, first is Filtration and second is sedimentation of large and small particles from the sewage. Supernatant or effluents formed from the primary settling tank is taken for secondary treatment.

ii. **Secondary treatment levels:** Secondary treatment is mainly done by Biological process. The effluent which is released from primary tank is now passed into large aeration tanks where it is constantly agitated mechanically and air is pumped into it. This allows the vigorous growth of useful aerobic microbes into flocs (masses of bacteria associated with fungal filaments to form mesh like structures). The organic matter present in the effluent is consumed by the microbes in large part while growing. This remarkably reduces the BOD (Biological oxygen demand) of the effluent. The greater the BOD (the amount of the oxygen that would be consumed if all the organic matter in 1 liter of water were oxidized by bacteria) of waste water more is its polluting potential. Once the BOD of sewage or waste water is reduced remarkably the effluent is then passed into settling tanks where the bacterial 'flocs' are allowed to sediment. This sediment is called activated sludge. A small part of activated sludge is pumped back into aeration tank to serve as inoculum. The remaining major part of sludge is pumped into large tanks called anaerobic sludge digesters. Here, other kinds of bacteria, which grow anaerobically, digest the bacteria and the fungi in the sludge. During this digestion, bacteria produce a mixture of gases such as methane, hydrogen sulphide and carbon dioxide. These gases form biogas and can be used as source of energy as it is inflammable (Benotti and Brownawell,2009).

iii. **Tertiary treatment levels:** It is the final cleaning process that improves waste water quality before it is reused, re-cycled or discharge to the environment. Example: by alum, chlorine, etc. It is also used to further reduce parameter value below the standards set out in national regulations (Bruce 2010). Now the effluent is generally released into natural water bodies like rivers and streams. This methodology has been practiced more than a century now in almost all parts of world. Till date, no man-made technology has been able to rival the microbial treatment of sewage (Kolpin et al., 2002).

Management of Pharmaceutical Metal Waste:

Metals can be used for industrial purposes. The good thing about metal waste is that, metals can be recycled over and over without altering its properties. The most common recyclable metals include aluminum and steel. The other metals for example silver, copper, brass and gold are so valuable that they are rarely thrown away to be collected for recycling. Therefore, they do not create a waste disposal crisis or problem.

The following are some of the benefits of recycling metal:

1) Preservation of Natural Resources
2) Reduction of Emission
3) Economic Development
4) Management of Energy Consumption
5) Saves your money

EFFECT OF PHARMACEUTICAL WASTE ON ENVIRONMENT AND HUMANS –

There has been a notable rise in the use of medicinal pharmaceuticals to resist different diseases and ill -health issues across the WHO. It is globally estimated that over half of all the medicines which are recommended, suggested, dispensed or sold are inappropriate, and half of all patients fail to take them as governed. As well as impacting negatively on individual health, and resulting in extensive resource waste, pharmaceutical use and "misuse" can have significant adverse repercussions on wildlife and ecosystems, particularly when unused medicines are disposed of inappropriately (Parasuraman, 2015, Patneedi and Prasadu, 2015).

Different pharmaceutical combinations are being used for a number of favorable causes in present day civilization but on the other hand pharmaceutical industries are releasing very harmful adulterants in the environment directly or indirectly or after chemical mitigation. 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 the applications of drugs. A huge amount of waste is being generated by the pharmaceutical industries during production activities and maintenance operations. Pharmaceuticals have been detected in wastewater treatment plant effluents and drinking water sources. Trace amount of pharmaceuticals in drinking water for longer period of time may cause substantial unfavorable consequence to human livelihood and aquatic life, though concentrations of pharmaceuticals detected in drinking water (in nano gram per liter range) (Parasuraman 2015, Patneedi and Prasadu 2015).

MOST COMMON ENVIRONMENTAL HAZARD / DISASTERS BY PHARMACEUTICAL INDUSTRIES (Medhi and Sewal, 2012)

The hazards from the pharmaceuticals can be categorized as:

- Toxic effect is released by micro-organisms which cause damage to the environment.
- Drugs which have some carcinogenic properties contribute to the causation of cancer.
- Some substance persists for a longer period of time in the environment and may cause fatal effects.
- Bio-accumulative–accumulates as it makes its way up the food chain.
- Manmade disaster like deforestation, forest fire during the development or during running of

pharmaceutical industry etc. may cause catastrophe, mishap, calamity or grave occurrence in any area.

There are many unchanged compounds that are released into drainage system like 95% of antibiotics. So, if the concentration of antibiotic is increased, it may result change in their DNA structure which affect their microbial community and ultimately food chain is affected (Costanzo et al. 2005). Non-steroidal anti-inflammatory drugs (NSAIDs), like ibuprofen, naproxen, etc. are widely being used and consequently are frequently detected in sewage, surface water and may be found in ground water system. Ibuprofen, ketoprofen, naproxen, indomethacin, diclofenac, acetyl salicylic acid and phenazone have been found in surface water system. However, diclofenac, ibuprofen and propyphenazone are the most commonly found drugs in the water bodies after clofibric acid. Moreover, diclofenac has been proven to be highly toxic for vultures and cattle's. NSAIDs like ibuprofen, naproxen and aspirin are the most commonly used drugs, which are usually found in effective quantities in municipal effluents (Medhi and Sewal, 2012).

REDUCTION OF ENVIRONMENTAL POLLUTION BY MINIMIZING THE PHARMACEUTICAL WASTE: (Gawad et al. 2016, Senthil, 2012)

Waste minimization motivates us to reduce the quantity of the generated waste. We cannot completely terminate the waste but we can decrease the toxicity being generated and then we can discard the waste material. The main objective of waste minimization technique is to use the raw materials, water and energy till the optimal use. Use is minimized by following three methods:

i. **Reduce**
ii. **Reuse**
iii. **Recycling**

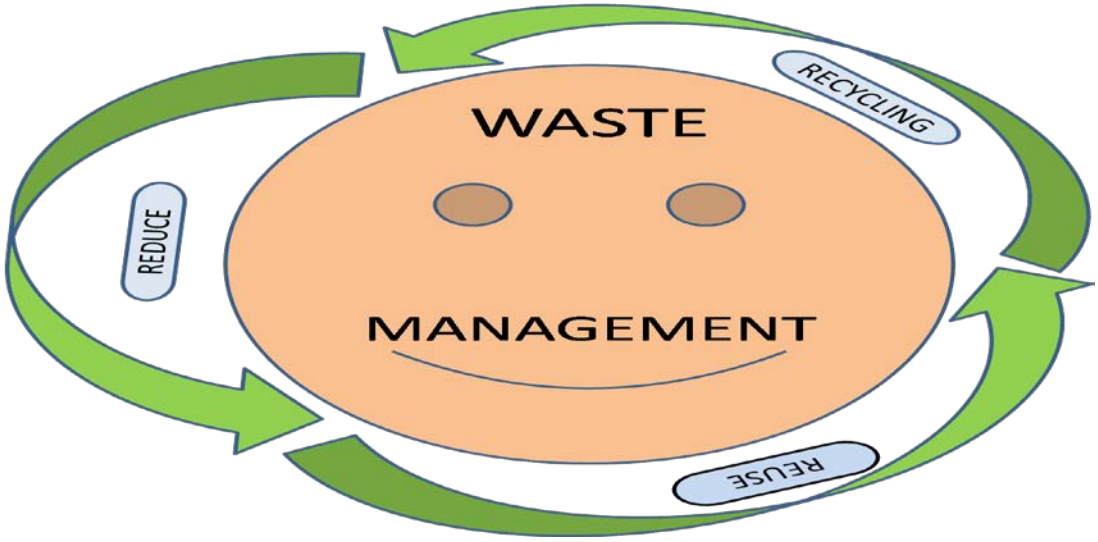

FIGURE-4 CYCLESHOWING REDUCTION OF PHARMACEUTICAL WASTE

i. Reduce

Reduction of the waste which is being generated is an important method of waste management and is known as waste reduction. Methods of prevention include using products again and again if they are reusable, fixing the damaged items instead of buying new, constructing products that can be reusable (such as cotton instead of plastic shopping bags), motivating consumers to avoid using disposable products (such as disposable cutlery), removing any food/liquid remains from cans, packaging, and designing products that use less material to achieve the same purpose (for example, light-weighting of beverage cans).

ii. Reuse

Re-use means that the product can be used multiple times, either for the same reason or for a different reason, without the need for reprocessing. Re-use avoids discarding a material to a waste stream when its initial use has concluded. There are some products which are left as it is so it is our duty not to discard it directly and these products should be sent to the preferable place for reusing it.

Some e.g., returnable plastic pallets, using an empty glass jar for storing items and using second hand clothes. Reuse precedes recycling as it reduces energy and material of earth.

iii. Recycling

Recycling is a process which involves the treatment of substance that can be recycled to its original form or to its intermediate form and this can be reused which reduces the consumption of more and more new products. It includes recycling of organic wastes but excludes energy recovery. Recycling benefits the environment by reducing the use of raw materials and can be saved for sustainable development. It is said that Recycle today, for better tomorrow.

BENEFITS OF WASTE MINIMIZATION PRACTICE: (Yang et al., 2010**)**

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

Waste minimization requires adherence from the head management and its employees. It is the company's duty to ensure that waste management programs are timely executed and employees shall be properly inspired, instructed, set goals and regularly update the results of the program. Effective waste minimization can only take place with full knowledge of the sources of waste by-products, the quantities produced and the sources of contaminants (Yang et al., 2010).

ROLE OF PHARMACIST-

Pharmacist is the best person that knows the worthlessness of most medicines. Pharmacist should take the responsibility for changing the entire medication use process, finding the cure

and minimizing the toxic effects of pharmaceuticals on environment. 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. Pharmacist also ensures patients safety and counsel patients about the adverse reactions and interactions with other medications, food, alcohol etc. This would aware people about the use and misuse of medicines and the way of disposing it and as a result, it would decrease the risk to the environment and well-being. Pharmacist being the most respected, trusted and most accessible drug information resource, empower learners of all ages with the technical skills about the medication. Pharmacists are in the forefront of tackling issues of prudent drug disposal methods to end users of drugs. All pharmacists should familiarize themselves with their region's drug disposal activities and be able to recommend them to their patients. Continuing education and training at every level is desirable to generate awareness of hazards associated with indiscriminate disposal of unused/expired pharmaceutical products–an emerging environmental issue (Pomati et al. 2006 and Abrons et al., 2010).

Pharmacists are the medication experts and the most knowledgeable health care professionals, which can provide valuable education to people on how to dispose the unwanted wastein an effective manner. Being a pharmacist, one can open a retail shop and can sell medicines on low cost to help the poor. Drug disposal programs and pharmaceutical collection events serve not only as resources to the community for safely disposing of unused or unwanted medications, but also as platforms for examining the causes of medication waste. Unused or unwanted drugs, accidental overdose, or prescription drug abuse cause a great threat to our society and have the potential to destroy our environment. Pharmacists provide information regarding proper disposal of medicines, drug abuse and several drug-managing programs and can be the part of several NGOs for environment protection (Kalyva, 2017, Ugya et al. ,2016).

REGULATORY BODIES THAT INVOLVED IN PHARMACEUTICAL WASTE MANAGEMENT (Sreekanth et al. 2014):

There are some main regulatory bodies for the control and management of waste.

1. Environmental Protection Agency (EPA)
2. Department of Transportation (DOT)
3. Drug Enforcement Administration (DEA)
4. Occupational Safety and Health Administration (OSHA)
5. State Environmental Agencies
6. State Pharmacy Boards
7. Local Publicly Owned Treatment Works (POTW)

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.

Entering of drugs or any pharmaceutical waste into ecosystem, biotic, abiotic factors and humans causing severe side-effects, so we should sincerely investigate to control them. All the stake holders, government, NGO'S, physician, pharmacists, patient and public should work hand in hand to make more and more awareness to professionals and well as consumers to reduce burden of unused and expired medicine on ecosystem.

As we take care of our mother, environment is also our second mother we should be equally concerned about it as it is the only source of life i.e. power, oxygen, and water. So, "COSUME LESS" "EMIT LESS" "CONSERVE MORE" and protect our environment.

SOME IMPORTANT ABBREVIATIONS FREQUENTLY USED IN THIS REVIEW:

PPCPS-Pharmaceuticals and personal care products
API - Active Pharmaceutical Agents
MSDS- Material Safety Data Sheet
RCRA-Resource Conservation and Recovery Act
TSDF-Treatment, Storage or Disposal Facility
RMW-Regulated Medical Waste
EPA-Environment Protection Agency
DEAR-Drug Enforcement Administration Regulations

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