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Review Article

Industrial Pharmacy

Effective Disposal of Biological and Pharmaceutical Waste: A Note to the Health Care Professional

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Abstract: The current appraisal aims to educate and give valuable information about disposal methods adopted in hospitals and health sectors. Many healthcare departments like microbiology labs, pharma industries, medical agencies, healthcare sectors all produce waste which usually contains unsafe materials that should not be exposed untreated to the atmosphere. In these health sectors, many types of wastes are separated as lab debris, chemical, and biological waste. These waste are rich in contaminants and pathogenic microbes which will be more lethal if they are not properly disposed of. The authors describe the various wastes and the definite discarding process to minimize costs and impact on the surroundings. Presently many of these sector professionals have some difficulty in disposal, these issues can be overcome by the systematic and easy plan described by the authors. Specific treatment must be required for this waste before they disposed off. This waste must be washed before introducing them into a particular disposable discard. Medical waste can be disposed of thoroughly as they contain infectious or non-infectious microorganisms. Biological and pharmaceutical waste must be disposed of, to prevent environmental hazards. Among the various approaches adopted for the disposing of these waste includes incineration, autoclaving, chemical disinfection, ignitability, etc. are popularly adopted. Each particular waste can be disposed of in a specific manner. The authors succeed in bringing the systematic approach in the disposal of waste in health care units and concludes that proper disposal is important to reduce the contamination and pollution of the environment and maintain a healthy atmosphere.

Keywords: Autoclaving, Microbiological waste, Pharmaceutical waste, Incineration, Ignitability.

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1. INTRODUCTION

Biological and pharmaceutical wastes may be corrosive, inflammable, fiery, or retort when exposed. These hazardous wastes are highly toxic to the environment, humans, animals, and plants. In research laboratories, the important part is the cautious discarding of organic and wastes. The communicable wastes when not properly managed poses severe physical condition risks to mankind.[1] The biological waste encompasses cultured stocks and plates, blood, molecular material, tissues of animal and plants, pathological waste, animal bedding waste, specimen bins, polluted animal bodies and biotechnology by-product wastes (i.e. recombinant DNA).[2] In laboratories, solid organic waste should be gathered in red-bag-lined cardboard boxes and liquid waste are sink-disposed. Sharp containers are chosen for gathering sharps. Whereas special disposal requirements are available for infected tissues of humans/animals. Medical waste involves pharmaceutical waste which contains unused medication, sharps, used test bands, over-the-counter products, and other supplies.[3] Specific treatments should be done in discarding pharmaceutical waste based on their origin (E.g., hospitals). The medicines disposed of into the atmosphere by being thrown away in un-metabolized condition produces health issues. Utmost care should be taken for the disposal of drugs like endocrine disruptors, heavy metals, and other compounds that are dangerous for surroundings.[4] If these wastes are not properly guarded it may be misused by some people that lead to health-related issues. Chemicals cause surroundings damage which is mainly present in the toiletry products. Traditionally surplus medications are flushed along with the toilet. If these enter into the food cycle causing lethal health issues. Though it is not followed because there are no specially equipped wastewater treatment plants for handling pharmaceuticals. Therefore, customers are told to cover their medication containers in sticky tape to stop leakage sooner, throw them away or pass them to the dangerous waste gathering spot.

1.1 Types of wastes

During working in a Microbiological laboratory different types of wastes are produced, which after used it should be disposed of. It may be physical, chemical, biological, and bioremediation. Different types of wastes are following

1.2 Biological wastes

These includes[5]

- Microbiological wastes
- Animal Wastes
- Human wastes
- Pathological waste

1.3 Microbiological waste

These include as illustrated in table 1.

Table 1: broad classification of sharps, solid, and liquid waste

Contaminated sharps	Contaminated solids	Liquid
Syringes with/without needles	Culture dishes	Liquid growth media
Glass slides	Flasks	Human body fluids
Slide covers	Petri dishes	Blood and its components; vaginal secretions
Specimen tubes	Gloves, Gowns, and masks	Cerebrospinal and synovial fluid; Semen fluid

1.4 Disposable methods

1.4.1 Incineration

The destruction of waste material by flaming at elevated temperatures(>1000°C), which radically drop the quantity and weight of the wastes treated.[7]

1.4.2 Chemical disinfection

Pathogens are killed by adding the chemicals. This technique is mainly used for treating liquid infections wastes involving blood, urine, faeces, and hospital sewage. Materials like 1% bleaching powder solution or a diluted active chlorine solution (0.5%) are used in treating the infectious wastes.[8]

1.4.3 Autoclaving

Autoclaving is a method that through the use of electricity renders waste free of the living microorganisms. This process is commonly employed in laboratories involves 121°C for 20 min at 15 pounds' pressure.[9]

1.4.4 Needle destruction

The melting of some needles kills others. Small powered machines are used to separate the needles from the used disposable syringes. Those are thrown away into deep pits.[10]

1.4.5 Shredders

Shredders are used by cutting solid waste which turns them into a small part. The implementation of shredders is vital in waste management and recycling. Shredders are more attractive as they are specified in the handling of any type of solid waste and available in many capacities that satisfy the various needs. Solid waste shredding size reduction needs the processing of many diverse materials. And, as the number of solid waste upsurges and the cost of landfill management rises, it is becoming more critical that waste management becomes more effective, economic and efficient. Shredded and compacted waste is easier and cheaper to transport and extends the life of the landfill. Also besides splitting out materials that can be reclaimed and recycled or that need to be incinerated or composted increases the landfill output while providing income to offset the costs of dispensation the solid waste. The shredders are easy to handle, economical, durable, no skilled operator required, continuous process, easy to clean, fewer installation costs, less operational costs, less maintenance, and consumes very little fuel. The blades in the shredders are made up of stainless steel which has a long life. Shredding technology produces homogeneous products appropriate for transport and endures further dispensation. These are set up as devices for the chemical or thermal disinfection. This provides a way of recycling plastics and needles under some situations.[11]

1.4.6 Encapsulation (solidification)

Solidification is the processes that capture solid waste and limit the immigration of contaminants by reducing the open surface area, which is open to leaching, when contacting liquids, and also by coating them with low-permeability materials. The solidification technique is the most popular approach in waste disposal. The solidification approach encapsulates solid waste and prevent its leach into the environment. The solidification and encapsulation process is done at about 120 °C to form durable polymer bonds. In this process the waste material causes leaching of harmful exudates into the environment such as ashes and slags from thermal processes, industrial dust, chemical waste from industries, waste from galvanic processes. Among the heavy and toxic metals, arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc are considered harmful to the environment. Even medical wastes (e.g., Sharps, mercury, etc.) may also be neutralized using the solidification and stabilization approach. In solidification, the waste is mixed with water and a stabilizer (helps in the binding process). Later the whole blend hardens into an impermeable block. Once it has dried, it will be water impermeable. The process of solidification further enhanced by stabilizing material like cement, clay, Portland, hydrocarbon polymers, and fly ash, etc. In the end, the solidification process is a monolithic block of waste with high structural integrity. It is best suitable for mixed waste containing many varieties of waste. The waste material which can be treated by solidification are inorganics in the soil, some organic material and also for low-level radioactive mixed waste.[12]

1.5 Categories of disposable material

1.5.1 Disposal of used culture Medias

Culture media in Petri dishes can be made free from the microorganisms by autoclaving and sealed in autoclavable bags. These bags are again sterilized and passed to micro waste containers which are disposed of either by municipal trash or incineration.[13]

1.5.2 Disposal of solids from microbiology lab waste

No new methods are available same approaches are followed but they should be strictly monitored and maintained The dirty and unpolluted glassware, contaminated broken glassware should be covered in plastic bags then sterilized. These are disposed of as industrial waste or by incineration. If it is an urban waste the uncontaminated glassware may be discarded.[14]

1.5.3 Animal waste

The animal waste may be in solid waste (dung) or a slurry.

1.5.4 Solid Manure

Generally, strong manure is thrown away for breakdown into a landfill. This manure will return to soil 75% of its fertilizer content. To prevent foul smell, all manure pits are placed about 200 m away from the residential houses.[15]

1.5.5 Collection of Manure

Manure waste (fecal matter and urinals) are excreted from animals or humans. These manure of Green manure (safe), farmyard manure (used as fertilizer), and Compost manure (rotten animal and plant waste used as compost), is first flushed along with other waste and then solid and liquid waste is isolated and used as manure. The first phase is primarily employed in areas that have plenty of water. It is important to position a U-shaped drain which drains the liquid water to a storage tank where it is circulated for manure to agricultural land. In the next step, a small pit for solid waste disposal is created. To avoid the diseases, the pit is situated away from water bodies, wildlife, and human buildings.[16]

1.5.6 Disposal of Manure

Since ancient time, animal manures have been utilized as nutrients in agriculture. As India is one of the largest domestic animal growing countries, large quantities of manure also produced. In olden days this manure was considered only as a fertilizer for field crops. The increased labor cost made manure disposal a burden to many farmers. To surpass these issues to farmers and to support the economic and environmental issues an alternative manure handling and disposal method are adopted. The manure contains valuable nutrients like nitrogen. Phosphorous, potassium, Sulphur, calcium, magnesium, copper, manganese, zinc, boron, and iron. The manure emits greenhouse gases like CO_2, N_2O, and CH_4, which contribute to climate change, on the other hand, ammonia and particulate matter worsen air quality/unpleasant odor. This may also lead to the pollution of drinking water and the environment. So an appropriate step to be taken to utilize the manure nutrients for enhancing the soil nature, present surface, and groundwater contamination, and protect public health. The manure may be disposed of in pits, disposed in open land, and fairly large in quantities may be utilized to generate biofuels. In villages, the manure is mixed with straw to make dung cakes which are used as fuel for cooking purposes (now a day it is rarely seen). Open animal manure is an enormous potential area for fly breeding and thus its sanitary disposal is essential. This can be prevented by disposing manure in biogas plants or through landfills or by composting. Community participation is the key to ensure success in the implementation of solid waste disposal.

1.5.7 Composting

The pits are built to test for desiccation with walls on three sides and a momentary roof. The side of the face will have a drain filled with cresol and water to restrict fly breeding, with the debris falling into the drain. The daily waste mixing composting is important. After piling, the temperature rose to 50° C within 24 h, and it reached 70° C within 3-8 days. It then declines to 50° C. These can be used as fertilizer for plants.[17]

1.5.8 Vermicomposting

This approach is gaining the attraction of formers, consumers, and even the government. This approach is the best method for utilizing waste disposal effectively. It is a technique that manages large amounts of agricultural and livestock waste. Various varieties of earthworms produce natural manure from agriculture and livestock wastes. Earth's waste is abundant in nitrogen, potassium, and phosphorus, as well as many micronutrients, enzymes (such as proteases, cellulose, amylases, and lipase), plant growth hormones, and

some nitrogen-fixing bacteria that strengthen vermicomposting's nutrient value. It also improves the soil structure, the ability to maintain the environment, soil texture, and reduces soil erosion, thereby producing good, harmless, and tasty food from the soil. It is a cost-efficient and easy method that can be followed easily by the rural farmers for their profit.[18]

1.5.9 Biogas Production

The methane gas evaluated from the fermentation of bio-waste fermentation is another way of effective management of waste. Finest waste management systems in Japan and China have been expansively overworked. The cycle includes organic matter which is then transformed into volatile fatty acids using anaerobic bacteria converted to methane and CO_2. The sultry is a crucial ingredient for field use.[19]

1.5.10 Disposal in Lagoons

Lagoon technique provides a means of treatment and storage of livestock manure before the terminal disposal on land. Appropriately designed and operated, lagoons can reduce organic matter up to 95% and reduce nitrogen up to 80% through ammonia volatilization. Owing to this, lagoons can provide plenty of area for the storage of manure and wastewater. Lagoons have very successful ratings in the disposal of waste is properly designed and maintained. The lagoon system for the treatment of waste is economical, low construction cost, minimum operational costs, less labor requirement, reduced fly problems. But this system has few pitfalls like loss of fertilizer value and offensive odor if improperly designed, need regular sludge removal, chances of groundwater pollution, mosquito habitat, and need for terminal disposal of effluent. It is a small pond where liquid manure is discarded and absorbed by bacteria. Lagoons are earthen constructions that act as digesters where microbes decompose organic matter. Anaerobic lagoons are used in the swine and poultry industry as it is efficient and economical. The lagoon minimizes organic material (the main source of odor), decreases the nitrogen content of the waste, and permits solids to settle out. Most of the phosphorus will gather in the sludge in the bottommost of the lagoon. Lagoons are not suggested for a site that has a porous subsoil or a high water content, since the issue of groundwater pollution. Additionally, lagoons are not advised for achieving maximum fertilizer value from the manure. Lagoons also are not suggested where minimum distances to property lines and houses cannot be maintained. [20]

1.5.11 Bacterial Action in Lagoon

Bacteria produce bad odor by acting on the lagoon. Airborne aerobic bacteria use CO_2, nitrate, and other nutrients and, besides the release of O_2 for aerobic bacteria to oxidize waste materials. Anaerobic bacteria can often take part in discarding waste and thus producing a un tolerable smell. The odor can be minimized by various approaches like adding sodium nitrate, recirculating pond effluent, and through scheduled cleaning.

1.5.12 Precautions

- Protective fencing around the lagoon to limit dog and childproof.
- Make the bottom equalized and resistant.
- The lagoon has to be cleaned once in 5 to 8 years or when required to take away accumulated sludge if filled up to the depth of one meter.

1.5.13 Human blood and its products

Contaminated human blood/plasma/serum/components[21] can be disposed of as mentioned in table 2.

Table 2: Specimen and disposal approach adopted

Specimen type	Disposal method
Blood, Faeces, and stored plasma	Yellow clinical waste bags discarded into a large yellow clinical waste bin in a cold room
Marrow	Disposed into a sharps bin
Cerebrospinal fluid	Place in hard plastic containers and then disposed of in the yellow clinical waste bag
Blood Gases	Discarded into sharps bin after analysis
Plasma, and serum	Clinical waste bins
Urine	Channel
Blood and bone marrow samples	Autoclave

1.5.14 Pathological waste

Doctor offices, veterinarians, hospitals, nursing homes, pharmacies, and other medical facilities each produce varied types and amounts of pathological waste. Pathological waste is one of medical waste and requires a specific disposal process. This waste must be separated, packaged, and labeled appropriately. Improper handling and disposal lead to environmental pollution and health issues. These pathological wastes must be judged harmless, distorted, and incinerating is the appropriate method. Pathological waste is generated from the areas (like hospitals, surgical centers, plastic/cosmetic surgeons, and veterinary clinics, etc.) where tissue or blood specimens are collected for diagnosis or treatment.The anatomical waste such as organs/body fluids must be packed in double-bagging, storing inappropriate plastic containers, or use of absorbents (to prevent leakage). On the other hand, some pathological waste like chemotherapy drugs/chemicals also is labeled appropriately as per the guidelines of regulatory bodies. As per the Bio-medical waste management rules, wastes can be categorized as follows

Category 1: human tissues, organs, and body parts
Category 2: Waste animal parts
Category 3: Waste from microbes
Category 4: Waste sharps
Category 5: Forbidden and cytotoxic drugs

Category 6: Solid wastes contaminated with blood, and body fluids including cotton, dressings, solid plaster casts, linen, beddings, other materials contaminated with blood)
Category 7: Solid wastes (Wastes generated from disposable items other than the waste sharps, such as tubing, catheter, intravenous sets, etc.)
Category 8: Liquid waste
Category 9: Incineration ash
Category 10: Chemical waste of pathological lab. The pathological waste must be separated from the standard regulated medical waste and they must be autoclaved then disposed of in a landfill.[22]

1.5.15 Pathological Waste Disposal

Each of these waste is sealed into a variety of containers. Biohazard tooters, cardboard boxes, and carts covered with red bags are widely used containers. Pathological waste collected shall be sent to disposal by the incinerator. It is safer to use "tissue digester" to remove vast amounts of pathological waste. It diminishes the amount of pathological waste and therefore neutralizes the infectious agents.[23]

1.5.16 Pharmaceutical waste

Pharmaceutical waste is not a single waste, but it comprises of a wide variety of material including intravenous (IV) preparation, general drugs, spills, breakage, partially used vials, syringes, IV sets, discontinued, unused preparations, unused tablets/capsules, blister/strip packing left out after tablet removal, and outdated pharmaceuticals. In hospitals, the pharmaceutical waste is usually discarded into the drain or landfill, except chemotherapy medicines (as they sent to a regulated medical waste incinerator). These practices were followed at a time when wisdom was not available about the potential adverse effects of introducing waste pharmaceuticals into the environment. Good pharmaceutical waste management is highly complex in environmental management for health care facilities. Pharmacists and nurses generally do not receive training on hazardous waste management during their academic studies, and safety and environmental services managers may not be familiar with the active ingredients and formulations of pharmaceutical products. The disposal of pharmaceutical waste can be very hazardous when it gets mixed with municipal solid waste. This can lead to a higher degree of environmental pollution, separately from posturing serious public health risks such as AIDS, Cholera, Hepatitis, Plague, etc. Small quantities at household medicines thrown in the municipal waste stream are also undesirable. The pharmaceutical wastes are disposed of as the following methods.[24]

1.5.17 Collection and Separation

The medical waste collected from the point of its origin. The different waste [25] is summarized in table 3.

Table 3: Types of wastes with their examples

Waste type	Examples
Medicinal	Expired drugs, chemotherapy drugs residues, open containers that cannot be used, and clean up materials
Hazardous	Liquids, solids, contained gases, or sludge
Special	Ignitability, corrosivity, reactivity, and toxicity
Characteristic	Solid waste
Non-hazardous	Sodium chloride, Dextrose Solutions
Chemotherapeutic	Methyl chloride, and formaldehyde

Proper containers should be used based on the type of waste as summarized below and figure 1.

Red : Blood, and tissues
Orange : Infectious materials, gloves
Yellow : Highly infectious waste
Blue : Unused drugs
Purple : Chemotherapy drugs
Black : Municipal waste
White : Dental wastes

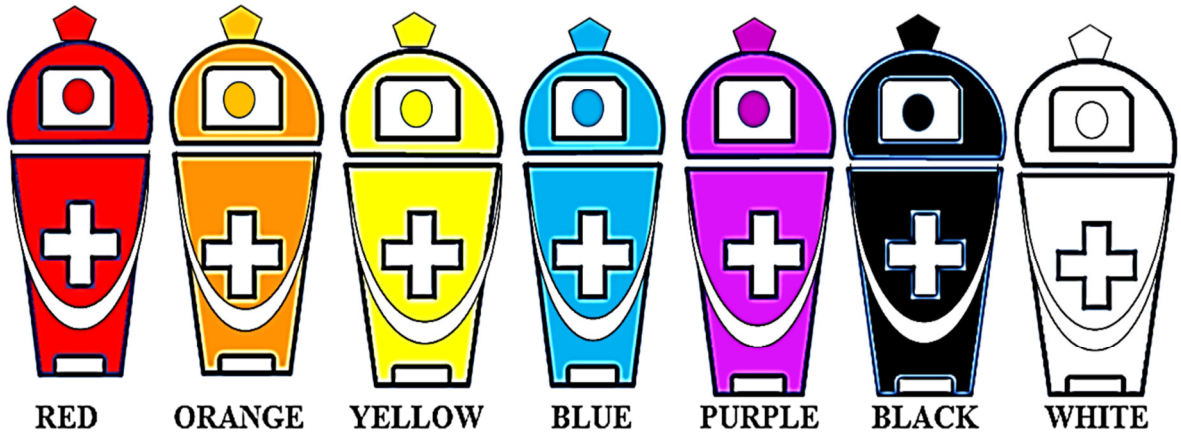

Fig1. Colour codes for the disposal of hospital wastes

7. CONCLUSION

The various waste generated and suitable approaches for the effective disposal studies, the authors conclude that waste does generate in medical and hospital premises which are rich in microbes, which is bioburden and causing environmental hazards. The selection of suitable disposing tactics will reduce the ill effects of these wastes. The authors also appeal to mankind not to generate unnecessary waste to keep the environment healthy.

8. AUTHORS CONTRIBUTION STATEMENT

ASL. and HAA conceived of the presented idea. CH and SSH developed the theory and performed the computations. KT, GS, and AN verified the manuscript. All authors discussed the outcome and proofing the final manuscript.

9. CONFLICT OF INTEREST

Conflict of interest declared none.

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