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A Review on Veterinary Medical Waste Disposal and Management

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Abstract

The purpose of this review is to highlight environmentally sound disposal methods of veterinary pharmaceutcals wastes and the risks associated with its improper disposal, with a systematic review. Pharmaceuticals are produced and used in large volumes increasingly every year throughout the world. Medicinal waste products are medicinal products which are not fit for sale or supply. Waste produced in veterinary practice in common with other medical disciplines can be broken down into general waste similar to household waste, clinical waste and hazardous waste. Disposal of pharmaceutical compounds is becoming a complex environmental issue. The safety and health of the environment is directly affected by the disposal methods. Improper medical waste disposal and management causes all types of pollution (air, soil, and water). Proper waste management have to be undertaken to ensure that it does not affect the environment and not cause health hazards to the people living there. Different types of medical waste require different disposal techniques. The appropriate safe disposal method recommended will depend principally on the pharmaceutical dosage form of the drugs. One of the best advisable veterinary waste disposal practices is to store the waste properly before collection and transportation. Some general medical waste can be disposed of in landfill, others require specialist treatment such as a medical incinerator. Appropriate safety precautions, which minimize the risk to the health and safety of pharmacy staff, should be taken when handling medicinal waste products. Extra precautions should be taken by staff in high-risk groups as they may be at increased risk if they come into contact with particular substances. The cost of pharmaceuticals waste disposal comprises of direct costs of supplies and materials used for collection, transport, storage, treatment, disposal, decontamination and cleaning, the cost of labor and material for training and maintenance, and will vary depending on the treatment method chosen, the capacity of the treatment facility and according to the waste quantity and quality.

Keywords: Medical Waste, Pharmaceuticals, Veterinary Drugs, Waste Disposal

List Of Abbreviations

ADR……...Adverse Drug Reaction
AVMA……. American Veterinary Medical Association
DNR……... Department of Natural Science
DOT…. ……. Department of Transportation
EPA……. Environmental Protection Agency of America
EWCHWL…. The European Waste Catalogue and Hazardous Waste List
FMHACA…. Food, Medicine and Health Administration and Control Authority of Ethiopia
IV……Intravenous
LD50…. ……Lethal Dose50
MSW…. ……. Medical Solid Waste
MSWM…… Medical Solid Waste Management
NMRA…… National Medicine Regulatory Authority
ºC……. Degree Celsius
PCBs……. Polychlorinated Biphenyls
PPE…. …… Personal Protective Equipment
PSI…. …… Pharmaceutical Society of Ireland
PVC……... Polyvinyl Chloride
RCRA……. Resource Conservation and Recovery Act of America
Tº……. Temperatures
UK……. United Kingdom
UN……. United Nations
US……... United States
USGS……. United States Geological Survey
VDFACA…… Ethiopian Veterinary Drug and Animal Feed Administration and Control Authority
WHO……. World Health Organization

Introduction

Veterinary drugs are a broad group of pharmaceuticals exhibiting many different chemical and therapeutic properties [13]. Veterinary drug means any substance or mixture of substances used in the diagnosis, treatment or prevention of animal disease and includes products used to treat against internal and external parasites and disease transmitting vectors, biological products and sanitary items [22]. Pharmaceuticals are produced and used in large volumes increasingly every year throughout the world. With this growth comes concern about the fate and effects of these compounds on the environment [8] Pharmaceutical compounds are increasingly being detected at low levels in ground and surface waters. Although environmental concentrations of pharmaceuticals measured to date are far lower than the intended therapeutic doses, there is concern that the potential exists for these chemicals to have an adverse impact on aquatic life and human health [12].

Medicinal waste products are medicinal products, including veterinary medicinal products, which are not fit for sale or supply. Medical and hazardous waste generated during veterinary practice is regulated waste due to its potential to cause harm to anyone who comes into contact with it. For this reason, it is important and that anyone handling untreated medical or hazardous waste is provided with appropriate PPE to minimize risk. Employees are also required to have training in the proper use and disposal of PPE. Pharmacy owners and pharmacists, as the generators and holders of waste, must ensure that all medicinal waste products are appropriately stored, transported and disposed off [19].

Disposal of pharmaceutical compounds is becoming a complex environmental issue. The safety and health of the environment is directly affected by the disposal method.[12] The disposal of waste medicinal products must be carried out in a manner which protects public health and safety, protects the health and safety of staff and patients, and causes no risk to the environment [19].

Objectives

The purpose of this paper is to highlight environmentally sound disposal methods of veterinary pharmaceuticals wastes and to ascertain the risks associated with its improper disposal, with a systematic review of previous works.

Waste Classification and Types

Veterinary care providers must, like healthcare facilities that serve human patients, separate certain types of waste out for special handling. Waste is all around; at work, at home and everywhere in between [18]. These waste streams fall under two broad categories; medical waste and hazardous waste.[24] Waste arises in many different forms and its characterization can be expressed in several forms. Some common characteristics used in the classification of waste includes the physical states (solid, liquid and gaseous), physical properties, reusable potentials, biodegradable potentials, source of production (household or domestic, industrial, agricultural, commercial, demolition, construction and mining) and the degree of environmental impact (hazardous and nonhazardous) [3]. Solid waste is further subdivided into subcategories as shown in figure 1 here under.

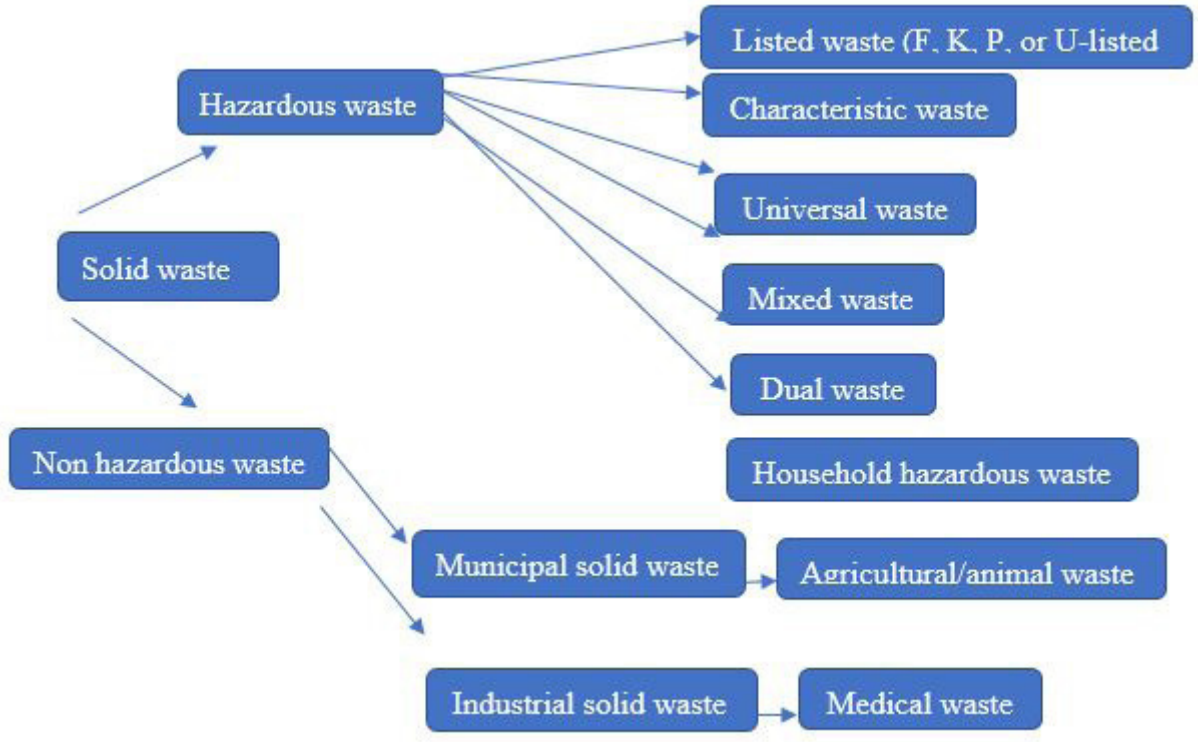

Figure 1: Categories of solid waste

Veterinary Medical Wastes

The waste generated in animal healthcare services are composed of plastic, paper, glass, cardboard, sharp objects, chemical or biological residue. Of these, veterinary drugs that play an important role in the production of animal protein are emphasized, guaranteeing food for millions of people, and the class of antimicrobials is one of the most used in agriculture worldwide. The increasing production of animal protein in an intensive system and lack of clear laws and regulations on the use of antimicrobials has generated an often-irrational increase in antimicrobial consumption [9].

Waste produced in veterinary practice in common with other medical disciplines, can be broken down into general waste similar to household waste, clinical waste and hazardous waste. Little information is available relating to quantitative estimates of the composition of veterinary waste in any country [20]. Medical waste includes discarded sharps (i.e., needle and syringe) and instruments used in surgeries, animal tissues, organs and body parts, biological liquids, animal vessels in a veterinary vicinity, specimens and other discarded matter in medical, dental/veterinary setup/research that can compromise human health and the environment when contact occurs [21].

Medical Waste Generated by Veterinary Care

Sharps waste: Traditionally sharps which comprise discarded injection needles, scalpel blades, lancets, surgical suture needles and all other sharp materials of medical origin have been regarded as hazardous waste across all medical disciplines for obvious

reasons [20]. Federal and state regulations require waste products that fall under this category to be segregated into approved sharps containers. Items that belong in sharps containers include any device that can pierce (cut) the skin, such as hypodermic needles, IV ports, razors, disposable scalpels/blades and some glass items, like vials, pipettes or broken glass that may be contaminated with biohazardous agents [24].

Biohazardous waste: Waste products that are categorized as biohazardous medical waste and are not sharps, must be segregated into red biohazard bags/containers. Pathology wastes such as animal parts, tissues, fluids or carcasses that may be contaminated with infectious agents falls under this category as does laboratory wastes such as specimens or cultures that may contain infectious pathogens. Items such as animal parts will need to be separately contained and labeled for incineration only. Other items that belong in biohazard containers include bedding, bandages or other materials soiled with urine, feces or other fluids that may contain infectious agents [24].

Hazardous wastes: Waste that's dangerous, but not infectious, like sharps, discarded surgical equipment and some chemical waste [5]. Certain cleaning fluids and disinfectants, some laboratory chemicals (formaldehyde, acetone, toluene, fixatives and alcohol), radiologicals, listed pharmaceuticals. These waste products must be segregated into approved, clearly marked, RCRA hazardous containers [24]. The EWCHWL, lists only cytotoxic and cytostatic medicines used in animal treatments as hazardous. Medicines are regarded as hazardous in the USA and as clinical waste in the UK. In the UK they also come under the category of "special waste" [20].

Pharmaceutical Wastes and Its Risks

Among the emerging pollutants, drug wastes pose a serious threat to human health and to environmental integrity, with studies already detecting drugs in sewage, treated wastewater, surface waters of rivers, river sediment, drinking water for the human population and marine ecosystems [17].

Improper MSW disposal and management causes all types of pollution: air, soil and water. Indiscriminate dumping of wastes contaminates surface and ground water supplies. In urban areas, MSW clogs drains, creating stagnant water for insect breeding and floods during rainy seasons. Uncontrolled burning of MSW and improper incineration contributes significantly to urban air pollution. Greenhouse gases are generated from the decomposition of organic wastes in landfills and untreated leachate pollutes surrounding soil and water bodies. Health and safety issues also arise from improper MSWM. Insect and rodent vectors are attracted to the waste and can spread diseases. Using water polluted by MSW for bathing, food irrigation and drinking water can also expose individuals to disease organisms and other contaminants [1].

Presence In Soil and Water and Its Impact

A large portion of the pharmaceuticals in water come from the improper disposal of unused (unwanted) drugs by households and medical facilities. Most people either flush them down the toilet or throw them in the trash [8]. Through improper disposal the drugs have found their way into the water supply and this has many negative side effects. In most water supplies, pharmaceutical residues are detected at trace levels, but even low concentration levels, between 1 part per trillion and 1 part per billion, can have toxic effects [7].

A report by the Toxic Substances Hydrology Program of the USGS indicated that water samples collected and analyzed from 139 streams in 30 states during 1999 and 2000 revealed a broad range of chemicals from human and veterinary drugs, among other household, industrial and agricultural chemicals. In 80% of the streams that were sampled, at least one of the 95 targeted chemicals was detected, and often more than one chemical was found. Of the 95 chemicals tested for in the study, 82 were detected at least once. Insect repellents, antibiotics, caffeine, steroids, hormones and other compounds were among the list of chemicals found in the stream samples. Though research on the impacts of these chemicals on aquatic life is limited, some researchers speculate that individual or mixtures of pharmaceutical chemicals may impact fertility of fish and other aquatic animals and may bioaccumulate in the tissue and blood of aquatic animals [12].

Another issue of growing concern is the contribution of pharmaceuticals in water to the development of antibiotic resistance. In addition to rivers and streams, pharmaceuticals have also been detected in treated drinking water at very low concentrations. Research has not determined the human health effects of exposure to these very low concentrations of pharmaceuticals and the extent of occurrence of pharmaceuticals in drinking water [12]. Resulted in high algal population in rivers and sea, and degrades water and soil quality [1].

Human and Animal Health Risks

For the general public, the main risks to health are indirect and arise from the breeding of disease vectors, primarily flies and rats [1]. The excessive and subtherapeutic antimicrobials doses used in animal production and inappropriate waste disposal of animal healthcare services contribute to disseminate drug resistant pathogens, both in animals and in humans, posing a significant threat to public health [9].

Uncontrolled hazardous wastes from industries mixing up with municipal wastes create potential risks to human health. Traffic accidents can result from toxic spilled wastes. There is specific danger of concentration of heavy metals in the food chain, a problem that illustrates the relationship between municipal solid wastes and liquid industrial effluents containing heavy metals discharged to a drainage and /or open dumping sites of municipal solid wastes and the wastes discharged thereby maintains a vicious cycle including these some other types of problem are as follows: chemical poisoning through chemical inhalation, uncollected waste can obstruct the storm water runoff resulting in flood, low birth weight, cancer, congenital malformations, neurological disease, nausea and vomiting, mercury toxicity from eating fish with high levels of mercury and plastic found in oceans ingested by birds. The US Public Health Service identified 22 human diseases that are linked to improper MSWM. Direct health risks concern mainly the workers in this field, who need to be protected, as far as possible, from contact with wastes. Waste worker and pickers in developing countries are seldom protected from direct contact and injury and the co-disposal of hazardous and medical wastes with MSW poses serious health threat. [1] Pharmaceutical wastes found in increasing concentrations in the surface water or rivers for human consumption and effluents when not efficiently removed by treatment plants may cause serious toxic effects on human health [17].

Environmental Risks

Disposing of unwanted or expired medicines by environmental unfriendly routes is becoming a big issue and can be a challenge for households [19]. The safety and health of the environment is directly affected by the disposal method [12]. The decomposition of waste into constituent chemicals is a common source of local environmental pollution [1]. The main routes of entry of veterinary drugs into the environment are through urine and feces from medicated animals, soil fertilization consisting of animal waste, improper disposal of packaging, sharp objects, disposal of leftover and expired drugs in the urban solid waste collection network and direct release into the water of drugs used in aquaculture [17].

Pathways Into the Environment for Veterinary Medicines

Veterinary medicines can take several routes to enter water and soil [6] as shown in fig 2.

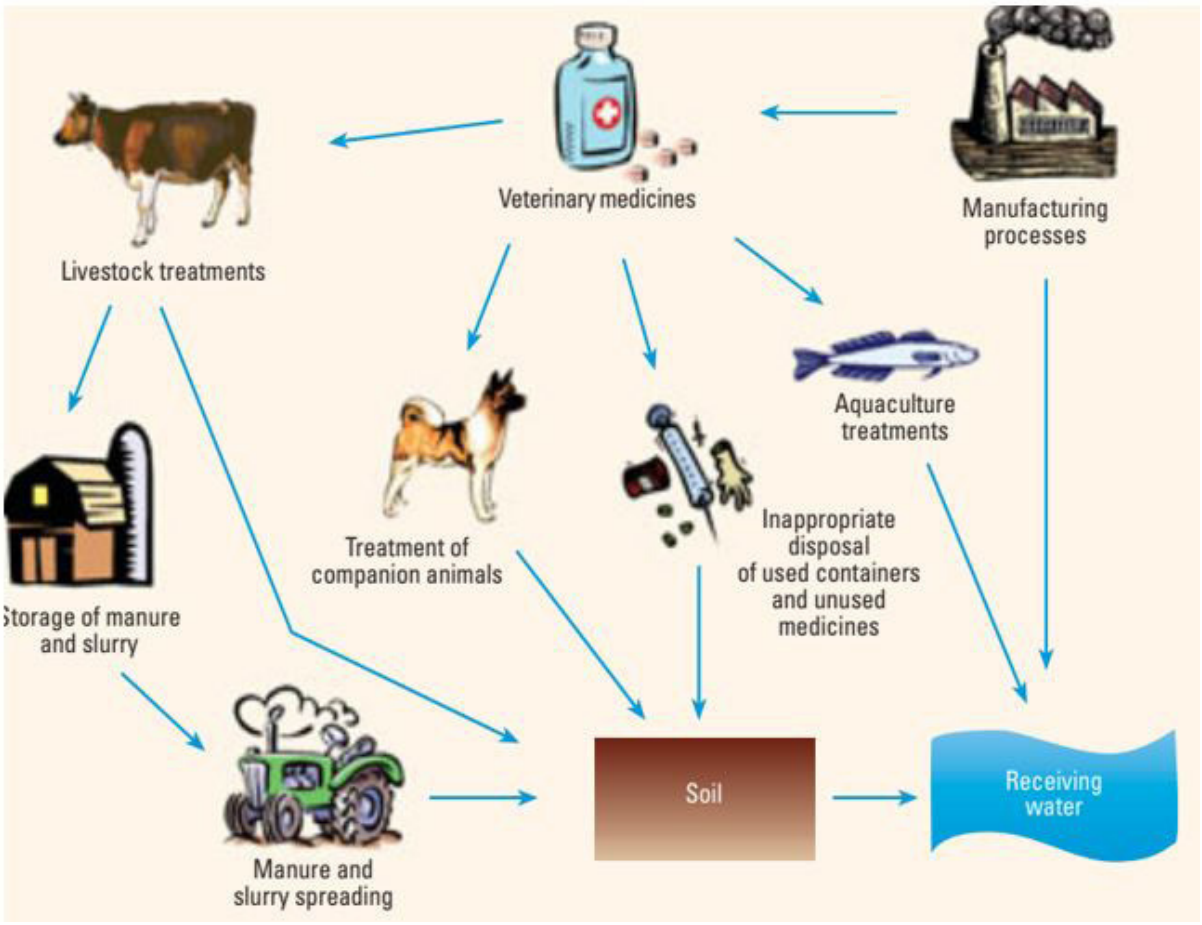

Figure 2: Pathways of Veterinary Medicines to The Environment

Preventive Measures to Reduce Risks of Medical Wastes

Proper solid waste management have to be undertaken to ensure that it does not affect the environment and not cause health hazards to the people living there. At the household-level proper segregation of waste has to be done [1].

Generation of waste should be decreased by promoting the production of goods which minimize waste generation after use; material recycling and recovery should be increased; promoting the use of plastic recycling identification codes and labels in order to make sorting and recycling of plastic packaging easier; municipalities increasing their level of service to the public regarding sorting of waste; education of producers, the public and people who work in the waste sector should be increased; promoting the use of less hazardous alternatives to hazardous chemicals during production of goods; legislation in the waste sector should be improved; and collection of hazardous waste at collection points shall be safe, secure and performed in an environmentally sound manner [1].

Only purchase what is need and can use prior to reaching the product's expiration date, refuse samples from your veterinarian if you do not expect to use them, keep track of the livestock medications you have on the farm by keeping them organized so you are not as likely to purchase more than you can use, and if you have products sitting around that are expired or no longer needed, remember to assess all options for disposal before throw it in the trash [12].

Veterinary Waste Handling, Storage, Transportation and Disposal

Medical and hazardous waste generated during veterinary practice is regulated waste due to its potential to cause harm to anyone who comes into contact with it. For this reason, it is important and that anyone handling untreated medical or hazardous waste is provided with appropriate PPE to minimize risk. Employees are also required to have training in the proper use and disposal of PPE. Other types of training are also mandated for all employees who handle or are exposed to medical or hazardous waste. These include bloodborne pathogens training, waste handling and

classification regulations training, hazardous communications and chemical safety training, and DOT hazardous materials transportation regulations training [24].

Storage of Medical Waste Products

Obviously, one of the best advisable veterinary waste disposal practices is to store the waste properly before collection and transportation [21]. Medicinal waste products should be processed immediately, into specialized waste bins, following their removal from pharmacy stock or return from patients. Waste bins should be stored securely in an area of the pharmacy designated for their storage. This storage area should be under the control of the pharmacist, inaccessible to members of the public and of sufficient capacity to allow for the safe storage of all medicinal waste products. It is recommended that a dedicated storage area is included in the premises ideally at the fit-out stage. If medicinal waste products cannot be processed immediately, they should be segregated from pharmacy stock, clearly labelled 'Medicines for Destruction' and stored under the control of the pharmacist in a specifically designated area, pending timely processing for disposal. Such waste should never be allowed to accumulate in the pharmacy. The designated storage area(s) for waste bins and medicinal waste products awaiting processing should not be in the working area of the pharmacy [19]. Depending on the amount and types of medical or hazardous waste your workplace generates and the length of time it will be stored, the availability of a refrigerator or freezer in the storage area may also be required [24].

Some steps on how to properly store veterinary medical waste before disposal: store it with the intention of minimizing health and environmental risks; put the stored medical waste in a secure location; bring and use all the necessary tools and equipment to clean and disinfect the area with the stored hazardous waste in veterinary practice. Accidental spillage, after all, can easily happen which can lead to problems; consider non-medical waste mixed with medical waste as medical waste too and store it properly, and finally, as for the sharps and other surgical instruments used place it into a container resistant to puncture, displayed with the universal biohazard label, accessible if needed, sealed tight, and safe from spilling or falling [21].

Drug Collection Options

To avoid hefty fines, it's vital that veterinary clinics find compliant and affordable veterinary medical waste disposal services [11]. The best method of disposal is "take back" programs in which drugs are returned to concerned authority, but is not commonly available in all the places, leaving people with few options [8].

Transportation of Medical Wastes

Transporting more than 50 pounds of medical waste requires a permit. However, applying for this permit is costly and requires lengthy training. For this reason, most waste producers outsource their medical waste disposal. Many infectious waste generators depend on a medical waste disposal company to pick up their waste to ensure they meet compliance obligations. However, producers of small amounts of infectious medical waste can also meet these requirements by disposing of the waste through a mail back system. You must store and transport your medical waste in containers that meet the DOT's requirements. Primarily, this involves using rigid containers that are leak-proof, tamper-proof, spill-proof, puncture-resistant and reusable. The entire process of storing and destroying waste must be transparent to the DNR. All waste must be manifested from its transportation to destruction, in a process called "cradle to grave" manifestation [11].

How To Dispose of Medicines at Home

Disposal In Trash

Throwing medicine in the trash can be dangerous since children and pets can find and accidentally consume it. Some municipal or local trash services may offer programs where pharmaceutical products can be dropped off for disposal. Expired medication is considered hazardous waste, so your local hazardous waste disposal facility may have recommendations for proper disposal. If no other options exist and the medications must be disposed of in the trash, take precautions to help ensure that the products cannot be accidentally consumed by a person or animal. Liquids can be solidified by mixing them with cat litter, sawdust or flour. Solid medications can be crushed or dissolved in liquid prior to adding them to cat litter or sawdust to make them unpalatable.

These mixtures should be placed in a disposal container that can be sealed. The container can then be placed in a garbage bag for removal with household waste [12].

Returning to a Veterinary Clinic

Local veterinary clinics may accept unwanted and expired pharmaceutical products for safe disposal, though they are not required to do so. Check with your local clinic for options. Likewise, drug companies may be willing to accept unused, expired medications [12].

Compliant Medical Waste Disposal Through the Mail

Often called a "Medical Waste Mail Back System." Through it, you can order a kit, which includes certified infectious waste collection containers. After receiving a kit, simply fill the container and ship it directly to the waste disposal company. They'll notify you by email once they receive it, and then again when they safely destroy the waste. This allows to manifest infectious waste destruction in accordance with the requirements. While the mail back system is convenient, it is not ideal for everyone. A mail back system is recommended to facilities that generate less than 2-gallon containers worth (20 pounds) of sharps and infectious waste per month. However, most small waste generators find that calling a waste disposal service could cost up to double the price of using a mail back system, depending on their amount of infectious waste and location [11]. Additionally, these facilities find it's much easier to simply stick their infectious waste in the mail as opposed to calling a service and preparing it for transportation. No matter how your veterinary clinic stores and disposes of its infectious and hazardous medical waste, it's crucial to do it competently and safely. If you produce a small amount of infectious medical waste, a medical waste mail back system may be the easiest and cheapest way stay in compliance [11].

Last, but certainly not least, one of the most important things to know about veterinary waste disposal is that your responsibility for it does not end when it leaves your facility. In fact, you are liable for any harm it causes from the moment it is generated all the way through until it is rendered harmless by treatment, destroyed or delivered to an approved disposal site. What that means for you is that it is crucial that you choose your waste services provider carefully. Make sure that the company you choose to manage your veterinary waste disposal is licensed to handle the types of waste you produce, has all necessary permits for transporting your waste, is complaint with all state and federal requirements, and provides you with a manifest at pick-up and a certificate of destruction once it has reached its final destination [24].

Steps To Be Follow While Disposing of Medicinal Wastes

A series of steps need to be taken when disposing of unwanted pharmaceuticals, and these are briefly summarized below.

Decision

Authorized officers/institutional supervising pharmacists/other responsible officers of the medical supplies division, hospitals, provincial health authorities, importers, health campaign and private sector institutions (whole sale pharmacies and drug stores) decide when action needs to be initiated, because of an accumulation of unwanted pharmaceuticals which are unfit for human consumption and for veterinary treatment [15].

Approval

Medicinal waste products should be assessed prior to their disposal, as particular disposal requirements apply to certain medicinal products (e.g., controlled drugs, cytotoxic and cytostatic medicinal products, and liquid medicinal products). Clarification on how to safely dispose of such waste should be obtained from the pharmacy's waste management company [19]. There is a myriad of regulations and requirements veterinarian clinics and all infectious and hazardous waste producers must follow to compliantly dispose of their waste [11]. A few guidelines are available for individual consumer's medicine disposal, but unfortunately it is less in practice not only in developing countries but also in developed countries and consequently left out and expired drugs are making their way into septic tanks, sewers or landfills. Septic systems represent another source of unwanted medicines to groundwater and ponds as these are also not equipped to break down pharmaceutical chemicals [19].

Planning

Planning, in terms of funding, necessary expertise, human resources, professional time, space, equipment, material and available disposal options will be required. This is essential before practical steps can be taken to start disposal. To obtain a rough estimate of the volume of materials to be sorted, it is recommended that measurements are made using a tape measure, and conversion from volume of material to weight is made using a density figure of 0.2 metric tons/M^3 [15].

Forming Work Teams

Work should be conducted by teams consisting of authorized officers and general medical workers, who are preferably pharmaceutical technicians or experienced pharmaceutical warehouse personnel. The size of each team, and the ratio of experts to workers, will be determined by the volume and composition of the stockpiles, and working conditions at the sites [15].

Health and Safety of Work Teams

All workers should wear appropriate PPE, including overalls and boots at all times, and gloves, masks and caps when appropriate. Masks should be worn when tablets or capsules are being crushed as part of the disposal technique and when there is a risk of powders being liberated. Particular care is required when handling antineoplastic [15].

Sorting

The objective of sorting is to separate the pharmaceuticals into separate categories for which different disposal methods are required. Substantial investment in human resources may be required for identifying and separating pharmaceuticals [15].

Disposal

Appropriate disposal of waste may seem straightforward at first, but differences in handling an item may contribute to factors that change its waste stream [4]. Disposal options vary considerably between situations, and the ideal solution may not be feasible [15]

Security

Controlled substances require tight security and control. In some countries, scavenging of material from landfills is a frequent problem and disposed drugs may be recovered and sold by the scavengers. Measures are therefore necessary to prevent diversion during sorting, and pilfering of drugs from landfills. Immobilization is the best method of preventing pilfering from a store or landfill. If, as a last resort, pharmaceuticals must be discarded direct to a landfill then they must be covered immediately with a large quantity of municipal waste [15].

Steps to be followed to dispose of pharmaceutical wastes is illustrated in fig 3.

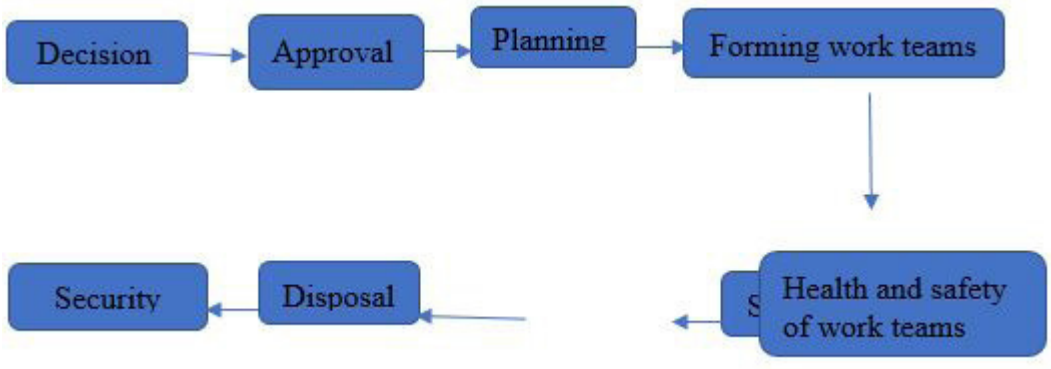

Figure 3: Summary of steps to be followed while disposing of pharmaceutical wastes

Disposal Of Medicinal Products

Medical waste has not always been as highly regulated as it is today. For many years, medical waste was often thrown into the standard waste stream. Out of sight, out of mind. Then, in the 1980's, the public began noticing medical syringes and other infectious waste washing up on several East Coast beaches. The Environmental Protection Agency took action. To protect the public and environment, the EPA developed a framework for proper medical waste disposal. This included segregating and disposing of medical waste separated from standard trash. In addition, tracking the disposal from transportation to destruction (also known as "cradle to grave" manifestation). While the policies and overseeing governmental agencies have changed since then, the goal is the same: Ensuring all medical waste, producers dispose of their waste in a compliant and safe manner [11].

Systems of Medical Waste Disposal

Though there are many dangers associated with pharmaceutical waste, it can be properly and safely treated.[6] Different types of medical waste require different disposal techniques to ensure that any infectious materials cannot contaminate or spread to other areas. Some general medical waste can be disposed of in landfill. Some requires specialist treatment such as a medical incinerator. The vast majority of medical waste must be incinerated to ensure that all traces of infections or pathogens are completely destroyed [5].

Return To Donor or Manufacturer

It can often be safer to return the pharmaceutical waste to the original manufacturer. If they are properly separated and not yet expired, these drugs even have the potential to be reused by the manufacturer with proper chemical purification. The problem arises when the pharmaceuticals are expired, because they are then classified as hazardous waste. Most pharmaceuticals that would be returned to the manufacturer or donor are expired and therefore cannot be resold without extensive chemical treatment [7].

Wherever practical the possibility of returning unusable drugs for safe disposal by the manufacturer should be explored; particularly drugs which present disposal problems, such as antineoplastics. For unwanted, unrequested donations, especially those that arrive past or unreasonably near their expiry date, it may be possible to return them to the donor or manufacturer for disposal [10, 15].

Cross-Frontier Transfer of Pharmaceutical Waste

There are currently no international conventions regulating transfer of pharmaceutical products across frontiers. However, expired or spoiled pharmaceuticals are considered as hazardous waste and as such, if transferred across frontiers, become regulated and subject to the Basel Convention on the Trans-frontier shipment of hazardous wastes. This involves prescribed procedures to obtain permission to cross international borders along the transit route prior to actual transport. These procedures can take several months to complete [25].

Landfill

The simplest method is to dispose of the waste in a landfill, though it has the potential to be very dangerous [6]. To landfill means to place waste directly into a land disposal site without prior treatment or preparation. It is the oldest and the most widely practiced method of disposing of solid waste,[15] and is the most simple and economical measure as far as natural decomposition occurs at the disposal site. Unscientific and ordinary landfilling is the common practice for solid waste disposal in many developing countries [1]. Using a landfill for pharmaceutical waste management should always be the last resort because of its likelihood to allow pharmaceuticals to enter waterways through runoff and thus impact the environment. Using landfills for medical waste is only safe when they are located far away from bodies of water, or are specially lined to contain hazardous waste. Most landfills used today are designed to contain household waste, not to prevent pharmaceutical waste from leaching out into the water supply [7].

Open Uncontrolled Nonengineered Dump

It a landfill where medicines waste is not covered with large number of municipal wastes and it is left open [10]. A nonengineered dump is probably the most common land disposal method in developing countries. Untreated waste discharged into an uncontrolled, nonengineered open dump does not protect the local environment and should not be used. Discarding of untreated waste pharmaceuticals into such

a site is not recommended except as a last resort. They should preferably be discharged after immobilization by encapsulation or inertization. As a last resort, where it is not possible to immobilize the waste pharmaceuticals, then the untreated wastes must be covered rapidly with large quantities of municipal waste to prevent scavenging. It should be noted that discarding in open, uncontrolled dumps with insufficient isolation from the aquifer or other watercourses can lead to pollution with the risk of drinking water contamination in the worst cases [25].

Engineered landfill

It has some features to protect from loss of chemicals into the aquifer. Direct deposit of pharmaceuticals is second best to discharging immobilized pharmaceutical waste into such a landfill [25,15].

Highly engineered sanitary landfill

It is an engineered landfill with landfill gas extraction, groundwater monitoring and leachate treatment facilities and monitored by trained staff. It is a process of dumping of MSW in a scientifically designed area spreading waste in thin layers, compacting to the smallest practicable volume and covering with soil on daily basis.[25] Site selection, design and management of operations of highly engineered sanitary landfill shall be in compliance with EIA and shall be properly constructed in order to protect the environment, the aquifer, other watercourses or air. Highly engineered sanitary landfill shall consist of an evacuated pit isolated from watercourses and above the water table. Its basement shall be closed and sealed with impermeable materials to prevent gas emission to the open air and water leachate to the environment [10]. The methane (rich biogas) is produced due to anaerobic decomposition of organic matters in solid waste.[1] Highly engineered sanitary landfill shall be constructed with gas extraction facility, groundwater monitoring facility and leachate treatment facility. The gas extraction facility shall be designed either to burn collected gas or convert into energy. Each day's solid waste shall be compacted and covered with soil to maintain sanitary conditions.[10]

Properly constructed and operated landfill sites offer a relatively safe disposal route for municipal solid wastes, including waste pharmaceuticals. The top priority is protection of the aquifer. An appropriate landfill consists of an evacuated pit isolated from watercourses and above the water table. Each day's solid waste is compacted and covered with soil to maintain sanitary conditions. The term "safe sanitary landfill" refers to such a site that is adequately situated, constructed and managed [15].

Waste Immobilization

Encapsulation

It is the practice of partially filling a plastic (steel) drum with pharmaceuticals and then completely filling it with concrete (other similar substances) to prevent the chemicals from leaching out into the environment.[7] It involves immobilizing the pharmaceuticals in a solid block within a plastic (steel) drum. Drums should be cleaned prior to use and should not have contained explosive (hazardous) materials previously. They are filled to 75% capacity with solid and semisolid pharmaceuticals and the remaining space is filled by pouring in a medium such as cement (cement-lime mixture), plastic foam (bituminous sand). For ease and speed of filling, the drum lids should be cut open and bent back.[15] Once the drums are filled, the mixture of lime, cement and water in the proportions 15:15:5 (by weight) is added and the drum filled to capacity. A larger quantity of water may be required sometimes to attain a satisfactory liquid consistency. Steel drum lids should then be bent back and sealed, ideally by seam or spot welding. The sealed drums should be placed at the base of a landfill and covered with fresh municipal solid waste. For ease of movement, the drums may be placed on pallets which can then be put on a pallet transporter. Encapsulation of antineoplastic drugs requires a slightly different technique.[15]

Inertization

It is a variant of encapsulation and involves removing the packaging materials, paper, cardboard and plastic, from the pharmaceuticals. Pills need to be removed from their blister packs. The pharmaceuticals are then ground and a mix of water, cement and lime added to form a homogenous paste. Worker protection in the form of protective clothing and masks is required as there may be a dust hazard. The paste is then transported in the liquid state by concrete mixer truck to a landfill and decanted into the normal urban waste. The paste then sets as a solid mass dispersed within the municipal solid waste. The process is relatively inexpensive and can be carried out with unsophisticated equipment. The main requirements are a grinder or road roller to crush the pharmaceuticals, a concrete mixer, and supplies of cement, lime and water. The approximate

ratios by weight used are as follows: pharmaceutical waste (65%), lime (15%), cement (15%) and water (5% or more to form a proper liquid consistency).[15]

Sewer

It is a flushing of medicines wastes to the sewerage system after proper dilution and regulation.[10] Some liquid pharmaceuticals (syrups and IV fluids), can be diluted with water and flushed into the sewers in small quantities over a period of time without serious public health or environmental affect. Fast flowing watercourses may likewise be used to flush small quantities of well-diluted liquid pharmaceuticals or antiseptics. The assistance of a hydrogeologist or sanitary engineer may be required in situations where sewers are in disrepair or have been damaged.[15]

Burning In Open Containers

Pharmaceuticals should not be destroyed by burning at low temperature in open containers, as toxic pollutants may be released into the air. Paper and cardboard packaging, if they are not to be recycled may be burnt. PVC plastic however must not be burnt. While burning pharmaceutical waste is not advocated as a method of disposal, it is recognized that it is not infrequently used. It is strongly recommended that only very small quantities of waste pharmaceuticals be disposed of in this way.[15]

Incineration

A less complex method for pharmaceutical waste management is incineration. It is the process of burning the pharmaceuticals at temperatures upwards of 1, 200°C. This method's major benefit is that the pharmaceutical is prevented from entering the water supply. However, incineration can be a costly disposal method. [6] It is a controlled combustion process for burning solid wastes in presence of excess air (oxygen) at high temperature of about 1000oC and above to produce gases and residue containing noncombustible material. One of the most attractive features of the incineration process is that it can be used to reduce the original volume of combustible MSW by 80-90%.[1] Globally, incineration is a fiercely debated issue, largely because of its negative impact on the environment, with incineration of medical waste being identified specifically as contributing to atmospheric pollution.[14]

Medium Temperature Incineration

In many countries there are no high temperature, two chamber incinerators designed to handle more than 1% halogenated compounds. Such incinerators meet strict emission control standards, such as those published by the European Union. However, it is likely that only medium temperature furnaces and incinerators will be available.[25]

In emergency situations the responsible authorities may consider it acceptable to treat expired solid form pharmaceuticals using a two-chamber incinerator that operates at the minimum temperature of 850 °C, with a combustion retention time of at least two seconds in the second chamber. Many older municipal solid waste incinerators are medium temperature incinerators and the use of these facilities is encouraged as an interim measure, rather than less safe options, such as inadequate discharge to a landfill. In this case, it is recommended that the pharmaceutical waste is diluted with large quantities of municipal waste (approximately 1:1000). Such incinerators are not designed to incinerate halogenated compounds safely.

The very low halogen content in most pharmaceuticals is likely to result in negligible halogen content in the combustion gases. [15]

Novel High Temperature Incineration

Industries which use high temperature technology, such as cement kilns, coal fired thermal power stations or foundries usually have furnaces that operate at temperatures well in excess of 850°C, have long combustion retention times and disperse exhaust gases via tall chimneys often to high altitudes. Many countries do not possess and cannot justify economically, expensive and sophisticated chemical waste disposal facilities. [15]

So, the use of an industrial plant provides a viable and cheap alternative. Cement kilns are particularly suited for the disposal of expired pharmaceuticals, chemical waste, used oil, tiers, etc. Several features of cement kilns make them suitable for pharmaceutical disposal. During burning the cement raw materials reach temperatures of 1450°C while the combustion gases reach temperatures up to 2000°C. The gas residence time at these high temperatures is several seconds. In these conditions

all organic waste components are effectively disintegrated. Some potentially dangerous or toxic combustion products become adsorbed into the cement clinker product or are removed in the heat exchange equipment.[15]

Chemical Decomposition

If an appropriate incinerator is not available, the option of chemical decomposition can be used in accordance with the manufacturer's recommendations, followed by landfill. This method is not recommended unless chemical expertise is readily available. Chemical inactivation is tedious and time consuming, and stocks of the chemicals used in treatment must be made available at all times. For disposal of a small quantity of antineoplastic drugs this method may be practical. However, for large quantities, for example, >50 kg of antineoplastics, chemical decomposition is not practical, as even small consignments need to be treated through repeated application of this method.[15] The various medicinal waste disposal methods are summarized in Table 1.

Disposal methods		Types of pharmaceuticals	Comments
Return to donor/ manufacturer, transfrontier transfer		All bulk waste pharmaceuticals (particularly antineoplastics)	Usually not practical, time consuming
High T° incineration with T° >1200 °C		Solids, semisolids, powders, antineoplastics, controlled substances	Expensive
Medium T° incineration with 2 chambers incinerators with minimum T° of 50°C Cement kiln incineration		In the absence of high T° incinerators, solids, semi-solids, powders, controlled substances	Antineoplastics
Engineered landfill	Waste encapsulation	Solids, semi solids, powders, liquids, antineoplastics, controlled substances	
	Inertization	Solids, semi solids, powders, antineoplastics, controlled substances	
Landfill	Highly engineered sanitary landfill	Limited quantities of untreated solids, semi solids and Powders	Disposal of waste pharmaceuticals after immobilization preferable. PVC plastics
	Engineered landfill	Waste solids, semi-solids and powders	Preferably after immobilization. PVC plastics
	Open uncontrolled non engineered Dump	As last resort untreated solids, semi solids, powders; must be covered immediately with municipal waste Immobilization of solids, semi-solids, powders are preferable	Not for untreated controlled substances
Sewer		Diluted liquids, syrups, IV fluids, small quantities of diluted disinfectants (supervised)	Antineoplastics, and undiluted disinfectants and antiseptics not recommended
Fast-flowing water course		Diluted liquids, syrups, intravenous fluids; small quantities of diluted disinfectants (supervised)	Antineoplastics, and undiluted disinfectants and antiseptics notrecommended.
Burning in open containers		As last resort, packaging, paper, cardboard	Not acceptable for PVC or pharmaceuticals.
Chemical decomposition		Not recommended unless special chemical expertise and materials available	Not practical for quantities >50kg

Table 1: Summary of medical waste disposal methods (Source[25, 7])

Categorization (Sorting) Of Medical Wastes

It is vital to understand the different types of medical waste and separate them accordingly, in order to protect healthcare workers and other patients, and to dispose of the waste safely and effectively.[5] The sorting process includes: identifying each item; If not usable, making a judgement on the optimal method of disposal and sorting accordingly; leaving packages and boxes intact until reaching their location, prior to definitive disposal or transport to an institution for use.[15]

Conditions For Sorting

Sorting should be done in the open or in a well ventilated and, if necessary, heated covered structure designated by the local authority. Sorting should be done as close as possible to the stockpile in an orderly way, with all sorted material clearly labelled and separated at all times. Staff supplied with PPE, should work under the direct supervision of a pharmacist, and should receive training on the sorting criteria, health and safety, and risks associated with handling the materials. Once sorted, the pharmaceuticals should be carefully packed into steel drums or into containers such as sturdy cardboard boxes, with the contents clearly indicated on the outside of the containers. The materials should be kept in a dry secure and preferably separate room to avoid being confused with in-date pharmaceuticals, until disposal is carried out.[15]

Sorting Categories

The top priority of the sorting process is to separate out the pharmaceuticals that are categorized as controlled substances (narcotics), antineoplastic (cytotoxic-anti-cancer) drugs and any other hazardous non-pharmaceutical products that may have been mixed among the pharmaceuticals. These must all be stored in separate, secure designated areas prior to their separate, safe disposal. The remaining unwanted pharmaceuticals must be further sorted into different categories by dosage form (capsules, powders, solutions, suppositories, syrups, tablets). The following sorting categories and subcategories are suggested.[15]

Particular precautions should be taken to separate hazardous waste, (cytotoxic or cytostatic medicinal products), and dispose of such waste in an appropriate hazardous waste bin. Sharp waste (needles or glass), should be disposed of in specialized sharps bins. Waste medicinal products should never be disposed of in regular waste and should never enter the mains water drainage system.[19]

Pharmaceuticals And Other Materials Which Can Still Be Used

A large proportion of the volume of a typical stockpile of waste drugs is not occupied by the pharmaceuticals themselves, but rather by other items, such as medical material and equipment, food, clothing, boxes, pallets, and general rubbish. The first step in dealing with these stockpiles is to remove and dispose of these non-drug, non-chemical items. All such items should be clearly separated from pharmaceuticals and chemicals.[25]

Non-Pharmaceutical Useful Materials

Various types of non-medical hazardous waste which can be generated in veterinary practice are fluorescent tubes, batteries (source of mercury), paints and thinners, batteries containing lead and cadmium, transformers which may contain PCBs, used electrical equipment such as fridges, televisions and computers, weed killer and computer ink cartridges.[20]

Useful Pharmaceuticals

Pharmaceuticals within their expiry date and considered useful should be separated out and immediately used by the institution or reallocated according to the needs and instructions of the regional health authorities. A list can be prepared giving details of the items available, quantities and expiry dates and circulated to others who can use the materials. While this separation is logical and appealing, experience indicates that it may not always be an efficient use of time and resources.[25]

Chemicals

Acids, alkalis, reagents, phenol-based chemicals used for cleaning floors, disinfectants, etc. can be put to good use. If large quantities of these items are found a list, may be prepared and offered to other potential users, such as hospitals, universities, or school laboratories.[25]

Expired Or Unwanted Pharmaceuticals

Pharmaceuticals that should never be used and should always be considered as pharmaceutical waste are: all expired pharmaceuticals, all unsealed syrups or eye drops (expired or unexpired), all cold chain damaged unexpired pharmaceuticals that should have been stored in a cold chain but were not (for example: insulin, polypeptide hormones, gamma globulins and vaccines), all bulk or loose tablets and capsules. If unexpired these should only be used when the container is still sealed, properly labelled or still within the original unbroken blister packs, all unsealed tubes of creams, ointments, etc. (expired or unexpired).[15]

No.	The basis of sorting	Pharmaceuticals	Examples
1	Active ingredient (Special disposal needed)	Controlled substances	Narcotics, psychotropic substances, anti-infective drugs, antineoplastics, cytotoxic, anticancer drugs, toxic drugs, antiseptics and disinfectants
2	Dosage form (all other pharmaceuticals)	Solids, semi solids and powders	Tablets, capsules, granules, powders for injection, mixtures, creams, lotions, gels, suppositories
		Liquids	Solutions, suspensions, syrups, etc).
		Ampoules	
		aerosol canisters	Including propellant-driven sprays and inhalers

Table 2: Expired or unwanted pharmaceuticals sorted by different criteria's

Hazardous (Potentially Hazardous) Nonpharmaceutical Materials

All nonpharmaceutical, potentially dangerous waste such as chemicals, cleaning solutions, batteries and waste oil must be dealt with on a case-by-case basis by the hazardous waste expert, and must not be handled by the pharmaceutical teams unless expressly directed to do so. This waste requires separate and careful labelling and storage until disposal.[25]

Recyclable Material

Waste paper, cloth, packing materials, clothes, gauze and wooden items, such as pallets, can be recycled, burned or disposed of as normal waste to a landfill. Plastic, metal and glass items can be reused (glassware can be given to laboratories, mechanical items given to scrap dealers), recycled or disposed of in a landfill. Depending on the type of material and its proposed reuse, appropriate treatment, such as cleaning or disinfection, may be needed. Other general rubbish can be disposed of in a landfill. If a recycling program exists for the reuse of such materials they can be separated from the pharmaceuticals prior to their disposal in the landfill.[15]

Recommended Disposal Methods by Sorting Categories

Solids, Semi-Solids and Powders

Anti-infective drugs, controlled drugs and antineoplastics

If it is not possible to return these to the manufacturer or adequate incineration is unavailable then encapsulation or inertization is recommended before discharge to a landfill. Anti-infective drugs and antineoplastics are encapsulated to delay release to the environment and avoid high concentrations. Controlled drugs should be immobilized under supervision of the pharmacist, the police or a judicial representative, depending on the local regulations.[15]

Other drugs

Small quantities of solid and semi-solid pharmaceuticals, typically not more than 1% of the total daily waste, can be disposed of directly in a landfill with large volumes of municipal solid waste, if no other suitable method is available. The figure of 1% is based on expert opinion rather than scientific evidence. It is further postulated that in emergencies and situations where the stockpile is large (many hundreds of tons), then 5-10% of the total daily municipal waste would be an acceptable daily disposal figure, where disposal of municipal waste is greater than 50 metric tons per day. In this case the landfill should be

well managed and the disposal should be for a fixed period of time. The pharmaceutical solid waste should be disposed of at the base of the working face of the landfill and covered immediately by fresh municipal waste. Security measures to prevent scavenging should be in place. Pharmaceuticals classed as readily biodegradable organic material in the solid or semi-solid form, e.g. vitamins, can also be disposed of in a landfill. Large quantities of solid and semi-solid pharmaceuticals are best destroyed by high temperature incineration as previously described. Medium temperature incineration is however widely practiced for solid form pharmaceuticals, provided that the pharmaceuticals are "diluted" in large quantities of municipal waste. Many countries however do not have access to either high or medium temperature incineration plants, and the use of the encapsulation method represents an acceptable, but not always feasible, method of disposal for large quantities of pharmaceuticals.[15]

Procedure For Pharmaceuticals Waste Disposal

Solids, Semisolids and Powders

Solids, semisolids and powders should be removed from their outer packaging but remain in their inner pack-aging and placed in clean plastic or steel drums, for treatment according to the encapsulation method. Removing outer packaging dramatically reduces the volume for disposal for methods such as encapsulation. Small quantities of pharmaceuticals still within their packaging may be discharged into a landfill as described above. They should be immediately covered with municipal waste. Outer packaging should be disposed of as nondrug, non-chemical materials by recycling or burning. The separation of materials should be as follows: tablets and capsules in plastic (foil blisters) should be removed from all outer packaging but not from blisters; tablets and capsules in bottles should be removed from outer packaging but not bottles; tablets and effervescents in tubes should be removed from outer packaging but not from tubes, and powders in sachets or bottles should be removed from outer packaging but not from sachets or bottles. Any large quantities of a single type of drug should be checked by the supervising pharmacist to ensure that the drug is not an anti-infective drug, antineoplastic or controlled substance.[15]

Liquids

Normally when disposing of liquid medicinal products, they should remain within an intact container prior to placing them in the waste disposal bin. Waste bins containing liquids should have sufficient absorbent material in the bin to absorb the bin's entire liquid content.[19]

Pharmaceuticals With No or Low Toxicity

Pharmaceuticals that can be classed as readily biodegradable organic material include liquid vitamins that may be diluted and flushed into a sewer. Harmless solutions of different concentrations of certain salts, amino acids, lipids or glucose may also be disposed of in sewers.[19]

Other Liquid Pharmaceuticals (Except Controlled Drugs, Antineoplastics or Anti-Infective Drugs)

Small quantities of other liquid pharmaceuticals, which are not controlled substances, anti-infective drugs, or antineoplastics, can be flushed into sewers. If there are no sewers or there is no functioning sewage treatment plant, liquid pharmaceuticals can be first diluted with large volumes of water and poured into large watercourses, providing they are immediately dispersed and diluted by the flowing river water. Liquid pharmaceutical waste may be disposed of using the cement encapsulation procedure. high temperature incineration or in cement kilns. It is not acceptable to discharge liquid pharmaceuticals, diluted or not, into slow moving or stagnant surface waters.[15]

Ampoules

These can be crushed on a hard-impermeable surface (concrete) or in a metal drum or bucket using a stout block of wood or a hammer. Workers doing this should wear protective equipment, such as eye protection, boots, clothing and gloves. The crushed glass should be swept up, placed in a container suitable for sharp objects, sealed and disposed of in a landfill. The liquids released from the ampoules should be diluted and disposed of as described above. Ampoules should not be burnt or incinerated as they will explode, possibly causing injury to operators and damage to the furnace or incinerator. Melted glass will also clog up the grate of a furnace or incinerator if the operating temperature is above the melting point of glass. Volatile liquids in small quantities can be allowed to evaporate in the open air.[15]

Anti-Infective Drugs

Anti-infective drugs should not be discarded in an untreated form. Generally, they are unstable and are best incinerated, and if that is not possible encapsulated or inertized. Liquid anti-infective drugs may be diluted in water, left for two weeks and disposed to the sewer.[15]

Controlled Substances

The preferred method of disposal of controlled substances is complete use of the substance such that there is none left to dispose of. Registrants should only purchase and store those quantities of controlled substances needed for current research or instructional activities. Controlled substances that are expired, surplus, or contaminated must be disposed of in accordance with applicable state and federal regulations.[16]

Controlled substances must be destroyed under supervision of an authorized officer. Such substances must not be allowed into the public domain as they may be abused. They should either be rendered unusable, by encapsulation or inertization, and then dispersed among the municipal solid waste in a landfill or incinerated.[15]

Antineoplastics

Antineoplastic drugs, previously called cytotoxics or anti-cancer drugs, have the ability to kill or stop growth of living cells. They are used in the chemotherapy of cancer which is usually performed in specialized treatment centers. It is extremely unlikely that they would form part of an aid donation in emergencies. However, if unwanted and discharged into the environment they can have very serious effects, such as interfering with reproductive processes in various life forms. Their disposal must therefore be handled with care. Antineoplastics should be segregated from other pharmaceuticals and kept separately in clearly marked containers with rigid walls. They should ideally be safely packaged and returned to the supplier for disposal. If this option is not possible, they must be destroyed in a two-chamber incinerator which operates at a high temperature of at least 1200°C in the secondary chamber, and is fitted with gas cleaning equipment. An after burner (the secondary chamber) is important for the destruction of cytotoxic waste, as it is possible that antineoplastic solutions could become aerosolized following the initial combustion in the primary chamber. As a result, without a higher temperature secondary chamber, degraded antineoplastic material may be emitted from the chimney. The secondary combustion chamber consequently ensures that such antineoplastic substances are fully incinerated. Antineoplastic drugs/waste should never be disposed of in a landfill other than after encapsulation or inertization. Work teams handling these drugs must avoid crushing cartons or removing the product from its packages. They may only be discharged in a sewerage system after chemical decomposition and must not be discharged untreated into surface water drains or natural watercourses.[15]

Special Treatment for Antineoplastics

For antineoplastics drums should be filled to 50% capacity with drugs, after which a wellstirred mixture of lime, cement and water in the proportions of 15:15:5 (by weight), should be added and the drums filled to capacity. A larger quantity of water may be required sometimes to attain a satisfactory liquid consistency. The drums should then be sealed by seam or spot welding and left to set for 7 to 28 days. This will form a firm, immobile, solid block in which the wastes are relatively securely isolated. The drums are then placed at the working face of a landfill which has been lined with an impermeable layer of clay or membrane.[15]

Methods of disposal	Return to supplier, high temperature incineration and waste encapsulation
Methods of disposal not to be used for antineoplastics	Low and medium temperature incineration, disposal to sewers and water courses, and directly to landfill

Table 3: Antineoplastic drug disposal

Disinfectants

In general disinfectants do not have an expiry date. They can be stored and gradually used over time so there is no real need to dispose of them. Large quantities of disinfectants must not be flushed into the sewer, as they may kill the bacteria in a sewage works and so stop the biological treatment of the sewage. Similarly, large quantities should not be put into water courses since the disinfectants will damage aquatic life. Small quantities of diluted disinfectant may be disposed of by discharge to a sewer providing the operation is supervised by a pharmacist and the quantities are strictly controlled to set limits. The guideline control proposed is 50 litres total per day, with the disposal spread over the whole working day. If possible, disinfectants should be used, for example for toilet cleaning in hospitals. Some disinfectants with strong bactericidal and antiviral activity, such as Lysol (50% cresylic acid), may have an expiry date. If this date has past, the material can still be used for general disinfection purposes at an appropriate dilution decided by a pharmacist, or disposed of in a chemical waste disposal facility or a cement kiln.[15]

Aerosol Canisters

Disposable aerosol canisters and inhalers should not be burnt or incinerated, as high temperatures may cause them to explode, possibly causing injury to operators and/or damage to the furnace or incinerator. Provided they do not contain poisonous substances they should be disposed of in a landfill, dispersed among municipal solid wastes.[15]

Disposal Of Medicinal Containers

Medicinal product waste bins are usually yellow with a sealable lid. Different color lids are used to identify different types of waste. Purple lids are normally used for medicinal product waste bins; this indicates that the contents are healthcare risk waste intended for incineration. Medicinal product waste containers should be UN approved and this should be marked on the waste bin. If appropriate, the bin should carry a hazard label and a further label containing specific information about the contents. The information label should, when appropriate, contain a UN number which indicates the type of waste in the container. Most medicinal product waste is not subject to ADR requirements but certain medicines may be classified as hazardous for transport, (cytotoxic and cytostatic medicinal products). These waste medicinal products and hazardous clinical waste (used needles), should be separated appropriately and disposed of in correctly labelled UN approved containers. The only waste which should be placed in these containers is the specific type of waste for which they are intended. Medicinal product waste bins should not be overfilled; they should be securely sealed when filled to the manufacturer's fill line or, if no fill line is present, when three-quarters full. When full and sealed, the bins should be removed from the pharmacy promptly by an appropriately authorized waste management company for incineration.[19]

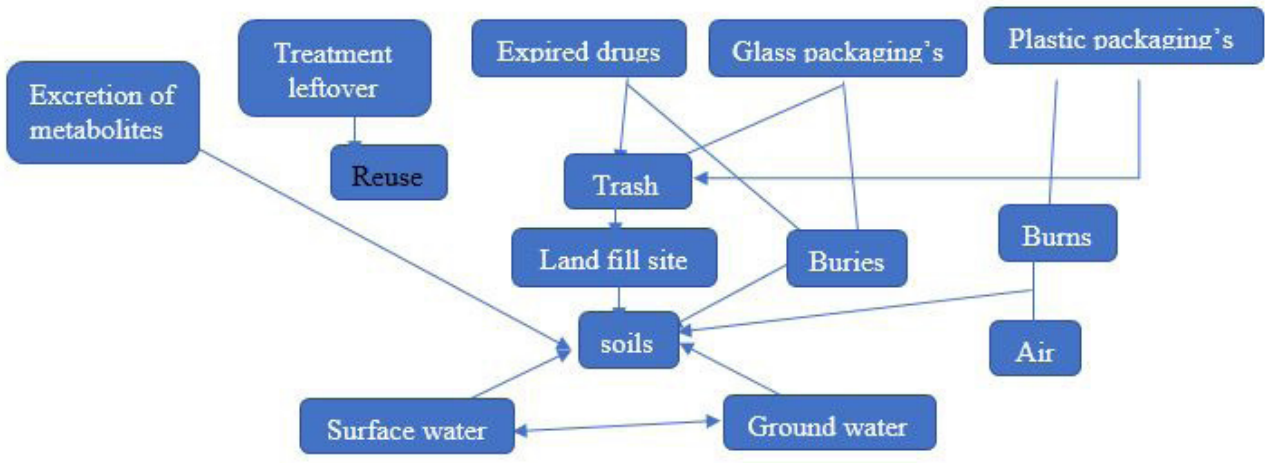

Figure 4: Illustration of veterinary drugs in rural areas

Category	Disposal methods	Comments
Solids	Landfill	No >1% of the daily municipal waste should be disposed of daily in an untreated form (non-immobilized) to a landfill
Semi-solids	Waste encapsulation	
Powders	Waste inertization Medium and high T° incineration (cement kiln incinerator)	
Liquids	Sewer	Antineoplastics not to sewer
	High T° incineration (cement kiln incinerator)	
Ampoules	Crush ampoules and flush diluted fluid to Sewer	Antineoplastics not to sewer.
Anti-infective drugs	Waste encapsulation	Liquid antibiotics may be diluted with water, left to stand for several weeks and discharged to a sewer
	Waste inertization	
	Medium and high T° incineration/cement kiln incinerator	
Antineoplastics	Return to donor or manufacturer	Not to landfill unless encapsulated.
	Waste encapsulation.	Not to sewer.
	Waste inertization	No medium T° incineratio
	Medium and high T° incineration (cement kiln incinerator) (chemical decomposition)	
Controlled drugs	Waste encapsulation	Not to landfill unless encapsulated
	Waste inertization	
	Medium and high T° incineration (cement kiln incinerator)	
Aerosol canisters	Landfill Waste encapsulation	Not to be burnt: may explode
Disinfectants	Use: To sewer or fast flowing watercourse: small quantities of diluted disinfectants; max. 50 litters per day under supervision	No undiluted disinfectants to sewers or water courses Maximum 50 littres per daydiluted to sewer or fast-flowing watercourse No disinfectants at all to slow moving or stagnant watercourses
PVC plastic, glass	Landfill	Not for burning in open containers
Paper, cardboard	Recycle, burn, landfill	

Table 4: Pharmaceutical categories and disposal methods

The Cost of Disposal of Waste Pharmaceuticals

The cost of waste pharmaceuticals disposal comprises of direct costs of supplies and materials used for collection, transport, storage, treatment, disposal, decontamination and cleaning, as well as the cost of labor and material for training and maintenance costs. These costs will vary depending on the treatment method chosen, the capacity of the treatment facility and according to the waste quantity and quality. Costs should be divided into capital and recurrent costs for all the options available. Capital costs are defined as resource items with a life time above one year, as opposed to recurrent costs that are items that are used on a regular basis and have a life time below one year. As all costs should be estimated on an annual basis, capital costs must be annualized.[26].

Quotations for disposing of the pharmaceutical waste in Croatia, Bosnia and Herzegovina in this way range from US$2.2/kg to US$4.1/kg. To incinerate the current stockpile of waste pharmaceuticals in Croatia would therefore cost between US$4.4 million and US$8.2 million. Constraints in funding for disposal of waste pharmaceuticals necessitate cost-effective management and methods. The main way to achieve this is to sort the material to minimize the need for expensive or complicated disposal methods.[25]

Consequences Of Improper Disposal or Non-Disposal

Recently, low levels of veterinary medicines have been detected worldwide in soils, surface waters, and groundwaters. Although the impacts of selected compounds, most notably anthelmintics and selected antibacterial compounds, have been extensively investigated, many other substances found in the environment are less publicly well understood. Too little is known about the effects of these compounds, their metabolites, and degradation products. As a result, researchers have raised. As a result, researchers have raised questions about the impact of veterinary medicines on organisms in the environment and on human health.[2]

In general, expired pharmaceuticals do not represent a serious threat to public health or to the environment. Improper disposal may be hazardous if it leads to contamination of water supplies or local sources used by nearby communities or wildlife. Expired drugs may come into the hands of scavengers and children if a landfill is insecure. Pilfering from a stockpile of waste drugs or during sorting may result in expired drugs being diverted to the market for resale and misuse. Most pharmaceuticals past their expiry date become less efficacious and a few may develop a different adverse drug reaction profile. There are some categories of expired drugs or defective disposal practices that carry a public health risk. The main health risks are: Contamination of drinking water must be avoided. Landfills must be sited and constructed in a way that minimizes the possibility of leachate entering an aquifer, surface water or drinking water system. Non-biodegradable antibiotics, antineoplastic and disinfectants should not be disposed of into the sewage system as they may kill bacteria necessary for the treatment of sewage. Antineoplastic should not be flushed into watercourses as they may damage aquatic life or contaminate drinking water. Similarly, large quantities of disinfectants should not be discharged into a sewerage system or watercourse but can be introduced if well diluted. Burning pharmaceuticals at low temperatures or in open containers results in release of toxic pollutants into the air. Ideally this should be avoided. Inefficient and insecure sorting and disposal may allow drugs beyond their expiry date to be diverted for resale to the general public. In the absence of suitable disposal sites and qualified personnel to supervise disposal, unwanted pharmaceuticals present no risk provided they are securely stored in dry conditions. If stored in their original packing there is a risk of diversion and to avoid this, they are best stored in drums with the pharmaceuticals immobilized.[15]

Precautions To Be Taken When Disposing of Medical Wastes

Appropriate safety precautions, which minimize the risk to the health and safety of pharmacy staff, should be taken when handling waste medicinal products. Extra precautions should be taken by staff in high-risk groups, (pregnant women or women of childbearing age), as they may be at increased risk if they come into contact with particular substances.[19]

All workers should wear appropriate protective equipment including overalls and boots at all times, and gloves, masks and caps when appropriate. Masks should be worn when tablets (capsules) are being crushed as part of the disposal technique (inertization) and when there is a risk of powders being liberated. Particular care is required when handling antineoplastics.[25]

Research is on-going to identify types and concentrations of pharmaceutical compounds in the environment and determine effects on aquatic life and human health. As studies like these continue, current efforts should remain focused on reducing improper disposal of these compounds. Keep livestock medications organized in a central location on the farm to reduce the chance of purchasing more than can be used by the expiration date. If expired and unwanted medications are currently on the farm, check with a local veterinary clinic, waste collection company for opportunities to safely dispose of these products. If other options are not available, take precautions when disposing of these products in the trash to ensure that people or animals do not consume them.[12]

Conclusion And Recommendations

Pharmaceuticals are produced and used in large volumes increasingly every year worldwide. With this growth comes concern about the fate and effects of these compounds on the environment, human and animal health. Veterinary care providers must separate certain types of wastes for special handling. Among the emerging pollutants, drug wastes pose a serious threat to human and animal health and to environmental integrity. Disposal of pharmaceutical compounds is becoming a complex environmental issue and can be a challenge for households. The safety and health of the environment is directly affected by the disposal method. There are potential risks to environment and health from improper handling of wastes. Improper medical waste disposal and management causes all types of pollution: air, soil, and water. For the general public, the main risks to health are indirect and arise from the breeding of disease vectors, primarily flies and rats. The excessive and subtherapeutic antimicrobials doses used in animal production and inappropriate waste disposal of animal healthcare services contribute to disseminate drug resistant pathogens, both in animals and in humans. In general, expired pharmaceuticals do not represent a serious threat to public and animal health or to the environment. Improper disposal may be hazardous if it leads to contamination of water supplies or local sources used by nearby communities, livestock or wildlife. Based on the above perspectives the following points are recommended:

• Proper waste management have to be undertaken to ensure that it does not affect the environment and not cause health hazards to the people, livestock and wild life living there. At the household-level proper segregation of waste has to be done.

• A series of steps need to be taken when disposing of unwanted pharmaceuticals.

• Different types of medical waste require different disposal techniques to ensure that any infectious materials cannot contaminate or spread to other areas.

• Store the waste properly before collection and transportation. Waste medicinal products should be processed immediately, into specialized waste bins, following their removal from pharmacy stock or return from patients. Store and transport medical waste in containers that meet the department of transportation's requirements.

• Appropriate safety precautions, which minimize the risk to the health and safety of pharmacy staff, should be taken when handling waste medicinal products. All workers should wear appropriate protective equipment including overalls and boots at all times, and gloves, masks and caps when appropriate.

• Keep livestock medications organized in a central location on the farm to reduce the chance of purchasing more than can be used by the expiration date. If expired and unwanted medications are currently on the farm, check with a local veterinary clinic, waste collection company for opportunities to safely dispose of these products. If other options are not available, take precautions when disposing of these products in the trash to ensure that people or animals do not consume them.

• The safety and health of the environment is directly affected by the disposal method, so it is important that we all be responsible when disposing of these products.

• There should be ongoing research to identify types and concentrations of pharmaceutical compounds in the environment and determine effects on aquatic life, human and animal health.

• There should be a continuous effort that focus on reducing improper disposal of pharmaceutical wastes.

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