VETERINARY LABORATORIES WASTE MANAGEMENT GUIDELINE

ANIMAL HEALTH INSTITUTE (AHI)

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EXECUTIVE SUMMARY

In our country Ethiopia Veterinary Laboratories are working to improve the animal health service of the country mainly focusing to increase animal production and productivity. Veterinary Laboratory service and animal health research are conducted by national and regional Veterinary Laboratories, University and research Institute Veterinary Laboratories, and clinic Veterinary laboratories. It is obvious that this Veterinary Laboratories can generate hazardous laboratory wastes. Laboratory wastes of different type and quantity can be generated in a day to day activity. Common hazardous laboratory wastes like; infectious waste, chemical waste, radioactive wastes, multi-hazardous wastes are generated and have a significant adverse effect on public health and the environment. The hazardous laboratory wastes require special management and the Laboratories that produced the waste are responsible for the proper management of the waste. In general, laboratory-generated wastes must be segregated, collected, stored, transported, treated and disposed as much as possible not to create possible danger for the Laboratory worker, the community and the environment. So far in our country there was no national guideline that assists the Veterinary Laboratory on how to properly manage the laboratory wastes. Therefore, the objective of this guideline is to provide guidance on laboratory-generated waste management to the Veterinary Laboratories. The following laboratory wastes were included in the guideline: chemical waste, infectious waste, radioactive waste, multi-hazardous waste, solid waste and non-hazardous laboratory wastes. This Veterinary Laboratories Waste Management guideline is expected to be used as supportive document by all veterinary clinical, diagnostic, research and regulatory laboratories. It is expected to standardize and improve the laboratory waste management system across Veterinary Laboratories in Ethiopia which ultimately contributes towards protecting the laboratory staff, community and the environment from the adverse effect that may possibly occur due to the laboratory wastes.

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DEFINITIONS

Anatomical Waste/ Pathological Waste: Anatomical Waste (also often referred to as pathological waste) consists of tissues, organs, body parts, blood and bodily fluids from animal fetuses and animal carcasses.

Autoclaving: Refers to the method of exposing items, including laboratory waste, using an apparatus that creates steam under pressure for effective sterilization.

Biohazard Symbol: Internationally recognized symbol for identification of materials containing biohazardous substances. This symbol is required on the side of all infectious and sharps waste containers.

Biohazard: An agent of biological origin (e.g., all infectious organisms, their toxins, allergens of biological origin, and genetic fragments) that has the capacity to cause ill-effects in humans and/or animals.

Biological Waste: Any waste containing microorganisms that are usually generated in a laboratory facility. Also included are laboratory supplies, plastic, or glassware that has been in contact with biological material that is either bio-hazardous or non bio-hazardous.

Broker: A consultant, contractor, or waste transport firm that evaluates waste material, determines the appropriate disposal method, and makes arrangements for transport and disposal.

Carcinogen: Any substance or agent capable of causing or producing cancer in mammals, including humans. A chemical is considered to be a carcinogen if it has been listed as such by the International Agency for Research on Cancer (IARC), by the National Toxicology Program (NTP) (latest edition), or if it is regulated by OSHA as a carcinogen.

Chemical Waste: Consists of discarded solid, liquid and gaseous products that contain dangerous or polluting chemicals, for example from diagnostic and experimental work and from cleaning, housekeeping and disinfecting procedures. Chemical waste from laboratories may be hazardous or non-hazardous.

Chemical: An element or a compound whether by itself, or in a mixture or a preparation, whether manufactured or obtained from nature; or a substance that is produced or used in a process (reaction) involving changes to atoms or molecules

Cleaning: Removal of contamination from an item to the extent necessary for further processing or for the intended use.

Contaminated: State of having been actually or potentially in contact with a contaminant. Examples: Pollutant, radioactivity, chemical, blood, etc.

Corrosive: Any substance that causes visible destruction of human tissue at the site of contact; examples include acids and bases or mixtures having a pH less than or equal to 2 or greater than or equal to 12.5.

Decontamination Area: Area of a laboratory facility designated for collection, retention and cleaning of soiled and/or contaminated items.

Decontamination: The process of removing pathogenic micro-organisms from objects or surfaces, thereby rendering them safe for handling.

Disinfection: A procedure that kills pathogenic microorganisms but not necessarily spores; they are used on inanimate surfaces and should not be used on skin or body tissues.

Disposal: Act of indefinitely sequestering either treated or untreated waste, such as by burial in a landfill or waste pile; indiscriminate release to the environment is also considered as disposal.

Effluent: Waste water, gas or other fluid, treated or untreated, discharged directly or indirectly into the environment.

Environment: The totality of all materials whether in their natural state or modified or changed by humans, their external spaces and the interactions which affect their quality or quantity and the welfare of human or other living beings, including but not restricted to, land, atmosphere, weather and climate, water, living things, sound, odor, taste, social factors, and aesthetics.

Explosive: The term "explosive" or "explosives" includes any chemical compound or mechanical mixture which, when subjected to heat, impact, friction, shock, detonation or other suitable initiation, undergoes a very rapid chemical change with the evolution of large volumes of highly heated gases which exert pressures in the surrounding medium. The term applies to materials that either detonate or deflagrate.

Flammable: capable of being easily ignited and of burning quickly. For solids, that may cause a fire and for liquids having a flashpoint of less than 140 through friction; show a burning rate faster than 2.2 mm (0.087 inches) per second; or any metal powders that can be ignited and react over the whole length of a sample in 10 minutes or less. Naphthalene, matches, aluminum powder, and magnesium are examples of flammable solids.

Flashpoint: The minimum temperature at which a liquid gives off sufficient vapor to ignite in the presence of a spark or flame.

Generator: A firm or institution that creates waste.

Genotoxic: Refers to a substance that is capable of interacting directly with genetic material, causing DNA damage that can be assayed. The term may refer to carcinogenic, mutagenic or teratogenic substances

- •Has a published LC50 equal to or less than 1000 ppm.
- •Has a published LD50 equal to or less than 0.5 g/kg of body weight.
- •Has an OSHA PEL or ACGIH TLV equal to or less than 10 mg/m3.
- •Has an OSHA permissible exposure limit (PEL) or ACGIH Threshold Limit Value (TLV) equal to or less than 5000 ppm.

Hazard: Intrinsic potential property or ability of any agent, equipment, material or process to cause harm.

Hazard material employee: A person who is employed by a hazard material employer and directly affects hazardous materials employed person (including a self-employed person) who loads, unloads, or handles hazardous material; tests, reconditions, repairs, modifies, marks, or otherwise represents packaging's as qualified for use in the transportation of hazardous material; prepares hazard material for transportation; is responsible for safety of transporting hazard material; or operates a vehicle used to transport hazard material.

Hazard reduction: An active or passive process, procedure, or method that reduces or eliminates the hazard of the waste; Examples include storing radioactive waste for decay, autoclaving infectious waste, and neutralizing waste mineral acids.

Hazardous material: means any substance in solid, liquid or gaseous state, or any plant, animal or microorganism that is injurious to human health or the environment.

Hazardous Waste: Waste that may, by circumstances of use, quantity, concentration or inherent physical, chemical, toxicological or infectious characteristics, have a significant adverse effect on public health and/or the environment.

Heavy metal: This refers to the 8 RCRA metals – Arsenic (As), Barium (Ba), Cadmium (Cd), Chromium (Cr), Mercury (Hg), Lead (Pb), and Selenium (Se), and Silver (Ag). If present in the waste in appreciable amounts, name the metal and its approximate concentration.

Ignitable: A substance that, under standard temperature and pressure, is capable of causing fire through friction, absorption of moisture, or other spontaneous chemical change and that, when ignited, will burn vigorously and persistently.

Infectious substance: Substances known or reasonably expected to contain a microorganism, toxin, or infectious particle that can cause disease in humans or animals.

Infectious waste: Waste containing viable micro-organisms or toxins which are known or suspected to cause disease in animals or humans because of its infectious nature.

Irritant: A chemical/material that causes a reversible inflammatory effect on living tissue, and may cause soreness, redness or discomfort.

Laboratory Waste: Waste derived specifically from a laboratory environment

Low-Level Mixed Waste: A subset of multi-hazardous wastes that contains both low-level radioactive waste (LLW) and chemicals regulated by the EPA or states as hazardous wastes.

Manifest: A shipping paper required by the regulatory authority when shipping laboratory waste that identifies the type of waste, the generator, and the transporter, as well as the destination.

Microbiological Waste: Special waste category, which includes cultures and stocks of infectious agents and other specimens generated in high volumes from diagnostic or pathology laboratories. This waste category includes culture dishes (plates) and other growth media and devices used to transfer, inoculate and mix. It is also considered infectious waste but is isolated as a special waste category due to the special handling, packaging and treatment procedures warranted.

Microorganism: Entity of microscopic size, encompassing bacteria, fungi, protozoa and viruses.

Minimum Recommended Concentration (MRC): Minimum concentration at which a liquid chemical sterilant is suitable for the decontamination procedure.

Multihazardous waste: Waste that contains any combination of hazardous chemicals, radioactive materials, or biohazardous agents.

Non-Hazardous: Designation for chemicals and compounds that do not cause direct threat to the health of humans, animals or the environment. Examples include neutralized caustics (pH between 5 and 10), collagen, cytosine, nutrients, starches, cellulase, many biologicals and media, saline, potassium thiosulfate, plasmin, calcium citrate, and many others.

Personal Protective Equipment (PPE): Specialized clothing or equipment worn by an employee for protection against a hazard.

Poison: A waste that either exhibits Toxic hazards as defined below, or is otherwise designated a Poison based on shipping labels on the constituent containers, on Safety Data Sheets, or container labels related to the contents of the waste container.

Pollutant: Any substance whether liquid, solid, or gas which directly or indirectly: (a) alters the quality of any part of the receiving environment so as to effect its beneficial use adversely; or (b) produces toxic substances, diseases, objectionable odour, radioactivity, noise, vibration, heat, or any other phenomenon that is hazardous or potentially hazardous to human health or to other living things.

Pollution: Any condition which is hazardous or potentially hazardous to human health, safety, or welfare or to living things created by altering any physical, radioactive, thermal, chemical, biological or other property of any part of the environment in contravention of any condition, limitation or restriction made under this Proclamation or under any other relevant law.

Radioactive waste: 1) Substances that are radioactive at levels above the exempt limits (more than 0.05 mCi) established by the National Regulatory Commission; NOTE: This waste is generated from the use of radioactive materials; 2) Low-level radioactive waste; defined in the Federal Low-Level Radioactive Waste Policy Act of 1980 as radioactive waste that is not classified as high-level, transuranic, spent fuel, or certain by-product material (the waste types within the domain of nuclear power plants and fuel facilities).

Reactive substance: Any material that combines violently with water, air, or other chemicals to generate heat, pressure, or toxic fumes.

Recyclables: A recyclable is any material that can be recycled. Recycling is the reprocessing of materials into new products, which generally prevents the waste of potentially useful materials, reduces the consumption of raw materials, lowers energy usage and decreases greenhouse gas emissions compared to virgin production

Recycle/Recycling: Set of processes (including biological) for converting recovered materials from the waste stream that would otherwise be disposed into useful materials and or products.

Release: Placing any pollutant in the environment in any way be it intentionally or otherwise.

Satellite accumulation: The act of collecting hazardous waste at or near its point of generation;

Segregation: Systematic separation of health care waste into designated categories.

Sensitizer: A chemical that causes a substantial proportion of exposed people or animals to develop an allergic reaction in normal tissue after repeated exposure to the chemical.

Sharp Wastes: Waste that may puncture the skin and cause disease. Examples: Needles, infusion sets, scalpels, knives, blades lancets and broken glass.

Sharp: Objects or devices used in the laboratory or workshop, that have sharp points, protruding pieces or cutting edges capable of cutting or piercing the skin. This includes (loaded or empty) syringes with needles, suture needles, glass slides and cover slips, broken glass, broken tissue-culture plastic-ware, scalpel blades, box-cutter blades, saw blades, broken bone edges, and pointy-tipped surgical instruments (e.g. small drill-bits, fine-nosed scissors and forceps). Sharps waste must be collected in a rigid, puncture-proof container.

Sodium Hypochlorite Solution: Widely used for decontaminating, laboratory equipment and spot-disinfection of countertops and floors in laboratories. Example: Berekina is the local trade name for sodium hypochlorite, which is sold widely.

Solid waste: 1) Defined by EPA as any solid, liquid, or gaseous waste; 2) In this guideline, the term "solid waste" is used to mean any waste that is not regulated nor considered hazardous.

Solvents: Identify if the waste contains materials that were used as a solvent or extraction fluid – either halogenated (methylene chloride, chloroform, trichloroethylene, dichloroethylene, Tetrachloroethylene, 1,1,1-trichloroethane, carbon tetrachloride, chlorinated fluorocarbons, etc.); or non-halogenated (Xylene, acetone, ethyl acetate, ethyl benzene, ethyl ether, methyl isobutyl ketone, n-butyl alcohol, cyclohexanone, and methanol, etc.)

Source reduction: A method of avoiding the generation of waste through reduction in the amount or hazard of the waste generated; NOTE: It is considered the preferred method of waste minimization; examples of source reduction include scaling down a process to generate less waste, changing a process to eliminate waste generation, and substituting materials to reduce or eliminate the hazard of the waste.

Source separation: Separation of wastes at the point of generation into management or disposal categories.

Special Waste: Comprised of hazardous and non-hazardous waste, which has physical or chemical characteristics, or both, that are different from anatomical / infectious sharps/ pathological, chemical, radioactive and general waste that requires special packaging and/or handling. Example: Lead, batteries, mercury, pressured containers, infectious laundry, microbiological waste, infectious food waste, amputated limbs and electronic waste.

Sterilization: A procedure that kills all microorganisms, including bacterial spores.

Toxic: A waste having the capacity to cause death, illness, or diminished function. A material that meets one or more of the following criteria should be considered toxic

Treatment: Process by which wastes are made less hazardous, nonhazardous, nontoxic, or noninfectious, or are converted to another physical form (e.g., stabilized or encapsulated).

Waste Management: Entire process of monitoring, collecting, sorting, storing and transporting for processing and reclamation of materials and energy resources and disposal of waste generated by a facility.

Waste Minimization: Application of activities such as waste reduction, re-use and recycling and behavior modification to minimize the amount of waste that requires disposal.

Waste segregation: The segregation of wastes immediately upon generation into different management categories.

Waste: A discarded material, no longer usable for its original purpose; NOTE: It may result from household or institutional activities (e.g., garbage) or from biologic activities (e.g., tissue samples).

1. INTRODUCTION

Veterinary laboratories whether they are research, diagnostic or clinical can generate wastes with various volume. Waste that may, by circumstances of use, quantity, concentration or inherent physical, chemical, toxicological or infectious characteristics, have a significant adverse effect on public health and/or the environment. Some of these wastes can be disposed of as ordinary waste. But there are wastes that require special managements like: infectious wastes, sharps, hazardous chemicals, radioactive wastes, and wastes with multiple hazards. Hence each diagnostic and research Veterinary laboratories are responsible for the proper management of the waste that they generate.

Environmental management issues associated with diagnostic or research laboratories present a unique challenge. This challenge stems from the fact that most of today's environmental management requirements are based on regulations which were designed for relatively simple processes in manufacturing (e.g. printing) and services (e.g. dry cleaning) entities. Whereas, laboratory operations in general, are very different from those manufacturing services. The uniqueness of laboratory operations means that traditional approaches to environmental management, which may work well for other operations, need careful consideration, and possibly adjustment, to address various laboratory operations.

The set-up of appropriate laboratory biological safety standards, ensuring healthy working conditions for laboratory personnel, is a priority in general. This can only be successful through understanding of the dangerous hazards and risks, the implementation of procedures, preventive measures (e.g. Laboratory waste management) concerning the premises, equipment, working processes and the overall hygiene of the laboratory.

Generally, wastes must be segregated, collected, stored, transported, treated and disposed as much as possible not to create possible danger for the Laboratory worker, the community and the environment. Furthermore to safeguard the environment, the methods of Laboratory waste handling, characterization, segregation, storage, treatment and disposal procedures shall be followed. However, the situation in most Ethiopian veterinary laboratories is quite different since they are not practicing such types of procedures to manage their waste.

Therefore, the purpose of this guideline is to fill the gaps and provide guidance to the laboratories on approaches for controlling laboratory-generated waste, specific handling techniques, treatment, disposal methods and legal requirements.

2. SCOPE

This guideline applies to all veterinary clinical, diagnostic, research and regulatory laboratories.

2.1 Role and responsibilities of actors

2.1.1. Laboratories

2.1.1.1. Institution's /Regional agricultural bureau's/ Wereda agricultural office management

Safety, compliance, and community goodwill are best achieved when Institution's /Regional agricultural bureau's/ Wereda agricultural office management demonstrate leadership in environmental stewardship. Institution's /Regional agricultural bureau's/ Wereda agricultural office management makes decision on waste disposal and avail adequate resources including budget, logistic, facilities, and authority to staff; that carries out environmental programs including waste management. The management has also the responsibility to train all actors on laboratory waste management, use of engineering controls and personal protective devices, and to ensure that all actors comply with safety directives and waste management guidelines.

2.1.1.2 General Director/Laboratory director/ *Wereda agricultural office head*

General Directors/Laboratory directors/ Wereda agricultural office head are legally responsible for proper waste management and must be familiar with the regulations and standards that apply to their particular organizations. They must design a system for preventing pollution, as well as for safe handling of unavoidable waste that provides for proper collection, segregation, storage, recycling, transport, disposal, monitoring, quality control, and record keeping by designating proper personnel for waste management.

- Facilitate trainings for lab actors and create awareness for stakeholders including Police, Medical health provider, Fire brigade and the likes.

2.1.1.3 Laboratory personnel

Laboratory personnel shall first be trained with established policies and procedures. They are responsible for identifying, segregating and labeling of all laboratory wastes as per the guideline at the point of waste generation.

2.1.1.4. Laboratory bio-risk manager/safety officer

The Laboratory ***bio-risk manager/safety officer*** shall:

- Work with the heads of departments and laboratory workers to develop and implement appropriate SOP.
- Monitor procurement, use, and disposal of chemicals used in the lab.
- Consult Laboratory's management on precautions and provision adequate resources.
- Know and implement the current international and national legal frameworks and best practice requirements concerning regulated and hazardous waste substances.
- Ensure proper use of engineering controls and personal protective devices
- Ensure effective implementation, review and update the LWM guideline on a regular basis

2.1.1.5. Ancillary staff (Sample reception, Washing and sterilization and Housekeeping staff) has a responsibility to adhere to the procedures and regulations on the waste management.

2.1.1.6. Security officers

Have the responsibility to follow up the proper disposal of wastes and adhere to different procedures applied to dispose laboratory wastes. Security officers give attention on infectious wastes disposal system.

3. OVERVIEW OF LAWS AND REGULATIONS ON WASTE MANAGEMENT

3.1. Global conventions

- The Basal convention; on the Control of Transboundary Movements of Hazardous Wastes and their Disposal

- The Stockholm convention; is a global treaty that aims to protect human health and the environment from the effects of persistent organic pollutants.

3.2. Federal policies and regulations

The concept of sustainable development and environmental rights are protected in article 44 and 92 of **the Constitution of FDRE**.

In article 44: Environmental Rights, all persons are entitled to:

- Live in a clean and healthy environment,
- Compensation, including relocation with adequate state assistance.

In article 92: Environmental objectives declared that:

- Government shall ensure that all Ethiopians live in a clean and healthy environment,
- Programs and projects design shall not damage or destroy the environment,
- Peoples have the right to full consultation and expression of views, and
- Government and citizens have the duty to protect the environment.

"Environmental protection organs establishment proclamation (proc.no.295/2002)" has stipulated the need to establish a system that enables to foster coordinated but differentiated responsibilities among environmental protection agencies at federal and regional levels. The proclamation has also required the establishment of Sectoral and Regional Environmental, Units and Agencies, respectively. This shows that institutionalizing and mainstreaming environmental concerns has a legal foundation.

Environmental policy to control hazardous materials and pollution addresses the following issues:

a. To adhere to the precautionary principle of minimizing and where possible preventing discharges of substances, biological materials or their fragments from industrial plants and personal or communal appliances or any other external sources that could be harmful, and to disallow the discharge when they are likely to be hazardous;

b. To adopt the "polluter pays" principle while endorsing the precautionary principle since pollution is likely to occur, and ensure that polluting enterprises and municipalities and Wereda councils provide their own appropriate pollution control facilities;
c. To establish clear linkages between the control of pollution and other policy areas including water resources, agriculture, human settlements, health and disaster prevention and preparedness;
d. To provide adequate regulation of agricultural (crop and livestock) chemicals and micro-organisms;
e. To ensure that pollution control is commensurate with the potency, longevity and potential to increase or reproduce of the pollutant;
f. To establish safe limits for the location of sanitary landfill sites in the vicinity of wells, bore holes and dams, and issue regulations to enforce them;
g. To review and develop guidelines for waste disposal, public and industrial hygiene and techniques to enable the cost-effective implementation of defined standards of control, and to issue regulations to enforce them;
h. To formulate and implement a country-wide strategy and guidelines on the management of wastes from the medical, agriculture and other sectors that may use potentially hazardous biological organisms, their fragments or chemicals, and to issue the necessary regulations to enforce them;
i. To establish a system for monitoring compliance with land, air and water pollution control standards and regulations, the handling and storage of hazardous and dangerous materials, mining operations, public and industrial hygiene, waste disposal, and water quality;
j. To maintain an up-to-date register of toxic, hazardous and radioactive substances, and to make the information available on request;
k. To maintain regular environmental audits to ensure the adoption of environmentally sound practices in all public and private development activities including industrial and mining operations;
l. To enforce the exhaustive labeling and detailing of the contents usage and expiry date of foods, drugs, cosmetics, other chemicals, and when any of the contents are poisonous or dangerous in any other way, the fixing of strikingly visible labels to that effect;
m. To promote waste minimization processes, including the efficient recycling of materials wherever possible;
n. To create by law an effective system of control, distribution, utilization and disposal after use or expiry of chemicals, biological organisms or fragments of organisms that could be hazardous but are required for use;
o. To prohibit from importation to and from transit through Ethiopia hazardous materials, organisms or fragments of organisms as agreed by African states in Bamako;
p. To hold as legally liable an employer who deploys employees in using or handling hazardous materials without adequately training them on how to deal with the hazard and without adequate equipment to protect each one of them for physical harm or disease that

is caused by working conditions whether the harm or disease starts in the place of work or away from it;

q. To foster better understanding of the dangerous effects of chemicals and organisms and their fragments through the provision of information in a form understandable to users, and provide or enforce the provision of information on the appropriate methods and technologies for the treatment and disposal of wastes.

4 CHEMICAL WASTE

Chemical waste is regulated as hazardous waste, as well as unregulated chemical waste that poses a risk to human and animal health as well as to the environment.

4.1 Types of laboratory chemical waste

To manage laboratory wastes properly, an institution should carefully survey its waste generation activities and identify those wastes that must be managed, handled, and disposed of separately. There are three general types of laboratory chemical waste:

- Chemical waste regulated as hazardous by United States Environmental Protection Agency (EPA) (i.e., hazardous waste);
- Controlled substances and other drugs; and
- Other chemical waste.

4.1.1 Hazardous chemical wastes

Hazardous chemical wastes are hazardous because of their chemical constituents or characteristics.

Ignitability, corrosivity, reactivity, and toxicity are four main chemical characteristics used by EPA to identify Hazardous Chemical Waste.

a. Ignitability

A substance defined as ignitable if that substance, under standard temperature and pressure, is capable of causing fire through friction, absorption of moisture, or other spontaneous chemical change and that, when ignited, will burn vigorously and persistently.

Liquid, ignitable hazardous waste has a flashpoint less than 60°C, or some other characteristic that has the potential to cause fire.

Solid, ignitable hazardous waste is capable of causing fire through friction, absorption of moisture, and spontaneous chemical changes; or when ignited, it burns vigorously and persistently.

Ignition temperature - The temperature at which there are sufficient vapors present at the surface of a liquid to be ignited (also referred to as flash point).

Lower explosive limit (LEL) - The minimum concentration of a substance needed to ignite and support combustion under normal atmospheric conditions.

Upper explosive limit (UEL) - The maximum concentration of a substance that can be ignited and support combustion under normal atmospheric conditions.

Chemicals that pose the greatest hazard have: low ignition temperature, low lower explosive limit and wide flammable range.

Fire Point is point at which a material gives off enough vapor to ignite, in the presence of a spark or flame, and continue to burn – sometimes referred to as the **Flame Point**.

Auto-Ignition Temperature: temperature at which a material will spontaneously combust, in the absence of an ignition source (spark or flame)

Flammable (Explosive) Range: The concentration of an ignitable substance that falls within the bounds of the upper and lower explosive limits.

Table 1. Flammability range of certain chemicals

	LEL	UEL
Acetone	2.5%	12.5%
Methanol	6%	36%
Kerosene	0.7%	5%
Gasoline	1.4%	7.6%
Ethylene oxide	3%	100%

Flammable gases and oxidizers also have the characteristic of ignitability, as shown in Table 2.

Table 2. Examples of Ignitable Chemical Waste

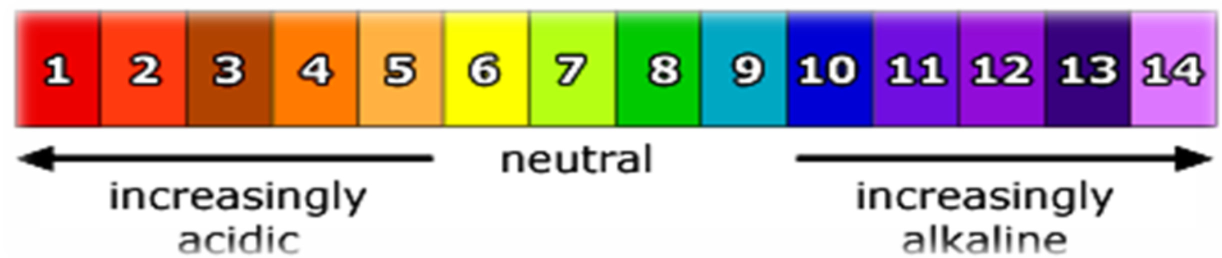
Flammable Liquids	Flammable Gases	Oxidizers
Organic solvents such as acetone, alcohols, toluene, xylene	Hydrogen, butane	Nitrate salts, peroxides

b. Corrosivity

Corrosion is the electrochemical degradation of metals or alloys, or the destruction of body tissues by exposure to concentrated acids or bases. An example of corrosion would be iron combining with oxygen to form iron II oxide (rust).

The pH (powers of Hydrogen) scale is used to measure the concentration of an acid or base. The pH reading represents the relative number of hydronium (H+) or hydroxyl (OH) ions in solution which increases by a factor of ten with each whole number change.

Diagram showing a pH scale:



Strength increases by a factor of 10 for each increment from 7.0 (neutral)

Corrosivity is classified as characteristic waste at a pH of 2.0 or less for acids, and 12.5 or greater for bases. Liquid, corrosive hazardous waste has a pH ≤ 2 or ≥ 12.5; or it has the capacity to corrode steel. Examples of corrosives acids include Sulfuric acid (Battery acid), phosphoric acid, Hydrochloric acid (or muriatic acid which is dilute HCl acid) and Nitric acid.

Examples of corrosives bases include sodium hydroxide (caustic soda), potassium hydroxide (potash), ammonium hydroxide, and Ammonia.

Practical considerations when working with corrosives are:

- Damage to tissue or containers from direct contact

- Toxic and flammable gases are often reaction products
- Fires or explosions when mixed with flammables

In order to prevent corrosion in steel drums, a liner is used or the material is stored in polyethylene or stainless steel drums.

c. Reactivity

Chemical reactions due to incompatibility are another hazard that substances may pose. Chemical incompatibility is defined as the combination of two or more reactive materials resulting in uncontrollable, undesirable conditions. Examples of chemical incompatibility include: Oxidizers and flammables, Acids and bases, and Corrosives and flammables.

Reactive hazardous waste includes chemicals that are unstable, readily undergo a violent change, react violently with water, are capable of detonation, or are explosive. Cyanide- or sulfide-containing waste is also considered reactive, as are other wastes that have the potential to generate toxic gases, vapors, or fumes (see Table 3).

Table 3. Some examples of reactive hazardous waste

Reactive	Potentially Explosive	Toxic Gas Source
Sodium, potassium, and other alkali metals	Dry picric acid; ether that contains peroxides	Cyanide or sulfide solution

d. Toxicity

Toxicity is ability of a substance to cause adverse effects in living organisms.

The term toxicity can be expanded to include: corrosivity, irritant actions, mutagenicity, carcinogenic potential, teratogenicity (including reproductive and developmental toxicity).

Risk is the degree of probability that there will be an adverse effect.

Chlorine, Ammonia, Toluene, Benzene, Methyl alcohol, Hydrogen cyanide, Lead, Mercury, Asbestos, Polychlorinated biphenyls are some of the chemical which poses the greatest risk.

EPA regulates toxic chemical waste in two ways:

First way: Leachate Toxicity (Toxic Constituent leachate Procedure; TCLP)

EPA has defined the characteristic of leachate toxicity, which is technically called "toxic constituent leachate procedure (TCLP)." If disposed of in a landfill, waste with this characteristic would create leachate (liquids that drain through or from the waste) containing toxic metals, pesticides, or certain other chemicals, thus posing a threat to ground water. As of EPA D identification numbers are used for waste exhibiting this characteristic.

Second way: Lists of Hazardous Waste

EPA identifies toxic hazardous waste is by listing specific chemicals. The P- and U-lists (referring to their identification number prefixes) name commercial chemical products and waste from the cleanup of spills from these materials. P- and U-list wastes do not include waste comprised of materials contaminated with P- and U-list chemicals, such as chemically contaminated gloves. The EPA does not regulate this type of waste, unless it possesses the characteristic of leachate toxicity.

A P-list waste is called an "acute hazardous waste." P-list wastes are important to small and conditionally exempt generators, because generation of more than 1 kg/month of a P-list waste will require the institution to comply with the most stringent generator requirements. The list of acute hazardous waste includes alkyl alcohol; arsenic pentoxide; carbon disulfide; cyanides including soluble cyanide salts; and osmium tetroxide, these wastes are hazardous and needs special precautions.

4.1.2 Controlled Substances and Other Drugs and Pharmaceuticals

Countries like U.S. have Drug Enforcement Agency (DEA) to regulate the disposal of controlled substances. Disposal options and policies may vary by region but they will contact their local DEA office for procedures to dispose of controlled substances. Specific guidelines are also available for the disposal of other drugs and pharmaceuticals. In most cases, surpluses are either returned to the manufacturer for disposal, or disposed of in a sanitary sewer system that leads to the local publicly owned treatment works.

4.1.3 Other laboratory chemical waste

Under other laboratory chemical waste list this guideline give due attention for Polychlorinated biphenyls PCBs which is mainly used in molecular diagnostic methods. It is regulated under the toxic Substances.

4.2 Accumulation and Storage

Plans for proper storage of chemical waste must consider regulatory requirements and conditions for safe accumulation.

4.2.1 Generator classifications

EPA regulates generators of hazardous waste differently according to the amount of waste generated per calendar month. Depending on the amount of waste they generate facilities fall into "large-quantity generator" category, "small-quantity generator" or "conditionally exempt small-quantity generator." However, the generation of more than1 kg/month of an acute hazardous waste can require compliance with the large-quantity generator requirements for that waste. These additional requirements may be imposed even in the case of one-time generation of 1 kg of an acute hazardous waste. It is therefore important to control the generation of this waste by disposing of acute hazardous waste regularly.

Table 4. Hazardous waste generator classifications

Criteria based on waste generation rate	
Generator(large-quantity generator)	>1,000 kg/month(or > 1 kg/month acute hazardous waste)
Small-quantity generator	< 1,000 kg/month and > 100 kg/month (and < 1 kg/month acute hazardous waste)
Conditionally exempt small-quantity generator	<100 kg/month (and < 1 kg/month acute hazardous waste)

4.2.2 Accumulation and Storage Requirements

EPA uses the term "storage facility" to mean a facility that has received a permit from EPA for long-term storage of hazardous chemical waste. Accumulation refers to the on-site accumulation of hazardous waste prior to shipment to permitted treatment, storage, or disposal facility. Large- and small-quantity generators may accumulate hazardous waste only in locations that meet EPA requirements for accumulation facilities, or at or near the point of waste generation—which is called "satellite accumulation."

In some situations, chemical collection containers in fume hoods serve as satellite accumulation sites for wastes generated by instruments. These “working containers” are small waste containers (i.e., two gallons or less), managed under the control of key staff, used at a bench or work station, and emptied into satellite accumulation at the end of every work shift.

a. Large-quantity generators

Large-quantity generators may accumulate hazardous waste away from its point of generation for up to 90 days. These “90-day accumulation facilities” must meet certain EPA requirements for contingency planning, container management, etc.

b. Small-quantity generators

Small quantity generators may accumulate no more than 6,000 kg of hazardous waste in any 180-day period. If they must transport waste further than 200 miles, the time limit is extended to 270 days. (Six thousand kg is equal to about thirty 55-gallon drums.)

c. Conditionally exempt small-quantity generators

There is no time limit for storage of hazardous waste by a conditionally exempt small-quantity generator. However, the generators in this category may store no more than 1,000 kg at any time. Accumulation in larger quantities requires compliance with small-quantity generator limits. (One thousand kg is equal to about five 55-gallon drums.)

4.2.3 Satellite accumulation for large- and small-quantity generators

Large- and small-quantity generators may accumulate up to 55 gallons of hazardous waste at its point of generation. This is called “satellite accumulation.” Laboratories can use this allowance for hard-to dispose-of wastes, and to accumulate sufficient quantities of low-volume wastes for a cost-effective shipment. The waste must be in an appropriate, closed, and labeled container at or near the point of waste generation. Secondary containment is also prudent.

4.2.4 Waste container requirements for all generators

Requirements for chemical waste containers at the point of generation as well as during handling, accumulation, and on-site storage include:

- Collecting waste in a container that is compatible with the waste type (i.e., chemically resistant plastics for solvents, glass for mineral acids);

- Using a “Hazardous Waste” label or marking, including the chemical name (e.g., “waste xylene”); and
- Making sure the container is tightly capped at all times except when adding or disposing of waste.

4.3 Special requirements for transporting hazardous chemical waste

At the time of shipment waste must be packaged, labeled, and marked. Transported hazardous waste must have an additional, special label.

Although conditionally exempt small-quantity generators are not required to use a manifest and get an ID number, some transporters insist on one as a condition of accepting waste. This is a good idea for conditionally exempt small-quantity generators, because it will help track wastes and limit liability.

Hazardous waste manifests must be accompanied by a Land Disposal Restriction (LDR or Land ban) certification. Both documents are difficult to complete properly. Completion requires an intimate knowledge of the waste, its method of generation, waste classification requirements, LDR requirements, and DOT identification and shipping paper requirements.

The two most common hazardous waste shipping containers from laboratories are the lab pack and bulk solvent drum. A lab pack is a plastic or metal drum into which smaller waste containers are placed. Absorbent material is added as filler. The lab pack is usually marked with a generic shipping name (e.g., “waste poison”) and appropriately labeled (e.g., “poison”). Plastic drums are used for lab packs that are to be incinerated.

Larger quantities of waste solvents can sometimes be combined into bulk 55-gallon steel drums at a great cost savings to the institution (compared to the cost of shipping many small containers of solvents in a lab pack). Precautions must be taken to ensure that the combined waste is compatible and accepted by the waste disposal firm. In addition, precautions must be taken to prevent harmful exposure to whoever combines the liquids; respiratory protection may be required. Check with the transporter for proper drums and labels required by DOT.

4.4 Treatment and disposal options

Perhaps the most important decision relating to hazardous waste management is the selection of treatment and/or disposal methods. These decisions should be based on a consistent strategy that takes into account regulatory requirements, future liability, occupational and environmental risk, institutional self-reliance, cost, and other values important to the institution. Some of these methods may also be considered waste minimization.

4.4.1 Redistribution of surplus chemicals

Some laboratory chemicals become unwanted when procedures change or when excess is purchased. If these surplus chemicals are in their original container and still usable, consider offering them for redistribution within the laboratory or institution. By doing so, these chemicals never become regulated as “waste” and usually result in less chemical waste.

4.4.2 Unknown wastes

A waste cannot be transported, treated, or disposed of unless its identity is known. One common problem is chemical containers with illegible, deteriorated, or missing labels. These are commonly referred to as “unknowns.” Prudent practices in the laboratory give guidelines that a chemist can follow to identify unknowns.

4.4.3 In-laboratory neutralization

Waste mineral acids can be disposed of inexpensively by neutralization. A chemist, or other technically qualified lab worker, will find most neutralization procedures to be simple, as long as certain personal safety precautions are taken.

The most common treatment is to neutralize highly acidic or alkaline solutions, leading to a desirable pH of 6 to 9. Thus, if this solution does not contain other toxic compounds it can be treated as regular trash and discarded in the sewage. Strong acids or bases must be neutralized before being released into the sewage, including those with the following cations: Al^{3+}, Ca^{2+}, Fe^{2+}, Fe^{3+}, H^+, K^+, Li^+, Mg^{2+}, Na^+, $(NH_4)^+$, Sn^{2+}, Sr^{2+}, Ti^{3+}, Ti^{4+}, Zr^{2+}; and anions: $(BO_3)^{3-}$, $(B_4O_7)^{2-}$, Br^-, $(CO_3)^{2-}$, $(HSO_3)^-$, $(OCN)^-$, $(OH)^-$, I^-, $(NO_3)^-$, $(PO_4)^{3-}$, $(SO_4)^{2-}$, $(SCN)^-$, Zn^{2+}.

4.4.4 On-Site Recycling

Solvent recycling by distillation is a useful way to recover spent solvents if the solvent can be recycled to a purity that is equal to or better than that of the purchased original, and if the volume of solvent generated makes it economically feasible. Proper segregation of the spent solvents will make the process more efficient. EPA considers recycling as a means of waste reduction to be the second preferred waste management alternative on their waste management hierarchy.

4.4.5 In-laboratory hazard reduction

Treatment or disposal of hazardous waste requires either an EPA permit or state license, both of which are beyond the resources of most laboratories. Many in-laboratory hazard reduction methods have been used by different laboratories. For example, oxidizing cleaners can be reduced for safe drain disposal. These methods are inexpensive disposal options for small amounts of certain chemical wastes. These are especially valuable for the smaller-waste generator who faces high waste pickup costs. Note that evaporation is not a legal disposal method for hazardous wastes.

The compounds listed below are readily biodegradable and can be discarded in the sink:

- Organic compounds: alkyl alcohols with less than 5 carbon atoms:
- t-myl alcohol; Alkanediols with less than 8 carbon atoms: glycerol, sugars alcoxi alkanes with less than 7 carbon atoms: n-C4H9OCH2CH2OCH2CH2OH, 2-Chloroethanol;
- Aldehydes: Aliphatic compounds with less than 5 carbon atoms;
- Amides: RCONH2 and RCONHR with less than 5 carbon atoms; RCONR2 with less than 11 carbon atoms;
- Amines: aliphatic compounds with less than 7 carbon atoms; aliphatic diamines with less than 7 carbon atoms, benzilamina, pyridine carboxylic acids: alkanoics acids with less than 6 carbon atoms; hydroxy alkanoics acids with less than 6 carbon atoms; amino alkanoic acid with less than 7 carbon atoms; class of ammonia salts, sodium and potassium salts of the acids mentioned above, with less than 21 carbon atoms; chloralkanoic acid with less than 4 carbon atoms;
- Esters: esters with less than 5 carbon atoms; isopropyl acetate. The compounds that have unpleasant odor, such as dimethylamine, 1,4-butanediamine, butyric and valeric acid,

must be neutralized and their salts should be discarded in the sink into sewage drain diluted with at least 1,000 volumes of water;

- Ketones with less than 6 carbon atoms;
- Nitriles: acetonitrile, Propionitrile;
- Sulfonic acid: sodium or potassium salts of these acids are acceptable.

4.4.5.1 Disposal via the sanitary sewer

Disposal of hazardous waste into the sanitary sewer is not allowed, except in limited situations. Following are the criteria for disposal of hazardous waste in the sanitary sewer:

- The hazardous waste must be mixed with domestic wastewater and pass through a sewer system to a publicly owned treatment works (POTW) for treatment.
- The waste type, amount, and concentration must meet the regulations and limits of the POTW that will receive the waste.

If approved by the local POTW, it may be allowable to dispose of dilute solutions of toxic metals and other hazardous chemicals in the sanitary sewer.

Some buildings, laboratories, and fume hoods have sinks that lead to mixing tanks that are designed to facilitate neutralization and dilution of waste acids prior to the wastewater's entry to the sanitary sewerage system. If mixing tanks are present, personnel should be trained in their proper use, and their efficacy should be checked periodically.

4.4.5.2 Disposal in the normal trash

Disposal of any amount of hazardous waste in the normal trash or as a solid waste is strictly forbidden. Off-site disposal of hazardous waste is only allowed at facilities that have an EPA or hazardous waste permit. Some states do allow conditionally exempt small-quantity generators to dispose of hazardous waste at other specifically approved facilities, but few facilities allow it.

4.4.6 Commercial disposal options

There are many off-site, commercial facilities that accept waste for treatment, incineration, recycling, and land filling. Recent EPA regulations have restricted and banned certain wastes from land filling, and as a result commercial disposal of these laboratory wastes today is by incineration and fuel blending. Use of recycling and other treatment technologies will likely expand in the future, and they should be investigated.

4.4.7 Commercial recyclers

Commercial recycling firms are available for recycling mercury and other wastes.

Reuse and recycle processes when possible in a new way, or treat and reuse it in the same way, or in another type of activity. Some examples of recycling are:

- Distillation of used solvents;
- In cleaning processes, the glassware can be initially washed with used solvents;
- Purchase only compressed gas cylinders from manufacturers that accept the return of empty or partially used ones;
- In pesticide studies, it is advisable to establish the practice of returning any unused material to the research sponsor;
- Avoid the contamination of fuel with solvents or heavy metals;
- Share chemical agents among the various university units;
- Control the use of metallic mercury.

Table 5. Chemical waste disposal methods summary

Category of Waste	**Description**	**Collection Container Type**	**Method of Disposal**
Dry waste with residual contaminants	Any material, but not limited to, plastic bags, empty bottles, plastic containers, paper towel, gloves, pipette tips, broken glassware, etc. contaminated with residual amounts of a chemical.	Cardboard box lined with a plastic bag.	1. Ship to Waste Management Facility. 2. Dry waste contaminated with low toxicity, corrosivity, flammability or environmental hazardous chemicals may be disposed with regular waste provided:

			• Triple rinse containers, dispose rinsate as liquid chemical waste; • Remove all chemical warning labels; • Slash plastic containers to prevent reuse; • Leave glass bottles intact, do not break; and • Dispose as regular garbage waste.
Empty pesticide containers	Any container contaminated with pesticide residue.	Original container.	Triple rinse all empty pesticide containers. Rinsate shall be collected as liquid chemical waste. Ship both types of waste to Waste Management Facility.
Equipment containing mercury waste	Any equipment containing mercury such as thermometers, barometers, blood pressure gauges, flasks of mercury, etc.	Puncture-proof, sealable container of appropriate size to contain the mercury and equipment. Do not use an oversize container as it will be disposed of as hazardous waste.	Ship to Waste Management Facility.
Gas cylinders	Any cylinder used to hold a gas or any container	Ensure gas cylinder valve is closed and protective cap is	1. Return to the manufacturer;

	used to hold a liquefied gas at or above atmospheric pressure.	secured to cylinder	2. Cylinders that cannot be returned to the manufacturer (cylinders older than ten years or not eligible for re-filling) shall be disposed of through a hazardous waste contractor. A cost is associated with the disposal of the gas cylinder.
Gel waste	Gels containing trace amounts of chemicals (i.e. ethidium bromide gel waste).	Sealable 20 litter pail lined with plastic.	Ship to Waste Management Facility.
HPLC/GC sample vials	Small vials containing solutions from analysis on gas chromatography (GC) or high performance liquid chromatography (HPLC) instruments.	Plastic lined cardboard box or 20 litter plastic pail.	Ship to Waste Management Facility.
Chemical waste	Pure chemicals (liquid, solid), mixtures of chemicals, chemicals mixed with aqueous liquids, oils, or hydraulic fluids no longer required for their intended purpose	Containers used to hold liquid chemical waste shall be leak proof, compatible with chemical waste and have a secure and sealable lid. Containers designed to store solid chemicals shall	Ship to Waste Management Facility.

	or are waste products.	not be used to hold liquid chemicals. Containers used to hold solids waste shall have secure lids and be packed in a cardboard box with sufficient cushioning to prevent breakage of containers. Maximum volume of flammable waste in a container is 5 litres and all other liquid chemical waste is 10 litres.	
PCB contaminated waste	Oils or fluids known to contain or suspected to contain polychlorinated biphenyls (PCB).	Containers shall be compatible with chemical substance and have a secure and sealable lid	Ship to Waste Management Facility.
Sharps	Sharps (e.g. scalpels, syringes, razors, needles).	Sharps container.	Ship to Waste Management Facility.
Unknowns	A chemical where the chemical composition characteristics are unknown.	Leave in original container and contact the Waste Management Facility.	Contact the Waste Management Facility for assistance. A cost may be associated with the handling and disposal of unknown chemicals.
Unstable	Chemicals that have decomposed or dried into potentially unstable compounds that may react or become	Do not handle or disturb potentially unstable	Contact the Waste Management Facility for assistance. A cost may be associated with the handling and disposal of

	explosive under certain conditions (e.g. ether or other peroxide forming compounds, picric acid).	compounds. Contact the Waste Management Facility immediately.	unstable chemicals.

4.5 Waste Minimization

Waste minimization is an essential part of any waste management planning. Table 6 describes examples of waste minimization activities.

Table 6. Examples of waste minimization activities

Method	Example
Source separation	• The use of multiple waste collection containers to keep waste types separate, so that each waste type can be optimally managed. • In offices, separate receptacles for recyclable paper.
Waste segregation	• Keeping waste types segregated during collection, storage, transport, treatment, and disposal. • Keeping needle boxes out of red bags.
Source reduction	• Purchasing of small, manageable quantities. This reduces the potential for future disposal costs of used and, more importantly, unused hazardous materials. • Use nonhazardous or less hazardous materials whenever possible. For example, there are substitutes available for xylene in the histology laboratory; formalin in histology and from surgical specimens; and mercuric chloride salts used in some fixation procedures. Use a scintillation cocktail that is not aromatic hydrocarbon-based. Each laboratory must determine if these products work satisfactorily.
Redistribution	• Identify surplus or unwanted laboratory chemicals, and relocate them to laboratories that can use them.

Recycling	• Solvents like xylene, xylene substitutes, and alcohols can be recycled and reused in the process from which they were generated. Formalin, a fixative, can also be recycled. • Many facilities have set up recycling programs for aluminum cans, paper, and other solid waste items.
Process changes	• Substitute non chromium cleaners for chromic acid. • Use miniaturized testing procedures to reduce the quantity of hazardous materials needed. • Substitute ozone-friendlier cryogenic sprays. • Use xylene substitutes in tissue processing, staining, and cover slipping.
Recovery	• Silver recovery units. • Heat recovery using waste solvents for fuel. This requires proper attachments to the facility fuel burner and may require permits in some areas. Be sure to check additional federal and state requirements.
Neutralization	• A treatment or procedure that reduces the hazard of the waste, making it easier or less expensive to dispose of. • When allowed, neutralize waste acids so that they can be disposed of in the sanitary sewer.

Conditionally exempt small-quantity generators are exempt from waste minimization requirements. However, generators are required to have a waste minimization program; therefore, small quantity generators must make a good faith effort.

In the process of waste reduction at source, the goal is to facilitate any activity that reduces or eliminates the generation of hazardous chemical waste. This activity can be implemented with good management when acquiring materials; when replacing toxic material with less harmful ones, and with good laboratory practice. Here are some suggestions that allow the reduction of waste at source.

- Implement a policy of minimizing waste in the university research and students practice laboratory, and train all those involved in these activities. The reduction at the source can be achieved through improvement of methods or processes and replacement of ineffective equipment. In educational institutions, this is not always possible, but one should consider using more modern extraction techniques, such as solid phase extraction, or supercritical fluid, to minimize waste by using smaller volumes of organic solvents;
- do not mix dangerous classes of waste with nonhazardous ones;
- Consider the possibility of using less toxic reagents, substituting for products with lower toxicity. In this context, it is possible to consider the replacement of products such as benzene, used as a solvent, with hexane or xylene; formalin or formaldehyde, used as a preservative for specimens in the laboratory, with ethanol; halogenated solvents in the extraction process with non-halogenated solvents; sodium dichromate with sodium hypochlorite, in some oxidation reactions;
- In studies using radioactive material, replace liquid scintillation-based toluene with a non-flammable solvent;
- In qualitative tests for heavy metals, replace sulfide ion with ion hydroxide.
- Replacement is not always possible because some substitutes do not always produce fully satisfactory results, or are toxic or too expensive. Thus, it is necessary to evaluate if the replacement material is suitable and delivers acceptable results.
- A common practice is to make an inventory of the compounds used in laboratories and to identify the likely replacement. The laboratory technician responsible for the use of these compounds needs to evaluate the possible replacements, using the information given by suppliers in the material safety data sheet (MSDS - Material Safety Data Sheet);
- Centralize the acquisition of chemicals, and biological and radiation materials;
- Dating all received material, thus facilitating earlier use of the oldest ones;
- Make an inventory of purchased and used chemical agents in the laboratory: maintain a file containing their location, which should be updated annually. This facilitates the reduction of the quantity stored, and avoids the purchase of unnecessary material;
- Provide employees with updated MSDS - Material Safety Data Sheet of the chemicals used in laboratories;
- Acquire any chemical, biological and radiation materials in the least possible amount. The motto of the American Chemical Society (2008), is “Less is better”, it is safe and environmentally correct to buy less material, use less and, ultimately, dispose of less,

allowing a reduction in risk of accidents, fires, or harm to human health, and at the same time reduces costs;

- Purchase the equipment needed for immediate use and avoid purchasing materials in large quantities, even it seems to be economically advantageous, since stocking can be expensive, or dangerous, and may lead to products exceeding their expiration date. A significant part of disposal done by universities is related to the purchase of unnecessary equipment;
- Label all reagents to allow their ready identification. Borrow material from other labs, or buy it in small quantities. There is a successful story about a chemicals redistribution program at the University of Wisconsin - Madison, which has existed since 1980. About 30% of excess chemical purchased for each quarter are redistributed by the university, which allows an economy of $ 10-20,000.00 on disposal of chemicals for the university. Thus, the institution donates chemicals to those who need them and at the same time, reduces the amount to be discarded, and all benefit from this type of procedure;
- Consider the possibility of testing in micro-scale, using new glassware and techniques that reduce quantities used to milligrams, which yields many benefits such as lower costs, since small-scale experiments using fewer solvents and other chemical agents are generally processed more quickly, because it is faster to heat or cool small volumes, reduces exposure to harmful agents and reduces harmful emissions. However, please note that this technique can only be implemented to achieve the analytical proposed objective;
- Consider prior separation of reagents and weighing in the laboratory, avoiding contamination of several rooms and environments;
- Avoid using reagents containing toxic metals such as lead, chromium, arsenic, mercury, barium, silver, cadmium and selenium;
- Do not use sulfochromic solutions: substitute them for less toxic solutions such as biodegradable detergents like Alconox.
- Evaluate the possibility of using hot water and detergent for cleaning glass, instead of solvents;
- Always keep the laboratory clean and in order;
- Discard some waste for disposal in the sink leading to the sewage system. Some organic and inorganic compounds may be discarded in the sewage system, in quantities of 100g and diluted 100 times. Generally, water-soluble organic compounds which have lower boiling temperature of approximately 50ºC should not be discarded in this manner. Some compounds are hydrophilic, when present at levels up to 3% and have low toxicity.

4.6 Contingency Planning

Train lab worker to properly handle waste and follow emergency procedures, as appropriate to their responsibilities. EPA requires annual training for lab workers who handle hazardous chemical wastes of large- and small-quantity generators. For first responders and spill-response teams, OSHA training standards apply. Spills are common chemical emergencies in laboratories. Spill clean-up procedures are specific to the chemical; (see additional references about spill clean-up procedures).

5 INFECTIOUS WASTES

Infectious laboratory waste is characterized principally as waste that contains microorganisms capable of causing infection in a healthy and susceptible host. Veterinary clinics, diagnostic laboratories, research institutions, and industrial facilities can generate infectious laboratory waste.

Proper management of infectious waste is important because of potential animal and human health consequences and environmental concerns. The health problem is the actual risk to animal and human health workers, waste handlers, laboratory workers, and the public posed by mismanaged infectious waste. As a health problem, infectious waste is primarily an occupational hazard for veterinary laboratory workers, waste handlers, and waste haulers. The risk of disease transmission is greatest at the point of origin, but it persists throughout the entire chain of waste handling.

The laboratory safety officer of the facility generating the waste has the responsibility for the development of a waste management program. Such a program should ensure proper containment of infectious waste and the development and implementation of appropriate methods for the efficacious decontamination of this waste. It is incumbent upon management to ensure that proper operational controls of selected treatment methods are maintained.

5.1 Types of infectious laboratory wastes

Table 7. Categories of infectious waste

Category	Examples
(1) Cultures and stocks of infectious agents and associated biologicals	• Cultures and stocks of infectious agents from clinical, research, and industrial laboratories; disposable culture dishes; and devices used to transfer, inoculate, and mix cultures • Discarded and expired, live and attenuated vaccines
(2) Pathological waste	• Specimens from medical and pathology laboratories • Wet tissues, organs, body parts, blood, and body fluids removed during surgery, autopsy, and biopsy
(3) Blood and blood products	• Waste blood, serum, plasma, and other blood

	components
(4) Contaminated sharps	• Contaminated hypodermic needles, syringes, scalpel blades, pasteur pipettes, broken glass, broken petridish used cover slips, and used glass slides
(5) Contaminated animal waste	• Contaminated animal carcasses, body parts, and bedding of animals known to have been exposed to infectious agents
(6) Isolation wastes	• Blood, excretion, exudates, and secretions from patients with highly communicable diseases

The infection control committee or safety committee of all veterinary laboratories, veterinary clinics, research institutions and industrial sectors should visit all relevant laboratories to determine the types, volumes, site of origin (generation site), and management of the infectious wastes that they generate. On the basis of this information, the committee should develop an infectious waste management policy that is in compliance with state and local regulations. This policy should specifically define categories of infectious waste that are generated in these laboratories.

5.2 Handling of infectious waste

When handling waste, waste handlers should wear appropriate PPE based on the risk assessment. Water-resistant utility gloves, rather than thin latex or vinyl gloves, are recommended for handling bagged infectious waste. Puncture resistant gloves should be used when handling containers of infectious waste that contain sharps (i.e., needles, blades, and laboratory glass).

Waste handlers should wash their hands after removing their gloves. Infectious waste should not be compacted except in compactors that are specifically designed for laboratory waste. To the extent feasible, handling and movement of infectious waste from the site of generation to the treatment equipment or the loading dock should be minimized. Special procedures must be used when handling wastes that may be contaminated with materials from biosafety level 3 and level 2 laboratories.

5.2.1 Source separation and waste segregation

Implementation of a waste management program requires segregation of the different waste types into designated categories to allow for the safest, most efficient, and most economical treatment or disposal options. Separation of waste should be performed at the point of waste discard by personnel knowledgeable in the origin and hazard potential of the waste. All infectious waste should be discarded directly into plastic bags or other containers that are clearly identifiable and distinguishable from the general waste stream.

All containers used for infectious waste, including sharps containers, must be red in color or labeled with the "Biohazard" symbol. Red containers need not be labeled, because the color red is generally recognized as designating untreated infectious waste. Waste receptacles that are easily distinguishable and appropriately marked for contaminated and for non-contaminated waste should be readily available in each area where infectious waste is generated.

Careful separation of infectious waste from the general waste stream will reduce extra handling and treatment costs. When non-contaminated material (such as wrappings and opened but unused materials) is kept out of the infectious waste stream, further savings will result.

Once separated from the general waste stream, infectious waste may be further segregated by the intended treatment method. For example, all laboratory cultures should be autoclaved in the laboratory, whereas other treatment methods may be more appropriate for other types of infectious waste.

5.2.2 Packaging and labeling

Infectious waste must be contained to protect veterinary laboratory workers, waste handlers, and the general public from exposure to the waste and from puncture/abrasion injury and disease transmission. Infectious waste should be contained from the point of discard until the material is no longer infectious and does not pose a risk of injury. Consequently, the container should be designed to maintain its integrity throughout handling, storage, movement, and shipping. In some instances, double bagging or placement of the bags in semi-rigid or rigid containers may be necessary.

Selection of packaging materials should take into account the type and volume of waste, its moisture content, handling procedures, and the treatment technique. Solid and semisolid wastes can usually be packaged in plastic bags. Liquid infectious waste should be placed in leak-proof, stoppered bottles, screw cap /flasks, or containment tanks. Packaging of sharps requires special attention. All containers including plastic bags must be securely closed or contained to prevent leakage and spills.

Polyethylene or polypropylene bags must be red or labeled to denote the infectious waste content. Plastic bags should have sufficient tensile strength to resist rupture from rough handling or overfill conditions; 165 g standard is a more reliable criterion for measuring tensile strength than bag thickness. Low-density polyethylene bags are widely used, but they are not heat-resistant and must be placed within high-density polyethylene bags for autoclaving.

The packaging should be compatible with treatment mechanisms. Specifically, the packaging materials should not thwart the decontamination process. Waste haulers, disposal agencies, or landfill operators may specify packaging requirements when infectious waste is to be shipped off-site for treatment or disposal.

All containers used to collect and transport untreated infectious waste must be labeled with the words, “Infectious Waste,” “Laboratory Waste,” or “Biohazard” (in both Amharic and English, where appropriate), as well as the universal biohazard symbol.

Consider a system to differentiate treated and untreated waste, both on-site and when treated waste is disposed of as normal trash. On containers of treated waste, markings and the biohazard symbol can be covered or defaced (using spray paint or tape), or a “treated” label can be added. Note that this may not be sufficient for some waste haulers and landfill operators who may balk at handling any waste in red bags or other red containers, even if the waste has been treated.

5.3 Storage

Infectious waste should be stored for as brief a time as possible. Storage can be temporary for hours or long-term for a few days. Length and conditions of storage (e.g., temperature) must be in accordance with state and local requirements. The storage area should be located near the treatment equipment or the loading dock (if the waste is shipped off-site for treatment). It must be properly identified with the biohazard emblem and have access restricted to authorized personnel. The area should be thoroughly cleaned each time it is emptied of waste contents. Direct connection to the sewer is recommended.

Waste should not be exposed to moisture, heat, or the weather. Storage conditions (temperature and duration) should prevent putrefaction; refrigeration may be necessary to limit microbial growth, decomposition and noxious odors and to comply with some regulatory requirements. Storage site and waste containers should prevent the storage area from providing a food source or breeding site for rodents or vermin (which could become disease vectors).

5.4 Transport of infectious waste within the facility

A variety of packaging items for containment and transport of infectious waste should be available. Infectious waste containers serve as primary barriers to protect the worker and to minimize the chance of environmental contamination. Typically, these containers shall be made from leak-resistant paper or cardboard, stainless steel, or temperature-resistant polymers. The nature and volume of the waste, the terminal treatment method and their costs are principal factors to consider in the selection of the mode of packaging.

Waste should be transported in clearly labeled, dedicated, leak-proof carts and stainless steel tray that are not used for any other purpose. These containers must be decontaminated before being used to move other wastes or supplies. Containers used for waste transport should be disinfected frequently with an appropriate disinfectant. Routes in the Veterinary laboratory facility should be designed to reduce the risk of exposure to laboratory worker, staff, and visitors. Service elevators, rather than public elevators, should be used for waste movement.

It is essential to maintain the integrity of the packaging during handling, transferring, and loading of containers of infectious waste. Mechanical devices should not be used to transfer or load infectious waste, because rupture of the packaging and spillage of waste may occur. Waste should be loaded by hand.

5.5 Treatment of Infectious Waste

Treatment of infectious waste is a process designed to reduce the level of pathogens in the waste below that which is necessary to transmit disease (decontamination), rather than their complete elimination (sterilization). Incineration and steam sterilization (autoclave) are the most frequently used methods of treatment. Other alternative treatment methods include thermal (low and high temperature), chemical, and ionizing radiation processes. Mechanical processes such as compaction, grinding, and shredding further help treatment by improving the decontamination, reducing waste volume, and/or physically changing the appearance of the waste.

Each treatment technology has different requirements for monitoring decontamination, including biological and physical indicators, frequency of testing and test methodologies. Certain treatment technologies (e.g., autoclaving) do not alter the appearance of the treated waste. This can present difficulties in disposing of the treated waste as well as in public perception. Therefore, it is usually advisable to select a treatment technology that renders the waste unrecognizable, or else to select a two-step treatment process that meets both goals: decontamination of the waste as well as its destruction.

5.5.1 Incineration

Incineration converts combustible solid waste materials into residual ash and gases, which are vented to the atmosphere. The process can inactivate biological materials, as well as reduce mass and volume (up to 95%). Incineration can be used as a treatment method for almost all types of infectious wastes such as pathologic waste and sharps, because they are rendered unrecognizable or unusable by the combustion process.

The effectiveness of the incineration process depends on incinerator design, the operating procedure, and the types and segregation of materials to be burned. Effective waste minimization programs can eliminate unnecessary incineration of laboratory waste not considered infectious. The incineration process should destroy microorganisms, maintain stack emissions in a locally acceptable range, and preserve the integrity and proper functioning of the incinerator.

5.5.2 Autoclaving

Autoclaving uses saturated steam under pressure to decontaminate infectious waste. Infectious laboratory waste, instruments, and glassware can be decontaminated in a gravity displacement or pre-vacuum autoclave. The effectiveness of autoclaving is determined by various factors, including:

- Amount of waste;
- Physical characteristics of the waste load (including size, density, and organic content);
- Use and number of autoclavable bags (self-venting bags or an acceptable alternative);
- Type of container (metal or polypropylene);
- Steam penetration throughout the entire waste load and direct contact with microorganisms;
- Exposure time; and
- Exposure temperature.

Decontaminating laboratory infectious waste by autoclaving is complex, because all the factors outlined above must be carefully considered. There is no standard method available for this type of monitoring. Laboratory autoclaves normally operate at a temperature of 250 °F (121 °C), a pressure of at least 15 psi, and a cycle time of 30 minutes verifying using chemical indicators.

With the exception of wastes containing prion agents or Transmissible spongiform encephalopathies TSE, steam sterilization is the appropriate treatment method for discarded stocks of etiologic agents and for any material that may be contaminated with organisms that should be handled with CDC Biosafety Level 3 precautions. Examples include:

Mycobacterium tuberculosis, Brucella species, Francisella tularensis, systemic fungi, rickettsial agents, and rabies virus. Types of waste that should not be autoclaved include antineoplastic agents, toxic chemicals, and radioisotopes (which will not be destroyed), as well as volatile chemicals (which could be vaporized and disseminated by the heat). Because heating certain wastes produces hazardous fumes, autoclaves and dry heat treatment devices should be vented to the outside. Autoclaving alone does not change the physical appearance of the waste and may be combined with a shredding or grinding process to render regulated medical waste unrecognizable.

5.5.3 Alternative thermal processes

Specialized equipment that combines compacting, grinding, or shredding with low-temperature heat is available. These systems operate at temperatures less than 300 °F (149 °C) and are easily adapted for onsite treatment of infectious medical waste. The order of operation typically involves waste introduction into a treatment unit or chamber, physical destruction by either pre- or post-heating, and discharge of the final unrecognizable end product into a dumpster with its shipment to a landfill for final disposal. Examples of these innovative treatment technologies include:

- High-vacuum autoclave with rotating drum and shredder;
- High-vacuum autoclave with compactor or shredder;
- Chemically enhanced continuous feed autoclave with shredder;
- Microwave heat-generating unit with shredder; and
- Microwave (electro thermal deactivation) heat generating unit with shredder.

5.5.4 Alternative chemical processes

Chemical waste treatment systems use high-level disinfectant solutions in combination with grinding or shredding to achieve decontamination. Examples of disinfectants used include chlorine dioxide and peracetic acid. The resultant liquid waste is discharged into the sanitary sewer, and unrecognizable solid waste is placed into a dumpster for final disposal in a landfill.

Reduction cremation by alkaline hydrolysis is an alternative to incineration for the treatment and disposal of infectious animal waste. The process of combining heat (230 °F to 248 °F [110 °C to 120 °C]) under pressure (15 psi) and alkali solution (sodium or potassium hydroxide) for a cycle time of 6 to 18 hours can result in complete digestion of all organic matter. The neutralized effluent can be discharged to the sanitary sewer.

5.5.5 Irradiation

Ionizing radiation from an electron beam source has been adapted for the off-site treatment of infectious laboratory waste. Electrons from the beam source interact with electrons in the molecular structure of the waste, depositing energy and breaking chemical bonds of organic compounds and inactivating the nucleic acids of microorganisms. Irradiation systems do require post-treatment shredding to render the waste unrecognizable and to reduce the waste volume. The penetration of electrons is limited so that only a thin layer of material can be treated.

5.6. Disposal

Disposal means final disposition of the waste. The term refers to disposal of the residue from treatment as well as disposal of untreated waste, some of which can be disposed of directly without treatment. The primary disposal options are the landfill and the sanitary sewer.

5.6.1 Landfill

All infectious wastes which under goes treatment shall be prepared for land filling**.** Even if decontamination has not been completely effective, most pathogens are inactivated by the temperature and acidic environments (temperature > 55 °C and pH < 5) created during degradation of waste in landfills.

5.6.2 Sanitary sewer

Disposal to the sanitary sewer is appropriate for certain types of laboratory wastes. Extreme caution must be exercised to prevent splashing and aerosolization during such disposal. Water should not be running in the sink while decanting blood or body fluids, but disposal should be followed with copious amounts of water. Special sinks and protective devices can be used to minimize splashing and aerosolization and the accompanying risk of exposure.

The use of personal protective equipment is advisable, specifically facial protection and a waterproof apron, in addition to gloves and a laboratory coat. Sinks used for biohazardous waste disposal should not be used for hand washing. Microbiological cultures should not be discarded into the sanitary sewer. These wastes should be autoclaved or incinerated before disposal.

5.7 Management of contaminated sharps

From the management aspect, sharps are of two types: contaminated and non-contaminated. Contaminated sharps are those that were used or may have come in contact with infectious agents. Non-contaminated sharps consist of items such as broken glassware and shards of hard plastic that were not in contact with infectious agents

Needles, scalpels, lancets, glass slides and cover slips, razors, and broken glassware that are contaminated with biological materials should be collected in red biohazard sharps containers. Needles and syringe units must be discarded as a unit without clipping, bending, breaking, shearing, or recapping. Sharps boxes that clip off the needle are prohibited. Sharps containers must be discarded when they are 2/3 full or at the fill-line. Sharps boxes should be rigid, leak proof, puncture-resistant containers that can be secured to prevent loss of contents. Each container must be prominently labeled with a universal biohazard sign or the word "Biohazard".

Sharps containers are autoclaved with a test indicator before disposal. Autoclaved biohazard sharps containers must be well sealed to ensure contents cannot spill out and are picked up by Safety and Risk Management. Regulated sharps containers must be placed in a red bio-waste bag and then placed in the bio-waste accumulation area until they are sent for incineration.

Pipettes and pipette tips are considered sharp and should be collected in a puncture proof lined container (such as a cardboard box). If contaminated with biological material, they should be autoclaved before disposal to the landfill. Do not enclose the cardboard boxes used for collecting sharps/glass within an autoclave bag as this will prevent steam penetration during autoclaving. Steam penetration is crucial during the decontamination process.

5.8. Contingency planning

Each laboratory should have contingency plans for handling unexpected events. These include spills, employee injuries, unavailable/inoperable sample collection equipment, and unavailable waste disposal services.

5.8.1 Worker injuries

Each laboratory should have written procedures that are to be followed in the event of worker injury or potential contamination (e.g., from needle sticks or exposure to spills). These procedures should define appropriate treatment agents, notification processes, and worker testing. The training program should include a segment on these procedures, so employees will know what they must do in case of injury. A manual that details these procedures should be readily available and accessible by employees. Procedures should concur with institutional employee health and infection control programs.

5.8.2 Inadequate treatment and disposal methods of infectious waste

In the event of disruption of the usual procedures for managing infectious waste, there must be a contingency plan for each laboratory that specifies back-up arrangements. For example, treatment equipment may not be usable because of equipment failure or downtime for maintenance, and disposal services may be disrupted by strikes or contract disputes. These contingency arrangements may include: duplicate equipment (e.g., autoclaves); prolonged storage of infectious waste; agreements with nearby medical facilities or other entities that have treatment and/or disposal capabilities; and back-up contracts with outside waste haulers, landfills, and incinerator facilities.

Independent laboratories must establish their own contingency plans for infectious waste management. These arrangements are usually made at the institutional level if the laboratory is part of a larger facility.

5.8.3 Emergency coordinator

Designate an emergency coordinator responsible for coordinating all emergency response measures. This person must be either on the premises or on call. The emergency coordinator or a designate has the following responsibilities:

- To plan for emergencies by establishing emergency procedures, making arrangements with local emergency responders, and informing laboratory personnel of the above actions; and
- In the event of a fire, explosion, or other release that could threaten human health outside the facility, or when the generator has knowledge that a spill has reached surface water, to notify the National Response Center (using their 24-hour). The report must include the name, address, and EPA ID number of the institution; the date, time, and type of incident; the quantity and type of hazardous waste involved in the incident; the extent of injuries, if any; and the estimated quantity and disposition of recovered material, if any. To demonstrate compliance, the emergency coordinator should document this notification.

5.8.4 Post information next to the telephone

The following information should be posted next to each telephone within any facility that generates hazardous waste:

- Name and phone number of the emergency coordinator; and
- The telephone number of the fire department.

The location of fire extinguisher, spill control equipment, and the fire alarm should also be posted. Large-quantity generators of hazardous chemical waste need to comply with more stringent contingency planning requirements.

5.8.5 Compliance planning

The waste management program should be integrated with the institution’s hazard communication plan, chemical hygiene plan, infection control plan, disaster plan, existing safety policies and procedures, risk management and loss control plan, and any other related or overlapping programs. It should include a plan for monitoring, reducing, and recycling waste in addition to waste treatment and disposal. Someone who is thoroughly familiar with applicable laws and the institution should design the waste management and its associated plans. Managers, facility engineers, and technical and professional staff should also consult.

5.8.6 Review and approval

Once the waste management program has been written, representatives from all of the affected departments should review it. A representative from top management should also review it. After changes and adjustments are made, it should be formally approved.

6. RADIOACTIVE WASTES

Radioactive waste is waste generated from the use of radioactive materials or any discarded material that is known to be contaminated with radioactive material. Radioactive material which is exposed to neutron radiation might consists of environmental samples containing radiological contamination, contaminated protective clothing, cleaning cloths, mops, filters, equipment, and tools. In the diagnostic veterinary laboratories of Ethiopia; except some which use molecular diagnostic techniques and NICETT which uses the gamma cell radiator for radiating tsetse flies and their blood meal; generation of radioactive waste is uncommon. Because of its complexity, highly regulated activity and its disposal is also considered as challenging activity. Such challenges encouraged laboratories on finding alternatives to radioactive materials and development of waste minimization methods to reduce dependence on off-site disposal facilities.

This section will provide an overview of radioactive waste minimization and management practices for laboratories. Radioactive wastes that also contain hazardous chemicals or bio-hazardous agents will be covered under Multi-hazardous Wastes.

6.1 Characterization of radioactive wastes from laboratories

6.1.1 Sources and types

Based on radioactive waste generation sources; radioactive wastes are characterized in to three: 1) wastes generated by laboratory procedures employing the use of radioactive materials; 2) procedures performed on specimens from Animals that received radiation diagnosis; and 3) other veterinary research activities. Examples of common types of radioactive wastes generated by clinical laboratories include: aqueous waste and other water-soluble liquids; mixed insoluble liquids; liquid scintillation counting vials; contaminated solids such as glass, plastic, paper, and sharps; blood, urine, other body fluids, and excreta; solid tissues; animal carcasses; cell culture dishes; gases; and source vials and other devices used to contain or shield radio nuclides. Most generators of infectious and chemical waste generate only low-level radioactive waste.

6.1.2 Radio-nuclides Content

The radionuclides typically present in veterinary laboratory wastes are limited in number, and vary by type and activity concentration with the function of the laboratory. Diagnostic laboratories primarily use radioactive materials in assay procedures. These procedures involve low activity concentrations and generate wastes with correspondingly low activities. The radionuclides commonly used in diagnostic reagents are of intermediate to long half-life to allow for shipping, storage, and use and include tritium (3H), 125I, and 32P.

Research laboratories use the widest variety of radionuclides, including most of those found in diagnostic applications and additional radionuclides, especially 14C, 33P, and 35S. Small quantities of waste containing uranium compounds may also be generated from staining procedures used in electron microscopy. The wastes from research laboratories tend to be high-volume, low-activity, and may include animal tissues, carcasses, and other waste types that are not routinely generated by diagnostic laboratories.

6.1.3 Other constituents of concern

Radioactive wastes from veterinary laboratories often contain other chemical and biohazardous constituents that affect how the wastes must be managed. Biohazardous agents, body fluids, and other materials subject to regulation as laboratory waste are frequently present, particularly in wastes from radio assay procedures performed with specimens of body fluids. Organic solvents and other hazardous chemicals used in reagents or as preservatives may be present in radioactive wastes and require them to be managed as mixed waste, or preclude disposal options such as atmospheric release or discharge to the sanitary sewer.

6.2 Regulatory Framework

6.2.1 Regulations

Regulations governing the use of radioactive materials depend on the origin of the materials. Source, special nuclear, and byproduct radioactive materials are regulated and supervised by the Ethiopian Radiation Protection Authority (ERPA). Any waste that contains or is contaminated with any of radioactive materials is subject to ERPA regulation. Regulations governing the use and disposal of radioactive materials are found in Radiation and Nuclear Protection Proclamation (Proclamation No. 1025/2017) of Federal Negarit Gazette of the Federal Democratic Republic of Ethiopia, which was issued by House of people's representative.

Virtually all of the radioactive wastes generated by laboratories are low-level waste (LLW). LLW is classified into three classes: class A, B, or C depending on the concentration of short- and long-lived radio-nuclides present in the waste. Most LLW generated by veterinary laboratories is class A.

6.2.2 Licensing

Most uses of radioactive materials in diagnosis, therapy, and research require the user to obtain a radioactive materials license from RPA. Licensees must assure complete internal control of the receipt, storage, use, transfer, and ultimate disposal of all radioactive materials. License conditions list the radio-nuclides, activities, and amounts that may be possessed, allowed uses, and may include specific waste management and disposal requirements.

6.3 Institutional management

6.3.1 Administration

A qualified person needs to be assigned to take responsibilities for the administration of the radioactive waste program. In small laboratories for the administration of the radioactive can be handled as a collateral duty of the laboratory technologist but institutions with larger radioactive materials use need to have radiation safety departments and should have employ health physicists.

6.3.2 Waste management plan

The laboratory should develop a plan covering all aspects of radioactive waste minimization and management. All personnel that generate wastes and those responsible for disposal should be involved in development of the plan. Typical plan elements include:

- Statement of management support and policy

- Designation of a person with overall responsibility for waste management operations
- Source reduction and waste minimization guidance
- Institutional waste identification, segregation, packaging, and storage procedures
- Regulatory compliance requirements
- Provisions for waste accounting, tracking, and recordkeeping
- A training program and
- Procedures for periodic audits and review, user feedback, and updating of the plan.

Waste profiles and Standard Operating Procedures: Many laboratories find it useful to establish profiles for each specific waste stream that the laboratory generates. Particularly for wastes generated by recurring procedures, the use of profiles can significantly simplify waste management and reduce or eliminate redundant characterization steps and confirmatory radio assays of the waste. Each profile should identify the procedure generating the waste; its physical form; radio-nuclides and activity ranges present; chemical and bio-hazardous constituents; shipping names and requirements; and disposal procedures. The specific methods for radioactive waste disposal should be requested in the license application and amendments, and approved by regulators before implementation.

Contingency planning: The procedure manual should specify the specific actions to be followed in the event of an accidental spill. Considerations include the amount of radioactivity estimated to have occurred and the radio toxicity of the nuclide. Two levels of response may be appropriate.

a. Response to minor radio waste spills: If a minor spill of nuclides with lower to moderate radio toxicity occurs, the following actions should be taken:

(i) Notify persons in the area that a spill has occurred.

(ii) Prevent the spread. Cover the spill with absorbent paper.

(iii) Clean up. Use disposable gloves and remote handling tongs. Carefully fold the absorbent paper and pad. Insert into a plastic bag and dispose of it in the radioactive waste container. Also insert into the plastic bag all other contaminated materials, such as disposable gloves.

(iv) Survey. With the appropriate survey meter, check the area around the spill; also check hands and clothing for contamination.

(v) Report. Report the incident to the Radiation Safety Office.

b. Response to major radio waste spills: If a major spill of a nuclide with high radio-toxicity occurs, the following actions should be taken:

(i) Clear the area. Notify all persons not involved in the spill to vacate the room.

(ii) Prevent the spread. Cover the spill with absorbent paper, but do not attempt to clean it up.

(iii) Ask all potentially contaminated personnel to assemble near the room entrance.

(iv) Close the room. Leave the room and watch the door(s) to prevent entry.

(v) Call for help. Notify the Radiation Safety Office immediately.

Record keeping: Regulations require documentation of the disposition of radioactive waste. Radioactive waste records should be maintained, recording the name, activity, description of the disposed waste, and method of disposal. Maintain these records even if the radioactive material is disposed of via a radioactive waste broker.

6.4 Waste avoidance (source reduction) strategies

Radioactive waste disposal is costly and laboratories need to implement strategies which can reduce the source and sometimes eliminating generation of radioactive wastes too. These include:

• Use of alternatives for radioactive methods. Methods employing chemiluminescent dyes, stable isotopes, and other nonradioactive materials have been developed for many procedures that previously required the use of radioactive materials.

• Substitution with short-lived radio-nuclides. Replacement of long-lived radio-nuclides with short-lived allows wastes to be decayed in storage and disposed of as nonradioactive waste.

• Avoid over ordering radio-nuclides, and use the minimum activity that can produce the required results.

• Restricting areas where radioactive materials are used. Limiting the areas where radioactive materials are used reduces the potential for contamination and generation of secondary wastes resulting from contamination.

6.5 Management of unavoidable wastes

6.5.1 On-site accumulation and storage

Careful selection, implementation, and supervision of on-site waste management methods will minimize potential radiation safety hazards and can greatly reduce (and sometimes eliminate) the need for off-site disposal.

Segregation: Proper segregation of wastes reduces unnecessary generation of wastes and maximizes the efficiency of disposal operations. General segregation guidance is presented in Table below.

Table 8: General radioactive waste segregation groups

Keep these radioactive waste types	**Separate from these**
Radioactive wastes	All other types of wastes
Wastes with known contamination	Wastes with unconfirmed contamination
Liquids	Solids
Aqueous liquids	Non-aqueous liquids
Wastes with only short-lived radio nuclides	Wastes containing long-lived radio nuclides
Wastes disposable on-site	Wastes that must be shipped off-site
Deregulated liquid scintillation vials	Regulated liquid scintillation vials
Radioactive sharps	Nonradioactive sharps
Deregulated animal carcasses	Regulated animal carcasses

Radio nuclides should be separated by half-life whenever possible. This allows for greater use of the decay-in-storage method of waste disposal and aids in reducing the amount of storage space needed and the amount of radioactive waste that requires disposal.

Collection containers and labeling: a) Waste collection containers; containers for radioactive waste should be specified and provided by the institution's radiation safety department and sized appropriately for the activities in the laboratory. All containers should be kept closed except when adding wastes. Wastes should be transferred to the treatment site, off-site storage area, and/or disposal site as often as practical to minimize potential exposures to laboratory personnel.

• Solid Wastes: A container that is clearly labeled and separate from general waste should be used for collection of dry, solid waste such as contaminated paper, gloves, etc. In most cases, cardboard containers or step cans with appropriate plastic bag liners are satisfactory for routine collection of contaminated solid wastes.

- Sharps: Radioactive sharps should be collected separately from nonradioactive sharps and placed in appropriately labeled, puncture-resistant sharps containers.
- Liquid Wastes: A capped, plastic container should be used for liquid waste.

b. Container labels; labels should be placed on all containers and should list:

- Identification of the laboratory and authorized user of radioactive materials;
- Date of accumulation;
- Radionuclides present and the estimated activity of each; and
- Source and type of waste.

c. Shielding; to determine the necessity of shielding waste containers, as well as the correct shielding; waste collection, handling, and storage areas should be evaluated by the radiation safety officer. Unnecessary use of shielding should be avoided, because it tends to become contaminated and adds to the volume of radioactive waste. For storage of wastes containing ^{32}P, a beta emitter of 1/2-inch poly (methyl methacrylate), should be used shielding not lead. If the waste contains gamma emitters lead may be used. If the waste contains both gamma emitters and ^{32}P, lead is placed around the outside of the poly (methyl methacrylate) shield. Contaminated lead is particularly problematic, as it is considered a mixed waste and must be decontaminated before disposal. Mixed radioactive waste is extremely costly, and treatment costs may be charged back to the generator.

d. Containment; collection and storage containers should be inspected regularly for leaks, proper closures, and signs of deterioration. Containers holding liquid wastes should be stored on trays or other devices providing secondary containment in the event of leakage or spills. Absorbent liners should be placed under containers to protect the surfaces in the holding area from contamination.

e. Security: radioactive waste must be secured from unauthorized access or removal. Warning signs indicating the presence of radioactive materials should be placed in all areas where radioactive wastes are collected, processed, and stored. Personnel with access to waste handling and storage areas should be trained in procedures and work duties.

6. 6 General treatment and disposal methods

Radioactive waste may be treated and disposed of by several methods, including decay-in-storage; release into the sanitary sewer system; dispersal into the atmosphere; or transfer to a waste disposal firm for offsite processing, incineration, or burial.

The treatment process and method of disposal chosen for each type of waste is dependent on several factors, including the following:

- The waste type (aqueous, gaseous, solid, organic, or animal carcass);
- The radioisotope and its half-life;
- Combustibility;
- State regulations;
- Institutional license conditions; and
- Availability of treatment and disposal facilities.

6.6.1 On-site waste management

Decay-in-Storage: Decay-in-storage (DIS) is the preferred method of radioactive waste management for all radioactive materials in any form with a half-life of 120 days or less when the licensee has sufficient space to store the volume generated. Wastes are usually held for a period of ten half-lives and then re-assayed for radioactivity. If the activity level is at or below background, or meets specific license requirements, it may then be disposed of as nonradioactive waste.

Volume Reduction: It is advantageous to use compactors to reduce the volume of the wastes on-site before shipment since off-site storage and disposal facilities may charge by units of volume.

Incineration: Incineration is the preferred method for treatment and disposal of solid LLW, radioactive, animal carcasses, or other wastes that cannot be disposed of by decaying in storage or by dilution into the sewer system. Incineration of radioactive material needs permission from the responsible authorities. Incineration of radioactive material is preferred for wastes containing ^{3}H and ^{14}CLW. Caution in incineration of radioactive material:

- No hazardous waste may be incinerated, unless such incineration is specifically authorized by the ERPA.
- Radio nuclides may not be incinerated without the prior approval of the Radiation Safety Department.
- The containers of LLW to be incinerated must measure less than 2.0 millirems/hour (mrem/hr.) at the surface, because the incinerator operator is limited to the regulatory requirements for exposure of persons in unrestricted areas. The radioactivity of the ash

must be monitored. If the limits in ERPA regulations are exceeded, the ash must be sent off for final disposal.

• The emissions from the LLW incineration process must be shown by calculation or by monitoring to be less than the maximum permissible concentrations for an unrestricted area for the radio nuclides in question.

Discharge to the atmosphere: Release into the atmosphere can be used for disbursable gases, radioactive carbon dioxide, or radioactive ^{133}xenon. The radioactive gas is delivered to a hood or a dedicated ventilation system that both dilutes it and exhausts it into the atmosphere. This method, in general, requires approval by the ERPA. The following conditions must necessarily be met during incineration:

- The exposure to persons performing the disposal cannot exceed 2 mrem in any hour, which is the limit for exposure to persons in an unrestricted area.
- The instantaneous concentration of the effluent cannot exceed the specified concentrations for an unrestricted area.

•Charcoal canisters may also be used to trap the gas for decay and delayed release

Discharge to the sanitary sewer: Most aqueous liquid radioactive wastes generated by clinical laboratories may be discharged to the sewer if the facility is served by a publicly owned treatment works. These wastes should not be discharged at facilities served by septic systems. Generally, aqueous liquid radioactive waste may be disposed of via the sanitary sewer system, if the following conditions are met:

• Each approved user of radio nuclides must use no more than one "hot" sink for disposing of the liquid waste.

• The quantity that can be released to the sewer in any one day cannot exceed the larger of the following:

- ✓ That quantity, if diluted by the average volume of sewerage effluent that will result in a concentration equal to that specified in ERPA.
- ✓ Ten times the quantity specified in ERPA.

• The average monthly concentration of radioactive material cannot exceed the limit specified in ERPA.

• The total amount of radioactive material released into the sewer system by the laboratory (except for ^{14}C and ^{3}H) cannot exceed one curie per year. For 3H, a maximum of 5 Ci (185 GBq) a year is allowed, while for 14C a maximum of 1 Ci (37 GBq) a year is allowed.

- Liquid waste must be readily soluble or dispersible in water. Any radioactive solids in the waste must be in dispersible form (biodegradable solids).

- Each sink used for radioactive liquid waste disposal should be identified and display the appropriate radiation warning sign.

Other guidance on disposal of wastes to the sanitary sewer:

- Do not exceed the daily limits of radioactive material release posted on each sink by the ERPA.

- Follow all releases of radioactive waste with copious amounts of water.

- Wastes containing oils, solvents that are in ignitable concentrations or not miscible with water, and other materials regulated as hazardous waste or restricted by the ERPA should not be discharged.

- Do not dispose of radioactive material via the sewer system that can be conveniently decayed in storage.

- Excreta from persons undergoing medical diagnosis or therapy with radioactive material are exempt from any of these limitations.

6.6.2 Off-site Waste Management

Off-site disposal is usually arranged through a radioactive waste broker and is usually considerably more expensive than on-site disposal methods. However, commercial, off-site facilities may offer a variety of options that may not be available on-site, including decay-in-storage; long-term storage; super compaction; incineration; nitrification; and burial. Any radioactive waste transported off-site for storage or disposal must be packaged in accordance with directives given by RPA of Ethiopia (Proclamation No. 1025/2017 (29-2b). After delivery of waste, the vehicle used must be surveyed for contamination.

7 MULTI-HAZARDOUS WASTES (MHW)

7.1 Introduction

Multihazardous wastes contain any combination of hazardous chemicals, radioactive materials, or biohazardous agents. These wastes are often the most problematic and costly of all of the types of wastes generated by laboratories. Multihazardous waste also requires special management considerations because the treatment method for one of the hazards may be inappropriate for the treatment of another.

Some examples of Multihazardous laboratory wastes include:

- Aqueous radioactive wastes containing chloroform or heavy metals
- Methanol/acetic acid solutions from electrophoresis procedures containing radioactive material Hazardous liquid scintillation counting fluids with radioactive content
- Radioactive trichloroacetic acid solutions
- Phenol/chloroform mixtures used to extract DNA from radio labeled cells
- Vacuum pump oil contaminated with radioactive material
- Chemical or radioactive wastes containing infectious agents
- Used animal bedding contaminated with at least two of the above listed hazard types (chemical, radioactive and infectious)
- Lead contaminated with radioactive material
- Aqueous radioactive liquids with pH = <2 or >12.5

7.2 Management Problems Associated with MHW

Some of the reasons that MHW is often highly problematic for laboratories to manage:

- Laboratories tend to classify wastes by their primary hazard and may fail to recognize the presence of subsidiary hazards.

- The analysis required to characterize the waste is difficult and costly. Most hazardous waste analysis laboratories will not accept MHW.

- Most MHW tends to be generated infrequently and in small volumes.

- Multidisciplinary expertise and oversight is required to assure appropriate management of the various types of hazardous materials in MHW.

- Regulatory burdens of dual or multiple regulatory systems complicate management.

- Determination of proper DOT shipping names, labeling, packaging, and transportation requirements can be very difficult and time consuming.

- Most commercial disposal facilities will not accept MHW.

7.3 Waste avoidance (source reduction) strategies

Waste avoidance is simply avoiding the production of waste this leading to safer condition in the laboratory while minimizing environmental impacts arising from the transport and disposal waste. It is often associated with the terms waste reduction or source reduction', as well as waste minimization .Waste avoidance can significantly reduce the amount of waste a laboratory handles, and is a critical part of any laboratory.

The difficulties encountered in management of MHW emphasize the need for laboratories to develop and strictly enforce policies that prevent unnecessary generation of MHW. If possible, procedures and areas where different types of hazardous materials are used should be kept separate.

Most of the source reduction strategies recommended for single-hazard wastes can also be applied to avoid generation of MHW: use of short-lived radio nuclides for long lived; use of alternatives to radioactive methods; and substitution of hazardous chemicals with less hazardous and/or non regulated chemicals.

7.3.1 Screening and survey methods

Laboratories that use multiple types of hazardous materials should have waste screening and testing protocols to ensure that wastes assumed to contain a single type of hazardous material do not contain subsidiary hazards. For example, if the laboratory uses radioactive materials, medical wastes, lead shielding, solvents, and other liquid hazardous wastes, they should be tested for contamination with radioactive materials before they are released or shipped for recycling or disposal. The presence of unexpected radioactive contamination in a waste shipment, even if only exempts materials, may often result in rejection of the shipment or have other serious repercussions.

7.4 General treatment and disposal strategies

7.4.1 On-site treatment

The primary treatment objective for multihazadous wastes is usually to reduce the hazardous properties such that it can be managed as a single-hazard chemical, radioactive, or medical waste. The sequence of treatment methods should be according to the degree of risk posed by the various hazardous constituents.

On-site treatment and methods of multi hazardous waste include:

- Inactivation of biohazardous agents by autoclaving although it is not advisable if volatile or thermally unstable chemicals or radioactive materials are present.
- Inactivation of biohazardous agents by chemical disinfection. Applications of this method is limited in its applications as other components in multihazadous waste

might render the disinfectant ineffective, and disinfectants may react with chemical constituents or liberate volatile radionuclides from the waste

- Storage of wastes containing short half-life radionuclides for decay. The waste is held until the radioactivity has decayed and then managed at a medical waste or hazardous waste disposal facility, as appropriate.
- Removal or decontamination of radioactive surface contaminants on lead or other items regulated as hazardous waste.
- Disposal to a sanitary sewer system, e.g., disposal of radioactive, biohazardous wastes generated from human clinical and diagnostic studies.
- Alkaline hydrolysis treatment of radioactively contaminated biohazardous carcasses and tissues to sterilize the waste and solubilize radionuclides that can be discharged to the sanitary sewerage system.

7.4.2 Long-term storage

For wastes containing long half-lived radionuclides and for which there are limited or no disposal options, indefinite on-site storage may be required.

7.4.3 Off-site treatment and disposal

Most forms of MHW are not shipped for treatment or disposal off-site without pretreatment to eliminate one or more hazardous constituents. Limited options exist for untreated LLMW. These include:

- Incineration at a commercial, EPA-permitted/RPA-licensed facility;
- Burning as fuel in an EPA-permitted/RPA licensed facility; and
- Treatment to meet EPA land disposal restrictions followed by disposal in an RPA-licensed LLRW burial site.

7.5 Guidance for management of common Multihazardous waste streams

The sequence of methods used to treat and dispose of MHW must often be determined on a case-by-case basis. The capabilities of the laboratory; access to disposal facilities; cost factors; quantity and composition of the waste; regulatory requirements; and many other factors must also be considered. See Guidelines for disposal of multi-hazardous laboratory wastes in Table 9.

Table 9: Guidelines for disposal of multi-hazardous laboratory wastes

<table>
<tr><th>Waste description</th><th colspan="2">Disposal method</th></tr>
<tr><td>Hazardous chemical(s) and Radioactive material</td><td colspan="2">“Mixed Waste"

Use the smallest non-glass container possible. Complete and attach to container a:

✓ Chemical waste label
✓ Radioactive Waste Pickup Receipt
✓ Radioactive material label</td></tr>
<tr><td rowspan="2">Infectious agent(s) and Hazardous

chemical(s) and Radioactive material</td><td>Infectious agent

Inactivated</td><td>“Mixed Waste"

Use the smallest non-glass container possible. Complete

and attach to container a:

✓ Chemical waste label
✓ Radioactive Waste Pickup
✓ Receipt radioactive material label.</td></tr>
<tr><td>Infectious agent not

Inactivated</td><td>Contact regulatory authority</td></tr>
<tr><td rowspan="2">Infectious agent(s) and Hazardous

chemical(s)</td><td>Infectious agent not

Inactivated</td><td>Contact regulatory authority</td></tr>
<tr><td>Infectious agent

Inactivated</td><td>Treat as chemical waste. Follow chemical waste procedures.</td></tr>
<tr><td></td><td>Infectious agent

Inactivated</td><td>Treat as radioactive waste. Follow radioactive waste procedures.</td></tr>
</table>

Infectious agent(s) and Radioactive material	Infectious agent not Inactivated	Treat as radioactive biological waste. Follow radioactive biological waste disposal procedures included in Waste Management Plan.

7.5.1 Animal Carcasses

Animal carcasses should be double bagged, labeled, placed in specially designated containers, and stored in a cold room. A tag should be filled out indicating the isotope, activity, and contents in the bag. The radiation safety should collect the containers and hold them in freezer storage in a radioactive waste storage area to allow for decay of short-lived radionuclides. Carcasses containing only ^{3}H or ^{14}C can be incinerated or treated by alkaline hydrolysis and discharged to the sanitary sewer if the requirements of other requirements are met. Treatment and disposal of wastes and release of residues from processing carcasses containing other isotopes and activities must be specifically authorized by the laboratory's radioactive materials license. If these treatment options are not available, carcasses can be shipped via a broker to an off-site radioactive waste management facility after being pretreated to meet disposal facility and broker requirements.

7.5.2 Liquid scintillation counting fluids

Liquid scintillation counting is typically performed on radio labeled samples in vials using a fluid containing various mixtures of acetic acid, solvents, surfactants, and scintillation agents. Wastes from liquid scintillation counting consist of vials containing spent fluids typically with very low levels of radioactivity. If the cocktail contains solvents like toluene or xylene, ignitable concentrations of unlisted wastes, or has a pH less than 2.0, the fluid is regulated as a hazardous waste and therefore low level multi-hazardous waste. Several trends have greatly reduced the volumes and hazardous characteristics of liquid scintillation counting wastes generated by laboratories. Generally, use of liquid scintillation counting has declined and been replaced by other methods such as solid scintillation counting. The liquid volumes required for processing liquid scintillation counting sample have dropped significantly from 20 mL routinely used in the past. Changes in technology allow use of micro centrifuge tubes.

8 HAZARDOUS GLASS AND PLASTIC, AND OTHER LABORATORY SOLID WASTE

8.1 Management of Broken Glass and Plastic

Sharps are any object with corners, edges, or projections that when inappropriately handled or disposed are capable of cutting or piercing skin, regular trash bags or waste containers. Examples of sharps include: Pasteur pipettes, other pipettes and tips (glass or plastic), slides and cover slips, any broken containers, broken or fragile glass (including chemically contaminated glass unless the chemical poses a significant hazard), bags of miscellaneous plastic ware that has been autoclaved to remove bio contamination, and syringe bodies (without needles).

Before you can properly dispose of your hazardous plastic and glass waste, you must first ensure all your disposal items have been adequately identified. Hazardous glass and plastic waste should never be placed directly into the wastebasket or other garbage receptacles. Because of the high risk of contamination, specially designed containers should be used. Plastic-lined cardboard boxes that are sturdy and leak proof are the best options. When preparing your container for collection, make sure the contents are appropriately labeled and that all seams are sealed with heavy-duty tape. Limit the weight of your waste collection containers to 20 pounds, and only include materials have been properly rinsed and dried. When dealing with broken glass, make sure to use gloves and safety glasses.

All containers should be clearly marked with the contents, date of packaging, and other essential information. Until the waste is collected, it should be stored in a separate area – ideally, a different room or building – and must be collected within a 48-72 hour window depending on the time of year and local climate conditions. The storage area should be clean and impermeable, with access to water, cleaning equipment, and protective clothing. Security monitoring is a must not only to should prevent unauthorized access but to also ensure animals and insects do not breach the collection perimeter.

Plastic pipettes and micropipette tips can puncture a plastic garbage bag. Broken plastic pipettes in a plastic garbage bag may present an unnecessary risk of injury to persons handling the garbage. These items should be regarded as potentially sharp or pointed objects and placed into the cardboard boxes along with glassware. Glass and plastic ware waste must never be placed in office garbage containers, plastic bags or other containers other than the approved containers.

Laboratories do generate sharp objects that are neither biohazardous nor radioactive. This waste includes items such as micropipettes that were used with noninfectious materials, broken glass, and broken hard plastic. These items do not have to be managed as infectious or radioactive waste, and they should not be so managed. The concern with these sharps is the risk of puncture wounds or lacerations. Therefore, special precautions are necessary to minimize/eliminate the risks of physical injury that any sharp presents to waste handlers. Inasmuch as these items are not biohazardous, they do not need decontamination or sterilization; therefore, they should not be placed in sharps containers that are used for infectious sharps. They should be placed in puncture-resistant containers such as strong cardboard boxes that are labeled "broken glass" but are not labeled "biohazard." Proper management of broken glass and plastic provides the necessary protection from sharps while avoiding the increased costs of waste treatment and disposal that would result from unnecessarily mixing wastes that are not biohazardous with wastes that are.

Items that could cut or puncture skin or trashcan liners. This waste stream must be boxed to protect custodial staff. It goes directly to the landfill without any treatment.

All other nonhazardous wastes generated in the laboratory do not present special concerns for containment and handling. Good management practices that include waste reduction and recycling programs will reduce the amount of waste generated and, therefore, the costs of disposal. The waste management program for the laboratory should also include specifics for management of nonhazardous wastes to ensure that they are managed in accordance with established policies in the most cost-effective manner.

Disposal Options

General trash is almost always removed from the facility for disposal. The waste that is sent off-site may become part of the municipal waste stream, or a private contractor may handle it separately. Either way, there are two options for its ultimate disposal: incineration or land filling. It is unlikely that the facility operates its own landfill for trash disposal, and regulations for prevention of air pollution from incineration will probably result in closure of most incinerators operated by healthcare facilities. Local ordinances may require special packaging of certain wastes (e.g., sharps) and segregation of certain types of waste (e.g., those that cannot be incinerated for energy recovery).

8.1.1 Packaging

All laboratories that generate glass and plastic waste are responsible for the packaging of their laboratory waste prior to its removal and disposal. Glassware, plastic pipettes and micropipette tips should not be disposed of as regular garbage as they can puncture plastic garbage bags and may present a risk of injury.

Glassware and plastic packaged for disposal must be free of chemical contamination, that is:

- It must be rinsed to remove any chemical residue It must not contain liquid Glassware and plastic must be packaged in the designated cardboard boxes. The box must not be overfilled and must be able to be closed. Broken glassware, intact small glass containers and tubes, and glass and plastic pipettes must be regarded as potentially sharp and pointed objects and placed into the appropriate colored totter as outline in the non-hazardous laboratory glass and plastics recycling program.
- Glassware must not protrude such that the lid cannot be closed.
- Glassware waste must not be placed into regular office garbage containers or plastic bags of solid waste.
- Do not put laboratory glassware into the general recycling bins. Its composition may differ from that of recyclable glass containers
- Very long or large glassware for disposal which does not completely fit into a tooter may be placed into a cardboard container after any necessary disinfection or decontamination. The glassware must be fully enclosed by the cardboard container.
- The cardboard container must be closed, taped shut and labeled **"GLASS for DISPOSAL- CAUTION"**.
- The sealed labeled cardboard container may be placed beside other waste awaiting removal by building service workers.
- The glassware must be free of biological, chemical or radioactive contaminants and liquids.

Biologically contaminated glassware and plastic ware packaging

- All containers must be empty and placed into the 20 litre Bio Waste pails supplied by Environmental protection services .
- Autoclaving of the 20 litre Bio Waste pail is **NOT** to be done at any time as it ruins the integrity of the pail.
- The pail must be placed with the other biological waste awaiting removal by the Environmental Protection Technicians
- Laboratories using large amounts of bottled cell culturing media and animal serum should contact the Environmental Protection Technicians to review other methods of packing the waste.

Chemically contaminated glassware and containers packaging

- Chemically contaminated glassware should be **triple rinsed and/or decontaminated** and placed into appropriate colored Totter supplied by Facilities and Services Department and available from the care takers/building service workers.
- Should the lab staff determine that the rinse from the glassware cleaning is hazardous, it should be collected, packaged and labeled as a chemical waste.

- For empty chemical containers that cannot be triple rinsed because of hazard or size, contact Environmental Protection Services for location of drums for contaminated glassware and plastic ware.
- Small, empty chemical containers that did not contain hazardous materials must be thoroughly rinsed. The original label must be defaced or removed and the container must be placed into the Teal colored Totter along with other glassware for disposal.
- Alternatively, use the empty container to package chemical wastes for disposal. This eliminates the problem of finding suitable containers to package chemical waste as well as the disposal of an empty container.
- **Do not** put empty chemical containers and laboratory glassware into the general recycling bins.

Radioactively contaminated glassware packaging

- No flasks, bottles, tubes, etc., containing any amount of free liquid are allowed in the solid waste containers.
- Do not put laboratory glassware into the solid radioactive waste containers or into the general recycling bins.
- All free liquid from glassware must be drained into the appropriate color-coded radioactive liquid waste container as outlined in Table 1. No liquid scintillation counting vials containing counting fluid are allowed in the radioactive solid waste container.
- Empty glassware, including glass pipettes must be decontaminated and free from contamination, prior to disposal as non-radioactive glassware. If glassware cannot be decontaminated, consult with EPS at 416.946.3473 prior to disposal

8.1.2 Labeling

- Biological contaminated glassware in pails requires the Bio Waste tag provided with the 20 litre Bio Waste pail to be filled in completely.
- Chemically contaminated glassware, if not dropped off at the contaminated glass and plastic drum location, should be labeled with the supplied hazardous chemical waste label.
- Radioactive contaminated glassware has no standard label BUT must be identified as a Radioactive Waste on the container.
- 20 liter orange pails labeled ‘Decontaminated Broken Glass Only’ have space for marking the Building Name and Room Number on them.

8.1.3 Storage / Disposal

- Do not overfill the coloured Toters (Non-hazardous Laboratory Glass and Plastics Recycling Program); allow a minimum 2″ head space below the edge to allow installation of the lid. Building service workers have been instructed to not remove overfilled Toters and to not remove bags of solid waste containing glass.

Biohazardous Sharps waste management

Sharps disposal containers are containers for storage, transportation, treatment and subsequent disposal of laboratory sharps. These containers must be leak-proof, rigid, puncture-resistant containers, and capable of being taped closed or tightly lidded to prevent loss of contents. Biohazardous sharps must be discarded in a rigid container, designed specifically for biohazardous sharps, with a clearly identified universal biohazard symbol OR clearly marked with the word “Biohazard”.

Sterilization, disinfection or decontamination of needle and blade waste may be required prior to disposal. The filled yellow plastic container of needle and blade waste must be closed by securing the attached cap over the top opening. The yellow container should be placed with the other biological waste pails for disposal.

General Sharp Objects Disposal procedures in Laboratories

Disposal of Sharp Objects (Sharps)

This procedure applies to the disposal of sharp objects that are contaminated with any of the following hazardous materials: biological hazards (Infectious agents), hazardous chemicals, radioactive materials, and **ALL** blades, needles and syringes, with or without needles, regardless of how they were used. Federal laws regulate proper disposal of Sharps. These regulations serve several purposes:

1. Prevent personal injury.

2. Prevent contamination of personnel or the environment.

3. Ensure proper containment of laboratory and infectious waste during collection, transfer, and disposal.

All sharps MUST BE collected and disposed in a sharps container, except for non-contaminated lab glass/plastic-ware which may be disposed in a laboratory glass disposal box.

Sharps Containers Availability

Labs are responsible for obtaining their own sharps containers either by:

1. Purchasing Sharps containers that meet the construction requirements stated below.

2. Contracting with a vendor to participate in a Recyclable Sharps Container Program.

Construction Requirements

All sharps containers must meet the following standards**:**

- Rigid, non-breakable and puncture resistant, impervious to moisture and leak proof
- have a self-closing lid, red in color with a universal biohazard label

Disposal of Sharp Objects in Laboratories

Sharp objects may be placed in the bag in a standard dry radioactive waste 5 gallon pail. If it is larger it must be collected as a separate waste container.

• Lab glassware may be decontaminated and disposed of in a glassware disposal box if monitoring confirms decontamination was successful.

* **Mixed waste** – If contaminated with any combination of radioactive, chemical, or biological materials:

• Decontaminate biohazard (if present), determine remaining physical hazard (radiation trumps other hazards) and dispose accordingly. If you have a question, contact EHRS prior to disposal

Disposal of Non-contaminated Laboratory Glassware/Plastic ware Containers

Laboratory glassware boxes are appropriate for collection and disposal of glass- or plastic ware that is either intact or broken. It **MUST NOT** be contaminated with chemicals, biological hazards or radioactive materials.

Before Disposal:

• Decontaminate if possible and dispose as Non-Contaminated Glassware.

• If applicable, check with survey meter or wipe test to confirm absence of radioactivity.

• Deactivate any infectious agents usually with 1:10 bleach, prior to disposal.

• Triple rinse empty chemical bottles (**Except P-listed hazardous waste containers**)

• Deface all hazard labels prior to disposal

Disposal:

• Dispose in a Laboratory Glassware Bucket labeled with “Non-Infectious Laboratory Glassware and Plastic ware Disposal” label (see below). Label is available from EHRS.

• Line boxes with a clear heavy plastic bag (included with purchase). **DO NOT** use a red or orange biohazardous waste bag!

• **DO NOT** overfill

• **DO NOT** place free liquids in the glassware container.

• Close lid and seal box with packing tape when full, label as “trash” and dispose as regular trash according to the policy for your building.

8.2 Management of Other Laboratory Solid Waste

Nonhazardous wastes generated in the laboratory do not need special requirement for containment and handling. Good management practices including waste reduction and recycling programs will reduce the amount of waste generated and, therefore, the costs of disposal. The waste management program for the laboratory should also include specifics for management of nonhazardous wastes to ensure that they are managed in accordance with established policies in the most cost-effective manner.

Solid wastes may go into a double-lined cardboard box with liners must be a minimum of 1.5 mil polypropylene bags. It is not recommended to use biohazard or radiation waste bags for regular solid waste accumulation, rather clearly labeled or black trash bags are preferred. Ethidium bromide containing solid and semi-solid waste should also be collected in double bags within cardboard boxes.

9 NONHAZARDOUS WASTES

Nonhazardous waste must be handled, managed, and disposed of properly. Nonhazardous waste is not risk free; for example, centrifuge tubes, fraction collection tubes, disposable flasks, petri dishes, micro-titre plates, weigh boats, uncontaminated gloves and gloves contaminated with residual chemicals, uncontaminated pipettes and pipette tips, empty hazardous plastic chemical containers, and hard plastics can cause injury if flying sharps are created when the plastic is compacted. When improperly disposed of, nonhazardous waste can cause aesthetic degradation of the environment, such as litter on the beach. Generally, it is not toxic in nature.

9.1. Type of non-hazard waste management

Not all laboratory wastes are hazardous. Non-hazardous waste may include the following:

9.1.1. Non-Hazardous Chemical Related Waste

Non-hazardous liquid waste may be poured down sink drains. Liquid waste (i.e., bottles of unused or partially used solutions) may never be disposed of in dumpsters, as liquid wastes are not permitted at the municipal landfill.

9.1.2 Empty containers of commercial products or chemicals may be placed

In the regular trash if no freestanding liquids remain in the containers and all disposal requirements noted on the label are met. Empty containers must be defaced by removing container labels or marking through labels to indicate the containers no longer contain hazardous materials. See the "Empty Containers" section on page 24 for more information.

9.1.3 Animal wastes containing non-hazardous preservative

It should be placed in a bucket or thick trash bag, after all liquid has been drained, and taken directly to the outside dumpster. No animal remains should be placed in the laboratory trash cans. Animal specimens preserved in formaldehyde, formalin, or other hazardous chemical preservative must be handled as hazardous waste.

9.1.4 Non-hazardous liquid preservative waste

- Such as waste may be poured down the lab sink drain.

9.1.5 Certain solid, non-hazardous chemicals

Are *certain solid, non-hazardous chemicals* suitable for disposal to the sanitary landfill? However, such chemicals should not be placed in laboratory trash cans, as custodial personnel have been instructed not to handle any chemical or potentially hazardous wastes. Non-hazardous solids should be placed directly into the dumpsters.

9.1.6 Chemical

A. Organic chemicals:

- Sugars and starches
- Naturally occurring a-amino acids and salts
- Citric acid and its Na, K, Mg, Ca, NH4 salts
- Lactic acid and its Na, K, Mg, Ca, NH4 salts+

B. Inorganic chemicals

- Sulfates: Na, K, Mg, Ca, Sr, NH4
- Phosphates: Na, K, Mg, Ca, Sr, NH4

- Carbonates: Na, K, Mg, Ca, Sr, NH4
- Oxides: B, Mg, Ca, Sr, Al, Si, Ti, Mn, Fe, Co, Cu, Zn
- Chlorides: Na, K, Mg
- Fluorides: Ca
- Borates: Na, K, Mg, Ca

C. Laboratory materials not contaminated with hazardous chemicals:

- Chromatographic absorbents
- Filter paper, filter aids, and glassware
- Rubber and plastic protective clothing

9.1.7 Non-hazardous gases

Carbon dioxide, nitrogen, argon, neon may generally be vented to the atmosphere via a certified and functioning laboratory fume hood. Please check to such venting, particularly for large volumes.

9.2. Management of nonhazardous wastes

Items those are neither sharp nor contaminated. This waste stream is handled directly by custodians and goes to landfill without further treatment. Items that present NO HAZARD if disposed of as normal trash: Unbroken glass and plastic that has been washed or decontaminated so as to present no chemical or biological hazard Petri dishes and plastic lab ware, weighing boats sturdy test and centrifuge tubes washed, uncapped empty bottles paper towels and gloves that have no significant contamination**.** Container: Lab trash can with plastic liner.

10 WASTE MANAGEMENT PROGRAM FOR THE LABORATORY

A laboratory waste management program should have as its purpose comprehensive control over the production, handling, storage, disposal, and monitoring of all waste originating in laboratories to ensure that the health of the exposed population and the surrounding biologic environment is properly protected. It should also address broader environmental concerns, such as the decreasing availability of landfill sites and the increasing desirability of recycling. An institutional program for laboratories may be developed by in-house staff or with the assistance of outside consultants

10.1 Planning for laboratory waste management

Development of a waste management program should be preceded by a waste audit of the facility; its procedures and functions; the hazardous materials used or available for use; the wastes that are generated (by type and amount); and the current methods of handling, segregation, storage, on-site treatment and disposal, transfer, and transportation of those wastes. The survey should address all wastes, whether hazardous or not. The ideal plan is one that meets regulatory requirements and accreditation standards, reduces liability, makes no unreasonable financial demands on the organization, and is acceptable to the employees. The first step in planning the program is to become fully informed before making any decisions on the elements of the laboratory waste management chain. One must also stay informed of constantly changing regulations, and new waste handling and minimizing technologies. To formulate waste management plans, the following conditions should be considered:

- Knowing the federal government and states regulations and accreditation standards.
- The costs of each management option
- A cost-benefit analysis of waste disposal methods including the relative costs of training
- Society and community feelings about hazardous and infectious waste, as well as public relations needs and
- Needs and waste generation habits of the facility.

10.2 Elements of a waste management program

The scope, goals, and objectives of the program must be defined with the participation of the managers who are affected. The goals and objectives should be not only to protect the health and the environment in general terms but also to meet the requirements of all applicable governmental laws and regulations.

In designing the program, the following objectives or components should be included. These elements follow a sequential path, from generation, accumulation, storage and shipment, to treatment and disposal.

10.2.1 Waste determination

Environmental protection agency (EPA) requires that all institutions examine the wastes they generate to determine if any are hazardous wastes. Once such a determination is made, all hazardous waste must be disposed of in a manner prescribed by EPA regulations.

10.2.2 Safety waste handling

Hazardous materials must be handled properly to avoid accidents and exposures. This is accomplished by following safe procedures, wearing personal protective equipment (PPE), and training all employees who routinely or occasionally handle hazardous materials. Handling techniques and other procedures designed to minimize contamination or exposure are examples of work practice controls. Work practice controls may also reduce worker risk, but they should supplement, and not substitute for, proper engineering controls, such as ventilation.

The choice of PPE depends on the activity, the hazards and characteristics of the material handled (e.g., volatility, permeation, penetration, and degradation), and available engineering controls. PPE is especially important when chemical exposure is possible, such as during transfer operations (e.g., adding waste to an open container, combining and mixing wastes, and neutralizing mineral acids). PPE can include goggles or face shields (regular or safety glasses are not appropriate for transfer operations), aprons or laboratory coats, and proper gloves. A respirator is appropriate when volatile hazardous materials are transferred outside of a fume hood.

10.2.3 Source separation and segregation of generated waste

Do not mix different waste types. Dilution of regulated waste with normal trash does not remove it from regulation, even if the waste mixture no longer has hazardous characteristics. Rather, the entire amount of the new waste mixture will be regulated. Further, mixing incompatible wastes can cause additional hazards. For recycling purposes, it is also advantageous to segregate certain nonhazardous wastes (e.g., newspapers, bottles, and aluminum cans). Thus, it is highly desirable to keep different waste types separate and well labeled from the other waste from its point of generation to its final disposition. Starting at the point of generation, each waste type should be collected separately and be kept segregated throughout storage, transportation, and disposal operations. If precautions are taken to avoid incompatibility and commercial disposal problems, it is appropriate to combine different waste types by collecting them in one container.

10.2.4 Prompt removal of accumulated waste

A key practice for managing waste is its prompt removal from the laboratory. Prompt removal minimizes the risk of spills and overfilling collection containers. This part of good housekeeping demonstrates an active, sound institutional waste management program to outsiders.

Reasonable exceptions to prompt removal of accumulated waste may be made for properly shielded radioactive waste held for decay-in-storage (DIS) at the point of generation, and for low-volume, hard-to dispose-of hazardous chemical waste held at its satellite accumulation location until cost-effective commercial disposal can be arranged.

10.2.5 Waste storage

The storage sites must be planned in such a way as to minimize inadvertent access by the untrained or unauthorized. Safe storage requires engineering controls appropriate to the type of waste.

While it is economically desirable to reduce the number of waste shipments, storage times must be weighed against the costs and hazards of storage. For example, radioactive materials with a short half-life may be allowed to decay in storage until they are safe for disposal. Alternatively, EPA limits storage for hazardous chemical.

10.2.6 Transportation of wastes

Arrangements for timely on-site movement and off-site shipment of wastes are critical elements of the waste management program and may comprise a significant fraction of overall program costs and potential liability. Transportation planning should consider safety; facility logistics; the frequency of waste removal services needed to support laboratory operations; manifest tracking and record keeping requirements; regulations; and training needs.

Almost all hazardous, infectious, radioactive, and multi-hazardous wastes generated by laboratories are classified as hazardous materials. Properly authorized and licensed haulers must perform the transportation of waste from the institution. Many laboratories rely on waste brokers and contractors to ensure compliance with shipping regulations. This may be convenient; however, the facility shipping the waste bears primary responsibility for compliance with regulations and liability for violations and incidents. Properly completed manifests and disposal records must be kept on file. Generators are forever liable for the proper management of waste that they generate. Nearly all institutions hire a commercial hazardous waste transporter when they plan to ship waste for offsite disposal.

Identification Number: All large generators and small quantity hazardous generators must apply for and receive an ID number from an authorized institution/organization like EPA. Waste transporters, as well as treatment, storage, and disposal facilities (TSDs) are also required to have ID numbers. Many states and transporters also use ID numbers, or similar ID numbers, for tracking shipments of other types of laboratory waste.

Manifests (Shipping papers for laboratory waste): Environmental laws require tracking wastes “from cradle to grave.” To achieve this, a manifest or shipping paper is required to document the transportation of laboratory waste. The manifest identifies the waste generator, transporter, and destination of the waste (i.e., the treatment, storage, or disposal facility (TSDF)), and it describes the waste and its quantity. Manifests also track and assign liability for hazardous waste, so it is prudent to keep these well beyond the three-year period required for record retention.

10.2.7 Waste treatment and disposal

Treatment and disposal usually occurs off-site at a commercial disposal facility. In certain instances, it is advantageous to treat laboratory waste on site. Examples are the decontamination or sterilization of infectious waste and neutralization of acids and bases.

10.2.8 Contingency and emergency planning

There must be a written contingency plan for emergencies such as leaks, spills, hood failures, and employee exposures to infectious and hazardous substances. Consider any foreseeable emergency or contingency, and include procedures for responding to these events. Conditionally exempt small-quantity generators are exempt from contingency planning requirements for hazardous chemical wastes. Even so, it is prudent for all users of hazardous materials to plan for and actively prevent emergencies. Contingency planning requirements for small-quantity generators are appropriate for all users of hazardous materials.

10.2.9 Compliance planning

The waste management program should be integrated with the institution's hazard communication plan; chemical hygiene plan; infection control plan; disaster plan; existing safety policies and procedures; risk management and loss control plan; and any other related or overlapping programs. It should include a plan for monitoring, reducing, and recycling waste in addition to waste treatment and disposal. Someone who is thoroughly familiar with applicable laws and the institution should design the waste management and its associated plans. Managers, facility engineers, and technical and professional staff should also consult.

10.2.10 Review and approval

Once the waste management program has been written, representatives from all of the affected departments should review it. A representative from top management should also review it. After changes and adjustments are made, it should be formally approved.

10.3 Safe facilities for waste management

To prevent accidents, releases, injuries, and exposures, various controls and engineering enhancements are appropriate for areas where laboratory waste is accumulated or stored. Some of these controls are required only of large laboratory waste facilities, but they are nevertheless prudent practices for smaller waste generators as well. These controls include ventilation, a containment system, security, fire protection, and sufficient aisle space.

10.3.1 Ventilation

Provide adequate ventilation for volatile chemicals, either by improving the room ventilation or by placing the waste in a ventilated storage area. Alternative fire-safe, non-ventilated chemical storage cabinets may be appropriate.

10.3.2 Containment system

Place liquid wastes only in an area surrounded by a dike, berm, or other containment. The EPA suggests that containment systems have sufficient capacity to contain either 10% of the volume of the containers or the volume of the largest of the containers, whichever is greater. For bench tops in laboratories, a high walled tray is usually sufficient. Containers should be raised so spilled or leaked waste in the containment system does not contaminate the outside of other containers.

10.3.3 Security

Security is needed to prevent access by unauthorized personnel to areas where laboratory waste is generated, accumulated, or stored. A warning sign is also recommended.

10.3.4 Fire protection

Fire protection should include proper waste collection containers, grounding of metal flammable liquid containers, flammable liquid storage cabinets, ready access to fire extinguishers, and building alarm systems. A fire suppression system is appropriate for the central accumulation areas for flammable wastes.

10.3.5 Passageway (Aisle) space

Adequate Passageway space is needed to allow an easy and fast exit.

10.4 Plan implementation

With the full commitment of and support from top management, the plan should be put into effect. This requires obtaining all the equipment and supplies, making arrangements with outside services (such as waste management firms), and appropriate training of staff.

10.5 Program evaluation and corrective action

During the implementation period, the plan should be frequently reviewed. It should be reviewed at least annually thereafter to determine how objectives are being met and how much the plan is costing the laboratory. Pertinent legislation, regulations, and accreditation requirements must be constantly monitored. Appropriate revisions and corrections should be made as needed.

11 PLANNING FOR POLLUTION PREVENTION, WASTE MINIMIZATION, AND RECYCLING

11.1. Guidance for Waste Minimization

The management of laboratory wastes remains a sensitive issue since highly infectious waste is often generated there. International standard procedures of highly infectious waste management should therefore be respected. Consequently, each laboratory should be equipped with the adequate material and rigorous protocols set-up to ensure a pre-treatment of the highly infectious waste before it joins the other hazardous waste for final treatment/disposal.

Highly infectious waste from research, diagnostic and regulatory laboratories, such as media, culture plates and others, should be collected in leak proof bags or containers suitable for autoclaving and properly sealed. Ideally, each laboratory should have an autoclave room dedicated for the specific pre-treatment of this category of waste only. No office waste or other miscellaneous waste should be placed in this room, which shouldn't be either used for waste storage. Once decontaminated or treated, medical laboratory waste should be collected and treated.

Environment Protection Agency's guidance for waste minimization is appropriate for all generators. The EPA recommends that an effective waste minimization program include the following elements:

- Top management support, such as a statement from the institution's director;
- Characterization of waste generation to promote understanding of the amounts and types of waste generated and to identify where waste minimization efforts would be most efficient and effective;
- Periodic waste minimization assessments and program evaluation;
- A cost allocation system in which individual departments and units are charged for disposal as a disincentive (Alternatively, every unit that generates hazardous waste should be notified of the disposal costs borne by the institution.);
- Encouragement of technology transfer

The following are Strategies used to minimize laboratory wastes;

a. Reducing the amount of wastes at source

- Choosing products that generate less waste: less covering material,
- Preventing wastage: in the course of care, for example, or of cleaning activities.
- Choosing equipment that can be re-used; such as glassware that can be washed rather than disposable.

b. Purchasing policy geared to minimizing risks

- Purchase of PVC-free equipment
- Purchase of mercury-free equipment: mercury-free thermometers (ICRC standards), mercury-free blood pressure gauges).
- If possible, purchase of new safe injection and blood materials
- Selecting for the least toxic products (cleaning products, for example).
- Purchase of long shelf-life laboratory consumables

c. Stock management

- Centralized purchasing.
- Chemical and pharmaceutical stock management aiming to avoid a build-up of expired or unused items: "first-expire – first out" (FEFO) stock management by monitoring expiry dates.
- Choice of suppliers according to how promptly they deliver small quantities and whether unused goods can be returned.
- Regularly monitor of stock and transfer short life laboratory consumables to other laboratories

d. Sorting at source

- Segregating waste is the best way to reduce the volume of hazardous wastes requiring special treatment.

e. Regulatory Exemptions

Some wastes may be exempt from regulations because of the production process, level of contaminants, volume of waste, or the waste management option chosen. Some radioactive wastes may be managed as non-radioactive if the total level of radioactivity is below an exempt or level.

f. Method Selection

The analytical method selected for sample analysis or handling determines the type and volume of waste generated. If two methods will achieve the required measurement quality objectives, the laboratory might select the method that produces the least amount or most easily managed waste. For example, biological laboratories can minimize the use of chemical disinfectants that require handling and disposal as hazardous substances by considering alternative disinfection procedures, such as autoclaving, that do not generate hazardous waste. Current laboratory guidelines for working with infectious microorganisms at Biosafety Level 2 and 3 (BSL-2 and 3) laboratories recommend that waste be decontaminated before disposal and that select agents be destroyed using a steam autoclave. In addition, substituting a short-lived radionuclide for a long-lived radionuclide may ultimately result in reducing radioactive waste.

g. Sample Amounts

To minimize the amount of sample waste, laboratories should receive only the amount of sample needed for sample analysis, analytical quality control, and a limited amount of excess in case of sample loss or other unforeseen problems or uses. Reserve sample amounts should be minimized with open planning. It may also be possible to convert a method to a micro-scale method that uses significantly less sample and reagents. To optimize method sensitivity in the situation of evaluating the effectiveness of decontamination, however, it may be necessary to use large quantities of sample material.

h. Reagent Procurement Controls

Amounts of reagents and materials purchased by a laboratory often are determined by price discounts available on large quantities, instead of the amount required. The real cost of purchasing these materials should include the initial purchase price plus disposal costs (lifetime costs). Procurement of hazardous material should be initiated only if a nonhazardous substitute is not available. Rotating chemical stock (first in, first out) also can help avoid expiration.

i. Re-Use of Materials

Some materials may be recovered from the analytical process and re-used in subsequent analyses. For example, distillation of certain used organic solvents may purify them sufficiently for reuse. Glassware and some disposable equipment can often be decontaminated and re-used or disposed of as non-hazardous waste.

11.2 Pollution Prevention and waste Recycling

12.2.1 Pollution prevention:

- Pollution prevention refers to source reduction of all toxic wastes including those released to air, water and land resource. Source of reduction include any practice that reduce the quantity or toxicity pollutant entering a waste streams prior to recycling, treatment and disposal example include:
    - ✓ Equipment or technology modification
    - ✓ Reformulation or redesign of products
    - ✓ Substitution of less toxic materials

- ✓ Improvement in work practices , maintenance, worker training and better inventory control

11.2.2 Recycling

- Direct use/ reuse of waste in the process to make a product, such as a purge product used to clean paint lines rather than disposing.
- Processing the waste to recover or regenerate as usable product such as collecting vapor from dry cleaning operations and turning it back into liquid and reusing the liquid to clean more clothes.
- Using /reusing waste as substitute for a commercial product. When mercury is recycled from old equipment like switches, it can be used in a new product that still requires mercury such as florescent bulbs.

12 TRAINING

Knowledge of wastes and its management by decision makers and stakeholders helps to support, monitor and coordinate the waste management program. Hence, awareness creation should be organized for sensitization of management body and stakeholders. More importantly, Lab WM actors should have thorough knowledge of wastes and technical skills on its management. This could be realized by organizing capacity building trainings for all actors.

Training gives needed information and skill to both management and employees at all levels in the organization and for all stages of waste management. It is a critical element of a successful waste management system. It is through training that all laboratory staff will understand the importance of best management practices for waste reduction and environmental protection. Therefore training which Emphasize a commitment to waste prevention and proper chemical management for new employees and refresher training for all staff are important.

Training is not only necessary for a successful program; it is also required under various regulations of multiple federal regulatory agencies like Environmental Protection Agency and Occupational Safety Health Administration. The training programs needed depend on the laboratory's waste management plan, and should consider the following elements : who needs training, what needs to be taught, when and how frequently training is needed, how best to present the training and how training will be documented.

12.1 Training program elements

Because there are common elements in many environment, veterinary laboratory, and safety training requirements, such training can be consolidated. All new employees will be trained in safety precautions: standard precautions, fire safety, flammable liquids, and compressed gas cylinders, potential hazards of infectious diseases, carcinogens, chemical hygiene and emergency equipment, how to keep spill response. The lab worker needs to be trained further in the components of the chemical hygiene plan covering proper chemical handling, storage and disposal of hazardous waste and such a training program must be documented and updated as needed or on a yearly basis. Training requirement applicable in the waste management of most laboratories indicated in Table 10.

Table 10: Training requirement applicable in the waste management of most laboratories

Training Requirements	**Who Must Be Trained**
Training on hazardous waste requirements Large-quantity generators: ➢ Facility personnel must complete a program of classroom instruction or on-the-job training that teaches them to perform their duties ➢ The training program must be directed by a person familiar with hazardous waste management procedures, and must include instruction in emergency response management. Small-quantity generators: ➢ Training should cover waste management and emergency response procedures relative to the employee's responsibilities.	Employees whose responsibilities include waste management activities such as waste identification, transfer, collection, facility emergency coordination, certifying hazardous waste shipments, and waste-related inspections.

Frequency: Employees must be trained annually.	
Training requirements for users of radioactive materials ➢ kept informed of the storage, transfer, or use of radiation and/or radioactive material ➢ Instructed in the health protection problems associated with exposure to radiation and/or radioactive material, in precautions or procedures to minimize exposure, and in the purposes and functions of protective devices employed. ➢ Instructed in, and required to observe (to the extent within the workers' control) the applicable provisions of authority regulations and licenses for the protection of personnel from exposure to radiation and/or radioactive material. ➢ Instructed of their responsibility to report promptly to the licensee any condition which may lead to unnecessary exposure to radiation and/or radioactive material. ➢ Instructed in the appropriate response to warnings made in the event of any unusual occurrence or malfunction that may involve exposure to radiation and/or radioactive material and	All individuals who in the course of employment are likely to receive in a year an occupational dose in excess of 1mSv (100 mrem).
Training requirements for occupational safety Hazard communication standard: ➢ Train employees on hazards of chemicals, labeling and other warning mechanisms, Material Safety Data Sheets (MSDSs), site-specific hazards, and protection measures for workers. Frequency: Initial and when new hazards are introduced.	Employees exposed to hazardous materials in the work place.
Emergency Response (First Responder Awareness Level)	Employees who participate in

First responders at the awareness level shall have sufficient training or have had sufficient experience to objectively demonstrate competency in the following areas: ➢ Understanding on what hazardous substances are, and the risks associated with them in an incident ➢ Understanding of the potential outcomes associated with an emergency created when hazardous substances are present ➢ The ability to identify the hazardous substance, if possible ➢ An understanding of the role of the first responder awareness individual in the employer's emergency response plan.	emergency response, except for laboratory personnel who clean up their own spills. Employers who will evacuate their employees from the danger area when an emergency occurs, and who do not permit any of their employees to assist in handling the emergency, are exempt
Transportation of Hazardous Materials: ➢ Each Hazardous Materials employer must train and test Hazardous Materials employees, certify the training, and develop and retain detailed records of current training for each hazardous material employee. Hazardous Materials training must include general awareness and familiarization with it, and safety training. Frequency: Initial training is required for new employees, or when an employee changes job functions. Recurrent training is required at least once every three years.	Employees engaged in activities relating to shipments of regulated forms of waste, including employees whose only shipping-related activity is signing waste manifests on behalf of the facility Custom clearance officers, cargo..

The training program will ensure that all workers know about:

- Personal Safety: Potential hazards, modes of transmission & prevention for infectious pathogens, personal protective equipment use, storage, decontamination, disposal and limitations, corrective actions when confronted with spills or personal exposure to fluids or tissue
- Decontamination: How to decontaminate infectious waste before disposal, autoclave, incineration, the types of containers for disposal including sharps, red bags, glass and general trash and approved disinfectants.
- Chemical Safety: Explanation of the biohazard symbol, color codes and precautions, where chemicals & carcinogens are used and stored; warning labels, decontamination and disposal procedures
- Flammable Liquid Policy: Use, storage and maximum amounts that can be stored in the laboratory.
- Emergency Equipment: How to operate emergency equipment (eyewash, shower, fire blanket, etc.) and the maintenance required.

12.2 Mandatory employee awareness training

Employees must be informed of the potential physical and health hazards of their work areas and precautions for their protection. The training material should include general safety principles; modes of exposure for chemicals; radioactive materials and infectious agents; methods of labeling; and proper work practices to minimize exposures. For chemicals, instructions on how to detect the release of and overexposure to a hazardous substance should also be presented.

Training should include injury prevention, waste avoidance and segregation, treatment/emergency procedures, reporting and follow-up policies. Use of personal protective equipment is one aspect of proper work practices that must be taught.

All employees who handle laboratory waste must receive training that covers the risks associated with all types of waste, whether regulated or not. Federal regulations and voluntary accreditation standards require that all employees who manage or handle hazardous or infectious materials or waste be trained. Training must be done when the waste management programs are implemented; when they are changed (as when a new chemical or a laboratory waste handling product is introduced); at the time of hire for new employees; and at least annually thereafter.

All employees must be informed about the applicable regulations, copies of which should be available to them. All employees should be informed about the contents and location of the laboratory waste management plan(s). The plan(s) must be explained and be available to everyone. The location of lists of hazardous chemicals, their Material Safety Data Sheets (MSDS), and instructions for accessing them must be included. The plan should also define the responsibilities of management, supervisors, and employees. The material taught should be appropriate in content and vocabulary to the educational level, literacy, and language background of the people to whom it is presented.

12.3 Annual refresher training requirements

Annual refresher training for employees who handle hazardous chemical wastes. Every three years, Department of transportation (DOT) requires refresher training for employees who are actively involved in preparing a shipment of chemical, infectious, or radioactive waste. OSHA requires annual refresher training for employees who use respiratory protection, and for members of the spill response team.

12.4 Emergency response training

Each employee must be taught his/her role in an emergency. Responders must contain the spill, prevent exposures to other personnel, and decontaminate the area. The laboratory's first responders must be trained to contact the appropriate outside agencies, and to differentiate spills that can be safely managed in-house from those for which outside help must be acquired. Larger spills will likely require response from the local hazardous team (or other specially trained personnel). HAZWOPER awareness training is prudent for all employees, and an annual refresher, for members of an in-house spill response team is required.

12.5 Requirements for prior approval

The waste management plan should also define circumstances under which training and prior approval is required before carrying out a particular operation, activity, or procedure. For example, procedures for distillation recovery of solvents or treatment of hazardous chemicals before disposal could specify that before any employee is allowed to perform the procedure for the first time, the employee must be trained, supervised, and given permission.

12.6 Training for supervisors

Support from supervisors is critical for the successful operation of an institution's waste management plan. The base to successful hazardous and laboratory waste management is to decrease the amount of waste in general. To make this happen, supervisors should be aware of waste management costs, as well as ways to reduce risks and costs. They need to know all the in-house options for handling wastes, how to do cost analysis on the options available, and how to make time for the training needed. They must ensure that solving one waste management problem does not make another one worse.

12.7 Training program evaluation

All employees involved in generating or handling hazardous, radioactive, multi-hazardous, or laboratory waste must be included reviewing training program and its documentation at least annually. The teaching materials should be regularly updated for new procedures, technologies, and requirements. Annual refresher training is required for employees with emergency response or other special duties, as well as for those who use personal protective equipment or wear respiratory protection. Special language or communication needs should be accommodated. Employees should demonstrate competency in following the contingency plans, first aid, and emergency procedures including spill response and use of the safety shower and the emergency eyewash.

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