REPUBLIC OF ZAMBIA
MINISTRY OF HEALTH

LABORATORY WASTE MANAGEMENT GUIDELINES

2024
First Edition

TABLE OF CONTENTS

FOREWORD

Effective waste management is a critical aspect of laboratory operations, ensuring the safety of personnel, the public, and the environment. As laboratories across Zambia continue to play a vital role in the diagnosis, treatment, and research of various health conditions, the generation of diverse waste streams has significantly increased. This necessitates a structured and comprehensive approach to managing laboratory waste, addressing both biosafety and biosecurity concerns.

The "Laboratory Waste Management Guidelines" serve as a foundational document, providing clear and actionable directives for the segregation, storage, transportation, treatment, and disposal of laboratory waste. These guidelines aim to mitigate the risks associated with hazardous materials, ensuring compliance with national and international standards while promoting sustainable waste management practices.

Our commitment to enhancing the health and safety of laboratory personnel and the broader community is reflected in the collaborative efforts that have shaped this document. This initiative aligns with the broader objectives of the Ministry of Health and our partners, who are dedicated to fostering a safer, healthier, and more sustainable environment.

It is my hope that these guidelines will not only improve waste management processes but also inspire continuous improvement and innovation in laboratory practices. Together, we can ensure that our laboratories remain at the forefront of safety, efficiency, and environmental stewardship. I implore all stakeholders in the management of laboratory waste to abide by the guidelines stated in this document.

Hon. Dr Elijah Muchima, MP.

Minister of Health

ACKNOWLEDGMENT

The Ministry of Health (MOH) wishes to acknowledge the individuals, institutions, and cooperating partners who contributed to the development of this document. We extend special gratitude to the Clinton Health Access Initiative (CHAI), the Association of Public Health Laboratories (APHL), and the African Society for Laboratory Medicine (ASLM) for their financial and technical support.

We also pay tribute to the Centers for Disease Control and Prevention (CDC), United States Agency for International Development (USAID), the Centre for Infectious Research in Zambia (CIDRZ), Zambia Environmental Management Agency (ZEMA), the Churches Health Association of Zambia (CHAZ), the World Health Organization (WHO), Ministry of Local Government and Rural Development, and the Ministry of Fisheries and Livestock for their commitment and leadership in developing these Laboratory Waste Management Guidelines. Their expertise in healthcare and waste management was instrumental in ensuring the completion of this comprehensive document.

Finally, I wish to express our gratitude to the staff members at the Ministry of Health headquarters who worked tirelessly to complete this document, incorporating critical insights and best practices. It is my hope that the aspirations outlined in these Waste Management Guidelines will be realized and contribute positively to our goals, fostering a safer and healthier environment.

Dr Kennedy Lishimpi

Permanent Secretary-Technical Services
Ministry of Health

CONTRIBUTORS

Name	Affiliation
Davy Nsama	MOH
Mweemba Muvwimi	MOH
Zephaniah Mtonga	MoH
Mutinta Shisholeka	MoH
Patricia Kafweta	MoH
Musonda Mandona	MoH
Zakeyo Mvula	MoH
Mwendabai Mulasikwanda	MoH
Taurai Machawi	MoH
Sabe Mwape	MoH
Nshimba Mwansa	MoH
Innocent Hamuganyu	MoH
Florence Kabinga	MoH
Clement Phiri	APHL
Milimo Delhan Hamoomba	APHL
Valery Kadima	APHL
Precious Bwalya	ASLM
Stanley S. Nyirenda	Central Veterinary Research Institute (CVRI)
Kizito M. Bukowa	Central Veterinary Research Institute (CVRI)
Lindiwe Nchimunya	CHAI
Yucheng Tsai	CHAI
Namwaka Mungandi-Mulenga	CHAI
Andrew Mwandila	CHAZ
Chilufya Chipango	CHAZ
Jonathan Mwenya	Chest Diseases Laboratory
Mutale Mubanga	CIDRZ
Physiwell Sikateyo	CIDRZ
Powell Choonga	CIDRZ
Felix Chibu	Kabwe Women and Newborn Hospital
Lweendo Namitondo	Lusaka Provincial Health Office

CONTRIBUTORS (CONTINUED)

Chinda Goma	Lusaka Provincial Health Office (LPHO)
Nachombe Nang'amba	Ministry of Local Government and Rural Development
Sumbukeni Kowa	National Food Laboratory
Matongo Hasalama	National Food Laboratory
Alan Musonda	Northwestern Provincial Health Office
Sody Munsaka	University of Zambia -School of Health Sciences
Imasiku Akokwa	University Teaching Hospital (UTH)
Esther Musongole	United Kingdom Health Security Agency (UKHSA)
Chileshe Chisanga	UTH
Lostone Lwanga	UTH
Stella Mulima	WHO
Frazer Mtine	Zambia National Public Health Reference Laboratory (ZNPHRL)
Otridah Kapona	ZNPHRL
Joshua Sichula	ZEMA

ACRONYMS

BSBS Biosafety and Biosecurity

PPE Personal Protective equipment

PVC Polyvinyl chloride

SDS Safety data Sheet

WSS Waste Storage Site

GLOSSARY

Term	Definition
Autoclaving	The use of high temperatures applied as moist heat (steam) under pressure for treatment of waste to render it harmless.
Chemical waste	Waste containing chemical substances (e.g. laboratory reagents; film developer; disinfectants that are expired or no longer needed; solvents; waste with high content of heavy metals, e.g. batteries; broken thermometers and blood-pressure gauges).
Decontamination	Reduction of viable biological agents or other hazardous materials on a surface or object(s) to a pre-defined level by chemical and/or physical means.
Disinfection	A process to eliminate viable biological agents from items or surfaces for further safe handling by chemical and/or physical means except for bacterial spores from inanimate objects.
Encapsulation	Processes where waste is placed in hard containers, such as metal drums, and an immobilizing material, such as cement, bituminous sand or clay is added.
Field Work	Work involving collection and/or analysis of raw data or samples conducted outside a laboratory or controlled environment.
Hazardous waste	Waste that has a significant adverse effect on public health and/or the environment, by circumstances of use, quantity, concentration or inherent physical, chemical, or toxicological characteristics.
Incineration	Combustion process in which the waste is burnt in the presence of oxygen by applying a high temperature of 800°C to 1200°C.
Inertisation	A process that involves mixing waste with cement and other substances before disposal to minimise the risk of toxic substances it contains.
Infectious waste	Waste contaminated with infectious agents which include but not limited to; blood, other bodily fluids and cultures.

Term	Definition
Point of Care waste management	This is management of waste from laboratory testing conducted close to the site of the patient.
Sterilisation	This is the process of complete destruction of all forms of microbial life (i.e. both vegetative and spore forms) which is carried out by various physical and chemical methods.
Transporter	Entity, institution or company licensed and authorised to collect, transport, and deliver laboratory generated waste material from laboratories to appropriate storage, treatment or disposal facilities.
Vehicle	Equipment such as trolleys, carts, mobile garbage bins, light trucks used for transportation of laboratory waste to storage or disposal site.
Waste storage areas	Sites where waste is temporarily held pending transportation, treatment or disposal.
Waste Disposal	The final placement of waste in landfills or other disposal facilities without intention or retrieval and includes the disposal of raw or intermediary handled inert or otherwise unwanted residues.
Waste Generator	An individual, organization or entity that produces or is in possession or control of waste as a result of their activities.
Waste Management	The strategies and approaches used in the collection, storage, removal, transportation, processing, treatment and disposal of material considered as waste.

1. INTRODUCTION

Globally, approximately 1.47 billion tonnes of solid waste are produced annually, with a significant 5.9 million tonnes originating from healthcare facilities, including laboratory waste.[1] This presents a considerable challenge, particularly in sub-Saharan Africa, where healthcare waste management often falls below international standards.[2] In Zambia, it is estimated that 56.9% of healthcare waste is poorly managed, which has resulted in significant health risks, such as a 31.3% rate of needle pricks among healthcare workers due to poor waste segregation.[3] Furthermore, as of 2022, only 43% of health facilities in Zambia had functional incinerators for infectious waste treatment.

Laboratories generate hazardous chemicals and infectious biological agents, posing risks to human, animal, and environmental health. The increasing population, climate change, emerging and re-emerging diseases, improved laboratory capacity, and decentralisation of healthcare systems have all contributed to the significant rise in laboratory waste generation. The development of various waste streams due to technological advancements further complicates waste management. Effective biosafety and biosecurity (BSBS) measures are crucial to mitigating these risks, and their integration into laboratory waste management is essential for comprehensive biorisk management and regulatory compliance.

The Healthcare Waste Management Plan under the Environmental Management Act No. 12 of 2011 guides waste management in Zambia. Multiple ministries, including Health, Fisheries and Livestock, Local Government and Rural Development, Finance, and Works and Supply, are involved in this effort. The strengths of Zambia's healthcare waste management system include the availability of national documents supporting waste management implementation, trained personnel, a multi-sectoral response mechanism coordinated by the Disaster Management and Mitigation Unit (DMMU), and ongoing research on waste management.

However, gaps remain, such as the lack of laboratory-specific waste management guidelines, limited incinerator coverage, and insufficient waste management supplies and staff training. These guidelines have been developed to bridge some of these gaps, ensuring safe and effective laboratory waste management with a focus on integrating biosafety and biosecurity principles and the One Health approach.

2. PURPOSE, OBJECTIVES, SCOPE AND AUDIENCE

2.1. Purpose

To provide guidance in the management of laboratory waste ensuring safe and effective laboratory waste management with biosafety and biosecurity considerations.

Note: These guidelines will be implemented in line with the already existing national/international regulations as indicated in Annex 5.

2.2. Objectives

2.2.1. Main Objective:

To provide guidance for safe and effective management of laboratory waste at all levels, with a particular emphasis on integrating BSBS principles to mitigate risks associated with biological waste materials.

2.2.2. Specific objectives

i. To provide guidance on processes to reduce the quantity and hazardousness of laboratory waste to minimise potential risks posed by biological agents, toxins and chemicals.
ii. To safeguard the health and safety of humans, animals, plants and the environment through proper waste generation, storage, transportation, and disposal procedures.
iii. To promote environmentally sustainable methods of laboratory waste management.
iv. To promote compliance with local and international waste management guidelines in line with best BSBS practices.

2.3. Scope

These guidelines encompass all activities related to laboratory waste management from human, animal, plant, and environmental laboratories in Zambia.

2.4. Target Audience

These guidelines are intended for use by all health and non-health workers involved in the waste management from generation to disposal in human, animal and environmental laboratories.

3. SOURCES AND CLASSIFICATION OF LABORATORY WASTE

3.1. Sources of Laboratory Waste

Laboratory waste refers to waste generated from human, animal, plant, and environmental laboratory activities. This type of waste typically includes materials used in testing, diagnosis, and research. This waste is generated from various sources including but not limited to:

Table 1: Sources and examples of laboratory waste

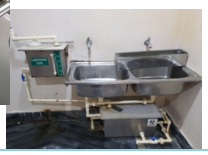
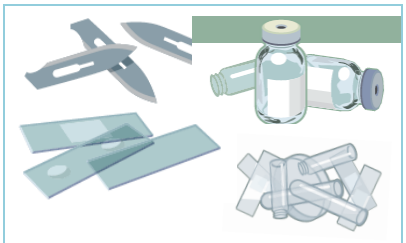
Sources and types of waste in the laboratory	Examples
Specimen This waste is in the form of blood, urine, faecal matter, body fluids, sputum, skin scrapings and tissue biopsies, sewage water, soil, plant material, etc.	  Urine blood
Microbiological Cultures and stocks of agents This waste is in the form of used/discarded cultures and stock agents that are harmful to human, animal, plant, and the environment.	 Culture plates, reference strains.
Discarded contaminated items These are items which are used to inoculate, transfer, or otherwise manipulate cultures or stocks of agents that are harmful to human, animal, plant, and the environment.	  Wire loops and swabs
Laboratory equipment Laboratory equipment generates mixed liquid waste that may be infectious and toxic to human, animal, plant, and the environment.	 Analyser effluent
Liquid waste Remnants and effluent from testing processes and platforms e.g. Guanidinium Thiocyanate (GTC).	 

Table 1: Sources and examples of laboratory waste *(continued)*	
Sources and types of waste in the laboratory	**Examples**
Chemical/Reagents This waste is generated from unused reagents, expired chemicals and residues from diagnostic tests which can be harmful to human, animal, plant, and the environment.	 Laboratory chemicals
Pharmaceutical This type of waste is generated from unused drugs, expired drugs and residues from diagnostic tests which can be harmful to human, animal, plant, and the environment.	 Drugs
Sharps Laboratories generate sharp wastes including needles, syringes, lancets, etc which are used in testing procedures and specimen collection.	
General waste Non-infectious waste generated from the day-to-day use in the work environment e.g. Paper, office stationery, empty boxes, etc.	

3.2. Classification of Laboratory Waste

The World Health Organization (WHO) refers to healthcare waste as all the waste generated within health-care facilities, research centres and laboratories related to medical procedures.[4] Waste from the laboratory covers a diverse range of categories as illustrated in table below:

Table 2: Categories of laboratory waste	
Class of waste	**Description and examples of hazards**
Infectious Waste 	Waste suspected to contain pathogens such as laboratory cultures, waste from isolation facilities, tissues (swabs), and equipment that have been in contact with infectious materials, humans, animals, or plant. **Hazards:** Risk of Infection and risk of Bioterrorism.
Pathological Waste 	Waste materials that consist of human or animal tissues, organs, body parts, foetuses, and fluids. This type of waste is generated in medical and research settings, particularly during surgeries, autopsies, and other medical procedures. **Hazards:** Risk infection and anaesthetic pollution.
Sharps 	Refers to any medical devices with sharp points or edges that can puncture or cut skin. This category of waste is generated in healthcare settings and includes items such as needles, syringes, lancets, scalpels, infusion sets, knives, broken glass, and broken plastic, used for medical purposes. **Hazards:** Risk of injury and infection.

Table 2: Categories of laboratory waste *(continued)*	
Pharmaceutical Waste 	Waste containing pharmaceuticals. Pharmaceuticals that have expired or unused, and bottles or boxes contaminated by or containing pharmaceuticals. **Hazards:** Risk of toxicity, antimicrobial resistance, carcinogenicity, environmental pollution and contamination
Genotoxic Waste 	Wastes containing substances with genotoxic properties. Waste containing genotoxic chemicals such ethidium bromide, formaldehyde, etc. **Hazards:** Risk of toxicity and carcinogenicity.
Chemical Waste 	Waste containing chemical substances such as laboratory reagents, chemicals that are expired or unused, and solvents. **Hazards:** Risk of toxicity, weaponisation, carcinogenicity, fire hazard, and physical injury such as burns and irritation.
Heavy metals waste 	Waste materials that contain heavy metals such as mercury, lead, cadmium, chromium, and arsenic. Sources include electronic waste, paints, medical equipment, batteries, broken mercury thermometers, etc. **Hazards:** Risk of injury, toxicity, persistence in the environment, and potential to bioaccumulate in living organisms.

Table 2: Categories of laboratory waste *(continued)*	
Pressurised containers 	Waste from pressurized cylinders includes discarded gas canisters, oxygen tanks, aerosol cans, and fire extinguishers. These items are potentially hazardous due to the high pressure and contents they hold. **Hazards:** Risk of fire, explosion, injury, and toxicity.
Radioactive Waste 	Waste containing radioactive substances. Unused liquids from laboratory research, contaminated glassware, packages, or absorbent paper. Urine or excreta from patients treated, or tested with unsealed radionuclides, sealed radionuclide sources, polyacrylamide gels and animal carcasses. **Hazards:** Risk of toxicity and carcinogenicity.
General waste 	Non-infectious waste generated from the day-to-day use in the work environment e.g. stationery, food waste, plastics. **Hazards:** Environmental contamination, air pollution

4. GUIDELINES FOR LABORATORY WASTE MANAGEMENT

4.1. Waste segregation and packaging:

Waste segregation at the point of production into suitable colour-coded packaging is vital to good waste management. It refers to the practice of separating different types of waste materials based on their characteristics, properties, or hazardousness. The Zambia National Health Care Waste Management Plan 2015-2019 has outlined the types of waste and colour-codes for the separation of different types of waste.

- Black for general waste
- Yellow for infectious waste, incinerator ash/sludge and sharps
- Red for highly infectious waste and sharps.
- Brown for pharmaceuticals.

Table 3 shows examples of waste commonly generated in the laboratory environment and their recommended segregation or packaging:

Table 3: Laboratory waste segregation and packaging

A. Toxic Waste

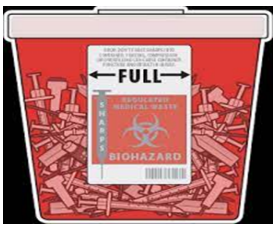
Examples	Packaging requirements
Guanidinium thiocyanate (GTC)	Reagents/Cartridges containing GTC waste should be packed in red Biohazard bags and sealed. The sealed bag should be placed in a leak proof container for disposal.

Recommended practices for toxic waste:

- Treat the toxic waste before disposal if applicable e.g. use of ground charcoal or sawdust to absorb liquid waste before disposal.
- Incinerate at temperatures of 850°C and above or use the precipitation method.

Table 3: Laboratory waste segregation and packaging *(continued)*

B. Sharps

Examples	Packaging requirements
Glass slides, needles, scalpels, blades, broken glassware. etc	Puncture-proof, rigid plastic sharps container, appropriately labelled and colour-coded.  

Recommended practices for sharps:

- Do not mix with non-sharp wastes.
- Do not handle sharp objects with bare hands. Use tongs, dustpans, or similar equipment.
- Sharps container should be located close to the work area.
- Do not re-cap or bend the needles.
- Do not disinfect sharps (e.g. pipette tips) prior to discarding into the sharps box.
- Properly package and label sharp containers for safe handling.
- Dispose of the Sharps containers when three-quarters (¾)full or less or filled according to the manufacture's instruction.
- Report all needle stick injuries.
- Substitute plastic ware for glassware whenever possible.
- Routinely inspect glassware and remove from service items that are damaged, cracked, or chipped.

Table 3: Laboratory waste segregation and packaging *(continued)*

C. Infectious waste

Examples	Packaging requirements
Pasteur pipettes, pipette tips, inoculation buds, vials, etc contaminated with blood and/or other bodily fluids.	Use a yellow bag suitably sealed off once three-quarters (3/4) full or less. 

Recommended practices for infectious waste:

- Do not mix with non-infectious waste.
- Do not handle infectious waste without proper PPE.
- Infectious waste container should be located close to the work area.
- Properly package and label infectious waste containers for safe handling.
- Seal off the infectious waste bin liner when three-quarters (¾)full or less.
- Autoclave infectious waste as required prior to disposal.
- Remove infectious waste from the laboratory at least once a day.

D. Highly infectious waste

Examples	Packaging requirements
Inoculated Culture media, controlled organisms and highly virulent organisms.	Use a red bag suitably sealed off once three-quarters (3/4) full or less. 

Recommended practices for highly infectious waste:

- Do not mix with non-infectious waste.
- Do not handle infectious waste without proper PPE.
- Infectious waste container should be located close to the work area.
- Properly package and label infectious waste containers for safe handling.
- Seal off the infectious waste bin liner when three-quarters (¾)full or less.
- Autoclave infectious waste as required prior to disposal.
- Remove infectious waste from the laboratory at least once a day.

Table 3: Laboratory waste segregation and packaging *(continued)*

E. Pathological waste

Examples	Packaging requirements
Human tissues and organs removed during surgeries, biopsies, or autopsies. Animal tissues and carcasses generated from veterinary procedures or medical research.	Although the fixed tissues are non-infectious, they should be discarded in a yellow-coloured bag, sealed off, and taken for incineration (**Do not discard in a general waste bag**). Unfixed pathological waste such as blood in packs should be disposed of in a yellow bag for incineration. ***Note:*** Fixed pathological waste is not infectious. Unfixed pathological waste is potentially infectious.

Recommended practices for pathological waste:

- This waste should be handled with appropriate PPE.
- When pathological waste is mixed with hazardous chemicals such as fixatives and other harmful chemicals:
  - Decant the fixative into a separate container for disposal as indicated in the safety data sheet (SDS).
  - The remaining tissue and the container should be discarded in a yellow biohazard bag and when three-quarters (¾)- full or less prior to disposal.

Table 3: Laboratory waste segregation and packaging *(continued)*

F. Chemical waste

Examples	Packaging requirements
Unused reagents, expired chemicals, used residuals from diagnostic tests, and pharmaceutical waste.	Tightly sealed corrosion-resistant containers made of materials such as stainless steel, aluminium, strong plastic materials. 

Recommended practices for chemical waste:

- Where possible, improve the management of chemical waste by waste minimization strategies such as substituting highly toxic and environmentally persistent cleaners and solvents with less toxic and environmentally friendly chemicals (refer to annex 2 for steps to identify, compare, and select safer chemical alternatives based on hazards, performance, and economic viability, and annex 3 for the list of safer alternatives to hazardous laboratory reagents).
- Always label containers correctly and never put chemicals in mislabelled containers.
- A Good label will consist of the chemical contents (and brand name if available), expiration date (if known), and the LOT/BATCH number of the chemical.
- A Safety Data Sheet (SDS) describing the hazards of a product and how it must be safely handled, used, stored, and disposed of shall be maintained and accessible for easy reference.
- Chemical waste should be segregated into the different hazard classes, namely, chemical, pharmaceutical, radioactive, genotoxic, cytotoxic waste, as applicable.

  Note: Hazardous chemical waste of different classes should never be mixed.
- A thorough inventory of all chemicals in the laboratory shall be maintained. A record of all disposed chemical waste shall be maintained. An example of such an inventory is indicated in the annex 1.

4.2. Storage of Laboratory Waste

Waste storage is the temporary placement of waste at the point of generation or an external storage site before transportation and/or final disposal. The following criteria should apply in all instances of waste storage:

- The waste storage site (WSS) shall be clearly demarcated and labelled as such.
- The WSS must have sufficient capacity to store all waste according to the unique waste generation profile (in line with agreed collection schedules), and for temporary stockpiling during unforeseen emergencies.
- It should be sheltered, enclosed with a lockable door and round the clock surveillance to protect it from sun, rain, unauthorised access as well as scavenging.
- It should be well ventilated to maintain the lowest possible ambient temperature to combat the potential of odour nuisance and accelerated decomposition.
- The floor of the WSS should be impermeable, slip-resistant, and hard standing to facilitate easy cleaning.
- The WSS should be suitably equipped with a fire extinguisher, a proximal water source to facilitate cleaning and good drainage connecting to the sewer.
- The WSS should be well lit, convenient, and easy to use, and accessible to waste handlers and waste collection vehicles.
- The WSS should be in a location where there is low public presence/passage.
- A staff member responsible for managing and maintaining the WSS should be suitably equipped with the necessary PPE, which should include but not limited to; gumboots, work uniform, elbow-length Polyvinyl Chloride (PVC) gloves or similar alternative, mask, protective eye goggles and an apron.
- Chemical waste of different classes should be stored separately before disposal.
- Laboratories should set standardized storage periods for laboratory waste according to the various categories in line with local and international regulations.

Figure 1. Inappropriate vs appropriate waste storage site

4.3. Transportation of laboratory waste

Waste transportation is the movement of waste from the point of generation to the waste storage and/or disposal site. The general requirements for transportation of laboratory waste are that:

a) It should be done in line with national (ZEMA) and international (Bamako conventions) regulations on the transportation of hazardous waste.
b) All necessary care must be taken to prevent odour nuisance to the neighbourhoods.
c) Where hazardous wastes and other wastes have been mixed, they must be considered hazardous and managed as such.
d) Laboratory waste must be transported directly to the disposal or treatment site within the shortest possible time.
e) Vehicles (trolleys, carts, mobile garbage bins, light trucks) used for transportation of Laboratory waste must be so constructed as to prevent the scattering of packaged wastes, spills, odour nuisance, must be leakproof and must not be used to transport any other materials other than laboratory waste.
f) The transportation should be undertaken according to approved times on approved routes and in approved vehicles with approved biohazard labels.
g) The offsite transporter must provide for the security of the waste and an emergency procedure plan.
h) Waste must not be compacted or subjected to any other treatment that could cause bags or containers to rupture.
i) Labels must be firmly attached to containers so that they do not become detached during transportation and handling.

4.4. Waste treatment and disposal.

Waste treatment and disposal refers to the process of managing, treating, and disposing of waste in a safe and environmentally responsible manner. The goal of waste treatment is to reduce the potential harm that waste can cause to human, animal, plant health and the environment. To achieve the most effective result, thermal and chemical methods are used. Waste disposal methods should ensure the waste's safe disposition and irretrievability. The waste that needs to be disposed of should be treated to a level that minimises or eliminates the hazardous properties. The disposal of waste should guarantee minimal or no impact on human, animal, plant, and environmental health and be performed following existing national legislation.

Table 4: Waste treatment methods		
Treatment Method	**Treatment Technology**	**Waste type**
Thermal	 **A. Autoclave** Autoclaving sterilises material using saturated steam under pressure (moist heat). Autoclaves should be used to sterilise equipment/products prior to use in the laboratory or to render items non-infectious prior to disposal.	All infectious waste e.g. reusable glassware, tongs, forceps, and scissors, etc.
	 **B. Incinerator** Incineration involves the chemical and physical breakdown of waste material through the process of combustion, pyrolysis, or gasification. occurs at temperatures above 850 °C.	All infectious and pathological waste.

Table 4: Waste treatment methods *(continued)*		
Treatment Method	**Treatment Technology**	**Waste type**
Chemical	**Disinfection** Chemical disinfectants are applied to objects and materials, such as surfaces and instruments to control and prevent infection. Examples include dissolved chlorine dioxide, sodium hypochlorite, peracetic acid, lime solution, or dry inorganic chemicals	Obsolete equipment, used materials such as pipettes tips, and applicator sticks.
	Neutralisation Acids must be neutralised by dilution with a base until a pH of 5.5 to 9.5 is achieved.	Sulphuric acid, Hydrochloric acid.
Irradiation	**Ultraviolet (UV) Light:** Involves the treatment of waste using UV sources to destroy pathogens. The effectiveness of pathogen destruction depends on absorbed dose by mass of waste. Irradiation is not commonly used due to its high investment cost.	Infectious waste
Other Methods	**Biodegradation:** Involves using biological enzymes to break down tissues, blood, and other organic materials found in medical waste. Enzymes expedite the decomposition process, converting hazardous biological waste into non-hazardous forms. This method ensures that pathogenic microorganisms are effectively neutralized. **Mechanical method:** Mechanical shredders are employed to reduce the size of pathological waste, including tissues, surgical remnants, and other medical debris. Shredding this waste into smaller pieces not only makes it easier to handle and transport but also enhances the efficiency of subsequent treatment processes such as incineration or chemical disinfection.	Pathological waste

Table 5: Waste disposal methods		
Waste type	**Disposal method**	**Description**
Incinerator ash	**Burial**	Burial disposal practices involve disposal of small amounts of waste material in the ground. If waste is to be buried, it should be done at the designated and approved sites by the competent authorities. The amount of waste to be buried should be limited to avoid pollution of groundwater. If waste is buried on the premises, additional safety measures such as restricting access to the area and preventing siting water sources.
Pharmaceuticals, sharps, glassware	**Encapsulation and Inertisation**	Encapsulation is the process of filling containers with waste, adding an immobilizing material, and sealing the containers. It utilizes either cubic boxes made of high-density polyethylene or metallic drums, which are three- quarters filled with sharps, chemical or pharmaceutical residues. The containers are sealed and placed into landfill sites. Inertisation follows the same procedure to minimize the risk of toxic substances contained in the waste migrating into surface water or groundwater.

Waste treatment and disposal methods have the potential to cause harm and injury and should be implemented using appropriate safety measures.

4.5. Equipment decontamination and disposal

The guidelines here apply to the proper decontamination and disposal of laboratory equipment which has been used in conjunction with or contaminated by hazardous materials such as biological agents (bacteria, viruses), corrosive or toxic chemicals. Equipment that has not been contaminated with or exposed to hazardous materials does not require decontamination.

Examples of laboratory equipment include, analysers, refrigerators, incubators, centrifuges, biological safety cabinets, and chemical storage cabinets. Obsolete equipment that is due for disposal shall be decontaminated for safe removal. If equipment needs to be stored before disposal, all safety considerations shall be made, such as storing it in safe and designated places. Equipment should not be stored in corridors as it poses injury hazards.

4.5.1. Equipment Decontamination

This is a process or treatment that renders a laboratory instrument or device safe to handle. Appropriate PPE commensurate with the risk assessment shall be worn when decontaminating equipment. Decontamination records for all obsolete equipment shall be maintained and retained as per the laboratory's procedure.

The following are ways in which decontamination can be achieved:

a. **Disinfection** – Treatment by a liquid chemical to eliminate all pathogenic microorganisms, except bacterial spores on equipment. Its effectiveness is influenced by the type and numbers of organisms, the amount of organic matter, the equipment to be disinfected, and exposure time to the chemical, temperature, and concentration. The disinfection procedures will depend on the risk assessment. Biological safety cabinets used for Risk Group 2 or higher infectious agents, human or animal derived materials of unknown risk group must undergo full gaseous decontamination.

b. **Sterilisation** – this uses physical or chemical procedures to destroy pathogens, including endospores. There shall be documented procedures for sterilisation at the facility level. Decontamination procedures shall be based on a documented risk assessment and written instructions.

4.5.2. Equipment Disposal

Disposal of public assets is guided by the Public Finance Management Act No. 1 of 2018. The disposal process has been decentralised to Ministries, Provinces, and Spending Agencies. The details of all disposed equipment shall be maintained in an Asset Register.

4.6. Waste management outside the laboratory setting

Testing may occur outside the laboratory settings such as field work. The waste generated should be treated to ensure it is rendered non-infectious and inaccessible to the general population, thereby preventing intentional access and the spread or retransmission of infectious diseases.

A unique challenge in disease outbreaks and other emergency settings is the potential for a significant increase in workload, the volume of waste produced, the occurrence of spillages, and staff fatigue. These factors collectively heighten the risk of errors and injuries, making effective waste management and safety protocols crucial.

In addition to the already outlined guidelines, the following are recommended in disease outbreaks and other emergency settings:

a) Set up hand wash stations in community settings.
b) Ensure that hygiene promotion activities/waste management training is part of the established infrastructure and practice.
c) Treat infectious waste before transportation for disposal.
d) Fence off waste storage areas from the public in community settings where outbreak centres have been established away from structured laboratory facilities.
e) Due to the high quantity of waste generated in these settings, waste storage sites, collection containers, and transport modes should frequently be disinfected and cleaned with appropriate disinfectant.
f) Use safe means of transportation of waste to offsite treatment and disposal sites.
g) A system for off-site treatment/disposal options such as incineration should be established.
h) Open dumping or open burning must be avoided as it poses a potential health hazard for waste scavengers, environmental contamination, emission of dioxins, furans, and particulate matter.

5. TRAINING IN WASTE MANAGEMENT

All staff working in the laboratory and any person that interacts with laboratory generated waste should be trained before handling laboratory waste. The training package should be structured and tailored to also meet the Biosafety and Biosecurity requirements of the laboratory. Periodic refresher training should also be conducted at least on an annual basis to update staff knowledge on waste management practices. Laboratory staff should participate in the establishment of a safety committee in the local workplace and actively participate in implementation of surveillance systems through risk management and use of data to prevent potential/further injuries and spread of infections.

The scope of training should cover but not limited to the following topics:

a) Sources and characteristics of laboratory waste
b) National regulations on hazardous waste
c) Overview of Biosafety and Biosecurity Principles
d) Occupational health (Including but not limited to vaccination, personal protective equipment (PPE), post-exposure prophylaxis (PEP))
e) Classification, segregation, and labelling of laboratory waste.
f) Storage and transportation of laboratory waste
g) Treatment and disposal methods
h) Management of all classes of waste
i) Contingency and management of waste spills
j) Infection prevention

Trainers in waste management should receive a structured Trainer of Trainers (TOT) training for them to offer a standard and auditable training. Records of staff trained in waste management should be centrally retained and available to managers and regulators on request.

6. OCCUPATIONAL HEALTH AND SAFETY

Laboratory waste management plays a pivotal role in safeguarding the occupational health and safety of healthcare workers involved in laboratory activities and support staff of laboratory waste, as well as in promoting Biosafety and Biosecurity measures. Proper management of laboratory waste not only ensures compliance with regulatory standards but also minimises exposure to hazardous materials, thereby reducing the risk of occupational illnesses and injuries among laboratory personnel. Here are key considerations for promoting occupational health and safety within laboratory waste management practices:

a) **Training and Education:** Comprehensive training programs should be provided to laboratory personnel on waste management practices as required by existing guidelines and regulations.

b) **Waste Minimization and Recycling:** Encouraging waste minimization strategies, such as reducing unnecessary packaging and optimising reagent usage, helps minimise the volume of laboratory waste generated. Implementing recycling programs for non-hazardous materials promotes sustainability while reducing waste disposal costs.

c) **Monitoring and Compliance:** Regular audits and inspections of laboratory waste management practices to ensure compliance with applicable regulations and internal policies. Monitoring occupational health indicators, such as injury rates and exposure incidents, helps identify areas for improvement and implement corrective actions to protect workers' well-being and enhance Biosafety and Biosecurity.

Table 6: Occupational Hazards of Laboratory Waste		
Hazards	**Health Effects**	**Control Measures**
Sharps	Injuries resulting in exposure to blood borne pathogens such as: Hepatitis B or C, HIV, human African Trypanosomiasis (HAT) or other blood borne infections	• Immunisation such as hepatitis B virus etc. • Appropriate disposal of sharps. • Use of engineered needles that automatically retract, blunt re-sheath, or disable the sharp. • Use appropriate PPE.
Other biological hazards	SARS, Tuberculosis, Influenza, anthrax, and rabies etc.	• Exhaust ventilation (natural or mechanical. • Standard precautions; Respiratory protection with N95, FFP3 respirators for high-risk cough-inducing procedures and other appropriate PPE • Treatment of laboratory waste in the laboratory before disposal.
Chemicals: Chlorine disinfectants (sodium hypochlorite)	Skin and respiratory sensitization, Eye and skin irritation, weakness, exhaustion, drowsiness, dizziness, numbness, and nausea	• Avoid soaking of sharps in chlorine. when they will receive autoclaving or incineration before disposal as the chlorine can produce toxic gases such as dioxins and furans. • Dilute chemicals appropriately according to the manufacturer's instructions for less toxic exposure. • Use appropriate PPE.

Table 6: Occupational Hazards of Laboratory Waste		
Hazards	**Health Effects**	**Control Measures**
High-level disinfectant glutaraldehyde	Irritation of the eyes, nose, throat and Skin sensitization. Occupational asthma where the symptoms in affected individuals include chest tightness and difficulty in breathing.	• Substitute with steam sterilisation except for pressure sensitive instruments. • Ensure appropriate dilution and use in closed, ventilated systems. • Use appropriate PPE.
Sterilant: ethylene oxide	Eye and skin irritation, difficulty breathing, nausea, vomiting, and neurological problems. Reproductive hazards linked to nerve and genetic damage.	• Substitute with steam sterilisation for ethylene oxide except for pressure-sensitive instruments. • Use only in a closed and ventilated system. • Use appropriate PPE.
Heavy lifting and handling heavy loads over long periods	• Back injuries and musculoskeletal disorders. • Degenerative diseases of the lumbar spine	• Reduce mass of objects or number of loads carried per day. • Use waste carts with wheels, automated waste transfer from cart to truck and treatment. • Use lifts and pulleys to assist in transferring loads. • Use appropriate PPE.

Adapted from the World Health Organization (WHO). Safe management of wastes from health-care activities, 2nd Edition. (2014).

By integrating **occupational health** considerations into laboratory waste management practices, healthcare facilities can create a safer and healthier work environment for laboratory personnel while promoting environmental sustainability and regulatory compliance.

5.0. Responsibilities of stakeholders

Managing laboratory waste is important and steps must be taken to assign roles and responsibilities to be mediated by various stakeholders. The roles and responsibilities of various stakeholders are indicated below.

Stakeholder	Role
Ministry responsible for health	Developing policies and guidelines for laboratory waste management and providing the necessary facilities for safe handling, storage and disposal of laboratory waste.
Ministry responsible for local government	Promoting sanitation and environmental health by developing policy and infrastructure development and providing facilities for waste management.
Ministry responsible for Infrastructure	The Ministry has the mandate to manage all public assets, in accordance with Gazette Notice No. 836 of 2016. It has the responsibility to keep an inventory of all government assets and determine the condition of equipment earmarked for disposal.
Ministry responsible for finance	It is responsible for authorising the disposal of obsolete equipment in accordance with the Public Finance Management Act No. 1 of 2018. This Act mandates the institutional management (Ministries, Provinces, and Spending Agencies) to establish a committee that will be responsible for verifying and processing obsolete equipment for disposal.
Zambia Environmental Management Agency (ZEMA)	ZEMA licences the generation, storage, transportation, and disposal of hazardous waste. In addition, they monitor compliance to waste regulations and practices.
Waste generator	Under Duty of Care of the Environmental Management Act Number 12 of 2011 of the Laws of Zambia, everyone including but not limited to public and private health facilities and laboratories, who produces, imports, stores, transports, treats or disposes of waste must take all reasonable steps to ensure that waste is managed properly from the point of generation to disposal.

7. MONITORING AND EVALUATION MATRIX

Objectives	Key Performance Indicators
i. To provide guidance on processes to reduce the quantity and hazardousness of laboratory waste to minimise potential risks posed by biological agents, toxins and chemicals.	• Number of Laboratories with Waste Management Guidelines. • Number of laboratories adhering to the waste management guidelines. • Reduction in the volume of hazardous waste generated, through reuse, recycling, and minimization strategies.
ii. To safeguard the health and safety of humans, animals, plants and the environment through proper waste generation, storage, transportation, and disposal procedures.	• Number of laboratory staff trained on WM Guidelines. • Proportion of laboratories conducting waste segregation and labelling as per laboratory waste management Guidelines. • Decrease in incidents related to improper waste management (spills, injury, etc.).
iii. To promote environmentally sustainable methods of laboratory waste management.	• Waste management trainings conducted for laboratory staff. • Increased awareness and adherence to waste management best practices among laboratory personnel.
iv. To promote compliance with local and international waste management guidelines in line with best BSBS practices.	• Number of laboratory waste management audits conducted. • Number of laboratories compliant with the waste management guidelines out of the total number of laboratories. • Number of cascaded trainings at district and provincial levels.

REFERENCES

1. Laboratory biosafety manual, fourth edition and associated monographs).
2. Chartier, Y.Jorge Emmanuel, Ute Pieper, Annette Prüss, Philip Rushbrook, Ruth Stringer, William Townend, Susan Wilburn and Raki Zghondi. (2014). *Safe management of wastes from health-care activities*. World Health Organization
3. Chisholm JM, Zamani R, Negm AM, Said N, Abdel Daiem MM, Dibaj M, Akrami M. Sustainable waste management of medical waste in African developing countries: A narrative review. Waste Manag Res. 2021 Sep;39(9):1149-1163. doi: 10.1177/0734242X211029175. Epub 2021 Jul 3. PMID: 34218734; PMCID: PMC8488638.
4. Kenny, C., & Priyadarshini, A. (2021). Review of Current Healthcare Waste Management Methods and Their Effect on Global Health. *Healthcare (Basel, Switzerland)*, *9*(3), 284. https://doi.org/10.3390/healthcare9030284
5. Leonard CM, Chunga CC, Nkaama JM, Banda K, Mibenge C, Chalwe V, Biemba G, Chilengi-Sakala S, Mwale FK. Knowledge, attitudes, and practices of health care waste management among Zambian health care workers. PLOS Global Public Health. 2022 Jun 22;2(6):e0000655.
6. Ministry of Health (MOH) Zambia. National Health-Care Waste Management Plan 2015-2019.
7. World Health Organization (WHO). Safe management of wastes from health-care activities, 2nd Edition. (2014).
8. Zambia Waste Management Project Report Summary 2019-2021, APHL

ANNEXES

Annex 1: Example of Chemical waste inventory

S/N	Chemical name	Quantity (specify units e.g. Litres, ml, kg)	Waste characteristics (e.g. corrosive, flammable)	Physical nature (solid, liquid, gas, mixed)	Recommended disposal method (Refer to SDS)	Reason for disposal
1	*Methylene Blue*	*500g*	*toxic*	*solid*	*Incineration*	*Expired*
2	*Formalin*	*5Litres*	*corrosive*	*Liquid*	*Incineration*	*Used*

Annex 2: Seven-step process to follow when choosing safer alternative chemicals.

1	Form a team to develop a plan for making the transition to a safer chemical.
2	Examine current use issues, including the purpose of each chemical, the hazards associated with its use, and if it is necessary to the process or product.
3	Identify alternatives that have been used in similar applications. Determine if any material or process changes could replace the use of the hazardous chemicals.
4	Assess and compare alternatives, looking at hazards, costs, and the performance of alternatives.
5	Select safer alternatives, examining the pros and cons of each substitution as it affects hazards, performance, cost, and environmental impact.
6	Pilot the alternative. OSHA recommends applying the alternative on a small scale and testing the results.
7	Implement and evaluate the alternative. Look at the impact on safety and health, efficiency, and performance.

Annex 3: **List of safer alternatives to some hazardous laboratory reagents.**

Hazardous chemical	Hazard associated with chemical	Use	Alternative substitutes
Ethidium Bromide	Carcinogen/ Teratogen	Staining of nucleic acids	Gel Green, Gel Red, SYBR Safe, Safe GLO, Gel Star
Xylene	Irritant to the nose, skin, and throat	Histopathology Clearing agent	Simple alcohols and ketones
Formalin	Carcinogen	Histology fixation	Histon-Fix, Mirsky's Fixative, Shandon Glyo-FixxTM, Uni-Fix (TM),
Phenol	Irritant and poisonous	MTB diagnosis Disinfectant	Cardinal, Lignin Tannin
Glutaraldehyde	Irritant, Carcinogen	High level disinfection	Hydrogen peroxide, peracetic acid and Alcohol
Chloroform	Toxic, Irritant and Carcinogenic	Solvent and Fumigation	methylene chloride
Dioxane	Irritant, Carcinogen	Dehydrate tissue and prepare slides for microscopy	Tetrahydrofuran
Mercury Thermometers:	Corrosive to the skin	Temperature measurement	liquid (alcohol), metal, or digital thermometers
Acetone	Irritant and Fire Hazard	Solvent, cleaner	Methyl Acetate

Annex 4: Colour coding for waste receptacle

Colour coding guide		
Types of waste	**Colour code**	**Type of receptacles**
General waste		
General	Black	Plastic bag of appropriate size
Infectious waste		
Sharps	Yellow	Puncture-resistant containers
• Patient waste • Culture /specimen • Pathological /organic Human Tissues, Animal and Plant.	Yellow	Plastic bags and containers
Highly infectious waste		
Highly infectious	Red	Plastic bags and containers
Pharmaceutical Waste		
Pharmaceutical waste	Brown	Plastic bags and containers

Annex 4: Colour coding for waste receptacle *(continued)*

Colour coding guide		
Types of waste	**Colour code**	**Type of receptacles**
Miscellaneous laboratory waste		
Acids		Polyethylene or polypropylene containers with label
Alkalis		High-density polyethylene (HDPE) containers with label.
Solvents		Glass or solvent-resistant plastic containers with label.
Organic substances		Polyethylene or polypropylene containers with organic substance's label
Heavy metal (e.g. mercury)		Stainless steel, high-density polyethylene (HDPE), polypropylene containers with label heavy metal's label
Incinerator Ash/Sludge		Metal containers labeled "sludge" "ash"

Annex 5: Waste Management Legal Framework

National

- The Public Health Act, Cap 295 of the laws of Zambia
- The Environmental Management Act No. 12 of 2011
- Environmental Management (licensing) Regulation (Statutory Instruments No. 112 of 2013)
- Medicines and Allied Substances Act No. 3 of 2013
- Ionizing Radiation Protection Act No.19, of 2011
- Local Government Act No. 2 of 2019
- Animal Health Act No. 27 of 2010
- Solid Waste Regulation and Management No. 20 of 2018
- The Plant Pests and Diseases Acts Chapter 233 of the Laws of Zambia

International Conventions

- The Stockholm convention on Persistent Organic Pollutants
- The Basel Convention Bamako Convention
- Minamata convention Biological Weapons Convention


Laboratory waste management
is everyone's responsibility.
Do your part now.