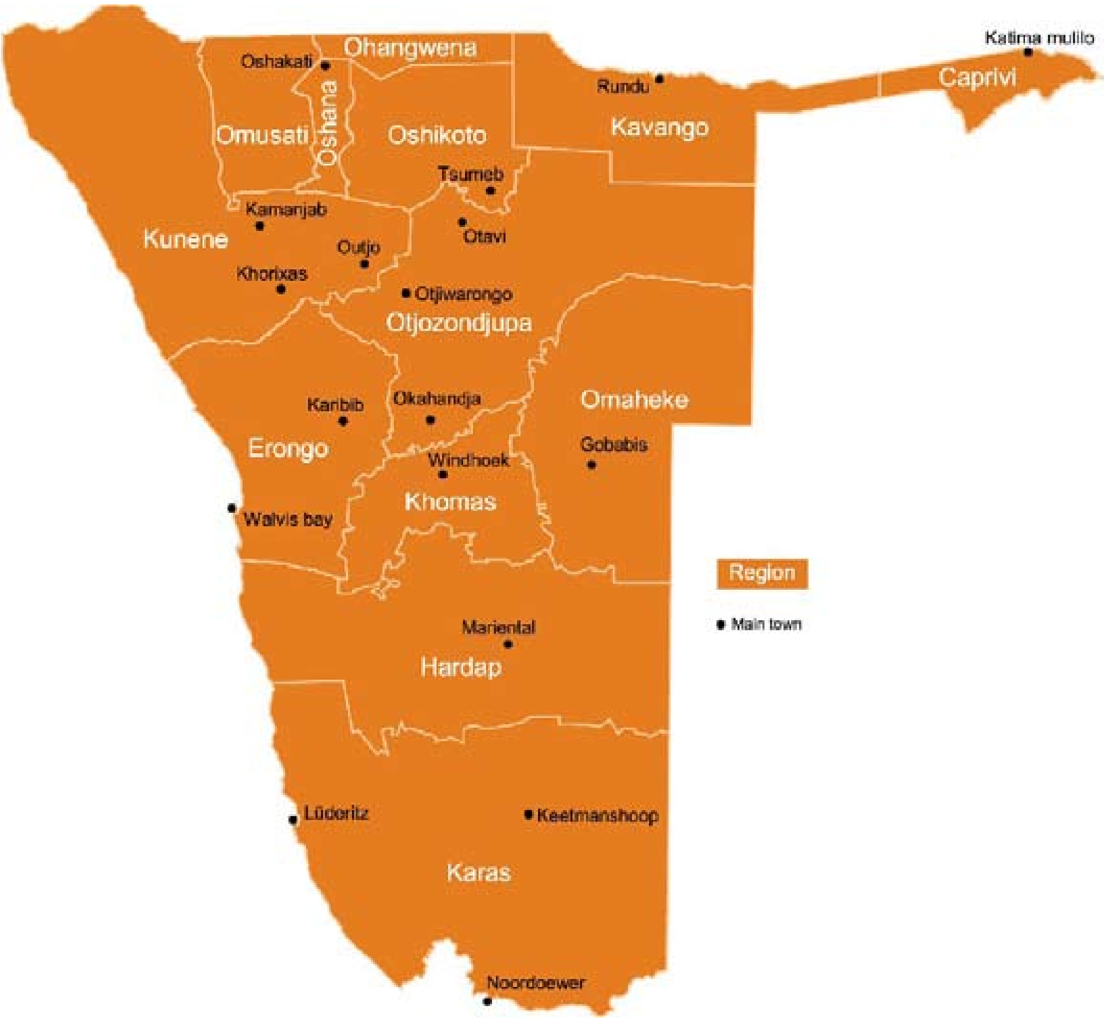
Republic of Namibia



Integrated Health Care Waste Management Plan

Acknowledgements

These guidelines would not have been successfully completed without the support and valuable participation of individuals from various governmental and non-governmental organizations who contributed to the development and finalization of this document. Special thanks go to the participants from MOHSS's Division of Quality Assurance, Division of Public and Environmental Health Services, Occupational Health Services, and University Research Co. LLC (URC) under USAID funded Medical Injection Safety Project and Health Care Improvement Project; and representatives from public and private hospitals who took part in the 2010 workshop to update the guidelines.

The guidelines are part of a dynamic process and undergo periodic review. They are intended to complement the National Waste management Policy issued in 2011.

The financial and technical support for the development of this plan was provided by the American people through the U.S. Agency for International Development (USAID) and its Bureau for global Health, Office of Health and Mission in Namibia. The support was provided under the USAID Health Care Improvement (HCI) Project, which is managed by URC under the terms of contract No. GHN-I-01-07-00003-00.

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Preface

Health care waste (HCW) can be defined as: all the waste generated in a health care setting. Waste that is dangerous and hazardous to either a person's health or the environment is referred to as Health Care Risk Waste (HCRW).

Improper management of HCRW can have direct and indirect negative impacts on patients, health care workers, local communities and the environment.

The goals of proper HCRW management are:

- To protect patients and health workers from hazards associated with healthcare waste,
- To protect the public from the hazards associated with HCRW, and
- To protect the environment

Management of HCW requires a multidisciplinary approach and each health administrative level at the national, regional and district has a role to play to ensure proper waste management. In addition, there is need to involve other stakeholders, partners and line ministries.

It is therefore crucial that each institution, small or large generating HCRW has a management plan and establishes an appropriate infrastructure and mechanisms to manage HCRW.

The main aim of Integrated Waste Management Plan (IWMP) is to provide the information to allow health care facilities to establish a good healthcare waste management system consistent with the regulatory requirements of Namibia.

To achieve proper waste management requires proper planning, staff training, procurement of necessary commodities, waste minimization; proper waste segregation; handling and collection; proper waste storage; transport; treatment and disposal.

The IWMP describes the roles and responsibilities of individuals and institutions related to health care waste management.

The development of this IWMP was based on a review of a number of documents from various sources with assistance of a consultant contracted by University Research Corporation (URC).

The implementation of IWMP will be in different phases: short term (<2 years) and medium (2-5 years) All relevant stakeholders should ensure proper implementation of this plan. The IWMP shall be reviewed after 5 years.

I wish to congratulate all those health care workers, stakeholders in particular: the Division Public and Environmental Health Services; Division Quality Assurance; Regional Health Management Teams; and National Health Training Centre for their contribution towards the development of this IWMP. My sincere and profound thanks is extended to the Chief of Party for University Research Corporation, Dr. Aziz O Abdallah, and the team for their technical and financial assistance.

Mr. A. Ndishishi
Permanent Secretary
Ministry of Health and Social Services

Abbreviations and Acronyms

BAT	Best Available Techniques
CBO	Community Based Organizations
CDC	Constituency Development Committee
CoW	City of Windhoek
CSO	Civil Society Organizations
EHP	Environmental Health Practitioner
EIA	Environmental Impact Assessment
HBV	Hepatitis B virus
HCF	Health Care Facility
HCV	Hepatitis C Virus
HCGW	Health Care General Waste
HCRW	Health Care Risk Waste
HCW	Health Care Waste
IAEA	International Atomic Energy Agency
IEC	Information, Education and Communication
IHCWM	Integrated Health Care Waste Management
IWMP	Integrated Waste Management Plan
LA	Local Authorities
MAWF	Ministry of Agriculture, Water and Forestry
MET	Ministry of Environment and Tourism
MLSW	Ministry of Labor and Social Welfare
MME	Ministry of Mines and Energy
MOD	Ministry of Defense
MOF	Ministry of Finance
MOHSS	Ministry of Health Social Services
MRLGHRD	Ministry of Regional Local Government, Housing and Rural Development
MSS	Ministry of Safety and Security
MTI	Ministry of Trade and Industry
MWTC	Ministry of Works, Transport and Communication
NGO	Non-Governmental Organization
PMO	Principal Medical Officer
POP	Persistent Organic Pollution
PPE	Personal Protective Equipment
QC/QA	Quality control and Quality Assurance
SANS	South Africa National Standards
SEA	Strategic Environmental Assessment
SME	Small and Medium Enterprises
SWM	Solid Waste Management
SWMP	Solid Waste Management Plan
UN	United Nations
URC	University Research Corporation
VDC	Village Development Committee
WHO	World Health Organization
WIS	Waste Information System

1. Introduction

The development of this Integrated Waste Management Plan (IWMP) for Namibia was based upon a review of a number of documents with major sources of information and data being:

- Ministry of Health and Social Services: National Waste Management Policy , July 2010
- Ministry of Health and Social Services – Draft Health Care Waste Management Guidelines, 2010
- Health Care Risk Waste (HCRW) Strategy & Plan – City of Windhoek, Department of Infrastructure, Water, and Waste Management, 2009

1.1 Health Care Risk Waste Management Overview

Improper management of Health Care Risk Waste (HCWR) can have direct or indirect negative impacts on patients, health workers, local communities, and on the environment. This waste poses biological, physical, chemical, and/or radiological hazards to those involved in their handling, treatment, and disposal. The waste is a public health risk when persons in the community, including children, come in contact with untreated health care waste (HCW). In addition, improper treatment methods can result in public health problems and pollute the environment.

Injuries involving needles and other sharps waste are the most common sources of combined physical and biological hazards associated with the waste. The World Health Organization (WHO) estimated that in 2000, injections with contaminated syringes caused:[1]

- 21 million hepatitis B virus (HBV) infections
- 2 million hepatitis C virus (HCV) infections
- 260,000 HIV infections.

Of these figures, injuries from contaminated needles and other sharps waste represented a particular threat. In 2000, an estimated 39% of health workers with hepatitis C, 37% of health workers with hepatitis B, and 4.4% of health workers with HIV were attributed to percutaneous injuries.[2]

Exposure to blood splashes is another way that blood borne pathogens are spread. Workers handling HCW could develop HIV due to blood splashes.[3] Broken cultures and stocks from clinical laboratories can release pathogenic aerosols (small droplets suspended in air), which can spread disease. This is how waste workers were found to have accidentally contracted tuberculosis in one documented case study.[4] Toxic chemicals, such as mercury and formaldehyde, from health care facilities can contaminate the soil, air, and groundwater and cause health problems to communities. The most vulnerable are scavengers, who pick waste from uncontrolled dumpsites.

1 "Safe health care waste management," policy paper, World Health Organization, Geneva, Switzerland, August 2004.

2 A. Pruss-Ustun., E. Rapiti, and Y. Hutin, Am. J. Ind. Med. 48(6): 482-90, December 2005.

3 "The Public Health Implications of Medical Waste: A Report to Congress," Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services, Atlanta, Georgia, September 1990.

4 Centers for Disease Control and Prevention. Guidelines for preventing the transmission of Mycobacterium tuberculosis in health-care facilities. *Morb Mort Weekly Rpt*, 1994, 43:RR-13.

Today, there is a greater recognition worldwide that HCW must be managed properly. For example, WHO has issued policy documents recognizing the importance of proper HCW management.[5] Namibia is a signatory to the Basel Convention on the Control of Transboundary Movements of Hazardous Waste and their Disposal, and to the Stockholm Convention on Persistent Organic Pollutants. Both have guidelines which incorporate proper HCW management. Many countries have developed laws and regulations dealing with HCW. Many of these laws are based on one or more of the following fundamental principles:

- **Duty of Care principle:** Any person or organization generating or handling HCW is morally responsible to take care of the waste while under their responsibility.
- **Precautionary principle:** If the outcome of a potential risk is suspected to be serious, but may not be accurately known, it should be assumed that this risk is significant; this obligates HCW generators to operate a good standard of waste collection and disposal, as well as to provide personal protection for their staff.
- **Cradle to Grave responsibility:** Parties that generate and handle waste is morally responsible for their waste from the point of generation until its final disposal.
- **Polluter Pays principle:** Waste producers are legally and financially responsible for the safe and environmentally sound disposal of their waste.

The goals of proper HCRW management are:

- To protect patients and health workers from the hazards associated with HCW
- To protect the public from the hazards associated with HCRW
- To protect the environment.

In keeping with these goals, the waste hierarchy (**Figure 1**) will be used as a guiding principle applied within IHCWM plan.

Figure 1

[5] See, for example, "Health care waste management," policy analysis, World Health Organization, Geneva, Switzerland, April 2005; and "Safe health care waste management," policy paper, World Health Organization, Geneva, Switzerland, August 2004.

1.2 Basic Concepts Regarding HCW

Figure 2 shows the different types of waste that may be generated in a health care facility (HCF). The larger facilities generate a greater amount and diversity of the waste stream.

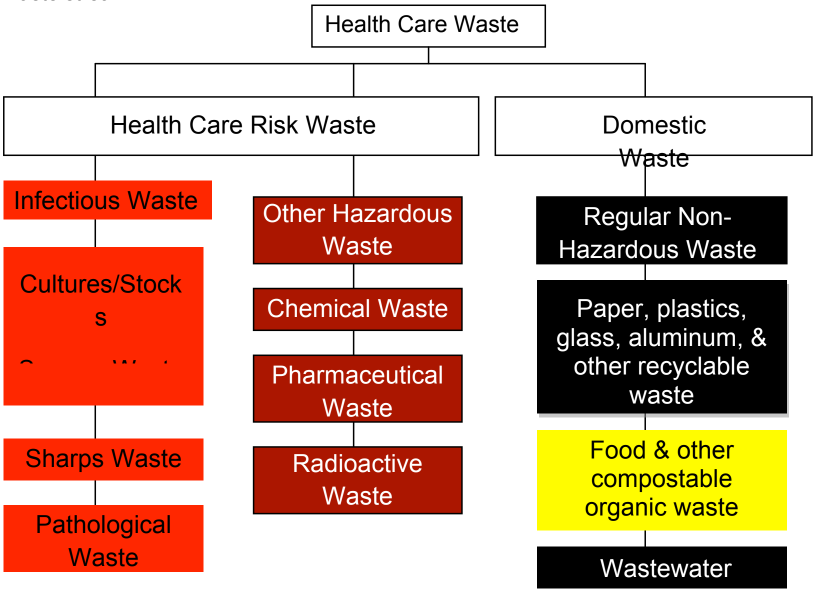

Figure 2

85% to 95% of the waste produced by HCF is non-risk or general domestic HCW, comparable to regular waste produced in homes, restaurants, hotels, and offices. Domestic waste comes mostly from the administrative, housekeeping, and yard cleaning functions of healthcare facilities. The remaining 5% to 15% of HCW is regarded as hazardous and may create a variety of health risks as noted above. However, when waste is poorly segregated and mixed with domestic waste, the percentage of hazardous HCW is much higher. The lack of a waste minimization program inflates the amount of HCW produced. Therefore, as described in this plan, segregation and waste minimization are essential principles of HCW management.

A typical hospital that segregates its waste produces about 85% domestic waste, 10% infectious waste including sharps and pathological waste, and 5% chemical, pharmaceutical, and other hazardous waste, as shown in the **Figure 3** below.

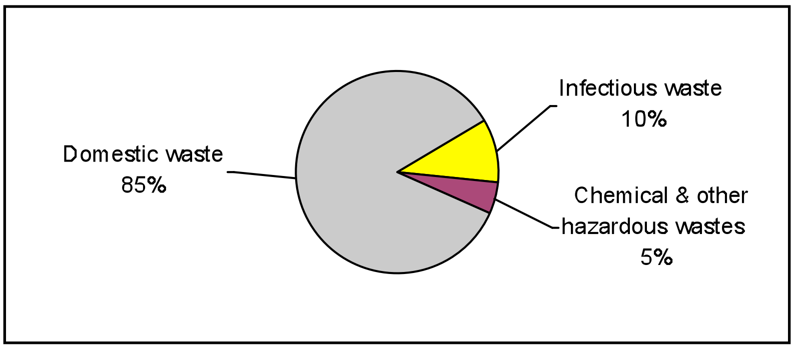

Figure 3

This national IWMP provides the information to allow HCF to establish a good HCW management system consistent with the regulatory requirements of Namibia. Among the major obstacles to good HCW management are bad attitudes or situations that need to change, such as:

- Some health care workers are unaware of risks associated with HCW
- Decision-makers are unaware of risks and put a low priority on HCW management.
- Decision-makers do not allocate adequate resources for HCW management
- No one knows or wants to know what happens to HCW.
- Some facilities do not have a plan for HCW management and training.

These IWMP describes the roles and responsibilities of individuals and institutions related to HCW management; the organizational structure required; procedures for HCW assessments; development of HCW management plans; classification of HCW; recommended practices for segregation, waste minimization, handling, collection, storage, transport, treatment, and disposal of HCW; contingency planning; training; public education; monitoring, evaluation, and corrective action; procurement and budgeting; and special considerations for small facilities, as well as off-site transportation and centralized treatment.

2. Legislation

Legislation is the necessary enabling medium for the regulation of HCW Management.

National legislation and regulations on HCW should comply with international regulations established by multilateral environmental and waste agreements or international institutions. The following are the major international regulations relevant for HCW management.

Namibia is a co-signatory to the following conventions:

a) **Basel Convention:** Adopted in 1989 in response to concerns about toxic wastes being dumped in developing countries, entered into force May 5, 1992. It prescribes the notification of transboundary movements of waste.

The Basel Convention makes specific reference to control of special HCW: sharps, pathological infectious waste, hazardous chemical waste, and pharmaceutical waste and includes the following waste categories that specifically refer to HCW:

- Clinical wastes from hospitals, health centers, and clinics.
- Wastes from the production and preparation of pharmaceutical products
- Pharmaceutical waste
- Waste from the production, formulation and use of biocides and phyto-pharmaceuticals

The Basel Convention has been signed by more than 100 countries. Namibia has accepted the principal that the only legitimate transboundary shipments of hazardous waste are exported, where the country lacks the facilities or expertise to dispose of the waste categories. This is applicable to the transportation of radioactive waste from Namibia to South Africa. Because suitable facilities are not available in Namibia, provided that the radioactive waste is labelled, temporarily stored and transported according to the United Nations (UN) recommended standards.

b) **Rotterdam Convention:** Prescribes the *Prior Informed Consent* procedures for certain hazardous chemicals and pesticides in international trade. Adopted in 1998, entered into force on February 24, 2004.

c) **Stockholm Convention:** Emphasizes the restriction and elimination of on persistent organic pollutants (POPs), especially the disposal of industrial and medical chemicals. It also provides information for future establishments to re-use, reduce and recycle waste with environmental friendly technologies e.g. autoclaving. It was adopted in 2001, and entered into force on May 17, 2004.

<u>**International Atomic Energy Agency (IAEA)**</u>

The IAEA is an autonomous intergovernmental organization within the UN system. The organization provides advice to member states on nuclear power development, health and safety, radioactive waste management, legal aspects of atomic energy, and prospecting for and exploiting nuclear raw materials. The agency has developed safety standards in the area of pre-disposal of hazardous waste, which includes collection, handling, treatment, conditioning, and storage of radioactive waste.

National Legislations

There are legislations in place that deal with aspects of hazardous waste management; however, some are outdated. These legislations span across several Government Departments leading to a very fragmented, ineffective approach and the weak enforcement of the present legislation. The *Pollution Control and Waste Management Bill* is not yet enforced, but it is a legislation that aims to regulate the treatment of hazardous waste in terms of Environmental Impact Assessment processes

The other pieces of legislation and some proposed draft legislation that will impact and stimulate the management of the HCW within Namibia are listed below in **Table 1**.

Table 1: Summary of enabling Legislation still to be promulgated / put into effect

	Ministry	Legislation	Comments
National and Regional	MOHSS	National Waste Management Policy	Complete
		Draft Public and Environmental Health Bill	Incomplete No specific mention given for HCWM
		Infection Prevention and Control Guidelines March 2010	In force Regulates procedures, safe handling and disposal of infectious materials
		PEP Guidelines November 2010	In force Enforces the administration of PEP incase of accidental exposure to infectious blood and body fluids, as well as in case of rape
		Medicine and Related Substances Control Act 13 of 2003	Enforces disposal of undesirable medicines
		Atmospheric Pollution Prevention Ordinance 11 of 1976	No provision for scheduled processes so excludes incineration No registration certificates required If the Pollution Control and WM Bill is finalized, this act will be repealed
		Public Health Act, 36 of 1919	Require local authorities to control a 'nuisance'. Presently enforced and enacted – but the Act is outdated. Local authorities have little power in enforcing National and Regional Government in complying with this Act; e.g. polluting emissions from the current HCRW incinerator.
National and Regional	MET	Environmental Management Act 7 of 2007	Disposal on an approved site Clearance certificate for certain activities Regulations in April 2008 for SEA and EIA requirements
		Draft Pollution Control and Waste Management Bill, 1999	Would repeal the Atmospheric Pollution Prevention Ordinance and the Hazardous Substances ordinance Pollution control and Waste Management Agency Licenses required for waste transporting, storing, treating and disposal of waste A National WMP and LA's to submit local WMP This bill will need to be finalized and promulgated

	Ministry	Legislation	Comments
National and Regional	MAWF	Water Resources Management Act, 24 of 2004	Water supply to be healthy and safe
		Hazardous Substance Ordinance No. 14, 1974	Enforced
	MWTC	Road Traffic & Transport Act, 22 of 1999	The Regulations are very similar to those of South Africa and also incorporate various South African National Standards (SANS[6]) standards relating to the identification and classification of dangerous goods and substances, as well as the packing and transportation of goods.
	MME/ MOHSS	Atomic Energy and Radiation Protection Act, 5 of 2005	License required for the disposal of radiation source or nuclear material Amended under hazardous substances ordinance Radioactive waste is presently transported across the borders as there is no disposal facility in Namibia
	MLSW	Regulation of Health and Safety of employees at workplace (Labor Act 1992 as amended 2007)	Enforced Occupational Health issues regulated by MOHSS Safety issues regulated by MLSW
	Other	International Health Regulations 2005	Regulates international traffic in as far as introduction of diseases into the country is concerned
Local Authority	CoW	Local Authorities Act, 23 of 1992	Set powers and duties for local authorities to deal with offensive waste material
		Health Regulations 1952	Would be superseded by the Draft Pollution Control and WM Bill
		Street & Traffic Regulations, 1930	Old and partly repealed by Road Traffic and Transport Act, 22 0f 1999 and regulations of 2001

CoW = City of Windhoek

6 SANS 10228:2006 & SANS 10229-1:2005

3. Current Situation in Namibia - Statistics

A comprehensive inventory of all HCFs and their generation rates of HCW have not been conducted. However, from several studies and assessments conducted over the past several years (primarily in the Khomas region) can be extrapolated and provide a baseline data of the current situation in Namibia as described in **Table 2**.

Table 2 - Number of Public Health Facilities in Namibia

Regions	Hospitals	Health Centers	Clinics
Caprivi	1	3	26
Kavango	4	6	40
Erongo	4	2	17
Hardap	2	3	12
Karas	3	3	13
Khomas	2	2	10
Kunene	3	2	24
Ohangwena	3	2	28
Omaheke	1	1	13
Omusati	4	8	42
Oshana	1	4	11
Oshikoto	3	3	19
Otjozondjupa	5	3	17
Total	**36**	**42**	**274**
Total Public Health Facilities			**352**

According to two studies conducted in early 2000 by the Ministry of Environment and Tourism (MET) and the CoW, and desktop review of the Ministry of Health and Social Services (MOHSS) reports, the following were the findings regarding waste management in Namibia:

3.1 Amount of Domestic Waste

The amount of domestic waste generated in Namibia is estimated to be 0.5 kg per capita per day, while that for HCW is 0.6 kg per capita per day. Quantities are expected to rise by 2.5% per annum[7].

The waste management system is evolving. The following waste management technologies are currently being used.

7 Draft document and Action Plan pollution control and Waste Management Program. Ministry of Environmnet and Tourism, May 2000, p.10-11.

3.2 Existing Waste Technologies and practices

In contrast to high waste generation there is no appropriate waste management system. What exist is embryonic. The following waste management technologies are currently being used:

a. Incinerators

Incineration is the current practice used in Namibia for medical/clinical waste disposal. If not managed properly, it can cause harmful substances; such as air pollution and other risks to human and the environment. According to the studies, many incinerators are not of an acceptable standard, lack skilled staff and improper maintenance among others.

b. Burning

Burning is not an advisable method of waste treatment, but if practiced should be under strict supervision. The studies found that majority of Namibian Regions/villages/towns are making use of burning mainly for medical and abattoir waste except the sharps containers that are collected for incineration at the district hospitals.

c. Landfill sites

Although being the most desirable method for final waste disposal only two towns in the country have effective sanitary landfill sites (Windhoek and Walvis Bay).

d. Dumping

Dumping is the most commonly used practice for household, garden, and construction waste (building rubble).

e. Effluent disposal

Sedimentation dams, evaporation ponds, septic tanks and waste stabilization ponds are the most commonly used method of effluent disposal practices. e.g. sewerage system and tailing dams (mines)

f. Hazardous chemical waste disposal

Despite the fact that there exist laws and regulations regarding chemicals, the country has very limited infrastructure and expertise as well as capacity to control these substances at entry points, and obsolete products inside the country. Farmers' Cooperation have direct access to manufactures/ suppliers of pesticides, fertilizers etc and can purchase directly without the knowledge of the government. These problems may lead to serious detrimental aesthetic and environmental impact.

3.3 City of Windhoek Data (2009)

Windhoek is a district within Khomas administrative region with a population of 274,957. There are two state hospitals in Windhoek: Katuturaand Windhoek Central.. These hospitals are also national referral hospitals. There three private hospitals: Medi-Clinic, Catholic and Rhino Park. The Windhoek population is also served by seven state clinics and one private clinic.

Health Care Facilities

According to the MOHSS, the Windhoek health district is serviced by five hospitals (two state and three private facilities) and eight clinics (seven state and one private). In 2008, the combined total number of hospital beds was 2,017, with an average occupancy rate of 85%. The total number of beds is set to increase to 2,112 by 2010. Population to health facility ratios for 2007 can be viewed in **Table 3**.

Table 3: **Windhoek Population – Health Facility Ratio**

Description	Total	Person Per Hospital	Person per Clinic	Beds per 1000 people
Population (2009)	274,957			
Hospitals	5	54,991		
Clinics	8		34696.6	
Beds	2017			2.017

3.4 Rehoboth

Health Care Facilities

The Rehoboth health district is serviced by one hospital and six clinics (five state and one private). According to the MOHSS, the Rehoboth health district services approximately 10% of the region's population. In 2008, the total number of beds in the hospital was 140, with an occupancy rate of 60%. The population to health facility ratios for 2007 can be viewed in **Table 4** below.

Table 4: Rehoboth Population – Health Facility Ratio

Description	Total	Persons Per Hospital	Persons per Clinic	Beds per 1000 people
Population (2007)	6,287			
Hospitals	1	6,287		
Clinics	6		1047.8	
Beds	140			.14

3.5 Okahandja

Okahandja is the only health district from Otjozondjupa region included in this study, because HCW from Okahandja is transported to the state owned incinerator in Windhoek for treatment.

Health Care Facilities

The Okahandja health district is serviced by one state hospital and two state clinics. The Okahandja health district services approximately 13% of the region's population. In 2008, the total number of beds in the hospital was 44, with an occupancy rate of 75%. The population to health facility ratios for 2007 can be viewed in **Table 5**.

Table 5: Okahandja Population – Health Facility Ratio

Description	Total	Persons Per Hospital	Persons per Clinic	Beds per 1000 people
Population (2007)	20,881			
Hospitals	1	20,881		
Clinics	2		10,440.5	
Beds	44			0.044

Table 6 displays the types of health care facilities included within the current study. Compared with the 2001/2002 list, there are 39 less HCFs in the study area. It should be noted that paramedics (two from the previous study) were not included in the current list, as their wastes are disposed of at the respective hospitals and therefore would be included in total waste volumes of the hospitals. The difference in the quantity of HCFs can be attributed to facilities closing or joining larger practices.

Table 6: Health Care Facilities in the Study Area

Description	Total
State Hospitals	4
Private Hospitals	3
Clinics	12
General Practitioners	162
Dentists / Dental Laboratories	46
Vets / Animal hospitals	13
Laboratories	14
Pharmacies	34
Specialists	30
Total	**318**

Quantities of Waste Generated

Figure 5 illustrates the percentage of HCRW (red bags) that each type of HCF contributes to the generation of HCRW in the study area. It was observed that the hospitals produce approximately 80% of the total HCRW generated within the study area.

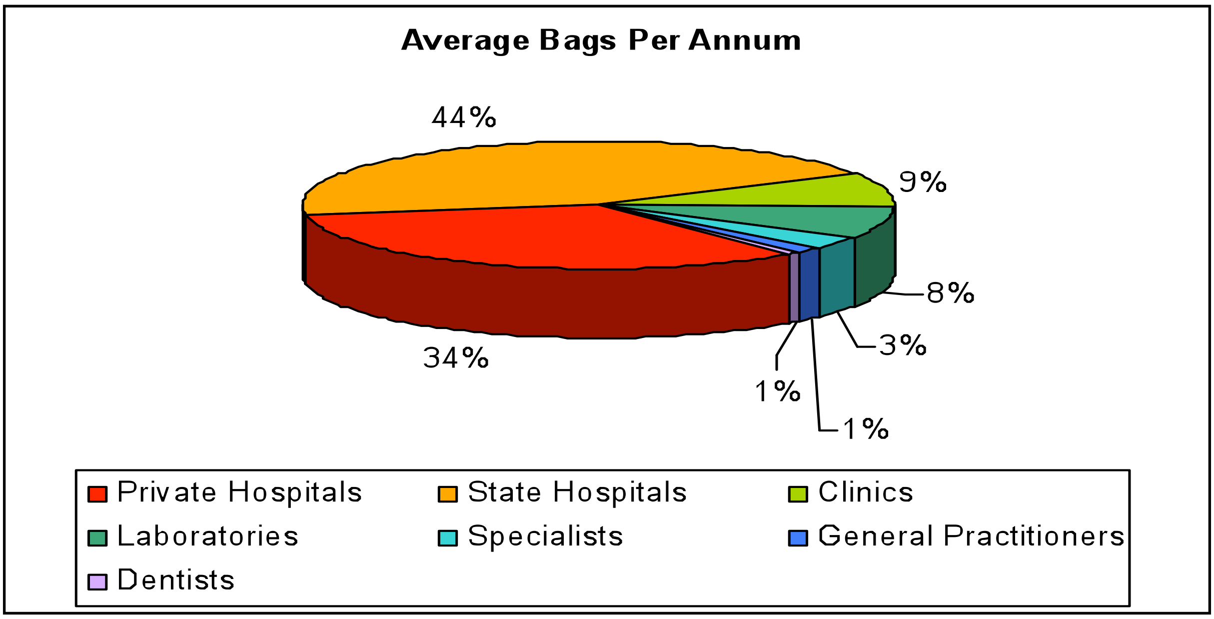

Figure 5: Health Care Facility Category Percentage of HCRW

The primary data obtained from the HCFs does not include a breakdown of the categories of HCW. The data provided was only for the amount of red bags generated and disposed. This makes any further compositional analysis very challenging. In order to try to provide insight into the type of HCW generated in the study area, information from the WHO and South Africa was reviewed. A further aim of understanding the composition of HCW is to understand whether proper segregation is being practiced at the HCFs.

According to the WHO (2000) HCW comprises of 80% of HCGW and 20% of HCRW. The total HCRW generated is further separated into:

- Pathological & Infectious: 75%
- Chemical or Pharmaceutical: 15 %
- Sharps: 5%
- Special (radioactive and cytotoxic): 5%

The above is not conclusive in terms of the HCW generated in the study area. However, it provides an insight into the composition of HCW.

Some additional data was collected from four other locations in Namibia:

Table 7: Other Health Districts HCW Practices

Districts	HCW Generate (kg/week)	HCW Practice
Omaruru	116.5 kg/week	Burned in pit
Swakopmund	2000 kg/week	Incinerated
Usakos	140 kg/week	Incinerated
Walvis Bay	255 kg/week	Incinerated

4. Current HCW Management Practices

4.1 Ward HCRW Storage and Collection

A review of previous documents from 2001 regarding practices compared to current (2011) indicates that management procedures at the ward level have improved (City of Windhoek “a health care risk waste management strategy for city of Windhoek and Municipalities of Rehobotth and Okahandja Final Report, Enviro Solution, Dec. 2000). However, more improvements are required; particularly the need of a consistent standard to be applied for all HCFs regarding appropriate segregation at source and storage.

The following have been identified as key challenges in the storage and collection of waste at a ward level:

- There currently is no limit to the quantity of HCRW placed into one red bag.
- Medical wards are using a variety of containers for the placement of HCW. The National infection Prevention and Control guideline recommends that a receptacle with a suitable pop-up lid is used. This will limit contact with infectious waste.
- Many HCFs displayed relevant good HCRW management practice posters inwards and all facilities. However, it was observed in a few instances that red HCW bags are not securely closed and labelled with the ward of origin, general contents and date. It is very important to have standard system be implemented.
- There is still a challenge of proper waste segregation at the ward level. However, the health care workers have a general understanding that HCW should be segregated in terms of HCGW & HCRW and that sharps must be placed in a designated receptacle.
- HCRW is collected from the wards and sometimes transported in inappropriate trolleys constructed out of metal meshing. After prolonged use, the metal bends and becomes jagged and poses a risk of damaging or tearing the HCRW waste bag. This may, result in the contents being spilling and causing potential health risk to the person transporting the waste to the storage area.

4.1.1 Designated Waste Storage Areas

The study revealed that that these facilities, particularly the State hospitals’ designated waste storage facilities, are poorly managed.

The following were found to be the key challenges:

- In most of the HCFs’ waste storage facilities were suitably locked, or managed. But only one had the relevant Biohazardous signage.
- Lack of suitable central storage areas
- Lack of control over cold storage areas used for HCRW. This has resulted in frequent overcrowding and frequent breakdowns
- Cold storage over capacity
- Lack of Emergency Procedures for example in managing spills

4.1.2 External Collection and Transport

An assessment of the transport methods (public or private) should be conducted. Pick-ups appear to be often used to transport waste. These vehicles should be secured and cleaned after waste has been transported for final treatment/disposal.

Presently it is not compulsory for the waste transporters to register with authorities, hence vehicles for the transport of HCRW do not comply with the SANS requirement for the transporting of HCRW. The following are identified as the bottlenecks:

- Currently, it is not a requirement to weigh waste before it leaves the HCF. This leads to inconclusive data being obtained. Present waste manifest system is not being fully utilised
- Waste is not weighed and accurately recorded before leaving the HCFs
- HCRW leaving the HCFs cannot be tracked. A simple recording procedure prior to the waste leaving the system is a good way to ensure that all HCW is treated and disposed of.

4.1.3 Treatment/Disposal

Incineration

It is observed that the incinerator does not operate at an optimal temperature, i.e. above 800°C. For the incinerators to remain at optimal temperatures, HCRW should be blended, instead of batch fed. HCRW with lower calorific values, such has blood, should be mixed with waste with a higher calorific value. Likewise, due to lack of labelling HCRW at the ward level stating the contents, blending of HCRW may prove to be difficult. Each incinerator is designed with a specific load capacity. For example, the facility located at Katutura State Hospital’s load capacity is 132.5 kg/hr. HCRW received is not weighed at the incinerator before it is loaded; therefore, it is uncertain how the loading is controlled.

The incinerators are not fitted with automatic feeding devices. This and the reduced temperature, increases the risk of the incinerator operator being injured due to vial and ampoules exploding. This is one of the reasons for vials and ampoules being banned from the incinerator.

During the site visits, the incinerator operators were using questionable personal protective equipment (PPE). It also found that HCRW handlers lack training. Furthermore, it was stated during the review that training was only conducted once in 1997. Training is imperative and should be ongoing.

4.2 Disposal

The MOHSS and the 2001 Strategy both recommended the disposal of certain HCRW (e.g. disinfected liquids) and pharmaceuticals to be disposed down the sewer. This practice should stop henceforth.

4.3 HCRW Information System

During the review of current practices, it was identified that HCRW data is incomplete and inconsistent in the study area. Most of the HCFs do not record their HCW data. Also, many of the HCFs that recorded waste data were sporadic, and inconsistent.

Currently, there is no clearly defined standard or control on the generator's activities, handling and storage of HCRW and/or labelling requirements. Furthermore, there is a major gap in terms of the registration or regulation of the generators, transporters and treatment disposal facilities.

4.4 Training and Awareness

Training and awareness is considered vital for the appropriate management of HCW. All facilities visited and consulted, reported that new staff are trained on the facilities infection control policies, which includes waste management. Ongoing training at the facilities varies from every six months to once a year. The designated infection control officers are responsible for providing the required training on HCW management. These officers are aware of the importance of HCW segregation and the consequences related to the lack thereof.

5. Institutional Framework

5. 1 Health Sectors

The MOHSS shall be the central coordination point for this IWMP. In the spirit of decentralization, the institutional framework will fall in the following components as indicated below:

5.1.1 National Level

The MOHSS shall distribute the IWMP to all stakeholders at all levels and shall:

- Integrate waste management into the agenda of the multi-sectoral team on implementation procedures, including organizing training courses;
- Develop and review of legislation, standards, and guidelines on waste management;
- Develop and distribute relevant Information, Education and Communication (IEC) materials on waste management;
- Conduct continuous in-service training on waste management;
- Plan and budget for implementation;
- Collect, analyze, and use data on essential waste management practice;
- Implement tracking and auditing systems to demonstrate that HCW has been rendered safe for reprocessing or destroyed in an environmentally sound manner;
- Mobilize financial and human resources to implement the program;
- Explore alternative methods on waste treatment and consult with relevant stakeholders on ideal places for a disposal site and incinerators;
- Ensure the involvement of training institutions (teaching hospitals and Universities) and inclusion of waste management in health care programs in training curricula.

5.1.2. Regional Level

A multi-sectoral sub-committee shall be established at Regional Level and chaired by the Regional Health Director to:

- Conduct regular meetings to review and monitor the implementation process;
- Coordinate a two-way communication from National and District level on training, communication, and IEC materials;
- Enforce regional waste management guidelines;
- Prepare and present the budget and plans on waste management;
- Distribute the IWMP to all stakeholders at regional and district levels;
- Facilitate and support continuous in-service training on waste management;
- Collect, analyze, and use data on essential waste management practice in the region;
- Establish a permanent position for Environmental Health Practitioner (EHP) at all points of entry;
- Explore alternative methods on waste treatment and consult with relevant stakeholders on ideal places for a disposal site and incinerators;

5.1.3 District Level

- Establish an inter-sectoral committee on waste management chaired by the Principal Medical Officer (PMO) involving community own resources persons:
- Implement policy and guideline on waste management through multi-sectoral committee at district level spearheaded by (EHP);
- Conduct continuous in-service training;
- Prepare and present action-plan and budget for implementation of the IWMP;
- Promote community participation;
- Involve community-owned resource persons as members of the multi-sectoral team;
- Ensure regular maintenance of waste management equipments;
- Establish a permanent position for Environmental Health Practioner at all points of entry.

5.1.4 Intermediate and National Referral Hospitals

The hospitals and the supportive departments are the main producers of medical, chemical, domestic and biological waste and therefore should have a well functioning infrastructure, equipment, transport (materials and logistics) in place as well as trained staff from all cadres to ensure proper waste management practices. It is of utmost importance to maintain the infrastructure, equipment and transport.

5.1.5 Community level

Constituency Development Committees (CDC) and Village Development Committees (VDC) should encourage active community participation in waste management activities e.g. planned and documented clean-up campaigns and information. Community leaders should disseminate and translate/explain the IWMP and IEC materials to the community in consultation with the relevant authorities

5.1.6. Other partners and line ministries

Ministry of Agriculture, Water and Forestry (MAWF):

- Regulates water pollution, hazardous and solid waste based on current legislation.

Ministry of Environment and Tourism (MET):

- Ensures and develop policies and legislation
- Conducts Environmental Impact Assessment (EIA) for the sitting of sanitary landfill sites.

Ministry of Trade and Industry (MTI):

- Enforces policy during registration of Small and Medium Enterprises (SME) and Industries regarding regulations on possible pollutants that may have a detrimental effect on the health and safety of the employees and the environment.

Ministry of Works, Transport and Communication (MWTC):

- Responsible for a routine maintenance and contingency plans for Health Care Risk Waste (HCRW) as well as maintenance and repair of buildings, and equipments (incinerators).

Ministry of Fisheries and Marine Resources:

- To prevent the illegal dumping of waste at sea in cooperation with NamPort relating to the safe disposal of all kinds of waste.

Ministry of Regional and Local Government and Housing and Rural Development; Local Authorities (Municipalities, Town Council, Village Councils, and Settlement areas):

- Ensures proper collection, storage, transportation and safe disposal of waste, at identified sites.
- Safety and Security measures are compulsory by putting up relevant signs and fencing of disposal site.

Ministry of Finance (MOF):

- Ensures training of officials and collaboration with Ministry of Health and Social Services at the Port and border crossings

Ministry of Mines and Energy (MME):

- Regulates all types of wastes produced during mining activities by enforcing them with waste management regulations.

Ministry of Defense (MOD):

- Enforcement of various regulations as needed. E.g. import, export and criminal activity. Safely dispose all waste generated as per the regulation.

Ministry of Safety and Security (MSS):

- Enforcement of various regulations as needed. E.g. import, export and criminal activity. Safely dispose all waste generated as per the regulation.

Ministry of Labor and Social Welfare (MLSS):

- As the custodian of Safety and Security for employees, should be on board to support the Health System with the implementation of preventative measures.

Private Enterprise and Contractors:

- Should adhere to all the waste regulations ensuring safe waste management and handling practices. They should be encouraged to explore waste minimization: recycling, and reuse practices. (Polluters pay).

Non-Governmental Organizations (NGOs):

- Should adhere to all the waste regulations and guidelines

Community Based Organizations (CBOs):

- Should adhere to all the waste regulations.

6. Health Care Risk Waste Management Practices

6.1. Definition and categories

Waste generated in HCFs are categorized in broad and specific terms. The term health care waste (HCW) includes all the waste generated in a healthcare setting. Health Care Risk Waste (HCRW) refers to all waste that can be considered dangerous or hazardous to either human health or the environment. They are further categorized and classified below. HCRW represents approximately 10-25% of the HCW stream.

6.1.1 Health Care Waste (HCW)

Because of the danger HCW poses to the population it is important that its management is done properly and in accordance with international guidelines. Namibia has adopted WHO guidelines as a resource tool to manage HCRW. This strategy also takes cognizance of the fact that the country is signatory to the Basel Convention; and therefore, these directives have been formulated in conformity with the Basel Convention.

6.2. Types and Risks of HCW

HCW can be categorized as follows:

Type	Examples	Risks/Hazards
Infectious waste	• Items contaminated with blood and body fluids • From isolation wards, laboratory specimens, stools.	• Infection - e.g. AIDS, viral • Hepatitis, respiratory infections, eye and skin infections.
Anatomical waste	• Body parts, organs, blood and other • Body fluids (urine, saliva, other secretions), fetuses	• Infection, as above
Sharps	• Discarded syringes, needles, blades, • Knives, lancets, scalpels, broken glass, • Surgical instruments.	• Injuries which help pathogenic • Organisms to enter the body.
Pharmaceutical waste	• All kinds of outdated/expired • Medications.	• Toxic substances
Chemical waste	• Solvents, disinfectants, laboratory • Reagents, mercury from thermometers, • Batteries.	• Poisoning, burns, injuries to • The eye or mucous membranes, • Headache.
Radioactive waste	• Unused liquids from radiotherapy, • Diagnostic test kits	• Carcinogenic, mutagenic
Pressurized containers	• Aerosol sprays, asthma inhalers, gas containers, “Doom”	• Explosion when burned
General waste	• Same as domestic waste (e.g. packaging, paper, plastic, etc.)	• Non-risk HCW

6.3 Sources of Health Care Waste

Sources of HCW include: HCFs, institutions, business establishments and other similar health services with activities or work processes. Below are examples of facilities that generate HCWs.

- Hospitals
- Clinics
- Veterinary
- Health centers and dispensaries
- Alternative medicine
- Dental
- Maternity
- Dialysis centers
- Physician Offices
- Laboratories and Research Centers
- Medical and Biomedical laboratories
- Medical research centers and institutions
- Blood banks and blood collection services
- Biotechnology laboratories
- Animal research and testing
- Nuclear medicine laboratories
- Drug Manufacturers
- Nursing homes
- Dental
- Paramedics
- Drug rehabilitation centers
- Veterinary
- Mortuary and Autopsy Centers
- Ambulances and Emergency Care
- Home Treatment (e.g. Dialysis, Insulin injections etc.)
- Hospices

6.4 Health Care Waste Management

Health Care Waste Management is a process to ensure proper health facility hygiene and safety. It also minimizes the risks associated with the waste outside of the facility. It includes planning and procurement, construction, staff training and proper transportation, treatment and disposal method inside and outside the facility.

It is therefore crucial that each institution, small or large, generating HCRW has a HCRW management plan and establishes an appropriate infrastructure and mechanisms to manage HCRW. This should include establishing waste management committees for larger facilities and/ or infection control committees.

The actual management of waste involves several key steps namely: Identification; segregation/ containerization; storage; transportation; treatment; and disposal. See **Figure 6.**

Key Steps	Definition
Identification	Identification and classification on waste material
Segregation/ Containerization	Segregation at the source based on categories: • Sharps (medical needles and other surgical instruments) • Infected waste (biomedical, from surgery, nursery) • General waste (food scraps, paper, plastics Sorting the waste into color-coded plastic bags or containers
On-Site Storage	Separate storage facilities (temporary before waste is transported to treatment facility) Packaging and labeling
Transportation	Using specific containers and designated vehicles to transport waste to treatment facility
Off-site Storage	Storage at treatment facility

step	location	healthcare waste stream	key points
0		*waste minimization*	*purchasing policy; stock management; recycling of certain types of waste…*
1	in medical unit	**generation**	
2		**segregation at source**	*one of the most important steps to reduce risks and amount of hazardous waste*
3	in health facility	**collection + on-site transport**	*protective equipment; sealed containers; specific easy to wash trolleys*
4		**on-site storage**	*lockable easy to clean storage room; limited storage time of 24-48 hours*
5		**on-site treatment / disposal**	*adequate storage room; limited time of max 48 hours*
6	outside of health facility	**off-site transport**	*appropriate vehicle and consignement note; HCF is informed about final destination*
7		**off-site treatment / disposal**	*appropriate vehicle and consignement note to ensure…*

Treatment/Disposal	Appropriate treatment of HCRW

Figure 6 – Key Steps to HCRW Management

The steps and the sub-steps that should be followed when managing HCRW within a facility are described in more details below.

6.4.1 Segregation and containerization

The National Waste Management policy discusses waste minimization based on the integrated hierarchy urges all facilities to reduce waste where possible with segregation being one of the effective ways to minimize HCRW. Segregation also reduces the amount of toxic substances release to the environment through disposal of general waste (e.g. removing mercury from general waste).

Segregation is the process of separating different types of waste and keeping them isolated from each other. This process should be done correctly at the point of generation. Segregation of waste relies on designated staff to correctly identify waste according to its category. Correct segregation ensures that the correct treatment and disposal of waste occurs.

6.4.1.1 Steps in Segregation of waste

Identify waste according to waste categories and place them in appropriate containers

A. General Health Care Waste

This waste should join the domestic refuse stream for disposal. Color-coded containers should be use: black containers for non-infectious dry waste (e.g. bottles, cans, papers and cartons) while yellow plastic bags should be used for non-infectious wet waste (e.g. kitchen waste) (**Photo 1**). It is important that the types of containers used at the point of generation are bags.

Black bags = General Waste

Yellow bags = Kitchen Waste

Photo 1

Aerosol containers may be collected with general HCW once they are completely empty. Aerosol containers should not be burnt or incinerated.

B. Infectious Waste

Place the waste in a **RED**, leak-proof and strong plastic bag container and mark "INFECTIOUS" - **Photo 2**.

Red bags = Infectious waste

Photo 2

- Small amounts of *chemical or pharmaceutical waste* may be collected together with infectious waste.
- Highly infectious waste, whenever possible, must be sterilized immediately by autoclaving.
- **Note:** Never re-sort waste. If general waste and infectious waste are mixed by accident in one bag, it should be treated as infectious waste.
- Place red bag in a container such as a pedal bin or wheelie bin in a location not easily accessible to passers-by or to children.
- Seal red bag with a tape or plastic tie when $3/4^{th}$ full to reduce the risk of spilling or breaking.
- If the red bags are not available, use any of the available color bag and mark with the Biohazard stickers - Universal biohazard waste symbol – **Figure 7**.

Figure 7

Universal Biohazard Symbol

- If the Biohazard sticker is not available, prepare a label with the following information: Type of waste, origin or where produced in the hospital, date collected, for incineration.

C. Body Parts/Human Tissues

Handling practices for body parts and human tissue are as follows:

- Wrap body part/tissue in an intact plastic bag.
- Re-wrap in the red plastic bag.
- Place in a prescribed Biohazard box, or any strong box.
- Seal the box with the Biohazard stickers/tape, or any strong tape.
- Write the following information on the box: Date collected origin and destination of the waste.

D. *Cytotoxic waste*, most of which is produced in major hospitals or research facilities, should be collected in strong, leak-proof containers clearly labeled "Cytotoxic wastes." Precautions must be taken during the handling of cytotoxic pharmaceuticals. The releases of these products can have adverse environmental impacts. The management of these wastes, in covered and impermeable containers, must therefore be strictly controlled. Solid containers must be used for collection- **Photo 3**

Photo 3

Example of a cytotoxic waste container with proper labeling

E. Sharps

- Place sharps waste in a **YELLOW** or other relevant sharps box as depicted below. When such containers are not available, use plastic containers or other rigid and mark with the words "SHARPS" and indicate with biohazard symbol – **Photo 4.**

Photo 4

- Sharps should all be collected together, regardless of whether or not they are contaminated.
- Containers should be puncture-proof (usually made of cardboard (per UNICEF/ WHO recommendations) or metal or high-density plastic) and fitted with covers.
- Sharps require that the measures be taken to prevent injury and infection during their handling within and outside of the HCFs.
- Containers should be 3/4th full
- Containers should be tied or placed in a trolley and not the floor

Note:

- **Use the appropriate shape and size containers for the sharps to be discarded.**
- **Do not press sharps to make room for more.**
- **When 3/4th full, seal the sharps container and place in a red bag for incineration.**

F. Hazardous chemicals/Pharmaceuticals

- Large quantities of chemicals should be packed in chemical resistant containers and sent to a designated facility. The identity of the chemical should be clearly marked on the containers. Hazardous chemical waste of different types should never be mixed.
- Large quantities of *obsolete or expired pharmaceuticals* stored in hospital ward or departments should be returned to the pharmacy for disposal. Other pharmaceuticals waste generated at this level, such as expired medicines or packaging containing drug residues should not be returned because of the risks of contaminating the pharmacy. It should be deposited in a specific container at the point of generation. (Refer to Chapter 10 on pharmaceutical wastes).

- Waste with high content of *heavy metals* (e.g. cadmium or mercury) should be collected separately. This waste should be sent to a designated facility.

G. Radioactive Waste

- Place waste in a lead box and label with the radioactive symbol - **Figure 8.**

Figure 8

- Radioactive waste should be segregated according to its physical form; solid & liquid and according to its half-life or potency; and short-live in specially marked containers.

NOTE:

Radioactive waste is presently not treated in the country but in South Africa due to lack of a facility. How the waste is handled and managed is the responsibility of the generator.

General rule:
When handling HCW, housekeeping staff and waste handlers should always be provided with and wear appropriate protective clothing. As a minimum the following should be provided: overalls or industrial aprons, boots and heavy duty gloves.

After wastes are placed in appropriate containers and segregated, the next step is to store the waste. The waste should be collected from the unit/location where it was generated and stored in designated waste storage area until transported to the treatment location. This area should be marked with a warning sign – **Figure 9**.

Figure 9

Designated areas are usually a separate location, yet not too far, from the main building of the HCF. All hospitals, health centers and large clinics should have cold storage units. In facilities where there is a lack of such spaces, daily collection and disposal should be enforced.

The following guidelines should be followed for temporary storage waste before treatment/ disposal:

- The waste must be kept in tight receptacles and under stable temperature (5-8°C) conditions when stored temporarily for prolonged period of time.
- Biodegradable general and hazardous waste should not be kept longer than 2 days to minimize microbial growth, putrefaction and odours.
- If the waste must be stored longer than 2 days, application of treatment like chemical disinfections or refrigeration at 2°C or lower is recommended.
- Maximum storage time should not exceed 48 hours during summer and 72 hours during winter.
- Non-risk HCW should always be stored in a separate location from the infectious / hazardous HCW in order to avoid cross-contamination.
- Cytotoxic waste should be stored in lead containers that prevent dispersion.
- The facility should be limited to authorized personnel.

6. 5 Requirements for Storage Facilities

- The storage area should have an impermeable, hard-standing floor with rounded floor of concave edges and good drainage, it should be easy to clean and disinfect.
- There should be water supply for cleaning purposes.
- Easy access to storage area for staff in charge of handling the waste.
- It should be possible to lock the storage area to prevent access by unauthorized persons.
- Easy access for waste collection vehicle and not located near kitchen areas
- Protection from sun, rain, strong winds, floods, etc.
- Good lighting and adequate ventilation.

6.6 Collection and Transportation

The proper collection and transportation is important in health care waste management. Its implementation requires the direct involvement of the HCF’s maintenance services, housekeeping services, fleet services and cooperation of all health personnel.

6.6.1 On-site Collection

The following are recommendations that should be followed by health care personnel directly involved in waste handling and collection.

- Staff members should ensure that waste bags are tightly closed or sealed when they are about three-quarters full.
  - Light-gauge bags can be closed by tying the neck, but heavier gauge bags will most likely require plastic sealing tag of self-locking type.
  - Bags should not be closed by stapling.

- Hazardous /infectious waste should be collected on separate trolleys
  - The trolleys should be marked with the corresponding color black /yellow and washed regularly.

- No bags should be removed unless they are labeled with their point of production (hospital ward or department) and contents.

6.6.2 On-site Transportation

- HCW should be transported within the hospital or other facility by means of wheeled trolleys.

6.6.3 Off-site Transportation

This step in the chain of health care waste management involves transportation of waste to treatment or disposal facilities and certain rules need to be followed:

6.6.3.1 Requirements for Packaging for Off-site Collection

- The HCW generator is responsible for the safe packaging and adequate labeling of waste to be transported off-site and for the authorization of its destination.
- Waste should be placed first in containers (e.g. cardboard boxes or wheeled, rigid, lidded plastic or galvanized bins) before is loaded on to a designated vehicle.
- The bags/containers should be sealed to prevent any spillage during transportation and should be robust to withstand vibration or changes in temperature, or atmospheric pressure.
- Infectious and pathological waste should be bagged in appropriate color-coded bags or other special containers when transported.
- All waste bags or containers should be labeled with basic information on their content and on the waste generator. This information may be written directly on the bag or container or on pre-printed labels, securely attached. Basic information should include but not limited to the following:

  - Type of HCW
  - Form of waste and waste category
  - Date of collection

- Volume/quantity of waste
- Precautions to be taken while handling
- Emergency procedures in the event of accident or spillage
- Destination of the waste

6.6.3.2 Requirements for Off-site Collection Vehicles

- The vehicle that transports special HCRW should be used exclusively for this purpose.
- Collection vehicles used for the transport of HCW should not be used for the transport of any other materials that could be seriously affected by contamination such as food, livestock, people or retail goods.
- The HCRW should be transported only by accredited transporter or carrier. The transporting organization should be registered as per Registration and Licensing strategy.
- The vehicle should have an enclosed leak proof body and capable of being locked to secure the waste.
- The vehicle must have a suitable size body with the height of 2.2 meters
- The vehicle must have a system to secure the load.
- The vehicle must have a separate compartment for emergency equipment
- Must have an interior that will allow steam cleaning.
- Internal finishing of the vehicle should allow it to be steam-cleaned, and the internal angles should be rounded.
- The vehicle should be cleaned at the end of each working day and in the event of any spillage.
- The vehicle should be marked with the name and address of the waste carrier.
- The international hazard sign and emergency telephone number should be displayed on the vehicle or container.
- Empty plastic bags, suitable protective clothing, cleaning equipment, tools, and disinfectant, together with special kits for dealing with liquid spills should be carried always and in a separate compartment.
- The waste must always be properly documented and all vehicles should carry a consignment note from the point of collection to the treatment facility. The information to be indicated on the note must include date of production, place of production, waste quantity, waste category and waste destination.

6.7 Consignment Note

The waste taken to a treatment and disposal facility should be accompanied by a consignment note. In the Namibian context this note will be known as "Manifest Document" (**Located in Appendix 1**)

- The transporter shall provide the waste generator with a copy of the consignment note for the generator's waste records.
- The transporter and the generator shall separately maintain a copy of the consignment note.
- The manifest document should contain information of both the transporter and the generator, even if the generator is also the transporter.
- Any waste generator transporting waste should meet all the requirements of a transporter.
- The transporter or generator transporting the waste should have the consignment note/ manifest document in his/her possession in the vehicle while transporting the waste.
- The tracking document should be available upon demand by any traffic enforcement agency personnel and/or waste management officers.
- The transporter shall provide the facility receiving waste with a copy of the original tracking document.

6.8 Routing

HCW should be transported by the quickest possible route. This should be planned before the journey begins.

7. Treatment and Disposal

The purpose of treating HCRW is to change the biological and chemical character of waste, minimizing its potential to cause harm. There are a number of technologies that are used in treatment of HCRW. Some of these technologies are on-site and some are off-site treatments. They are divided into a) thermal; b) chemical; c) biological processes; d) radiation technology, e) encapsulation and f) inertization. These technologies are discussed in Chapter 9

Each class of HCW will require specific treatment and the following basic steps should be followed:

- Non-risk HCW: If segregated properly can be disposed with domestic waste.
- Highly infectious waste: All laboratory samples containing body fluids, tissues or faecal stools must always be pre-treated at source by autoclaving or disinfected in a concentrated 2% solution of sodium hypochlorite and then placed in red bags. Discard with infectious HCW before it is taken to any disposal facility.

- Sharps require certain measures to be taken to prevent injury and infection during their handling within and outside of the HCFs. Two possibilities currently exist to dispose of needles and syringes:
    - They can be collected in safety boxes that are then disposed of by means of incineration or encapsulation.
    - They can also be destroyed on the spot using a needle destroyer or separating the needle from the syringe using a device where the needle drops directly in a puncture-proof container.

- Pharmaceutical waste: Non- hazardous pharmaceutical waste can be managed jointly with municipal waste. However, potentially hazardous and hazardous pharmaceutical wastes should be managed as hazardous.
    - They should be returned to a national central collection point to ensure that they are properly neutralized or incinerated at temperatures above 1200ºC
    - Alternatively and only if the return cannot be ensured, an inertization[8] technique may be used and the inerted waste disposed of in at a landfill like Kupferberg.

- Cytotoxic pharmaceutical wastes must be collected separately from pharmaceutical waste and return to supplier and if not possible incinerate at high temperature. This is for reasons of occupational safety.
- Blood and body fluids waste should be disposed of with HCRW or at a hazardous sanitary landfill
- Body fluids and excreta of infected patients with hazardous communicable diseases shall not be discharged to the sewerage system. Because there is no strict separation between the waste

8 Inertization is a process of mixing waste with cement and lime in a container before disposal to minimize the risk of toxic leakages into the surface or groundwater - Source WHO Health Care Waste Plan

9 Encapsulation is a process in which the wastes are place in strong plastic containers or metal drums. When the containers are full, immobilizing materials such as plastic foam, sand, cement or clay is added. When dry, the containers are sealed and disposed of in a landfill or waste burial pit - Source WHO Health Care Waste Plan

and drinking water installations and the sewerage system connected to the waste water plant.

- Large quantities of chemicals should be returned to the supplier for encapsulation[9]. Incineration of certain combustible wastes is possible but landfill is not recommended.
- Waste with high contents of heavy metals should normally be treated in specific recycling/ treatment facilities.
- The following items should NEVER BE INCINERATED or be sent for incineration: pressurized gas containers, PVC plastics, glass vials, X-ray/photographic materials and batteries.
- Waste with heavy metals, in particular mercury or cadmium should never be incinerated. Export these items to countries with specialized facilities or encapsulate.

7.1 Incineration

It will be ideal to establish centralized treatment facilities in Namibia. This is the most cost- effective option compared to a facility- based treatment facility and to standard appropriate technologies.
Once installed, identification board would be displayed at the entrance of the facility. The name of the facility, the address and the telephone number of the operator and, the hours of operation and the telephone numbers of personnel to be contacted will be displayed on the signage.

A number of rules would be applied when managing HCRW at the treatment facility:

- When HCRW is delivered to the incinerator plant, the packaging will be checked to ensure that it is undamaged.
- Facilities would be available at the incineration site for the cleaning and disinfections of transportation equipment, including vehicles.
- Automatic loading device for bags and containers rather than manual will be used to ensure protection of the safety of workers.
- HCRW will not be stored for more than 24 hours at the incineration plant; If HCRW is store for more than 24 hours, a cooling facility will need to be established.
- The incinerator operator is required to wear protective clothing and wash hands regularly.
- The operator shall be vaccinated against Hepatitis B virus (HBV) and tetanus, and will have regular medical checkups (every six months).
- Adhere to the instructions in the manual to destroy medical waste deposited.
- The operator shall receive the consignment note/manifest document and verify the information and ensure that the form is signed appropriately.
- The operator shall verify that any waste received is appropriately packaged.
- The operator should weigh the waste and record it in the log book provided.
- If the waste is not packaged correctly, this will be reported to the supervisor
- The operator shall weigh the waste to be incinerated and record the quantities on the Manifest Document (**Appendix 1).**
- The operator shall incinerate the HCRW in accordance with “best practices”,
- The operator shall submit all records regarding waste management to the supervisor on a monthly basis.
- Keep a carbon copy of all records at the facility. These records must always be available for inspection at the site.
- Complete the Waste Deposited form upon disposal of ash or treated waste (**Appendix 2**).

7.2 Spill Control

Spillage is probably the most common type of emergency involving infectious and other hazardous material or waste. Spills include: accidental tipping over of containers, and dropping and breaking of containers. Likewise, it also involve spills which may occur mainly because of splashing during manual transfer, overfilling, and leaks in process equipment and piping.

Guidance for spill control:

- Vacate and secure the area to prevent further exposure of other individuals
- Provide first aid and medical care to injured indvidual
- Inform the designated person (e.g. waste management officer), who should coordinate the necessary actions
- Determine the nature of the spill
- Limit the spread of the spill
- Vacate all people not involved in the cleaning if the spillage involves particulary hazardous substance
- Neutrilize or disinfect the spilled or contaminated material, if indicated
- Collect all spilled and contaminated material (sharps should never be picked up by hand). Spilled material and disposable contaminated items for cleaning should be placed in the appropriate waste bags or containers
- Decontaminate or disinfect the area
- Decontaminate or disinfect any tools that were used
- Seek medical attention if exposure to hazardous material has occured during the operation
- Remove any contaminated clothing
- Flush out contaminated eyes and skin as soon as possible at a suitable water supplyIf sharps are involved, use a mechanical means, such as tongs, forceps, or dustpan and broom. Do not use your hands to pick up any sharps items, even if gloves are worn.

Figure 10: Generic Spill Kit Requirements

Generic Spill Kit Requirements	
2 x Disposable Latex gloves	1 x Dust Masks
32 sachets Biocide – D	1 x Dust pan and brush
1 x pair of Heavy Duty Reusable gloves (black)	2 x pairs nitrite gloves (green)
1 x small roll barrier red and white tape	25 x white disposal plastic aprons
1 x packet cable ties	2 x large 60 micron red plastic bags
1 x roll absorbent paper towels	x laminated procedures
1 Anti-bacterial wipes	Syringe and needle to suck up any mercury

Figure 10 – Spill Control

8. Options for Treatment of Infectious Waste

Treatment of infectious waste is the process by which the character of infectious waste is changed through disinfection or the destruction of pathogens rendering the waste non-infectious and reducing the risk of spreading disease. At a minimum, treatment may mean isolating and burying the waste to prevent access by people and allowing natural decomposition to destroy the infectious pathogens. In general treatment involves a thermal, chemical, biological, or irradiative process that achieves a high level of disinfection. This provides greater protection to waste handlers, transporters, workers at a dumpsite or landfill, and scavengers.

Treatment may also include a physical process (such as a grinder, shredder or compactor) to reduce waste volume and render the waste unrecognizable for aesthetic or cultural purposes. In the case of sharps waste that will be discarded in an uncontrolled manner at a dumpsite, proper treatment requires the removal of both biological and physical hazards. The ideal treatment process is one that renders the waste completely harmless without giving rise to other health and environmental problems.

Infectious waste shall be treated by steam, incineration, or an alternative process approved by the regulatory authority. If treatment is not available, final disposal by burial in the manner described below is permitted on an interim basis. Pathological waste can also be buried directly in burial grounds or cemeteries as described in the section on “Final Disposal.” Treatment should occur as soon as possible after collection, transportation, or the end of the storage period.

8.1 Treatment Scenarios

There are several scenarios for the treatment of infectious waste: (1) on-site treatment in the facility; (2) sharing an on-site treatment system to treat waste from several nearby facilities, such as a cluster of hospitals or a hospital and surrounding health centers; (3) treatment at an off-site treatment center, such as a central facility outside the city or at the landfill; and (4) treatment using a mobile treatment system mounted on a truck that goes from hospital to hospital to treat their waste. Several flow diagrams depicting different approaches are presented in **Appendix 4.**

Table 8 below presents the advantages and disadvantages of various treatment scenarios.

Table 8: Advantages and Disadvantages of Various Treatment Scenarios.

TREATMENT SYSTEM APPROACH	DESCRIPTION	ADVANTAGES	DISADVANTAGES
On-site treatment at the facility	Equipment is installed at the hospital or clinic. The waste is treated on site, and the treated waste is then sent to a landfill.	• Avoids the problem of transporting untreated waste • Treated waste can be sent to the landfill with domestic waste • Technologies using steam can use the facility's central steam • Technology is under closer supervision by managers of the facility • Microbial inactivation tests can be done at the facility	• Requires space which is often limited at healthcare facilities • Ventilation may be needed to avoid odor problems from the treatment unit • An on-site system does not take advantage of the economies of scale and would be less cost-effective than a shared or centralized system
On-site technology at a facility used to treat waste from other facilities	Waste from nearby hospitals or health centers are transported to the facility to be treated along with waste from the facility itself, and the treated waste is sent to a landfill	• On-site technology serves a large base • Treated waste can be transported to the landfill with domestic waste • Technologies using steam can use facility's central steam • Technology is under closer supervision by managers of the facility • Microbial inactivation tests can be done at the facility • This shared arrangement is more cost effective than separate on-site systems	• Requires space which is often limited at healthcare facilities • Ventilation may be needed to avoid odor problems from the treatment unit • A larger technology requires a higher capital cost • Increased traffic of waste from other facilities may impede traffic at the facility • Untreated waste has to be transported to the facility from other locations
Mobile treatment system	The treatment system is mounted on a truck or special vehicle which travels to different hospitals. After waste is treated on site, the mobile system moves to the next hospital. Treated waste is sent to a landfill with other domestic waste.	• Avoids the problem of transporting untreated waste • Treated waste can be sent to the landfill with domestic waste • Technologies can use the facility's central steam or use its own steam generator • Avoids the need for sitting, permanent installation, and commissioning • Microbial inactivation tests can be done at one of the facilities • Sharing capital and operating costs with other facilities is cost effective than separate on-site systems • The vehicle can be parked in a way that minimizes use of space at the facility • A mobile technology could serve a large base	• Costs would include capital cost of a special vehicle, as well as fuel, insurance, maintenance, labor, and other operating costs associated with transport • The technology is exposed to the risk of damage from traffic accidents, poor road conditions, weather, etc. • Requires good coordination to ensure timely treatment of waste and avoid long storage times

TREATMENT SYSTEM APPROACH	DESCRIPTION	ADVANTAGES	DISADVANTAGES
Centralized treatment at an off-site regional facility	Waste from the facility and many other healthcare institutions are transported and treated at a central site; treated waste is then sent to the landfill	• Centralized technology serves a very large base • Treated waste can be transported to the landfill with domestic waste • A central facility allows more space for safe movement of waste • Odor problems can be ameliorated if the site location is well chosen • Public access is minimized if the site is outside the city • This is a favored approach in many industrialized countries	• Requires installation of steam and electrical sources • A very large technology requires a higher capital cost • A system of safe transport of untreated waste has to be put in place • In an urban setting, road conditions and traffic can make transportation difficult
Centralized treatment at a landfill	Similar to a centralized treatment facility except that the treatment is done at or adjacent to the landfill	• Centralized technology serves a very large base • Treated waste can be immediately disposed off at the adjacent landfill • This is a favored approach in many industrialized countries	• Requires installation of steam and electrical sources • A very large technology requires a higher capital cost • A system of safe transport of untreated waste has to be put in place • In an urban setting, road conditions and traffic can make transportation difficult • If the landfill is an uncontrolled dumpsite, public access has to be prohibited; workers may be exposed to hazards related to the dumpsite

The *recommended approach is sharing among hospitals, because of the cost effectiveness*, (second approach in **Table 8** above) be given preference especially with the pilot hospitals.

8.2 Treatment Processes

The four basic processes used in treatment of infectious waste are:

1. Thermal processes
2. Chemical processes
3. Irradiative processes
4. Biological processes

The majority of treatment technologies employ the first two processes listed above.
Each of these is described below. Mechanical processes may supplement the four fundamental processes.

Thermal Processes

Thermal processes are those that rely on heat (thermal energy) to destroy pathogens in the waste. This category can be further sub-divided into low-heat and medium to high-heat thermal processes. This sub-classification is necessary because physical and chemical mechanisms that take place in thermal processes change markedly at medium and high temperatures resulting in environmental problems.

Low-heat thermal processes are those that use thermal energy to disinfect the waste at temperatures insufficient to cause chemical breakdown or to support combustion or pyrolysis. In general, low-heat thermal technologies operate between 100°C to about 180°C. The two basic categories of low-heat thermal processes are wet heat (steam) and dry heat (hot air) disinfection. Wet heat treatment involves the use of steam to disinfect waste and is commonly done in an autoclave. Microwave treatment is essentially a steam disinfection process. Water is added to the waste and disinfection occurs through the action of moist heat and steam generated by microwave energy. In dry heat processes, no water or steam is added. Instead, the waste is heated by conduction, natural or forced convection, and/or thermal radiation using infrared or resistance heaters.

Medium and high-heat thermal processes take place at temperatures from about 200°C to over 1000°C. They involve the chemical and physical breakdown of organic material through the process of combustion, pyrolysis, and/or gasification. A major disadvantage of these technologies is the creation of toxic byproducts, which are then be released into the atmosphere and with the ash.

Chemical Processes

Chemical processes use disinfectants such as: dissolved chlorine dioxide, bleach (sodium hypochlorite), peracetic acid, or dry inorganic chemicals. To enhance exposure of the waste to the chemical agent, chemical processes often involve shredding, grinding, or mixing. In liquid systems, the waste may go through a dewatering section to remove and recycle the disinfectant. Besides chemical disinfectants, there are also encapsulating compounds that can solidify sharps, blood, or other body fluids within a solid matrix prior to disposal. Another example of a chemical process is a system that uses heated alkali to digest tissues, pathological waste, anatomical parts, or animal carcasses in heated stainless steel tanks.

Irradiation-based technologies involve electron beams, Cobalt-60, or UV irradiation. These technologies require shielding to prevent occupational exposures. The pathogen destruction efficacy depends on the dose absorbed by the mass of waste. This is related to waste density and electron energy. Electron beams are powerful enough to penetrate waste bags or containers. Germicidal ultraviolet radiation (UV-C) has been used as a supplement to other treatment technologies. However, they are not use as a treatment system by itself because of the inability of UV radiation to penetrate into the waste bags.

Biological Processes

Biological processes employ enzymes to destroy organic matter including pathogens. However, there are not commercial systems available. Composting and vermiculture are also biological processes and have been used successfully to decompose kitchen waste and placenta waste.

<u>*Mechanical Processes*</u>
Mechanical processes—such as shredding, grinding, mixing, and compaction—are not capable of destroying pathogens and are not considered treatment processes by themselves. Although they can supplement other treatment processes. Mechanical destruction can render the waste unrecognizable and is used to destroy needles and syringes, so as to minimize needle-stick injuries or to render them unusable. In the case of thermal- or chemical-based processes, mechanical devices such as shredders and mixers can also improve the rate of heat transfer or expose more surfaces to chemical disinfectants. Mechanical processes can add significantly to the level of maintenance required.

Unless shredders, mixers, and other mechanical destruction processes are an integral part of a closed treatment system, they should not be used before the waste is disinfected. Otherwise, workers would be exposed to pathogens in aerosols released to the environment by mechanical destruction of untreated waste bags. If mechanical processes are part of a system, the technology should be designed in such a way that the air in and from the mechanical process is disinfected before being released to the surroundings.

8.3 Description of Common Treatment Technologies [10]

8.3.1 Autoclaves
An autoclave consists of a metal chamber with a door and surrounded by a steam jacket. Steam is introduced into both the outside jacket and the inside chamber; which are designed to withstand high pressures. Heating the outside jacket reduces condensation in the inside chamber wall and allows the use of steam at lower temperatures. Because air is an effective insulator, the removal of air from the chamber is essential to ensure penetration of heat into the waste. This is done in three general ways: gravity displacement, pre-vacuuming, and pulsed vacuuming. A gravity-displacement autoclave takes advantage of the fact that steam is lighter than air; steam is introduced under pressure into the chamber forcing the air downward into an outlet port in the lower part of the chamber. A more effective method is the use of a vacuum pump to evacuate air before introducing steam, which is similar in pre-vacuum autoclaves. Pre-vacuum autoclaves need less time for disinfection due to their greater efficiency in taking out air. Newer autoclaves may use pressure pulsing to evacuate air. That is, alternating cycles of vacuum and steam pressure are used to achieve rapid penetration of steam.

A retort is similar to an autoclave except that it has no steam jacket. Retorts are cheaper to construct but requires a higher steam temperature than an autoclave. Retort-type designs are commonly found in large-scale applications.

10 Non-Incineration Medical Waste Treatment Technologies: A Resource for Hospital Administrators, Facility Managers, Health Care Professionals, Environmental Advocates, and Community Members, J. Emmanuel, Health Care Without Harm

A typical operation for an autoclave or retort involves the following:

- Waste collection: Infectious waste bags are placed in a metal cart or bin. As an option, the cart or bin is lined with plastic liners to prevent waste from sticking to the container.
- Pre-heating (for autoclaves): Steam is introduced into the outside jacket of the autoclave.
- Waste loading: The metal cart or bin is loaded into the autoclave or retort chamber. With every load, a chemical color-changing indicator is attached to the outer surface of the waste bag in the middle of the waste load to monitor disinfection. The charging door is closed, sealing the chamber.
- Air evacuation: Air is removed through gravity displacement, pre-vacuuming, or pulse vacuuming as explained above.
- Steam treatment: Steam is introduced into the chamber until the required temperature is reached. Additional steam is automatically fed into the chamber to maintain the temperature and pressure for a set time period.
- Steam discharge: Steam is vented from the chamber, usually through a condenser, to reduce the pressure and temperature. In some systems, a post-vacuum cycle is used to remove residual steam and dry the waste.
- Unloading: Additional time is usually provided to allow the waste to cool down further. Afterwards, the treated waste is removed and the indicator strip is evaluated. The process repeats, if the color-changing indicator shows that the treatment cycle was insufficient.
- Documentation: A written log is maintained to record: the date, time, and operator name; type and approximate amount of waste treated; and a post-treatment confirmation results from any automated equipment recording or temperature-pressure monitoring indicator, such as the indicator strip.
- Mechanical treatment: If desired, the treated waste is fed into a shredder or compactor prior to disposal in a landfill.

Autoclaves and retorts are capable of treating a wide range of infectious waste including: cultures and stocks, sharps, materials contaminated with blood and limited amounts of fluids, isolation and surgery waste, laboratory waste (excluding chemical waste), and soft waste (gauze, bandages, drapes, gowns, bedding, etc.) from patient care. Moreover, it is technically possible to treat tissue waste with sufficient time and temperature, Due to ethical, legal, cultural, and other considerations preclude their treatment. Autoclaves and retorts are generally not used for large anatomical waste (body parts). Because it is difficult to determine beforehand the time and temperature parameters needed to allow full penetration of heat to the center of the body part.

Volatile and semi-volatile organic compounds, chemotherapeutic waste, mercury, other hazardous chemical waste, and radiological waste should not be treated in an autoclave or retort. Huge and bulky bedding material, large animal carcasses, sealed heat-resistant containers, and other waste loads that impede the transfer of heat should be avoided.

Odors can be a problem around autoclaves and retorts, if there is insufficient ventilation. Waste streams that are not properly segregated to prevent hazardous chemicals from being placed in the treatment chamber can result in toxic contaminants releasing into the air, condensate, or in the treated waste. This is the case when waste loads contaminated with laboratory solvents or heavy metals such as mercury are put in the autoclave. Thus, poorly segregated waste may emit low levels of alcohols, phenols, formaldehyde, and other organic compounds in the air.

Disinfected waste from an autoclave or retort retains its physical appearance. If desired, a mechanical process such as a shredder or grinder is used to make the waste unrecognizable. Shredding reduces the volume of the treated waste by 60 to 80 percent.

Autoclaves and retorts require a minimum exposure time and temperature to achieve proper disinfection. A minimum recommended exposure temperature-time criterion is 121°C for 30 minutes. This corresponds to a pressure of 205 kPa or 2.05 bar (15 psig or 30 psia).

Color-changing chemical indicators, such as strips that contain thermochromic agents (any of a number of chemicals that change color when the reach a given temperature) or so-called integrators (chemical indicators that respond to both time and temperature), should be used with each load to verify that the required temperatures have been achieved. The color-changing indicator should be taped or affixed to the surface of the bag that is placed at the center of a large waste load.

A more indicative test that demonstrates proper disinfection involves the use of biological monitors (*B. stearothermophilus* or *B. subtilis* subsp. *niger* spore strips; also referred to as *Geobacillus stearothermophilus* and *Bacillus atrophaeus*, respectively). One of these biological indicators should be placed periodically at the center of waste loads to test for microbial inactivation efficacy. The easiest method is using commercially available self-contained biological indicators along with a small incubator. The self-contained biological indicator consist of a spore strip; sealed glass ampoule with growth medium and a pH indicator system; and a cap with holes for steam penetration coupled with a hydrophobic filter as a bacterial barrier. After sterilization, the vial is squeezed to allow the growth media to mix with the processed spore strip. The vial is incubated for 48 hours. The self-contained biological indicators contain pre-determined amounts of spores such that a negative test result corresponds to a Log 4 kill of the biological indicator. A change to specific color indicates surviving spores and a positive result. These microbiological tests should be conducted at least once a week for the first month that an autoclave is first used. If all the tests show successful treatment, microbiological tests should be conducted once a month from then on.

If an autoclave or other steam-based treatment unit is being placed into service, the minimum operating temperature, pressure, and treatment time should first be determined according to the following procedure:

1) Test loads of infectious waste of the maximum weight and density of HCW to be treated shall be prepared.
2) Prior to treatment, *Geobacillus stearothermophilus* spores shall be placed at the bottom and top of each treatment container. Specially, at the front of each treatment container, at a depth of approximately one-half of the distance between the top and bottom of the load, in the approximate center of each treatment container, and in the rear of each treatment container at a depth of approximately one-half of the distance between the top and bottom of the load.

3) If the operating parameters used during the treatment of the test loads demonstrate a minimum Log 4 kill of *Geobacillus stearothermophilus* spores at all locations, the steam treatment unit shall operate under those parameters when placed into service.
4) If the operating parameters fail to provide a minimum Log 4 kill of *Geobacillus stearothermophilus* spores at all locations, treatment time, temperature, or pressure shall be increased and the tests must be repeated until a minimum Log 4 kill of *Geobacillus stearothermophilus* spores is demonstrated at all locations. The steam treatment unit shall be operated under those parameters when placed into service. Tests shall be repeated and new parameters established if the type of HCW to be treated is changed.

A written operating procedure must specifying, at a minimum, the parameters (temperature, pressure and treatment time) that provide consistent treatment as determined from the test, and a description of the standard containers and placement of load in the autoclave.

Below are some of the advantages of autoclave technology:

- Steam treatment is a proven technology with a long and successful track record.
- The technology is easily understood and readily accepted by hospital staff.
- It is approved or accepted as a treatment technology worldwide and is the most widely used technology is some industrialized countries.
- The time-temperature parameters needed to achieve high levels of disinfection are well established.
- Autoclaves are available in a wide range of sizes, capable of treating from a few kilograms to several tons per hour.
- If proper precautions are taken to exclude hazardous materials, the emissions from autoclaves and retorts are minimal.
- Capital costs are the lowest compared to other treatment technologies for the same capacities.
- Many autoclave manufacturers offer many features and options such as: programmable computer control, tracks and lifts for carts, permanent recording of treatment parameters, autoclave able carts and cart washers, and shredders.

The disadvantages of autoclave technology are as follows:

- The technology does not render waste unrecognizable and does not reduce the volume of treated waste unless a shredder or grinder is added.
- Any large, hard metal object in the waste can damage any shredder or grinder.
- Offensive odors can be generated and need to be minimized by proper air handling equipment.
- Toxic contaminants can be released into the air, wastewater, or remain in the waste to contaminate the landfill. If hazardous chemicals such as formaldehyde, phenol, cytotoxic agents, or mercury are in the waste.
- If the technology does not include a way of drying the waste; the resulting treated waste will be wet and heavier that when it was first put in because of condensed steam.
- Barriers to direct steam exposure or heat transfer (such as: inefficient air evacuation; excessive waste mass; bulky waste materials with low thermal conductivities; or waste loads with multiple bags, air pockets, sealed heat-resistant containers, etc.) may compromise the effectiveness of the system to decontaminate waste.

Below are suggestions when using autoclave or other steam-based treatment systems:

- Make sure that an effective waste segregation plan is in place to keep chemicals and other hazardous waste from being placed in an autoclave or other steam-based system.
- Air evacuation is more effective in autoclaves with a pre-vacuum cycle or multiple vacuum cycles. With higher vacuum levels and more vacuum cycles, the heat penetration is deeper and the heating of the waste load is more uniform.
- Certain load configurations, such as placing bags in multi-level racks with sufficient spaces between the bags to allow for more surfaces to be exposed to steam are more efficient compare to tightly stacked containers or carts piled with red bags, and other configurations.
- Facilities should define a standard load and waste configuration. Operators should then monitor waste loads sizes, load configurations, waste containment and other conditions that may result in less than optimal heating conditions. If those conditions arise, exposure times and steam temperatures should be increased to provide a margin of safety.
- Continuous monitoring of temperature during the exposure time and at various points in the chamber is important in detecting heating problems.
- Run a standard cycle with an empty autoclave or retort should be done annually. Any significant changes from the previous years in temperature-time profiles, vacuum, and steam pressure readings indicate a potential problem.
- Maintain records of chemical or biological indicator tests, time-temperature profiles, maintenance activities (such as replacing filters and gaskets), and periodic inspections.
- Ensure sufficient ventilation to minimize odor problem. Provide worker training to include: a basic understanding of steam-based treatment systems, standard operating procedures, occupational safety (ergonomics, proper waste handling techniques, hazards associated with steam and hot surfaces, needle-stick injuries, blood splatter or aerosolized pathogens if waste bags are broken or compacted, etc.), record keeping, identifying waste that should not be treated in the unit, recognizing heating problems, dealing with unusual waste loads and other less than optimal conditions, periodic maintenance schedules, and contingency plans (e.g., what to do in case of a spill or power outage).

8.3.2 Advanced Steam Treatment Technologies

A second generation of steam-based systems have been developed for the purpose of improving the transfer of heat into the waste; achieving more uniform heating of the waste, rendering the waste unrecognizable, and/or making the treatment system a continuous (rather than a batch) process. These new systems have sometimes been referred to as advanced autoclaves or advanced steam treatment technologies.

These systems basically function as autoclaves or retorts but they combine steam treatment with pre-vacuuming and various kinds of mechanical processing before, during, and/or after steam disinfection. The combinations include:

- Vacuum / steam treatment / compaction
- Steam treatment-mixing-fragmenting / drying / shredding
- Internal shredding / steam treatment-mixing / drying
- Internal shredding-steam treatment-mixing / drying
- Steam treatment-mixing-fragmenting / drying
- Internal shredding / steam treatment-mixing-compaction.

Each of these systems operates differently. Nevertheless, they treat the same types of waste and have similar emission characteristics as an autoclave or retort. Also, they share similar of the advantages and disadvantages of autoclaves.

As mentioned earlier, pre-shredding or pre-grinding should not be done before disinfection to protect workers from exposure to pathogens released in the air by the mechanical process; some state laws explicitly prohibit this. The exception is when shredding or grinding is internal. Because it is an integral part of a closed system designed in such a way that the air stream from the mechanical process cannot escape or is disinfected before being released to the surroundings.

An example of a system that combines steam treatment – mixing - fragmenting, drying, and then shredding is a rotating autoclave designed with fixed internal vanes. The Rotoclave is designed as a pressure vessel with a rotating internal drum. Waste bags and boxes are loaded into the drum using an optional cart dumper. The initial step is a vacuum to remove air. The evacuated air is mixed with steam and passed through a condenser and filter to destroy pathogens. The rotating pressure chamber operates at about 147°C for 30 minutes. As containers are pushed against the vanes of the rotating drum and fall, the combined effect of the steam and the rotational force, causes boxes and bags to break apart. The agitation also helps eliminate cold spots. After treatment, the steam is passed through a condenser and the condensate is discharged to the sewer while any residual air is vented through a carbon filter to remove odors. The control system cools the chamber down and dries the waste. Decontaminated waste is then automatically unloaded by reversing the rotation of the Rotoclave. This discharges the waste to a conveyor and to a post-treatment grinder, which reduced waste volume to about 80%. The units are controlled by programmable microprocessors.

An example of a system that combines internal shredding, steam treatment - mixing, and drying is a semi-continuous system known as a Chemclav. The waste is loaded via feed conveyors or cart dumpers into the hopper. This is where a negative pressure is maintained by drawing air through a high efficiency particulate air (HEPA) filter. The waste in the hopper drops into a heavy-duty shredding unit where downward pressure is applied using a ram. The feed mechanism is controlled by an integral process controller. Shredded material enters a rotating auger conveyor where low-pressure steam is introduced through multiple ports raising the temperature in the conveyor from 96 to 118°C. The steam is discharged through a vent at the very end of the conveyor and through a condenser causing the waste to dry off. The decontaminated waste exits the conveyor into a self-contained compactor or roll-off container for transport to a landfill. The heavy-duty shredder reduces waste volume up to 90%.
The Hydroclave is an example of a system combining steam treatment-mixing-fragmenting, drying, and post-treatment shredding. The chamber is basically a double-walled (jacketed) cylindrical vessel with mixing/fragmenting paddles inside. The waste is loaded through the loading door on top of the vessel. After the door is closed, high temperature steam enters the outside jacket to heat up the waste via the hot inner surface. During this time, a shaft and paddles rotate inside to fragment and tumble the waste. The moisture in the waste turns to steam and pressurizes the inner vessel; however, if there is not enough moisture, a small amount of steam is added until the desired pressure is met. The temperature is maintained at 132°C for 15 minutes while the mixing paddles rotate. After treatment, the steam is vented through a condenser while maintaining heat input, causing the waste to dry. The steam to the jacket is shut off. The discharge door is opened and then the shaft and paddles reverse rotation to

scoop the waste out through the loading door onto a conveyor or waste container. A strip chart recorder documents the process parameters. The waste is then shredded.

The advantages of these advanced steam treatment technologies are their abilities of achieving high levels of disinfection at shorter times because of the improved rates of heat transfer. They are highly automated and computer controlled and thus, they require very little operator attention. Treatment parameters are automatically recorded; thereby, providing the required documentation. Many are designed to remove odors using activated carbon or HEPA filters. Since they involve internal or post-treatment shredding and many have a drying cycle; the resulting waste is not only unrecognizable but also dry and compact, corresponding to as much as 85 to 90% volume reduction. Unlike autoclaves, some of these advanced systems such as the Rotoclave have been tested successfully for use with animal waste. This could potentially be used with pathological waste including anatomical parts. The biggest disadvantage of these high-tech systems is the capital cost, which is higher than that of a standard autoclave or retort for the same capacity. Advanced steam systems also have some of the same disadvantages as standard autoclaves, such as the need to keep chemicals out of the waste stream.

8.3.3 Microwave Technology

Microwave disinfection is essentially a steam-based process since disinfection occurs through the action of moist heat and steam generated by microwave energy. In general, microwave disinfection systems consist of a disinfection area or chamber into which microwave energy is directed from a microwave generator (magnetron). Typically, 2 to 6 magnetrons are used with an output of about 1.2 kW each. Some systems are designed as batch processes and others are semi-continuous. A typical semi-continuous microwave system, such as the Sanitec, consists of an automatic charging system, hopper, shredder, conveyor screw, steam generator, microwave generators, discharge screw, secondary shredder, and controls. The equipment includes hydraulics, high efficiency particulate air (HEPA) filter, and microprocessor-based controls protected in an all-weather steel enclosure.

The operation of a microwave unit such as a Sanitec is as follows:

- Waste loading: Waste bags are loaded into carts that attach to the feed assembly. High temperature steam is then injected into the feed hopper. While air is extracted through a HEPA filter, the top flap of the hopper is opened and the container with the waste is lifted and tipped into the hopper.
- Internal shredding: After the hopper flap is closed, the waste is first broken down in the hopper by a rotating feed arm and ground into smaller pieces by an internal shredder.
- Microwave treatment: The shredded particles are conveyed through a rotating conveyor screw. They are exposed to steam and then heated to between 95° and 100°C by four or six microwave generators.
- Holding time: A holding section ensures that the waste is treated for a minimum total of 30 minutes.
- Optional secondary shredder: The treated waste may be passed through a second shredder that breaks it into even smaller pieces. This is used when sharps waste is treated in the microwave unit. The optional secondary shredder can be attached in about 20 minutes prior to operation. It is located at the end of a second conveyor screw.

- Discharge: The treated waste is conveyed using a second conveyor screw or auger. This takes waste from the holding section and discharging it directly into a bin or roll-off container. The bin can be sent to a compactor or taken directly to a sanitary landfill.

The types of waste commonly treated in microwave systems are identical to those treated in autoclaves and retorts: cultures and stocks, sharps, materials contaminated with blood and body fluids, isolation and surgery waste, laboratory waste (excluding chemical waste), and soft waste (gauze, bandages, drapes, gowns, bedding, etc.) from patient care. One microwave system was successfully tested with animal waste. This can potentially be used to treat pathological waste such as tissues. Volatile and semi-volatile organic compounds, chemotherapeutic waste, mercury, other hazardous chemical waste, and radiological waste should not be treated in a microwave.

The odor problem is somewhat reduced except in the immediate vicinity of the microwave unit because a fully-enclosed microwave unit can be installed in an open area. Likewise, a HEPA filter is used to prevent the release of aerosols during the feed process,

Microwave technology has the following advantages:

- It is easy for hospital staff and communities to understand and accept the technology. Because many people are familiar with microwave ovens for cooking.
- It is accepted or approved as an alternative technology in many countries with units in operation for many years.
- If proper precautions are taken to exclude hazardous material, the emissions from microwave units are minimal.
- There are no liquid effluents from some microwave technologies like the Sanitec.
- The shredders reduce waste volume up to 80%.
- The technology is automated and easy to use and requires one operator.

Some of the disadvantages are:

- If hazardous chemicals are in the waste, these toxic contaminants are released into the air or remain in the waste to contaminate the landfill.
- There may be some offensive odors immediately around the microwave unit.
- The secondary shredder used for sharps can be noisy.
- Any large, hard metal object in the waste could damage the shredder.
- The capital cost is relatively high compared to standard autoclaves, retorts, and advanced steam treatment systems.

Below are some suggestions when using microwave technology:

- Make sure that an effective waste segregation plan is in place to keep hazardous materials from being treated in a microwave system.
- It is important to make sure that no heavy metal objects, such as prosthetic steel, are included in the waste stream to damage the shredder. Since the shredder is the highest maintenance item.
- Unlike autoclaves and other steam-based systems, the Sanitec microwave operates at or below the boiling point of water. The combined effects of steam and microwave heating can effectively destroy pathogens. However, microbiological tests should be used to verify disinfection levels.

- A microwave energy detector should be provided and workers need to periodically test for microwave energy leakage.
- Periodic inspections should include cleaning around the hopper area at the top of the containment shelter where some debris may accumulate.
- Workers should follow the list of routine preventive maintenance tasks described in detail in the operating manuals.
- Worker training should include: a basic understanding of microwaves and steam-based treatment systems, standard operating procedures, occupational safety (ergonomics, proper waste handling techniques), record keeping, identifying waste that should not be treated in the unit, recognizing shredder problems and what to do when soft waste gets stuck in the shredder section, periodic inspections and preventive maintenance, and contingency plans (e.g., what to do in case of a spill or power outage).

8.3.4 Dry Heat Technologies

Circulating hot-air ovens have been used to sterilize glassware and other reusable instruments. The concept of dry heat disinfection has been applied to treatment of infectious waste. In dry heat processes, heat is applied without adding steam or water. Instead, the waste is heated by conduction, natural or forced convection, and/or by thermal radiation. In force convection heating, air heated by resistance heaters or natural gas, is circulated around the waste in the chamber. In some technologies, the hot walls of the chamber heat the waste through conduction and natural convection. Other technologies use radiant heating by means of infrared or quartz heaters. As a general rule, dry heat processes use higher temperatures and longer exposure times than steam-based processes. They are not as commonly used and are usually available for the treatment of small volumes.

8.4 Interim Treatment Methods for Small Facilities

Ideally, infectious waste from small facilities (generating less than 50 kg a month) should be treated in small on-site treatment systems or sent to central treatment center or treatment facilities at nearby hospitals. However, these options may not be available for many clinics and rural health centers. Interim treatment methods include on-site waste burial or the use of small on-site pressure cooker designs.

An on-site waste burial pit simulates a sanitary landfill on a small scale and could be constructed at the back of the small facility. The pit should have proper drainage and not be located in an area that floods. The bottom of the pit should be at least 1.5 meters higher than the groundwater (water table). The pit should also be downhill from any nearby wells and about 50 meters away from any water sources such as streams. The construction method involves: (1) digging a pit 1 to 2 meters wide and 2 to 5 meters deep; (2) lining the bottom of the pit with clay or a low-permeable material if available; (3) constructing an earth mound around the mouth of the hole to prevent surface water from entering the pit; (4) constructing a fence or barrier around the area to keep animals, scavengers, and children; (5) periodically placing batches of waste inside the pit and covering each batch with a 10-cm layer of soil, or as an alternative, a mixture of lime and soil can be used as a covering layer; and (6) when the pit is about 50 cm of the ground surface, covering the waste with soil and permanently sealing it with cement. While the preferred method of sealing is to use cement, another alternative is to embed a sheet of wire mesh within a final 50-cm layer of soil cover. The burial pit - **Figure 11-** should only be used for infectious waste and not domestic waste to keep it from filling up quickly.

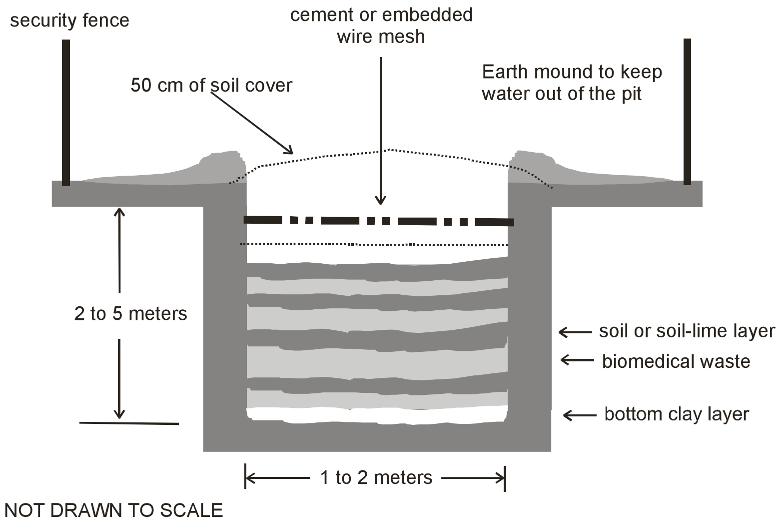

Figure 11 - On-Site Burial Pit

Another interim option is to use a commercially available pressure cooker as a substitute autoclave. The typical pressure cooker is designed to operate at 121ºC. This is the minimum recommended temperature for an autoclave. Small waste bags could be placed in an open aluminum container and put inside the pressure cooker with enough water to be able to maintain operating pressures for 30 minutes as instructed in the operating manual. The pressure cooker with the waste could be heated on an electric or gas stove, or using locally available fuels. When the pressure cooker reaches its maximum pressure as indicated by the release of steam from the pressure control valve, the operator should begin to time the cycle. After 30 minutes at the operating pressure, the pressure cooker could be removed from the source of heat and allowed to cool down. When the vessel has cooled to ambient temperatures, the waste could be safely removed and discarded with domestic waste.

Sharps are a special case. Even if they are treated in a pressure cooker or autoclave, they should not be discarded with domestic waste unless they are properly disposed in a controlled sanitary landfill. Otherwise, they should be shredded. Another interim solution is burial in a sharps pit. To construct the sharps pit, cement hollow blocks can be used in conjunction with 10mm reinforced steel bars spaced evenly every 0.4m. A mixture of cement, sand, and graded gravel is poured to form 0.1m walls and slabs. Construction generally takes two to five days involving between two to six workers. Basic masonry and carpentry skills were required. **Figure 12** shows a common design for a large sharps pit to handle syringes from a mass immunization campaign. The design could be scaled down depending on the size of the facility and the estimated amount of sharps waste generated in a year.

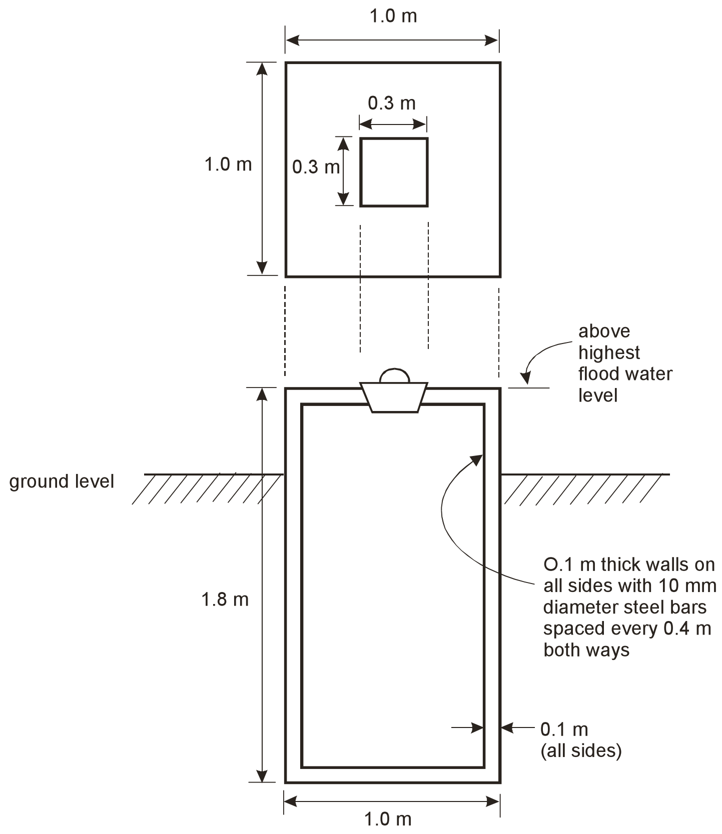

Figure 12 - Sample Sharps Pit Design

Another interim option for sharps waste from small facilities and rural health centers is the use of needle destroyers. These are small, portable, point-of-use devices that destroy the syringe immediately after use. Some are mechanical devices that require no batteries or electricity. A typical mechanical device cuts the whole needle into small pieces while cutting the hub of the syringe to render it useless. After the needle is inserted vertically down an orifice, the operator then pushes the handle downwards. A pot underneath collects up to 250 needles and can be sealed when full. Some devices can destroy 200,000 needles before requiring sharpening and other maintenance. Different models can handle the traditional Luer Slip needles attached to plastic syringes, Luer Lok needles, as well as double-ended needles used in Vacutainers and dentistry.

Other needle destroyers operate using electricity or batteries. As soon as the needle is inserted into an orifice, an electric charge melts the needle in a matter of seconds. Some devices only melt the tip while others melt the entire needle, reducing them into small metal balls which fall into an inside container and can be discarded when full. These needle destroyers are available commercially.

9. Incineration as an Interim Technology

Incineration was the standard and most common technology to treat infectious waste for many decades. In recent years, there has been recognition of the serious environmental and health consequences of incineration. The WHO released a policy paper in 2004 calling for the promotion of non-incineration treatment technologies.[11] The policy was formulated after a WHO-commission health risk assessment concluded that the emissions from small-scale incinerators used for only short periods of time could result in unacceptable cancer risks.[12]

Namibia ratified the Stockholm Convention on Persistent Organic Pollutants (POPs) in June of 2005. The treaty seeks to reduce and ultimately eliminate POPs such as dioxins and furans that are among the pollutants produced by medical waste incinerators. Dioxins can travel great distances in the atmosphere, are highly persistent (with environmental half-lives of 25 to 100 years in subsurface soils), can bio-concentrate and move up the food chain, and are toxic at extremely low concentrations. Article 5 of the Stockholm Convention stipulates that countries must require the use of best available techniques (BAT) for new or substantially modified sources of Part II source categories such as medical waste incinerators no later than 4 years after entry into force. The convention states that priority consideration should be given to alternative non-incineration technologies that do not generate dioxins and furans such as the technologies described above.

A medical waste incinerator releases into the air a wide variety of pollutants including highly toxic dioxins and furans, metals (such as lead, mercury, and cadmium), particulate matter, acid-forming gases, and carbon monoxide, as shown in **Table 9.**

Table 9 - Pollutants from Medical Waste Incinerators

POLLUTANT	EXAMPLES / NOTES
Dioxins and furans	2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)
Other organic compounds	benzene, carbon tetrachloride, chlorophenols, trichloroethylene, toluene, xylenes, trichloro-trifluoroethane, polycyclic aromatic hydrocarbons, vinyl chloride
Heavy metals	arsenic, cadmium, chromium, copper, mercury, manganese, nickel, lead
Acid gases	hydrogen chloride, hydrogen fluoride, sulfur dioxides, nitrogen oxides
Carbon monoxide	(a common product of incomplete combustion)
Pathogens	(found in the residues and exhaust of incinerators operating in conditions of poor combustion)
Particulate matter	fly ash
Bottom ash residues	usually contaminated with dioxins, furans, other organics, leachable heavy metals

11 "Safe health care waste management," policy paper, World Health Organization, Geneva, Switerland, August 2004.
12 "Assessment of Small-Scale Incinerators for Health Care Waste," S. Batterman, report conducted for the World Health Organization, January 21, 2004.

These emissions have serious adverse consequences on worker safety, public health, and the environment. Dioxins is a potent carcinogen and has been linked to chronic lymphocytic leukemia, soft tissue sarcoma, non-Hodgkin's lymphoma, as well as lung, laryngeal, prostate, and other cancers. Dioxin is also believed to adversely impact the immune and reproductive systems and may be linked to diabetes, birth defects, and other health effects. Mercury is associated with nervous system disorders particularly affecting developing fetuses and small children. Medical waste incinerators are a leading source of dioxins and mercury in the global environment.

Lead at low concentrations can cause anemia and reduced IQ in children. Chronic exposure to cadmium has been associated with progressive lung diseases, heart disease, anemia, and other health problems including lung cancer. Chronic exposure to carbon monoxide at low concentrations may aggravate heart conditions.

Acid gases react in the atmosphere to form acid rain contributing to the environmental degradation of forests, lakes, and streams. Hydrogen chloride, which is formed when chlorinated plastics commonly found in medical waste is incinerated, readily forms hydrochloric acid in contact with moisture and is corrosive and toxic to plants. Research has also shown that pathogens could be released in the stack and/or ash residue if incinerators are not operated under good combustion conditions.[13]

Fly ash (ash that is carried by the air and exhaust gases up the incinerator stack) contains heavy metals, dioxins, furans, and other toxic chemicals that condense on the surface of the ash. Even when the fly ash is removed from the exhaust stream by pollution control devices such as baghouse filters, the toxic materials remain concentrated on the filter cake and are hazardous. Incinerator ash remaining at the bottom of an incinerator after a burn down also contains heavy metals that may leach out, as well as dioxins and furans. Recent studies have shown that as much as 22% of the dioxins created by incinerators can be found in the ash or slag, and another 72% are found in the filter ash.[14] For this reason incinerator ash should be handled as hazardous waste.

Many studies related to the emissions from incinerators show adverse impacts on human health. A summary of epidemiological studies from 1988 to 2005, showing serious health effects among waste incineration workers and community residents living near incinerators, is presented in **Table 10** below in chronological order. The epidemiological studies show significant associations between exposure to incinerator emissions and lung cancer, laryngeal cancer, ischemic heart disease, urinary mutagens and promutagens, as well as elevated blood levels of various toxic organic compounds and heavy metals.

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13 M. Barbeito and M. Shapiro, Journal of Medical Primatology, 6:264-273, 1977; S. Klafka and M. Tierney, Proceedings: National Workshops on Hospital Waste Incineration and Hospital Sterilization, EPA-450/4-89-002, U.S. Environmental Protection Agency, January 1989.

14 Giugliano et al., Chemosphere 43, 743 (2001).

Table 10: Summary of Epidemiological Studies on Adverse Health Effects Associated with Incinerator Emissions

STUDY SUBJECTS	CONCLUSIONS REGARDING ADVERSE HEALTH EFFECTS	REFERENCE
Workers at an incineration plant for infectious waste in Japan	Measured polychlorinated dibenzo-p-dioxin and dibenzofuran concentrations in serum samples	S. Kumagai and S. Koda, *Journal of Occupational and Environmental Hygiene* 2, 120-125, February 2005.
Mothers living close to incinerators and crematoriums in Cumbria, north west England, from 1956 to 1993	Increased risk of lethal congenital anomaly, in particular, spina bifida and heart defects around incinerators, and increased risk of stillbirths and anacephalus around crematoriums	T. Drummer, H. Dickinson and L. Parker, *Journal of Epidemiological and Community Health*, 57, 456-461 (2003)
Residents from 7 to 64 years old living within 5 km of an incinerator and the incinerator workers	Levels of mercury in hair increased with closer proximity to the incinerator during a 10 year period	P. Kurttio et al., *Arch. Environ. Health, 48*, 243-245 (1998)
Residents living within 10 km of an incinerator, refinery, and waste disposal site	Significant increase in laryngeal cancer in men living with closer proximity to the incinerator and other pollution sources	P. Michelozzi et al., *Occup. Environ. Med., 55*, 611-615 (1998)
532 males working at two incinerators from 1962-1992	Significantly higher gastric cancer mortality	E. Rapiti et al., *Am. J. Ind. Medicine, 31*, 659-661 (1997)
Residents living around an incinerator and other pollution sources	Significant increase in lung cancer related specifically to the incinerator	A. Biggeri et al. *Environ. Health Perspect.*, *104*, 750-754 (1996)
People living within 7.5 km of 72 incinerators	Risks of all cancers and specifically of stomach, colorectal, liver, and lung cancer increased with closer proximity to incinerators	P. Elliott et al., *Br. J. Cancer, 73*, 702-710 (1996)
10 workers at an old incinerator, 11 workers at a new incinerator	Significantly higher blood levels of dioxins and furans among workers at the old incinerator	A. Schecter et al., *Occup. Environ. Medicine, 52*, 385-387 (1995)
122 workers at an industrial incinerator	Higher levels of toluene, lead and cadmium in the blood, and higher levels of tetrachlorophenols and arsenic in urine among incinerator workers	R. Wrbitzky et al., *Int. Arch. Occup. Environ. Health, 68*, 13-21 (1995)
53 incinerator workers	Significantly higher blood and urine levels of hexachlorobenzene, 2,4/2,5-dichlorophenols, 2,4,5-trichlorophenols, and hydroxypyrene	J. Angerer et al., *Int. Arch. Occup. Environ. Health, 64*, 266-273 (1992)
37 workers at four incinerator facilities	Significantly higher prevalence of urinary mutagen/promutagen levels	X.F. Ma et al., *J. Toxicol. Environ. Health, 37*, 483-494 (1992)
56 workers at three incinerators	Significantly higher levels of lead and erythrocyte protoporphyrin in the blood	R. Malkin et al., *Environ. Res., 59,* 265-270 (1992)
86 incinerator workers	High prevalence of hypertension and related proteinuria	E.A. Bresnitz et al., *Am. J. Ind. Medicine, 22*, 363-378 (1992)
104 workers at seven incinerator facilities	Significantly higher prevalence of urinary mutagen and promutagen levels	J.M. Scarlett et al., *J. Toxicol. Environ. Health, 31*, 11-27 (1990)
176 incinerator workers employed for more than a year from 1920-1985	Excessive deaths from lung cancer and ischemic heart disease among workers employed for at least 1 year; significant increase in deaths from ischemic heart disease among workers employed for more than 30 years or followed up for more than 40 years	P. Gustavsson, *Am. J. Ind. Medicine, 15,* 129-137 (1989)
Residents exposed to an incinerator	Reproductive effect: frequency of twinning increased in areas at most risk from incinerator emissions	O.L. Lloyd et al., *Br. J. Ind. Medicine, 45*, 556-560 (1988)

In light of this, incineration should be seen as an interim solution and phased out in the immediate term. Priority should be given to non-incineration treatment technologies, which should be promoted in accordance to the Stockholm Convention and WHO policy.

9.1 Standards for New Incinerators

General principles

Incinerator emissions should comply with national standards and in accordance with the Stockholm Convention BAT/BEP guidance in those countries that have signed the convention. If the relevant authorities have not established such regulations, the BAT/BEP guidelines or international standards are examples of those that could be followed.

			US EPA emission limits			EU emission limits			
Pollutant	Units	Standard conditions[1]	Small[2]	Medium[2]	Large[2]	Daily ave	Half-hour ave[3]	0.5-8 hour ave	AP 42[6]
Particulate matter or total dust	mg/m³	20°C, 101.3kPa, 7% O_2, dry	66	22	18				223
		273°K, 101.3kPa, 11% O_2, dry				10	10, 30		
Carbon monoxide	ppm(v)	20°C, 101.3kPa, 7% O_2, dry	20	1.8	11				127
	mg/m³	273°K, 101.3kPa, 11% O_2, dry				50	100 [4]		
Dioxins/furans	ng TEQ /m³	20°C, 101.3kPa, 7% O_2, dry	0.013	0.014	0.035				4.1
	ng TEQ /m³	273°K, 101.3kPa, 11% O_2, dry						0.1 [5]	
Gaseous & vaporous organics as total organic carbon	mg/m³	273°K, 101.3kPa, 11% O_2, dry				10	10, 20		15
Hydrogen chloride	ppm(v)	20°C, 101.3kPa, 7% O_2, dry	15	7.7	5.1				1106
	mg/m³	273°K, 101.3kPa, 11% O_2, dry				10	10, 60		
Hydrogen fluoride	mg/m³	273°K, 101.3kPa, 11% O_2, dry				1	2, 4		
Sulfur dioxide	ppm(v)	20°C, 101.3kPa, 7% O_2, dry	1.4	1.4	8.1				54.6
	mg/m³	273°K, 101.3kPa, 11% O_2, dry				50	50, 200		
Nitrogen oxides	ppm(v)	20°C, 101.3kPa, 7% O_2, dry	67	67	140				93
	mg/m³	273°K, 101.3kPa, 11% O_2, dry				200	200, 400		
Cadmium	mg/m³	20°C, 101.3kPa, 7% O_2, dry	0.017	0.0098	0.00013				0.3
Cadmium and thallium	mg/m³	273°K, 101.3kPa, 11% O_2, dry						total 0.05	
Mercury	mg/m³	20°C, 101.3kPa, 7% O_2, dry	0.014	0.0035	0.0013				5.4
	mg/m³	273°K, 101.3kPa, 11% O_2, dry						0.05	
Lead	mg/m³	20°C, 101.3kPa, 7% O_2, dry	0.31	0.018	0.00069				3.6
Antimony, arsenic, lead, chromium, cobalt, copper, manganese, nickel, vanadium and their compounds	mg/m³	273°K, 101.3kPa, 11% O_2, dry						total 0.5	

Different standard conditions are defined for EPA and EU limits; corrections have to be made to convert between different standard temperatures and percent oxygen. [2] EPA defines small incinerators as having a waste burning capacity ≤ 200 lbs/hr, medium capacity as > 200 to 500 lbs/hr, and large capacity as > 500 lbs/hr. [3] At least 97% of half-hourly average concentrations must meet the first value and 100% must meet the second value. [4] All half-hourly average concentrations taken in any 25-period must meet this value. [5] The sampling period for dioxins/furans must be a minimum of 6 hours and a maximum of 8 hours under the EU directive. [6] AP 42 (EPA, 1996) are emission estimates for incinerators without air pollution equipment and are shown for comparison; adapted from Batterman (2004). Source: US Environmental Protection Agency (2011). *Standards of Performance for New Stationary Sources and Emissions Guidelines for Existing Sources: Hospital/Medical/Infectious Waste Incinerators – Final rule amendments*, 40 CFR Part 60; European Parliament and the Council of the European Union (2000). Directive 2000/76/EC on the incineration of waste.

Any proposed incineration plant should have all the following units:

- Furnace or kiln as the primary combustion chamber
- Afterburning chamber as the secondary chamber
- Dry, wet or catalytic flue gas cleaning device system
- Wastewater treatment plant.

The incinerator should employ one of the following firing technologies:

- Degassing and/or gasification (pyrolysis)
- Rotary kiln
- Grate incineration specially adapted for HCW
- Fluidized bed incineration.

Single-chamber, drum and brick incinerators will not be accepted.
The incinerator should meet the following requirements for primary measures and process optimization:

- Introduction of the waste in the combustion chamber only at temperatures of 850 °C; the plant should have an automatic system to prevent waste feed before the above-mentioned temperature is reached
- Installation of auxiliary burners (for start-up and shut-down operations)
- Avoidance of starts and stops of the incineration process
- The chambers should not operate at temperatures below 850°C and there should be no cold regions
- Control of oxygen input depending on the heating value and consistency of feed material to provide sufficient oxygen content at an average of 6% O_2 by volume average
- Minimum residence time of 2 sec at between 1300°C to 1500ºC in the secondary chamber
- High turbulence of exhaust gases and reduction of air excess by injection of secondary air or re-circulated flue gas, pre-heating of the air-streams, regulated air inflow
- On-line monitoring for combustion control (temperature, oxygen content, CO, dust), and operation and regulation of the incinerator from a central console.

The incinerator should meet the requirements for secondary measures by a combination of the following flue gas cleaning systems:

- Separation of dust and non-volatile heavy metals: Fabric filters, electrostatic precipitators and fine wet scrubbers are used for dust separation. Pre-cleaning of flue gases can be done with cyclones that are efficient for separation of larger particles.
- HCl, HF, SO_2 and Hg removal: The removal of acid components and Hg can be reached by different dry or wet adsorption methods (adsorption on activated coke or lime) as well as by scrubbing (1- or 2-stage wet scrubbing).
- NO_x removal: Primary measures consist in the use of low-NOx burners, staged combustion and recirculation of the flue gas, secondary measures are SNCR and SCR.
- The reduction of organic emissions and PCDD/F can be performed by primary measures such as: limitation of the de-novo synthesis and optimized combustion. Secondary measures includes: dust separation (see above), activated coke filter, flow injection with activated coke/ furnace coke and lime hydrate, catalytic oxidation.

The incinerator should also have appropriate fly and bottom ash and wastewater treatment systems. The main waste fractions are fly ash, slag, filter cake from the waste water treatment, gypsum and loaded activated carbon. This waste is predominantly hazardous waste and needs to be disposed of properly by land filling in proper double-walled containers, solidification and subsequent land filling, etc.

The incineration plant should have:

- Well-trained and qualified personnel
- Operation and monitoring of the incinerator by periodic maintenance (cleaning of combustion chamber, de-clogging of air inflows and fuel burners)
- Personal protective equipment for their personnel
- Standard environmental monitoring protocols
- Audit and reporting systems
- General infrastructure, paving, and ventilation.

Before an incinerator is permitted to operate, it must demonstrate that it can meet the following emission limits (based on EU standards):

Air Emission Limit Values (daily average)

DAILY AVERAGE VALUES:	
Total dust	10 mg/m^3
Gaseous and vaporous organic substances, expressed as total organic carbon	10 mg/m^3
Hydrogen chloride	10 mg/m^3
Hydrogen fluoride	1 mg/m^3
Sulfur dioxide	50 mg/m^3
Nitrogen monoxide and nitrogen dioxide, expressed as nitrogen dioxide for existing incinerator plants with a nominal capacity exceeding 6 tonnes per hour or new incinerator plants	200 mg/m^3
Nitrogen monoxide and nitrogen dioxide, expressed as nitrogen dioxide for existing incinerator plants with a nominal capacity of 6 tonnes per hour or less	400 mg/m^3

Air Emission Limit Values (half-hourly average)

HALF-HOURLY AVERAGE VALUES:	(100%) A	(97%) B
Total dust	30 mg/m³	10 mg/m³
Gaseous and vaporous organic substances, expressed as total organic carbon	20 mg/m³	10 mg/m³
Hydrogen chloride	60 mg/m³	10 mg/m³
Hydrogen fluoride	4 mg/m³	2 mg/m³
Sulfur dioxide	200 mg/m³	50 mg/m³
Nitrogen monoxide and nitrogen dioxide, expressed as nitrogen dioxide for existing incinerator plants with a nominal capacity exceeding 6 tonnes per hour or new incinerator plants	400 mg/m³	200 mg/m³

Average Values for Heavy Metals, over the sample period of a minimum of 30 minutes and a maximum of 8 hours:

Cadmium and its compounds	Total 0.05 mg/m³
Thallium and its compounds	Total 0.05 mg/m³
Mercury and its compounds	0.05 mg/m³
Antimony and its compounds	Total 0.05 mg/m³
Aresenic and its compounds	Total 0.05 mg/m³
Lead and its compounds	Total 0.05 mg/m³
Chromium and its compounds	Total 0.05 mg/m³
Cobalt and its compounds	Total 0.05 mg/m³
Copper and its compounds	Total 0.05 mg/m³
Manganese and its compounds	Total 0.05 mg/m³
Nickel and its compounds	Total 0.05 mg/m³
Vanadium and its compounds	Total 0.05 mg/m³

Note: These average values cover also gaseous and the vapor forms of the relevant heavy metal emission as well as their compounds.

Average values for Dioxins and Furans, measured over a sample period of a minimum of 6 hours and a maximum of 8 hours

Dioxins and furans	0.1 ng/m³

Note: The emission limit value refers to the total concentration of dioxins and furans calculated using the concept of toxic equivalence.

Emission Limit Values of Carbon Monoxide Concentrations:

- 50 mg/m³ of combustion gas determined as daily average value
- 150 mg/m³ of combustion gas of at least 95% of all measurements determined as 10-minute average values or 100 mg/m³ of combustion gas of all measurements determined as half-hourly average values taken in any 24-hour period

Note: standard conditions in relation to measurements of emission values are based on 273 K, 101.3 kPa, 11% oxygen, and dry gas.

Additional requirements are:

1) Slag and bottom ashes total organic carbon content – less than 3% or their loss on ignition is less than 5% of the dry weight of the material
2) Automatic feed systems to control waste feed in order to meet temperature and continuous emission limit requirements; infectious clinical waste should be placed straight in the furnace without first being mixed with other categories of waste and without direct handling
3) Control and monitoring: measurement equipment to monitor parameters, conditions and concentrations
4) Measurement requirements including continuous monitoring:
   - Continuous measurement of NOx, CO, total dust,TOC, HCL, HF (may be omitted if HCl is treated and limits not exceeded), and SO_2; HCl , HF and SO_2 may be done periodically instead if operator can prove that limits can never be exceeded under any circumstance
   - Continuous measurements of temperature in combustion chamber, O_2 concentration, pressure, temperature, and water vapor content of exhaust gas;
   - At least two measurements per year of heavy metals, dioxins and furans; one measurement every three months for the first year;
   - Verification of residence time, minimum temperature and O_2 in exhaust at least once.

Records must be maintained and made available during inspections by regulatory authorities. The regulatory authority will halt the operation of the plant if any of the emission limits specified above are exceeded. Tests of heavy metals, dioxins, and furans should be conducted by an independent third party using a laboratory that is certified for dioxin/furan testing. Other testing requirements include:

- Testing conducted while burning representative waste loads
- Testing at the rated burn capacity of the incinerator
- Minimum sampling time of 6 hours
- Isokinetic sampling
- Sampling port at least 8 stack diameters downstream and 2 stack diameters upstream from flow disturbances
- Collection using a sample probe, sampling train and packed column of adsorbent material
- Analysis using high-resolution gas chromatography and high-resolution mass spectrometry
- Standardization of results for dry conditions, 11% oxygen, 101.3 kPa (14.7 psi) and 273 ºK
- Quality control and quality assurance (QC/QA), including calibration, sampling train collection efficiency check, internal standard recovery, surrogate standard recovery, rinsate tests, and performance audits
- Chain-of-custody procedures
- Reporting of sampling protocol, test method, QA/QC procedures, test results, and minimum detection limits
- Submission of the full test report including sampling and testing procedures to regulatory authority.

Other technical requirements for the incinerator involve wastewater monitoring and stack height. The plant should have a wastewater treatment system and the effluents regularly monitored to ensure that they meet existing discharge limits. The height of the stack or chimney of the new incinerator should be 2.5 times higher than the height of any structure within at least 6 times the length of the incinerator enclosure.

Because dioxin concentrations are greatest within the first 800 to 1000 meters of an incinerator, the new incinerator should be located 1000 meters away from the nearest residences, commercial establishments, agricultural farms and grazing fields, and bodies of water that may be used for fishing. The presence of chlorine in the waste contributes significantly to the emission of dioxins and furans. If possible, chlorinated waste such as polyvinyl chloride plastics should be minimized or eliminated from the waste that is incinerated.

In addition to the technical and organizational requirements given below, new incineration plants must also have social acceptance by civil society organizations (CSOs) and the surrounding communities, who may have to shoulder the environmental health consequences of the incinerator. An open and transparent process of consultations with NGOs and communities under the principle of “prior informed consent” is recommended. Such a process includes: requiring an environmental impact assessment, seeking out and involving all potential stakeholders that may be affected by the new plant, holding open public meetings wherein the known and unknown risks are accurately communicated, carefully considering and addressing all the concerns of stakeholders, and providing the opportunity for communities and civic groups to participate meaningfully in decision-making.

10. Pharmaceutical Waste

Four procedures are recommended for pharmaceutical waste:
(1) Return of expired pharmaceuticals to supplier,
(2) Incineration,
(3) Inertization,
(4) Encapsulation,
(5) Sewer discharge.

Many healthcare facilities worldwide have arrangements with pharmaceutical companies to send back expired or condemned drugs. This is the preferred method of handling this waste stream.

High temperature incineration is another way to dispose of pharmaceutical waste. The waste should be disposed of with their cardboard packaging to ensure optimal combustion conditions. Low temperature incineration/burning, as is currently practiced in Namibia, provide only limited treatment for this type of waste and are therefore not recommended. Pyrolytic or Rotary kiln incinerators are particularly well suited for the treatment of pharmaceutical waste since the temperatures reached often exceed 1'200-1'400°C, thus ensuring both complete combustion and near to zero toxic exhaust gases. Pharmaceuticals should be introduced into the furnaces as a reasonably small proportion of the total fuel feed. It is suggested that as a sensible "rule of thumb" no more than 5% of the fuel feed into the furnace at any one time is pharmaceutical material.

If the waste cannot be returned to the supplier, another alternative is inertization. Solid pharmaceutical waste is removed from packaging or containers, ground up and then mixed with cement, lime, and water. The following ratio is recommended: 65% pharmaceutical waste, 15% lime, 15% cement, and 5% water. The homogeneous mixture is allowed to harden into cubes or pellets. The hardened mass should then be disposed in a hazardous waste landfill engineered to prevent groundwater contamination. In the absence of a hazardous waste landfill, the hardened mass may be disposed in a restricted portion of a sanitary landfill or buried in specially designed trenches or burial pits within the healthcare facility premises. In the latter case or if a sanitary landfill is not available, the trenches or pits must be lined with clay or a membrane liner to prevent leaching into groundwater, secured with a fence to restrict access, and eventually capped to prevent percolation of water. A waste minimization program should be in place so that only small amounts of pharmaceutical waste are disposed of in this manner.

A fourth alternative is encapsulation. Solid, semi-liquid, or liquid pharmaceutical waste could be placed in drums. These drums are filled to 3/4ths their capacity. The drums are then filled with cement mortar or clay, sealed, then buried in a hazardous waste landfill engineered to prevent groundwater contamination. Again, in the absence of a hazardous waste landfill, the sealed drums may be buried in a restricted area of the sanitary landfill. As with inertization, a waste minimization program should be in place so that only small amounts of pharmaceutical waste are disposed of in this manner.

A fifth alternative applies only to moderate quantities of relatively mild liquid or semi-liquid pharmaceuticals such as: vitamin solutions, cough syrups, eye drops, saline solutions, intravenous fluids, etc. It is acceptable to discharge these liquid drugs into a sanitary sewer while diluting with large amounts of water. Antibiotics and chemotherapy drugs should not be discharged into the sanitary sewer.

10. 1 Cytotoxic/Genotoxic Waste

Cytotoxic or chemotherapeutic waste is either bulk agents or materials, such as vials or gloves, contaminated with amounts of chemotherapy agents. They are, also called antineoplastic agents or cytotoxic drugs, and have the ability to killor stop growth of living cells. They are used in the chemotherapy of cancer which is usually performed in specialized treatment centres. However, if unwanted and discharged into the environment they can have very serious effects, such as interfering with reproductive processes in various life forms. Their disposal must therefore be handled with care. Examples of these cancer therapy drugs are Chlorambucil, Cytoxin, Daunomycin, Mitomycin C, Streptozotocin, Melphalan, and Uracil Mustard. They require special handling procedures because of their toxic characteristics.
All waste minimization options should be considered before looking at treatment methods. In the case of cytotoxic/genotoxic waste, the facility should consider inventory management, and procedures for preparation, storage, administration and waste segregation that result in reducing the amount and type of material that needs special disposal. General principles of handling and disposing cytotoxic waste include:[15]

- Dispose sharps, containers, and cytotoxic waste according to the appropriate procedure in a plastic bag designed for hazardous waste.
- Do not clip or recap needles. Discard the needle-syringe unit into a convenient and appropriately labeled, puncture-proof container.
- Discard all gauze, tubing, bags, and bottles etc. in appropriately labeled bags and seal. Remove gown and gloves and discard in a similar manner.
- When disposing cytotoxic/genotoxic waste, wear personal protection equipment (latex-free gloves, low-permeable gown with long sleeves and solid front, face mask designed for aerosols)
- Clean up spills using available chemicals and disposable towels or sponges.
- For large spills, double gloving is recommended.
- If direct exposure occurs, immediately rinse the area with running water. In case of exposure with eyes, rinse eyes with an eyewash solution or sterile saline. Report all episodes of drug exposure to concerned physician immediately. Wash face and hands completely with running water.

There are three recommended procedures for dealing with bulk quantities of cytotoxic/genotoxic waste: (1) Return to supplier; (2) Chemical degradation; (3) and high temperature incineration. The preferred method is for bulk quantities of cytotoxi/genotoxic agents to be repackaged, marked “outdated” or “not for use,” and returned to the supplier for processing. Cytotoxic/genotoxic waste should be segregated from other pharmaceuticals and kept separately in clearly marked containers with rigid walls. They should ideally be safely packaged and returned to the supplier for disposal.

15 “Practical Guidelines for Disposing Cytotoxic Waste,” Vijay Roy, Puneet Gupta and MC Joshi, Express Health Care Management, http://www.expresshealthcaremgmt.com/20050430/wastemanagement01.shtm

If the waste cannot be returned to the supplier, chemical degradation methods exist for chemotherapy agents. The Table below lists examples of simple chemical degradation methods and gives examples of agents on which it has been tested.

DEGRADATION METHOD	NOTES
Heated alkaline hydrolysis	Commercially available
Oxidation by sulfuric acid and potassium permanganate (KMnO4)	Used to degrade doxorubicin, daunorubicin, methotrexate, dichloromethotrexate, vincristine, vinblastine, 6-tioguanine, 6-mercaptopurine, procarbazine
5% sodium hypochlorite (bleach) for 1 hour	Successfully tested on about 34 cytotoxic agents
Alkaline hydrolysis with dimethylformamide	Used to degrade cyclophosphamide, ifosfamide
Acid hydrolysis followed by alkaline hydrolysis	Used to degrade cyclophosphamide
Potassium permanganate in alkali	Used to degrade methotrexate
Denitrosation by hydrobromic acid	
Reduction using nickel and aluminum	
Reduction by zinc powder	Used to degrade cisplatin
Reaction with diethldithiocarbamate	Used to degrade cisplatin
Degradation by 30% hydrogen peroxide	

Examples of treatment methods for common cytotoxic/genotoxic agents are listed below:[16]

- Bleomycin 5% Sodium Hypochlorite or 1% Potassium Permanganate
- Carboplatin 5% Sodium Hypochlorite
- Cisplatin 5% Sodium Hypochlorite
- Cytarabine 5% Sodium Hypochlorite
- Doxorubicin HCL 5% Sodium Hypochlorite
- Dactinomycin 5% Tri Sodium Phosphate
- Daunorubicin 5% Sodium Hypochlorite
- Epirubicin 5% Sodium Hypochlorite
- Etoposide 5% Sodium Hydroxide
- Flurouracil 5% Sodium Hypochlorite
- Idarubicin 5% Sodium Hypochlorite
- Methotrexate 5% Sodium Hypochlorite
- Mitomycin 5% Sodium Hypochlorite or 1% Potassium Permanganate
- Mitoxantrone 5% Sodium Hypochlorite
- Plicamycin 10% Trisodium Phosphate
- Vinblastine 5% Sodium Hypochlorite
- Vincristine 5% Sodium Hydroxide

16 "Practical Guidelines for disposing Cytotoxic Waste," *Ibid.*

The Unit of Gene-Environment Interactions of the International Agency for Research on Cancer (IARC, 150 Cours Albert-Thomas, 69372 Lyon Cedex 08, France) is a source of information for chemical degradation methods. Chemical degradation can also be used to clean up spills or contaminated urinals.

Incineration of cytotoxic/genotoxic agents is only permitted in specialized dual-chamber incinerators operating at very high temperatures, above 1200 ºC, with a minimum residence time of 5 seconds, and is fitted with gas cleaning equipment. An after-burner (i.e. the secondary chamber) is important for the destruction of cytotoxic waste, as it is possible that Cytotoxic/genotoxic solutions could become aerosolized following the initial combustion in the primary chamber. As a result, without a higher temperature secondary chamber, degraded Cytotoxic/genotoxic material may be emitted from the chimney. The secondary combustion chamber consequently ensures that such Cytotoxic/genotoxic substances are fully incinerated.

Cytotoxic/genotoxic waste should never be disposed of in a landfill other than after encapsulation or inertization. Work teams handling these drugs must avoid crushing cartons or removing the product from its packages. They may only be discharged in a sewerage system after chemical decomposition and must not be discharged untreated into surface water drains or natural watercourses.

Special treatment for Cytotoxic/genotoxic

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

Cytotoxic/genotoxic drug disposal

Methods of disposal:	1. Return to supplier 2. Chemical degradation 3. High temperature incineration 4. Waste encapsulation
Methods of disposal of cytotoxic/genotoxic **NOT** to be used:	5. Low and medium temperature incineration 6. Disposal to sewers and water courses 7. Directly to landfill

Some cytotoxic/genotoxic waste in minimal quantities remains in vials, in tubing and IV bags, or on gloves, gowns, gauze and syringes. These small quantities are hard to extract from the materials, very toxic, and cannot be deactivated with water. It is recommended that waste contaminated with only trace amounts of cytotoxic agents be encapsulated (placed in drums filled to 3/4ths their capacity, then filled with cement mortar or clay, and sealed) and buried in hazardous waste landfills or restricted sections of a sanitary landfill engineered to prevent groundwater contamination.

17 "Mercury Report to Congress," U.S. Environmental Protection Agency, Washington, DC, 1997; estimates of Environment Canada on mercury in the sewage system.
18 "Mercury in Health Care," policy paper, World Health Organization, Geneva, Switerland, August 2005.

10.2 Other Hazardous Waste

Other hazardous chemical wastes include: spent organic solvents, degreasers and oils used by the engineering staff, mercury from broken thermometers, etc. Four general disposal methods are recommended: (1) Return to supplier, (2) Chemical degradation, (3) Encapsulation and disposal in a hazardous waste landfill, or (4) Sewer discharge. Appropriate provisions may be included in the original purchase contract of chemicals. This will allow for the return of spent or outdated chemicals to the original supplier in a country with the expertise and facilities to dispose of the waste safely and in an environmentally sound manner. Shipment for the purpose of returning the waste should comply with international agreements including the Basel Convention.

It may be possible to degrade or neutralize some chemical waste (e.g., acids or bases) at a special treatment facility. If neither of these alternatives is possible, the chemical waste should be encapsulated in small quantities in drums and buried in an approved hazardous waste landfill engineered to prevent groundwater contamination. Large amounts of disinfectants should not be encapsulated because they are corrosive and sometimes flammable. Hazardous chemical waste of different compositions should be stored separately to avoid unwanted chemical reactions. Some mild chemicals, such as mild disinfecting or cleaning solutions, may be discharged in the sanitary sewer while diluting with large amounts of water.

In one country, incineration of HCW was found to be the fourth largest source of mercury in the atmosphere. Moreover, in another country, healthcare facilities including dental offices were found to be responsible for more than a third of the mercury in the sewage system.[17] Because healthcare facilities are a significant source of mercury pollution, mercury waste is discussed separately below.

10.3 Mercury Waste

Mercury can be found throughout a HCF in products such as: thermometers, sphygmomanometers, dilation and feeding tubes, batteries, thermostats, fluorescent tubes, laboratory fixatives, and some medicinal preservatives. Mercury is neurotoxic and can damage the central nervous system; especially during fetal and childhood development. Mercury exposure can cause tremors, impaired vision and hearing, paralysis, insomnia, emotional instability, developmental deficits during fetal development, attention deficit, and developmental delays during childhood. Mercury vaporizes and may stay in the atmosphere for up to a year. Mercury ultimately accumulates in the sediments of rivers and lakes, where it is transformed into a more toxic form, methylmercury, which builds up in fish tissue. In the last 100 years, the levels of mercury in the global environment have been rising. International organizations such as the United Nations Environment Program are developing programs to address the global mercury problem.

Some of the recommendations from the WHO's policy paper on mercury in healthcare facilities are:[18]

- Develop mercury clean-up and waste handling and storage procedures that minimize and eliminate patient, occupational, and community exposures. Proper procedures should include spill clean up response, educational programs, protective gear, appropriate waste storage containment, staff training, and engineered storage facilities.

19 "White Paper on Mercury Elimination," Jamie Harvey, presented at Setting Healthcare's Environment Agenda, October 16, 2000.

- Countries that have access to affordable alternatives should develop and implement plans to reduce the use of mercury equipment and replace them with mercury-free alternatives. Ensure that new devices conform to recommended validation protocols.
- Increase efforts to reduce the number of unnecessary use of mercury equipment. Hospitals should inventory their use of mercury. This inventory should be categorized into immediately replaceable and gradually replaceable.
- Replaced devices should be taken back by the manufacturer or taken back by the alternative equipment provider. Progressively discourage the import and sale of mercury containing health-care devices and mercury use in health-care settings.
- Promote the principles of environmentally sound management of HCW containing mercury, as set out in the UN Basel Convention on the Control of Transboundary Movements of Hazardous Waste and their Disposal.
- Support the allocation of human and financial resources to ensure procurement of mercury free alternatives and a sound management of health-care waste containing mercury.

Success of a mercury reduction and elimination program is highly dependent on facility-wide education and understanding of the adverse impacts of mercury to the environment, public health, and worker health and safety. Experience demonstrated that an education and communication program within all departments is imperative for the support of staff and ultimate success. Development of any program requires not only financial resources and administrative support, but also a long-term vision and commitment, especially as mercury-free alternatives become more and more available and affordable in the coming years.

A mercury reduction program begins with the formation of a mercury pollution prevention taskforce. The taskforce should make an assessment of the use of mercury in the facility (including identification of mercury-containing materials, amounts of mercury waste such as broken thermometers and blood-pressure devices, and locations in the facility where mercury is used), conduct research on mercury-free alternatives, develop spill clean-up and mercury containment procedures, develop plans and prioritize, provide training, and take action steps to reduce or eliminate the quantities of mercury in the facility. Examples of action steps are:[19]

- Collecting all unused thermometers within the facility, maintaining an inventory of mercury thermometers, and controlling their distribution
- Segregating mercury waste such as batteries, mercury-containing fluorescent bulbs, and mercury-containing equipment
- Regularly cleaning waste traps especially in dental facilities; collecting and storing mercury removed from waste traps
- Developing replacement plans and a budget for purchasing mercury-free equipment including mercury-free thermometers
- Purchasing equipment that do not contain mercury switches
- Replacing mercury-containing laboratory reagents, fixatives, and preservatives with mercury-free substitutes.

20 Best management practices for amalgam waste. American Dental Association Web site. http://www.ada.org/prof/resources/topics/amalgam_bmp.asp. Assessed November 2, 2009

Examples of mercury-free clinical thermometers are: digital thermometers, galinstan thermometers that use gallium-indium-tin instead of mercury, glass alcohol-dye thermometers (also known as spirit thermometers), tympanic thermometers that have infrared sensors and are used on the ear, and chiral nematic liquid crystals thermometers used on the skin or forehead. An example of a mercury-free blood-pressure device is the aneroid sphygmomanometer. Mercury switches could be replaced with mercury-free mechanical, pressure, or electronic switches.

Until such time that a centralized mercury recovery, recycling or engineered storage facility is available, it is recommended that all liquid mercury be collected in impermeable rigid plastic containers containing enough water to prevent volatilization of mercury in the air space of the container. The containers should be kept close, labeled "MERCURY WASTE," and stored in locked cabinets or steel drums to prevent unauthorized access. Ideally, cabinets or steel drums should be ventilated to the outside air. If glass bottles are used, the bottles should be placed in plastic containers to prevent breakage. An alternative is to encapsulate the mercury using commercially available amalgam powder or powdered sulfur to form a solid and reduce volatilization during storage. The resulting amalgam should be stored in closed, labeled containers.

The basic elements of mercury spill clean-up procedures include:

1) Determine the extent of the spread of the mercury spill;
2) Evacuate the immediate area, restrict public access, close doors and temporarily shut off local ventilation to prevent spreading vapors;
3) Put on personal protection equipment such as rubber gloves and an apron (Note: remove all jewelry to prevent mercury from forming an amalgam with any precious metals);
4) Use a small scoop, cardboard or folded paper to collect the large mercury beads and place them in a rigid plastic container with water;
5) Use a medicine dropper, syringe, aspirator bottle, or pipette to suction all the remaining mercury droplets including those that fall under carpets or in crevices in the floor [Note: a vacuum cleaner should not be used since it will spread mercury vapor into the room]; if necessary, use sticky tape to remove small beads;
6) Place all the mercury in the air-tight plastic container with water
7) Clean hands and personal protection equipment thoroughly;
8) Open windows and aerate the area with fans for at least 24 hours to eject and dilute any remaining vapors to the outside air;
9) Seal, label, and store the container.

10.4 Management of Spent Photographic Chemicals (Fixer and Developer)

Undeveloped film and used fixer solution are considered hazardous because of their high silver content. Silver used in fixer solutions is in the form of silver thiosulphate complexes. They are extremely stable and have very low dissociation constants. Waste water treatment processes convert the silver thiosulphate into mostly silver sulfide. Two suitable methods manage fixer waste: a) separation of used fixers from depleted developers; b) use of a silver recovery unit for a practitioner's developing system. Dentists can also use digital x-ray equipment, which eliminates the need for processing chemicals and the resulting waste. In addition, digital x-rays can reduce patient radiation exposure.[20]

10.5 Management of ampoules

These can be crushed on a hard impermeable surface (e.g. concrete) or in a metal drum or bucket using a stout block of wood or hammer. Workers doing this should wear protective equipment, such as eye protection, boots, clothing and gloves. The crushed glass should be swept up, placed in a container suitable for sharps objects, sealed and disposed of in a landfill. The liquids released from the ampoules should be diluted and disposed of.

Ampoules should not be burnt or incinerated as they will explode, possibly causing injury to operators and damage to the furnace or incinerator. Melted glass will also clog up the grate of a furnace or incinerator if the operating temperature is above the melting point of glass

Ampoules of cytotoxic/genotoxic or anti-infective drugs must not be crushed and the liquid discharged to sewers. They should be treated using the encapsulation or inertization disposal methods.

11. Requirement for Occupational Safety and Health Practices

Each HCF is responsible for providing a safe, healthy workplace and safe systems of work for all. The management of waste presents a number of potential hazards to employees requiring the appropriate measure of risk identification, risk assessment, and risk control. Health care workers have an obligation to follow instructions regarding safe work practices. This section explains their responsibilities and obligations.

11.1 Occupational Safety and Health Provisions

1) Health-care waste management policies or plans should include provision for the continuous monitoring of workers' health and safety to ensure that correct handling during segregation, storage, collection, transportation, treatment and disposal procedures of waste are being followed.

2) Essential occupational health and safety measures include the following:
    a) Training of workers on infection transmission.
    b) Provision of personal protective equipment;
    c) Establishment of an effective occupational health program that includes immunization, post-exposure prophylactic treatment, and medical surveillance.

3) Training in health and safety should ensure that workers know of and understand the potential risks associated with health-care waste, the value of immunization against viral HBV among other diseases, and the importance of consistent use of personal protection equipment.

11.2 Employer Responsibilities

1) HCF management is responsible under the Labor Act 1992 (Act 6 of 1992 amended as Act 11, 2007) to provide appropriate information, education, training and ensuring that safe systems of work are developed and maintained.

2) Key among the responsibilities is to provide information on HBV vaccination among other required vaccinations and a register of vaccinated personnel maintained.

3) Approved work practices from all technical areas in health care should be documented and promoted.

4) Standard operating procedures should:
    a) Specify accepted waste management practices, waste segregation procedures and approved waste handling procedures;
    b) Detail appropriate steps required for waste generators, and handlers;
    c) Specify personal protective equipment required for waste handling tasks;
    d) Detail spill management strategies and designate trained personnel for spill management onsite;

e) Identify first aid resources and needle stick injury treatment protocol; and
f) Specify how to operate the information, education, training and safe working systems.

11.3 Personal Protective Equipment (PPE)

1) Managers and all workers are encouraged to assess risks and provide suitable PPE for the nature and degree of the hazard they are likely to be exposed to.

2) PPE must be worn when required.

3) PPE is the last option in the hierarchy of hazard controls and should only be used if elimination, engineering controls and or changes to work practices do not adequately remove / reduce the risks.

4) Waste collectors should be made aware of their obligations/responsibilities

5) Waste collectors are under a statutory obligation to wear appropriate PPE. The risk of spills or splash exposures necessitates the wearing of face and eye protection. Protection of the legs is also required.

6) Carrying of HCW bags is to be minimized and where it cannot be avoided, the waste collector should wear protective garments and apron to minimize the risk of injury.

7) Protective garments should be worn whenever collecting waste, even if the process involves wheeling a securely covered waste trolley to the holding area.

8) The type of protective clothing used will depend on the risk associated with the health-care waste, but the following should be made available to all personnel who collect or handle health-care waste:
   a) Helmets, with or without visors-depending on the operation.
   b) Face masks-depending on operation.
   c) Eye protectors (safety goggles)-depending on operation.
   d) Overalls (coveralls)-obligatory.
   e) Industrial aprons-obligatory.
   f) Leg protectors and/or industrial boots-obligatory.
   g) Disposable gloves (medical staff) or heavy-duty gloves (waste workers) -obligatory.

9) Operators of manually loaded incinerators should wear protective face visors and helmets.

10) During ash and slag removal and other operations that create dust, dust masks should be provided for operators.

11) Employees should comply with health care waste management policies, procedures and instructions given on correct use of safety and protective equipment for the protection of their own health and safety and the health and safety of others.

11.4 Workers' Protection

1) The individuals responsible for management of health-care waste should ensure that all risks are identified and that suitable protection from those risks is provided.

2) A comprehensive risk assessment of all activities involved in HCW management, carried out during preparation of the waste management plan, will allow the identification of necessary protection measures.

3) Once the assessment is completed, personnel should receive suitable training.

4) Measures should be designed to prevent exposure to hazardous materials or other risks, or at least to keep exposure within safe limits.

11.5 Infection Control Committee

1) The infection control committee has responsibilities to review:
a) the provision and installation of facilities and protective equipment;
b) work practices;
c) incidents and accidents;
d) provision and status of information, education and training;
e) relevant records;

2) An effective management tool is to provide a link between the infection control committee and the facility management by reporting on progress and challenges

11.6 Monitoring Performance of Infection Control Committees

1) Incident and accident reporting and recording is an essential management information system for identifying causative factors of injuries relating to waste handling.

2) Incident and accident reporting and recording should facilitate costing of associated financial loss and enable management to make injury prevention investment decisions based upon accurate data.

3) Waste treatment, operating and disposal costs should be reviewed periodically to evaluate any fluctuations.

11.6.1 Hygiene

1) Regular washing and maintenance of equipment used to contain and transport waste should be done by providing hand-washing facilities (with warm running water and soap) for employees.

2) It is important for health care facilities to promote regular hygiene procedures that comply with the National Infection Prevention and Control Guideline. This is of particular importance at storage and incineration facilities.

3) It may be useful also to designate specific areas for equipment maintenance in hygienic workplaces that are properly equipped with emergency shower rooms and drainage to sewers or septic tanks.

4) Emergency shower rooms should be provided in all health care facilities.

11.6.2 Immunization

1) Viral hepatitis B and Tetanus immunizations should be provided for health-care personnel and waste handlers.

2) Each HCF is required conduct immunization for all newly employed staff.

3) The HCF should also maintain and keep long term records of vaccinations

11.7 Precautions for Sharps, Blood and Body Substance Exposures

Precautions must be implemented to protect against exposure to sharps, blood and body fluids. These precautions include:

1) Providing a purposely designed sharps container as close as practicable to the point of generation of the sharps;

2) Providing appropriate PPE for potential blood and body substance exposures;

3) Conducting compliance checks to confirm that people wear protective clothing;

4) Investigating all incidents to identify causes of exposures

5) Take remedial action to eliminate risks;

6) Infection Control Committees or an appropriate forum must review incident reports and confirm appropriate action taken;

7) Train staff in first aid and injury management procedures for sharps injury and body substance exposure;

8) Reinforce the need for staff to report all incidents and injuries;

9) Analyze statistics to identify any risk exposure trends for necessary interventions.

11.8 Response to Injury and Exposure

All personnel who handle health-care waste should be trained to deal with injuries and exposures.

1) The program should include the following elements:
   a) Immediate first-aid measures, such as cleansing of wounds and skin, and irrigation (splashing) of eyes with clean water;
   b) An immediate report of the incident to a designated responsible person;
   c) Retention, if possible, of the item involved in the incident;
   d) Details of its source for identification of possible infection;
   e) Additional medical attention in an accident and emergency
   f) Alerting Matron and the infection control committee, as soon as possible;
   g) Medical surveillance;
   h) Blood or other tests if indicated;
   i) Recording of the incident;
   j) Investigation of the incident; identification and implementation of remedial action.

2) Waste handlers are particularly at risk from the waste. In all stages they require:-
   a. PPE
   b. Hold waste containers at the handle or at the top of liner bag
   c. Avoid any waste falling on the floor during collection and transportation
   d. Non-complying waste (in terms of segregation) should not be sorted by hand
   e. Waste storage/chamber should be well ventilated and compartmentalized.
   f. Cloak rooms for changing and showering
   g. Waste handlers should also receive post exposure prophylaxis for HIV/AIDS

12. Community Health Outreach

Community Health offer a range of services based on Community Health outreach or at external locations such as patients' homes and school dental clinics.

12.1. Clinical Waste Generated at Community Health Outreach

1) It should be the policy of all health facility management committee to ensure clinical wastes are returned to the health care facility for appropriate disposal (in circumstances where applicable).
2) Waste must be transported in a designated vehicle supplied with a spill kit

12.2 Sharps Containers

1) Safety boxes should be supplied at all sites that generate sharps

12.3 Waste Transportation

The following points should be observed:

1) Lids shall be securely fitted to the containers to ensure that the wastes are prevented from spilling;
2) Containers should be thoroughly cleansed and disinfected before re-use;
3) Containers used for the transportation of clinical wastes shall be clearly marked;
4) During transportation, containers holding the wastes shall be securely held inside the vehicle to prevent movement of the containers and spillage of wastes; and
5) The transporter shall ensure that vehicles being used for the transportation of clinical wastes shall be securely locked when left unattended.

13. Collection and Disposal of Waste Water from Health Care Establishments

13.1 Characteristics and Hazards of Wastewater from Health-Care Establishments

1) Wastewater from health-care establishments is of a similar quality to urban wastewater, but may also contain various potentially hazardous components.
2) The principal area of concern is waste-water with a high content of enteric pathogens, including bacteria, viruses, and helminthes, which are easily transmitted through water.
3) Contaminated wastewater is produced by wards treating patients with enteric diseases and is a particular problem during outbreaks of diarrheal disease.
4) It may also contain various potentially hazardous components, such as microbiological pathogens, hazardous chemicals, pharmaceuticals and radioactive materials which are discussed below:
    a) Small amounts of chemicals from cleaning and disinfection operations are regularly discharged into sewers.
    b) Small quantities of pharmaceuticals are usually discharged to the sewers from hospital pharmacies and from the various wards.
    c) Radioactive isotopes should be discharged into holding tanks by oncology departments
    d) The toxic effects of any chemical pollutants contained in wastewater on the active bacteria of the sewage purification process may give rise to additional hazards.

13.2 Waste Water Management

1) The basic principle underlying effective wastewater management is a strict limit on the discharge of hazardous liquids to sewers.
2) Only in an outbreak of acute diarrheal diseases should excreta from patients be collected separately and disinfected.
3) Where water use is commonly high, sewage is usually diluted.
4) For effluents treated in treatment plants, no significant health risks should be expected, even without further specific treatment of these effluents.

13.3 Connection to a Municipal Sewage Treatment Plant

It is acceptable to discharge the sewage of health-care establishments to sewers without pre-treatment, provided that the following requirements are met:

1) The municipal sewers are connected to efficiently operated sewage treatment plants that ensure at least 95% removal of bacteria;
2) The sludge resulting from sewage treatment is subjected to anaerobic digestion, leaving no more than one helminthes egg per liter in the digested sludge;
3) The waste management system of the health-care establishment maintains high standards, ensuring the absence of significant quantities of toxic chemicals, pharmaceuticals, radionuclides, cytotoxic drugs, and antibiotics in the discharged sewage;
4) Excreta from patients being treated with cytotoxic drugs may be collected separately and adequately treated (as for other cytotoxic waste).

5) In normal circumstances, the usual secondary bacteriological treatment of sewage, properly applied, complemented by anaerobic digestion of sludge, can be considered as sufficient.
6) During outbreaks of communicable diseases, effluent disinfection by chlorine dioxide (chlorine powder) or by any other efficient process is recommended.
7) If the final effluent is discharged into coastal waters close to shell fish habitats, disinfection of the effluent will be required throughout the year.

13.4 On-Site Treatment or Pre-Treatment of Waste Water

1) Health care establishments in particular those that are not connected to any municipal treatment plant, should have their own sewage treatment plants e.g. septic tanks.
2) Efficient on-site treatment of sewage should include the following operations:

    a) *Primary treatment*
    b) *Secondary biological purification*. Most helminths will settle in the sludge resulting from secondary purification, together with 90-95% of bacteria and a significant percentage of viruses; the secondary effluent will thus be almost free of helminths, but will still include infective Concentrations of bacteria and viruses.
    c) *Tertiary treatment*. The secondary effluent will probably contain at least 20 mg/litre suspended organic matter, which is too high for efficient chlorine disinfection. It should therefore be subjected to a tertiary treatment, such as lagooning. If no space is available for creating a lagoon, rapid sand filtration may be substituted to produce a tertiary effluent with a much reduced content of suspended organic matter (<10mg/litre).
    d) *Chlorine disinfection*. To achieve pathogen concentrations comparable to those found in natural waters, the tertiary effluent will be subjected to chlorine disinfection to the breakpoint. This may be done with chlorine dioxide (which is the most efficient), sodium hypochlorite, or chlorine gas, chlorine powder.
    e) Another option is *ultraviolet light disinfection.*

3) Disinfection of the effluents is particularly important if they are discharged into coastal waters close to shell fish habitats, especially if local people are in the habit of eating raw shell fish.

13.4.1 Sludge Treatment

1) The sludge from the sewage treatment plant requires anaerobic digestion to ensure thermal elimination of most pathogens.
2) Alternatively, it may be dried in natural drying beds and then incinerated together with solid infectious health-care waste.
3) On-site treatment of hospital sewage will produce a sludge that contains high concentrations of helminths and other pathogens.

13.5 Reuse of Wastewater and Sludge in Agriculture and Aquaculture

1) According to WHO guidelines, the treated wastewater should contain no more than **one helminth egg per liter** and no more than **1000 faecal coliforms per 100 ml** if it is to be used for unrestricted irrigation.
2) It is essential that the treated sludge contains no more than **one helminth egg per kilogram** and no more than **1000 faecal coliforms per 100g**.
3) The sludge should be applied to fields in trenches and then covered with soil.

13.6 Options for Establishments that apply Minimal Waste Management Programs

1) Lagooning
   a) In a region or an individual health care establishment that cannot afford sewage treatment plants, a lagooning system is the minimal requirement for treatment of wastewater.
   b) The system should comprise two successive lagoons to achieve an acceptable level of purification of hospital sewage.
   c) Lagooning may be followed by infiltration of the effluent into the land, benefiting from the filtering capacity of the soil.
   d) There is no safe solution for the disposal of sewage from a hospital that cannot afford a compact sewage treatment plant and that has no space available to build a lagooning system.

13.7 Minimal Safety Requirements for Sewerage Treatment

For healthcare establishments that apply minimal programs and are unable to afford any sewage treatment, the following measures should be implemented to minimize health risks:

1) Patients with enteric diseases should be isolated in wards where their excreta can be collected in buckets for chemical disinfection; this is of utmost importance in case of cholera outbreaks, and strong disinfectants will be needed.
2) No chemicals or pharmaceuticals should be discharged into the sewer.
3) Sludge from hospital cesspools should be dehydrated on natural drying beds and disinfected chemically (e.g. with sodium hypochlorite, chlorine gas, or preferably chlorine dioxide).
4) Sewage from health-care establishments should never be used for agricultural or aquaculture purposes.
5) Hospital sewage should not be discharged into natural water bodies that are used to irrigate fruit or vegetable crops, to produce drinking water, or for recreational purposes.
6) Small-scale rural health-care establishments that apply minimal waste management programs may discharge their wastewater to the environment.
7) An acceptable solution would be natural filtration of the sewage through porous soils, but this must take place outside the catchment area of aquifers used to produce drinking-water or to supply water to the health-care establishment.

13.8 Sanitation

1) Human excreta are the principal vehicle for the transmission and spread of a wide range of communicable diseases, and excreta from hospital patients may be expected to contain far higher concentrations of pathogens, and therefore to be far more infectious, than excreta from households.
2) Adequate sanitation in every health-care establishment should be provided.
3) The fecal-oral transmission route-and other routes such as penetration of the skin-must be interrupted to prevent continuous infection and re-infection of the population.

13.9 Safe Management of Wastes from Health-Care Activities

The health-care establishment should ideally be connected to a sewerage system.

1) Where there are no sewerage systems, technically sound on-site sanitation such as the simple pit latrine, ventilated pit latrine, and pour-flush latrine, and the more advanced septic tank with soak-away or the aqua-privy should be provided.
2) In temporary field hospitals during outbreaks of communicable diseases, other options such as chemical toilets may also be considered.
3) In addition, convenient washing facilities (with warm water and soap available) should be available for patients, personnel, and visitors in order to limit the spread of infectious diseases within the health-care establishment.

14. HCRW Management Plan

Planning of HCWM is not limited to the preparation of internal guidelines/instructions for the management of health care waste but rather a process to sustain and optimize the operation of HCWM systems in health care establishments. It is the ambition of the Ministry of Health and Social Services and its development partners that through the setting up of institutional structures, the implementation of this action plan will result in improved HCW management in Namibia.

This plan endeavors to tackle the HCWM challenges in Namibia that comprise the following components:

1. Legal and Regulatory (Including institutional framework)
2. Standardize Healthcare Waste Management Practices.
3. Capacity-building, training, and awareness-building measures.
4. Waste information system
5. HCWM pollution prevention
6. Improved treatment and disposal practices

In order to implement this plan therefore, it is necessary for policy makers and those in decision making positions to appreciate the need for financial allocation to the management of HCW based on plans which have been developed, budgeted and discussed and further approved by a recognized body in that institution e.g. the EHP and the ICC focal person.

The areas that will need financial allocation include;

i) Investment on waste handling facilities, e.g. waste storage areas or refuse transfer stations, incinerators and fencing off the waste handling site.

ii) Fuel for operating on-site incinerator.

iii) Purchase of equipment such as;
   - trolleys, trolley bins,
   - waste bins,
   - weighing scales for weighing waste generated on daily basis in the hospitals,
   - Workers' personal protective gear (helmets, plastic goggles,respirators, heavy duty gloves, gumboots, overall and aprons).

iv) Funds for maintenance of HCWM equipment such as:
   - Repairing incinerators, and replacing them as they become obsolete.
   - Repairing and replacing trolleys and trolley bins,
   - Performing regular maintenance for the building structures and fences that surround waste management storage and treatment areas.

v) Waste operation tools such as;
- shovels,
- steel rods for poking the fire,
- brooms,
- Waste-ash-buckets for use at the refuse storage areas, incinerator and final waste disposal area.

vi) Purchase consumable materials required for daily implementation of good segregation practices which include;
- Safety boxes for sharps,
- Bin-liners of different colours and sizes for different waste generation areas.
- Stickers for labelling waste.

vii) Funds for contractual services for out sourced waste from the facility and cleansing services.

viii) Meeting transportation cost within the facility or to the waste treatment sites.

14.1 Legal and Regulatory (Including institutional framework)

Activity	Responsibility	Short term 2 years						Medium Term 2 - 5 years	KPI
		1 – 12 months			12 – 24 months				
		4	8	12	16	20	24		
Define a specific budget line dedicated to HCWM at all levels	Regional Health Management Teams		X	X	X	X	X	Ongoing	Specific budget line exist in each district budget
Disseminate HCWM guidelines to all facilities	Division of Public and Environmental Health Services		X	X					100% Availability of guidelines at all health service levels
Update the training material (teaching posters and notes, posters, pamphlets etc.) in line with the National Guideline	Division of Public and Environmental Health Services and Division of Quality Assurance		X	X				Ongoing	Availability of updated training materials
Assist with the implementation of the HCRWM Guideline in all HCF's through training and awareness programmes	Division of Public and Environmental Health Services, Regional Health Teams and Division of Quality Assurance		X	X	X	X	X	Ongoing	90% of HCF have trained personell

14.2 Standardize HCW Management Practices

Activity	Responsibility	Short term 2 years						Medium Term 2 - 5 years	KPI
		1 – 12 months			12 – 24 months				
		4	8	12	16	20	24		
Designate an EHP in each district and referral hospital	Division of Public and Environmental Health Services		X	X	X	X		ongoing	100% availability of EHPs in each district and referral hospital
Develop facility-based HCWM plans	PMOs and District EHP			X	X	X	X		100% facilities have plans in place
Set up pilot facilities at different levels of the healthcare delivery that demonstrate best practices of HCWM	Regional and District Management Teams			X	X	X		Ongoing	4 pilot sites in each region
Review and disseminate tools to assist facility managers in planning and carrying out HCWM activties	Division of Public and Environmental Health Services and Division of Quality Assurance		X	X					Planning tools developed
Equip facilities with proper supplies for managing and handling waste	Regional Management Teams and Central Medical Stores		X	X	X	X	X	Ongoing	100% health facilities have required supplies
Equip healthcare facilities with new equipment where needed for treatment and final disposal of waste	Division of Public and Environmental Health Services , Logistics and Finance				X	X	X		Incinerators installed and working
Establish linkages with the private sector and put in place systems that will allow recycling or other treatment of waste	Division of Public and Environmental Health Services, Regional Management Teams				X	X	X		Recycling companies identified Recycling waste collected from facilities

14.3 Capacity Building, Training , and Awareness Creation

Activity	Responsibility	Short term 2 years: 1 – 12 months			Short term 2 years: 12 – 24 months			Medium Term 2 - 5 years	KPI
		4	8	12	16	20	24		
Update curriculum and training materials for pre-service and in-service training	Division of Public and Environmental Health Services Division of Quality Assurance				X	X		Ongoing	Availability of updated curriculum
Develop a monitoring plan for improved collection and transportation of dangerous goods.	Division of Public and Environmental Health Services and Division of Quality Assurance		X	X				Revision 2014	Monitoring and evaluation plan available
Carry out regular inspections and audits	Regional Management Teams		X	X	X	X	X	Ongoing	Audit reports

14.4 Waste Information System

Activity	Responsibility	Short term 2 years: 1 – 12 months			Short term 2 years: 12 – 24 months			Medium Term 2 - 5 years	KPI
		4	8	12	16	20	24		
Waste Information System developed	Division of Public and Environmental Health Services and Division of Quality Assurance				X	X	X	Ongoing	Functional of WIS
Implement the WIS within each region	Regional Management Teams					X	X	Ongoing	100% Participation
Ensure that there is capacity within each region to record and analyse the WIS data (staff, technical equipment, budget)	Regional Management Teams					X	X	Ongoing	Functional WIS that is constantly being updated, monitored & analyzed
Record and Analyze the data and use for future planning	Regional Management Teams					X	X	ongoing	Evidence of use of data in planning
Introduce mechanisms (penalties or incentives) to ensure waste manifest system is used and information reported to each region when requested.	Regional Management Teams			X	X	X	X	Ongoing	100% Participation

14.5 HCW Pollution Prevention

Activity	Responsibility	Short term 2 years						Medium Term 2 - 5 years	KPI
		1 – 12 months			12 – 24 months				
		4	8	12	16	20	24		
Periodically carry out evaluations of efficiency and emissions of HCW incinerators	Regional Management Teams		X	X	X	X	X	Ongoing	- Number of audits carried out - Types of emissions recorded
Work with different stakeholders to identify issues and solutions for environmental approaches to HCWM	Division of Public and Environmental Health Services and Division of Quality Assurance		X		X		X	Ongoing	Minutes of meetings Proposed solutions
Adopt less polluting technologies	Division of Public and Environmental Health Services and Division of Quality Assurance				X	X	X		4 health facilities piloting alternative means of waste treatment
Introduce mechanisms for enforcing the requirements of the Acts and Regulations both national and at local level.	National & Regional Departments (Collaboration)		X	X	X	X	X	Ongoing	Availability of mechanism

14.6 Improved Treatment & Disposal Practices

Activity	Responsibility	Short term 2 years: 1 – 12 months: 4	8	12	12 – 24 months: 16	20	24	Medium Term 2 – 5 years	KPI
Upgrade of the existing incinerator and introduce better operational practices in line with international best practice.	Division of Public and Environmental Health Services, Division of Quality Assurance , and Finance and Logistics			X	X	X	X	Ongoing	# of incinerators upgraded
Assess alternative treatment & disposal options.	Division of Public and Environmental Health Services, Division of Quality Assurance , and Finance and Logistics			X	X	X			Assessment report and recommendations
Investigate the implementation of possible public / private partnerships for the introduction of better treatment methodologies	Division of Public and Environmental Health Services and Division of Quality Assurance			X	X	X	X	Ongoing	# of PPP established
Develop a monitoring plan for improved treatment and disposal of HCRW.	Division of Public and Environmental Health Services, Division of Quality Assurance		X	X					100% availability of plan in the districts
Carry out regular inspections and audits of all treatment and disposal facilities.	Division of Public and Environmental Health Services, Division of Quality Assurance		X	X	X	X	X	Ongoing	Inspection/audit reports
Request quarterly HCRW data from State owned treatment facilities	Division of Public and Environmental Health Services	X	X	X	X	X	X	Ongoing	Availability of quarterly reports from all districts
Establish feedback mechanism for all involved; authority, HCF, waste service provider and treatment & disposal	Division of Public and Environmental Health Services				X	X	X		# of feedback reports provided

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Appendix 1: Manifest Document

MANIFEST DOCUMENT

(In terms of Section 10 of the Public Health Act No 36 of 1919)

A. TRANSPORTER

Name:________________________________Address:____

Telephone No.:______________________Accreditation No.:___________________________________

Type of Waste Transported:_____________________________________Quantity (kg):_____________

B. GENERATOR

Name:_________________________________Address:_______________________________________

Telephone No.:____

Daily Load No.:__________________________________Delivery Date:__________________________

Contact Person:____

C. TREATMENT FACILITY

Name of Treatment facility:____

Name of Manager/Authorized Representative:____

Address:______________________________Telephone No.:____________________________________

Permit to Operate: Permit No.:____

Signature of Manager/Authorized Representative:____

D. DATE WASTES ARE COLLECTED/TRANSPORTED/RECEIVED

Date Collected/Removed from Generator's Facility:____

Date Received by the Transfer Station (Point of Consolidation):_________________________________

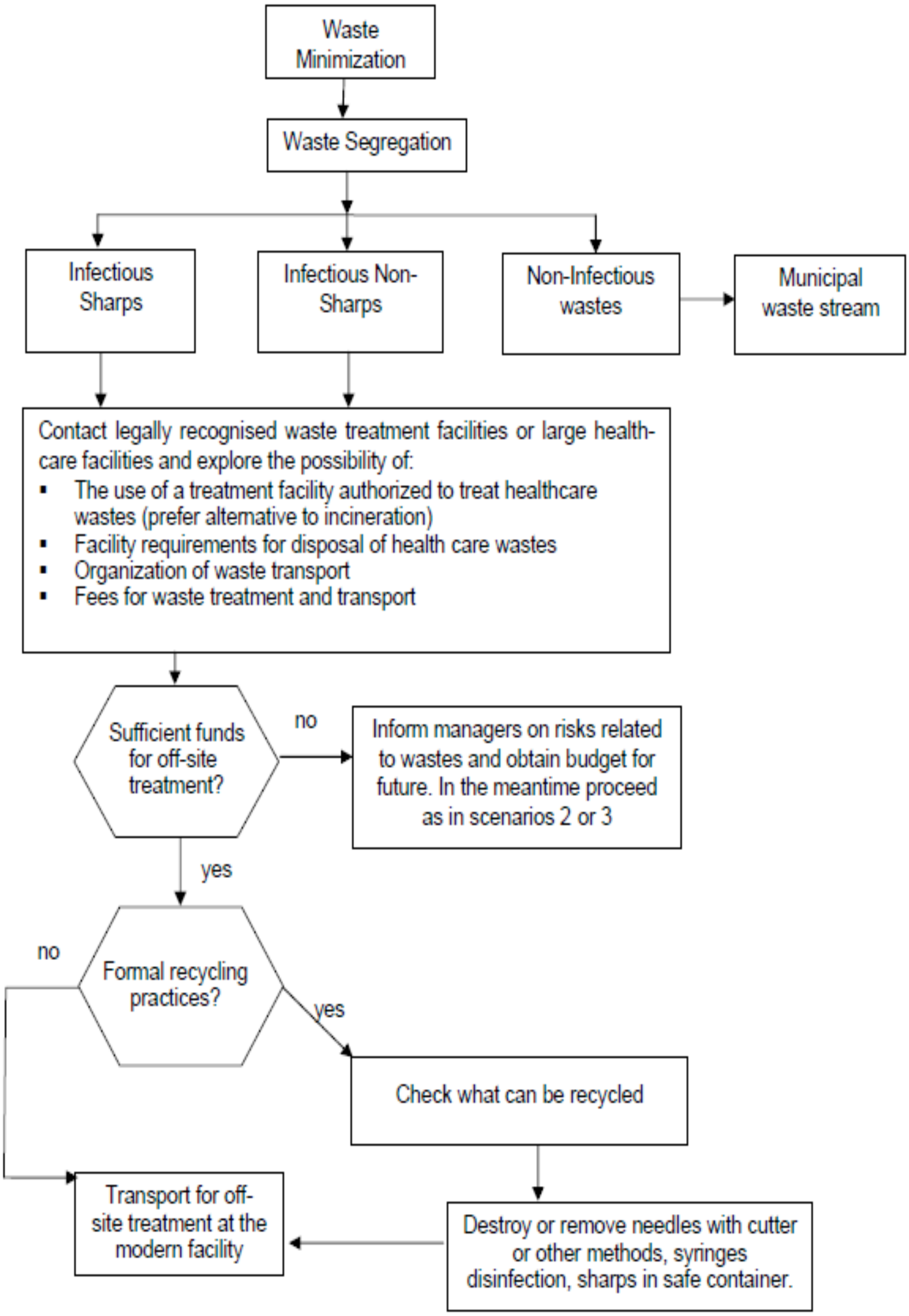
Date Received by the Treatment Facility:____

Appendix 2: Waste Deposited Form

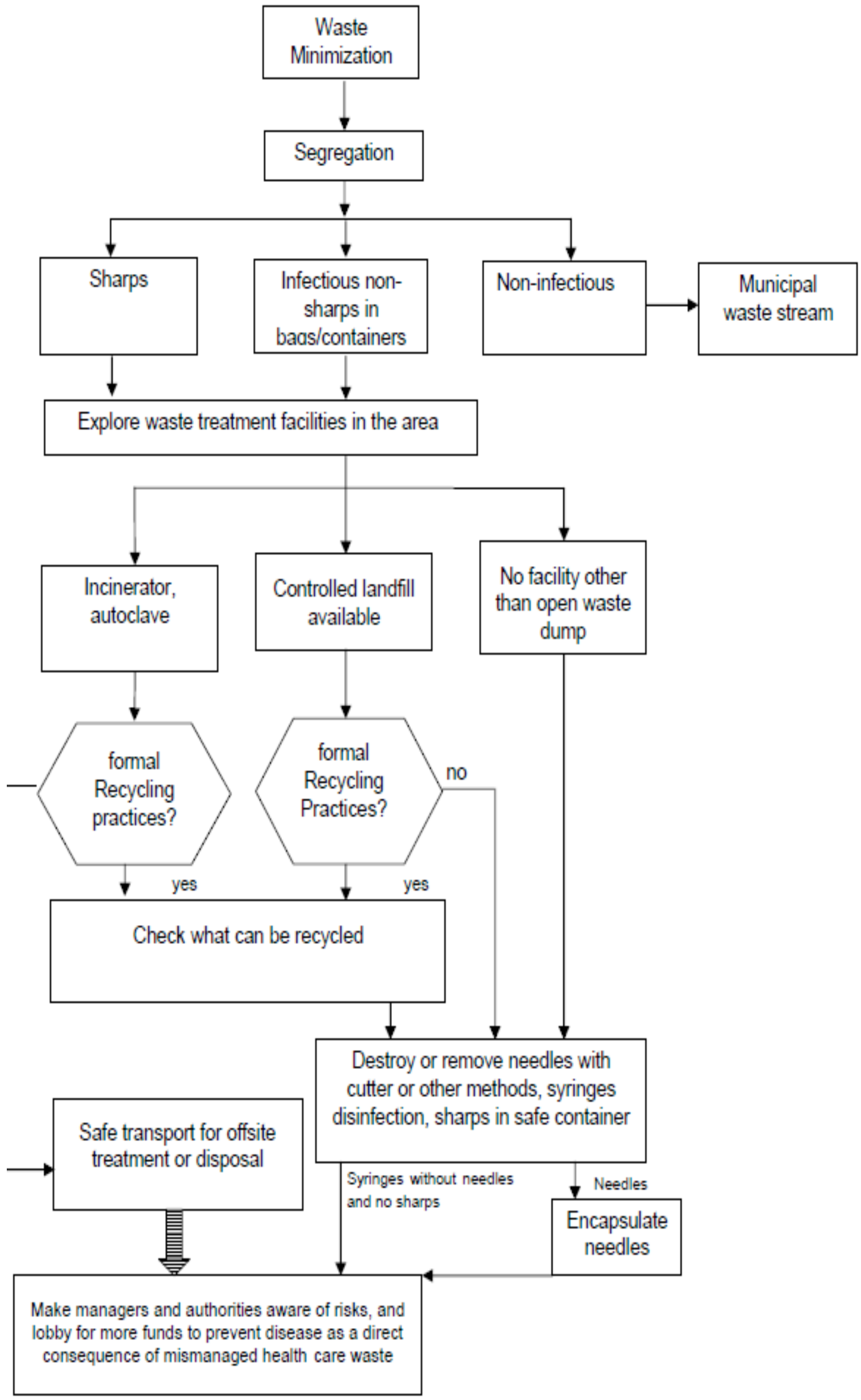
Waste Deposited – Form				
Health Facility/Institution/ Private Practitioner:			Month, Year:	
Name of Incinerator Operator:				
Day of the Month	Waste deposited		Origin of the waste	Name of person depositing waste
	Waste category	Quantity		

Appendix 3: Scenarios for HCW Management

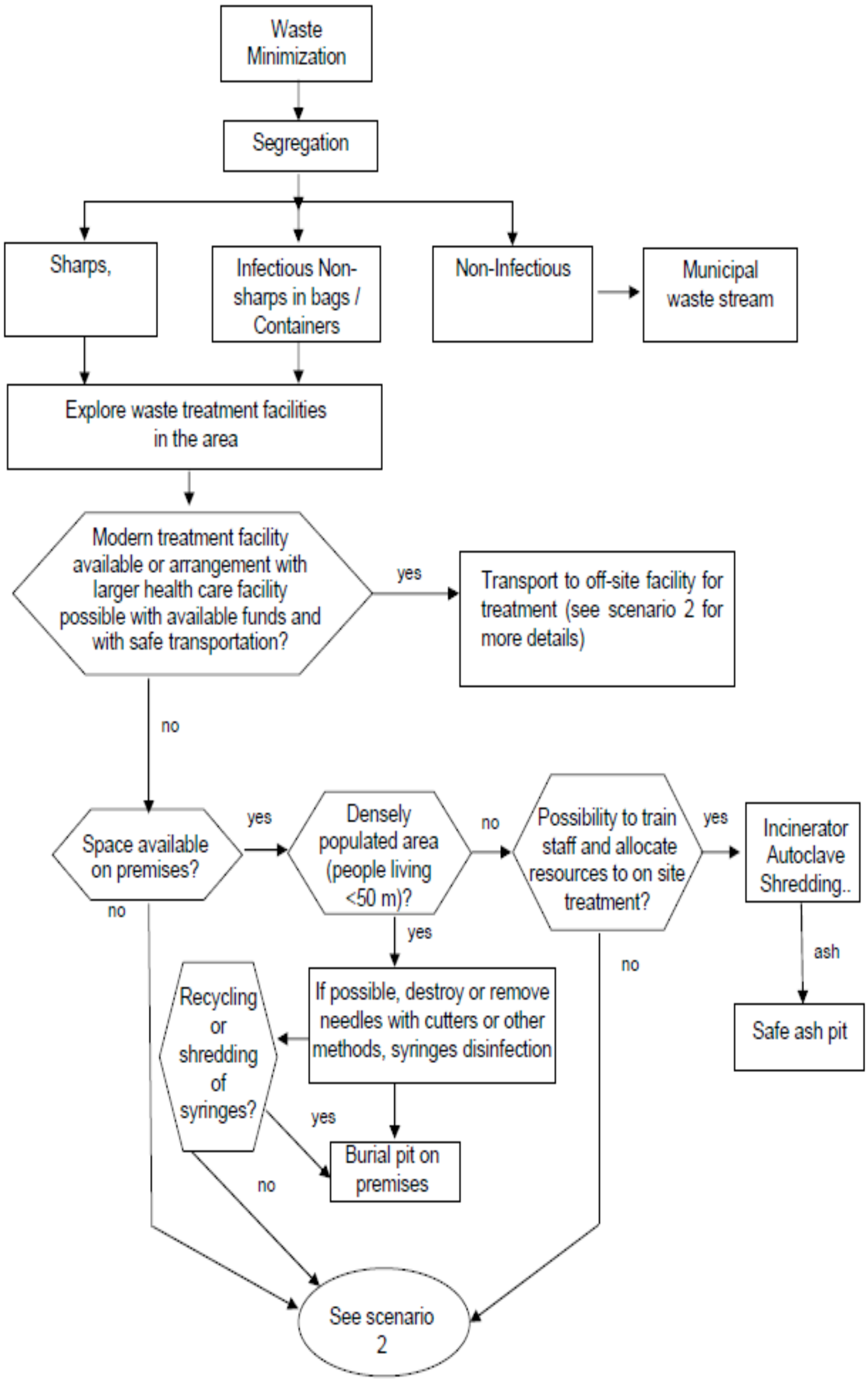
Scenario 1: Urban area with access to a legally approved modern waste treatment facility



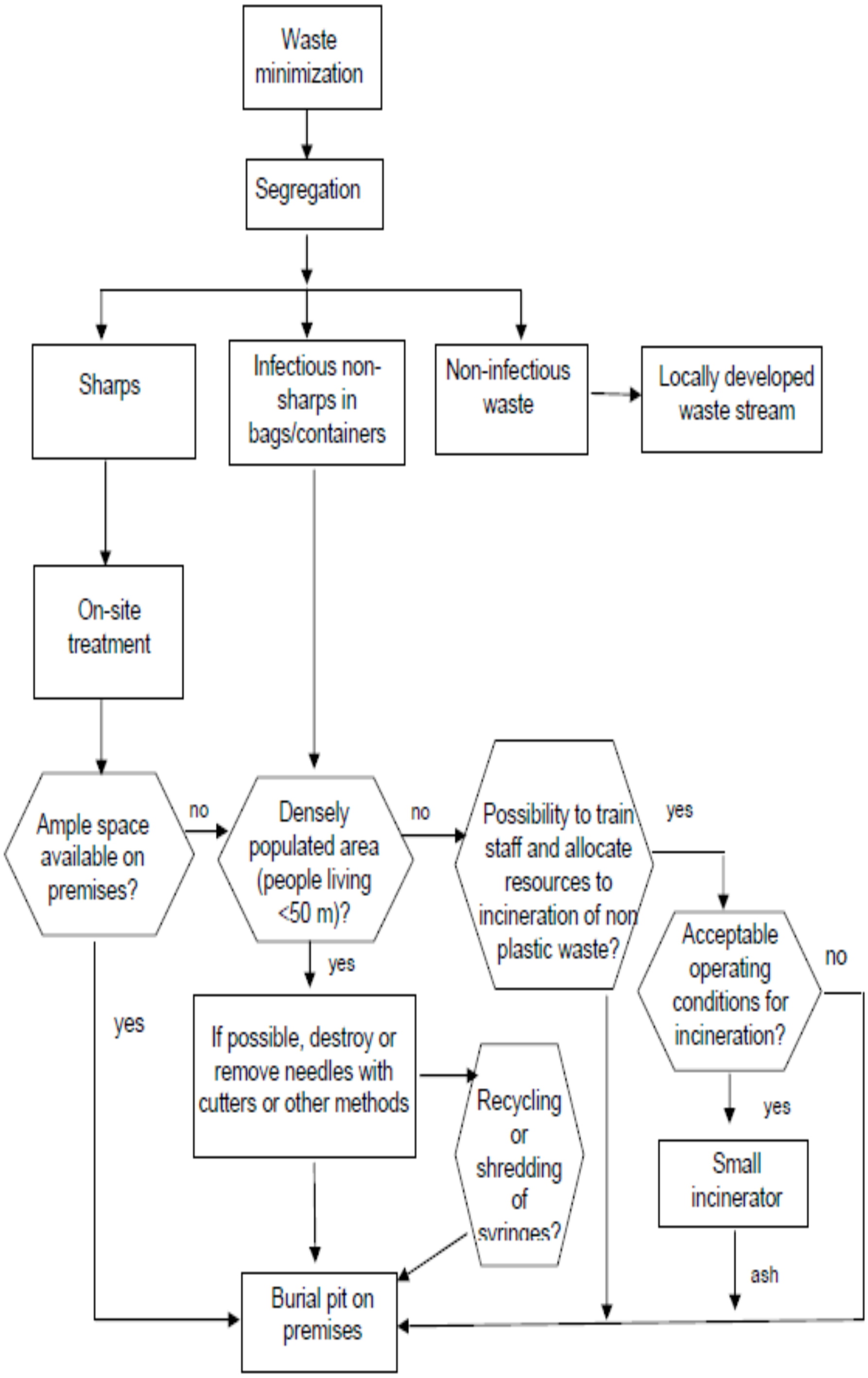
Scenario 2: Urban area without access to a legally approved modern waste treatment facility



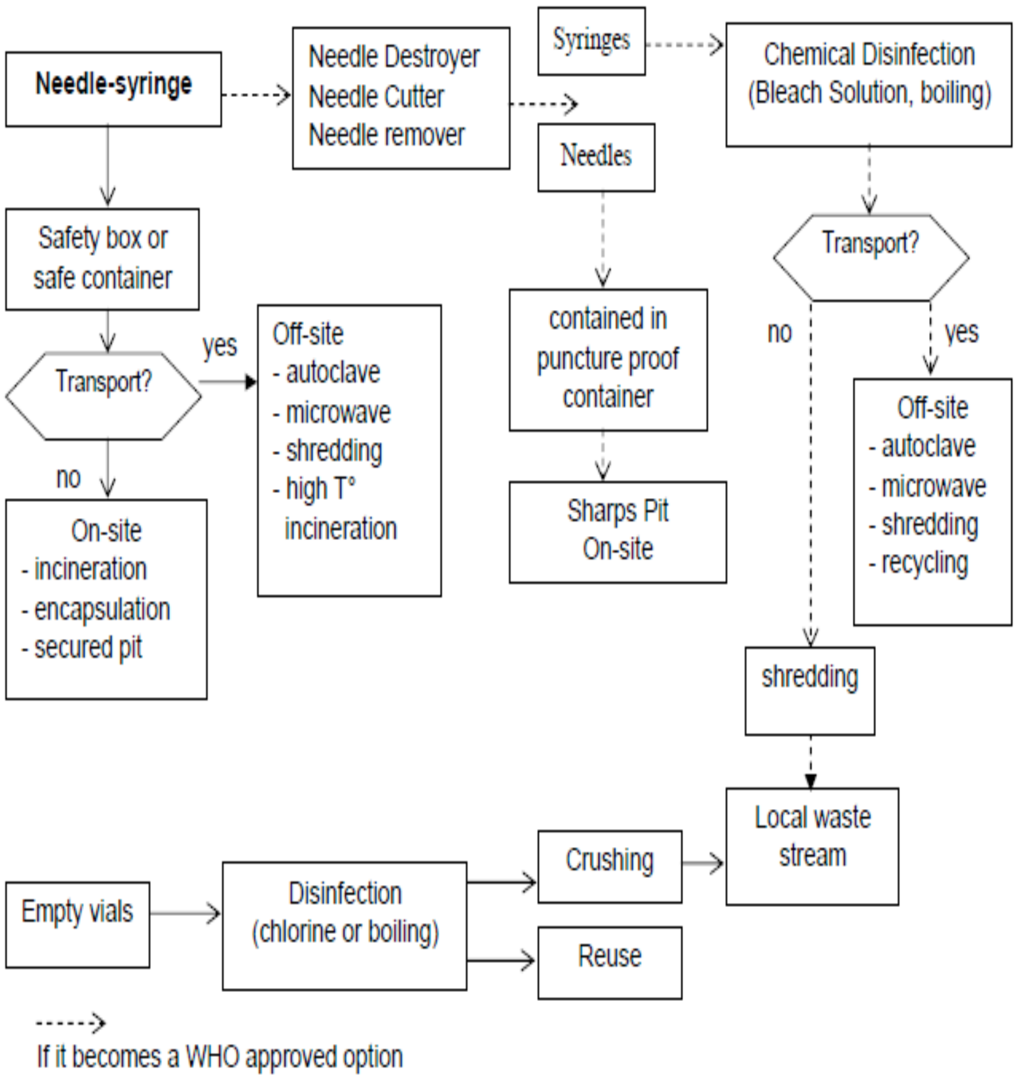
Scenario 3: Peri-urban area



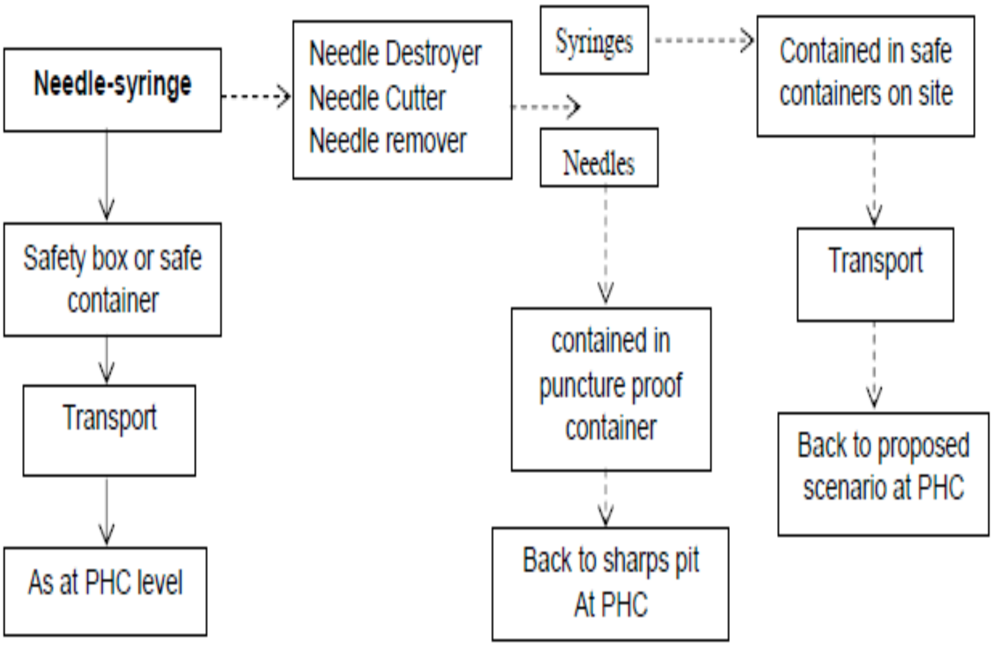
Scenario 4: Rural area without access to a legally approved modern waste treatment or disposal facility



Scenario 5: Needle-syringes waste management - immunization at PHC



Scenario 6: Needle-syringes waste management - outreach immunisation activities.



-----> If it becomes a WHO approved option

Empty vials back to PHC

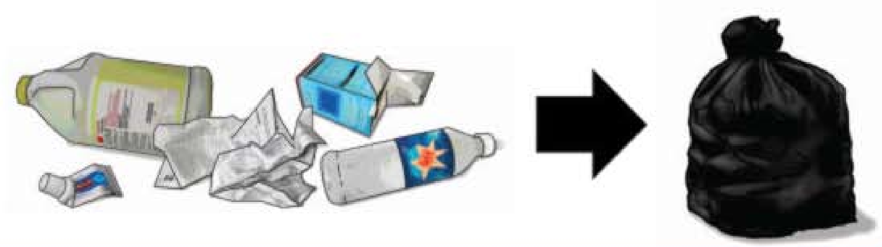
Appendix 4: Waste Segregation According to Different Colour Bags

Dispose of waste properly to protect yourself and those around you from infection, disease, and injury.

Please collect and store waste in the allocated colour coded bags for infection control purposes and cost effective waste removal and final disposal.

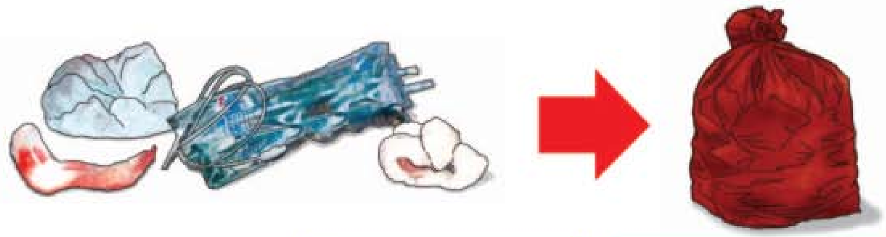
Soiled and Blood Stained Linen Only

Domestic/ Household Waste Only



Left Over Food Only

Infectious Waste Only



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Appendix 5: Integrated Waste Management Workshop Attendees

Windhoek, Namibia
7-11.3.2011

Name	Position	Facility representing	Telephone Number	Email address
Mr. L.A.Uusiku	Environmental Health Practioner	City of Windhoek	(26481) 129-2980	lau@windhoekcc.org.na
Mr. D. Nicodemus	Environmental Health Practiioner	MOHSS Namibia	(26481) 274-5312	danieldicodemus@ymail.com
Ms. Rosie Palmer	Control Reg. Nurse	MOHSS Namibia	(26464) 410-6009	
Mr. Gregg Willemse	Control Environmental Health Officer	MOHSS Namibia	(26464) 410-6009	gnwillemse@iway.na
Mr. Edward Chiota	Environmental Health Practioner	MOHSS Namibia	(26181) 420-1469	edwardchiota20@yahoo.com
Mr. John Damon	Chief Environmental health Practitioner	MOHSS Namibia	(26481) 294-4052	damonj@iway.na
Mr. Andre Nolte	Chief Environmental health Practitioner	MOHSS Namibia	(26481) 322-9761	noltea@ymail.com
Sr. Sebastiaan Lovely	R/N Infection Control	MOHSS Namibia	(2646) 625-8277	lovelysebastiaan@yahoo.in
Ms. EllaH K Munkonze	Regional Coordinator	URC Namibia	(26481) 303-2974	ellam@urc-na.com
Mr. Jamela Dube	Chief Environmental health Practitioner	MOHSS Namibia	(26481) 232-1234	jamela.dube@yahoo.com
Ms. Loide Shiimi	Control Office	Ondangwa Town Council	(26481) 246-8644	cleasingoffice@ondangwatown.com
Ms. Daphne Shiimie	Chief Environmental health Practitioner	MOHSS Namibia	(26481) 626-3722	dnchekerwa@yhaoo.com
Mr. Pentrick Gowaseb	Public Health	MOHSS Namibia	(264812) 950-1358	pgowaseb@gmail.com
Ms. C. S. Gordon	Senior Control R/N	MOHSS Namibia	(26481) 124-8785	gordonc@iway.na
Dr. Apollo Basenero	Medical officer	MOHSS Namibia	(26481) 361-3637	apobase77a@yahoo.com
Dr. Elpha R Ballesfin	National Health training Center	MOHSS Namibia	(26481) 249-3623	elphab@yahoo.com
Mr. Jaco Labuschagne	Senior Environmental Health Practitioner	Town Council Outjo	(2648) 244-6303	jacolab@mweb.com.na
Mr. jean-Paul Ngandu Mbanga	Regional Coordinator	URC Namibia	(26481) 288-0935	jean-Pauln@urc-na.com
Dr. Aziz Abdallah	Chief of Party	URC Namibia	(2646) 123-7022	aziza@urc-na.com
Mrs. Ida Bouwer	Administrator	URC Namibia	(2646) 123-7022	idab@urc-na.com
Ms. Joyce Namuhuja	Control Reg. Nurse	MOHSS Namibia	(26481) 127-8571	joyce55joyce@yahoo.com
Mr. T Kapofi	Chief Environmental health Practitioner	MOHSS Namibia	(26481) 202-9316	tkapofi@gmail.com
Ms. Charmaine Jansen	Head Of Department Environmental Health Services	Polytechnic of Namibia	(2648) 120-2411	cjansen@polytechnic.edu.na
Mr. C. I Munsu	Chief Environmental health Practitioner	MOHSS Namibia	(26181) 289-7018	munsuvi89@yahoo.co.uk
Mr. Edward Krisiunas	Health Care Waste Consultant	WNWN International	1-860-675-1217	ekrisiunas@gmail.com