GUIDELINES FOR
HEALTH-CARE WASTE MANAGEMENT
IN
PAPUA NEW GUINEA

(Draft)

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1.0 ABOUT THE DOCUMENT

Wastes generated in health-care establishments may be hazardous and pose direct and indirect health risks to patients, personnel in health-care establishments, workers of support services and the general public.

The risks would be significant if the wastes are not handled and disposed of in a satisfactory manner.

In Papua New Guinea, the health and environmental risks from the poor management of health-care wastes are high and need immediate attention due to the following reasons:

- Unclear policies on health-care wastes management, including the general wastes management in Papua New Guinea.
- Absence of guidelines on health-care waste management.
- Unclear organisational structure for proper management of health-care wastes
- Poor management practices.
- Outdated and poor maintenance of health-care waste handling, treatment and disposal facilities
- Lack of financial resources.
- Lack of understanding of the degree of risks involved.
- Lack of training and capacity building of personnel involved in health-care waste management.

This document has been prepared into two parts:

- Part 1: Policies and planning for health-care waste management in Papua New Guinea.
- Part 2: Technical Guidelines for health-care waste management in Papua New Guinea.

Part 1 provides practical action plan for the development of waste management policies and implementation of health-care waste management plans and specific requirements for appropriate segregation, collection, storage, handling, transport and disposal of all categories of wastes generated from health-care facilities in Papua New Guinea. This part also reviews the relevant laws and legislation for the management of health-care wastes in Papua New Guinea.

Part 2 provides the detailed technical guidance and procedures for essential aspects of health-care waste management in Papua New Guinea. The aspects include health-care waste categorization; waste segregation, handling and storage in health-care establishments; treatment and disposal of health-care waste; transport of waste outside the health-care establishment; and emergency procedures to deal with accidents and incidents. The technical guidelines also provide the training mechanisms of all related personnel involved in health-care waste management, either directly or indirectly.

This document is to be used by various types of health-care establishments, including government hospitals, private hospitals, teaching hospitals, dental hospitals, polyclinics, health centres, health-care research institutions, health-care laboratories and other establishments where health-care wastes are generated.

It is hoped that this document will also he useful to waste disposal regulatory authorities, environmental agencies, educational establishments as well as the health-care waste disposal service sector.

PART 1: POLICIES AND PLANNING FOR HEALTH-CARE WASTE MANAGEMENT IN PAPUA NEW GUINEA

1.0 PRESENT CONDITIONS OF HEALTH-CARE WASTE MANAGEMENT IN PAPUA NEW GUINEA

The management of health-care wastes in Papua New Guinea is reaching an alarming level. This is recognised not only by the National Department of Health but also directors and managers of hospitals, heads of departments, and also at individual health establishment including nurses, technicians and waste management operators.

The problems include unclear policies, guidelines and organisational structures, poor management practices, outdated and poor maintenance of facilities, lack of financial resources, lack of understanding of the degree of risks involved, and lack of training and capacity building of personnel involved in health-care waste management.

The major sources of health-care wastes in Papua New Guinea include hospitals, health centres, nursing stations, laboratories, clinics, research centres, blood banks, nursing homes, mortuaries and autopsy centres.

Other sources include physician offices, dental clinics, cosmetic piercing and tattooing, funeral services, paramedic services and institutions for disabled persons.

The amount and types of health-care wastes produced in country is unknown since it was not a policy for each health-care establishment to provide this information to the Central Government or the Department of Health of each Province.

The types of health-care wastes generated from health-care establishments in Papua New Guinea include infectious wastes, pathological wastes, sharps, pharmaceutical wastes, genotoxic wastes, chemical wastes, pressurised containers and radioactive wastes.

Although some efforts are being done to segregate and manage the health-care wastes, there is no clear policy and guidelines to manage these wastes. Visits to a number of health-care establishments have revealed the following findings:

- There are informal initiatives being carried out by the infection control officer of large hospitals in Papua New Guinea to manage the wastes. These include:
    - Identification of health-care wastes that are potentially infectious and the general wastes.
    - The use of separate containers for health-care wastes and general. In most cases the health-care wastes are kept in yellow containers and the general wastes are stored in either green or black containers.
    - The use of standard containers or containers that are puncture-proof for sharps.
    - Some health-care establishments have proper instructions for hospital staff on the segregation of wastes and the proper use of bags and containers.
    - The use of some pre-treatment and treatment of health-care wastes. Most large hospitals are using incinerators to treat the wastes. However, some health-care wastes including the ashes are disposed off at the municipal dumping sites.
- The definition and hence the classification of health-care wastes are not clear. At the moment, they are segregated loosely into infectious wastes that include all health-contaminated wastes other than sharps. Wastes from laboratory cultures, wards, tissues (swabs), material or equipment that have been in contact with infected patients, human tissues, blood and other body fluids are not properly identified, segregated and they could be stored in common infectious waste containers.
- Most establishments segregate sharps in separate containers.
- The cytotoxic, pharmaceutical and radioactive wastes are separated from other health-care wastes but there is no clear policy on the types and colour of containers to be used.
- Heads of wards, laboratories, pharmacies and other small units are not required to provide reports to the Heads of Health-care establishments on the amount and types of health-care wastes produced, leading the national government and each establishment unclear of the issues faced.
- There is a wide range of plastic bags and containers used to store the health-care wastes. The containers for the sharps are also non-uniform
- There is no proper identification of the waste bags or containers and this could lead to high risk of mixture and possible contamination to the patients, staff, waste collection workers and operators of the incinerator and disposal sites.

- **Sharps could also be found in non-sharps containers and some infectious wastes and sharps could also be found in containers for general wastes.** This could be due to improper guidelines and lack of understanding on the segregation procedures amongst the staff.
- There is no clear organizational structure and hence the identification of a specific person to be responsible for the management of health-care wastes, particularly at the health-care establishment level. At the moment, the responsibility is fragmented and generally lies with the infection control officers, head-nurses and technicians of each department.
- The health-care wastes being collected by general workers in the absence of proper collection or picking-up procedures. With this method, there is a possibility that infectious waste bags could be deposited in the collection vehicles without proper treatment.
- At large hospitals, all infectious wastes and sharps are burnt in the incinerator. Some of the major findings are as follows:
    - There is no record being kept by the incinerator operator on the amount and types of the wastes being incinerated and as a result, there is a possibility that some of the infectious wastes are not treated here.
    - **The wastes are fed into the chamber manually and the ashes are also manually emptied.** This method is highly risky to the workers as they are exposed to contamination of not only infectious contaminants but also hazardous chemicals in the ashes. The workers are not aware of the danger and risks they are exposed.
    - Some incinerators are relatively old and this has definitely affected the combustion efficiency.
    - Many incinerators are located at the vicinity of the residential houses, hospital wards and other facilities such as the hospital laundry. The risk of exposure to the public is high.
    - There is an urgent need for the hospital management to provide the tightest security fence surrounding the incinerators.
    - In the longer term the incinerators should be relocated to other safer places, preferably outside the hospital compound.
- There are smaller incinerators located in smaller hospitals and also health centres but most of them are too old. The location of these incinerators is also unacceptable as

they could pose direct health and safety risks to the general public. In smaller establishments such as the nursing stations, the health-care wastes are burnt in open space or open pits.

- Some establishments bury their wastes within the compound. All these practices are not properly regulated and no minimal safety procedures are provided.
- The ashes from the incinerator and possibly sharps and other infectious untreated wastes are disposed of at the city dumping sites. Visits to a number of dumping sites revealed the following findings:
    - They are open dumps with very minimal control on the types of wastes being disposed.
    - The municipal landfill sites could pose direct danger and risks to the workers, people living surrounding the site and the environment. There is proper cover materials used, no compaction on the wastes, no security fence, no proper collection and containment facilities for leachate, no gas venting systems, no monitoring mechanisms of the environmental conditions surrounding the landfill sites. At the moment all these landfills are extremely in degraded conditions and hence require urgent action by the authorities.
    - All wastes including the incinerator ash and other health-care wastes are dumped together with the municipal wastes.
- Subjects on health-care waste management taught at training and teaching institutions for pre-service and in-service health officers including medical doctors, health inspectors, nurses and technicians are minimal. They are taught as a minor portion of the subject on solid waste management. Formal training on the procedures and handling of facilities for proper health-care waste management are not emphasised.
- Research activities on health-care waste management carried out by universities and training institutes are negligible and hence a large gap on knowledge on local conditions and problems. This will definitely affect the effective formulation and development of plans and strategies for proper health-care waste management in the country.
- Knowledge and understanding of health-care personnel on health-care waste management is relatively weak, leading to unsystematic management of these wastes.

2.0 EXISTING LEGAL FRAMEWORK ON HEALTH-CARE WASTE MANAGEMENT IN PAPUA NEW GUINEA

The following laws and guidelines are available in Papua New Guinea and should be used as the guidance for proper management of health-care wastes in Papua New Guinea:

- National Health Administration Act 1997:
- Infection Prevention Policy Guidelines for Health Facilities:
- National Health Plan 2001-2010
- Minimum Standards for District Health Services in Papua New Guinea
- Environment Bill 2000
- Environmental Contamination Act and Regulations.
- Water Supply and Sanitation Act.
- Pure Food Act and Regulations.
- Traditional Laws Governing Burial Areas.
- Quarantine Act and Regulations.
- International Health Regulations.
- Occupational Health and Safety Act.

3.0 POLICIES AND PLANNING FOR HEALTH-CARE WASTE MANAGEMENT IN PAPUA NEW GUINEA

3.1. Term

The term to be used in this document is “Health-care waste”.

3.2. Definition of Health-care wastes

Health-care wastes include all wastes that are generated from all sources of health-care establishments in Papua New Guinea. The types of wastes that are generated can be divided into two types. The first type is the infectious or potentially infectious wastes, which can be termed in this document as MEDICAL WASTES. The second category is other wastes that are generated in the health-care establishments that are normally referred to as solid wastes. In this document this second type of waste is termed as GENERAL WASTES.

3.3. Definition of Medical Wastes

Medical Waste may be defined as:

- Any waste which consists wholly or partly of human or animal tissue, blood or other body fluids, excretions, drugs or other pharmaceutical products, swabs or dressings, syringes, needles or other sharp instruments, being waste which unless rendered safe may prove hazardous to any person coming into contact with it
- Any other waste arising from medical, nursing, dental, veterinary, pharmaceutical or similar practice, investigation, treatment, care, teaching or research, or the collection of blood for transfusion, being waste which may cause infection to any person coming into contact with it.

3.4. Categories of Medical Wastes

Medical wastes can be categorised into the following types:

- Infectious and pathological wastes.
- Sharps.
- Pharmaceutical Wastes.
- Genotoxic Wastes.
- Chemical Wastes.
- Waste with High Content of Heavy Metals.
- Pressurised Containers.
- Radioactive Wastes.

3.5. Definition of General Wastes

These are the solid or semi-solid wastes that are generated from all units within the health-care establishment which include food wastes and other putrscibles, paper and cardboard, plastics, glass and bottles, ferrous and non-ferrous metals (aluminium cans).

3.6. Categories of General Wastes

Paper, plastics, glass and bottles and cans that are used for the storage of medical items or on contact with health-care wastes are categorised as health-care wastes and should not be considered as general wastes.

3.7. Colour-Coding for Waste Bags and Containers

Health-care wastes shall be segregated at source and placed in colour-coded plastic bags and containers, of suitable strength and durability, prior to collection and disposal.

All health-care establishments in Papua New Guinea shall adopt the standard colour coding according to specifications summarised in Table 1.

Table 1: Recommended Colour-Coding for Health-care wastes in Papua New Guinea

Type of Wastes	**Colour of Container and Markings**	**Type of Container**
MEDICAL WASTES:		
Infectious wastes, Pathological and Anatomical Wastes	Yellow, marked "INFECTIOUS WASTES"	Strong, leak-proof plastic bag, or container capable of being autoclaved
Sharps	Yellow, marked "SHARPS"	Puncture-proof container
Chemical and pharmaceutical wastes	Yellow, marked "CHEMICAL AND PHARMACEUTICAL WASTES"	Plastic bag or container
Radioactive wastes	Red, marked "RADIOACTIVE WASTES"	Lead box, labelled with radioactive symbol
GENERAL WASTES:		
General health-care waste	Black	Plastic bag

For smaller health establishments such as nursing stations, the segregation and colour-coding systems are summarised in Table 2.

Table 2: Segregation and Colour Coding For Health-care wastes in Smaller Health Establishment (eg. Nursing Stations)

Designation	Infectious Waste Container	Sharps Container	General Waste Bag
Type of receptacle	Container or plastic bags in a holder	Sealable box or drum, or cardboard	Plastic bag or container
Colour	Yellow, marked "INFECTIOUS WASTES"	Yellow, marked "SHARPS"	Black
Characteristics	Leak proof, suitable for autoclaving	Puncture-proof and leak proof	No special requirements
Waste categories	Infectious non-sharp wastes	Sharps	Waste similar to municipal wastes, not contaminated by hazardous or infectious substances

Where possible, health-care waste which requires autoclaving, or other equivalent treatment, before disposal in the normal manner shall be stored in suitable bags or containers before such treatment but should be placed in standard yellow plastic bags after treatment.

3.8. Waste Segregation

Health-care wastes and general wastes produced in health-care establishments should not be mixed but, where this has occurred, a mixture must be treated as health-care waste.

3.9. Sharp Containers

Syringes, needles and cartridges should be discarded intact and placed in a suitable sharps container which, when full, should be enclosed in a yellow health-care waste bag before collection and disposal.

3.10. On-Site Waste Collection and Transport

Collection and transport of waste within the health-care establishment should be carried out using suitable designed trolleys and follow pre-determined collection route and collection time. Health-care wastes and general wastes should be collected at least daily from the source of generation to the central storage area.

3.11. Central Storage Area

Bulk storage area for health-care waste must be sited separately from the general waste storage area. Wherever possible, health-care waste should be removed daily from the bulk storage area for disposal.

3.12. Transport of Waste Outside the Health-Care Establishment

The transport of health-care waste from the health-care establishment to an off-site treatment or disposal facility should be carried out using suitable vehicles approved by the relevant authorities in Papua New Guinea. The drivers of such vehicles should be trained to carry out the job safely and be familiar with the procedures to be taken in the event of spillage or accidents.

3.13. Documentation

Proper documentation should be completed before a consignment of health-care waste leaves the health-care establishment. The consignment note system allows waste to be traced from the point of collection to the final disposal facility.

3.14. Disposal of Health-care wastes

3.14.1. Disposal of Medical wastes

For areas where suitable incineration facilities are available, incineration of medical wastes would be an appropriate treatment and disposal option. In the event of incinerator failure, contingency disposal arrangements for the disposal of medical wastes must be specified in the medical establishment's waste management plan.

However, for areas where no such facility is available, disposal of medical waste by landfilling can be carried out provided it is done in a sanitary manner, meeting all environmental and health requirements. Other methods of treatment should also be considered, such as chemical disinfection, wet-thermal treatment, autoclaving and microwave.

Emissions from medical waste incinerators must conform to all the standards and requirements stipulated by the Department of the Environment. Where a high temperature medical waste incinerator is not available, cytotoxic waste and halogenated plastics such as PVC should be segregated and should not be incinerated. Every effort should be made to eliminate the use PVC in medical establishments.

3.14.2. Disposal of Radioactive Wastes

All waste containing radioactive materials should be properly labelled and its handling, storage and disposal must comply with all the requirements and regulations of the relevant agency in Papua New Guinea.

3.14.3. Disposal of Chemical Wastes

Hazardous chemical waste should be stored in leak-proof containers and labelled to identify the contents. Any waste that cannot be incinerated must be handled and disposed of by an authorised waste management organization.

3.14.4. Disposal of Pressurised Wastes

Pressurized containers, such as disposable aerosol cans should be placed in black non-health-care waste bags, and disposed of together with general waste. Compressed gas cylinders should be returned to the manufacturers.

3.14.5. Disposal of General Wastes

General waste should be placed in black plastic bags. Separate arrangements must be made for the transportation and disposal of general waste and health-care waste.

3.15. Guidelines for Policy Implementation

The document entitled *Technical Guidelines for Health-care waste Management in Papua New Guinea* should be referred to by health-care establishments in the implementation of this policy.

3.16. Legal Framework

The treatment and disposal of health-care waste must comply with the requirements of all relevant legislation in Papua New Guinea

4.0 MANAGERIAL RESPONSIBILITIES

4.1. The Department of Health

The Department of Health, Papua New Guinea shall be responsible for ensuring that the Health-care waste Management Policy outlined in this document will be implemented by all health-care establishments in the country.

Health-care waste management committees both at the Central Government and each health-care establishment shall be established to assist the Department of Health to carry out this task.

4.2. Structure of Health-care waste Management Committees

The Department of Health, Papua New Guinea shall set up a formal health-care waste management committee at the national and individual health-care establishment levels. The department of Health, PNG should also determine the organisational structure and liaison paths from the National Committee to individual health-care establishments. The appropriate number and composition of individuals in the committee should be decided

as appropriate by the committee. All committees should be headed by a Chairperson and the Secretary to the committee is the Health-care waste Management Officer, who will be responsible to the daily operation and management of health-care wastes..

4.3. Central Government Health-care waste Management Committee

The committee should be known as the National Health-care waste Management Committee or Board.

This Central Government Committee should be headed by an appropriate person at the Department of Health Papua New Guinea, with Health-care waste Management Coordinator as the secretary to the committee. The Chairperson should suggest the number and composition of the National Health-care waste Management Committee Members.

The Health-care waste Management Coordinator should be appointed from the office of the Department of Health Papua New Guinea who shall be responsible for the day to day operation of the health-care waste management system.

4.4. Health-care waste Management Committees at Individual Health-care Establishments

The Head of individual health-care establishments in Papua New Guinea shall be responsible for the implementation of the Policy and, for this purpose, shall form a Health-care waste Management Committee of each establishment to develop and implement a Health-care waste Management Plan for that health-care establishment.

The members in the committee should be under the discretion of the Head of each Health-care establishment and the Head is also responsible to appoint a Health-care waste Management Officer for the establishment who will also act as the Secretary to the committee. For smaller health-care establishments, the individual responsible to manage the health-care wastes should be appointed directly the National Health-care waste Management Committee.

4.5. Responsibilities of Officers-in-Charge

4.5.1. Head of National Health-care waste Management Committee

The Head of National Health-care waste Management Committee should:

- Formulate a written Health-care waste Management Plan to ensure systematic implementation of the health-care waste management policy in Papua New Guinea. Within this plan, the duties, responsibilities and functions of all members of the National Health-care Committee Members shall be clearly defined in respect of health-care waste management. Clear lines of accountability shall be indicated in the management structure
- Establish the National Health-care waste Management Committee, to advise the Permanent Secretary of Health Papua New Guinea in the development and implementation of the Health-care waste Management Plan.
- Incorporate suitable monitoring procedures to assess the efficiency and effectiveness of the health-care waste management system in Papua New Guinea and to effect continuous improvement and updating of the Health-care waste Management Plan.
- Allocate adequate resources, both manpower and financial, to ensure efficient operation of the health-care waste management system
- Appoint a Health-care waste Management Coordinator to take control of the day to say operation of the waste management system and assign adequate number of supporting staff to this officer to ensure efficient operation of the system
- Oversee the development and implementation of a training programme to ensure proper training of all health-care and non-health-care staff on health-care waste management. Such a programme should take into account the needs for continuous updating/upgrading of knowledge and skill of all staff.
- Submit an annual report to the Ministry of Health on the status of health-care waste management in Papua New Guinea and an assessment of the performance of the health-care waste management system in Papua New Guinea.

4.5.2. Head of Health-Care Establishments

The Head of each health-care establishment shall be responsible for the implementation of the policy on health-care waste management as outlined in this document. The Head should:

- Ensure systematic implementation of the health-care waste management policy prepared at the National levels in his health-care establishment. Within this plan, the

duties, responsibilities and functions of all members of staff, both health-care and non-health-care, shall be clearly defined in respect of health-care waste management. Clear lines of accountability shall be indicated in the management structure

- Establish a Health-care waste Management Committee for his/her establishment comprising the appropriate strategic personnel in his/her establishment.
- Incorporate suitable monitoring procedures to assess the efficiency and effectiveness of the health-care waste management system within his/her health-care establishment and to effect continuous improvement and updating of the Health-care waste Management Plan.
- Allocate adequate resources, both manpower and financial, to ensure efficient operation of the health-care waste management system.
- Appoint a Health-care waste Management Officer in his/her establishment to take control of the day to say operation of the waste management system in the establishment. If the establishment is small, such as the nursing station, the head can also be the Health-care waste Management Officer.
- Recommend the needs of a training programme to ensure proper training of all health-care and non-health-care staff on health-care waste management. Such a programme should take into account the needs for continuous updating/upgrading of knowledge and skill of all staff
- Submit an annual report to the Department of Health Papua New Guinea on the status of health-care waste management in his/her health-care establishment.

4.5.3. National Health-care waste Management Coordinator

The National Health-care waste Management Coordinator shall be responsible for the day to day operation of the health-care waste management system in Papua New Guinea. He shall be directly responsible to the Head of National Health-care waste Management Committee and shall perform the following functions:

- Assist the Head of National Health-care waste Management Committee to formulate, review, update/upgrade and implement the Health-care waste Management Plan.
- Ensure the effective and efficient operation of the health-care waste management system through:
    - Monitor and, wherever necessary, initiate remedial action to ensure all activities related to health-care waste management are carried out according to the Policy

and the recommendations of these guidelines in an effective and efficient manner.

- Ensure continuous supply and efficient utilization of resources, i.e. materials and manpower, provided for health-care waste management.
- Liaise with all Heads of Departments in the health-care establishments to ensure that all health-care and non-health-care staff are properly trained on correct health-care waste management procedures
- Manage the central bulk storage facilities for health-care waste and maintain all relevant records and documentation with due diligence towards health risks control, security and accountability, and to meet all legal requirements
- Ensure that supporting tools, equipment and materials needed for health-care waste management including those needed for emergency situation, such as spillage of health-care waste, are available and all staff have been adequately trained on the emergency procedures.

- Investigate and report to the Head of National Health-care waste Management Committee on any incident or accident related to the handling of health-care waste
- Assist the Head of National Health-care waste Management Committee in the preparation of annual report on health-care waste management
- Assist the Head of Nursing Department in the development and implementation of a health-care waste management training programme
- Liaise with the Head of Nursing Department to ensure the assistance of ward nurses in managing the day to day operation of health-care waste management at the ward and departmental level
- Carry out the duties of the Secretary to the National Health-care waste Management Committee.

4.5.4. Health-care waste Management Officer of Each Health-care Establishment

At present, the Infection Control Officer of each health-care establishment in PNG is also responsible for the management of health-care wastes, in particular the infectious and pathological wastes. By virtue of existing management structure of infection control programme and to avoid duplication of responsibilities and operation, it is recommended that the Infection Control Officer should also be appointed as the Health-care waste Management Officer of the establishment.

The Health-care waste Management Officer shall be responsible for the day to day operation of the health-care waste management. He shall be directly responsible to the Head of the health-care establishment and shall perform the following functions:

- Assist the Head to formulate, review, update/upgrade and implement the Health-care waste Management Plan.
- Ensure the effective and efficient operation of the health-care waste management system in the Establishment through:
    - Monitor and, wherever necessary, initiate remedial action to ensure all activities related to health-care waste management are carried out according to the Policy and the recommendations of these guidelines in an effective and efficient manner
    - Ensure continuous supply and efficient utilization of resources, i.e. materials and manpower, provided for health-care waste management
    - Liaise with all Heads of Departments in the health-care establishment to ensure that all health-care and non-health-care staff are properly trained on correct health-care waste management procedures
    - Manage the central bulk storage facilities for health-care waste and maintain all relevant records and documentation with due diligence towards health risks control, security and accountability, and to meet all legal requirements
    - Ensure that supporting tools, equipment and materials needed for health-care waste management including those needed for emergency situation, such as spillage of health-care waste, are available and all staff have been adequately trained on the emergency procedures.
- Investigate and report to the Director on any incident or accident related to the handling of health-care waste
- Assist the Head in the preparation of annual report on health-care waste management
- Assist the Head of Nursing Department (HND) in the development and implementation of a health-care waste management training programme.
- Liaise with the HND to ensure the assistance of ward nurses in managing the day to day operation of health-care waste management at the ward and departmental level.

4.5.5. Head of Nursing Department

The Head of Nursing Department (HND) in each health-care establishment shall be responsible for the development and implementation of a health-care waste management

training programme to cover all health-care and non-health-care staff including any new staff reporting for duty.

To assist the HND in carrying out the task, a Health-care waste Management Training Taskforce headed by the HND shall be formed to develop and implement the training programme. Members of the Task Force shall include the inspection control officer as well as the Health-care waste Management Coordinator and other suitable staff appointed by the Director.

HND with the assistance of the Task Force, shall review the training programme regularly to ensure its effectiveness in meeting the needs.

4.5.6. Engineer/Technician

The Engineer in the health-care establishment shall ensure that all waste storage facilities and handling equipment in the health-care establishment are installed and maintained to the standards specified in these guidelines.

The Engineer shall ensure that all his staff are trained in the principle of waste disposal. Where on-site incineration of health-care waste is carried out, the Engineer shall be responsible for the operation and maintenance of the incinerator and he shall ensure that his staff are trained in the principle of waste incineration.

4.5.7. Heads of Departments

All Heads of Departments shall give due consideration to the requirements of health-care waste management and ensure that all staff under them have been trained and adhere to all health-care waste management procedures.

Heads of Departments who are members of the Health-care waste Management Committee shall perform the duties specified for the members and assist the Director of the health-care establishment to implement the health-care waste management policy in an effective and efficient manner.

4.6. Time of Implementation and Frequency of Meetings

The National Health-care waste Management Committee should be established three months after the formulation of the National Health-care waste Management Plan, thereafter the Health-care waste Management Committee of each health-care establishment.

The Health-care waste Management Committees shall meet once every four weeks during the initial period of the formulation and implementation of the Waste Management Plan. Thereafter, the team should meet at least once every six months to review the system performance.

Having designated responsibilities in accordance with the Guidelines, the team shall first carry out a review of existing health-care waste management in each health-care establishment in Papua New Guinea. Each member with specific responsibilities shall present a written report to the Waste Management Committee for discussion. The report shall evaluate existing practice in the light of the policy and Guidelines and make recommendations on how the policy can be implemented in the area under their jurisdiction.

4.7. Survey of Waste Generation Rates and Types

The National and Divisional Waste Management Committees shall initiate a survey of all health-care waste generation rates and its composition in the health-care establishments to estimate the total quantities of waste generated. Health-care waste generation shall be categorised using the waste classification system specified in the guidelines. The Health-care waste Management Coordinator shall be responsible for coordinating the survey and analysing the results.

Survey results shall be presented in the form of average daily generation rate in each category, from each health-care department. Special care should be taken to assess the potential for peak loading where extraordinary quantities of wastes may be produced. Account must also be taken of slack periods or other unusual circumstances that may cause significant cyclical variations in waste quantities. This information must be collected for all departments and must include an assessment of any future changes due to changes in hospital designation or development in departmental growth or the formation

of new departments. Estimates must also be made of the impact of epidemics and other emergency cases that may affect the quantity of waste arising.

The statistics generated by the waste arising shall form the basis on which an appropriate waste management system can be developed. In the absence of local data and prior to the completion of the survey it may be possible to make preliminary estimates of personnel and equipment for implementation of the waste management policy using statistics which have been obtained by the Ministry of Health for central planning purposes. However these statistics must not be the sole basis for the individual hospital plans and must be supplemented, as soon as possible, with local data.

5.0 DEVELOPMENT OF THE HEALTH-CARE WASTE MANAGEMENT PLAN

The Health-care waste Management Coordinator shall be responsible for developing the Health Waste Management Plan using the statistics on waste arising and the reports prepared by other members of the Health-care waste Management Committees.

The Health-care waste Management Coordinator shall prepare a Draft Discussion Document for the Waste Management Committee, including the following detailed information describing the new waste management system:

- Drawings showing designated bag holder sites for every ward and department in the hospital. Each bag site shall be appropriately designated as health-care or non-health-care.
- Drawings showing the paths of waste collection trolleys through the hospital, with individual collection routes clearly marked.
- A timetable showing the frequency of collection for each trolley route, the type of waste to be collected, the number of wards and departments to be visited on one round and indicating the central storage point in the hospital for that particular waste.
- Drawings showing the site of the central storage for health-care waste and the separate site for general waste. Details of the arrangements for security and arrangements for washing and disinfecting trolleys or containers should be included. A discussion on the potential for the provision of refrigerated facilities should also be included.
- Drawings showing the type of bag holders to be used in the hospital wards and departments.

- Drawings showing the type of trolley or container to be used for bag collection.
- An estimate of the number of personnel required for waste collection.
- A definition of the responsibilities of hospital attendants in relation to the collection and handling of wastes from each ward and department in the hospital. Where special arrangements are required, for example with radioactive waste, hazardous chemical waste, etc., it shall be clearly defined at what stage the attendants become involved in waste handling.
- An estimate of the numbers and cost of bag holders and collection trolleys.
- An estimate of the numbers and costs of. yellow and black plastic bags to be used annually.
- Drawings of sharps containers with their specification.
- An estimate of the number of sharps containers required annually, categorised into different sizes if appropriate.
- Definitions of duties and responsibilities for each of the different categories of personnel involved in the generation, segregation, storage and handling of hospital waste.
- The procedures required for segregation, storage and handling of wastes requiring special arrangements prior to disposal.
- Training Courses and Programme.
- Emergency Procedures.

The preparation of the Draft Discussion Document shall be carried out in consultation with all members of the Health-care waste Management Committees and their staff.

The Draft Discussion Document will form the basis of the Hospital Waste Disposal Plan and shall be presented to a meeting of the Health-care waste Management Committees for approval. The Health-care waste Management Coordinator shall be responsible for amending the Draft Discussion Document in the light of comments made by the Health-care waste Management Committees. When full agreement has been reached, the document shall be known as the Health-care waste Management Plan.

5.1. Implementation of the Waste Management Plan

The final Waste Disposal Plan for any health care establishment shall contain information on the line management structure and the liaison paths in diagrammatic form. It shall

make provision for interim measures to be introduced as a precursor to the complete implementation of the new waste disposal system. A bar chart shall be included showing the dates of implementation of each part of the new system. Provision for future expansion shall also be made. Emergency procedures shall be clearly-defined with names and telephone numbers of responsible personnel who must be notified in the case of an emergency. It is the responsibility of the Head of the establishment to ensure that personnel are in the designated posts and notices are widely circulated, updating names and numbers when personnel change post.

Training programmes for all staff shall be organised and supervised by the Health-care waste Management Coordinator who shall liaise closely with the members of the Health-care waste Management Committee. All members of hospital staff should attend initial training sessions, including medical staff, who should be urged to be vigilant in monitoring the performance of non-medical staff in their waste disposal duties. It shall be the responsibility of the Health-care waste Management Coordinator to decide on the speakers, the content and the type of training given to each category of personnel.

The implementation of the Waste Management Plan is the responsibility of the Head of the establishment. Day to day operation and monitoring of the waste management system is the responsibility of the Health-care waste Management Coordinator. Training courses are the responsibility of the Health-care waste Management Coordinator. The Head of the establishment may designate the Health-care waste Management Coordinator to supervise and coordinate the implementation of the Health-care waste Management Plan, however, such an appointment shall not relieve the Head of the establishment of his overall responsibilities outlined in the Policy Document.

In implementing the Waste Disposal Plan, the Health-care waste Management Coordinator shall also liaise with private haulage and disposal contractors, where appropriate.

The Health-care waste Management Coordinator shall be responsible for ensuring that statistics on waste arising are updated annually.

The Health-care waste Management Coordinator shall record incidents resulting in injury, “near misses”, or failures in the handling, segregation, storage, transport or disposal system and note remedial action taken to prevent recurrences. Such incidents should be reported as soon as possible to the Head of that health-care establishment.

The Health-care waste Management Committee shall review the Health-care waste Management Plan annually and initiate changes in those parts of the system which require upgrading.

PART 2: DRAFT TECHNICAL GUIDELINES FOR HEALTH-CARE WASTE MANAGEMENT IN PAPUA NEW GUINEA

12.0 INTRODUCTION

The Department of Health, Papua New Guinea has acknowledged that wastes generated in all health-care establishments may be hazardous or offensive and pose a health risk to patients, personnel and the general public if they are not managed properly.

These guidelines have been prepared for the management of health-care wastes in Papua New Guinea.

The elements covered in this guidelines include the assessment of the current waste generation and management systems in health-care institutions; review of related legislation; proposal for proper handling, separation and storage of wastes at source; collection and transport systems; options available for treatment and disposal; and finally on the training requirement including appropriate research and development programmes.

The target users of this guidelines are officials of the national government agencies responsible directly or indirectly for the health-care waste management both at national and regional levels, and waste managers, collection workers, and operators of waste treatment and disposal facilities.

13.0 INFORMATION AND DATA ON HEALTH-CARE WASTE MANAGEMENT

The national and provincial agencies including head of health centres and nursing stations should be fully aware of the sources, types and amount of health-care wastes generated. Hence, the importance of developing national and individual health-care establishment database of health-care waste management in Papua New Guinea.

All these information need to be collected in a systematic manner using a standard format and the information should be validated at random by the Health-care waste Management Coordinator.

Essential data that should be established can be as follows:

- About the institution:

- number of hospital bed
- occupancy rate.

- About the wastes:
  - sources, types and quantity of waste produced.
- About the waste management:
  - segregation, storage, labelling, collection and transport, treatment and disposal.

The survey form to be completed by each department, units or wards in each health-care establishment is given in **Annex 1**. This form is to be submitted to the Health-care Waste Management Officer of the establishment by the end of the month.

At the health-care establishment levels, the survey form that needs to be completed is shown in **Annex 2**. The completed form is to be submitted to the National Health-Care Waste Management Coordinator at the end of each month and also at the end of each year.

Through the survey, problems associated with the health-care waste management in a particular institution can be identified and a national database system for health-care waste management could be established.

The data should be collected at regular interval, preferably on a monthly basis so that the Health-care waste Management Coordinator could establish national and provincial data at daily, monthly and annual rates.

13.1 Information on the Number of Health Care Establishments in Papua New Guinea

The information on the number of health-care establishments that could indicate the magnitude of health-care waste management is summarised in Tale 3.

Table 3: Information of Health-Care Establishment in Papua New Guinea According to Province

Province	Population Served (1999)	No. of Health Centres	No. of Aidpost
Western:	150,230:	38	100
Gulf Province	73,256	23	78
Central Province	167,702	29	99
National Capital District	295,426	15	0
Milne Bay Province	193,302	41	128
Oro Province	117,884	19	48
Southern Highlands Province	412,738	54	197
Enga Province	323,567	28	127
Western Highlands Province	416,534	30	123
Simbu Province	189,042	26	78
Eastern Highlands Province	324,445	31	106
Morobe Province	456,686	38	262
Madang Province	298,874	38	169
East Sepik Province	288,276	35	158
Sandaun Province	168,398	30	127
Manus Province	40,547	12	72
New Ireland Province	111,741	30	60
East New Britain Province	250,136	29	83
West New Britain Province	183,704	28	91
North Solomons Province	185,675	35	-

14.0 RELEVANT LAWS AND REGULATION

The following laws and guidelines are available in Papua New Guinea and should be used as the guidance for proper management of health-care wastes in Papua New Guinea:

14.1 National Health Administration Act 1997:

Sections of the Act that need to be referred in the implementation of the Health-care Waste Management Guidelines are:

- Part II – National Health Plan and National Standards.
- Part III – National Health Board and Provincial Health Board and District Health Management Committees.

- Part IV – Administration of Health Functions.
- Part V – Finances, Planning and Information.

14.2 Infection Prevention Policy Guidelines for Health Facilities:

This is the most relevant national guidelines that are related to health-care waste management in Papua New Guinea. This document should be used in entity because all articles in the Guidelines are directly relevant and useful to the issues of health-care waste management. These include:

- Handwashing.
- Antiseptics.
- Protective clothing.
- Wound dressing techniques.
- Decontamination and cleaning.
- Sterilisation and high level disinfection.
- Processing sterile gloves and needles and syringes.
- Operation of central sterile supply department.
- Hospital cleaning services.
- Water supply and drainage in health facilities.
- Excreta disposal systems.
- Safe handling and disposal of waste.
- Clean and safe kitchen.
- Preventing infection in the laboratory.
- Preparation and storage of medicines in the pharmacy.
- Proper handling and storage of clean and contaminated linen.
- Isolation.
- Infection prevention in selected patient care practices.
- Management of an infection prevention program.
- Teaching about infection prevention.

Chapter 13 of the Guidelines deals directly with safe handling and disposal of wastes. It provides clear explanation on safe collection of non-contaminated wastes, safe handling of contaminated wastes and methods of waste disposal. On the disposal of contaminated wastes, the Guidelines provide clear instruction for the disposal of sharps, infectious

wastes, liquid wastes, microbiological wastes and chemical containers. Basic designs on waste incinerators are also provided.

14.3 National Health Plan 2001-2010

This Plan identifies priority health issues in Papua New Guinea at National, Provincial and Local Levels. The issues that are relevant to health-care waste management in Papua New Guinea include health promotion, disease control, control of air-borne diseases, food-borne and water-borne diseases, mosquito-borne diseases and family health. The plan also provides the national health indicators and the one that is directly relevant for health-care waste management is the environmental health programmes that provides the following indicators:

- Proportion of communities having easy access to safe water.
- Proportion of households having safe human waste disposal systems.
- Proportion of provinces with trained staff in all sustainable development and healthy environment.
- Proportion of urban areas with safe solid waste management.

In this respect, the Plan provides specific responsibilities at the National, Provincial and Local levels. The national tasks include the development of standards and guidelines for environmental health impact assessment and monitoring and improvement of hospital systems for biological waste management. The tasks at the provincial level include monitoring of waste management and workplace safety. At the local level, one of the responsibilities is to provide facilities for the safe disposal of biological wastes.

14.4 Minimum Standards for District Health Services in Papua New Guinea

Section 6 of the document stipulates the need of health-care establishment in Papua New Guinea to establish a multi-discipline committee or a designated officer for infection control. This indicates that there is already an official structure in health-care establishments in the country that could be adopted easily for the management of health-care wastes. Some of the terms of references of the committees or the officer could be extended further for the management of health-care wastes since these two responsibilities are inter-related.

14.5 Environment Bill 2000

This is the National Bill that provides the National Goals and Directive Principles in the following areas:

- To provide for the protection of the environment in accordance with the Fourth National Goal and Directive Principle (Natural Resource and Environment) of the Constitution.
- To regulate the environmental impacts of development activities in order to promote sustainable development of the environment and economic, social and physical well-being of people by safeguarding the life-supporting capacity of air, water, soil and ecosystems for present and future generations and avoiding, remedying and mitigating any adverse effects of activities on the environment.
- To provide for the protection of the environment from environmental harm.

Articles of the Bill that are relevant for the management of health-care wastes in Papua New Guinea include:

- Part IV – Environment Policies.
- Part V – Environment Permits:
  - Division 3 – Environmental Impact Assessment.
- Part VI – Environmental Management.

14.6 Other Relevant Laws and Regulations

Other existing laws and regulations that need to be referred in implementing the Guidelines on health-care Waste Management in Papua New Guinea are as follows:

- Public Health Act 1992
- Environmental Contamination Act and Regulations.
- Water Supply and Sanitation Act.
- Pure Food Act and Regulations.
- Traditional Laws Governing Burial Areas.
- Quarantine Act and Regulations.
- International Health Regulations.
- Occupational Health and Safety Act.

15.0 SOURCES AND TYPES OF WASTES

15.1 Types of Wastes.

There are different types of waste classification in many countries. Some are classifying their wastes according to different laws governing each waste type while some countries are classifying wastes to enhance waste minimisation and recycling.

In Papua New Guinea, the types of waste can be classified broadly into four namely Municipal Solid Wastes, Toxic and Hazardous Wastes, Health-care Wastes, and Radioactive Wastes. There would possibly mixtures of these wastes from a particular source. Wastes from the households, for example, may not only constitute the general solid wastes, but also toxic and hazardous materials. Similarly, wastes that are generated from hospitals may constitute all the four types of wastes.

15.1.1 Municipal Solid Wastes

These are the wastes that are solid or semi-solids generated from residential houses, business establishments, and also the general wastes from industries.

These are the food wastes, paper, plastics, textiles, ferrous and non-ferrous metals, glass and also garden wastes.

15.1.2 Toxic and Hazardous

These are the wastes that are solid, liquid and gaseous chemicals that are generated from industries.

These wastes are considered to be hazardous if it has at least one of the following properties:

- Toxic.
- Corrosive (eg. Acids of pH < 2 and bases of pH > 12).
- Flammable.
- Reactive (explosive, water reactive, shock sensitive).

Hazardous waste can be defined further as any refuse, sludge or other waste material or combination of refuse, sludge or waste materials in solid, semi-solid, liquid or contained

gaseous form which because of its quantity, concentration, or physical, chemical, or infectious characteristics may:

- Cause or significantly contribute to an increase in mortality or an increase in serious irreversible, in incapacitating reversible, illness; or
- Pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed; and
- Also include explosive substances, inflammable substances, oxidising and peroxidising substances, toxic substances, pathogenic substances, corrosive substances, irritating substances, or other substances whether chemical or not, which may cause danger to human health, animal, plant, property or the environment; and
- Shall include any other waste that, in the opinion of the Government of Papua New Guinea should be classified as hazardous wastes.

15.1.3 Health-care wastes:

Health care wastes are all waste generated from all health-care establishments. They can be broadly divided into two types: the **Medical Wastes**; and **General Solid Wastes**, the latter has been defined in 4.1.1.

Medical wastes are the wastes arising from health-care, nursing, dental veterinary, pharmaceutical or similar practice, investigation, treatment, care, teaching or research, or the collection of blood for transfusion, which by nature of its infectious, toxic, dangerous content may prove to be hazard or give offence unless previously rendered safe and inoffensive.

Medical wastes include any waste which consists wholly or partly of human or animal tissue, blood or other body fluids, excretions, drugs or other pharmaceutical products, swabs or dressings, syringes, needles or other sharp instruments, including waste which may prove hazardous to any person coming into contact with it.

15.1.4 Radioactive Wastes:

These are wastes containing radioactive substances. These include:

- Radionuclides continuously undergo spontaneous disintegration (known as "radioactive decay") in which energy is liberated, generally resulting in the formation of new nuclides.
- The process is accompanied by the emission of one or more types of radiation, such as α- and β-particles, and γ-rays emitted by radioactive substances.

15.2 Categories of Health-care Wastes

Health-care wastes in Papua New Guinea should be classified according to their toxicity levels and risk and hazard that they may pose to human beings and the environment. Hence the level and urgency of management of each category could be different.

Health-care waste may be categorised as follows:

- Infectious Wastes.
- Pathological Wastes.
- Sharps.
- Pharmaceutical Wastes.
- Genotoxic Wastes.
- Chemical Wastes.
- Wastes with high content of heavy metals.
- Pressurised containers.
- Radioactive Wastes.
- General Wastes.

15.2.1 Infectious Wastes

These are wastes that are suspected to contain pathogens (bacteria, viruses, parasites, or fungi).

This category includes:

- Cultures and stocks of infectious agents from laboratory work.

- Waste from surgery and autopsies on patients with infectious diseases (eg. Tissues, and materials or equipment that have been in contact with blood or other body fluids).
- Waste from infected patients in isolation wards (eg. Excreta, dressings from infected or surgical wounds, clothes heavily soiled with human blood or other body fluids).
- Waste that has been in contact with infected patients undergoing haemodialysis (eg. Dialysis equipment such as tubing and filters, disposable towels, gowns, aprons, and laboratory coats);
- Infected animals from laboratories.
- Any other instruments or materials that have been in contact with infected persons or animals.
- Cultures and stocks of highly infectious agents, waste from autopsies, animal bodies, and other waste items that have been inoculated, infected or in contacted with such agents are called highly infectious wastes.

15.2.2 Pathological Wastes

Consists of tissues, organs, body parts, human fetuses and animal carcasses, blood, and body fluids.

This category includes:

- Human materials removed during surgery, labour and delivery, autopsy, embalming, or biopsy, including: body parts and tissues or fetuses;
- Products of spontaneous or induced human abortions, regardless of the period of gestation, including: body parts, tissues or fetuses, organs, and bulk blood and body fluids.
- Laboratory specimens of flood and tissue after completion of laboratory examination; and
- Anatomical remains: recognizable human or animal body parts.

15.2.3 Sharps

This category shall include but not limited to the following, regardless of contamination:

- Needles.
- Hypodermic needles.

- Hypodermic syringes with attached needles.
- Scalpel blades.
- Razor blades, disposable razors, and disposable scissors used in surgery or other Health-care procedures.
- Glass Pasteur pipettes.
- Glass pipettes.
- Broken glassware.
- Specimen tubes.
- Blood culture bottles.
- Microscope slides.

15.2.4 Pharmaceutical Wastes

Include expired, unused, spilt, and contaminated pharmaceutical products, drugs, vaccines, and sera that are no longer required and need to be disposed of appropriately.

The category also includes discarded items used in the handling of pharmaceuticals, such as bottles or boxes with residues, gloves, masks, connecting tubing, and drug vials.

15.2.5 Genotoxic Wastes:

These are highly hazardous wastes that have mutagenic, teratogenic, or carcinogenic properties.

May include:

- Cytostatic drugs (eg. Azathioprine, chlorambucil, chlornaphazine, ciclosporin, cyclosphamide, melphalan, semustine, thiotepa and treosulfan)
- Vomit, urine, or faeces from patients treated with cytostatic drugs.
- Contaminated materials from drug preparation and administration such as syringes, needles, gauges, vials, and packaging.

15.2.6 Chemical Wastes.

The properties of these are as described in Section **4.1.2**. These are wastes from diagnostic and experimental work and from cleaning, housekeeping, and disinfecting procedures:

The common types of wastes are as follows:

- Formaldehyde: used to clean and disinfect equipment, to preserve specimens, to disinfect liquid infectious waste, and in pathology, autopsy, dialysis, embalming, and nursing units.
- Photographic Chemicals: photographic fixing and developing solutions used in X-ray departments.
- Solvents: Waste solvents produced from pathology and histology laboratories and engineering departments. The wastes are halogenated compounds such as methylene chloride, chloroform, trichloroethylene, and refrigerants, and non-halogenated compounds such as xylene, methanol, acetone, isopropanol, toluene, ethyl acetate, and acetonitrile.
- Organic Chemicals: These include:
    - Disinfecting and cleaning solutions such as phenols-based chemicals used for scrubbing floors, perchloethylene used in workshops and laundries.
    - Oils such as vacuum-pump oils, used engine oil from vehicles.
    - Insecticides, rodenticides.
- Inorganic Chemicals:
    - Acids and alkalis (eg. Sulfuric, hydrochloric, nitric, and chromic acids, sodium hydroxide and ammonia solutions).
    - Oxidants such as potassium permanganate and potassium dichromate.
- Reducing agents such as sodium bisulfite and sodium sulfite.

15.2.7 Waste with high content of heavy metals:

These are:

- Mercury wastes.
- Residues from dentistry.
- Cadmium wastes from discarded batteries.
- Drugs containing arsenic.

15.2.8 Pressurised containers:

These are:

- Pressurised gas containers (cylinders, cartridges, and aerosol cans)

- Many types are used in health-care (anaesthetic gases, ethylene oxide, oxygen, and compressed air.), and are often stored in pressurised cylinders, cartridges, and aerosol cans. Many of these, once empty or of no further use (although they may still contain residues), are reusable, but certain types, notably aerosol cans, must be disposed of.
- Whether inert or potentially harmful, gases in pressurised containers should always be handled with care; containers may be explode if incinerated or accidentally punctured.

15.2.9 Radioactive Wastes:

The waste produced by health-care and research activities involving radionuclides, and related activities such as equipment maintenance, storage, etc., can be classified as follows:

- Sealed sources.
- Spent radionuclide generators.
- Low-level solid wastes eg. Absorbent paper, swabs, glassware, syringes, vials.
- Residues from shipment of radioactive materials and unwanted solutions of radionuclides intended for diagnostic or therapeutic use.
- Liquid immiscible with water.
- Waste from spills and from decontamination of radioactive spills.
- Excreta from patients treated or tested with unsealed radionuclides.
- Low-level liquid waste eg. From washing apparatus.
- Gases and exhausts from stores and fume cupboards.

15.3 General Wastes

15.3.1 General Domestic Wastes

These include household-type wastes from offices, corridors, public areas, supplies department, catering areas etc.

Examples of components are newspapers, letters, documents, packing materials, cardboard containers, flowers, floor sweepings etc.

15.4 Sources of Health-care wastes

The composition of wastes is often characteristic of the type of source.

The different units within a hospital would generate waste with the following characteristics:

- Health-care wards: mainly infectious waste such as dressings, bandages, sticking plaster, gloves, disposable Health-care items, used hypodermic needles and intravenous sets, body fluids and excreta, contaminated packaging, and meal scraps.
- Operating theatres and surgical wards: mainly anatomical waste such as tissues, organs, fetuses, and body parts, other infectious wastes, and sharps.
- Other health-care units: mostly general wastes with a small percentage of infectious waste.
- Laboratories: mainly pathological (including some anatomical), highly of infectious waste (small pieces of tissue, microbiological cultures, stocks of infectious agents, infected animal carcasses, blood and other body fluids), and sharps, plus some radioactive and chemical waste.
- Pharmaceutical and chemical stores: small quantities of pharmaceutical and chemical wastes, mainly packaging (containing only residues if stores are well managed), and general waste.
- Support units: general waste only.
- Health care provided by nurses: mainly infectious waste and many sharps.
- Physician's offices: mainly infectious waste and some sharps.
- Dental clinics and dentists' offices: mainly infectious waste and sharps, and waste with high heavy metal content.
- Home health care (eg. dialysis, insulin injections): mainly infectious waste and sharps.

16.0 SEPARATION, HANDLING AND STORAGE OF HEALTH-CARE WASTES

16.1 Segregation of Health-care Waste into Colour Coded Bags and Containers

The key to effective management of health-care wastes is segregation (separation) and identification of the wastes. Segregation should always be the responsibility of the waste producer, should take place as close as possible to where the waste is generated, and should be maintained in storage areas and during transport. The same system of segregation should be force throughout the country.

The most appropriate way of identifying the categories of health-care waste is by sorting the wastes into colour coded bags or containers.

In Papua New Guinea, the colour-coded scheme is recommended as in Table 4.

Table 4: Recommended Colour-Coding for Health-care waste

Table 1: Recommended Colour-Coding for Health-care wastes in Papua New Guinea

Type of Wastes	**Colour of Container and Markings**	**Type of Container**
MEDICAL WASTES:		
Infectious wastes, Pathological and Anatomical Wastes	Yellow, marked "INFECTIOUS WASTES"	Strong, leak-proof plastic bag, or container capable of being autoclaved
Sharps	Yellow, marked "SHARPS"	Puncture-proof container
Chemical and pharmaceutical wastes	Yellow, marked "CHEMICAL AND PHARMACEUTICAL WASTES"	Plastic bag or container
Radioactive wastes	Red, marked "RADIOACTIVE WASTES"	Lead box, labelled with radioactive symbol
GENERAL WASTES:		
General health-care waste	Black	Plastic bag

For smaller health establishments such as nursing stations, the segregation and colour-coding systems are summarised in Table 5.

Table 5: Segregation and Colour Coding For Health-care wastes in Smaller Health Establishment (eg. Nursing Stations)

Designation	**Infectious Waste Container**	**Sharps Container**	**General Waste Bag**
Type of receptacle	Container or plastic bags in a holder	Sealable box or drum, or cardboard	Plastic bag or container
Colour	Yellow, marked "INFECTIOUS WASTES"	Yellow, marked "SHARPS"	Black
Characteristics	Leak proof, suitable for autoclaving	Puncture-proof and leak proof	No special requirements
Waste categories	Infectious non-sharp wastes	Sharps	Waste similar to municipal wastes, not contaminated by hazardous or infectious substances

16.2 Sharps Containers

Containers for the disposable of used needles and sharp instruments are manufactured and supplied in a wide range of sizes. They are made from plastics or fibreboard materials (with plastic lining) or can be of composite construction, having fibreboard sides with a metal base or top.

There is no limitation on the size of containers. Different sizes of containers may be considered, say 2.5, 6, 12 and 20 litres. The larger containers should be used in areas where the amounts of sharps produced are high. In addition there have wider aperture, allowing insertion of large items without the need to force items through the aperture with the consequent risk of injury. The smaller containers are suitable for low volume areas where frequent disposal of partially filled container is unacceptable.

Sharps should be collected altogether, regardless of whether or not they are contaminated.

The following design features should be considered into the specifications for sharp containers:

- Be rigid, puncture resistance and leak proof (usually made of metal or high-density plastics), even if they topple over or are dropped.
- Be capable of being handled and moved while in use with minimal danger of the contents spilling or falling out.
- Be provided with handle(s) that is not part of any closure device. The position of the handle must not interfere with the normal use of the container.
- Be provided with an aperture, which under normal conditions of use, will inhibit removal of contents.
- Have a closure device attached for sealing when three quarter full or ready for disposal. The container shall be capable of being securely closed and remain closed during normal transport.
- Have a horizontal line to indicate when container is ¾ full, and marked with the words **“WARNING – DO NOT FILL ABOVE THE LINE”**.
- Be made of materials, which can be incinerated, if incineration is the selected option for the treatment or disposal of sharps for the health-care institution.
- Be coloured **YELLOW**.
- Be clearly marked with the words **“SHARPS ONLY”**.

- Be clearly marked with international symbol for **"BIOLOGICAL HAZARDS"** as shown in **Figure 2.**
- An appropriate specification for the disposal sharps containers is given in British Standard 7320:1990.

16.3 Infectious and Pathological Wastes Containers

Bags and containers for infectious wastes should be marked with the international infectious substance symbol.

Highly infectious waste should, whenever possible, be sterilized immediately by autoclaving. It therefore needs to be packaged in bags that are compatible with the proposed treatment process: yellow bags, suitable for autoclaving, are recommended.

Cytotoxic waste should be collected in strong, leak-proof containers clearly labelled **"CYTOTOXIC WASTES"**.

The following design features should be considered into specifications of infectious waste containers:

- Be of a maximum nominal capacity of 0.1 m^3.
- Be of a minimum gauge of 225 (55 microns) if of low density, or minimum gauge 100 (25 microns) if of high density, or of equivalent standard of containment.
- Be able to match the chosen container or fitting in use.
- Where practicable, the identification of the health-care establishment should be clearly marked.
- In areas where wastes produced are low, smaller sizes of yellow bags may be considered.
- An appropriate specification for disposable plastic bags made from polyethylene is given in British Standard 6642:1985.

16.4 General Health-care waste Containers

All general ie. non hazardous wastes should be handled in the same manner as domestic refuse and collected in black bag.

Should join the domestic refuse stream for disposal.

16.5 Chemical and Pharmaceutical Waste Containers

Small amounts of chemical or pharmaceutical waste may be collected together with infectious waste.

Large quantities of obsolete or expired pharmaceuticals stored in hospital wards or departments should be returned to the pharmacy for disposal. Other pharmaceutical waste generated at this level, such as spilled or contaminated drugs or packaging containing drug residues should not be returned because of the risk of contaminating the pharmacy; it should be deposited in the correct container at the point of production.

Large quantities of chemical wastes should be packed in chemical-resistant containers and sent to specialised treatment facilities. The identity of the chemicals should be clearly marked on the containers; hazardous chemical wastes of different types should never be mixed.

Waste with a high content of heavy metals (eg. cadmium or mercury) should be collected separately.

Low level radioactive infectious wastes (eg. swabs, syringes for diagnostic or therapeutic use) may be collected in yellow bags or containers for infectious waste if these are destined for incineration.

16.6 Labelling

16.6.1 Types of Label

All bags must be identified as to the point of production of the waste contained therein. Should any problem arise, such as spillage of the contents or sharp items put into a plastic bag, the source can be readily identified and remedial action taken.

Labelling can be undertaken in a number of ways:

- Writing the information on the bag.
- Using pre-printed tape.
- Using pre-printed self adhesive address labels supplied on a peel-off roll.

- Tie on tag labels, which need the information written on them

16.6.2 Proposed Label for PAPUA NEW GUINEA

The label proposed for identification of bags and containers is shown in **Figure 1**.

DATE OF PACKAGING:_____		
NAME OF HEALTH-CARE ESTABLISHMENT **Tel No: _____Name of Health-care Waste Officer:_____**		
Category of Wastes (Please Tick One Only):	**SYMBOL**	**PLEASE TICK**
• Infectious and pathological wastes.		
• Sharps.		
• Pharmaceutical Wastes.		
• Genotoxic Wastes.		
• Chemical Wastes.		
• Waste with High Content of Heavy Metals.		
• Pressurised Containers.		
• Radioactive Wastes.		
Waste Quantity:_____kg ; Waste Destination:_____		

Figure 1: Label of Health-care Waste Bags or Containers

16.6.3 Symbols

The label used on health-care waste should also have symbol to ensure that the systems followed in PAPUA NEW GUINEA are in consistent with the international standard. **Figure 2** provides the symbol that can be used to identify the different types of health-care waste in Papua New Guinea. These are also the United Nations packaging symbols.

16.7 Manual Handling of Health-care waste Bags and Sharps Containers

People who repeatedly move health-care wastes from receptacles (yellow bags) to large containers (eg. wheeled trolleys or waste collection vehicles) may become complacent with what becomes a routine activity.

The risk of injury is therefore increased for those staff who handle waste in large quantities within relatively short time periods when loading such containers.

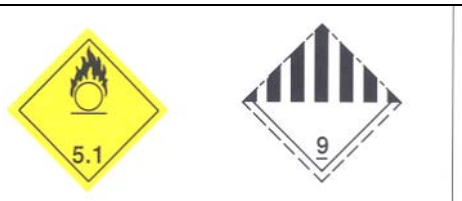
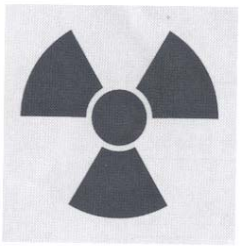
Category of Waste	Symbol
• Infectious and pathological wastes.	
• Sharps.	
• Pharmaceutical Wastes.	
• Genotoxic Wastes.	
• Chemical Wastes.	 or
• Waste with High Content of Heavy Metals.	No symbol
• Pressurised Containers.	No symbol
• Radioactive Wastes.	

Figure 3: Symbols to be used with the label of Health-care Waste Bags or Containers

Staff who handle health-care waste bags and containers should be **TRAINED** to be aware of the following:

- First check that waste storage bags and containers are effectively sealed.
- Ensure that the origin of the waste is marked on the waste bag or container.
- Bags should be picked up by the neck only and placed so that they can be picked up by the neck again for further handling. Manual handling of the waste bags should be minimised wherever possible. This is the main source of needlestick injuries.
- Bags should not be clasped against the body nor should collection staff attempt to carry too many at a time.
- Try to avoid the bag hitting the body when being carried. The hazard most likely to endanger health is a needle-stick injury. Hypodermic needles which are not properly segregated into correct sharps containers can cause this type of injury.
- Sharps have been known to pierce the sides and bottoms of polypropylene containers. These containers should be picked up and carried by the handle provided. The other hand should not be used to support the bottom of the container.
- Ensure that Health-care and domestic waste bags are not mixed and that bags and containers are to be kept only in specified storage areas (not to be left in open spaces).
- Know the appropriate cleaning and disinfection procedures in case of accidental spillage and how to report an accident.

16.8 Collection of Health-care Wastes

Health-care waste bags should be removed **DAILY** from wards and departments or, as frequently as circumstances demand.

As part of written procedures, no bags should be removed unless properly identified, and secured to prevent spillage.

Sealed sharps containers should be placed in a labelled yellow health-care waste bag before removal from the ward/department.

Hospital attendants or ancillary workers must collect health-care wastes in closed yellow bags and store the bags in a designated central storage area within the hospital. It is the duty of hospital attendants or ancillary workers to immediately replace the bags with new uncontaminated bags.

Under no circumstances shall yellow bags be replaced by black bags.

Bag holders should be clearly identified in the wards and departments as either Health-care or non-Health-care.

A stock of both bags must be held in each department.

16.9 Transport of Waste Inside the Health-Care Establishment

To minimise the passage of waste through patient care areas and other clean areas, waste routes should be designated in the health-care establishment between the primary storage areas in the wards and departments, and the central storage area.

Dedicated wheeled containers, trolleys or carts should be used to transport the waste containers to the main storage area. These vehicles should be reserved solely for the transport of Health-care waste. They should be thoroughly cleaned and disinfected immediately following spillage.

Wheeled containers, trolleys or carts used for transferring health-care wastes within health-care establishments should be designed and constructed so that:

- They do not have sharp edges that could tear open waste bags during loading and unloading.
- They should contain any leakage from damaged waste bags.
- They can easily be cleaned, disinfected and drained.
- The waste may be easily loaded, secured and unloaded.

16.10 Central Storage Area

Health-care waste bags will need to be stored either immediately prior to treatment on-site or prior to transport for treatment and disposal off-site.

Health-care waste storage areas must be sited separately from the general waste storage areas and should be clearly identifiable (with clear warning signs) as for health-care wastes only. These areas should be locked when access is not required; however hospital attendants and ancillary staff must have access to the key throughout the 24 hour period.

Storage areas should be accessible only to authorised persons.

16.10.1 Location

The central health-care waste storage area should be covered and sited, where possible, to minimise the movement of waste in the open from initial storage area. It should be sited away from food preparation, public access and egress routes. It needs to be easily accessible to internal transport, and off-site transport where wastes are disposed of elsewhere.

The central health-care waste storage area should be sited on well-drained, impervious hard-standing. It should be well lit and well ventilated and should be kept secure from entry by animals and free from infestations by rodents or insects.

16.10.2 Facilities

Washing facilities should be available at the storage site for employees. Protective equipment and materials for dealing with spillage should be provided at the storage area. Facilities for washing down and disinfection of the storage area should be provided.

All wastes from the cleaning process should be discharged to the sewer.

16.10.3 Storage Capacity

Sufficient storage capacity should be provided to allow for the proposed frequency of collection and should take into account public holidays. In any case, waste storage areas should have a minimum capacity of 2 days storage. This storage is for contingency purposes only. Wherever possible, health-care wastes should be removed daily from the central storage area for disposal.

Storage of Small Amounts of Health-care wastes

At places other than hospitals, where waste accumulations in small quantities daily, provided the waste is sealed in suitable bags, they may be stored until collection is due. The interval between collections should be as short as reasonably practicable and, in any case, not in excess of one week.

16.11 Handling and Storage of Special Health-care wastes

16.11.1 Handling of Cytotoxic Wastes

A staff (eg. the hospital pharmacist) should be appointed to be responsible for safety arrangements for the use of cytotoxic drugs in the hospital. He or she should produce suitable written procedures specifying safe working methods to cover each process, which is being carried out within each affected employee's sphere of responsibility. Information on possible hazards associated with the materials should be included, taken directly from data sheets provided by the respective drug manufacturer. The documents should also cater for the respective drug manufacturer. The documents should also cater for emergency action, for example in the event of spillage in a non-designated area.

Only persons who have been trained and nominated under the foregoing arrangements should be employed in handling or administering cytotoxic drugs, insofar as this is compatible with the need to respond to Health-care emergencies.

In view of the potential harm, which could result from handling cytotoxic materials, wastes containing cytotoxic drugs are required to be segregated from other wastes. Under no circumstances should a waste contractor be expected to open waste containers to examine their contents.

Cytotoxic wastes and associated contaminated materials (e.g. swabs, tubings, contaminated towels, etc.) should be placed in yellow bags. Sharp objects contaminated with cytotoxics, such as glass fragments, empty vials, ampoules, syringes and needles, must be placed in designated cytotoxic sharps containers. Yellow Health-care waste bags for cytotoxic waste should comply with the specification outlined in **Section 5.2**. Cytotoxic sharps containers should comply with the specification outlined in **Section 5.3**. Yellow bags and sharps containers for cytotoxic wastes should be marked with the words **"CYTOTOXIC WASTE".**

To cater for accidental spills, adequate supplies of suitable absorbent and cleansing materials should be readily available in the area of constitution or administration of cytotoxic drugs. The resultant wastes should be treated as cytotoxic wastes. An absorbent material (paper towel or absorbent granules) may be placed at the bottom of the waste container to absorb excess fluid.

16.11.2 Storage of Radioactive Wastes

Since the half-life of most radioactive materials used in hospitals is in the range of hours or days, storage for a period of one or two months can be followed by disposal to the ordinary waste system with appropriate monitoring. If the waste is to be disposed of with general waste to a landfill site, it must be placed inside a black plastic bag. Yellow bags must not be sent to a landfill site.

All radioactive waste designated for storage to allow decay, should be kept in suitable containers which prevent any dispersion of the contents. A plastic bag in a large can or drum is an appropriate container. Containers of radioactive waste, other than low-level waste for disposal by the local authority (i.e. in black bags), should be clearly labelled to show the radionuclide(s), activity on a given date and period of storage required.

Red bags and sharps containers for radioactive waste should comply with the specification outlined in **Section 5.2** and **Section 6.3**, respectively. However, they should be marked **"RADIOACTIVE WASTE"** and should carry the radiation symbol, as shown in **Figure 3.**

Containers of radioactive waste should be stored either in a specifically marked area in a general store for radioactive substances or, in a store reserved for radioactive waste. The storage record should be endorsed specifically to indicate the items, which are **"radioactive waste"**.

17.0 GUIDELINES FOR THE DISPOSAL OF HEALTH-CARE WASTE

17.1 On-Site Versus Off-site Disposal

Treatment and disposal methods commonly used for health-care wastes include:

- Incineration.

- Sterilisation/disinfection such as wet thermal disinfection, autoclaving, chemical disinfection, microwave irradiation.
- Landfill.
- Discharge to sewers.

The sterilization or disinfection of small quantities of highly infectious waste (e.g. microbial cultures) is usually carried out, as a pre-treatment before disposal, near the source of the waste within the healthcare establishments. The other disposal methods such as incineration, landfilling, discharge to sewers, wet- thermal treatment and microwave irradiation can be carried out on-site or off-site. For example, waste can be incinerated within the premises of a healthcare establishment or at a regional or centralized incineration plant, including a municipal waste incinerator. Similarly, solid waste could be buried on-site or transported to an off-site, usually to a municipal landfill. Aqueous waste can be discharged to the public sewer or to an on-site treatment facility. Large-scale wet-thermal disinfection equipment and micro- wave irradiation equipment may be installed on-site or at a regional facility.

Off-site disposal options such as using a municipal waste incinerator, landfill and public sewerage system will not be possible if there are no such off-site facilities within a reasonable distance. Even if such an off-site facility exists, the option may cause a high health risk if the off-site facility is not adequately operated (e.g. open-dumping and waste scavenging at municipal landfills).

Various combinations of on-site and off-site treatment and disposal options may be possible, and should be evaluated in terms of their costs and health risks. Details of the various methods employed to treat and dispose of the different categories of health-care waste are given in **Section 6.0.** Some methods are technically preferred to others, although the preferred methods may not be financially feasible.

Guidelines for the disposal of the various types of health-care wastes are elaborated **Sections 6.2 to 6.6**. **Section 7.2** assumes that incineration facilities are available or have been selected as the main disposal method for Health-care waste.

Disposal by the landfill method can be considered only when an incinerator is not available and even so, this has to be carried out under strict supervision.

17.2 Disposal of Infectious and Pathological Wastes

17.2.1 Infectious or Pathological Wastes Required Autoclaving (Optional)

This section provides the disposal of the following wastes:

- Soiled surgical dressings, cotton wool, gloves, swabs, and all other contaminated waste from treatment areas; plasters and bandaging which have come into contact with blood or wounds; cloths and wiping materials used to clear-up body fluids and spills of blood.
- Material other than reusable linen, from cases of infectious disease (eg. human biopsy materials, blood, urine, stools).
- Pathological wastes, including all human tissues (whether infected or not), organs, limbs, body parts, placenta and human fetuses; animal carcasses and tissues from laboratories and all related swabs and dressings.

These wastes should be placed in yellow waste bags in bag holders at the point of generation. Bags containing these wastes should be replaced daily or when three quarters full. They should be sealed either with a string or plastic tie or, in the case of light gauge bags, by tying off the neck. Yellow bags should be labelled with the name of the health-care establishment and the department concerned clearly identified on it.

Materials from cases of infectious disease should be made safe to handle (by autoclaving or other equivalent treatment) before disposal by incineration.

In a situation where autoclaving or other equivalent treatment systems are not available, these wastes shall be disposed by direct incineration.

17.2.2 Sharps

This section provides the disposal of the following wastes:

- Discarded syringes.
- Needles.
- Cartridges.

- Broken glass.
- Scalpel blades.
- Saws and other sharp instruments that could cause a cut or puncture.

Sharps should never be placed in receptacles used for the storage of other wastes. They should be placed, as soon as possible after use, in a safe manner into properly constructed sharps containers.

The containers shall be seepage proof under normal conditions so that they can be handled by staff with minimum danger of injury from the contents by cutting, puncturing or contamination. The aperture to the container should inhibit the removal of its contents and be easily and effectively closed and sealed when the container is ready for disposal. The container should be capable of being handled and moved while still in use with minimal danger of the contents spilling or falling out. The container itself should be capable of incineration and should be of yellow colour.

Syringes, cartridges and needles should be disposed of intact. Disposable needles should not be removed from syringes or other appliances after use, nor should they be recapped after use. However, removal of needles from syringes may be necessary in some circumstances, such as during the collection of blood samples. In these instances, care should be taken during the removal.

Sharps containers should be sealed when three quarters full. Care should be taken not to overfill or compress the contents. The scaled containers should be placed in a labelled, yellow Health-care waste bag before removal from the source.

17.2.3 Infectious and Pathological Wastes that Do Not Require Autoclaving or Pretreatment

These include:

- Used disposable bed-pan liners.
- Urine containers.
- Incontinence pads.
- Stoma bags.

- Health-care waste produced from laboratories (eg. pathology, haematology and blood transfusion, microbiology, histology).
- Post mortem wastes.
- Other than wastes that require autoclaving or pretreatment.

Health-care waste arising from laboratories (e.g. pathology, haematology and blood transfusion, microbiology, histology) and post mortem room waste should be disposed of by incineration. The waste should be secured in Health-care waste bags or sharps containers, which should be labelled, and transported to a Health-care waste incineration facility.

Health-care or laboratory staff should ensure that highly infectious wastes such as cultures and stocks of infectious agents from laboratory work should be made safe by autoclaving (or equivalent treatment) before leaving the laboratory for disposal by incineration. Bags or containers for waste destined for autoclaving (or equivalent treatment) should be made of a material suitable for this purpose. After autoclaving (or equivalent treatment) these waste should be placed in the yellow Health-care waste bags or sharps containers by the Health-care or nursing staff. Hospital attendants and ancillary workers should not handle these wastes until they are placed and sealed in a yellow bag.

17.3 Pharmaceutical and Cytotoxic Wastes

These include:

- Pharmaceutical wastes such as expired drugs, vaccines and sera, including expired drugs that have been returned from wards, drugs that have been spilled or contaminated, or are to be discarded because they are no longer required.
- Cytotoxic wastes that include expired cytotoxic drugs and materials (eg. swabs, tubings, towels, sharps) contaminated with cytotoxic substances during the preparation, transportation and administration of cytotoxic drug therapy.
- Cytotoxic drugs are also known as anti-neoplastic drugs or cancer chemotherapy drugs. The names refer to a category of drugs which have the ability to kill or arrest the growth of living cells. They play an important part in the therapy of various neoplastic conditions but are also finding a wider roles as immuno-suppressive drugs in transplantation and in treating various diseases with an immunological basis. Cytotoxic drugs are most often used in specialist units such as oncology and

radiotherapy unit whose main work is the treatment of cancer. However, there is a significant and increasing usage in other wards and departments of hospitals.

Pharmaceutical Wastes

A staff of the pharmacy in the healthcare establishment should be responsible for the disposal of all obsolete or expired medicines. Large quantities of obsolete or expired medicines stored in the wards must also be returned to the pharmacy for disposal. However, other pharmaceutical waste generated at ward level, such as drugs that have been spilled or contaminated should not be returned to the hospital pharmacy. This is to prevent any unnecessary contamination at the pharmacy.

Incineration is the preferred disposal route for solid medicines (e.g. tablets and capsules) and injectables, vaccines and sera, except where manufacturer's advice differs. Small quantities of tablets or capsules (say, up to 500 tablets or capsules) and other liquid medicinal products may be disposed of by flushing into the sewer. Large consignments can be flushed into the sewerage system over a period of two to three days. In cases involving medicines which may affect the microbiological flora of the sewage treatment process, incineration is still the preferred disposal route. Under no circumstances should pharmaceutical waste be disposed of down surface water drains, such as road and rainwater drains.

Where large quantities of solid pharmaceutical wastes are to be disposed of, eg. as a result of closing down a pharmacy, materials suitably bagged should be taken to an incineration plant. No large amount of pharmaceuticals or chemicals should be discharged to sewers and none should be placed in a dustbin for removal or taken to a household waste disposal site. Disposal by the landfill method can be considered only when an incinerator is not available and even so, this has to be carried out under strict supervision.

Cytotoxic Wastes

The most effective disposal method for cytotoxic waste is incineration at a high temperature. The temperature in the secondary combustion chamber should be at a minimum of 1000^{o}C for the duration of the burn **<see Section 7.1.5>**. An after-burner (i.e. the secondary chamber) is important for the destruction of cytotoxic waste, as there

is a possibility of a cytotoxic solution being aerosolized, following combustion in the primary chamber. As a result, undegraded cytotoxic material may be emitted from the chimney. The secondary combustion chamber ensures that such cytotoxic substances are destroyed.- The temperatures attained by most modem purpose-built incinerators are sufficient to meet the current recommendations of the manufacturers of each of the 25 licensed cytotoxic drugs widely used (**see Table 3**).

Table 3: Recommended Minimum Temperature for the Destruction of Cytotoxic Drugs

Drug	Destruction Temperature (^{o}C)
Asparaginase	800
Bleomycin	1000
Carboplatin	1000
Carmustine	800
Cisplatin	800
Cyclophosphamide	900
Cytarabine	1000
Dacarbazine	500
Dactinomycin	800
Daunorubicin	700
Doxorubicin	700
Epirubicin	700
Etoposide	1000
Fluorouracil	700
Idarubicin	700
Melphalan	500
Methotrexate	1000
Mithramycin	1000
Mitomycin C	500
Mitozantrone	800
Mustine	800
Thiotepa	800
Vinblastine	1000
Vincristine	1000
Vindesine	1000

In the absence of a suitable incinerator in the health-care establishment, the services of a specialist waste disposal contractor should be employed. If an appropriate incineration service is not available, chemical decomposition should be carried out in accordance with the manufacturer's recommendation. However, chemical inactivation is tedious and time consuming. Moreover, stocks of treatment chemicals must be made available at all times.

Where possible, cytotoxic wastes should be collected on a regular basis and transported to regional incinerators for incineration.

17.4 Disposal of Radioactive Wastes

17.4.1 Options for Disposal

Most radioactive wastes generated in healthcare establishments are low level activity and can be disposed of by landfill, incineration or discharge to sewers, depending on the nature of the waste.

Generally, low level radioactive waste containing no alpha-emitters and no ^{90}Sr may be disposed of:

- by landfill together with refuse, provided that in any container at the time of disposal the activity is not greater than 10 microcuries (370 kBq), that the activity of any article is not greater than 1 microcurie (37 kBq), and that the volume of refuse is not less than 0. $1m^3$.
- by incineration, provided that the activity burnt is not greater than 30 microcuries (1.1 MBq) in any day and that the residual ash from burnt waste is disposed of as for other solid waste, i.e. so that the activity in any 0.1 m^3 of other solid non-radioactive waste does not exceed 10 microcuries (370 kBq),
- by discharge to a sewerage system, provided that in any four consecutive weeks the activity does not exceed 10 millicuries (370 MBq) if the system connects to a public sewer or 2 millicuries (74 MBq) if it does not.

17.4.2 Disposal of Solid Radioactive Waste

Solid waste, such as contaminated paper tissues, swabs, glassware, and similar materials, where the activity does not exceed 37 kBq per article, may be disposed of with an appropriate volume of ordinary refuse.

Disposal hypodermic syringes should be emptied at a place designated for the disposal of liquid waste and then stored in sharps container to allow decay, if necessary, of any residual activity. Normal arrangement for disposal of syringes and needles may then be used.

Combustible waste contaminated with radionuclides other than ^{90}Sr or alpha emitters can be burned in an incinerator. Incineration is particularly useful for disposal of low-level radioactive waste which might give rise to a biological hazard. The waste should be placed in yellow Health-care waste bags. Care should be exercised when disposing of non-volatile radionuclides in this way since they will concentrate in the ash which is normally disposed of by landfill to which activity limits apply **<,see Section 6.4.1)>.**

17.4.3 Disposal of Liquid Radioactive Wastes

Liquid waste of low activity arising from the dispensing and making up of solutions for hospital use, or from the washing of apparatus should be disposed of immediately to the sewer. Liquids which are immiscible with water, such as scintillation counting residues, should not be disposed of in this manner; alternative methods of disposal, such as incineration, should be used. Contaminated oil should be placed in marked drums and disposed of by an authorized waste management organization.

If higher level radioactive material (e.g. therapy doses of ^{131}I)**,** is left over or unused and if the solution is in a readily manageable form and of sufficiently short half-life to render storage for decay convenient, then they should be stored until their activity permits disposal to the sewer via designated sinks.

The drains serving these designated sinks should be identified; if repairs are necessary, measurements of radiation levels should be made as the drain/sewer is opened up and appropriate precautions taken.

Radioactive waste resulting from the cleaning-up operations after a spill or other accident should be retained in suitable containers, unless it is clear that the activity is low enough to permit immediate disposal. If excessive activity enters the sewer accidentally, a large volume of water should be allowed to flow to provide dilution to 1000 Bq I^{-1}. The relevant government agency should be informed as a matter of urgency, preferably by telephone, if radioactive waste, in excess of the amounts permitted by an authorisation, has been discharged to sewers, atmosphere or the general environment. After the immediate emergency is over, the activity of the resulting waste should be assessed and the relevant government agency should be informed in writing of the circumstances surrounding the incident.

It is not usually necessary to collect and **confine** patient's waste. Excreta from hospital patients containing unsealed radioactive substances should **normally** be discharged to the sewer.

17.4.4 Disposal of Gaseous Radioactive Wastes

Radioactive gases, such as ^{113} Xe used in diagnostic tests, should be discharged directly to the outside so as to be dispersed in the atmosphere. In general, all gaseous wastes including exhausts from stores and fume cupboards should be discharged in such a manner as to prevent re-entry into any part of the premises. It is important, therefore, that the points of release to the atmosphere should be carefully sited. Radiation and contamination levels near discharge points should be checked periodically by the staff responsible for radiation protection. Atmospheric dilution will be safe if the resulting activity in the atmosphere is compatible with the WHO air quality guideline value of 1 Bq per cubic metre.

17.4.5 Disposal of High Level Radioactive Wastes

The type, form and level of radioactive material used in healthcare establishments results usually only in low-level radioactive waste (lower than 1 Megabecquerel, MBq). With proper handling, almost all radioactive waste generated in health-care establishments can be disposed of through the normal waste disposal channels. However, the disposal of very high level radioactive waste from certain hospitals and research laboratories should be carried out by the relevant government agency. Such waste are normally retained at a permanent storage or burial site. This method of disposal is unnecessary for most healthcare establishments.

17.5 Disposal of Chemical Wastes

17.5.1 Non-Hazardous Chemical Wastes

These may be sub-divided into wastes which can be recycled and those which cannot. Recyclable wastes should be packaged, labelled and stored according to their compatibility, awaiting despatch to the recycling operation. Both recyclable and non-recyclable wastes should be put into leak-proof containers which should be labelled to readily identify their contents.

Non-recyclable, non-hazardous chemical waste may be disposed of along with general waste.

17.5.2 Hazardous Chemical Wastes

Special measures are required for dealing with chemical wastes of a hazardous nature. Whenever it is feasible and economic to do so, hazardous chemicals should be recycled. In determining the economic viability of recycling, the costs of alternative disposal methods should also be taken into account rather than just the cost of the recycling process and the value of the reclaimed material.

Hazardous chemical waste which cannot be recycled for either technical or economic reasons must be disposed of by the most appropriate means according to the nature of the hazard presented by the waste. Any waste which cannot be incinerated must be handled and disposed of by an authorized hazardous waste management organization. Where the quantity of such waste produced is small, the development of a regional cooperative collection and disposal system is advisable and may provide an economic disposal option.

Hazardous chemical waste should be stored in leak-proof containers and labelled to identify the contents. Because it often has toxic or flammable properties, hazardous chemical waste should not be disposed of in the sewer system.

17.5.3 Disposal of Pressurised Containers

Pressurised containers, such as aerosol cans, should be collected as and when and where they arise and placed in black non-Health-care waste bags and disposed of together with general waste. These should not be placed in yellow bags destined for incineration.

Although the incineration of Health-care waste contaminated with isolated aerosol cans will not present a major hazard since modern incinerators are designed to withstand minor explosions caused by disposable aerosol cans, it should be noted that, under no circumstances must compressed gas cylinders for industrial or commercial use be incinerated manufacturers.

17.6 Disposal of General Wastes

General waste is not considered hazardous in a Health-care sense and it is not necessary, therefore, to incinerate it. These wastes should be placed in black plastic bags and disposed of as any other household/domestic waste.

The collection of general waste should be arranged at a frequency which will be determined in cooperation with the local waste disposal authority or private contractor and will be dependent on the extent of waste generation as well as storage bin capacity. It is preferable that all general waste are collected daily from health related institutions.

When ordinary domestic waste is generated in premises where Health-care waste arises, separate arrangements must be made for storage, collection, transportation and disposal of these wastes. There should never be any possibility of Health-care waste being mixed with the domestic waste stream. A mixture of Health-care and domestic waste must be treated as "Health-care" waste and disposed of accordingly.

18.0 TREATMENT OF HEALTH-CARE WASTES

18.1 Incineration

Incineration is a dry oxidation process which reduces organic and combustible waste into inorganic incombustible matter at high temperature. The process is usually selected to treat wastes which cannot be recycled, reused or dumped in a landfill site.

Advantages and Disadvantages of Incineration

Incineration of health-care wastes provides the following advantages:

- Reduction in the mass and volume of wastes.
- Destruction of infectious organisms (pathogens) in infectious wastes.
- Destruction of pathological wastes (eg. human organs, body parts, animal carcasses) which are considered aesthetically objectionable.

In addition, a purpose-built high temperature incinerator with flue gas cleaning can destroy hazardous chemical waste (e.g. cytotoxic, pharmaceutical and chemical wastes) to an acceptable level.

For these reasons, incineration by a purpose-built and properly managed high temperature incinerator is considered to be an effective method for the safe disposal of infectious and other hazardous health-care wastes.

However, incineration has some drawbacks, including:

- High cost of construction, operation and maintenance, particularly of a purpose-built high temperature incinerator.
- Requirement of skilled operators.
- Emission of hazardous air pollutants if the incinerator is not properly designed or operated

18.1.1 Types of Incinerators

Incineration may be classified into:

- Open burning.
- Single combustion.
- Two combustion chambers with secondary chamber designed to operate at a temperature of about 800^{o}C to 1000 ^{o}C and a gas residence time of 0.5 to 1.0 second, without flue gas cleaning.
- Two combustion chambers, with the secondary chamber designed to operate at a temperature of over 1000 ^{o}C and a gas residence time of at least 2.0 seconds, and with flue gas cleaning.

The cost and requirement for skilled operators increase from open burning to an incinerator with two combustion chambers. Some representative cost figures of different sizes, types of equipment and modes of operation for waste incinerators surveyed in Malaysia are shown in **Table 4** as a guide. The increase is sharp from an incinerator with a single combustion chamber to an incinerator with two combustion chambers and from an incinerator without gas cleaning to an incinerator with gas cleaning.

Table 4: Costs of Health-care Waste Incinerators

Capacity	Equipment/Operation	Estimated Cost
50 kg/day	Without flue gas cleaning manual loading. One combustion chamber. Manual de-ashing	USD20,000
200 kg/day	Without flue gas cleaning. Manual loading Two combustion chambers (1) Manual de-ashing.	USD150,000
800 kg/day	Without flue gas cleaning Mechanical loading Two combustion chambers (1) Manual de-ashing	USD400,000
7200 kg/day (300 kg/hr for 24 hours/day)	With flue gas cleaning. With emission monitoring. Automatic loading (2) Two combustion chambers (3) Waste heat recovery. Automatic de-ashing	USD2,000,000

Notes:

1. Primary and secondary combustion chambers, with secondary combustion chambers designed to operate at a temperature up to 1,000 oC and a gas residence time up to 1 second.
2. Automatic loading device, consisting of a waste container hoist, a feed hopper and a ram feeder.
3. Primary and secondary combustion chambers, with the secondary combustion chambers designed to operate at a temperature in excess of 1000 oC and a gas residence time in excess of two seconds.

18.1.2 Open Burning

Open burning should be avoided as much as possible because the control of air pollution is difficult, if not impossible.

It must not be carried out in heavily urbanized areas. However, if there is no other alternative to dispose of infectious waste, open burning can be permitted for non-plastic infectious waste.

The location of such open burning should be as far as possible from, and downwind of, the healthcare establishment and potentially affected communities.

An enclosure structure may be required to minimize fire hazards to the surrounding areas. While burning, the site must be attended by an operator, and as soon as the burning is

finished, the operator should ensure that the fire is completely extinguished and ash is properly disposed of (e.g. by applying soil cover).

18.1.3 Single Chamber Incinerator

A single chamber incinerator may be a mechanical "oven-type" incinerator or a "brick-type" incinerator.

Combustion in a single chamber incinerator is initiated by the addition of fuel oil or kerosene, and is then allowed to continue to bum on its own.

Air flow is usually based on natural ventilation from the air intake opening to the chimney, although some incinerators may have mechanical ventilation.

Loading and emptying of ash operations are performed manually. Atmospheric emissions will usually include acid gases such as S02, HCI, HF and black smoke, fly ash, carbon monoxide, nitrogen oxide, heavy metals and volatile organic chemicals. To limit these emissions, pollution sources should be excluded from the waste to be incinerated, whenever possible. Therefore, the types of waste which can be safely burnt are limited for a single chamber incinerator. Hazardous chemical and cytotoxic wastes cannot be safely burnt with this type of incinerator.

The combustion of plastic waste, contaminated or uncontaminated, by a single chamber incinerator is not recommended, unless the quantity is very small. Therefore, only non-plastic waste (e.g. contaminated paper, cloth) can be safely incinerated by a single chamber incinerator.

18.1.4 Double Chamber Incinerator Without Gas Cleaning

A commonly used health-care waste incinerator is the double chamber incinerator. The waste is thermally decomposed in the first combustion chamber, producing solid ashes and gases. A fuel burner is used to start the process in the first combustion chamber. The gases produced in the first chamber are burnt in the second (or post-combustion) chamber at about 8000C to I000 ^{o}C, by a fuel burner and with excess of air to minimise smoke and odours. The gas residence time in the second combustion chamber is about 0.5 to 1.0 second.

Small-scale incinerators used inside healthcare establishments (of a capacity between 50 and 1000 kg /day), operate on demand and are loaded and emptying of ash manually each day.

Larger incinerators for regional facilities (capacities in excess of 1.0 ton/day) are usually design to function on a continuous basis, with automated loading of waste, removal of ashes and the internal movement of the burning waste. These incinerators need to be operated and monitored by well trained technicians.

18.1.5 Double Chamber, High Temperature Incinerator With Gas Cleaning

The proper control of hazardous pollutant emissions from the combustion of hazardous chemical, cytotoxic and plastic (particularly chlorinated plastic) wastes requires a secondary combustion chamber designed to operate at a high temperature (over 1000 ^{o}C) and a gas residence time of at least two seconds, with flue gas cleaning.

If these wastes are to be incinerated, but the design of the incinerator does not meet the above requirements, or the incinerator is not operated under the specified conditions, then hazardous air pollutants will be emitted.

The most appropriate type of incinerator for treating hazardous healthcare waste is the double chamber, high temperature incinerator with flue gas cleaning.

The design of the incinerator may be that of a fixed hearth type (i.e. static combustion chambers), or a rotary kiln type (i.e. rotating combustion chamber followed by a static post combustion chamber).

The post-combustion chamber is operated at a temperature of not less than 1000 ^{o}C and a gas residence time of not less than 2.0 seconds.

18.1.6 Environmental Control Technology for Incinerators

Incinerator emissions should comply with the national standards. In case the relevant authorities have not established such standards, they may refer to foreign models such as

the European or the American standards. An example of the standards for incinerator emissions in the European Union is show in **Table 5**

Table 5: Standards for incinerator emissions in the European Union

Substance	Daily Average (mg/Nm3)	Hourly Average (mg/Nm3)	4 hours Average (mg/Nm3)
Total dust	5	10	-
Total organic carbon	5	10	-
Chlorine compounds	5	10	-
Fluorine compounds	1	2	-
Sulphur oxides as SO2	25	50	-
Nitrogen oxides as NO2	100	200	-
Carbon monoxide	50	100	-
Mercury	-	-	0.05
Cadmium and thallium	-	-	0.05
Lead, chromium, copper, and Manganese	-	-	0.5
Nickel and arsenic	-	-	0.5
Antimony, cobalt, vanadium and tin	-	-	0.5
Dioxins and furans	-	-	0.1
Oxygen content	At least 6 % at any moment		

Flue gas from incinerators consist of fly ash, which may contain heavy metals, dioxins, furans, thermally resistant organic compounds, etc., and gases such as nitrogen oxides, sulfur oxides, carbon oxides and halogenated acids.

At least two different treatments are needed to clean the flue gas, i.e. a de-dusting unit to remove most of the fly ash, followed by a gas washing unit to remove halogenated acids and sulfur oxides with alkaline substances.

Before entering the de-dusting unit, the temperature of the flue gas coming out of the post- combustion chamber has to be reduced to about 300 ^{o}C, usually in heat exchangers or cooling towers.

18.1.7 Dust Removal

The most common types of dust removals used in incinerators are cyclone scrubbers, fabric baghouse, electrostatic precipitators and ceramic filters.

- Cyclone scrubbers are static devices in which gases circulate in spiral movements and centrifugal forces separate the particulate matter.
- However, the efficiency for removing very small particulate matter of diameter below 15 micrometer is low.
- Therefore, cyclone scrubbers constitute only a preliminary dust removal and are usually followed by an electrostatic precipitator or ceramic filter unit.
- Fabric baghouse are widely used.
    - They are highly efficient, but investment and operating costs are relatively high, and they have limited life at high temperatures.
    - They are made of jute or synthetic textiles which are relatively resistant to chemical aggressions.
- Electrostatic precipitators are extensively used in large municipal incinerators as they have a high efficiency and operating costs are moderate.
    - However, investment costs are high. The flue gas is put in contact with a series of electrodes charged at 1000 to 6000 volts.
    - Particulate matter gets charged and precipitate on to the electrode, from which they are removed mechanically and collected in a container located below.
    - They are only used for large incinerators above 5 tons/hour capacity.
- A recent advancement in gas filtration technology is in the use of ceramic elements for gas cleaning, particularly at high temperatures.
    - Ceramic filters are very efficient in removing fine particulate matter but investment and operating costs are relatively high.
    - Flue gas is blown through banks of ceramic filter elements which retain the particulate matter.
    - The particulate matter is automatically removed from the filter elements by reverse air flow.

18.1.8 Removal of Acids

Three processes, known as wet, semi-wet and dry process, are available for the removal of acids such as hydrofluoric acid (HF), hydrochloric acid (HCI) and sulfuric acid **(H2S04).**

In the *wet process,* gases are washed in a spray tower with soda or lime solutions. This method also contributes to gas cooling and to the removal of small particulate matter. The alkaline solution is continuously recycled, with periodic addition of fresh solution. However, the wastewater produced requires treatment by chemical neutralization, flocculation and settling of sludges, before being discharged into any sewer.

In the *semi-wet process, a* lime suspension is injected in the gas column. The neutralization results in the formation of salts, which then have to be removed. In the *dry process, lime* powder is injected in the gas column.

Similarly, the salts produced during neutralization have to be removed, e.g. using ceramic filtration technique.

In summary, a two-chamber, high-temperature incinerator with flue gas cleaning is costly, but a variety of infectious and other hazardous waste from healthcare establishments can be safely processed. A single-chamber incinerator is a low- cost technology, but its use should be limited to incineration of non-plastic infectious waste. Open burning should be avoided, and must not be carried out in urban areas. However, if there is no other choice, the open burning of non- plastic infectious waste may be exercised under strictly controlled conditions.

18.2 Disinfection/Sterilisation

18.2.1 Chemical Disinfection

Chemical disinfection is used routinely in health-care to clean certain instruments and equipment, floors and walls. It has more recently been extended to the disinfection of healthcare waste by addition of chemicals that kill or inactivate the infectious agents contained in the waste. This treatment usually results in disinfection rather than sterilization. It is mostly suitable to treat liquid waste such as blood, urine or stools. Solid healthcare waste such as highly hazardous wastes (e.g. microbiological cultures), sharps,

etc., may also be disinfected chemically. It is most appropriate for the disinfection of small quantities of infectious liquid waste prior to disposal, e.g. patient's stools in the case of cholera outbreaks.

Chemical disinfection is economically attractive if relatively cheap chemical disinfectants are easily accessible on the local market. The speed and efficiency of chemical disinfection will depend on the operating conditions, including the following:

- The kind of chemical used.
- The amount of chemical added.
- The contact time.
- The degree of contact between disinfection and waste.
- Other conditions as necessary, such as the operating temperature, pH etc.

Disinfection is achieved when 99.999% of the micro-organisms are killed. Various disinfectants are effective in killing or inactivating either specific types or all types of microorganisms. Therefore, it is essential to know which is the target microorganism to be destroyed.

Selection of disinfectant should thus depend on their effectiveness, but also on the hazards that are related to their handling, and their corrosiveness.

The types of chemicals used for disinfection of healthcare waste include mainly aldehydes, chlorine compounds, ammonium salts and phenolic compounds.

Examples of commonly used disinfectants include formaldehyde (HCHO), glutaraldehyde ($CHO-(CH_2)_3-CHO$) and sodium hypochlorite (NaOCI).

The use of ethylene oxide is not recommended in developing countries due to major hazards related to its handling.

Powerful disinfectants are hazardous and toxic, they are harmful to skin and mucosal membranes. Disinfection operators should therefore wear protective clothes, including gloves, and eye glasses. Disinfectants are also aggressive to certain building materials, and should be handled and stored accordingly.

18.2.2 Wet Thermal Treatment

Wet thermal treatment technologies range from the well known and small scale autoclave, commonly used in healthcare facilities, to specifically developed large scale facilities.

More and more off-site facilities are currently being constructed. A major advantage of this method in comparison to incineration is the absence of emission of combustion gases.

Wet-thermal disinfection is based on exposure of shredded infectious waste to high temperature, high pressure steam, similar to the autoclave sterilization process. It inactivates most types of microorganisms if temperature and contact time are sufficient. For sporulated bacteria, a minimal temperature of 121 ^{o}C is needed.

The wet-thermal process requires pre-shredding of waste, and is not appropriate to treat anatomic waste or animal carcasses. For sharps, pre-milling or crushing is recommended to increase disinfection efficiency.

The disadvantages of the wet thermal process are as follows:

- The shredder is often the source of mechanical failures.
- The efficiency of disinfection is very sensitive to the operational conditions.
- It is not the final disposal process.

The advantages of the wet-thermal process are the relatively low investment and operating costs and the low environmental impact. This process could be considered when incineration is not practicable.

The wet-thermal process is a disinfection process expected to inactivate 99.9999% of the microorganisms, whereas the autoclave is a sterilization process expected to inactivate all or at least 99.9999% of micro-organisms.

Disinfected waste should be placed into black plastic bags and disposed of together with municipal waste.

Operation and Technology

The reacting tank is a horizontal steel cylinder, connected to a steam generator and preceded by a shredder, and a mill or crusher for sharps. The steam generator and the reacting tank can withstand up to 6 bars pressure and 160 ^{o}C. The system also includes a vacuum pump and electricity supply to provide mechanical and thermal energy. Pressure and temperature are controlled and monitored during the process. The operation of the system may be automated. Wet-thermal processes are usually batch systems, but may also be continuous.

The operation starts by the shredding the waste and milling the sharps, which are then introduced into the tank. Optimal operational conditions are achieved when the waste is shredded into small pieces and does not fill more than half of the tank volume. When the contact time is over, the reacting tank is cooled down and then emptied and cleaned.

The effectiveness of wet-thermal disinfection is checked through the "bacillus subtilis' or the "bacillus stearothermophillus" tests. Theses should be performed on a routine basis. They are performed as outlined below:

- Dried test spores are placed in a thermally resistant and steam permeable container near the centre of the waste load and the apparatus is operated under normal conditions
- At the end of the cycle, the test organisms are removed from the load; within 24 hours, test discs or strips should be aseptically inoculated in 5.0 ml soybean-casein digest broth medium and incubated for at least 48 hours, at 30 ^{o}C for "bacillus subtilis" and at 55 ^{o}C for "bacillus stearothermophillus";
- Then, the media should be examined for turbidity as a sign of bacterial growth; any growth should be sub-cultured onto appropriate media to identify the organisms either as the test microorganism or as an environmental contaminant.

The equipment should be operated and maintained by adequately trained technicians. Maintenance is mainly needed for the shredder.

Investment and Operating Costs

Numerous equipment suppliers are present on the European, North-American and Pacific markets. Investment costs range from 80,000 to 300,000 US dollars for the full equipment, with tank capacities between 20 litres to 8 m^3 and operating temperatures between 120 ^oC and 160 ^oC. For example, the costs of a wet-thermal equipment with a treatment capacity of 50 tons per year is about 150,000 US dollars on the European market. The operating costs are about 400 US dollars per ton of waste, or less in developing countries.

Large Scale Equipment for Off-site Treatment

Large-scale wet-thermal disinfection apparatus with reacting tanks of capacities up 8m^3 may be used for regional infectious healthcare waste treatment facilities. Their technological characteristics are similar to equipment with lower capacities.

18.2.3 Autoclaving

Autoclaving is an efficient wet-thermal disinfection process. Typical autoclaves used in healthcare establishments, usually used for the sterilization of recyclable items, only allow for the treatment of limited quantities of waste. Therefore, it is usually only used for highly infectious waste, such as microbial cultures, sharps.

Infectious waste contaminated with toxic, radioactive, or other hazardous chemicals should not be autoclaved because of the potential for exposure of equipment operators to such hazardous chemicals. Examples include those infectious wastes that contain antineoplastic drugs, toxic chemicals, or chemicals that could be volatilized by steam.

18.2.4 Microwave Irradiation

In this process most microorganisms, but not all parasite eggs and sporulated bacteria, are destroyed by the action of microwaves of about 2450 MHz, and a wave length of 12.24 cm, which allows for quick heating of wastes.

The loading device transfers the wastes into a shredder, where it is reduced to small pieces. Then, the waste is humidified and transferred to the irradiation chamber equipped with a series of microwave generators. There, the waste is irradiated for about 20

minutes. After irradiation, the waste is compacted inside a container and joins the municipal waste stream. The efficiency of microwave disinfection should be checked routinely through bacteriological and eventually virological tests. In the USA, routine bacteriological test are recommended using "bacillus subtilis" to demonstrate a 99.99% reduction of viable spores. The testing procedure is similar to the one described above for wet-thermal disinfection.

This process is widely used in Germany and is becoming more and more popular in the USA. Microwave irradiation equipment including loading device, shredder, steam humidification tank, irradiation chamber and its microwave generators, and also a waste compactor, costs about 0.5 million US dollars for a capacity of 250 kg/hour.

18.3 Landfilling

Healthcare waste can be buried on-site or transported to a municipal landfill. The on-site burial may be appropriate if the healthcare institution has a large area with the underlying soil of low permeability which would limit the movement of leachates, hence reducing the potential for polluting ground and surface water nearby. Soil to cover the waste should be available and applied immediately after depositing the waste. Often a trench or pit is dug and the excavated soil is used to cover the waste. The on-site burial of waste would not be appropriate in urban areas. It could be used at health-care institutions in rural areas (e.g. outpost healthcare centres) which satisfy the above conditions.

Although disposal at municipal landfill is not considered to be an appropriate disposal option for untreated infectious and other hazardous wastes, this method is commonly practised now and is likely to continue so in Papua New Guinea for -some time, until sufficient incineration and/or sterilization capacity is available.

When infectious waste is landfilled, it should be sterilized, as much as possible, before taken to the landfill.

Healthcare establishments have a responsibility to ensure that Health-care waste is appropriately contained for collection and transportation by the municipal authority, and that adequate information is given to the waste disposal personnel to ensure that they are aware of the risks from handling these materials.

18.3.1 Designated Landfill Site

For a landfill site to accept any Health-care and hazardous waste, it should first be authorised by the regulating authority who should specify the types of waste which can be accepted and any special operating procedures required. Landfill sites receiving Health-care and other hazardous wastes must be operated to the highest standards possible. Health-care wastes can represent a significant risk to water resources even though most pathogens of concern will not survive for long in the landfill environment. Leaching of organisms from Health-care wastes is likely to be significant during periods of heavy rainfall. Therefore, Health-care wastes should not be disposed of at landfill sites located on sensitive aquifers or near sources of water abstraction.

Any landfill site used for the disposal of Health-care and other hazardous healthcare wastes should be securely fenced and a sign board posted to notify the public of potential dangers. The site should be located far enough from any dwelling so that potential health and visual impacts are minimized. A record of the quantities and sources of healthcare waste received at the landfill site should be kept centrally by the appropriate authority.

18.3.2 Landfill Operation

Only two types of operation are considered suitable for the disposal of health-care waste. Healthcare waste could be deposited in specially constructed cells and immediately covered with at least 0.5 metres of suitable cover material.

These cells are located at a designated area within the landfill site, separately from the areas where general waste is deposited. The main purpose of cover in this case, apart from aesthetic considerations, is to protect the deposited waste from being exposed by the action of machinery operating on the landfill.

Therefore, it is important to ensure that the cover is laid thickly enough to prevent such incidents as well as to prevent animals or birds disturbing the waste. The availability of cover in sufficient quantities is, therefore, a major factor in the selection of landfill sites for healthcare waste. An adequate supply of appropriate cover material should be a condition of the authorization for use of the site for healthcare waste disposal.

Compaction of the material in the landfill should take place only after the waste is covered.

Alternatively, for those landfill sites operating on the working face principle, health-care waste should be deposited so that it is not within 1 metre of the working surface of the site or less than 2 metres from the face of the flanks. Again it should be covered immediately. Thin-layering techniques of waste disposal are not suitable. If the lift or depth of the working area is less than 1.75 metres, or if a compactor is being used, then a trench should be dug in an area where there is sufficient depth to bury the waste and cover it with the excavated soil. Direct compaction of healthcare waste is not a recommended procedure, due to the probability of these wastes being trapped on the compactor.

Regardless of whether the special cell method or the working face method is used, the areas which have received healthcare wastes should not immediately be re-excavated.

18.3.3 Landfilling of Large Quantities of Pathological Wastes

In the event of a major emergency resulting in the need to dispose of large quantities of infectious material or body parts, the use of lime pits may be advocated.

This involves digging a pit or trench to a depth of about 2 metres, half filling with the waste then covering with lime to within 50 cm from the top before covering with soil to prevent any form of access by animals. Caution must be exercised when locating lime pits.

They should be as far as possible from water courses, potable groundwater supplies, housing or land used for growing crops, and should not be in areas which are subject to flooding or erosion.

These locations should be unmistakably marked and records kept by both the healthcare establishment and the municipal authority.

18.3.4 **Refuse Transfer Station**

The use of refuse transfer stations by waste disposal authorities has implications for the disposal to landfill of large amounts of health-care waste.

Mechanical handling is a fundamental feature of such transfer stations. If bags of Health-care wastes were to enter a transfer station it is unlikely they could survive such handling intact. It must be expected, therefore, that if Health-care wastes enter a transfer station, they would cause contamination of both the machinery used and the other wastes handled. Even with suitable cleaning equipment such contamination is unlikely to be acceptable, on aesthetic and risk grounds, to the workforce and management. Special handling of Health-care wastes at transfer stations would increase the cost of the transfer operation.

It is recommended that Health-care wastes destined for landfill should bypass any transfer systems and go directly to the landfill site.

Health-care waste should reach the landfill in undamaged bags or containers.

18.3.5 Transport Vehicles

Vehicles capable of mechanically discharging their contents into the landfill must be employed for large deliveries.

It is not recommended that refuse collection vehicles which have integral compaction units are used to transport Health-care wastes in bulk as compaction will almost certainly lead to Health-care waste containers bursting inside the vehicle, necessitating cleaning after every delivery.

If road vehicles are required to go onto the landfill site to discharge their loads then suitable internal roads must be maintained.

Road vehicles should not run over Health-care waste which may be trapped on the vehicle and taken off-site from the landfill.

Alternatively, Health-care wastes could be transported to the site on demountable containers which could then be transferred to special site vehicles to be taken to the working area

18.3.6 Safety Precautions

If the procedures described above are followed, then landfilling of Health-care and other hazardous healthcare wastes should pose no significant health risk to landfill operators, except for sharps which could cause injury.

Site operators should be informed of this risk and reminded that they or anyone else should not sort through this type of waste.

The handling of healthcare waste by drivers or site operatives should be kept to a minimum.

Adequate protective clothing should be worn and the operators should be trained in the procedures to be followed when landfilling these wastes. If injury occurs, Health-care advice should be sought immediately.

18.4 Discharge to Sewers

The discharge to sewer of aqueous wastes, together with their associated suspended colloidal and dissolved solids, which arise in healthcare establishments, has traditionally been acceptable by sewerage authorities in many countries.

Any discharge of waste to the municipal sewerage system, other than domestic sewage, may require permission from the appropriate sewerage authority, which will limit the types and quantities of materials which can be discharged.

Generally, a consent for a discharge to sewer will include conditions setting limits of pollutant concentrations, solids content, temperature, pH and, sometimes, rate of the discharge. Discharge of petroleum spirit, calcium carbide and halogenated organic solvents are invariably prohibited.

The discharge to sewer of mercury in aqueous effluents from hospitals, dental establishments, veterinary surgeries and similar premises must be controlled and minimized. Disposal of any chemical by this route requires careful consideration.

An unauthorised discharge to sewer is usually not only an offence but it can be dangerous to workers in sewers and can have unacceptable effects on the efficiency of sewage treatment works.

18.5 Pharmaceutical Wastes

Where it is not reasonably practicable to return pharmaceutical waste to a hospital pharmacy, discharge to the sewer may be suitable for small quantities of liquid Health-care and chemical products, as well as small amounts of solid pharmaceuticals. However, this disposal option is not suitable for large quantities of solid or liquid pharmaceutical waste.

18.6 Surface Water Drains

Surface water drains generally discharge directly to water courses, rivers and the sea without any of the flow being treated. Therefore, polluted water (i.e. wastewater) or water used as a means of conveying insolubles should not be permitted to enter surface water drains.

This is especially so in areas where the surface water drains are discharged directly to streams, rivers or other water courses which may at some later stage be used for extracting water for either human or animal consumption.

Where no municipal sewerage system is available for discharge of wastewater, the healthcare establishment should install its own treatment facility before discharging the effluent to a surface water body.

18.7 Maceration

Maceration followed by discharge to sewer, particularly of bed-pan liners, has been practised in hospitals in many industrialized countries. It is possible to macerate such disposable items, unless they are from high-risk areas, and discharge them and their contents to sewers. Used incontinence pads and used disposable bed-pan liners could be

macerated, then discharged to the sewer. Small amounts of tissue or small animal carcasses (e.g. from laboratories) could also be macerated and then discharged to the sewer, with the agreement of the appropriate sewerage authority. However, hospitals in Papua New Guinea do not have purpose-built disposal units and, therefore, these items should be placed in Health-care waste bags for disposal.

Even with maceration, discharge to sewer is not a recommended disposal route for a large volume of waste. Even for items such as disposable bed-pan liners, the amount that can be discharged to the sewer will depend on the capability of the treatment works receiving the waste.

19.0 TRANSPORT OF WASTE OUTSIDE THE HEALTH-CARE ESTABLISHMENT

The transport of general or other pre-treated wastes which can be disposed of as household waste at a municipal landfill is usually carried out by the municipal collection service.

For the transport of Health-care waste from the central storage area of a healthcare establishment to an off-site disposal facility, the use of dedicated vehicles is recommended.

As a minimum, such a dedicated vehicle should have a cover over the load compartment.

However, where resources are available, the use of specially constructed vehicles may be considered. There are two options for such transport:

- By a specially dedicated vehicle.
- By the use of specially constructed bulk containers which can be mechanically lifted on to the chassis of a vehicle.

19.1 Dedicated Transport Vehicles

A vehicle used for the transport of bagged Health-care waste should be fitted with a fully enclosed body lined internally with stainless steel or aluminium to provide a smooth impervious finish for easy and effective cleaning. All corners and angles should be covered to prevent lodgements of waste matter. A bulkhead should separate the driver's compartment from the load compartment. The load compartment could be refrigerated,

particularly for transporting Health-care waste over long distances in hot climates. The load compartment of an un-refrigerated vehicle should be provided with a ventilating system, e.g. roof vents.

Health-care waste collection vehicles should not be used for any other purpose. The load identification sign using the biological hazard label and the name, address and telephone number of the haulier should be shown on the sides and rear of the vehicle

19.2 Bulk Containers

The use of specially constructed bulk containers which can be lifted onto the chassis of a vehicle may be considered in situations where the full-time use of a specially dedicated vehicle for the transport of Health-care waste cannot be justified. The container may be used for bulk storage of waste at the healthcare establishment and replaced with an empty container when collected. Refrigerated containers are advantageous for a long haulage distance. As in the case of dedicated vehicles, the design and specification of these containers for the storage and movement of Health-care waste must include full access, adequate lighting and security, and a smooth impervious finish for ease of cleansing and disinfection.

19.3 Use of a Secondary Container System

Health-care waste bags may be placed directly into the collection vehicles for transport to the off-site disposal facility. However, it is safer to place them into a further container (e.g. cardboard boxes and wheeled, plastic or galvanised bins) for transport and disposal. This secondary containment system has the advantage of reducing the handling of filled bags. The filled bags are placed in the secondary container at or close to source and the secondary container is then transported to the off-site disposal facility. However, it must be recognised that the use of a secondary containment system will invariably result in higher disposal costs.

19.4 Cleansing and Disinfection

Vehicles used for Health-care waste collection shall be thoroughly cleaned and disinfected immediately following any internal spillage. The cleaning should be carried out on a proper surfaced area with the drainage running to a sewer. The transport operator should carry at all times a supply of plastic bags, protective clothing, cleaning tools and

disinfectant to cleanse and disinfect any matter which has been contaminated by any spillage of waste during loading, transport or unloading.

19.5 Safety Precautions

The transport operator should have a safe operational system to ensure that:

- drivers, collectors and other handlers are aware of and trained in the nature and risks of the waste being carried
- such operators are familiar with the procedures to be taken in the event of spillage or accidents, and that written instructions are provided on the vehicle
- such operators must be provided with, and wear, approved protective clothing and footwear
- an emergency telephone number is provided
- they should be protected by vaccination where this is considered necessary.

19.6 Vehicles Not Suitable for Transporting Health-care wastes

Open-topped vehicles should never be used for the transportation of Health-care waste. Compaction vehicles are also not suitable for the transportation of Health-care waste, as compaction will break the bags, causing waste spillage.

19.7 Documentation

Correct documentation and recording of Health-care waste (e.g. by using a consignment note system) is necessary to allow waste to be traced from the point of collection to the final disposal facility. The consignment note travels with the waste and proof of its final disposal is returned to the control authorities who can ensure that the waste has been correctly dealt with.

The consignment note system can be operated in the following manner:

- Each time that waste is collected, a consignment note will be issued, bearing details of the quantities of waste collected. This will be in five copies, one copy to be kept by the healthcare establishment and the remaining four copies must accompany the load of waste from site of origin to point of disposal.
- On arrival at the disposal site, the details of each consignment will be noted and initialed at the site by the site operator, who will return one copy of the consignment note to the transporter. Since the transporter has to have his copy of the consignment

note initialed by the site operator, there is a written assurance that the waste has reached its intended destination. (This record can be requested by the Head of the establishment or his staff for corroboration)

- On completion of the disposal, the site operator shall return a copy of the note to the relevant authorities (e.g. the Ministry of Health and the Department of Science, Technology and Environment), retaining one copy for himself

The consignment note can be of very simple design, stating the name of the healthcare institution, the name and signature of the responsible officer at the healthcare institution, the quantities of waste collected, the name of the transporter and his signature, and similar information relating to the site operator. Each person shall put his signature in the relevant place, along with the date. These records should be retained by the respective personnel for a minimum period of one year. An example of a consignment note is shown in Annex 3.

The consignment note system can also be used to develop a database on the quantities of waste generated in the healthcare establishment. This information will prove invaluable for planning future waste management strategies in the healthcare establishment.

20.0 Accidents and Incidents

20.1 Personal Protection

Health-care establishments should ensure that the following personal protective equipment or facilities are provided, used and maintained and, all staff should be made aware of these facilities:

- Protective clothing and gloves should be provided to all personnel handling, loading and unloading Health-care waste
- Because there is a risk of contamination of the employee's skin whilst engaged in clearing up body fluids, disposable gloves and disposable aprons should be worn. In certain circumstances, face visors may be necessary to protect employees from potential splashing
- Sturdy shoes should be worn to protect the feet against bags or containers that might be accidentally dropped. The soles of such shoes (or boots) will also offer protection in the storage area, as a precaution against the spillage of sharps and where floors may become slippery

- Protective face visors and helmets should be provided where incinerators are charged manually
- Where dust masks are deemed appropriate, for example during the ash/residue removal process after incineration, they should be provided to the operators
- Basic personal hygiene is important in reducing the risk from handling Health-care waste. Convenient washing facilities should be available for persons handling Health-care waste. This is particularly important at storage and incineration facilities
- Hepatitis B and tetanus primary immunisation or booster doses (as appropriate) should be considered for all staff at risk from handling Health-care waste.

20.2 Reporting Accidents and Incidents

Healthcare establishments should have a prompt and formal reporting procedure and records should be kept. The report should include the nature of the accident or incident, where and when it occurred and which staff were directly involved. Incidents such as spillages, damaged containers, inappropriate segregation or cases involving sharps should be reported to and investigated by the officer responsible for waste management. Such incidents should also be reported to the officer responsible for control of infection.

The investigation of these accidents and incidents should establish the cause and what action should be taken to prevent a recurrence.

20.3 Dealing with Sharps and Injury

Health-care establishments should identify procedures, including first aid, for dealing with accidents or incidents giving rise to risks to staff or to other people. They should have a specific sharps injury procedure. This should include at least:

- immediate reporting to a responsible, designated person
- retention, if possible, of the item and details of its source for identification of possible infection
- attendance at an accident and emergency department as soon as possible
- containing the waste and decontaminating the area as appropriate; recording the accident
- investigation, determination and implementation of remedial action.

20.4 Dealing with Spillage

Any spillage should be reported as soon as possible to the officer responsible for waste management, who should investigate, preferably before the damaged container is disposed of, in order to identify the cause of the problem.

Spillage procedures should specify safe handling systems for those personnel clearing up the waste and appropriate protective clothing. Appropriate equipment for collecting the waste and placing it in new containers should be provided. On no account should sharps be picked up by hand because this would present a high risk of inoculation injury. Absorbent materials- (e.g. towels, paper or gauze pads) could also be used to deal with liquid spillages after disinfection. These materials should be placed in a Health-care waste container for incineration or other appropriate treatment and disposal. The area of spillage should be then disinfected.

Appropriate disinfectants should be available, as specified by the officer responsible for control of infection. Disinfectants containing 10,000ppm available chlorine are recommended for spillages. The use of granules or tablets is recommended because made up solutions lose activity with time and require regular replacement. Care should be taken in the use of disinfectants, taking into account the release of chlorine and the quantities likely to be used, especially for large spillages. Problems may arise in confined space.

The following procedure should be adopted for dealing with spillage of cytotoxic drugs:

- individuals must wear protective clothing which includes gloves, goggles, plastic apron, etc.
- spillages must be contained as far as possible
- the spillage should be thoroughly and immediately cleaned up
- where appropriate, neutralizing solutions should be available, with clear instructions as to their use
- adequate quantities of clean water and absorbent material (e.g. paper, towels or gauze pads) must be used and disposed of correctly
- appropriate facilities for the disposal of waste should be available. These include yellow plastic bags of an adequate thickness.

21.0 TRAINING

10.1 Public Education on Hazards Linked to Health-care Wastes

Promotion of the appropriate handling and disposal of Health-care waste is important for community health, and every member of the community should have the right to be informed about potential health hazards. The objectives of public education on health-care waste are the following:

- *To prevent exposure* to health-care waste and related health hazards; this exposure may be voluntary, in the case of scavengers, or accidental, as a consequence of unsafe disposal methods.
- *To create awareness and foster responsibility* among hospital patients and visitors to health-care establishments regarding hygiene and health-care waste management.
- *To inform the public* about the risks linked to health-care waste, focusing on people living or working in close proximity to, or visiting, health-care establishments, families of patients treated at home, and scavengers on waste dumps.

The following methods can be considered for public education on risks, waste segregation, or waste disposal practices:

- Poster exhibitions on health-care waste issues, including the risks involved in scavenging discarded syringes and hypodermic needles.
- Explanation by the staff of health-care establishments to incoming patients and visitors on waste management policy. This may be difficult to achieve, in which case the distribution of leaflets should be considered.
- Information poster exhibitions in hospitals, at strategic points such as waste bin locations, giving instructions on waste segregation. Posters should be' explicit, using diagrams and illustrations to convey the message to as broad audience as possible, including illiterate people.

For maximum effectiveness, all information should be displayed or communicated in an attractive manner that will hold people's attention.

In the health-care establishment, waste bins should be easily accessible for patients and visitors and should be clearly marked with the waste category for which they are intended.

Growing awareness of health and environmental hazards has greatly increased public demand for information and guidance on these issues. Demand has intensified as the prevalence of HIV/AIDS and viral hepatitis B has risen. Health-care establishments should set an example to society by managing their waste in a manner designed to protect health and the environment.

10.2 Education and Training of Health-care Personnel

10.2.1 Principles

Aim

A policy for the management of health-care waste cannot be effective unless it is applied carefully, consistently, and universally. Training health-care personnel in implementing the policy is thus critical if a waste management programme is to be successful. The overall aim of training is to develop awareness of the health, safety, and environmental issues relating to health-care waste, and how these can affect employees in their daily work. It should highlight the roles and responsibilities of health-care personnel in the overall management programme. Health and safety at the workplace and environmental awareness are the responsibility of all and in the interests of all.

Employees to be trained

All hospital personnel, including senior Health-care doctors, should be convinced of the need for a comprehensive health-care waste management policy and the related training, and of its value for the health and safety of all. This should ensure their collaboration in the implementation of such a policy.

Separate training activities should be designed for, and targeted to, four main categories of personnel:

- hospital managers and administrative staff responsible for implementing regulations on health-care waste management;
- Health-care doctors;
- nurses and assistant nurses;
- cleaners, porters, auxiliary staff, and waste handlers.

Since action is needed at management level, by those producing the waste as well as by the waste handlers, training of all of these categories of personnel is equally important.

Health-care doctors may be educated through senior staff workshops and general hospital staff through formal seminars. The training of waste managers and regulators, however, could take place outside the hospitals, at public health schools or in university departments.

Content

Staff education programmes should include:

- information on, and justification for, all aspects of the health-care waste policy;
- information on the role and responsibilities of each hospital staff member in implementing the policy;
- technical instructions, relevant for the target group, on the application of waste management practices.

One of the best ways of learning is through practice, and hands-on training of small groups of personnel should be considered where appropriate. Testing the participants at the end of the course, by means of simple true/false or multiple-choice questions, often provides an incentive for learning, and allows the course organizers to assess the knowledge acquired by participants. Training

The instructors should have experience in teaching and training, and be familiar with the hazards and practices of health-care waste management; ideally, they should also have experience in waste handling.

3.2 Follow-up and refresher courses

Periodic repetition of courses will provide refreshment training as well as orientation for new employees and for existing employees with new responsibilities; it will also update knowledge in line with policy changes.

Follow-up training is instructive for trainers, indicating how much information has been retained by course participants and the likely need for future refresher courses.

Training responsibility

The Infection Control Officer (ICO) should be given responsibility for all training related to the segregation, collection, storage, and disposal of health-care waste. He or she should

ensure that staff at all levels are aware both of the hospital waste management plan and policy and of their own responsibilities and obligations in this regard. A record should be kept of all training sessions, and the content of training programmes should be periodically reviewed and updated where necessary.

For similar training of those concerned with smaller sources of health- care waste, the regional health authority may be able to make centralized arrangements for courses.

10.2.2 Implementing a Training Course

The training package

A training package could be developed by the national government agency responsible for the disposal of health-care wastes or by an inter- national or development agency. The package should be suitable for various types of health-care establishments, including government, private, teaching, and dental hospitals, polyclinics, health centres, health-care research institutions, and clinical laboratories. It would also be useful for more general educational establishments and for organizations that provide services for health-care waste disposal.

The package should be liberally illustrated with drawings, diagrams, photographs, slides, or overhead transparencies. These should reflect the environments in which trainees work and provide examples of measures that have been (or will be) implemented. Where it is likely that waste handlers and other workers are illiterate, all procedures should be care-fully represented in diagrams and photographs.

Selection of participants

The ideal number of participants in a training course is 20-30; larger groups may make effective discussions and exercises difficult. Courses should be aimed at all categories of personnel; discussions may be easier and more useful if the group is composed of trainees from various disciplines (e.g. supervisors, Health-care and nursing staff, laboratory staff, engineers, ancillary staff) or at least contains one or two Health-care assistants and nurses. It may also be valuable to include senior administration staff and heads of departments in certain training groups to demonstrate their commitment to the waste management policy and to show the relevance of the policy to all personnel of health-care establishments.

Line managers may find it worthwhile to run the training sessions themselves, for their own personnel.

Training recommendations: health-care personnel

The training course should provide an overview of the waste management policy and underlying rationale and information on practices relevant to the targeted group of trainees. For personnel who provide health-care, waste segregation is a key element in their training in waste management.

In addition to the practices outlined in the various chapters of this book, which may form the basis for the course, the following precautions should be emphasized:

- The greatest care should be taken if needles have to be removed from syringes.
- In no case should any attempt be made to correct segregation mistakes by removing items from a bag or container or by placing one bag into another of a different colour. Hazardous and general waste should not be mixed. If the two are accidentally mixed, the entire mixture should be treated as hazardous health-care waste.
- Nursing and clinical staff should ensure that adequate numbers of bag holders and containers are provided for the collection, and subsequent on-site storage, of health-care waste-in the wards, clinics, operating theatres, and other areas where waste is generated. These receptacles should be located as close to the common sources of waste as possible.

Training and waste segregation

All staff who produce health-care waste should be responsible for its segregation, and should therefore receive training in the basic principles and practical applications of segregation. Waste is generated by a large number of personnel, many of whom are directly involved with care of patients, often in conditions of urgency; management of the waste generated in such circumstances may thus seem to be of little importance. Training should make staff aware of the potentially serious implications of the mismanagement of waste for the health of waste handlers and patients, provide them with an overall view of the fate of waste after collection and removal from the ward, and teach them the importance of proper segregation of the different categories of waste.

Training recommendations: waste handlers

Again, relevant chapters of this book may form the basis for a training course. Topics covered may include the waste management policy, health hazards, on-site transportation, storage, safety practices, and emergency response. Among staff who routinely handle health-care waste, aware- ness of the need for safety may decrease with time, which will increase the risk of injury. Periodic refresher training is therefore recommended.

Training of waste handlers

- Check that waste storage bags and containers are sealed; no bags should be removed unless properly labelled and securely sealed to prevent spillages.
- Bags should be picked up by the neck only. They should be put down in such a way that they can again be picked up by the neck for further handling. Manual handling of waste bags should be minimized whenever possible.
- Waste bags should not touch the body during handling and collectors should not attempt to carry too many bags at one time-probably no more than two.
- When moving of waste bags or containers is complete, the seal should again be checked to ensure that it is unbroken.
- To avoid puncture or other damage, waste bags should not be thrown or dropped.
- Sharps may occasionally puncture the side or bottom of a polypropylene container; the container should therefore be carried by its handle and should not be supported underneath with the free hand.
- Bags for hazardous health-care waste and for general waste should not be mixed, but segregated throughout handling; hazardous waste should be placed only in specified storage areas.
- Appropriate cleaning and disinfection procedures should be followed in the event of accidental spillage; any such incident should be reported immediately to the responsible member of staff.
- Adequate protective clothing should be worn during all waste handling operations.

10.3 Training of Health-care Waste Management Operators

The minimal training for waste management operators should include:

- . information on the risks associated with the handling of health-care waste;
- procedures for dealing with spillages and other accidents;

- instructions on the use of protective clothing.

The training needs will obviously depend on the type of operations the operators perform, but may well include specific topics such as operation of incinerators and waste transportation.

10.3.1 Training for Staff Who Transport Waste

The health-care establishment itself may carry out the transportation of waste, or it may contract this operation to an "authorized" waste transporter. Drivers and waste handlers should be aware of the nature and risks of the transported waste. In particular, transport staff should be trained in the procedures listed below. They should be able to carry out all procedures in accordance with the instructions, without help from others.

- Correct procedures for handling, loading, and unloading waste bags and containers.
- Procedures for dealing with spillages or other accidents; written instructions for these procedures should be available in the transport vehicle.
- The wearing of protective clothing and strong footwear at all times.
- The availability at all times in dedicated waste collection vehicles of spare plastic bags, protective clothing, and the cleaning tools and disinfectants needed to deal with any spillage that occurs during loading, transport, or unloading.
- Documentation and recording of health-care waste, e.g. by means of a consignment note system, to allow waste to be traced from the point of collection to the final place of disposal.

The head of the health-care establishment should liaise with the transport contractor to ensure that members of the waste collection crew are well trained. Untrained personnel should never be allowed to handle hazardous health-care waste.

10.3.2 Training of treatment plant operators

Qualified operators are needed for incinerators and other treatment facilities. If no qualified operators are available, health-care establishments should arrange to train an adequate number of personnel.

Treatment plant operators should have received technical education to at least secondary school level, and should be specifically trained in the following areas:

- general functioning of the treatment facility, including heat recovery and flue-gas cleaning technologies, where appropriate;
- health, safety, and environmental implications of treatment operations;
- technical procedures for operation of the plant;
- emergency response, in case of equipment failures and alarms for example;
- maintenance of the plant and record-keeping;
- surveillance of the quality of ash and emissions, according to the specifications.

10.3.3 Issues to address in training treatment plant operators

Waste handling

- Procedures for receiving, handling, and storage of health-care waste.
- Loading of waste into the treatment unit.

Operation of the plant

- Operation of the plant equipment, including start-up and shut-down procedures.
- Operation and testing of control, alarm, and instrumentation systems; corrections where necessary.
- Optimum operating temperatures, pressures, concentrations of emissions, speeds, flows, etc., and maintenance of correct conditions.
- Detection of defects or malfunctions (following written procedures) and servicing.
- Safe removal of residues and ashes.

Maintenance

- Daily, weekly, monthly, semi-annual, and annual tests, inspection, cleaning, lubrication, replacement and replenishment of consumables (e.g. thermocouples), and overhaul, with special attention to major components of the installation; appropriate action when necessary.

Safety measures and emergency response

- Use of protective equipment; personal hygiene.
- Fire precautions.
- Procedures for emergency response, including manual operation of the plant under emergency conditions; dealing with spillages, accidents, and other incidents. ,

- Contingency plans for implementation during breakdown or planned maintenance.

Administrative procedures

- Licence conditions and regulations governing emissions.
- Record-keeping.
- Reporting of spillages, accidents, and other incidents.

10.3.4 Training of landfill operators

In many middle- and lower-income countries, "safe burying" will continue to be used for the disposal of health-care waste until there is sufficient capacity for incineration or other disinfection. The training of landfill operators is important for limiting the risks associated with buried health-care waste, in relation to both scavenging and the quality of groundwater. Landfill operators should therefore be trained in the following issues:

- health risks related to health-care waste;
- hazards related to the sorting of this type of waste, which should *not* be practised either by the landfill operators or by other people;
- minimizing the handling of health-care waste by drivers or site operators;
- use of protective equipment, and personal hygiene;
- safe procedures for landfilling the wastes; .procedures for emergency response.

11.0 GUIDELINES FOR HEALTH-CARE WASTES FOR SMALL HEALTH-CARE ESTABLISHMENTS

This chapter provides the waste management practices and selects the options that are suitable for use by establishments that produce minimal amounts of health-care wastes. These situations include smaller rural health-care establishments or field hospitals

The selected practices should ensure that health and safety requirements are met and an acceptable level of hazard protection is achieved.

However, the recommendations should not be viewed as a substitute for the longer-term aim of establishing the more rigorous procedures described in earlier in this guidelines.

The first step would be the introduction of waste segregation: too often, health-care establishments treat hazardous health-care wastes in the same manner as general waste.

Separation of the sharps may be a good starting point. Specific methods for the disposal of hazardous health-care waste can then be introduced, followed by efforts to encourage waste minimization and the safe reuse of materials wherever possible.

11.1 Basic Principles

The total absence of management measures to prevent exposure to hazardous health-care wastes results in the maximum health risk to the general public, patients, health-care personnel, and waste workers. It is therefore emphasised that even very limited management measures can dramatically reduce the risk.

Effective confinement of waste and safe handling measures provide significant health protection. For example:

- burning hazardous health-care waste in open trenches or small furnaces is better than uncontrolled dumping.
- reducing the amount of hazardous waste by segregation is better than accumulating large quantities.
- good stock management of chemicals and pharmaceuticals not only reduces waste quantities but also saves purchase costs.
- proper identification of waste packages warns health-care personnel and waste handlers about their contents.

The principles of “doing something is better than doing nothing” is important and underlies any effort to initiate a system for the management of health-care waste. The basic elements of minimal programmes of health-care waste management are represented schematically in Figure 4. At the local level, the following basic actions should be taken:

- Assessment (quantitative and qualitative) of waste production.
- Evaluation of local treatment and disposal options.
- Segregation of health-care wastes from general (or municipal) wastes.
- Establishment of internal rules for waste handling, (storage, colour coding, collection frequency etc).
- Choice of suitable or better treatment and disposal options.

11.2 Health-care Waste Segregation

11.2.1 Waste Categories

Health-care wastes from smaller establishments can be categorised into two namely:

- General (non-risk) waste including uncontaminated waste similar to domestic waste; may represent about 80 percent of the total waste production from health-care establishments.
- Hazardous or infectious health-care wastes.

Hazardous or Infectious Health-Care Wastes

Low Hazardous Wastes:

- Anatomical or pathological wastes, waste contaminated with human blood or other body fluids, excrete, and vomit.
- Chemical and pharmaceutical residues, eg. cans, bottles, or boxes containing such residues, and small quantities of outdated products.
- Non-recyclable and discarded pressurised containers, which are hazardous only if burned as they may explode.

3.2 Highly Hazardous or Infectious Wastes

- Sharps, especially hypodermic needles.
- Highly infectious non-sharp wastes, including microbial cultures, carcasses of inoculated laboratory animals, highly infectious physiological fluids, pathological and anatomical wastes.
- Stools from cholera patients or body fluids of patients with other highly infectious diseases.
- Bulk quantities of outdated hazardous chemicals, such as strong disinfectants, or significant quantities of waste containing mercury.

11.2.2 Segregation and Packaging

In any area that produces medical wastes, separate containers will be needed. Recommendations for the segregation of waste are already given in Table 2 and reproduced as follows:

Designation	Infectious Waste Container	Sharps Container	General Waste Bag
Type of receptacle	Container or plastic bags in a holder	Sealable box or drum, or cardboard	Plastic bag or container
Colour	Yellow, marked "INFECTIOUS WASTES"	Yellow, marked "SHARPS"	Black
Characteristics	Leak proof, suitable for autoclaving	Puncture-proof and leak proof	No special requirements
Waste categories	Infectious non-sharp wastes	Sharps	Waste similar to municipal wastes, not contaminated by hazardous or infectious substances

The bags should be should be sealed or containers firmly closed before they are filled to three-quarter of their capacity.

The equipment should be **simple, robust and locally available.**

11.2.3 Safe Handling and Storage

The waste should e collected daily. General waste should be stored in convenient places that facilitate collection by the municipal service, but infectious health-care wastes should be stored in a closed room.

Waste should not be stored close to patients or where food is prepared.

Infectious wastes should be disposed of within the following periods:

- Maximum 48 hours during the cool seasons.
- Maximum 24 hours during the hot seasons.

Before containers of infectious health-care wastes are loaded on to a truck for transport off site, they should be sealed. Waste bags and containers should also be labelled with the address of the producer and the waste category.

For safety reasons, it is strongly recommended that infectious wastes should be disposed of within the establishment premises.

11.3 Treatment and Disposal of Infectious Wastes

Affordable treatment and disposal methods for infectious wastes from small health-care establishments may be classified into three categories:

- Thermal processes.
- Chemical processes.
- Containment processes

11.3.1 Thermal Processes

Three systems can be used ie:

- Static-grate single-chamber incineration.
- Drum or brick incinerators.
- Open-burning

Static-Grate Single-Chamber Incinerator

- Waste may be burned in a simple furnace, with a static grate and natural air flow.
- The low heating value of properly segregated health-care waste is high enough for combustion, but addition of a small amount of kerosene may be needed to start the fire.
- Blowing of air may also help in establishing good combustion.
- The burning efficiency should reach 90 to 95 oC and 5 to 10 percent of the material may be remain unburned in the ashes and slag.
- The operating temperature will be around 300 oC, which will kill most microorganisms but will not be sufficient to destroy thermally resistant chemicals and pharmaceuticals.
- The advantages of this system are as follows:
    - Good disinfection efficiency.
    - Drastic reduction of waste.
    - The residues may be landfilled.
    - No requirements for highly qualified operators.
    - Relatively low investment and operation costs.
- The drawbacks of the systems are as follows:
    - Generation of emissions containing atmospheric pollutants, including flue gases and fly ashes; may produce odours.

- Periodic removal of slag and soot necessary.
- Inefficiency in destruction of thermally resistant chemicals and drugs.

Drum or Brick Incinerators

- Where a single-chamber incinerator is unaffordable or available, simple confined burning may be applied.
- A steel drum or walls of bricks or concrete can be erected over a screen or fine grate and covered with a second screen to prevent dispersion of ashes or light materials.
- The waste is placed inside and burned with the help of manual ventilation and addition of kerosene if necessary.
- The combustion efficiency may reach 80 to 90 oC and kills 99 percent of microorganisms.
- The temperature will not exceed 200 oC
- Advantages:
  - Drastic reduction of weight and volume of the waste.
  - Very low investment and operating costs.
- Drawbacks:
  - Relatively poor destruction efficiency.
  - No destruction of many chemicals and pharmaceuticals.
  - Massive emission of black smoke, particulates and toxic flue gases.

Open-burning

- Open-air burning of infectious waste should be carried out only as a last resort, in rural dispensaries or isolated health posts.
- Pathological wastes shall not be burned in the open.
- If possible, the burning should take place in the pit of final disposal (ie. where the residues will be buried), and the process should be supervised by the person responsible for waste management in the health-care facilities.
- It should be performed downwind of, and as far as possible from, the facility or other communities.
- The area within which the burning is carried out should be fenced to prevent unauthorised persons and animals from entering.

11.3.2 Wet Thermal Disinfection

- This process involves exposure of shredded infectious waste to high temperature, high pressure steam.
- Shredded waste is introduced into a reacting tank, vacuum conditions are established, and steam is introduced.
- Precise operating procedures have to be followed by qualified technicians for efficient disinfection.
- The advantages of this system are as follows:
  - Environmentally sound.
  - Reduction of waste volume.
  - Relatively low investment and operating costs.
- The advantages of this system are as follows:
  - Shredders subject to breakdown and poor functioning (and are thus the weak point of the process).
  - Qualified operators are required.
  - Inadequate for anatomical, pharmaceutical, and chemical wastes, and wastes that are not easily penetrated by steam

11.3.3 Autoclaving

- Autoclaving is an efficient wet thermal disinfection process.
- Autoclaves are used in hospitals for the sterilization of recyclable items, and these units allow for the treatment of only limited quantities of waste.
- They are therefore generally used only for highly infectious waste, such as microbial cultures and sharps.
- The advantages and drawbacks of the autoclave are similar to those of wet thermal processes.
- Advantages .Efficient.
  - Environmentally sound.
  - Relatively low investment and operation costs.
- ***Drawbacks***
  - Qualified operators essential.
  - Inadequate for anatomical, pharmaceutical, and chemical waste, and waste that is not easily penetrated by steam.

- The hospital autoclave used for sterilization has capacity for treatment of only limited quantity of waste.

11.3.4 Chemical disinfection

- Chemical disinfection is an efficient process, but costly if the prices of disinfectants are high.
- For safe operation it requires trained technicians provided with adequate protective equipment and is therefore not recommended for treating all infectious health-care waste.
- The process can be useful in specific cases, such as disinfection of recyclable sharps or disinfection of stools from cholera patients.
- **Chemical sterilization of recyclable sharps**
  - Chemical sterilization of scalpels, syringes with needles, and other recyclable sharps
  - May be considered as an alternative or complementary method to thermal sterilization.
  - After thorough cleaning and drying, the sharps are placed in a tank and exposed to a strong disinfecting gas or liquid, such as ethylene oxide, formaldehyde, or glutaraldehyde.
- Advantage
  - Highly efficient (may be more efficient than thermal sterilization).
- Drawbacks. .
  - Trained operators essential.
  - Costly if the chemical disinfectants are expensive.
  - Uses hazardous substances that necessitate safety measures.
- **Chemical disinfection of stools from cholera patients**
  - *Vibrio cholerae,* the causative agent of cholera, is not very resistant and its elimination does not require the use of very strong chemical disinfectants.
  - Buckets containing stools of patients with acute diarrhoea may be disinfected through addition of chlorine oxide powder or dehydrated lime oxide (CaO).
  - Other liquid or powder disinfectants may also be used.
  - In case of a cholera epidemic, hospital sewage must also be treated and disinfected.

- Where there is sufficient space, sewage may be treated through lagooning, followed by effluent disinfection with sodium hypochlorite.
- In cholera epidemics in emergency situations these disinfection measures should also be applied in field hospitals to prevent the spread of the disease.
- Advantages
  - Efficient disinfection.
  - No need for highly trained operators.
- Drawback
  - Not significant compared with the benefits.

11.3.5 Containment processes

Landfilling in municipal disposal sites

Waste may be landfilled in municipal disposal sites if it cannot be treated before disposal. However, health-care waste should not be deposited or scattered on the surface of open dumps.

If landfilling is planned, the following minimal requirements should be met:

- measures established by a municipal authority for the rational and organized deposit of municipal wastes that could be used to dispose of health-care wastes;
- if possible, engineering work instigated by the municipal authority to prepare the disposal site to retain wastes more effectively;
- rapid burial of the health-care waste, so that human or animal contact is as limited as possible.

In addition, it is recommended that health-care waste is deposited in one of the following two ways:

- in a shallow hollow excavated in the mature municipal waste, in the layer below the base of the working face, where it is immediately covered by a 2-m layer of fresh municipal waste; scavenging in this part of the site must be prevented.
- in a deeper pit (1-2 m) excavated in mature municipal waste (at least 3 months since being landfilled) which is then backfilled with the mature waste that was dug out; again, scavenging in this part of the site must be prevented.

Alternatively, a specially constructed small burial pit could be prepared to receive health-care waste only. The pit can be 2 m deep and filled to a depth of 1 m. Each load of waste should be covered with a soil layer 10- 15 cm deep. (Lime may be placed over the waste if coverage with soil is not possible.) In case of a disease outbreak involving especially virulent pathogens (such as the Ebola virus), both lime and soil cover may be added. Access to this area should be restricted and closely supervised by the responsible staff to prevent scavenging.

Before health-care wastes are sent for land disposal, it is prudent to inspect the proposed landfill site to ensure that there is satisfactory control of waste deposition.

Advantages

- Low costs.
- Relatively safe if access is restricted and the site is selected according to the above conditions.
- Effective biodegradation of the biological components of health-care waste if landfill operations are properly carried out.

Drawbacks

- Access restrictions may not always be guaranteed.
- It may be difficult to assess whether the conditions for safe landfill are being met.

Safe burying inside premises

In certain health-care establishments in remote locations, temporary refugee camps, and areas experiencing exceptional hardship, safe burial of wastes on hospital premises may be the only rational option available at times.

To limit risks to health and of environmental pollution, some basic rules should be applied:

- Access to the disposal site should be restricted to authorized personnel only.
- The burial boundary should be lined with a material of low permeability (e.g. clay), if available.
- Only hazardous health-care waste should be buried.

- Large quantities (over 1 kg) of chemical wastes should not be buried at the same time; burial should be spread over several days.
- The burial site should be managed in the same way as a landfill, with each layer of waste being covered with a layer of earth to prevent development of odours and infestation by rodents and insects.

The safety of waste burial relies critically on operational practices. Safe on-site burial is practicable for only relatively limited periods of time, e.g. 1-2 years, and for relatively small quantities of waste, say up to 5-10 tonnes in total. Where these limits are exceeded, a longer-term solution, involving treatment of the waste or disposal at a municipal solid waste landfill, will need to be found.

Advantages

- Less hazardous than letting waste accumulate and remain accessible.
- Low costs.

Drawbacks

- Risks of pollution in permeable soils if the waste becomes saturated with water.
- It may be difficult to prevent scavenging at all times.

Encapsulation

Encapsulation is recommended as the easiest technology for the safe disposal of sharps. Sharps are collected in puncture-proof and leak-proof containers, such as high-density polyethylene boxes, metallic drums, or barrels. When a container is three-quarters full, a material such as cement mortar, bituminous sand, plastic foam, or clay is poured in until the container is completely filled. After this material has dried, the container is sealed and may be landfilled, stored, or buried inside the hospital premises. It is also possible to encapsulate chemical or pharmaceutical residues together with sharps.

Advantages

- Simple and safe.
- Low costs. .
- Also applicable to chemicals and pharmaceuticals.

Drawback

- Not recommended for non-sharp infectious waste.

11.4 Management of hazardous health-care waste by waste categories

11.4.1 Infectious waste and sharps

Most treatment methods outlined in section 11.3 above are suitable for infectious waste and sharps, except that:

- in the wet thermal process, shredding of sharps is problematic;
- encapsulation is not suitable for infectious waste.

Incineration in single-chamber incinerators should be the method of choice in establishments that apply minimal waste management programmes. Highly infectious waste, such as cultures and stocks of infectious agents from laboratory work, should be sterilized by wet thermal treatment (e.g. autoclaving) at the earliest stage, i.e. inside the health-care establishment, and soon after production, if possible. For other infectious health-care waste, disinfection to reduce microbial concentration is sufficient.

Sharps should also be incinerated whenever possible and can be incinerated together with other infectious waste. Encapsulation is also suitable for disposing of sharps.

Blood should be disinfected before discharge to the sewer (unless there is an adequate wastewater treatment plant) or may be incinerated.

After incineration or other disinfection process, residues may be landfilled.

11.4.2 Pharmaceutical waste

Sound management of pharmaceutical products, with a view to waste minimization, is of prime importance. Small quantities of chemical or pharmaceutical waste can be disposed of easily and relatively cheaply, but large amounts may require special, more costly treatment, such as high-temperature incineration. Comprehensive management of pharmaceutical stores should be supervised by the Chief Pharmacist of the health-care establishment.

Small quantities of pharmaceutical waste are usually collected in yellow containers together with infectious waste and therefore follow the same disposal pathway, being either incinerated or safely buried. It should be noted, however, that temperatures reached in a single-chamber furnace may be insufficient to disintegrate thermally resistant pharmaceuticals. Small quantities of pharmaceutical waste, such as outdated drugs (except cytotoxics and antibiotics), may also be discharged to the sewer but should not be discharged into natural waters (rivers, lakes, etc.).

Significant quantities of pharmaceutical waste may be disposed of by the following methods:

- Incineration (if an incinerator able to reach a combustion temperature of 800°C is available); the incineration residues may be landfilled.
- Discharge to the sewer. Water-soluble, relatively mild pharmaceutical
- mixtures, such as vitamin solutions, cough syrups, intravenous solutions, eye drops, etc., may be diluted with large amounts of water and then discharged to sewers (where sewerage systems exist). This process should *not* be used for antibiotics.
- Encapsulation. When incineration is not feasible and water dispersion is not recommended, pharmaceutical waste should be encapsulated.
- Return to the original supplier if possible.

Note: Cytotoxic drug residues and other cytotoxic waste should *never* be mixed with other pharmaceutical waste, but should be processed separately according to the procedure described in this handbook

11.4.3 Chemical waste

As for pharmaceutical waste, improved management of chemical waste starts with waste minimization efforts. The proper management of chemical stores will be supervised by the Chief Pharmacist of the health- care establishment.

The hospital's Infection Control Officer, Chief Hygienist, or Chief Pharmacist should be designated to supervise the use of chemicals throughout the health-care establishment. The main users of chemical disinfectants, which are among the most hazardous chemicals used in the establishment, are likely to be the Infection Control Officer/Chief Hygienist and his or her staff.

Small quantities of chemical waste will include residues of chemicals in their packaging, outdated or decomposed chemicals, or chemicals that are no longer required. These are generally collected in yellow containers, together with infectious waste, and follow the same disposal pathway (either incineration or safe burying).

Large quantities of chemical waste should *not* be collected in yellow plastic bags or containers. There is no safe and cheap method for their disposal; the treatment options are the following:

- Incineration under subcontract by a public or private agency equipped for the safe disposal of hazardous chemical waste. The thermal reactivity of the waste should be checked; certain solvents will burn and can therefore be incinerated in simple incineration units, although it must be remembered that those containing halogens could cause air pollution.
- Return to the original supplier (if the supplier has facilities for safe disposal). In this case, appropriate provisions should be included in the original purchase contract for chemicals.
- Exportation to a country with the expertise and facilities to dispose safely of hazardous chemical waste. Shipment of chemical waste should comply with international agreements, such as the Basel Convention and the United Nations *Recommendations on the transport of dangerous goods.*

All three options are costly and may be unpracticable, which makes it particularly crucial that chemical waste is minimized. The following recommendations should also be observed:

- Hazardous chemical wastes of different nature should never be mixed.
- Hazardous chemical waste should not be disposed of in sewer systems.
- Large amounts of chemical waste should not be buried as they may contaminate groundwater.
- Large amounts of chemical disinfectants should not be encapsulated as they are corrosive and sometimes flammable.

11.4.4 Cytotoxic waste

Cytotoxic drugs are highly hazardous to the health of the individual and to the environment. Disposal options are the following:

- Return to the original supplier.
- Incineration at high temperatures, e.g. in rotary kilns or high- performance double-chamber pyrolytic incinerators (if available).
- Chemical degradation.

The following recommendations should also be observed:

- Residues from cytotoxic drugs or other cytotoxic waste should never be mixed with other pharmaceutical waste.
- Cytotoxic waste should never be discharged into natural water bodies or landfilled.

In countries where the above disposal procedures are not feasible, use of cytotoxic and radioactive products should be restricted to university research and teaching hospitals.

11.4.5 Radioactive Waste

For safety reasons, medical use of radioactive isotopes should be restricted to university hospitals, and any hospital that uses radioactive products should appoint a qualified Radiation Officer.

11.4.6 Pressurized Containers

Undamaged pressurised containers should be returned to the supplier for refilling, and adequate provision for this should be included in the original purchase contracts. If return is not possible, containers may be buried safely. Any residual pressure should be released before disposal. Aerosol containers cannot usually be refilled and should be buried. Pressurized containers should never be burned or incinerated because of the severe risk of explosion.

11.4.7 Used batteries and thermometers

Batteries, thermometers, and various items of measuring equipment may have a high metal content, including toxic heavy metals such as mercury or cadmium. Disposal options are as follows:

Recycling by specialized cottage industries. This is the best disposal solution when available.

- Exportation to a country with the expertise and facilities to dispose safely of hazardous chemical waste. Conditions of shipment should comply with the Basel Convention.
- Encapsulation. If neither of the two options above is feasible, encapsulated waste may be disposed of in an impermeable landfill (if available) or other landfill.

This type of waste should not be incinerated because of the toxic metallic vapours emitted, nor should it be buried without encapsulation as this may cause pollution of groundwater.

However, if the quantities of wastes with high heavy-metal content are minimal (similar to the quantities in municipal waste) and there are no opportunities for reuse of heavy metals within the country, they may also join the municipal waste stream.

11.5 Workers' training and safety at work

For personnel who handle wastes, including hospital cleaners and technicians, training in safety measures should cover the following issues:

- packing, handling, and storing of hazardous health-care waste;
- the need to wear protective gloves and aprons when handling waste
- containers;
- operation of on-site treatment and disposal methods, such as single- chamber furnace operations, encapsulation, and safe burying.

Technicians in charge of chemical disinfection should be trained to implement appropriate safety precautions and emergency measures and be informed about chemical hazards. Nurses and cleaning personnel should be made aware of the occupational risks linked to handling of sharps.