CHAPTER TWO: LITERATURE REVIEW

2.1 CLINICAL WASTE GENERATION AND IDENTIFICATION

2.1.1 CHARACTERISTICS OF CLINICAL WASTE

Clinical waste is pathogenic and pathogens need to be made inert before being finally disposed of. In certain cases, monitoring is required even after disposal due to certain cysts being tolerant to any destructive processes. The prime motif of careful disposing of clinical waste is mainly to prevent or eradicate communicable diseases. Some of the diseases include cholera, small pox, acquired immune deficiency syndrome (AIDS), rabies, hepatitis and tetanus.

Handlers precautionary Measures

Handlers of clinical waste carry out grouping, autoclaving, transporting, loading, off-loading and disposing activities at one time or other. These personnel primarily need:

i. To have thorough knowledge of clinical waste characteristics,
ii. To identify the various types of waste and their generation rate, and
iii. To immunize themselves against easily infecting diseases.

Essentially, immunization against tetanus and hepatitis viruses is prescribed for handlers of clinical wastes.

2.1.2 GENERATION AND IDENTIFICATION

The generating points of clinical wastes, though identical in general, differ from point to point depending on the activities of the section. Each type of waste has its own gravity of infection. For example, quarantine waste is more infectious then waste arising from general wards. Human tissues generated, as waste from operation theatre, is more harmful then tissue waste arising from gynecology ward.

Hospitals and other health care institutions and facilities are part of a modern society. In many ways hospital is a small human settlement. As such, inevitably it produces a

great variety of wastes. In fact, experience shows that both the quantity and the level of complexity of hospital wastes have increased tremendously over the years due mainly to the rapid advancement of health care technology and practices (Zulkifli, 1998). Table 2.1 shows the type of waste and their origin in a hospital environment. Many types of wastes are generated in a hospital. However, not all of them are hazardous. Therefore, it is important to differentiate general hospital wastes from clinical wastes (Agamuthu, 1998).

2.1.3 SCHEDULED WASTE

Environmental Quality Act (1974) and the following subsidiary regulation (Environmental Quality (Scheduled Waste) Regulation 1989, clearly specify the list of elements which come under scheduled substances. These elements have either direct or sustained harmful effect on environment. The characters like corrosivity, erodibility, reactivity and ignitibility toxicity and infectivity are the factors based on which the elements are determined for inclusion in the list (Anon, 1980). The generation of this scheduled waste is mostly confined to industries and chemical plants where the end product is either consumer durable or other chemicals, which are used as raw materials for another product.

2.1.4 SCHEDULED SUBSTANCES

Scheduled substances are scheduled wastes. They contain inorganic or organic compounds and heavy metals that are toxic to human health and cause environmental degradation in excess of permitted levels. Many of these elements are found in clinical wastes. Scheduled wastes differ from special waste by its dose tolerance and source of origin.

Types of clinical wastes and their possible source of generation points within the hospital or health care establishments are indicated in Table 2.1

Table 2.1 Waste type and generation points

Source of generation (Wards, Department, Units, Etc)	**Possible types of waste generated (by category)**
Clinics (All clinics in the out-patient department, specialist clinics and dental clinics)	A,B,D,E
Endoscopy room	A, B, D.
X-Ray department	A, B, D.
Operations theatres	A,B,D,E (stoma bag, urine bag attached to the patient)
Casualty department (Including ambulances, and other vehicles that bring patients to the department)	A, B, D, E.
Haemodialysis	A, B, D, E
Physiotherapy/occupational therapy units	A, B, D, E.
Pharmacy	B, D **
Pathology department	A, B, C, D, E.
Blood bank	A, B, C, D.
Wards, (Medical, Surgical, Orthopedic, Pediatric, Neurology, Urology/Nephrology, Radiotherapy, Gynecology, Obstetric, Psychiatry, Ophthalmology, E.N.T., Intensive Care Unit, Coronary Care Unit, Hematology, Special Care Nursery Day Care Wards)	A,.B, D, E.

(** Bulk of the waste)(Waste classification given in Table 1.6)
Source: Engineering Division, Ministry of Health Malaysia (1996).

Insecticides and pesticides contain these elements in different proportions depending on the gravity of activity assigned to such products. The following list shows a part of chemicals that come under scheduled substance:

2.1.5 SPECIAL WASTE IDENTIFICATION GUIDELINE

A logical approach to assess the nature of the waste has been designed by the Public Health Department of Wales and Scotland (1981) (as shown in Fig. 2.1). A waste or pharmaceutical product could be identified as scheduled waste when the answer is 'Yes'at any point of the flowchart. However application of such guidelines alone does not absolutely determine the special waste (Brian, 1981). Fig. 2.1 represents a logical approach to the assessment of a waste's status according to the defined criteria, but the order in which the question appears does not imply any grading of importance, but will usually provide a quick decision.

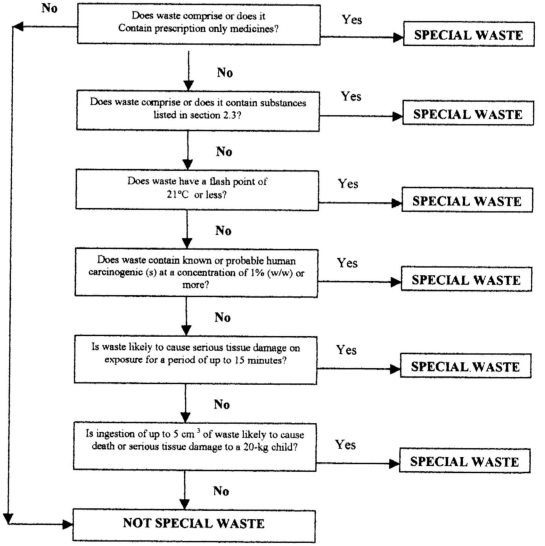


Fig 2.1 Special waste assessment procedure diagram
Source: Public Health Dept of Wales and Scotland (1981).

Plate 2.1: Group 'A' Clinical waste items. Human tissues and surgical dressings.

Plate 2.2: Group 'B' Clinical waste items. Discarded syringes and glass.

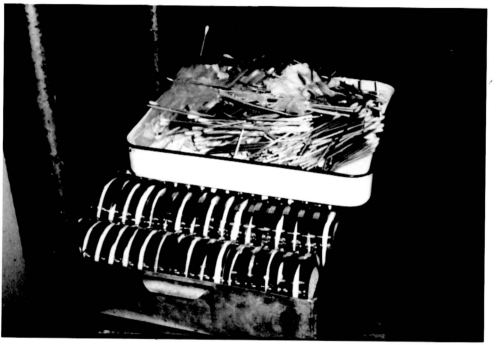


Plate 2.3: Group 'C' Clinical waste items. Microbiological cultures and laboratory waste

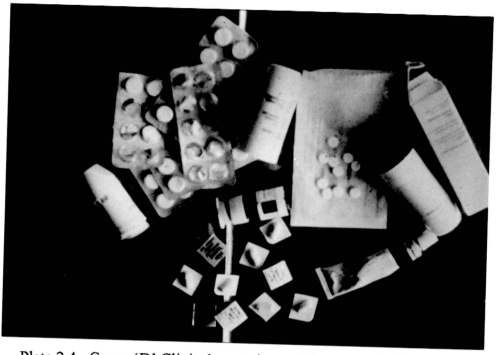


Plate 2.4: Group 'D' Clinical waste items. Pharmaceutical waste.

Plate 2.5: Group 'E' Clinical waste items. Disposal items.

2.1.6 DISTINGUISHING FEATURES OF CLINICAL WASTES

Clinical waste is a member of Scheduled waste, which in turn comes under solid waste hierarchy (Table 2.2). Nevertheless, the treatment, handling and disposal of clinical wastes remain differed from that of common waste. All such differences are due to clinical waste being pathogenic in effect and needs to be rendered harmless before final disposal.

Table 2.2 Clinical wastes – distinguishing features

Distinguishing base factors	Common solid waste	Clinical waste
Generation	Industrial Commercial, Domestic, Agricultural sectors	Medical and Paramedical institutions
Collection	External to hospital and paramedical institutions	From hospitals and paramedical institutions
Compaction	Normally compacted and compacting machinery used	Not to be compacted as per regulations
Character	Non harmful Non-pathogenic	Harmful Infectious
Treatment	Sorting, pulverisation, baling etc	To be rendered harmless before final disposal
Collection bags	Normal thrash bags (preferably black)	Yellow bags
Sub classification	Glass, plastics etc	Grouped into A, B, C, D & E
Recyclability	Practicable to larger volume	A small portion can be recovered for recycling (packing, shells, fillers etc)
Incineration	Can be done	Need to be done
Disposal	Dump yard or Sanitary landfill	Secure landfill only
Storage	Normal storage	To keep below 6°C
Regulatory Governance (in Malaysia) *	Environmental Quality(Scheduled Wastes) Act 1974, and Regulations 1989 And Control of Infectious Diseases Act 1988	Environmental Quality(Scheduled Wastes) Act 1974, and Regulations 1989 And Control of Infectious Diseases Act 1988
Handling staff	Not necessarily trained	Necessarily trained
Personal Protection	Mandatory	Strictly mandatory
Health safety	Immunization against certain diseases recommended	Immunization against certain diseases are mandatory
External transport	Open	Prescribed routes/Closed transport only.
Transfer stations	Normal	Cold storage
Energy recovery	Possible	Not really
Documentation	Internal and within city councils and consortiums administrations	Recordable with Department of Environment and MOH
Cost of disposal (in Malaysia) *	RM1.00 to 1.45 per kg	RM5.00 to 6.00 per kg

(Source: London Waste Regulation Authority 1991)

* Adapted from Consultant's (Faber Mediserve Sdn. Bhd) Operation Manual.

2.1.7 LOGO FOR CLINICAL (INFECTITIOUS) WASTE

In order to identify and be aware of the harmful effects of infectious waste, the World Health Organization has approved and allotted a symbol and the symbol is recognized globally for Infectious Waste. The logo implies cross infection when come in to contact and is expressed by the superimposing of three rings overlapping each other (Anon 1984).

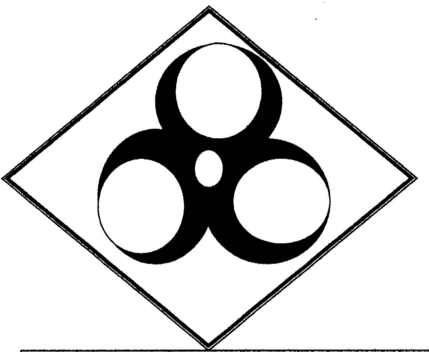


Fig: 2.2 Logo to indicate infectious wastes

Shape: Three Crescents superimposed by a central rin
Colour: Black Background: White
(Source: Legal Research Board, 1997, Pub: International Law Book House Page: 183)

2.1.8 CLINICAL WASTE ARISING FROM RESEARCH

Culture and other petri dishes used in the laboratories of research centres, universities and independent investigating centres are also sources of infectious waste and do need proper and careful procedure of disposal. Though very tiny or small in volume or numbers, it can create outburst of infectious diseases when not taken care or not handled cautiously (Stephen, 1992). Research may be carried out by independent contractors or other organizations in premises such as hospitals or clinics. University, public health laboratories or other employers may be involved and there should be clear agreed arrangements for disposal of clinical waste generated in these areas, preferably by the host employer to avoid confusion and possible error.

Full liaison between employers is essential to make sure that the waste is dealt with appropriately and that any special risks are identified, along with safe procedure for dealing with them. Waste produced in the research area can range from small items such as culture dishes to large animals. It may include soiled bedding and sharps and in many cases the waste may contain infectious agents. Only trained and authorised staff should handle infectious and potentially infectious waste before making it safe for autoclaving and incineration. Hazardous wastes need to be handled and disposed of in a controlled manner so as to ensure that environmental pollution does not result. Even less hazardous categories of clinical waste need to be handled with much precaution. This can only be achieved by the use of enforceable codes of practice and guidelines for all aspects of the handling, storage, transport and disposal (Masagne, 1997). It is disheartening to observe that in some cases hazardous wastes including medical wastes are mixed up with Municipal Solid Waste and disposed of in landfills or dump yards (Reuben, 1997).

2.1.9 CLINICAL WASTE FROM VETERINARY CENTRES AND PRACTICES

Waste from veterinary practices including animal tissues and evacuations, drugs or medical products, sharps, swabs, dressings and similar substances or materials from veterinary practices is classified as clinical waste. The safe disposal of this waste is the responsibility of the veterinary surgeon. The veterinary surgeon is under no statutory obligations to dispose the body of a pet belonging to a client, but in many cases will undertake this service. There are commercial pet crematoria providing disposal service contracts for veterinary surgeons and some local authorities offer a disposal service (Stephen,1992).

In Malaysia, the disposal of bodies of pet animals is the responsibility of the veterinary centres. Small in-house incinerators in such centres serve the purpose of safe disposal. On no account clinical waste be put into domestic waste. The local authority may provide a special collection and disposal service for clinical waste from commercial premises and a charge will be made for this service. There are several commercial firms offering a disposal service to veterinary practices. Facilities for storage should be provided, so that a regular collection service can be made (perhaps weekly). A refrigerated room, a freezer or designated areas suitable for the volume of the waste is required. Sharps generated from the veterinary surgeon in clients premises should be disposed by the veterinary surgeon by placing them in a sharps container and taking them to the clinic for safe disposal (Smith, 1993).

2.1.10 CYTOTOXIC (DRUG) WASTES

Drugs having toxicity effect on men come under Scheduled waste. Certain drugs which are used in the Oncology Department (cancer treatment section) do have the capability to penetrate tissues and spoil the normal growth of cells. Certain section in hospitals deal with drugs of toxic nature and the resulting waste is considered having either partly or fully the same toxicity (Graham, 1998). Evidences of therapeutic doses link cytotoxic drugs to human carcinogens, however, evidence of absorption of these substances by workers is not established or validated.

Cytotoxic wastes, also known as antineoplastic drugs or chemotherapic drugs, used for treatment of cancer have the ability to kill or arrest the growth of living cells. They form an important part in the therapy of various nepotistic conditions, but more recently as immunosuppressive drugs in transplantation and various diseases with an immunological basis. Cytotoxic drugs are often used in specialty units such as Oncology and Radiotherapy where the main function is the treatment of cancer (Collins, 1987). Toxins enter a human body by inhalation ingestion and contact. Injection or infusion commonly administers the drug, but some are given by mouth in tablet, capsule or suspension. The main exposure arises during the preparation and manipulation of cytotoxics, which may be in the form of freeze-dried materials or powder, requiring mixture with dilutent. However, exposure may also occur while handling, transporting or treating infected materials or drugs for disposal from manufacturer, distributor, pharmacies, hospitals etc. The toxins, in the body system, do not exhibit linear symptoms but has a great chance of coming in cycles. Elimination of toxins from the body system may take a very long time depending on the volume and gravity of toxicity (Hert, 1993).

2.1.11 RADIOACTIVE WASTE

Radioactive wastes, shown in Table 2.3, are generated by hospitals and clinics. They are usually generated during imaging of organs (X-rays) and tumour removal. The source of generation is classified as open source and sealed source. Open source is any chemical that may contain small or low traces of radioactive substances, whereas sealed source is from equipment and tools, which exert radio-chemicals (Saw, 1992).

Table 2.3 Radio Nucleus Elements commonly present in clinical care centres

Radionuclide	Principal Emission	Half-Life	Application
^{3}H	Beta particle	12.3 γ	Research
^{14}C	Beta particle	5730 γ	Research
^{32}P	Beta particle	14.3d	Therapy
^{51}Cr	Gamma ray	27.8d	In vitro diagnosis
^{57}Co	Beta particle	270d	In vitro diagnosis
^{59}Fe	Beta particle	45.5d	In vitro diagnosis
^{67}Ga	Gamma ray	72 h	Diagnosis imaging
^{75}Se	Gamma ray	120d	Diagnosis imaging
^{99m}Tc	Gamma ray	6 h	Diagnosis imaging
^{123}I	Gamma ray	13 h	Diagnostic uptake
^{125}I	Gamma ray	60d	Diagnostic uptake
^{131}I	Beta particle	8d	Therapy
^{133}Xe	Beta particle	5.3d	Diagnostic imaging

Source: World Health Organization (1981)

2.1.12 REACTIVE WASTES

Reactive wastes are commonly generated in wards of Health Care Centres or Hospitals of terminally ill patients. In addition, certain equipment or tumor localizing devices radiates reactive wastes, which gain entry into tissues and subsequently cause damaging effects. The gamma rays could be blocked or hindered only by dense sealing like 15 mm lead lining (Grayling, 1997). Table 2.4 shows a list of elements which usually contains reactive wastes.

Table 2.4 Reactive elements (in hospitals/clinics)

Shock sensitive:

- Diazo compounds
- Metal azides
- Notro-cellulose
- Perchloric acid
- Perchlorate salts
- Peroxidizable chemicals
- Picric acid and picrate salts
- Polynitroaromatics

Other Reactive materials

- Nitric and above 71% (fuming Nitric acid)
- Phosphorous (red and white)

Water reactive

- Alkali and alkaline earth salts, Lithium reagents, Baron trifluoride solutions, Grignard reagents, Hybrides of Al, B, Ca, K, Li and Na.
- Metal halides (anhydrous) of Al, As, Fe, P, S, Sb, Si, Sn & Ti, Phosphorous oxychloride
- Phosphorous pentoxide
- Sulphuryl chloride
- Thionyl chloride

Source: World Health Organization (1981)

2.2 CLINICAL WASTE COLLECTION AND STORAGE

2.2.1 CLINICAL WASTE: SOURCE IDENTIFICATION CODES USED IN MALAYSIA

The waste generation points are found to have certain identification codes for different waste items. The identifying codes are mainly based on the areas where the wastes are generated as shown in Table 2.5.

Table: 2.5 Clinical wastes identification codes

Code No.	Wards/Departments/Laboratories
101	Medical Ward including general medicines, cardiology, nephrology, chest, neurology, rhumatology and dermatology
102	Surgical Ward including general surgery, cardiothoracis, urology, gastroentrology, neurosurgery and plastic surgery
103	Obstetrics & Gynaecology including gynaecology ward, labour rooms and nursery
104	Paediatrics including general ward, neonatal intensive care unit and isolation ward
105	Orthopaedics
106	Opthalmology
107	Ear, Nose and Throat (ENT)
108	Psychiatry
109	Intensive care unit (ICU)
201	Out Patient Department (OPD) All wastes generated from the general out-patients department and the following our patient clinics, medical clinics, including chest, skim, cardiology and nephrology clinics, surgical clinics, antenatal clinic, postnatal clinic, gynaecology clinic, paediatric clinic, orthopaedic clinic, ophthalmology clinics and ENT clinics
202	Accidents and Emergencies: (A&E) All Wastes from the treatment area, A&E ward, A&E operating theatre, A&E Radiology Units and the plaster room.
203	Dental clinic Department
301	Operating theatres (OT) including general OT, maternity OT, orthopaedic OT, Eye OT, ENT OT and minor OT
302	Heamodialysis Unit
303	Radiology
304	Post-mortem room
305	Laboratories including Blood Bank, haematology, histopathology, cytology, microbiology and biochemistry
306	Pharmacy
307	Physiotherapy
401	Kitchen
402	General waste – wastes from offices, canteen, central sterilization department, engineering department, laundry and general wastes from corridors, lobbies, waiting areas within the hospital compound.

Source: Ministry of Health Malaysia (1991)

Codes are mainly for identification purposes so that the waste is treated or handled in the required manner. These codes are of much use to waste handling staff. Such codification further helps a handling staff to exercise the required care when handling and transporting to the next stage of disposal.

2.2.2 COMMUNICABLE DISEASES

Clinical waste can cause diseases ranging from serious to fatal, when not handled the way it ought to be. Certain diseases are killer diseases and can cause epidemic. Disinfecting is one of the treatments of Clinical waste whereby the pathogens are rendered inert. A final disposal is mandatory only after certain pre-treatment such as autoclaving, incinerating etc. Nonetheless, the cysts of certain germs are said to be tolerant for high temperature (Ministry of Health, 1990). When disinfection is not carried out, some or all of the diseases (Table 2.6) could result.

Table 2.6 List of communicable diseases

Anthrax	Mononucleosis infectious
Brucellosis	Mumps
Candidiasis	Paratyphoid
Chicken pox	Plague
Cholera *	Pneumonia
Conjunctivitis	Poliomyelitis acute
Diarrhoea	Psittacosis
Diptheria	Rabies
Gonorrhoea	Respiratory diseases
Gonococcal vulvo vaginitis of children	Salmonellosis
Gonococcal ophthalmia neonatorum	Shigellosis
Granuloma inguinale	Staphylococcal disease
Hepatitis	Streptococcal diseases
Human Immuno Deficiency Virus (HIV) Infection	Trachoma
Leprosy	Tuberculosis
Lymphogranuloma venereum	Urethritis(non-gonococcal)
Measles	Whooping cough
Meningitis, aseptic	Yaws

Source: Ministry of Health Malaysia - Disinfection and Sterilization Policy, 1990.

2.2.3 HANDLING AND PERSONAL PROTECTION

Basic personal hygiene is important in reducing the risk from handling clinical waste. Convenient washing facilities should be available for persons handling clinical waste. This is particularly important at storage and incineration facilities. All those who work and produce clinical waste should be aware of the hazards associated with its handling and disposal. (Staff should be trained to recognize the hazards) It is imperative that those who handle the filled containers are also made aware of the hazards of handling clinical waste (Dennis, 1992). Establishment and enforcement of waste management practices would ensure that health workers and the community are protected. Such medical waste disposal methods would cover the isolation, sorting, collecting, transportation and proper treatment of medical waste under environmentally sound conditions. And it would ensure that risk and hazardous waste on one hand and non-hazardous waste on the other would be correctly identified and processed (Mukonde, 1996).

2.2.4 RECORDING AND DOCUMENTATION OF CLINICAL WASTE

Statutory requirement stresses that all clinical waste need to be recorded by character, weight or volume, point of generation etc. Implementation of this procedure is emphasized based on two purposes: one is to have a primary data of the waste generated and the second being the "safety" of environment and humankind (MOH Malaysia 1996).

Recording and documenting clinical waste generated is essential for identification and "cradle to grave" accountability. Some steps in documentation are:

- Each hospital shall be provided with a logbook. The logbook shall have removable pages so that the waste collection records can be removed and secured for future reference,
- The logbook shall have five columns. Column 1 shall have the date of collection and column 2 shall be the wheel bin number into which the waste bag was placed.

Column 3 shall be the collection staff members' identification and the remaining two columns shall contain removable prenumbered stickers.

- These stickers shall be prenumbered in the following manner:

XX/YY/ZZ: XX refers to the Hospital code, YY refers to the ward code, ZZ refers to 3 digits in sequence from 000 to 999

The procedure of clinical waste documentation requires that two Government Agencies (Ministry of Health Malaysia and Department of Environment) and the corporate sector consortium that renders support services for the handling and disposal are involved (MOH Malaysia, 1998).

2.2.5 LIST OF HAZARDS AND RISKS

Risks and hazards (Appendix: V) are common while handling and transporting clinical wastes . Physical injuries may lead to health injuries when exposed to infectious organisms. Handling personnel need to be well versed with the likely physical injuries, which may happen during waste handling activities (Bentley, 1992).

2.2.6 SEALING AND TAGGING

Although sealing and tagging is a simple procedure, it must be carried out in the presence of Ministry of Health Malaysia authorities as per their instructions (MOH Malaysia, 1998). Collection of clinical waste should be carried out at a minimum of once per day from all areas and used bags should be tied with one way plastic seal and labeled.

The label (tag) should contain the information like name of hospital, ward/department, date, name of MOH representative and signature of MOH representative. Also

- the sealed and labelled waste bag is removed, placed into a wheeled bin and transferred to the waste storage area or direct to the incinerator facility,

- under no circumstances should waste be compacted in the bag for ease of sealing, and
- the collection times and routing for the collection of clinical waste within hospitals are to be decided by the head of the establishment.

2.2.7 WEIGHING AND RECORDING

Scheduled Waste Consignment Note is the stationery tool where all clinical waste is recorded. Weight is determined by physical weighing and MOH authorities personally inspect the procedure. The Clinical Wastes discarded shall be placed in yellow bags or in the case of sharps, in suitable 'once use only' or ' sharps only' containers. These bags or containers shall be tagged to permit 'cradle to grave' identification and are placed in a wheeled bin and then transferred to the hospital central storage depot for collection and transport to the incinerator. Each bin shall be referenced marked with a bin number to permit tracking of wastes from the source to the incinerator (Saw, 1996). The weights of bin contents shall be recorded on the Scheduled waste Consignment Note. A copy of this record shall be supplied to the authorized Ministry of Health representative and also the Consortium transport driver. A waste generator shall complete 6 copies of Part 1 of the sixth schedule and give all 6 copies of the Schedule to the contractor to whom the scheduled waste are delivered.

Two copies will go to waste generator after part 1 and part II are filled in, 4 copies go to occupier who fills in Part III (of 6^{th} schedule). Occupier (Faber Mediserve), after filling Part III, retains one for himself and gives away one to the contractor and the last copy goes to Department of Environment. Within 30 days, the occupier must return his copy to the generator after disposal of the waste at the incinerator and failing which DOE will initiate action.

2.2.8 SEGREGATION OF WASTE

Segregation becomes very important when a waste is classified. Classification is necessary for determining the destination. Disposing cost of clinical waste is expensive. In addition, general medical waste, which is not segregated, is taken as clinical waste demanding more labour and cost of disposal. In segregating medical wastes, some skill or training on identifying the items is required (Cole, 1997). Waste segregation procedures and facilities in hospitals must be appropriate for the type of treatment to be applied to the waste material. Not all treatment processes are the same and they require different material preparation, segregation, containment and handling protocols and facilities as set out in hazardous waste schedule.

2.2.9 CLINICAL WASTE BAGS AND SPECIFICATIONS: WASTE BAGS FOR INFECTIOUS WASTE

Size of the bag is usually 20 litres and bags should be made of materials suitable for autoclaving. Minimum gauge size is 55 microns if of low density and 25 microns if of high density and provided with self-adhesive closing on the bag's upper rim or provided with suitable bag ties. The colour should be blue and clearly marked with words (in appropriate size) and biological hazard symbols in black ink(Fig.2.3) as follows (MOH Malaysia, 1995)

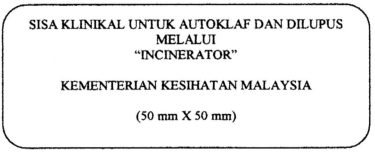


Fig: 2.3 Label design for infectious waste

The waste bags for incineration need to be leakproof from seams, to provide suitable one way plastic ties for sealing the bags, The colour should be predominantly yellow and clearly marked with words (Fig.2.4) in appropriate size and biological hazard symbols in black ink as follows: All supply of plastic bags shall have valid certificate issued by SIRIM.

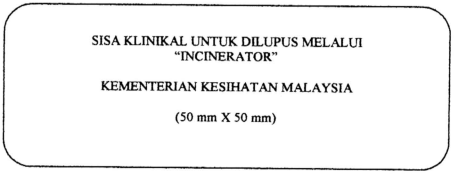


Fig: 2.4 Label design for incinerator bound waste

SHARPS CONTAINER

Sharps containers are to be leak resistant, the colours of containers shall be predominantly yellow and clearly marked with words in appropriate size and biological hazard symbols in black ink (Fig.2.5) as follows: sharps containers should meet British Standards 7320: 1990. Nominal use of sharps containers should be 2 litres, 7 litres and 20 litres.

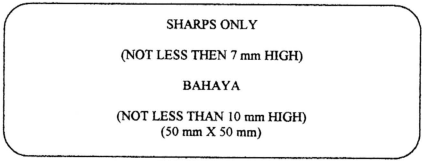


Fig: 2.5 Label design for sharps

To separate hospital waste from the rest, specially marked waste containers are needed at the source. It is not relevant whether this waste is collected in specifically provided synthetic bags, cardboard packaging or synthetic containers. What is important is that this separation should not entail additional labor for the personnel. Transport from the hospital to the place of disposal should take place using special vehicles allowing cooling of the cargo space. This is necessary above all in warmer countries, since otherwise optimum temperatures for the spreading of pathogens may be reached. Where applicable, storage, even for 1 or 2 day, should be possible in special cooled rooms. This interim storage is important when day-by-day disposal is not possible due to the small quantities of waste involved, or if disposal is taken care of at a central facility and is not collected every day (Thomas, 1997). Source separation following regulated guidelines alone does not guarantee a waste is safe from causing infection. Improperly packaged waste pose health hazards by spreading pathogens. Cross infection is imminent if any of the set guidelines are ignored (Andrew, 1987).

2.2.10 COLLECTION OF CLINICAL WASTE AND DATA

Though collection of clinical waste is not a task, it involves risks that may endanger the personnel involved. The risk may vary from minor to lethal depending on how grave the exposure and contact occurred. Secondly, the data that is maintained in a facility with regards to clinical waste may not be constant as fluctuation in patients strength very often happens. Potential problem areas related to collection of waste data helps to stress the importance of gathering accurate information on the various types of clinical waste generated at the facility. Although some of the relevant data may be obtained through existing reports or various files maintained in the relevant office, there is no substitute for directly observing the operation that generate the waste at site (Convey, 1987). Interference by political bodies may infringe the maintenance of quality services and eventually lead to ignorance of guidelines and regulations. Collection of clinical waste is handled by private consortiums in most parts of the world. Additionally, the burden of expenditure for equipment and other capital outlay are placed on the private consortiums (Hegerty, 1973).

2.2.11 CENTRAL STORAGE FOR CLINICAL WASTE

Until the time of further disposal by incineration, the clinical waste is to be carefully stored under certain conditions. All clinical waste handlers must strictly adhere to these conditions. The waste should not be stored more than 20 days and the temperature should be maintained at or under 6°C, which vary depending on the geographical/environmental condition of the area (Brian, 1994). All attempts need to be made to incinerate the waste within 24 hours of its arrival at the plant. However, due to circumstance beyond foreseeable factors, the incineration can be delayed but not more than MOH/DOE stipulations. In general, all the Clinical waste central storage areas shall have the security to prevent theft or disturbance of waste by dadah addicts or any other unauthorized person, separation from general wastes, weighing facilities, wash down facilities, control of vermin procedures and refrigeration as required. The clinical waste central storage area shall be equipped with the following safety equipment and all staff approved to access the area shall be thoroughly trained to deal with the cleanup of clinical waste spillage (Hart,1994). The equipment to be made readily available for spillage cleanup purposes shall consist of absorbent material, hospital grades disinfectant, broom, shovel, plastic bags, warning signs and tape, sealing tape etc. The bag label needs to be worded as 'SISA KLINIKAL SAHAJA' and 'TIADA BENDA TAJAM'. The label must be to the size of 50 mm x 50 mm.

2.3 CLINICAL WASTE TREATMENT AND DISPOSAL

2.3.1 AUTOCLAVING OF INFECTIOUS CLINICAL WASTE

This pre-treatment is mainly due to the high infectability of the waste. (Wain and Rowland, 1994). It must be emphasized that autoclaving is not a disposal method in its own right but a pre-treatment at an interim stage. It does not reduce the quantity of material requiring incineration, it only makes it safe. However, until the waste goes to incineration, this treatment guarantees against any cross infection. Autoclaving is a wet thermal disinfection process carried out at 160° C under high pressure (MOH

Malaysia, 1996). If the waste is infectious, the waste generator determines if the waste can be autoclaved (Sue Kirk, 1998).

Wastes arising or generated from operation theatres (surgery) and labour wards are otherwise called as Special Waste which need special care in handling due to its nature being as tissues or other wastes like swabs, fluids etc that may cause immediate harm to any one coming into contact. If those wastes do not need autoclaving, they should be arranged for disposal reducing the ageing time. Such wastes are to be packed in yellow bags for further disposal. In no circumstances they shall be compacted or packed to the brim of bags. On the contrary, only upto three quarter of the bag shall be filled in. Immediate transfers need to be followed up in to a wheeled bin (MOH Malaysia, 1996).

Operation theatre wastes include human tissues, human fluids, human bones, bone marrow, swabs, bandages, gauze, needles, syringes, saline bottles, blood and blood stains, smears and smeared surgical knives, transfusion apparatus (disposable) and other disposables used for surgical purposes. Labour ward wastes include placenta, fluids and blood spots. Ministry of Health guidelines set forth the following procedure for handling such wastes.

The common autoclave operating temperature is nominally 250°C. This temperature is above the threshold of volatilization of plastics. It was delibrately set to allow the "melting" of "autoclavable plastic bags", a technique frequently used in small installations to solve the penetration-steam exposure issue (Weiser, 1998).
Raising temperatures higher improves heat transfer characteristics but introduces rapid volatilization of plastics and creates a volatile organic compound emissions. Infectious wastes, once sterilized, cannot be considered as normal waste, nor should be treated the way a normal waste is treated. It may still contain pathogens that need further treatment to ensure a complete destruction. A complete destruction is not guaranteed by further sterilization but need higher degree of treatment (Greig, 1998).

2.3.2 TRAINING AND CARE WITH CLINICAL WASTE HANDLING

Major and difficult part of work involving clinical waste management is handled by machinery (incineration, transport and landfilling), however, initial or basic chores are to be manually handled (sorting, packing, tagging, loading and off loading). Unless sufficient training is imparted to the handler, it will lead to vulnerable proportion to the handler and society, too. Hence, training becomes inevitable to one having a career in the clinical waste management world. The training must be in a way that it should impart certain knowledge to handle independently and courageously when there happens an incident or accident. The imminent dangers due to wrongly handled waste should be thoroughly conveyed to the trainee (Allen, 1997).

2.3.3 SPILLAGE MANAGEMENT

Spillage is divided into two subclasses namely 'small spillage' and ' large spillage'. Spillage can occur anywhere within hospital premises or in highways. All precautions are taken to avoid spillage at any points. However, beyond control of human capability, some accidents or incidents do happen and, on such occasions, the transporting personnel need to be courageous and fully equipped to face and manage the event (Patrick, 1997). Any spillage of clinical waste must be effectively handled to prevent the possibility of cross infection to other patients, members of staff or the general public. The staff shall have access to safety equipment and shall be thoroughly trained to deal with the cleanup of clinical waste spillage. All clinical waste spillage shall be reported. Minor spillage shall be noted and recorded. Reports on major spillage shall be completed by senior administration staff (MOH Malaysia, 1997).

2.3.4 WASTE ENCAPSULATION

Encapsulation is a type of treatment whereby the waste is thoroughly mixed with lime, cement and water in a predefined proportion, usually 65:15:15:5 by weight respectively. The drums so contained need to be kept for 21 to 28 days before disposal in order to achieve a full concoction of contents (Powel, 1992). The steel

drums should be filled to 90% capacity with solid and semisolid pharmaceuticals. For ease and speed of filling the drum, lids should be cut open and bent back. Once the drums are filled to 90% capacity, a mixture of lime, cement and water in the proportions 15:15:5 (by weight) should be added and the drum filled to capacity. The drum is placed at the working face of a landfill, which has been lined with a layer of clay or impermeable membrane. For ease of movement of the drums they should be placed on pallets which can then be moved by pallet transporter.

Determining a waste of its hazard characteristics, after expiry date shall be left to the expert and no personnel, under any circumstances, should take a decision on it (Taylor, 1993). Waste such as chemicals, disinfectant solutions, and any substance unfamiliar to the supervising pharmacists should be referred to the hazardous waste expert, and must not be handled by members of the pharmaceutical teams unless under the direct supervision of the hazardous waste expert.

2.3.5 SORTING AND DISPOSAL OF PHARMACEUTICALS

So long a drug/medicine is within the expiry date, it remains a drug and, once expires, the same becomes a waste, which need to be handled as carefully as other clinical waste. Different pharmaceuticals or drugs are to be sorted out depending on their various types and characteristics and Figure 2.6 is a typical guideline to dispose them. To ensure that a drug is still good to use, periodic check ups as to know paramedical staff in a hospital carries out their validity. A drug which is valid causes effective reactions and the same causes advert reactions after its expiry. So, a drug is curative when it is active and destructive when not. Pharmaceuticals, before being considered as waste, need to be classified (Manesh, 1996). Care should be taken to ensure that all groups are clearly marked and separated from each other. Useful unexpired pharmaceuticals (Group A) should be removed and sorted separately, preferably in another room or building. For pharmaceuticals, which are still suitable for use, the usual pharmaceutical dispensing norms should apply. When sorting the pharmaceuticals suitable for immediate use under no circumstances should the expired or defective products be considered for use.

Solids and semi-solids (Group B) should be removed from their outer packaging and placed in clean steel oil drums, for treatment according to the inertization/encapsulation procedure. Packaging should be disposed of as for non drug, non chemical materials. Intravenous solutions (Group C) should be gradually poured into the sewage system and the packaging and bottled disposed of as for non drug, non chemical materials. Ampoules (Group D) excluding antineoplastics and antibiotics) should be removed from their packaging, placed in a drum or bucket, and carefully crushed using a heavy block of wood. Aerosols (Group E) should be removed from packaging and disposed of in a landfill. Small inhaler aerosols may be disposed with solid and semi solid materials in steel drums. Packaging should be disposed of as non-drug, non-chemical material. Intravenous solutions (Group C) should be gradually poured into the sewage system and the packaging and bottled disposed of as for non-drug, non-chemical materials. Ampoules (Group D) excluding antineoplastics and antibiotics) should be removed from their packaging, placed in a drum or bucket, and carefully crushed using a heavy block of wood. Aerosols (Group E) should be removed from packaging and disposed of in a landfill. Small inhaler aerosols may be disposed with solid and semi solid materials in steel drums. Packaging should be disposed of as non-drug, non chemical material.

2.3.6 VEHICLES TRANSPORTING CLINICAL WASTE

Vehicles transporting clinical waste are different from other vehicles normally used to transport other wastes. These special adaptations are mainly due to keep the vehicles free from any leftovers, which may pose pathogenic. The main features of adaptations are its shape to have a fully closable structure and corners blunted so that no left overs are lodged and finally the inner body to be either stainless steel or lead (Ruth, 1990). The load compartment is to be fitted with a cooled ventilation system or if necessary,

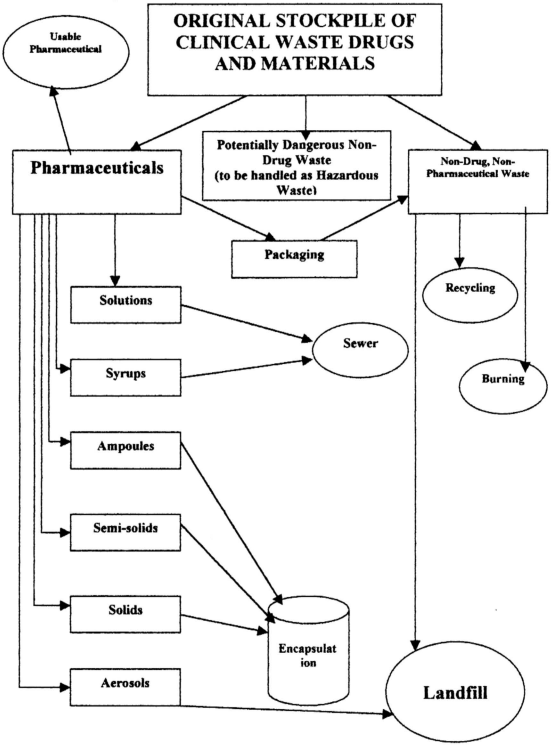


Fig: 2.6 Flowchart of clinical drug waste disposal
(Source: Rushbrook, 1997)

be refrigerated if clinical waste is to be transported over a long distance in hot climates. The vehicles shall be fitted with a spillage kit. The vehicles shall have load identification sign using the biological hazard label and the name and address of the haulier, together with his phone number, which must shown on the sides and rear of the vehicles.

2.3.7 TRANSPORT ON THE HIGHWAYS

Movement of clinical waste on a highway is scheduled and is monitored according to some pre-set guidelines. Deviations shall not be permissible on any circumstances unless it is absolutely necessary. Specific roads are chosen and many factors including time are considered when choosing the route. Time is also a factor and to which some importance is attached (Sudhakhar, 1993). The personnel moving are required to be well aware of managing any incident or accident, which might occur.

2.3.8 ALTERNATIVE METHODS FOR TREATING CLINICAL WASTES

Pyrolysis: The prolonged subjection of waste to intense heat at 500 - 1000° C in an atmosphere devoid of oxygen brings about chemical disintegration of waste. The waste is reduced to an elemental carbon with gas and oil residues, which can be utilised as a fuel (Larry, 1992).

Microwave technology: This entails the shredding of clinical waste followed by a high heat steam spray. The bacterial count having been reduced, the waste is then passed across a number of microwave power packs and the temperature is increased to at least 100°C for a prolonged period of time.. The technique is NOT appropriate for wastes from pathological laboratories or human or animal tissues (Larry, 1992)

Chemical Disinfection: This too involves the shredding of clinical wastes. They are then mixed with chemical disinfectants. The resulting liquids, including disinfectants, are released in sewers while the solid residues, drained of the disinfectants, are disposed of at landfill sites (Larry, 1992).

Gas Sterilization: This technique, practiced in America and other countries, entails putting the clinical waste in an airtight chamber, removing the air and adding to the waste a sterilizing agent such as formaldehyde or ethylene oxide. Gas then penetrates the waste and kills infectious bacteria. This is NOT considered to be a very satisfactory technique (Larry, 1992).

2.3.9 INCINERATION OF CLINICAL WASTE, WEIGHING AND ACCOUNTING

Incinerator is the place where the active pathogenic clinical wastes find its ways for a complete destruction. However, track records of its treatment have to be maintained even after the 'death' of a clinical waste (MOH Malaysia, 1992). The clinical waste collected from hospitals and health care establishments and institutions shall be delivered to the incineration facilities in wheeled bins. These bins, once unloaded, shall be weighed and their contents recorded. The weights shall be recorded on the clinical waste consignment note and a copy of which shall be supplied to the Department of Environment and the waste generator for collation and retention, once the waste has been disposed. The incineration facility operators shall be responsible for the receiving, weighing and documentation of waste and for the completion of the DOE Scheduled waste Consignment Note. Incinerator staff shall be responsible for all incinerator-related procedures. When wastes arrive at the incineration facility, the following procedures shall be performed (Saw, 1993):

- Scheduled waste Consignment Note from vehicle driver is collected.

- Clinical waste bins from the transport vehicle are unloaded and weighed. The number of clinical waste bins or receptacles shall be compared to the number quoted on the Scheduled waste Consignment Note. Any inconsistencies are to be recorded. The Scheduled waste Consignment Note ensures that all concerned parties have full records of all waste movements.

2.3.10 PATHOGENIC DESTRUCTION

A modern Incineration facility involves complex engineering of many disciplines. To ensure safe and reliable operation of the facility with minimal emissions to the environment, experienced personnel must operate an incineration plant. The responsible personnel at an incinerator need to act prudently to safeguard from undue happenings (Anon, 1995). To ensure a proper operation and to be in line with DOE and MOH Malaysia guidelines, the disembarking of clinical load at an incinerator should have the relevant Consignment Note and it complies with the description on the accompanying consignment and is packaged to standards as specified in the Ministry of Health Guidelines 1993.

Waste will be stored in containers located on well drained hard impervious flooring. The maximum amount of stored waste on any site is not to exceed the rated capacity of the disposal facility over a standard 48 hours period, unless stored under reduced temperature conditions (DOE Malaysia, 1996). Clinical wastes arriving at an incinerator plant undergo some major process apart from weighing and documenting. These process will only ensure that the waste is effectively incinerated or reduced or rendered pathogen free. The processes are: preheating, manual or automatic loading (if fitted), burn cycle, burn down and cool down (Martin, 1997). Incinerating clinical wastes requires the fluctuating heat quantity depending on the type of waste being incinerated. Certain items require a high heat value whereas other items may require less heat. These fluctuations need to be regulated (Kriton, 1992). Incinerator needs to be designed in such manner to accommodate fluctuations when burning different waste characteristics so that manual interference is not required every now and then during operation. Properly designed incinerator capable of accommodating fluctuations of waste qualities and characteristics is free from interference by climate and weather, too. (Pavoni, 1975). When the process of incineration takes place, a more efficient performance can be achieved by being prudent in feeding in. This

would save over stress as well time of the machinery and man handling the waste. In all the waste-to-heat process, the non-combustible materials can be recovered either before incineration in "front-end-recovery" or after incineration – the "back-end-recovery" (Allen, 1983).

After many considerations, incineration is chosen to be the ideal way of disposing clinical waste as it ensures maximum destruction of pathogenic elements. In addition, it also extensively reduces the waste volume by 90% compared to any other methods available currently. Many landfill operations will not accept even sterilized medical wastes and incineration is the only option (Stanley, 1980). The operations of small bio-medical incinerators are complicated by the variable and often unknown composition of the wastes. Usually the bags are fed into incinerator without opening and the operator may not know how well the contents will burn. The heat contents of the waste constituents may be as high as 20000 kcal/kg for polyethylene and 1000 kcal/kg for pathogenical wastes (Manahan, 1990).

2.3.11 MONITORING INCINERATOR EMISSIONS

Emissions of gas from the stacks of incinerator are factors of importance to concern environmentally. The gases contain dioxins and furons which need to be filtered before being reduced into the atmosphere. In order to achieve the limits prescribed by Department of Environment, various controlling methods are to be adopted. To adopt controlling measures, the out-flow or emissions are monitored. Monitoring intermittently is not encouraged whereas a Continuous Emission Monitoring (CEM) is considered to be ideal (Fred, 1996). It is worth noting that all in-situ gas analyzers (which include cross-stack analysers) which measure the composition of flue gases are done on a wet-gas basis. This means that they check the composition of the flue gas with the water vapour present. However, most emission limits are expressed on a dry-gas basis, which makes it necessary for the reading from in-situ analysers to be converted to a dry-gas equivalent before comparisons with the limits can be made.

It is also important to realise that there are few if any cross-stack CEM (Continuous Emission Monitoring) systems, with TUV Approval for Co or No analysis (Coleman, 1997). There is no doubt that extractive CEM analysers are easier and less expensive to maintain, check, calibrate and, should the need arise, repair.

2.3.12 DISPOSAL OF RESIDUES AND ASH

Fly ash resulting from the combustion process is removed from the gas scrubbing system. It frequently contains high concentrations of heavy metals. It may also contain dioxin and other toxic organic compounds. The assessment should identify control measures for safe working environment. Automatic dust handling procedures and the provision of ventilation and damping down are essential. The provision of protective clothing and suitable respirators will be necessary in addition to other control measures (Stephen, 1992). Fly-ash should be double bagged, and sealed for safe disposal. Containers, which are designed for the collection and transportation of residues, should be made from non-combustible materials, be able to withstand accidental impact, be provided with covers or lids and be securely locked during transportation. Yellow sacks should not be used for this purpose. Spillage should be cleaned up by use of a vacuum cleaner equipped with a filter, a wet system or similar suitable equipment. Dry sweeping of spillage should not be permitted (Derek, 1991).

2.3.13 NEEDLES AND SYRINGES DISPOSAL

MOH Malaysia (1991) under the Disinfection Policy, identified the following methods whereby the needles and syringes are disinfected before disposal by incineration, heat treatment, autoclave and other chemical disinfectants before landfilling are the four types of disinfecting (Fig 2.7).

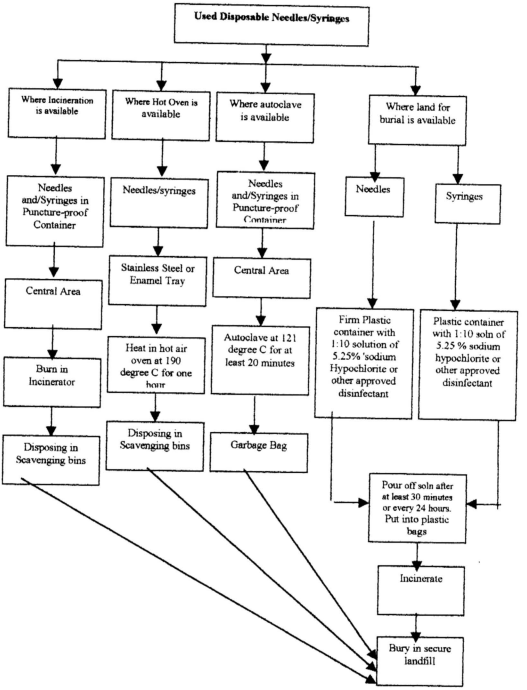


Fig 2.7 Disposal of syringes and needles

2.3.14 CLINICAL WASTE DISPOSAL METHODS

World Health Organization has given the following quick reference table (Table 2.7) of disposal of different clinical waste items:

Table: 2.7 Various disposal methods of clinical wastes

Pharmaceutical Substance/Form	Landfill	Encapsulation	Inertization	Sewer	High-temp incineration	Medium temp incineration	Chemical waste disposal	Chemical decomposition	Return to manufacturer
Solid	√	√	√		√	√			
Semi-solid		√	√		√	√			
Liquid Antibiotics				√	√	√			
		√	√		√	√		√	
Cytotoxics		√	√		√		√	√	√
Narcotics	√	√	√		√		√	√	
Flammable/ Reactive Damaged- Pressurized- Containers	√						√	√	
Aerosols	√								

(Source: Rushbrook, 1997)

Note:

- Narcotics should be first rendered unusable and then dispersed amongst municipal solid waste if disposed to a landfill
- Narcotics to be disposed under police supervision
- Higher Temperature Incineration includes clinical waste incinerators, cement kiln, iron foundries and power plants
- Inertization is a process where chemical catalysts are used to induce a reaction that renders the whole mass infective of its characteristics.

2.3.15 CLINICAL WASTE DISPOSAL PLAN

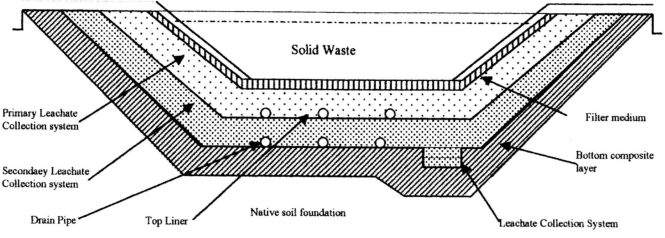
Managing clinical waste successfully remains with how far a integrated effort is carried out by various teams and departments. Hospital is the major generation point of clinical waste, rather the cradle of the waste. Hence, plans and proposals for successful management needs to hatch out here. More over, the remaining part of handling mostly depends on how efficiently a plan is drafted out in a Hospital (Paul, 1997). The Waste Disposal Officer shall be responsible for developing the Waste Disposal Plan using the statistics on waste arising and the reports prepared by other members of the Waste Management Team. The Disposal Plan should include the following items:

- Illustrations showing designated bag holder sites for every ward and department in the hospital.
- Illustrations showing the paths of waste collection trolleys through the hospital,

A timetable showing the frequency of collection, illustrations showing the site of the central storage for clinical waste, the type of bag holder to be used, the type of trolley, an estimate of the number of personnel, a definition of the responsibilities, an estimate of the numbers and costs of yellow and black required, definitions of duties and responsibilities, the procedures required for segregation, training courses and programmes and emergency procedures should also be available (Vandervalle, 1997).

2.3.16 SECURE LANDFILL

Landfill is the final point of disposal of clinical waste or the grave. Encapsulated in scavenger boxes, the clinical waste finally finds its way to a secure landfill (Fig 2.8) in the form of residues (Goddard, 1988). Sanitary landfill is a single process and a complete means of disposal. It does not require the subsequent rehandling of wastes as do incineration or composting, thereby reduces total cost of disposal (Rimberg, 1975). In practice every solid waste system is unique in characteristics and cost of disposal (Clayton and Huie, 1973).



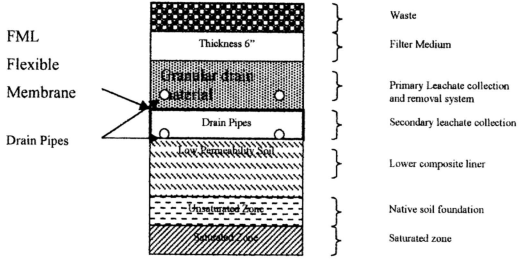


Fig.2.8 Cross sectional view of secure landfill
Source: Anon – 1989 Environmental Protection Agency - EPA 1989 (B) and 1991

Although landfilling is not considered to be an appropriate disposal option for untreated clinical waste, this method is likely to continue in use in Malaysia for some time, until sufficient incineration capacity is available (Anon, 1993).

For landfill site to take in any clinical waste, it must first be authorized by the regulating authority who should specify the type of clinical waste which can be accepted and any special operating procedure required. Landfill sites taking clinical waste must be operated to the highest standards. Clinical wastes can cause its significant risk to water resources even though most pathogens of concern will not survive for long in the thermophilic landfill environment. Leaching of organisms from clinical waste is likely to be significant during periods of heavy rainfall, so to provide complete reassurance, clinical waste should not go to landfill sites located near aquifers or near sources of water abstraction unless they are operated as containment sites (MOH Malaysia, 1993). Any landfill site used for the disposal of clinical wastes should be securely fenced. The site should be located far enough from any dwelling so that visual impacts are minimized.and, where possible, all deposits of clinical waste should be far enough from the public view to cause as little offence as possible. Clinical waste could be deposited in specially constructed cells and immediately covered with at least 0.5 meters of suitable cover material. It is undesirable for the daily intake of clinical waste to exceed more than 5 percent of the average daily domestic and non-hazardous industrial waste intake into the site (MOH Malaysia, 1994).

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 meters, half filling with the waste then covering with lime to within 0.5 m of the top before covering with soil to prevent any form of access by animals (MOH Malaysia, 1994). If the procedures are followed, then landfilling of clinical wastes should pose minimal health risk..

2.3.17 MEDICAL PROFESSIONALS

According to a New Straits Times (June 14, 1999) report based on the Health Ministry sources, the doctor to population ratio was 1:2153 in 1995 and this has improved to 1:2076 in the year 1996. The year 1997 had a ratio of 1:1521 and this has further improved to 1:1477 in 1998. The northern states of Peninsular Malaysia Perlis , Kedah , Pulau Pinang and Perak had a ratio of 1:1896, 1:1882, 1:1882 and 1:1061 respectively for the years 1995, 1996, 1997, 1998. Sabah and Sarawak have a current doctor and population ratio of 1:2585 and 1:4249 respectively. Kuala Lumpur has the best ratio of 1:345, which is a great leap from 1995 that stood at 1:529. The Government is planning to take drastic steps to improve the ratio by one doctor to every 800 people, for the whole of country by 2020.

The proposed increase planned by the government is indicative of providing more medical facilities. More medical facilities mean increased volume of clinical waste generation. In order to manage the steadily increasing clinical wastes, more qualified personnel in areas of environment and health may be needed towards achieving better clinical waste management.