NATIONAL OPEN UNIVERSITY OF NIGERIA

FACULTY OF HEALTH SCIENCES

COURSE CODE: EHS520

COURSE TITLE: BIOMEDICAL AND SPECIAL WASTE

COURSE GUIDE

EHS 520
BIOMEDICAL AND SPECIAL WASTE

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INTRODUCTION

EHS 520 titled "Biomedical and Special Waste" is a one (1) Unit course with four (4) Modules and Sixteen (16) Units.

Biomedical special waste refers to materials generated as a result of patient diagnosis, treatment, or immunisation of human beings or animals. Given the diversity of scientific opinions and interests of individuals, groups and agencies involved in the medical waste issue (e.g., physicians, health departments, hospitals, trade unions, state, and federal legislators), these differences are not surprising. However, in this chapter, we will be considering medical waste as a subset of hospital waste and continue to use biomedical waste in place of these descriptive terms.

WHAT YOU WILL LEARN IN THIS COURSE

In this course, you have the course units and a course guide. The course guide will tell you what the course is all about. It is general overview of the course materials you will be using and how to use those materials. It also helps you to allocate the appropriate time to each unit so that you can successfully complete the course within the stipulated time limit.

The course guide also helps you to know how to go about your Tutor-Marked Assignment which will form part of your overall assessment at the end of the course. Also, there will be regular tutorial classes that are related to this course, where you can interact with your facilitator and other students. Please, I encourage you to attend these tutorial classes.

COURSE AIM

This course aims to give you an in-depth understanding of Biomedical Special Waste. It is hoped that the knowledge will equip you with the necessary skill to excel in your examination and beyond.

COURSE OBJECTIVES

To achieve the aim set above, there are objectives. Each unit has a set of objectives presented at the beginning of the unit. These objectives will guide you on what to concentrate / focus on while studying the unit. Please read the objectives before studying the unit and during your study to check your progress.

The Comprehensive Objectives of the Course are given below. By the end of the course/after going through this course, you will be able to:

- Define the term Biomedical waste
- Explain the sources of hospital waste
- List the types of hospital waste
- Write on risk and non-risk waste
- Human health and Environmental concerns
- Waste disposal systems and the challenges.

WORKING THROUGH THIS COURSE

To successfully complete this course, you are required to read each study unit, read the textbooks materials provided by the National Open University.

Reading the referenced materials can also be of great assistance.
Each unit has self-assessment exercises which you are advised to do and at certain periods during the course you will be required to submit your assignment for the purpose of assessment.

There will be a final examination at the end of the course. The course should take you about 17 weeks to complete.

This course guide will provide you with all the components of the course how to go about studying and hour you should allocate your time to each unit so as to finish on time and successfully.

COURSE MATERIALS

The major components of the course are:

1. Course Guide
2. Study Units
3. Text Books
4. Assignment File
5. Presentation Schedule

STUDY UNITS

There are 16 study units and 4 modules in this course. They are as follows:

Module 1

Unit 1 Sources of Biomedical Special Waste
Unit 2 Types of Hospital Waste
Unit 3 Human Health and Environmental concerns
Unit 4 Biomedical Special Waste Processes

Module 2

Unit 1 Traditional (Crude) Biomedical Special Waste Disposal Methods
Unit 2 Sanitary Landfill
Unit 3 Incineration
Unit 4 Composting

Module 3

Unit 1 Other Methods/Technologies
Unit 2 Waste Minimisation/Reduction
Unit 3 Waste Recycling and Reuse (Waste to Wealth)
Unit 4 Integrated Biomedical Waste Management

Module 4

Unit 1 Field Sampling and Monitoring of Waste Sites
Unit 2 Effects of Biomedical Waste on the Environment and Health
Unit 3 Waste Transfer and Transport
Unit 4 Resources Recovery

There are activities related to the lecture in each unit which will help your progress and comprehension of the unit. You are required to work on these exercises which together with the TMAs will enable you to achieve the objectives of each unit.

PRESENTATION SCHEDULE

There is a time-table prepared for the early and timely completion and submissions of your TMAs as well as attending the tutorial classes. You are required to submit all your assignments by the stipulated time and date. Avoid falling behind the schedule time.

ASSESSMENT

There are three aspects to the assessment of this course.
The first one is the self-assessment exercises. The second is the tutor marked assignments and the third is the written examination or the examination to be taken at the end of the course.

Do the exercises or activities in the unit by applying the information and knowledge you acquired during the course. The tutor-marked assignments must be submitted to your facilitator for formal assessment in accordance with the deadlines stated in the presentation schedule and the assignment file.

The work submitted to your tutor for assessment will count for 30% of your total course work.

At the end of this course, you have to sit for a final or end of course examination of about a three hour duration which will count for 70% of your total course mark.

TUTOR-MARKED ASSIGNMENT

This is the continuous assessment component of this course and it accounts for 30% of the total score. You will be given Three (3) TMAs by your facilitator to answer. The three of which must be answered before you are allowed to sit for the end of course examination.

These answered assignments are to be returned to your facilitator.

You're expected to complete the assignments by using the information and material in your readings, references and study units.

Reading and researching into you references will give you a wider via point and give you a deeper understanding of the subject.

1. Make sure that each assignment reaches your facilitator on or before the deadline given in the presentation schedule and assignment file. If for any reason you are not able to complete your assignment, make sure you contact your facilitator before the assignment is due to discuss the possibility of an extension. Request for extension will not be granted after the due date unless there in exceptional circumstances.

2. Make sure you revise the whole course content before sitting or the examination. The self-assessment activities and TMAs will be useful for this purposes and if you have any comment please do before the examination. The end of course examination covers information from all parts of the course.

COURSE MARKING SCHEME

Assignment	Marks
Assignments 1 – 3	three marks of the each–30% of course
End of course examination	70% of overall course marks
Total	100% of course materials.

FACILITATORS/TUTORS AND TUTORIALS

Sixteen (16) hours are provided for tutorials for this course. You will be notified of the dates, times and location for these tutorial classes.

As soon as you are allocated a tutorial group, the name and phone number of your facilitator will be given to you.

These are the duties of your facilitator: He or she will mark and comment on your assignment. He will monitor your progress and provide any necessary assistance you need. He or she will mark your TMAs and return to you as soon as possible.

(You are expected to mail your tutored assignment to your facilitator at least two days before the schedule date).

Do not delay to contact your facilitator by telephone or e-mail for necessary assistance if you do not understand any part of the study in the course material. You have difficulty with the self assessment activities. You have a problem or question with an assignment or with the grading of the assignment.

It is important and necessary you acted the tutorial classes because this is the only chance to have face to face content with your facilitator and to ask questions which will be answered instantly. It is also period where you can say any problem encountered in the course of your study.

SUMMARY

According to the Environmental Protection Agency (EPA) and Centre for Disease Control and Prevention (CDC, 2003), hospital waste refers to all waste, biological or non-biological, that is discarded and not intended for further use. Medical waste refers to materials generated as a result of patient diagnosis, treatment, or immunisation of human beings or animals. Given the diversity of scientific opinions and interests of individuals, groups and agencies involved in the medical waste issue (e.g., physicians, health departments, hospitals, trade unions, state, and federal legislators), these differences are not surprising. However, in this chapter, we will be considering medical waste as a subset of hospital waste and continue to use biomedical waste in place of these descriptive terms.

Finally, you are expected to apply the knowledge you have acquired during this course to your practical life.

I wish you success in this course.

MAIN COURSE

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MODULE 1

UNIT 1 SOURCES OF BIOMEDICAL SPECIAL WASTE

CONTENTS

1.0 INTRODUCTION

Efficient handling and management of medical waste is a major problem globally because of growing populations and increasing medical attention at various health facilities that are generating more and more waste in the environment. More than half of the nations of the world, at the least, are experiencing environmental challenges associated with waste disposal. Unlike hazardous industrial waste which is normally encountered outside urban settlements, biomedical waste is relatively closer to residential zones due to the location of clinics, pharmacies, and hospitals in the heart of many cities.

It has been shown that this waste can be washed down and thus and its way into rivers, streams and underground water, which could lead to epidemics of water-borne diseases and influence the increase of multiple drug-resistant pathogens in the communal water supply. Direct contact of contaminated waste with sharp edges such as needles and broken vials capable of damaging the skin and introducing infectious agents are some of the risks associated with improper disposal of waste from medical sources. Waste workers and rag pickers who rummage through all kinds of waste material while trying to salvage items for sale are often the worst affected in the process. They may be exposed to poisonous materials and infectious objects and so are often in danger of serious infections and diseases such as hepatitis, plague, cholera, etc., which pose grave health risks.

Some of the major reasons for the ineffective management and control of biomedical waste in many countries are financial and technological constraints, and lack of education and proper training of personnel on duty. Many countries still facing biomedical waste challenges today are largely the developing ones due to their slow pace in technological advancement and civic development. Although developed countries are not often left out of this dire situation, the frequency of occurrence is far lower than in developing countries.

2.0 OBJECTIVE

By the end of this unit, you will be able to:

- define the term Biomedical waste.

3.0 MAIN CONTENT

3.1 Definition of the Term Biomedical Waste

Several studies and reports on health-care-related waste have emerged on the issue of hospital waste and its management; as a result, many conflicting opinions have come up regarding the acceptance of definitions for specific terms associated with this topic, for example, regulated medical waste, infectious waste, bio-hazardous waste, and biological waste. Unfortunately, there are no universally agreed definitions for "hospital waste" and "medical waste." According to the Environmental Protection Agency (EPA) and Centre for Disease Control and Prevention (CDC, 2003), hospital waste refers to all waste, biological or non-biological, that is discarded and not intended for further use.

Medical waste refers to materials generated as a result of patient diagnosis, treatment, or immunisation of human beings or animals. Given the diversity of scientific opinions and interests of individuals, groups and agencies involved in the medical waste issue (e.g., physicians, health departments, hospitals, trade unions, state, and federal legislators), these differences are not surprising. However, in this chapter, we will be considering medical waste as a subset of hospital waste and continue to use biomedical waste in place of these descriptive terms.

3.2 Sources of Biomedical Waste

There are different sources of waste generated from the biomedical point of view. It is important to stress that the hospital is not the only source of biomedical waste; there are other health-care facilities of significant concern. As said earlier, hospital waste refers to biological and non-biological waste that is disposed of and is no longer intended for further use in the hospital. Although hospitals are considered the primary generators of waste by volume, there are also several nonhospital facilities that generate waste. There are numerous private dentists' and private physicians' offices, medical clinics, veterinarian centers, and medical laboratories that generate hazardous and infectious medical waste across the globe. Some of these sites generate medical waste faster than certain hospitals because of the frequency of which people patronize them and because most of them do not possess an efficient system for waste management. Hence they contribute largely to the improper disposal of waste. There are currently no reliable data on the quantity of waste generated by these nonhospital centers but their role in waste generation cannot be underestimated.

4.0 CONCLUSION

Several studies and reports on health-care-related waste have emerged on the issue of hospital waste and its management; as a result, many conflicting opinions have come up regarding the acceptance of definitions for specific terms associated with this topic, for example, regulated medical waste, infectious waste, bio-hazardous waste, and biological waste. Unfortunately, there are no universally agreed definitions for "hospital waste" and "medical waste." According to the Environmental Protection Agency (EPA) and Centre for Disease Control and Prevention (CDC, 2003), hospital waste refers to all waste, biological or non-biological, that is discarded and not intended for further use. Medical waste refers to materials generated as a result of patient diagnosis, treatment, or immunization of human beings or animals.

5.0 SUMMARY

Biomedical waste refers to all waste, biological or non-biological, that is discarded and not intended for further use. Medical waste refers to materials generated as a result of patient diagnosis, treatment, or immunisation of human beings or animals. Given the diversity of scientific opinions and interests of individuals, groups and agencies involved in the medical waste issue (e.g., physicians, health departments, hospitals, trade unions, state, and federal legislators), these differences are not surprising. However, in this chapter, we will be considering medical waste as a subset of hospital waste and continue to use biomedical waste in place of these descriptive terms.

6.0 TUTOR-MARKED ASSIGNMENT

1. Differentiate between hospital waste and medical waste.

7.0 REFERENCES/FURTHER READING

Altaf. A., Janjua, N. Z., Aamir, J. K., Mujeeb, S. A. & Samad, L. (2004). An assessment of the quality of syringes in Pakistan. Study conducted by safe injection network, Karachi, Pakistan funded by World Health Organization, 30 p.

Altaf, A. and Mujeeb, S. A. (2002). Unsafe disposal of medical waste: A threat to the community and environment. Journal of Pakistan Medical Association 56(2): 232–233.

UNIT 2 TYPES OF HOSPITAL WASTE

CONTENTS

1.0 INTRODUCTION

Normally, waste is mostly categorized based on the risk it holds. Different authors, scientists, observers, and regulatory bodies have classified medical waste in various ways and from different perspectives. The classification is (i) based on their form or state, that is, solid or liquid form, (ii) based on their sources, and (iii) some focused on their potential risk to the public.

2.0 OBJECTIVE

By the end of this unit, you will be able to:

- discuss term Hospital waste and its various types.

3.0 MAIN CONTENT

3.1 Types of Hospital Waste

Normally, waste is mostly categorised based on the risk it holds. Different authors, scientists, observers, and regulatory bodies have classified medical waste in various ways and from different perspectives. The classification is (i) based on their form or state, that is, solid or liquid form, (ii) based on their sources, and (iii) some focused on their potential risk to the public. The Ministry of Environment and Forests in India and other regulatory bodies have also described 10 categories of biomedical waste. These categories cover all the types of waste that are generated in all medical facilities including hospitals, which are known to generate the highest amount of waste. All these classifications are mostly based on what is usually obtained in each country or geographical zone. However, the definitions and classifications of the regulatory authorities of how a particular waste should be classified or handled, treated and disposed are usually adopted because of the serious ramifications involved. All categories and classifications of medical waste can be seen to generally fall into two main broad types: risk and non-risk waste.

3.2 Risk Waste and Non-Risk Waste

Risk Waste

Risk waste consists of several aspects of hospital and other biomedical wastes considered dangerous to the public because of the presence of certain components with the intrinsic ability of spreading infections or causing harm to the community. Risk waste may be sub-divided into many categories, but it is important to note that each category is unique in its components, sources, and the potential hazard it may cause. We shall be discussing below the subdivisions of risk waste.

Infectious Waste

Infectious waste is a biomedical waste that has been previously contaminated with any type of pathogen with sufficient virulence capable of infecting a susceptible host thereby resulting in an infectious disease. This includes bacteria, virus, parasite, or fungi that are capable of causing infection or spread of infectious diseases in the community. Some believe that infectious waste could just be classified as any waste with the presence of micro-organisms.

However, this approach needs careful consideration because certain factors are necessary for waste to be actually termed infectious. It is important for waste to harbor pathogenic micro-organisms with virulence capabilities and in sufficient amount of dosage required for infection in a susceptible host. Such waste can be termed infectious.

Pathological Waste

This includes anatomical waste from human and animals usually generated from hospitals and veterinary hospitals. Examples include blood, body parts such as amputated legs or arms, placenta, and tissues. They are potentially dangerous with a high risk of disease and infection in a susceptible individual who has direct contact with them.

Microbiological/Clinical Waste

This is closely related to pathological waste in terms of high risk but the contents are quite different from pathological waste. It is usually generated from laboratories during the course of experiments and clinical trials. Examples include human and animal cell cultures from clinical experiments, microorganisms, blood collection tubes, body fluid, drainage bags, vials, used culture dishes, and other materials that were previously in contact with infectious agents.

Sharps

Sharps consist of both used and unused sharp objects such as hypodermic needles, syringes, scalpels, broken ampoules, and glassware. They are considered highly dangerous because they are not only capable of causing punctures and cuts on the skin but they also harbor dangerous pathogenic bacteria, which may be introduced into the body via wounds or punctures. Sharps are usually generated in the operation theatre where surgical activities are carried out. Other areas where they are generated include all wards and laboratories.

Pharmaceutical Waste

Under normal circumstances, pharmaceutical waste constitutes a very low percentage (3%) of medical waste. However, the unsafe disposal of such items may pose a significant threat. Pharmaceutical waste is generated by various means but not limited to the following: chemicals, substandard and expired drugs, preparations of drugs added to an intra-venous solution, pharmaceutical products such as drugs. It is very important to note that pharmaceutical waste does not include empty glass ampoules, drugs, and other metabolic products excreted by patient undergoing therapy, empty pills bottles or strip packages from where the drug/capsules have been previously removed.

Chemical Waste

Chemical waste materials include those that are generated during the production of biological preparations such as disinfectants and insecticides, in medical, dental, and veterinary laboratories.

Radioactive Waste

These are solid, liquid, or gaseous forms of waste generated from the medical or research use of radiology, radionuclide (e.g., during radioimmunoassay), and other radiological procedures which are capable of emission of radiation at above the level set by regulatory authorities as exempt. Examples are found in nuclear medicine treatments, cancer related therapies, and medical devices that use radioactive isotopes.

Cytotoxic and Genotoxic Wastes

These include unused cytotoxic drugs, solid materials such as sharp objects, tissues, IV bags, and any other items which may have come into contact with a cytotoxic drug and/or carcinogenic matter.

Non-Risk Waste

Non-risk waste is general waste that is generated within hospitals and they are similar to municipal waste from a normal home. They are considered non-infectious and non-hazardous and are generated by almost everyone in the hospital. Non-risk waste includes office waste, food waste, that is, leftover food, fruits, vegetables, etc., aerosols, as well as non-infectious, non-anatomical waste from patient care areas (i.e., disposable diapers, pads, papers, cartons, gloves, trays, catheters/bags (empty), and casts).

4.0 CONCLUSION

Different authors, scientists, observers, and regulatory bodies have classified medical waste in various ways and from different perspectives. The classification is (i) based on their form or state, that is, solid or liquid form, (ii) based on their sources, and (iii) some focused on their potential risk to the public. The Ministry of Environment and Forests in India and other regulatory bodies have also described 10 categories of biomedical waste.

5.0 SUMMARY

Risk waste consists of several aspects of hospital and other biomedical wastes considered dangerous to the public because of the presence of certain components with the intrinsic ability of spreading infections or causing harm to the community. Risk waste may be sub-divided into many categories, but it is important to note that each category is unique in its components, sources, and the potential hazard it may cause. While Non-risk waste is general waste that is generated within hospitals and they are similar to municipal waste from a normal home. They are considered non-infectious and nonhazardous and are generated by almost everyone in the hospital. Non-risk waste includes office waste, food waste, that is, leftover food, fruits, vegetables, etc., aerosols, as well as non infectious, non anatomical waste from patient care areas (i.e., disposable diapers, pads, papers, cartons, gloves, trays, catheters/bags (empty), and casts).

6.0 TUTOR-MARKED ASSIGNMENT

1. Differentiate between Risk and Non-risk waste.
2. List five subdivisions of the risk waste.

7.0 REFERENCES/FURTHER READING

Barek, J. and Castegnaro, M. (1998). Chemical degradation of wastes of antineoplastic agents amsacrine, azathioprine, asparaginase and thiotepa. The Annals of Occupational Hygiene. 42**(4)**: 259–266.

Batterman, S. (2004). Assessment of Small-Scale Incinerators for HealthcareWaste. WHO, Geneva, 69 pp.

UNIT 3 HUMAN HEALTH AND ENVIRONMENTAL CONCERNS

CONTENTS

1.0 INTRODUCTION

Inefficient handling and management of medical waste may lead to problems such as spread of disease and infections, environmental pollution, etc., and the groups of people at the highest risk of such encounters are health-care staff, rag pickers and scavengers, municipal workers, and the public. Several ways in which medical waste pose dangers to the public shall be discussed below.

2.0 OBJECTIVE

By the end of this unit, you will be able to:

- discuss Human Health and its Environmental concerns.

3.0 MAIN CONTENT

3.1 Definition of Term

Ensuring safe public health and a clean environment in the face of improper medical waste disposal is of great significance. While there are studies indicating unavailability of data to show the direct evidence of the harm done by the mishandling of medical waste, the dangers associated with these occurrences are obvious. Inefficient handling and management of medical waste may lead to problems such as spread of disease and infections, environmental pollution, etc., and the groups of people at the highest risk of such encounters are health-care staff, rag pickers and scavengers, municipal workers, and the public. Several ways in which medical waste pose dangers to the public shall be discussed below.

Spread of Infection and Disease

As discussed earlier in the previous section, medical waste often contains certain materials that are termed "infectious." Some of these materials have been discussed in the previous sections. There is a strong evidence of transmission of certain infectious agents such as blood-borne pathogens via medical waste. It has been estimated that the chances of infection after a needle-stick injury from a contaminated syringe is 0.3% for HIV, 1.8% for hepatitis C but 30% for hepatitis B. The hepatitisB virus is very persistent in dry air and can survive for several weeks on a surface, brief exposure to boiling water and to some antiseptics, including 70% ethanol. An infective dose of hepatitis B or C virus can survive for up to a week in a blood droplet trapped inside a hypodermic needle. Due to unsafe medical waste management, there is risk of the spread of such an infection, which may affect those in-house as well as the surrounding population.

There are other notorious bacteria living as opportunistic pathogens such as *Pseudomonas aeruginosa* and *Acinetobacter baumannii* that are commonly found adhering to medical devices, for example, hypodermic needles, blades, etc., and capable of causing serious infections in immunocompromised individuals. The presence of these and many more pathogens can pose a serious threat to the public especially during cases of injury from sharps such as needles, blades, etc., that are easily found littering places where medical waste is dumped. Waste recycling is an important activity with many benefits. It helps in the protection of the environment against pollution, production of biogas through anaerobic digestion processes, composting, and so on.

Normally, medical waste is often excluded from municipal waste that is meant for recycling. Cases whereby recycling facilities becomes hazardous usually occur whenever medical waste enters the mix. Unauthorised sweepers and rag pickers who scavenge waste sites for disposable items such as bottles, hypodermic needles, blades, etc., often cause such unfortunate occurrences. They process these untreated items either by granulation or making them into other products, or by washing and repackaging them for resale. Rag pickers and sweepers with such practices are common in many parts of the world with particular reports in Asian countries with large populations, for example, India, Pakistan, Bangladesh, as well as some African countries, for example, South Africa. These activities are dangerous and can constitute a major threat to the public and cause the spread of infection among susceptible individuals who may by chance get into contact with these recycled items.

The possibility of transference of disease and infection from animals to humans (zoonosis) is well established. The spread of infection and disease through vectors such flies, mosquitoes, insects, as well as mammals, such as monkeys and bats, has been well documented.
According to the UK Health and Safety Executive (2000), there are approximately 40 zoonotic diseases in the United Kingdom of which salmonella and influenza (avian flu and H1N1) are among the notable ones. Animals, such as dogs, cats, rats, cattle, goats, birds, and even elephants, are usually found roaming waste sites looking for something to eat. These animals face a grave danger of contracting diseases such as tuberculosis, anthrax, and other infections which may possibly be transferred to humans who consume their meat.

However, the extent to which they can spread infection has not been extensively reported.

Spread of Resistant Pathogen

Antibiotic-resistant bacteria pose an enormous risk to global health because they are responsible for the failure of treatment in many hospitals. Inadequate waste management from the hospital, especially in waste that contains pathogenic organisms, can affect the environment in a number of ways. Firstly, they affect the flora and fauna by increasing the pathogenic strains of hospital origin and decreasing the commensals that contribute beneficially to the ecosystem. Secondly, they pose great risk to the public because hospital waste harboring resistant nosocomial bacteria that are found at waste dumping sites can contaminate the groundwater, streams, and rivers via flooding thereby making such water unfit for drinking. There have been reports of groundwater contaminated with drug resistant Gram-negative bacteria such as *Escherichia coli, Klebsiella pneumoniae, Enterobacter spp.,*etc. Most of these isolated bacteria are commonly encountered in hospitals. Another significant way by which the environment and public health is affected is through the spread of resistance genes. Certain bacteria are known to easily acquire resistance genes via plasmids and integrons through their interaction with other resistant bacteria of the same or different genera in the environment, this is called horizontal gene transfer. Many bacterial resistant genes that are widely disseminated across the globe are mostly of hospital origin. Antibiotic-resistant bacteria are a pressing global health concern. Over the last three decades several types of bacteria have emerged with different resistance genes causing therapeutic failure among individuals that are infected. Recently, other bacteria with a new gene called New Delhi Metallo β-lactamase have emerged from India and have been detected in more than 13 countries in Europe, Asia, North America, the Middle East, and Africa. The gene was initially isolated from a hospital patient from India and has since been predominantly found among people who had previously been to India or Pakistan.

Dangers to the Public

The public is also at risk of activities associated with inefficient medical waste management in society. Developing countries where people do not have effective water supply are in great danger of consuming water that is already contaminated with bacteria washed from waste sites. These can result to development of sickness and ailments such as tuberculosis, typhoid, and other water borne diseases. The role of rag pickers and scavengers, who assist unscrupulous recyclers in the repackaging of medical equipment such as syringes, hypodermic needles, expired drug, and other waste medical items for resale, also contribute immensely to the dangers to the public. They end up selling such material to small pharmacies patronised by members of the public who may be asked to provide their own syringes, needles, and even drugs. Anyone involved in these unfortunate scenarios are at high risk of contracting disease and infection. Many of such cases of outbreak of diseases have been reported in countries such as India where doctors are blamed for reusing syringes and also transacting in second-hand syringes.

4.0 CONCLUSION

Developing countries where people do not have effective water supply are in great danger of consuming water that is already contaminated with bacteria washed from waste sites. These can result to development of sickness and ailments such as tuberculosis, typhoid, and other water borne diseases. The role of rag pickers and scavengers, who assist unscrupulous recyclers in the repackaging of medical equipment such as syringes, hypodermic needles, expired drug, and other waste medical items for resale, also contribute immensely to the dangers to the public. They end up selling such material to small pharmacies patronized by members of the public who may be asked to provide their own syringes, needles, and even drugs.

5.0 SUMMARY

Ensuring safe public health and a clean environment in the face of improper medical waste disposal is of great significance. While there are studies indicating unavailability of data to show the direct evidence of the harm done by the mishandling of medical waste, the dangers associated with these occurrences are obvious. Inefficient handling and management of medical waste may lead to problems such as spread of disease and infections, environmental pollution, etc., and the groups of people at the highest risk of such encounters are health-care staff, rag pickers and scavengers, municipal workers, and the public.

6.0 TUTOR-MARKED ASSIGNMENT

1. List three ways in which medical waste pose dangers to the public.

7.0 REFERENCES/FURTHER READING

Brown, J. (1993). Hospital waste management that saves money--and helps the environment and improves safety. Regulatory analyst. Medical waste, 1(10): 1–3.

Biomedical Waste Centers for Disease Control and Prevention (2003).

Guidelines for environmental infection control in health-care facilities: Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). MMWR 52: 1–4.

UNIT4 BIOMEDICAL SPECIAL WASTE MANAGEMENTPROCESSES

CONTENTS

1.0 INTRODUCTION

Waste (also known as rubbish, trash, refuse, garbage, junk, litter) is unwanted or useless materials. In biology, waste is any of the many unwanted substances or toxins that are expelled from living organisms; such as urea, sweat or faeces. Litter is waste which has been disposed of improperly.

Waste is directly linked to human development, both technologically and socially. The compositions of different wastes have varied over time and location, with industrial development and innovation being directly linked to waste materials. An Example of this include plastics and nuclear technology. Some components of waste have economical value and can be recycled once correctly recovered.

There are many waste types defined by modern systems of waste management, notably including:

- Municipal Waste includes household waste, commercial waste, demolition waste
- Hazardous Waste includes Industrial waste
- Bio-medical Waste includes clinical waste
- Special Hazardous waste includes radioactive waste, Explosives waste, E-waste

Waste is sometimes a subjective concept, because items that some people discard may have value to others. It is widely recognised that waste materials are a valuable resource, whilst there is debate as to how this value is best realised. Such concepts are colloquially expressed in western culture by such idioms as "One man's trash is another man's treasure."

2.0 OBJECTIVE

By the end of this unit, you will be able to:

- define the term waste and its management processes.

3.0 MAIN CONTENT

3.1 Sources of Waste

Sources of Waste
Everything on the planet earth, living or non-living has its source, waste is not an exception. On volumes or mass.

i) Domestic
ii) Industrial
iii) Commercial
iv) Agricultural
v) Construction
vi) Mining

Taxonomically, waste can be categorized in terms of state of matter i.e: solid, liquid and gaseous.

Also, it can be toxic, hazardous or volatile. A typical solid domestic waste will consist of paper, glass, plastic, metals, textiles, woods, vegetables etc. liquid waste include gey water, kitchen sludges, oils, grease while gaseous include CH_4, CO_2, CO, aerosols.

Identification of waste source helps in giving proper nomenclature to waste. It also helps in identification of the required collection, storage, transportation and disposal. Similarly, analysis of waste involves quantification in volumes or mass.

3.2 Waste Management Process

Waste managementis the collection, transport, processing, recycling or disposal, managing and monitoring of waste materials. The term usually relates to materials produced by human activity, and is generally undertaken to reduce their effect on health, the environment or aesthetics. Waste management is also carried out to recover resources from it. Waste management can involve solid, liquid, gaseous or radioactive substances, with different methods and fields of expertise for each.

Waste management practices differ for developed and developing nations, for urban and rural areas, and for residential and industrial producers. Management for non-hazardous waste residential and institutional waste in metropolitan areas is usually the responsibility of local government authorities, while management for non-hazardous commercial and industrial waste is usually the responsibility of the generator.

Integrated waste management

Integrated waste management using LCA (life cycle analysis) attempts to offer the most benign options for waste management. For mixed MSW (Municipal Solid Waste) a number of broad studies have indicated that waste administration, then source separation and collection followedby reuse and recycling of the non-organic fraction and energy and compost/fertilizer production of the organic waste fraction via anaerobic digestion to be the favoured path.

Waste Storage

Storage of waste takes place at the spot where the waste is generated. Domestic refuse is normally stored continually in a container or sack until collected. The daily production is usually stored inside until it is carried outside for collection. There can be 1 unit/household or per several households, or local communal collection points where garbage is emptied in a bin or container. In some developing countries, old oil barrels, concrete tubes and other improvised enclosures may be used for storage often without any systematized garbage collection taken place. Industry and business often have their own systems with relatively large storage units.

Some factories run large refuse heaps on the factory's premises without any form of regular collection. Containers used as storage units are common for a great many industries and outside large market places.

Waste Collection

Collection of waste generally take place by loading from the storage containers unto a vehicle e.g. hand-cart (simple), donkey-cart (complex), tractor with trailer (sophisticated), special garbage truck. The garbage is usually collected and emptied by the crew of the vehicle (garbage collectors) but in some cases, collectors make a sound signal in which members come and empty their garbage into the vehicle.

Collection requires passable routes and the choice of technology must be adapted to the existing quality of roads, streets and settlement.

A simple cart can often be more useful than a modern garbage truck and labour intensive method, more efficient than modern mechanized ones. The choice of technology should also be considered on the basis of available facilities for maintenance. In some places, tractors ordinarily used for agricultural purposes have proved useful for collection and transportation of waste.

Moreover, in agricultural areas where tractors are sued, there is often a food infrastructure with garages available spare parts. Where there is systematic collection, small scale industries and businesses are usually included. Major manufacturing industries producing large amount of waste usually run their own system for collection and transport.

Collections of liquid waste (sludge) from waste water treatment plants require separate collection routes.

Also, gaseous wastes are often collected through emission pipes (stacks) to be emitted into the atmosphere.

4.0 CONCLUSION

Waste management practices differ for developed and developing nations, for urban and rural areas, and for residential and industrial producers. Management for non-hazardous waste residential and institutional waste in metropolitan areas is usually the responsibility of local government authorities, while management for non-hazardous commercial and industrial waste is usually the responsibility of the generator.

5.0 SUMMARY

Waste management is the collection, transport, processing, recycling or disposal, managing and monitoring of waste materials. The term usually relates to materials produced by human activity, and is generally undertaken to reduce their effect on health, the environment or aesthetics. Waste management is also carried out to recover resources from it. Waste management can involve solid, liquid, gaseous or radioactive substances, with different methods and fields of expertise for each.

6.0 TUTOR-MARKED ASSIGNMENT

1. Define the term waste.
2. List five sources of waste.

7.0 REFERENCES/FURTHER READING

Chauhan, M. S. and Kishore, M. (2002). Existing solid waste management inhospitals of Indore city. *Indian Journal of Environment and Science* 6: 43–49.

Collins, C. H. and Kennedy, D. A. (1992). The microbiological hazards of municipal and clinical wastes. *Journal of Applied Bacteriology*. 73: 1–6.

MODULE 2

UNIT 1 TRADITIONAL/CRUDE BIOMEDICAL WASTE DISPOSAL

CONTENTS

1.0 INTRODUCTION

The traditional methods of biomedical waste disposal in most Nigerian communities and cities include but is not limited to the following: - barging into the waters (streams, rivers and sea), open dumping on land, crude or open air burning, feeding of hogs or other animals, burying etc.

2.0 OBJECTIVE

By the end of this unit, you will be able to:

- explain the term traditional/crude method of biomedical waste management.

3.0 MAIN CONTENT

3.1 Definition of Term

In our earlier discussions of biomedical waste concept, we noted that the history of waste is closely tied to the varied activities undertaken by man on earth. Hence solid waste disposal has been part of our development and history. What actually have continued to change are the improvements in the techniques and benefits of biomedical waste management.
The traditional methods of biomedical waste disposal in most Nigerian communities and cities include but is not limited to the following: - barging

into the waters (streams, rivers and sea), open dumping on land, crude or open air burning, feeding of hogs or other animals, burying etc.

Burial of Solid Waste

This would have been a good method of solid waste disposal as it tends to obey natural process of returning materials especially organic matter content to the soil. However, burial can only be applied to smallest quantities of solid waste and even at that it is still cost and labour intensive.

Advantages of Burial Method

- It encourages the recycling mineral elements and natural energy resources
- It may increase soil fertility
- It is eco-friendly
- It can be handled at household level
- It does not require skilled labour for operation.

Disadvantages

- It is laborious
- It is not suitable for scale up operations
- It is costly to apply
- It may lead to contamination of land and water resources
- It is not sustainable.

Open Dumping (Crude Tipping)

This method involves the indiscriminate dumping of solid waste without adequate consideration to their environmental and health effects. Most of the municipal solid waste in developing countries is dumped on land in a more or less uncontrolled manner. Those dumps make very uneconomical use of the available space and often produce unpleasant and hazardous smoke from slow-burning fires.

The present disposal situation is expected to deteriorate even more as, with rapid urbanisation, settlements and housing estates encircle existing dumps and the environmental degradation associated with the dumps directly affects the population. Waste disposal sites are, therefore, also subject to growing opposition, and it is becoming increasingly difficult to find new sites that meet public approval and are located a reasonable distance from the collection area.

Advantages Open Dumping

- It is cheap to operate

- It requires little or no planning
- It does not utilise skilled labour in operation.

Disadvantages

- It produces objectionable odours and it is also unsightly
- It can lead to fire accidents
- It provides ideal breeding places for rats and vermin
- It can lead to fire and physical accident
- It is not sustainable and eco-friendly
- Ground water and run off pollution.

Dumping into Water Bodies (Barging into the Sea)

This is a method popular in riverine communities but is now in abuse getting popular in unplanned areas of our major cities in the country.

Riverine communities with inadequate arable lands use canoes and barges to carry solid waste far into the sea for disposal. However, it is not uncommon to find in Nigerian semi-urban and crowded urban settlements people who dump solid waste directly into small streams as disposal system.

Dumping of solid waste into water bodies is not a good practice as the wastes not only provide nutrients in the water bodies leading to the condition called eutrophication. This causes high oxygen crises for aquatic species and makes the water unsuitable for drinking and other domestic uses.

Advantages Dumping into Water Bodies

- It is almost cost free
- It is a final disposal method as the waste is not amenable to further handling
- It is free of odour nuisance
- It takes care of large volume of solid waste
- It encourages aqua culture when applied to appropriate
- It is convenient to operate.

Disadvantages

- It is a source of water pollution
- It can lead to destruction of aquatic life instead of promoting aquaculture
- It often constitutes grave nuisances as refuse are swept back to the shore either due to wind or water wave action.

Open Air Burning

This involves the ignition of waste matter in the open from which the products of the combustion are emitted directly into the air without passing through a stack of chimney filter. Open burning can be done in open drums or metal baskets, in fields or yards and in large open sites. Materials commonly disposed of in this manner in some Nigeria cities today includes municipal waste, automobile scrap components, landscape wood, refuse, agricultural field waste, bulky industrial waste, scrap furniture and leaves with other materials raked during street cleaning.

Open burning has been practiced by a number of urban centres because it reduces the volume of refuse received at the dump and therefore extends the life of their dumpsite.

Garbage may be burnt because of the ease and convenience of the method or because of the cheapness of the method. In countries where house holders are required to pay for garbage disposal, burning of waste in the backyard allows the householder to avoid paying the costs associated with collecting, hauling and dumping the waste.
Open burning has many negative effects on both human health and the environment. This uncontrolled burning of garbage releases many pollutants into the atmosphere.

These include dioxins, particulate matter, polycyclic aromatic compounds, volatile organic compounds, carbon monoxide, hexachlorobenzene and ash. All of these chemicals pose serious risks to human health. The dioxins are capable of producing a multitude of health problems; they can have adverse effects on reproduction, development, disrupt the hormonal systems or even cause cancer. The polycyclic aromatic compounds and the hexachlorobenzene are considered to be carcinogenic. The particulate matter can be harmful to persons with respiratory problems such as asthma or bronchitis and carbon monoxide can cause neurological symptoms.

The harmful effects of open burning are also felt by the environment.
This process releases acidic gases such as the halo-hydrides; it also may release the oxides of nitrogen and carbon. Nitrogen oxides contribute to acid rain, ozone depletion, smog and global warming. In addition to being a greenhouse gas carbon monoxide reacts with sunlight to produce ozone which can be harmful. The particulate matter creates smoke and haze which contribute to air pollution.

Advantages of Open Air Burning

- Disease pathogens are eliminated in the fire
- It is cheap as it requires less manpower.

Disadvantages

- It may lead to fire accident
- It generates air pollution and may lead to acid rain
- It produces odour nuisance
- Resources are lost in the fire
- Half burnt refuse could afford breeding place for flies and food for rats and other vermin.

Hog Feeding

This is a method of feeding domestic animals especially pigs with wastes of garbage class. This practice is encouraged as it is in compliance with the principle of integrated waste management. It encourages waste sorting and reuse, energy recycling and serious cost reduction. However it is only most practicable in waste streams composed mainly of garbage and adequately separated at source.

Advantages of Hog Feeding

- It is a source of food to domestic animals
- It saves costs
- It is sustainable and eco-friendly
- It can lend itself to large scale application.

Disadvantages

- It is an intermediate and not final method of solid waste disposal
- It may give rise to nuisances like odour, fly breeding and rodent infestation.
- Scavengers are pre-disposed to diseases like tuberculosis, anthrax and other zoonosis.

4.0 CONCLUSION

Traditional waste management practices are efficient when applied to local situations in small communities with sparse population densities.
The methods are however overwhelmed when applied to bulk waste emanating from densely populated urban communities with sophisticated life styles and generating complicated waste profiles.

Knowledge and experiences gained in operating the traditional disposal systems may however be a good resource in developing technologies that will help address the challenges of semi urban and urban waste management.

5.0 SUMMARY

In this unit, you were able to identify various methods of traditional waste management. These traditional waste management systems which include earth burial, open dumping, deposition in large water bodies, use as feed for animals, open air burning and earth burial. You also learnt traditional waste disposal systems including their advantages and disadvantages. In any case, no matter how numerous their advantages and how convincing they sound, their disadvantages outweigh them especially when measured against the backdrop of environmental effects and public health concerns.

6.0 TUTOR-MARKED ASSIGNMENT

1.Describe three type of traditional waste disposal methods.

7.0 REFERENCES/FURTHER READING

Phillips, G. (1999). Microbiological aspects of clinical waste. *Journal of Hospital Infection.* 41**(1)**: 1–6.

Potron, A. and Nordmann, P. (2009).Nosocomial spread of ESBL-positive *Enterobacter cloacae* co-expressing plasmid-mediated quinolone resistance Qnr determinants in one hospital in France. *Journal of Antimicrobial Chemotherapy*. 64: 653–654.

UNIT 2 SANITARY LANDFILL

CONTENTS

1.0 INTRODUCTION

In unit one, you were given a refresher course on the traditional (crude) methods of Biomedical Special Waste management in our rural, semi-urban and some of our urban communities and local councils, thus capping up our study plan for module one which we devoted to preliminary description of the concept of solid waste and solid waste management.

Why were the methods described in unit one above referred to as crude?
What will be the improvements in the conventional methods we are going to discuss in subsequent units of this module? Find out as we start with discussion of sanitary landfill.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- define sanitary landfill
- outline the basic requirements of sanitary landfill
- describe the processes involved in landfill site operations
- state the advantages and disadvantages of sanitary landfill.

3.0 MAIN CONTENT

3.1 What is Sanitary Landfill?

Sanitary landfill also known as controlled tipping is the practice of waste disposal in which waste is stacked to decay under controlled conditions. *Wikipedia Encyclopedia* defines it as a site for the disposal of waste materials by burial. Historically, landfills have been the most common methods of organised waste disposal and remain so in many places around the world. Some landfills are also used for waste management purposes, such as the temporary storage, consolidation and transfer, or processing of waste material (sorting, treatment, or recycling).

Landfill Site in Poland
Landfills are sites where waste is isolated from the environment until it is safe. It is considered safe, when it has completely degraded biologically, chemically and physically. Four basic conditions should be met before a site can be regarded as a sanitary landfill. The ways of doing this should be adapted to local conditions. The immediate goal is to meet, to the best extent possible, the four stated basic sanitary landfill conditions, with a longer term goal to meet them eventually in full. Figures 1.1 (A, B, C): Landfill Sites in Poland, Ontario and Perth.

(b) A Section of a Landfill Located in Barclay, Ontario
(c) Landfill Site in Perth Western Australia

3.2 Basic Requirements of Sanitary Landfill

As a minimum, four basic conditions should be met by any site design and operation before it can be regarded as a sanitary landfill:

i. Full or partial hydro geological isolation: if a site cannot be located on land which naturally contains leachate security, additional lining materials should be brought to the site to reduce leakage from the base of the site (leachate and help reduce contamination of groundwater and surrounding soil. If a liner - soil or synthetic - is provided without a system of leachate collection all leachate will eventually reach the surrounding environment. Leachate collection and treatment must be stressed as a basic requirement.
ii. Formal engineering preparations: designs should be developed from local geological and hydro geological investigations. A waste disposal plan and a final restoration plan should also be developed.
iii. Permanent Control: trained staff should be based at the landfill to supervise site preparation and construction, the depositing of waste and the regular operation and maintenance.

iv. Planned waste emplacement and covering: waste should be spread in layers and compacted. A small working area which is covered daily helps make the waste less accessible to pests and vermin.

3.3 Components of a Landfill

The main components of any secured, permitted landfill are:

a. Bottom Liner:- The bottom liner separates and prevents the buried waste from coming in contact with underlying natural soils and groundwater. In municipal solid waste landfills, the bottom liners are generally constructed using some type of durable, puncture-resistant synthetic plastic HDPE (high density polyethylene) ranging from 30 to 100 mils thick. The plastic liners may also be designed with a combination of compacted clay soils, along with synthetic plastic.

b. Cells (old and new):- This is the area in a landfill that has been constructed and approve for disposal of waste. These cells range in size (depending upon total tons of waste received each day at the landfill) from a few acres to as large as 20+ acres. Inside these larger cells are smaller cells known as the daily workface, or sometimes referred to as cells. This is where the waste coming into the landfill for disposal that day is prepared by placing the material in layers or lifts where the waste is then compacted and shredded by heavy landfill compaction machinery.

c. Leach ate collection system:- The bottom of each landfill is typically designed so that the bottom surface of the landfill is sloped to a low point, called a sump. This is where any liquids that are trapped inside the landfill — known in the waste industry as leach ate — are collected and removed from the landfill. The leach ate collection system typically consists of a series of perforated pipes, gravel packs and a layer of sand or gravel placed in the bottom of the landfill. Once the leach ate is removed from the sump, it is typically pumped or gravity-flowed to a holding tank or pond, where it is either treated on site or hauled off site to a public or private wastewater treatment facility.

d. Storm Water Drainage: - This is an engineered system designed to control water runoff during rain or storm events. This is done by directing the runoff through a series of berms or ditches to holding areas known as seed ponds. In these ponds the runoff water flow is slowed down or held long enough to allow the suspended soil particles to settle out before the water is discharged off site.

e. Methane Collection System:- Bacteria in the landfill break down the trash in the absence of oxygen. This process produces landfill gas, which is approximately 50 percent methane. Since methane gas has the potential to burn or explode, it has to be removed from the landfill. To do this, a series of pipes are embedded within the landfill to collect the methane gas. This gas, once collected, can be either naturally vented or control-burned.

Waste that is placed in a cell is required to be covered daily with either six inches of compacted soil or an alternative daily cover. Some examples of alternative daily covers are the application of spray-on cover material, such as foam or a flame-retardant fiber material. Another type of alternative daily cover is large panels of tarpaulin-type material that is laid over the waste at the end of each day and removed the next day before waste is placed. Other areas within the cells that are not to final grade and will not receive placement of additional waste for a period of time may require additional cover. This is known as intermediate cover — generally 12 to 18 inches of soil. Covering (or capping) is performed in order to isolate the waste from exposure to the air, pests (such as birds, rats and mice) and to control odours. When a section of the landfill is finished or filled to capacity, it is permanently covered with a combination of a layer of polyethylene plastic, compacted soil and a layer of topsoil that will support growth of vegetation to prevent erosion.

Groundwater Monitoring Stations: - Stations are set up to directly access and test the groundwater around the landfill for presence of leachate chemicals. Typically a groundwater monitoring system will have a series of wells that are located up-gradient of the landfill disposal area and a series of wells down-gradient. The up-gradient wells test the water quality before it moves under the disposal area in order to get a background analysis of the water.

The down-gradient wells then allow testing of the water after it has passed under the disposal area so it can be compared to the quality of the up-gradient wells to make sure there has been no impact or contamination of the groundwater.

3.4 Landfill Operation

Typically, in non-hazardous landfills, in order to meet predefined specifications, techniques are applied by which the wastes are:

- Confined to as small an area as possible
- Compacted to reduce their volume
- Covered (usually daily) with layers of soil.

During landfill operations the waste collection vehicles are weighed at a weighbridge on arrival and their load is inspected for wastes that do not accord with the landfill's waste acceptance criteria. Afterward, the waste collection vehicles use the existing road network on their way to the tipping face or working front where they unload their contents. After loads are deposited, compactors or bulldozers are used to spread and compact the waste on the working face. Before leaving the landfill boundaries, the waste collection vehicles pass through a wheel cleaning facility. If necessary, they return to the weighbridge in order to be weighed without their load. Through the weighing process, the daily incoming waste tonnage can be calculated and listed in databases. In addition to trucks, some landfills may be equipped to handle railroad containers. The use of 'rail-haul' permits landfills to be located at more remote sites, without the problems associated with many truck trips.

Typically, in the working face, the compacted waste is covered with soil or alternative materials daily. Alternative waste-cover materials are chipped wood or other "green waste"[, several sprayed-on foam products, chemically 'fixed' bio-solids and temporary blankets. Blankets can be lifted into place at night then removed the following day prior to waste placement. The space that is occupied daily by the compacted waste and the cover material is called a daily cell. Waste compaction is critical to extending the life of the landfill. Factors such as waste compressibility, waste layer thickness and the number of passes of the compactor over the waste affect the waste densities. Note that the area being filled is a single, well-defined "cell" and that a rubberised landfill liner is in place (exposed on the left) to prevent contamination by leachates migrating downward through the underlying geological formation.

The decomposition which takes place within the tip is similar to the septic breakdown of sewage and to the action of composting. Anaerobic biolysis occurs accompanied by a rise in temperature; the maximum temperature may be expected within 14 days and may reach 160^0F.
After three or four months, the temperature will have dropped to atmospheric and the content of the tip will be inert. The high temperature ensures the destruction of pathogens. It is most desirable to prevent the access of flies to landfill operations.

Usually, the temporal cover will be sufficient to prevent ovipositor by the female fly; there is danger, however, that housefly eggs or larvae may have been brought to the site in the refuse and it had been shown that a newly hatched fly can wriggle through four feet of earth. A temperature of 140^0F and above during their larval stage of 3 –5 days will be sufficient to destroy them. The temporary seal should be sufficient to render the tip unattractive to vermin, which may however, gain access with the refuse.

3.5 Advantages and Disadvantages of Sanitary Landfill

3.5.1 Advantages

Sanitary landfills when properly sited and operated:

- Do not pollute the ground water
- Checks fly breading and infestation by rodents and vermin
- Prevents unsightliness and odour nuisances

- Is a source of useful energy like methane gas
- Yields manure for agricultural purposes
- Provides employment for numerous operators

3.5.2 Disadvantages

Apart from the prohibitive initial capital outlay and the large expanse of land taken up by landfill sites, a large number of adverse impacts may occur from landfill operations. Damage occurrence can include:

- Infrastructure (e.g., damage to access roads by heavy vehicles)
- Pollution of the local environment (such as contamination of groundwater and/or aquifers by leakage or sinkholes and residual soil contamination during landfill usage, as well as after landfill closure)
- Off gassing of methane generated by decaying organic wastes (methane is a greenhouse gas many times more potent than carbon dioxide, and can itself be a danger to inhabitants of an area)
- Harboring of disease vectors such as rats and flies, particularly from improperly operated landfills, which are common in developing countries
- Injuries to wildlife
- And simple nuisance problems (e.g., dust, odour, vermin, or noise pollution).

This list is growing steadily as time passes.

4.0 CONCLUSION

Sanitary landfill was originally meant to be the last destination of waste materials. As such, by the year 2000, more than 50 per cent of all waste generated nationally in developed countries ended up in landfills. The continuing development of more stringent requirements for landfills is making this ultimate disposal option less environmentally offensive, but more costly. The increasing ability to recover methane from landfills is providing a positive use for what has historically been a non-valued disposal method. Bioreactor landfill technology has the potential to further reduce the environmental impact of landfills and maximise methane recovery from these systems.

5.0 SUMMARY

In this unit, you have learnt about one of the modern waste management technologies – the sanitary landfill. This technology use to be an advancement or improvement of the traditional burial of solid waste which allow bulk and varied waste sorts to be handled. You have seen that when properly sited, engineered and operated, sanitary landfill not only serve for the disposal of community or municipal solid waste but is a source of income for investors, provides job for numerous workers and above all provides a good resource for the generation of energy and recovery of other reclaimable materials.

However, under sub optimal operational conditions, its operation may lend itself to environmental problems like air and ground water pollution, damage of infrastructure like access road and common nuisances like odour, fly and rodent infestation etc. Also, the initial capital outlay for construction is a disadvantage.

6.0 TUTOR-MARKED ASSIGNMENT

1 Define the term ‘sanitary landfill’.
2 Outline the basic requirements of sanitary landfill.

7.0 REFERENCES/FURTHER READING

Pruss, A. and Rushbrook, P. (1999). Safe Management of Wastes from Health—Care Activities. World Health Organisation, Geneva, pp. 77–128.

Simonsen, L. and Kane, M. (1999). Unsafe infections in the developing world and transmission of bloodborne pathogens: A review. Bulletin of the World Health Organization 77(10): 789–800.

UNIT 3 INCINERATION

CONTENTS

1.0 INTRODUCTION

In unit 2, you were taken through the discussion of sanitary landfill as a method of final waste disposal. The method involved compacting waste for long time storage underground leading to waste transformation into harmless organic and mineral resources which on the long run may become source of wealth as is already being explored in technology advanced countries.

In this unit, we will describe and discuss incineration as another good technology that can be favourably applied in the management of solid waste. This time the waste is not stored but burnt under controlled conditions to recover energy, remove contamination and reduce bulk.

What is the difference between open burning of waste and incineration?
What type of solid waste can be incinerated? Find out these and more as you go through this unit.

2.0 OBJECTIVES

By the end of this unit, you should be able to:

- define incineration
- describe the incineration process
- outline various types of incinerators
- describe general features of incinerators
- argue in favour or against incineration.

3.0 MAIN CONTENT

3.1 Incineration

Incineration is the process of destroying waste materials by burning it within the temperature range of 9000℃ – 12000℃. This is a controlled combustion process for burning solid combustible wastes to gases and residue containing little or no combustible material when properly carried out. It is a volume reduction process.

When incineration is operated correctly, it reduces the waste bulk by 90%. This reduction depends upon the recovery degree and composition of materials. This means that incineration however, does not replace the need for land filling but it reduced the amount to be thrown in it. The ash will be safe to use for filling low areas of land (such as erosion site).
It is recognised as a practical way of disposing hazardous waste materials such as biological medical waste.

In the past, incineration was conducted without separating materials thus causing harm to environment. This un-separated waste was not free from bulky and recyclable materials, even. This resulted in risk for plant workers health and environment. Most of such plants and incinerations never generate electricity.

Incineration comes with a number of benefits in specific areas like medical wastes and other life risking waste. In this process, toxins are destroyed when waste is treated with high temperature.

Though incineration is still widely used in many areas (developing countries especially) it is a waste management tool that is becoming controversial for several reasons.

It destroys not only the raw materials, but also all the energy, water, and other natural resources used to produce it. Some energy can be reclaimed as electricity by using the combustion to create steam to drive an electric generator.

3.2 Incineration Process

Before waste products are subjected to incineration, it is good to have such wastes sorted in the first place. Thus, readily combustible materials especially dry ones will burn faster and generate fine ash whereas wet bulky materials may require being pre-treated or they take longer period and energy to burn. Some recommended steps for handling incinerators include the following:

a. The incinerator must be fully heated up before wastes are added, requiring about 30 min or longer, depending on ambient temperature, type of fuel, fuel moisture content, etc. however, most of the 14 small-scale units surveyed in Kenya (Taylor,2003) were not being operated in this fashion, rather, safety boxes were loaded prior to lighting.
b. Firewood must have a low moisture content (<15%)
c. Temperature monitors when not used, there will be no indication that suitable temperature have been reached. (Grey or black smoke indicates poor combustion and low temperatures).
d. Manual operation requires the constant presence of an operator and when burning waste Dry, fuels must be added every 5 – 10 min.
e. Flame must not be extinguished during burnings.
f. Grates must be regularly checked and raked to keep clear.

Other Process Includes

1. Garbage receiving and treatment procedures, including: entrance odometer, dumping platform, garbage bunker, garbage crane, ash bunker, ash crane, burning chamber, hearth system, etc.
2. Combustion air procedures, including: primary and secondary air blower, air preheated, air re-heater, etc.
3. Bottom slag procedures, including: each bottom slag conveyor, ash ejector, vibration conveyor, etc.
4. Fly ash procedures, including: fly ash conveyor, pneumatic conveying system, fly ash storage tank, fly ash stabiliser, etc.
5. Waste metal procedures, including: magnetic selector, waste metal conveyor, waste metal bunker, waste metal compressor, waste metal crane, etc.
6. Steam procedures, including: high pressure steam distributor, steam turbine, power generator, steam condenser, etc.
7. Condensed water procedures, including: condensed water recycling equipment, such as condensed water tank, degassing & water feeding tank, etc.
8. Waste gas treatment procedures, including: dioxin prevention equipment, nitrogen oxide removal equipment, semi-dry scrubber, bag filter dust collector, attraction exhaust fan, etc.
9. Wastewater procedures, including: inorganic wastewater treatment system, organic wastewater treatment system, sludge production system, etc.

3.3 Incinerators and their Types

Incinerator can be understood more precisely as a furnace where waste is burnt. Modern incinerators are equipped with pollution improvement systems, which play their part in cleaning up the flue gas and such toxicants. The following are the types of plants for burning waste.

3.3.1 Moving Grate

The incineration plant used for treating MSW is moving grate. This grate is capable for hauling waste from combustion chamber to give way for complete and effective combustion. A single such plant is capable for taking in thirty-five metric ton of waste every hour for treatment. Moving grates are more precisely known as incinerators of municipal solid waste. This waste is poured in the grate with a help of crane from and opening or throat. From here, the waste has to move towards the ash pit. Waste is further treated and water locks wash out ash from it. Air is then flown through the waste and this blown air works for cooling down the grate. Some of grates are cooled with help of water.

Air is blown through the boiler for another time but this time comparatively faster than before. This air helps in complete burning of the flue gases with the introduction of turmoil leading to better mixing and excess of oxygen. In some grates, the combustion air at fast speed is blown in separate chamber.

3.3.2 Fixed Grate

This was the fixed and much older version for grate. This kind generally is lined with the brick while lower or ash pit is made up of metal. This grate generally has an opening at the top and for loading purpose; a side of the grate is left open. A number of fixed grate were first formed in houses, which today are replaced by waste compactors.

3.3.3 Rotary-kiln

Industries and municipalities generally use this sort of incinerator. This incinerator consists of two chambers i.e. primary and secondary chamber.

3.3.4 Fluidised Bed

In this sort of incineration, air is blown at high speed over a sand bed.
The air gets going through the bed when a point come where sand granules separates and let air pass through them and here comes the part of mixing and churning. Therefore, a fluidised bed comes in to being and fuel and waste are then can be introduced. The sand along with the pre-treated fuel or waste is kept suspended and is pumped through the air currents. The bed is thus mixed violently and is uptight while small inert particles are kept suspended in air in form of fluid like form. This let the volume of the waste, sand and fuel to be circulated throughout the furnace, completely.

3.4 Desirable Features of Incinerators

Incinerators are designed to efficiently and safely burn waste at specified rates and temperatures, with the residual ash containing no combustible material.

i. Air and fuel are mixed in correct proportion
ii. Regulated combustion air
iii. Minimum exhaust gas residence time 1-2 seconds in the secondary chamber
iv. Proper residence time to obtain a complete burn out
v. Provide for creating turbulence in combustion chamber
vi. High temperature and chemical resistant refractory lining
vii. Satisfy and exceed pollution control norms.

3.5 A Debate over Incineration

Usage of incineration is for waste management is divisive. The debate for incinerators generally involves business interests, regulations of government, activists if environment and citizens.

3.5.1 Arguments supporting incinerations

- The first concern for incineration stands against its injurious effects over health due to production of furans and dioxin emission. However, the emission is controlled to greater extent by developing of modern plants and governmental regulations
- Incineration plants are capable for producing energy and can substitute power generation plants of other sort
- The bottom ash after the process is completed is considered non injurious that still is capable for being land filled and recycled
- Fine particles are removable by processing through filters and scrubbers
- Treating and processing medical and sewage waste produces non injurious ash as product.

3.5.2 Arguments against Incinerations

- Extremely injurious matter needs adequate disposing off. This requires additional miles and need special locations for land filling this material
- Although after a lot of regulations and restrictions and developments concerns are still alive about emission of furans and dioxins
- Incinerating plants are producers of heavy metals, which are injurious even in minor amounts
- IBA is consistent over a considerably high level of heavy metals and can prove fatal if they are not disposed off or reused properly
- Initial investment costs are only recovered through long periods of contract for incinerating plants
- Local communities always have opposed the presence of incinerating plant in the locality
- The upheld view is to recycle, reuse and waste reduction instead of incineration.

4.0 CONCLUSION

Incineration is the combustion of waste in the presence of oxygen. After incineration, the wastes are converted to carbon dioxide, water vapour and ash. This method may be used as a means of recovering energy to be used in heating or the supply of electricity. In addition to supplying energy, incineration technologies have the advantage of reducing the volume of the waste, rendering it harmless, reducing transportation costs and reducing the production of the greenhouse gas methane.

5.0 SUMMARY

In this unit, you were able to learn how to describe incineration as a method of treatment of solid waste. You have also seen that incineration lays itself applicable in handling different waste types. That is, there are many types of incinerators which can be applied according to the size and complexity of the waste type. Incineration reduces waste volume and eliminates hazardous components of wastes especially microorganisms and if properly sited and operated is suitable for small scale as well as municipal waste processing. However, if not suitably sited and operated, it may contribute greatly to pollution of the environment.

6.0 TUTOR-MARKED ASSIGNMENT

1. Define the term “incineration”.
2. State five desirable features of an incinerator.

7.0 REFERENCES/FURTHER READING

Mujeeb, S. A. and Luby, S. (2003). Recycling of injection equipment in Pakistan. *Infection Control and Hospital Epidemiology*. 24**(**92): 145–146.

Odumosu, B. T. and Chandra, R. (2013). Analysis of integrons and associated gene cassettes in clinical isolates of multidrug resistant Pseudomonas aeruginosa from Southwest Nigeria. Annals of Clinical Microbiology and Antimicrobials 12: 29–36.

UNIT 4 COMPOSTING

CONTENTS

1.0 INTRODUCTION

In unit 1, you were able to look at incineration as biomedical waste management technology which involves the use of controlled burning to dispose solid waste. In this unit, we shall discuss composting as a solid waste management technology.

You will find out that whereas incineration destroys both waste and flora, composting benefits from the presence of microorganisms and worms, particularly earthworms to transform organic solid waste materials to manure for further benefit to farmers. We shall adopt a practical oriented approach in describing this most eco-friendly solid waste management technology. Enjoy your reading!

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- define composting
- list various techniques of composting
- describe the composting process
- state the advantages of composting.

3.0 MAIN CONTENT

3.1 Composting (Manure Pit)

Composting is one of the options for treatment of solid waste. In composting process the organic matter breaks down under bacterial action resulting in the formation of humus like material called compost.
The value of compost as manure depends on the quantity and quality of feed materials poured into the compost pit. Composting is carried out in two ways:

- Aerobically (in presence of oxygen) and
- Anaerobic ally (in absence of oxygen).

During aerobic composting, aerobic micro – organisms oxidises organic compounds in the solid waste to carbon dioxide, nitrite and nitrate. The carbon from organic compounds is used as a source of energy while nitrogen is recycled. Due to exothermic reactions, temperature of the mass rises.

During anaerobic process, the anaerobic micro-organisms, while metabolising the nutrients, break down the organic compounds through a process of reduction. A very small amount of energy is released during the process and the temperature of the composting mass does not raise much. The gases evolved are mainly methane and carbon dioxide. An anaerobic process is a reduction process and the final product is subjected to some minor oxidations when applied to land.

Manure from composting gives better yield to a farmer and it is also environment friendly. Biodegradable solid waste can be composted either in compost pit or in a Vermi compost pit. Compost pit can be underground unlined compost pit or over-ground compost – heap method or over-ground brick line compost pit. Vermi compost can be done in Vermi tank (four pit model) or Vermi-compost in sheds.
Composting of bio degradable solid waste can take place in biogas plants also. Slurry from the biogas plant can also be utilised for production of Vermi compost.

Composting (Manure Pit)
Composting is carried out in a simple manure pit or garbage pit (lined or unlined). in this process aerobic microorganisms oxidise organic compounds to carbon- dioxide and oxides of nitrogen and carbon from organic compounds is used as a source of energy, while nitrogen is recycled. As discussed above, in the composting process, due to exothermic reactions, temperature of mass rises. In areas/regions with higher rainfall composting in over ground heaps is advisable. The factors affecting the composting process are: (a) micro-organisms; (b) moisture, (c) temperature and (d) carbon/ nitrogen (C/N) ratio.

3.2 Household Level Composting

At each household, two manure pits should be dug. The size of the pit will depend upon the quantity of refuse to be disposed of per day. Each day the garbage, cattle dung, straw, plant and agriculture wastes are dumped into the manure pit. When one pit is closed the other one is used. In 5 to 6 months time, the refuse is converted into manure, which can be used in the fields. This is the most effective and simplest method of disposal of waste for the rural households. Cow dung can also be disposed of easily by this method. Mixing of cow dung slurry with the garbage will help greatly in converting the refuse into compost, which provides good manure.

Household level composting pits may be constructed by adopting either lined or unlined pits as described below:

3.3 Underground Unlined Manure Pit or Garbage Pit

Applicability

- Rural areas with low rainfall
- Houses with an open space of about 7 square m
- Houses with no cattle or with single cattle.

Action

House owner can make this pit with little technical know how

Description

- Dig two pits of 1m x 1m x 1m dimension
- Give a single layer of broken bricks at the bottom
- Make a ridge with the help of mud at the periphery of the pit & compact it by light ramming.

Use and Maintenance of the Pit

- Go on adding garbage from the house over the layer of bricks (only biodegradable type)
- When the garbage attains a height of about 150 mm, add dung slurry, mix it with garbage & level it
- Spread a very thin layer of soil over it (once a week) to avoid odour and fly nuisance
- Continue to add garbage everyday
- Follow the above procedure & repeat the layers till the pit is full.
- It is recommended to fill the pit up to about 300 mm above ground level
- After 3-4 days the garbage above ground settles down
- Plaster it with soil
- Leave the pit as it is for 3-6 months for maturation
- After 3-6 months take out the compost & use it in the fields
- Till the manure in the pit matures, use another pit of the same dimensions, dug at a minimum distance of 1 m from the first pit.

Limitations
Not suitable for heavy rainfall areas and rocky terrain.

3.4 Advantages of Composting

1. By proper decomposition, biodegradable waste gets converted into good quality organic manure whereby waste is turned into wealth
2. Prevents vector breeding and breeding of rodents
3. In aerobic composting process considerable heat is generated, resulting in destruction of pathogens and weed seeds
4. Insanitary conditions arising out of solid waste are removed and esthetically, environment looks neat and clean.

4.0 CONCLUSION

Composting is the controlled aerobic decomposition of organic matter by the action of microorganisms and small invertebrates. The process is controlled by making the environmental conditions optimum for the waste decomposers to thrive. The rate of compost formation is controlled by the composition and constituents of the materials i.e. their carbon/nitrogen (C/N) ratio, the temperature, the moisture content and the amount of air.

The C/N ratio is very important for the process to be efficient. The microorganisms require carbon as an energy source and nitrogen for the synthesis of some proteins. Moisture content greatly influences the composting process. The microbes need the moisture to perform their metabolic functions. If the waste becomes too dry the composting is not favoured. If however there is too much moisture then it is possible that it may displace the air in the compost heap depriving the organisms of oxygen and drowning them.

A high temperature is desirable for the elimination of pathogenic organisms. However, if temperatures are too high, above 75^{o}C then the organisms necessary to complete the composting process are destroyed.
Optimum temperatures for the process are in the range of 50-60^{o}C with the ideal being 60^{o}C. Aeration also is a very important and the quantity of air needs to be properly controlled when composting. If there is insufficient oxygen the aerobes will begin to die and will be replaced by anaerobes. This will slow the process, produce odours and also highly flammable methane gas. Air can be incorporated by churning the compost.

5.0 SUMMARY

In this unit, you were exposed to the description of composting as a biomedical waste management technology. We adopted a practical oriented approach to emphasise the various composting techniques available for efficient management of biomedical waste both at household and community levels including in vessel composting, windrow composting, vermin composting and static pile composting. You have seen that composting is achieved by making the environmental conditions optimum for the waste decomposers to thrive. The rate of compost formation is controlled by the composition and constituents of the materials i.e. their carbon/nitrogen (C/N) ratio, the temperature, the moisture content and the amount of air. Composting have numerous advantages including the yield of good quality organic manure, prevents breeding of vectors, rodents and vermin; destroys pathogens and weed seeds; promotes aesthetics and is environmental friendly.

6.0 TUTOR-MARKED ASSIGNMENT

1. Define Composting.
2. State the advantages of Composting.

7.0 REFERENCES/FURTHER READING

Collins, C. H. and Kennedy, D. A. (1992). The microbiological hazards of municipal and clinical wastes. *Journal of Applied Bacteriology* 73: 1–6.

Eigenheer, E. and Zanon, U. (1991). O quefazer com osresiduoshospitaleres.

Propostaparaclassicacao, embalagem, coleta e destinacaonal. *Arquivos Brasileiros de Medicina.* 65**(3)**: 233–237.

MODULE 3

UNIT 1 OTHER METHODS/TECHNOLOGIES

CONTENTS

1.0 INTRODUCTION

In our last unit, you learnt about the concept and various techniques of composting as a veritable technology for the management of biomedical waste both at individual household, small communities and large municipality levels. In this unit, we will describe other methods or technologies which are equally sound in the management of solid waste, even those that can be composted and those that cannot be composted. Other technologies to be described in this unit include pyrolysis, pulverisation and the biogas technology. Read on as we explore the advances in waste management technology.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- outline other biomedical waste management technologies
- describe the technologies outlined
- state five advantages and two disadvantages of each technology
- recommend appropriate technology for a prevailing local situation.

3.0 MAIN CONTENT

3.1 Other Methods/Technologies

We have previously described most conventional methods/technologies for biomedical waste treatment available to all especially in the third world or developing economies. We shall use this section to describe the emerging waste treatment technologies which are equally sound and with varying benefits. These technologies includes but not limited to: pyrolysis/gasification, pulverisation, biogas digester etc. We shall describe each technology in turn.

3.2 Pyrolysis and Gasification

Pyrolysis and gasification are quite new methods for treatments of municipal Biomedical waste and remain relatively unproven in African usage compared with classical methods. Despite the fact that these technologies are widely used and well established as industrial processes for energy recovery from hydrocarbons feedstock, their use as process for dealing with mixed municipal waste streams is at an early stage of development.

Both pyrolysis and gasification turn wastes into energy rich fuels by heating the waste under controlled conditions. In contrast to incineration, which fully converts the input waste into energy and ash, these processes deliberately limit the conversion so that combustion does not take place directly. Instead, they convert the waste into valuable intermediates that can be further processed for materials recycling or energy recovery e.g. a mixture of carbon monoxide and hydrogen, oils and char.

Pyrolysis is a thermal decomposition of fuel in the absence of air. Solid waste is converted to a gas and/or liquid, which is then converted to electricity by combustion in a gas turbine or diesel engine. Some solid residue generally remains. Heat has to be provided to the fuel for decomposition to occur and this is normally integrated into the overall process scheme.

One advantage of the pyrolysis technique is that some liquid fuel can be produced, which is versatile, easily transportable and could be used, for example, as a transport fuel in an international combustion engine.

Because much of the fuel produced in the pyrolysis process is consumed within the operation, pyrolysis tends not to be an efficient conversion technology.
Gasification is a reaction between the fuel and oxidant (steam and oxygen) carried out in a restricted supply of oxygen so that complete combustion of the fuel does not take place. Instead the volatile gas comprising combustible components, such as hydrogen, carbon monoxide, methane and higher hydrocarbons is produced, which is subsequently burned to generate electricity, normally in a gas turbine.

Gasification reactions include partial oxidation of the fuel and the water gas reaction and so are generally autothermic, not requiring heat to be supplied

from elsewhere in the process. Therefore, thermo-chemical conversion of the fuel to electricity effectively takes place in two stages.
The advantage of this is that pollutants can be removed from the small fuel gas stream. Also, the second stage is often in a gas turbine or diesel engine. Consequently a higher overall plant efficiency can be achieved through the use of combined cycles with the potential for further increase as gas turbine firing temperatures are increased.

Gasification is an energy efficient technique for minimising the solid waste volume and for recovering energy. It generates 500-600 kWh useable energy per ton of waste. This technology has been used more widely than pyrolysis because it doesn't have problems with heat transfer and is a more efficient process that produces a single gaseous product.

3.3 Pulverisation/Shredding

Although dictionaries differentiate between shredding and pulverising, the expressions are often used interchangeably when applied to the processing of solid waste. This discussion of the processing of solid waste for size reduction and uniformity will adopt the accepted interchangeable use of shredding and pulverising. However, it is noted that the end product of the process does differentiate between the shredded or cut and torn shape, and the pulverised or crushed and ground fine particle.

There are four types of shredders used for the shredding or pulverising of solid waste: hammer mills, drum pulverisiers, crushers, and wet pulverisiers. Each type of equipment has a variety of designs, advantages, and disadvantages. Major considerations in selecting a shredder are its capacity, speed, power requirements, maintenance needs, ability to produce the end product desired and, most important, and reliability. These characteristics will differ significantly for various types of solid waste and differing end products. In choosing a type and particular design of a shredder, it is desirable to obtain information on the performance of the shredder in circumstances similar to those for which the machine is to be used.
Solid waste is shredded for several reasons, including volume reduction. Under certain circumstances, shredded refuse can be disposed of in a landfill without requiring as stringent compaction and cover procedures as would be applied to unprocessed refuse.

If solid waste is to be converted to refuse derived fuel (RDF), shredding and/or pulverising is an element of the RDF production process.

Resource recovery plants that separate waste into recyclables often include one or more shredding operations to improve the mechanical separation characteristics of the waste. If solid waste is to be transported mechanically, pneumatically, or hydraulically, shredding is a desirable if not essential first step before transport. It is obvious that shredding and pulverising of solid waste is a process with many uses.

3.4 Biogas Technology

3.4.1 Background

When biodegradable organic solid waste is subjected to anaerobic decomposition, a gaseous mixture of Methane (CH_4) and Carbon dioxide($C0_2$) known as Biogas could be produced under favourable conditions.

The decomposition of the waste materials is mainly done by the fermentation process which is carried out by different group of microorganisms like bacteria, fungus, actinomycetes etc. The group of micro-organisms involved for biogas generation is mainly the bacteria.

The process involves a series of reactions by several kinds of anaerobic bacteria feeding on the raw organic matter. “In anaerobic conditions, anaerobic bacteria disintegrate the biodegradable solids by a biochemical process shown below.

3.4.2 Digestion Process

The anaerobic digestion of the organic waste matter occurs in three different stages:

i. Hydrolysis
ii. Acidogenesis
iii. Methanogenesis.

3.4.2.1 Hydrolysis

Most of the organic waste materials subjected to bio-methanation contain the macromolecules like cellulose, hemicellulose, lignin etc. which are insoluble in water. In the first step of digestion, these macromolecules are subjected to breakdown into micro-molecules with the help of some enzymes which are secreted by the bacteria. In the initial step, oxygen in the feed materials is used up by oxygen loving bacteria and large amounts of carbon dioxide (CO_2) are released and the major end product of this step is glucose.

3.4.2.2 Acid Formation

The components released during the hydrolytic breakdown become the substrate for the acid forming bacteria. The acid forming bacteria convert the water soluble substances into volatile acids. The major component of the volatile acid is acetic acid. Besides this, some other acids like butric acid, propionic acid and gases like CO_2 and H_2 are also produced. The acid forming bacteria during the conversion process utilise the amount of oxygen remaining in the medium and make the environment anaerobic.

3.4.2.3 Methane Formation

This is the last stage of the biogas generation. In this stage, the methanogenic bacteria convert the volatile acids formed in the second step by the acidogenic bacteria to methane and carbon di-oxide. Some excess CO_2 in the medium is also converted to methane gas by reacting with the hydrogen present in the environment.

The End Products of Bio-Gas Technology are:

Biogas: It is a marsh gas, a mixture of Methane (55- 65%),
Carbon di—oxide (35- 45%), trace amount of Hydrogen,Hydrogen Sulphide and Ammonia. It is a combustible gas and can be used for heating, lighting, powering irrigation pump, generating electric power and for local use for cooking purpose.
The gas is smokeless, environment friendly and efficient fuel.

Left over slurry: Environmental friendly manure would be produced which can be used as organic fertiliser for gardening and agricultural purpose. It can be used to enrich the soil. It can also be dovetailed to vermin composting to enrich manure value of compost.

3.4.3 Fuel Efficiency of Biogas

The fuel efficiency of cattle dung is 11% and that of Biogas from same dung is 60%, Biogas technology holds promise of revolutionising energy scene-conserving forests, preventing soil erosion and providing energy security in rural areas. Normally a 3 cubic meter capacity Biogas plant is considered sufficient to meet the heating and lighting needs of a rural family of 6 to 9 persons.

3.4.4 Biogas Plant Construction

Currently in Nigeria, the Environmental Health Officers Registration Council of Nigeria is championing the course of widening the horizon of knowledge of the public that the biogas plant can be constructed a hundred percent using local materials. Two types of the plant are being advocated by EHORECON for domestic biogas plant – the flexible type and the dome type.

The flexible type is made of rectangular sewn air tight tarpaulins material with provisions for charging the plant and removal of the gas and spent slurry respectively. A flexible tank of 2.5 cubic meters submerged about one (1) meter on the surface of the ground will be sufficient for a family of 4 – 10 persons.

3.4.4 Use of Biogas Technology for Biomedical Waste Management

The biogas technology can be used for management of biodegradable biomedical waste (portion) generated from:

i. Household
ii. Community
iii. Commercial Establishment.

3.4.5.1 Household Level

Kitchen waste, cattle dung, garden waste, leaves of trees can be digested and digested product reused at household level.

3.4.5.2 Community Level

Community biodegradable waste such as cattle dung of stray cattle and from abattoirs, garden waste, leaves of roadside trees, human excreta from individual/community toilet etc., can be digested in community biogas plant and end products can be reused.

3.4.5.3 Commercial Establishment

Commercial biodegradable waste generated from hotels, parks and gardens, and leaves of roadside trees etc. can be digested in commercial biogas plant and the end products can be fruitfully utilised commercially such as gas engine, liquefied natural gas productions, lifting water for irrigation purposes etc.

The gas production varies from 0.29 cubic metres per kg of volatile solids added per day to 0.19 cubic metre 0.16 cubic metres per kg added per day in different seasons. The volatile solids destruction ranges from 40 to 55%. The sludge has good manurial value of Nitrogen, FE phosphorous, and potassium (NPK ratio is 1.6: 0.85: 0.93). The process gives a good performance at a retention time of 30 to 55 days varies as per season.

4.0 CONCLUSION

Amongst the sundry technologies for the management of biomedical waste described in this chapter, it is obvious that pyrolysis/gasification and pulverisation/shredding require advanced technological development though pyrolysis may be applied to a wide range of biomedical waste materials. It is only the biogas technology that is within the technological reach of the third world and less developed countries like ours. Besides this, the biogas technology holds a great promise as a source of manure for farmers aside from its energy recovery characteristics. The technology can serve individual households, communities and small to medium scale industries as energy source.

5.0 SUMMARY

In this unit, our major focus has been the description of sundry methods and technologies available for waste treatment aside from the conventional ones earlier described. Apart from the fact that some of these methods especially pyrolysis/gasification and pulverisation and shredding require a bit of technological advances and cost, pyrolysis/gasification can handle a broad spectrum of waste types and is very efficient energy recovery technology. Pulverisation/shredding minimises waste volume and is very useful in waste handling and recycling processes. Biogas technology on its own is not so very capital intensive and can be operated at household and community level as well as large scale municipal waste treatment situation. It is very eco-friendly, efficient energy recovery and generates by-product of great use in agriculture.

6.0 TUTOR-MARKED ASSIGNMENT

1.Write on the use of Biogas technology for biomedical waste management.

7.0 REFERENCES/FURTHER READING

Health and Safety Executive (HSE). (2000). Health and Safety Statistics 1999–2000. HSE, London.

Lin, J., Biyela, P. T. and Puckree, T. (2004). Antibiotic resistance proles of environmental isolates from Mhlathuze River, KwaZulu-Natal (RSA). Water SA. 30: 23–28.

UNIT 2 BIOMEDICAL WASTE MINIMISATION/REDUCTION

CONTENTS

1.0 INTRODUCTION

In the last unit, you learnt about the various technologies involved in the management of solid waste. In this unit, we will describe the concept of waste minimisation, a procedure for limiting the occurrence of waste or in the alternative reducing the volume of waste to be handled and treated. As usual, the lesson is going to be a living type as the subject of waste minimisation and reduction is our everyday experience.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- define Biomedical waste minimisation
- outline the processes of Biomedical waste minimisation
- classify Biomedical waste minimisation techniques
- state the importance of Biomedical waste minimisation.

3.0 MAIN CONTENT

3.1 Definition of Term

Traditionally, waste is viewed as an unnecessary element arising from the activities of any industry. In reality, waste is a misplaced resource, existing at a wrong place at a wrong time. Waste is also the inefficient use of utilities such as electricity, water, and fuel, which are often considered unavoidable overheads. The costs of these wastes are generally underestimated by managers. It is important to realise that the cost of waste is not only the cost of waste disposal, but also other costs such as: - disposal cost, purchase cost of wasted raw material, production cost for the waste material, management time spent on waste material, lost revenue for what could have been a product instead of waste and potential liabilities due to waste.

3.2 What is Biomedical Waste Minimisation?

Biomedical waste minimisation can be defined as "systematically reducing waste at source". It means:

- Prevention and/or reduction of waste generated
- Efficient use of raw materials and packaging
- Efficient use of fuel, electricity and water
- Improving the quality of waste generated to facilitate recycling and/or reduce hazard
- Encouraging re-use, recycling and recovery.

Waste minimisation is the process and the policy of reducing the amount of waste produced by a person or a society. It involves efforts to minimise resource and energy use during manufacture. For the same commercial output, usually the fewer materials are used, the less waste is produced. Waste minimisation usually requires knowledge of the production process, cradle-to-grave analysis (the tracking of materials from their extraction to their return to earth) and detailed knowledge of the composition of the waste.

Waste minimisation is also known by other terms such as waste reduction, pollution prevention, source reduction and cleaner technology. It makes use of managerial and/or technical interventions to make industrial operations inherently pollution free. It should be also clearly understood that waste minimisation, however attractive, is not a panacea for all environmental problems and may have to be supported by conventional treatment/disposal solutions.

3.2.1 Processes of Biomedical Waste Minimisation

a. Resource Optimisation

Minimising the amount of waste produced by organisations or individuals goes hand-in-hand with optimising their use of raw materials. For example, a dressmaker may arrange pattern pieces on a length of fabric in a particular way to enable the garment to be cut out from the smallest area of fabric.

b. Reuse of Scrap Material

Scraps can be immediately re-incorporated at the beginning of the manufacturing line so that they do not become a waste product.

Many industries routinely do this; for example, paper mills return any damaged rolls to the beginning of the production line, and in the manufacture of plastic items, Off-cuts and scrap are reincorporated into new products.

c. Improved Quality Control and Process Monitoring

Steps can be taken to ensure that the number of reject batches is kept to a minimum. This is achieved by increasing the frequency of inspection and the number of points of inspection. For example, installing automated continuous monitoring equipment can help to identify production problems at an early stage.

d. Waste Exchanges

This is where the waste product of one process becomes the raw material for a second process. Waste exchanges represent another way of reducing waste disposal volumes for waste that cannot be eliminated.

e. Ship to Point of Use

This involves making deliveries of incoming raw materials or components direct to the point where they are assembled or used in the manufacturing process to minimise handling and the use of protective wrappings or enclosures.

3.2.2 Classification of Biomedical Waste Minimisation (BWM) Techniques

The waste minimisation is based on different techniques.

Source Reduction

Under this category, four techniques of BWM are briefly discussed below:

a) Good Housekeeping- Systems to prevent leakages & spillages through preventive maintenance schedules and routine equipment inspections. Also, well-written working instructions, supervision, awareness and regular training of workforce would facilitate good housekeeping.

b) Process Change: Under this head, four CP techniques are covered:

(i) Input Material Change - Substitution of input materials by eco-friendly (non-toxic or less toxic than existing and renewable) material preferably having longer service time.
(ii) Better Process Control - Modifications of the working procedures, machine-operating instructions and process record keeping in order to run the processes at higher efficiency and with lower waste generation and emissions.
(iii) Equipment Modification - Modification of existing production equipment and utilities, for instance, by the addition of measuring and controlling devices, in order to run the processes at higher efficiency and lower waste and emission generation rates.
(iv) Technology Change - Replacement of the technology, processing sequence and/or synthesis route, in order to minimise waste and emission generation during production.

c) Recycling
i) On-Site Recovery and Reuse - Reuse of wasted materials in the same process or for another useful application within the industry.
ii) Production of useful By-product - Modification of the waste generation process in order to transform the wasted material into a material that can be reused or recycled for another application within or outside the company.

d) Product Modification
Characteristics of the product can be modified to minimise the environmental impacts of its production or those of the product itself during or after its use (disposal).

3.2.3 Importance of Biomedical Waste Reduction

In affluent countries, the main motivations for waste reduction are frequently related to the high cost and scarcity of suitable sites associated with the establishment of new landfills, and the environmental degradation caused by toxic materials in the deposited wastes. The same considerations apply to:

1) Large metropolitan areas in developing countries that generally are surrounded by other populous jurisdictions, and
2) Isolated small communities (such as island communities).

However, any areas that currently do not have significant difficulties associated with the final dispositions of their wastes disposal pressures can still derive significant benefits from encouraging waste reduction.
Their solid waste management departments, already overburdened, are ill-equipped to spend more funds and efforts on the greater quantities of wastes that will inevitably be produced, if not otherwise controlled, as consumption levels rise and urban wastes change.

3.3 Key Concepts in Municipal Waste Reduction

Action for waste reduction can take place at both the national and local levels.

3.3.1 At the National Level

Some strategies for waste reduction include:

- Redesign of products or packaging
- Promotion of consumer awareness and
- Promotion of producer responsibility for post-consumer wastes.

3.3.2 At the local level

The main means of reducing waste are:

- Diversion of materials from the waste stream through source separation and trading
- Recovery of materials from mixed waste
- Pressure on national or regional governments for legislation on redesigning packaging or products and
- Support of home composting, either centralized or small-scale.

3.3.3 Household Waste Minimisation

- Waste minimisation at household level can be achieved by the adoption of a variety of strategies. But in a domestic situation, the potential for minimisation is often dictated by lifestyle. Some people may view it as wasteful to purchase new products solely to follow fashion trends when the older products are still usable.

  Adults working full-time have little free time, and so may have to purchase more convenient foods that require little preparation, or prefer disposable nappies if there is a baby in the family.

- Appropriate amounts and sizes can be chosen when purchasing goods; buying large containers of paint for a small decorating job or buying larger amounts of food than can be consumed create unnecessary waste. Also, if a pack or can is to be thrown away, any remaining contents must be removed before the container can be recycled
- Home composting, the practice of turning kitchen and garden waste into compost can be considered waste minimisation. Individuals can reduce the amount of waste they create by buying fewer products and by buying products which last longer.
  Mending broken or worn items of clothing or equipment also contributes to minimising household waste
- The amount of waste an individual produces is a small portion of all waste produced by society, and personal waste reduction can only make a small impact on overall waste volumes. Yet, influence on policy can be exerted in other areas. Increased consumer awareness of the impact

and power of certain purchasing decisions allows industry and individuals to change the total resource consumption. Consumers can influence manufacturers and distributors by avoiding buying products that do not have eco-labelling, which is currently not mandatory, or choosing products that minimise the use of packaging

- Where reuse schemes are available, consumers can be proactive and use them.

3.4 Systems of Biomedical Waste Reduction

3.4.1 Industrialised Countries

Perhaps in no field of municipal solid waste management are the differences between the industrialised countries and the developing countries so apparent as in waste reduction and materials recovery. Rising overall living standards and the advent of mass production have reduced markets for many used materials and goods in the affluent countries whereas, in most of the economically developing countries, traditional labour-intensive practices of repair, reuse, waste trading, and recycling have endured. Thus, there is a large potential for waste reduction in economically developing countries, and the recovery of synthetic or processed materials is now being emphasised. Public or consumer financing of the full range of initiatives for waste reduction (from changes in manufacturing and packaging, to waste reduction audits to identify waste reduction opportunities) are practiced by several affluent industrialised countries.

One of the main motivations, from the point of view of municipal authorities, is to reduce materials that must be collected and deposited in landfills. At the national level, under the concept of producer responsibility, governments have created agreements and legal frameworks designed to reduce the generation of waste. For instance, industry is given responsibility for achieving certain levels of packaging reduction goals of a certain percentage within a given time period.

3.4.2 Developing Countries

In many developing countries, waste reduction occurs naturally as matter of normal practice because of the high value placed on material resources by the people, as well as other factors.

Consequently, reuse of a variety of materials is prevalent. The motivations for materials reuse in developing countries include: scarcity or expense of virgin materials; the level of absolute poverty; the availability of workers who will accept minimal wages; the frugal values of even relatively well-to-do households; and the large markets for used goods and products made from recycled plastics and metals. Wastes that are of no use in affluent societies and cannot be recycled have value in developing countries e.g. coconut shells and dung used as fuel. If one takes into account the use of compost from dumps sites as well as materials recovery, in countries like India, Vietnam, and China, the majority of municipal wastes of all kinds are ultimately utilised.

Waste reduction that could be achieved by legislation and protocols (such as agreements to change packaging) is not, at present, a high priority in these countries, although some are now moving in this direction. Because unskilled labour costs are low and there is a high demand for manufactured materials, manufacturers can readily use leftovers as feedstock or engage in waste exchange. Residuals and old machines are sold to less advanced, smaller industries. Public health is benefiting from plastic and boxboard packaging that reduces contamination of foods and much of the superior packaging is recovered and recycled.

In offices and institutions, cleaners and caretakers organise the sale of paper, plastics, etc. At the household level, gifts of clothes and goods to relatives, charities, and servants are still significant in waste reduction.
All cities and towns have markets for used goods. However, the greatest amount of materials recovery is achieved through networks of itinerant buyers, small- and medium-sized dealers, and wholesaling brokers. The extent to which the waste trading enterprises are registered ("formalised") varies in developing regions: in Latin America and Asia, there is more formal registration than in Africa. The system is adaptive to market fluctuations, as the lowest level workers form a dispensable labour cushion: they must find other work, if they can, when there is reduced demand for the materials that they sell.

From the point of view of waste reduction, the traditional practices of repair and reuse, and the sale, barter, or gift-giving of used goods and surplus materials are an advantage to the poorer countries. Quantities of inorganic post-consumer wastes entering the MSW stream would be higher if these forms of waste reduction did not exist.

4.0 CONCLUSION

In conclusion, biomedical waste minimisation involves all processes and techniques applied to preclude as much as possible or reduce to the barest minimum the occurrence of waste and wasteful situations in the production, distribution and use of any product and services. Waste minimisation strategies are applied at different levels especially in the industries during product design and production and continue up to the consumer level.

At the consumer/household level, discrimination as to what to buy and in what quantity, product quality, re-use or recycling etc. are some of the major considerations to be taken to minimise waste. Household waste minimisation or reduction is influenced by level of knowledge, socioeconomic status and lifestyle.

5.0 SUMMARY

In this unit, our focus has been on the understanding of the concept of waste minimisation/reduction. You have seen that although waste is inevitable, it can be minimised or drastically reduced through quality production and considerate use. When manufacturers build quality into their products through good housekeeping and process change and recycle defective ones; and consumers make considerate purchases and good use of products including re-use, exchange (barter) and recycle of materials, the bulk of waste in the municipal waste stream would have been reduced. In the next unit, we shall be discussing waste recycling and reuse.

6.0 TUTOR-MARKED ASSIGNMENT

1. Define Biomedical waste minimisation.
2. Outline the processes of Biomedical waste minimisation.

7.0 REFERENCES/FURTHER READING

Mujeeb, S. A. and Luby, S. (2003). Recycling of injection equipment in Pakistan. *Infection Control and Hospital Epidemiology*. 24**(92)**: 145–146.

Odumosu, B. T. and Chandra, R. (2013). Analysis of integrons and associated gene cassettes in clinical isolates of multidrug resistant Pseudomonas aeruginosa from Southwest Nigeria. *Annals of Clinical Microbiology and Antimicrobials*. 12: 29–36.

UNIT 3 WASTE RECYCLING AND REUSE

CONTENTS

1.0 INTRODUCTION

In unit 2, you learnt the concept of Biomedical waste minimisation, the processes and methods of minimising waste and the associated economic, social, health and environmental benefits inherent in waste minimisation. In this unit, you will learn the concept of waste recycling and reuse.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- define waste recycling
- describe some Biomedical waste recycling processes
- state the advantages and constraints to waste recycling
- differentiate between waste recycling and reuse.

3.0 MAIN CONTENT

3.1 What is Biomedical Waste Recycling?

Recycling involves the collection of used and discarded materials which are processed and turn into making new products. It reduces the amount of waste that is thrown into the community dustbins thereby making the environment cleaner and the air more fresh to breath. From this definition recycling occurs in three phases: first the waste is sorted and recyclables collected, the recyclables are used to create raw materials. These raw materials are then used in the production of new products.

Serious attention has been shown by government and non-government agencies in the country on the need to recycle wastes having all recognised the importance of recycling wastes. However, the methodology for safe recycling of waste has not been standardised. Currently, less than 7 %-15% of the waste is recycled in the country. If recycling is done in a proper manner, it will solve the problems of waste or garbage.

3.2 Steps Involved in Waste Recycling

The steps involved in the process prior to recycling include:

a) Collection of waste from doorsteps, commercial places etc.
b) Collection of waste from community dumps
c) Collection/picking up of waste from final disposal sites.

The sorting of recyclables may be done at the source (i.e. within the household or office) for selective collection by the municipality or to be dropped off by the waste producer at a recycling centres. The pre-sorting at the source requires public participation which may not be forthcoming if there are no benefits to be derived. Also a system of selective collection by the government can be costly. It would require more frequent circulation of trucks within a neighborhood or the importation of more vehicles to facilitate the collection.

Another option is to mix the recyclables with the general waste stream for collection and then sorting and recovery of the recyclable materials can be performed by the municipality at a suitable site. The sorting by the municipality has the advantage of eliminating the dependence on the public and ensuring that the recycling does occur.

The disadvantage however, is that the value of the recyclable materials is reduced since being mixed in and compacted with other garbage can have adverse effects on the quality of the recyclable material.

3.3 Strategies for Carrying out Waste Recycling

Before developing a strategy for implementing 3R practices, municipal authorities must answer the following questions:

- Who are the recyclers?
- What are the advantages of recycling Biomedical waste?
- What is being recycled?
- What is not being recycled and why?
- What are the main challenges?

- What steps are necessary to improve the recycling and resource recovery of materials?

Ideally, the 3R (reduce, reuse and recycle) concept will be applied as early as possible in the waste generation and management chain so that managers of waste can:

- maintain the high material quality and value of recyclable waste materials
- reduce the loss of valuable natural resources and virgin raw materials
- limit pollution of land
- reduce long-distance transport of waste
- reduce landfill space requirements and environmental pollution
- minimise the costs of both production of goods and management of waste.

3.4 Recycling Materials

Almost every material can be recycled; however, the value of the recycled material can vary significantly depending on the demand and uses for it. Indeed the value of a material is the driving factor for private recycling initiatives or—in the case of many developing countries—the informal sector. If and how a material is recycled depends not only on local policies but also on the availability of a buyer, processing facilities, and a transport chain.

Most of the garbage generated in the household can be recycled and reused. Organic kitchen waste such as leftover foodstuff, vegetable peels, and spoilt or dried fruits and vegetables can be recycled by putting them in the compost pits that have been dug in the garden. Old newspapers, magazines and bottles can be sold to the waste vendor the man who buys these items from homes. In your own homes you can contribute to waste reduction and the recycling and reuse of certain items. Table below shows some household wastes that can be recycled or reused.

3.5 Materials Recycling Process

3.5.1 Paper Recycling

This is the process of turning waste paper into new paper products.
There are three categories of paper that can be used as feed stocks for making recycled paper: mill broke pre-consumer waste, and postconsumer waste. The process of paper recycling involves mixing used paper with water and chemicals to break the paper down. The paper is then chopped up and heated, which breaks the paper down further into strands of cellulose, which is a type of organic plant material from the pulp. The resulting mixture called slurry is strained through screens, which remove any glue or plastic that may still be in the mixture then cleaned, de-inked, bleached, and mixed with water. Then this can be made into new paper. The same fibres can be recycled about seven times, but they get shorter every time and eventually are strained out.

Mill broke is paper trimmings and other paper scrap from the manufacture of paper, and the paper recycled internally in a paper mill. Pre consumer waste is material which left the paper mill but was discarded before it was ready for consumer use. Post-consumer waste is material discarded after consumer use, such as old corrugated containers, old magazines, old newspapers, office paper, old telephone directories, and residential mixed paper. Paper suitable for recycling is called “scrap paper”, often used to produce moulded pulp packaging. The industrial process of removing printing ink from paper fibres of recycled paper to make deinked pulp is called deinking, an invention of theGerman Jurist Justus Claproth.

Steps in Paper Recycling
Here is how paper waste is recycled:

1. **Collection, Transportation and Storage**
   The biggest task for paper recycling companies is probably the collection, transporting and sorting of waste paper. This is because we always add paper to other waste items and get them contaminated with food, plastics and metals. Sometimes collected paper is sent back to the landfills because they are too contaminated for use. Try to keep waste paper in separate grades at home or in the office —example, do not mix newspapers and corrugated boxes up.

   All paper recovered is sent to the recycling center, where it is packed, graded, put into bales and sent to the paper mill. At the mill, all the paper is stored in a warehouse until it is needed.

2. **Repulping and Screening**
   From the storage shelves, they are moved into a big paper-grinding machine called a vat (pulper). Here the paper is chopped into tiny

pieces, mixed with water and chemicals and heated up to break it down into organic plant material called fibre. After, it is screened to remove contaminants such as bits of plastic and globs of glue.

3. **Deinking**
This involves 'washing' the pulp with chemicals to remove printing ink and glue residue. Sometimes, a process called floatation is applied to further remove stubborn stains and stickies. Floatation involves the use of chemicals and air to create bubbles which absorb the stickies in the pulp.

4. **Refining, Bleaching and Colour Stripping**
Refining involves beating the recycled pulp to make them ideal for paper-making. After refining, additional chemicals are added to remove any dyes from the paper. It is then bleached to whiten and brighten it up.

5. **Paper Making**
At this stage, the pulp is ready to be used for paper. Sometimes new pulp (virgin pulp) is added to give it extra strength and smoothness. Water is added to the pulp and sprayed onto a large metal screen in continuous mode. The water is drained on the screen and the fibres begin to bond with each other. As it moves through the paper-making machines, press rollers squeeze out more water, heat them dry and coat them up. They are then finished into rolls.

3.5.2 Aluminium Recycling

In recent time, there has been a massive improvement in recycling aluminium cans. In 2003, it was reported that Americans recycled 62.6 billion aluminium cans. Those cans, placed end-to-end, could make 171 circles around the earth. Every minute an average of 105,800 aluminium cans are recycled. That is how important can recycling has become. But what is involved here?

1. **Collection**
Local councils provide special can recycling containers (bins) that are clearly marked. This helps people to know what to place in them. The various cans include soda cans, fruit cans and vegetable cans. Trucks come for these at pick up spots to the recycling centres. Cans may also be metallic or steel, but people do not know the difference.
2. **Preparation**
At the collection centre, a huge magnet is rolled over them as they move on the conveyor belt to pull out all the metal and steel cans. Only the aluminium cans are washed, crushed, condensed in to 30-pounds briquettes for other companies for further processing. The rest is also sorted and sent to their appropriate recycling centres.
3. **Melting**

The crushed cans are loaded into a burning furnace, where all printing and designs on the cans are removed, melted and blended with new (virgin) aluminium. The molten (liquid) aluminium is poured into moulds and made into bars called ingots.

4. **Sheets**
   The ingots are then fed into powerful rollers, which flatten them into thin sheets of aluminium of about 25.4 in thickness. These thin sheets are rolled into coils and sold or sent to can-making factories. They use the aluminium coils to prepare cans and containers for other food and drink manufacturers. It is estimated that cans collected at collection points take up to 60 days to be appear in the shops again as new cans containing your favourite soda, juice or food.

3.5.3 Glass Recycling

How is glass recycled?
Recycling glass starts in your home. There is a reason why many local types of council provide different containers for green, brown, plain glass and even glass from broken windows. The reason is that they are all made very differently and mixing them can create huge problems at the recycling centre.

1. **Collection**
   Many cities have collection spots. Trucks may also pick them up from your home, or you may be required to drop them off at a point in your town. In all cases, try to do what the authorities have suggested. So, be sure you know the various glass types that are collected from your home. Always wash and separate them into the required grades for collection.

2. **Cleaning and Crushing**
   The glass is transported to the processing plant where contaminants such as metal caps and plastic sleeves are removed. Different grades are treated separately. Clean glass is then crushed into small pieces called cullet. Cullet is in high demand from glass manufacturers. It melts at a lower temperature and it is cheaper than raw glass materials.

3. **Ready for Use**
   The cullet is then transported to glass-making factories. Here, it is mixed with sand, soda ash and limestone. It is heated at very high temperature and melted into liquid glass. This liquid is then poured into moulds that give glass its shape. Glass is used for many things—depending on what grade they were recycled from. A few items made of recycled glass include fibre-glass, countertops, bottles and jars.

3.6 Advantages of Waste Recycling

Waste recycling has some significant advantages. Recycling turns materials that would otherwise become waste into valuable resources and generates a host of environmental, financial, and social benefits. It prevents the emission of many greenhouse gases and water pollutants. Recycling decreases the need to extract and process virgin material, which pollute air, soil and water with toxic material. It saves energy necessary to produce new materials. It can save from 1.5 to 5 times more energy than is generated by incineration. In summary, waste recycling offers the following advantages:

i. For the Managers of Waste:

- Reduction of waste volume
- Cost savings in collection, transport, and disposal
- Longer life span for landfills
- Reduction of adverse environmental impacts.

ii. For the Economy

- Reduction of imports (for fertilisers or soil amendments) and thus less foreign currency required
- Job opportunities and income for the people
- Cheap products (made from recycled materials) for the poor
- Reduces the amount of energy required to manufacture new products.

iii. For the Environment

- Sustainable use of resources: for example, less energy consumption and thus less pollution
- Reduced amount of waste going to storage sites, resulting in a more manageable system
- Reduces environmental impacts arising from waste treatment and disposal
- Makes the surroundings cleaner and healthier.

3.7 Waste Reuse

Waste recycling and reuse are very closely associated terms which are often used interchangeably but are not essentially the same when viewed closely at its micro levels. Whereas waste recycling describes the reprocessing of waste materials into new useful products of the same or varied type from the original waste, waste reuse is the application of waste materials to same or different use by a different user. This is essentially very advantageous given that the term waste is a relative description of use of materials to satisfy human needs. Commonly reused materials include clothing materials, jewellery and trinkets, kitchen utensils, household furniture, books and electronic equipment and to a larger extent motor vehicles and other heavy machinery.

Waste reuse is very economical and a ready aid to the less ostentatious and the poor. However, it may pose serious environmental and health challenges as the disposal challenges are shifted to the less endowed who may not have the education and capacity to dispose the waste finally.

4.0 CONCLUSION

In conclusion, waste recycling involves all processes applied to preserve waste materials and put it into further use. Successful recycling of waste starts with separation of the waste at point of generation which ensures the quality of the waste product as a potential raw material for future processing into new desirous products. Waste reuse goes further to describe the continued use of a product by another user when the initial owner or user had done with the said materials and discarded them.

Product quality, re-use and or recycling potential are some of the major considerations to be taken to minimise waste. Waste recycling and reuse has great economic advantages aside from its environmental friendly and sustainability considerations.

5.0 SUMMARY

You have seen that recycling is processing used materials (waste) into new, useful products. This is done to reduce the use of raw materials that would have been used. Recycling also uses less energy and great way of controlling air, water and land pollution. Effective recycling starts with household (or the place where the waste was created). In many serious countries, the authorities help households with bin bags with labels on them. Households then sort out the waste themselves and place them in the right bags for collection. This makes the work less difficult.
Items usually recycled include Plastic waste (plastic bags, water bottles, rubber bags and plastic wrappers), Glass waste (broken bottles, beer and wine bottles), Aluminium waste (Cans from soda drink, tomato, fruit cans and all other cans can be recycled).

Recycling is beneficial in many ways. It helps protect the environment, pollution of the air, land, water and soil is reduced, it conserves natural resources and saves energy.

6.0 TUTOR-MARKED ASSIGNMENT

1 Define the term "waste recycling".
2 Steps Involved in Waste Recycling.

7.0 REFERENCES/FURTHER READING

Phillips, G. (1999). Microbiological aspects of clinical waste. *Journal of Hospital Infection.* 41**(1)**: 1–6.

Potron, A. and Nordmann, P. (2009). Nosocomial spread of ESBL-positive Enterobacter cloacae co-expressing plasmid-mediated quinolone resistance Qnr determinants in one hospital in France. *Journal of Antimicrobial Chemotherapy.* 64: 653–654.

UNIT 4 INTEGRATED WASTE MANAGEMENT

CONTENTS

1.0 INTRODUCTION

In the last units, you learned how to describe various methods and models of sound waste management including waste minimisation, waste reduction, recycling and reuse, composting, incineration, sanitary land fill etc. you were able to appreciate the individual benefits and challenges of each of these waste management techniques and technologies. In this unit, we present to you a good description and vivid illustration of yet a sound waste management model which is, some kind of interplay of the various waste management techniques and methods. This is called integrated waste management. You will find in the unit yet another interesting presentation.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- define integrated Biomedical waste management
- outline the guiding principles of integrated Biomedical waste management
- illustrate integrated Biomedical waste management using a named waste type
- enumerate the benefits of integrated Biomedical waste management.

3.0 MAIN CONTENT

3.1 Concept of Integrated Waste Management

3.1.1 What is Integrated Waste Management?

Integrated Biomedical waste Management, or IBWM, is a tool to determine the most energy-efficient, least-polluting ways to deal with the various components and items of a community's solid waste stream. The IBWM hierarchy is based upon the material and energy that is embodied in solid waste and that is associated with its recycling and disposal.

3.1.2 The Goals of Integrated Biomedical Waste Management

The twin goals of IBWM are to:

(1) Retain as much as possible of that energy and those materials in a useful state, and
(2) Avoid releasing that energy or matter into the environment as a pollutant.

3.2 Hierarchy of Integrated Biomedical Waste Management

Integrated waste management sets up a hierarchy of approaches and technologies for managing solid waste in order to meet these goals.
Generally, the farther "up" the hierarchy from which the technology is chosen, the more benefits in efficiency and retained economic value.
The very highest option in the hierarchy is, don't create the solid waste in the first place, and is termed “source reduction.” Source reduction can be done in several ways:

- Manufacturing processes can be devised which create fewer or less toxic waste by-products
- Consumers can choose not to purchase products with excessive packaging or
- Consumers can choose not to purchase products which are unnecessary "luxuries," which require unjustifiably large amounts of energy or natural resources to manufacture, or which cause toxic waste problems in manufacture, use, or disposal.

The other higher level IWM options are (in order):
Reuse - The use of a product more than once in its same form for the same or similar purpose.

Recycling -- The process, by which materials otherwise destined for disposal are collected, processed, remanufactured into the same or different product, and purchased as new products.

Composting -- The controlled process whereby organic materials are biologically broken down and converted into a stabilised humus material.

Materials retain their value for longer periods of time if they are handled within these "top four" levels of the IBWM hierarchy.

3.2.1 Integrated Waste Management (IWM): The Case of the Corrugated Box

- Energy is used to transform raw materials into a corrugated cardboard box. The first consideration for the box in a waste management planning process is to look at strategies for source reduction, or not using the box at all, if it represents excessive packaging (or using alternative packaging which requires fewer raw materials and less energy to manufacture; or packaging which is more readily re-usable or recyclable, etc.)
- After unpacking the TV set that was delivered in the box, the Smiths discard it into the waste stream. The box's utility/value derives from the properties of its current ordered state (rectangular, dry, strong, closeable, etc.)
- The highest and best use for the box is to re-use it again as a box.The management strategy would then be to keep the box from becoming crushed, wet or otherwise damaged, in order to reuse it as packaging several more times.
- If it is already crushed, the next best thing is to recycle it – to expend new energy to transport it to a paper mill and process it into a new product, then re-sell it, etc
- If it can't be recycled for some reason, several options are available which limit the use of the box's energy to a one-time recapture. The box might be composted for use as a soil amendment; made into refuse-derived fuel to be burned in a boiler for its energy value; or it might be mass-burned (incineration with energy recovery) together with mixed solid waste to produce steam or electricity#

3.3 Practical Applications of IBWM for Rural Communities

3.3.1 IBWM and Local Economies

There are several ways to describe integrated waste management and its benefits. Perhaps the best way for our purposes is to look at the effect of solid waste on the economy and environment of a community. The job creation and economic potential of IBWM stem from the following:

i. The economic value of recovered materials as re-usable products (either "as is," or through refurbishment) or as raw materials.

ii. The opportunity for simpler, more decentralised sometimes more labor-intensive solid waste management solutions which can create jobs in rural communities. Such decentralised solutions often work better in more sparsely-populated, rural communities because they do not depend upon high population densities to achieve economies of scale (e.g., centralised solutions may be expensive in rural areas because of the long transport distances required to serve relatively few people. Community or backyard composting of yard, food, and other organic waste is often better suited to rural areas because it saves transportation of these heavy waste stream components over relatively longer distances than in urban areas).

iii. Opportunities to intentionally create and recruit businesses and industries which use the waste streams of existing business as feed stocks. Such arrangements can help to plug economic "leaks" from our rural communities. Such methods can be integrated into the strategies of local business development specialists, industrial recruiters, and existing industry managers.

iv. The short-term and long-term economic value to rural communities of avoided land filling.

Benefits of this include:

- Deferring expensive landfill sitting processes
- Reducing annual operation and maintenance costs for existing landfills
- Reducing transportation costs to the community and
- Reducing the rate at which successive cells of expensive new subtitle D landfills must be developed and lined.

Community resources saved at the landfill can be diverted into economic development efforts.

The traditional economic model views economic activity – and its benefits – as the extraction of raw materials, their manufacture or processing, the sale of the product or commodity, and then its use by consumers. The rest of the life cycle of the raw materials and energy consists of disposal at some cost, and control of the associated pollutants. In other words, once a product, by-product or material becomes classified as a "waste," it has not only zero value but a negative value, i.e., the cost to local government of "disposal," pollution control, and the health cost to society of any pollutants not successfully controlled.

3.3.2 Benefits of Integrated Biomedical Waste Management

Integrated waste management provides a new approach to solid waste. It seeks to keep products, the materials and energy embodied in their manufacture, and the by-products of their manufacture, in the productive part of the economy -- and out of the "waste" stream -- as long as possible, and to wring as much economic value out of them as possible before giving up on them as "waste." When this is done, the following happens:

a. Local and regional economies benefit by the continued exchange value of the reclaimed materials and products and the jobs created in reprocessing and reselling them.
b. Private businesses often find these materials a cheaper source of raw materials than virgin sources, especially when virgin materials are becoming scarce, more difficult to access, under more stringent regulatory controls, or must be shipped from far away.
c. It often takes less energy to reprocess or re-manufacture these reclaimed materials than raw materials, because of the energy already embodied in their original manufacture. This increases the value of these materials to industry, since energy savings in manufacturing can be added to the acquisition savings for a more competitive "bottom line."
d. National and global resource natural depletion is reduced, contributing to a more sustainable long-term economy.
e. Local governments benefit through reduced cost of ultimate "disposal" of the materials because many would-be "waste" materials and products are diverted from their landfills for an extended period of time.
f. Pollution from landfills is reduced because many toxic or otherwise polluting materials are diverted from the landfills, and because the overall volume of land filled material is reduced.

Another valuable feature of IWM is that it applies to all solid waste situations, from the largest city or industry to commercial and office waste streams, right down to the individual household. This means that its positive impact can be understood and enjoyed by the whole community, not just by solid waste managers and planners. It also means that the economic impact of IWM can be felt by all economic sectors in the community.

3.4 Guiding Principles of IBWM

Experience has shown that designing one neatly-packaged, systematic approach for communities to achieve the greatest possible measure of IWM benefits may be difficult. However, the following set of integrated waste management application principles has opened up some new opportunities in guiding the community planning process in our region. We've found that these "application principles" are consistent with the values, culture, resources and preferences commonly held in rural areas.

3.4.1 Principle 1: Search for Value

Solid waste only becomes "waste" when people lose sight of its value.
Virtually everything in the "waste stream" has residual value for someone or some business in the community. The key message to the IWM planning team and the community is, find the value and redirect it back into the community. Part of this process is to find or create local markets for reused, recycled, reprocessed or composted materials. Another important element in redirecting value is to create new local enterprises based on waste stream redirection.

3.4.2 Principle 2: Start Upstream

If we think of solid waste as a flow of materials entering the community at different places, travelling through the community as they are used one or more times, and ending up in other places, we can use the analogy of a river or stream. Intercepting a would-be waste item as far "upstream" as possible after its initial use has several advantages:

- It often has more value left in it
- It is usually cleaner & easier to re-use or recycle
- Less energy has been wasted transporting it and
- The original purchaser of the item has the first opportunity to reuse it.

In this way of looking at solid waste management, we try to intercept each item as far upstream as possible, redirecting it before it becomes defined as "waste." First owners of the item get the first chance to re-use it. Waste management becomes the responsibility of each member of the community, and doesn't just "get passed on to the ward, city or town."

3.4.3 Principle 3: Use the IBWM Hierarchy to Retain Value

The integrated waste management hierarchy gives us a systematic way to search for the value in would-be waste items. For example, it suggests that re-using an item usually captures more value and saves more money than, say, burning it. In combination with Principle 2, we can systematically look at each component of the waste stream.

3.4.4 Principle 4: Start Where the Community Is

Each rural community - and each person, business, institution and local government in the community - has its own unique culture and way of looking at solid waste and its economy. The solid waste management process works best if it reflects both the values of the community and the local approach to waste management practices. Some communities may have specific waste issues on the table, such as toxic wastes, cost of disposal, tipping fees, flow control, meeting regulatory mandates, or controversial waste management technologies. Not only will one waste management strategy not work for all rural communities, but even different industries, businesses, or neighborhoods may prefer different approaches.

Planners should be sensitive to what motivates each waste generator, and encourage innovative, localised solutions.

3.4.5 Principle 5: Keep Materials Separated

Mixing unlike solid wastes together often contaminates otherwise useful materials and reduces their value.

It also causes additional processing to be done to re-separate the materials or items farther "downstream." Materials and items are often transported great distances and handled several times, wasting public funds which could better be used elsewhere.

3.4.6 Principle 6: Minimise Handling, Transportation and Processing

This is related to principles 2, 3 and 5. The earlier in the "waste stream" an article or material can be intercepted and returned or diverted to its next use, the more money the community saves in hauling and handling costs -- including vehicle fuel and its polluting effects, labor, and equipment costs.

3.4.7 Principle 7: Start with the Low-Tech, Low-Cost, Flexible Solutions

People find it easier to participate in low-technology solid waste solutions. It is easier to visualise doing your part in a backyard or small town composting operation than to send your garbage to a high-tech, regional incinerator in the next county. Low-tech solutions usually cost less to put in place and less to abandon, dismantle, or alter if they are no longer viable. Citizens who have participated first hand in such solutions will learn their pros and cons, and may be better able to understand the need for higher tech and/or regional solutions at a later date. Solid waste management is a rapidly-changing endeavour. A community's strategy for dealing with old newspapers should include a contingency plan for rising and falling paper recycling markets. Without an alternative solution such as storage or composting, a mountain of old newsprint can get out of control.

When the market prices are low, inflexible contingency plans may trap a program in a system which is not economically viable. When prices are high, an inflexible system may not allow a community to take full advantage of the market.

3.4.8 Principle 8: Measure Results in a Meaningful Way

Three guidelines of the "total quality" philosophy in business are "measure, measure, and measure." In order to monitor the success of a rural community's solid waste management strategies, solid waste managers must first measure results against the objectives the community intended to achieve. Secondly, it must measure the total costs and benefits in some agreed-upon way. In a community whose primary motivation is to defer the sitting of a new landfill, measuring reductions in compacted-in-place, buried waste may be the most appropriate and important measure of success. In a community which chooses to use solid waste management to create new jobs, the number of jobs created and the dollar value of materials and items recovered may be the most important measure. At the same time, the costs to the community of achieving their solid waste goals should not be ignored.

For example, if the community seeking to extend the life of its landfill decides to ship waste out of the county, it should have some way of measuring the costs associated with hauling, liability risks, reduced motivation for waste reduction within the community, etc. Some form of full cost accounting should be agreed upon and adopted by the community, so that offsetting costs and benefits of each solution can be recognised and evaluated.

4.0 CONCLUSION

Integrated Biomedical Waste Management (IBWM) takes an overall approach to creating sustainable systems that are economically affordable, socially acceptable and environmentally effective. An integrated solid waste management system involves the use of a range of different treatment methods, and key to the functioning of such a system is the collection and sorting of the waste. It is important to note that no one single treatment method can manage all the waste materials in an environmentally effective way. Thus all of the available treatment and disposal options must be evaluated equally and the best combination of the available options suited to the particular community chosen.

Effective management schemes therefore need to operate in ways which best meet current social, economic, and environmental conditions of the municipality.

5.0 SUMMARY

In this unit, you have been given a good description of the principles and practice of integrated waste management a hypothetical master solution to all waste management challenges. Actually, it combines all the gains and advantages of the different waste management techniques that form part of the integral constituents of this strategy. In this, the principal focus is to reduce the waste as much as possible, and encourage the reuse of materials for the original intended purposes or other useful alternatives and recycle the recyclable ones. This is known as the 3Rs principle whose successes largely depend on waste separation or segregation at source. Other elements of integrated waste management include composting, incineration and landfill. Despite the fact thatintegrated waste management does not discriminate on the waste type, it lays itself open to and encourages minimisation, reuse and other energy recovery techniques and wealth generation from waste. It also creates employment, is eco-friendly and sustainable.

6.0 TUTOR-MARKED ASSIGNMENT

1 Define the term “integrated biomedical waste management”.
2 State the goals of integrated biomedicalwaste management.

7.0 REFERENCES/FURTHER READING

Pruss. A., Giroult, E., and Rushbrook, P. (1999). Safe Management of Wastes from Health—Care Activities. World Health Organisation, Geneva, pp. 77–128.

Simonsen, L., Kane, A., Lloyd, J., Zaffran, M., and Kane, M. (1999). Unsafe infections in the developing world and transmission of bloodborne pathogens: A review. *Bulletin of the World Health Organization.* 77**(10)**: 789–800.

MODULE 4

UNIT 2 FIELD SAMPLING AND MONITORING OF WASTE SITES

CONTENTS

1.0 INTRODUCTION

In the last unit, you learnt the various waste management techniques and their strategies with the integrated waste management options. In this unit, you will focus attention on the assessment of waste sites for the quantification and qualification of wastes in terms of magnitude of deposits and physico/biochemical characteristics for a better appreciation of the properties and insight into the mode of handling and management. Thus, we shall be discussing the sampling and monitoring of waste sites.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- state the rational for waste sampling
- outline a sampling plan
- develop a checklist for waste sampling
- explain how take waste samples and send to appropriate laboratory.

3.0 MAIN CONTENT

3.1 Rationale for Waste Sampling

Why collect waste samples? There are a wide variety of reasons for collecting samples and various sampling strategies for different situations. It is important that the purpose of the sampling and associated data quality objectives be identified before fieldwork begins. For example, samples may be collected to determine the existence and/or to define the extent of contamination at a site, to allow waste characterisation and classification for disposal or recovery, or to determine compliance with existing regulations. Once the objective is known, decisions about analytical parameter selection, national certified laboratory selection, quality control samples, sample location and frequency; etc. can be made more confidently. In sampling to assess permit compliance, some of these selections may have been mandated by the department.

Here, the permit applicant has the responsibility of assuring that any proposed requirements will be achievable if made mandatory. Defining sampling and data quality objectives is important to assure that the sampling plan is complete.

Environmental sampling is often conducted to gather data that will be the basis for remedial decisions. Because of the potential threat to health and environment and high costs usually associated with site remediation, strict adherence to quality assurance measures is strongly recommended.
In such a case, the objective of the sampling helps to dictate what should be prescribed in the sampling plan.

3.2 Sampling Plan

An integral part of any sampling programme is planning. Before a plan can be written, site-specific information must be gathered to insure that the plan is logical, will meet the required objectives and the course of action is achievable. The purpose of developing a sampling plan is to detail a “plan of action.” The person writing the plan must be very familiar with the site specific conditions and those implementing the plan must be very familiar with the plan’s contents. A properly prepared sampling plan that is correctly implemented will allow the sampling objectives to be met, help avoid confusion in the field, preserve health and safety, and ultimately save time and money. In the development of the sampling plan, other pre-sampling activities must be heavily relied upon. Some factors to be taken into account will be discussed in the subsequent sections.

The Triad Approach
The commitment to a successful sampling is in streamlining the site investigation and remediation process at contaminated sites without compromising data quality and reliability. This goal can sometimes be better

achieved by implementing the Triad approach, a process that integrates systematic planning, dynamic work plans, and real-time measurements to achieve more reliable, timely and cost-effective site characterisation and cleanup. The Triad approach seeks to recognise and manage the uncertainties involved in generating representative data from heterogeneous environmental matrices. The department supports and encourages the use of the Triad approach for sites undergoing investigation and remediation within the site remediation and waste management program.

3.3 Sample Methodology and Matrix

Once the appropriate numbers and locations have been chosen, consideration must be given to what collection method will be used to assure that representative samples of site conditions are obtained. The selected sampling methodology will be matrix dependent. In some instances, there may be several acceptable options available for collecting a sample. In other instances, site-specific conditions may dictate that only one approach will work, even though that method may not be the preferred method. In all cases, the construction material of the sampling device, its design, decontamination, and proper use are critical factors and should be included in the proposed sampling plan.

3.3.1 Waste Sampling Equipment

Selecting appropriate equipment to sample wastes is a challenging task due to the uncertainty of the physical characteristics and nature of the wastes. It may be difficult to separate, homogenize and/or containerize a waste due to its physical characteristics (viscosity, particle size, etc.). In addition, the physical characteristics of a waste may change with temperature, humidity or pressure. Waste streams may vary depending on how and when a waste was generated, how and where it was stored or disposed and the conditions under which it was stored and disposed. Also, the physical location of the wastes or the unit configuration may prevent the use of conventional sampling equipment.

Given the uncertainties that a waste may present, it is desirable to select sampling equipment that will facilitate the collection of samples that will meet the study's objective, and that will not unintentionally bias the sample by excluding some of the sample population that is under consideration. However, due to the nature of some waste matrices or the physical constraints of some waste units, it may be necessary to collect samples knowing that a portion of the desired population was omitted due to limitations of the equipment. Any deviations from the study plan or difficulties encountered in the field concerning sample collection that may have an effect on the study's objective should be documented in a logbook, reviewed with the analytical data and presented in the report.

Waste sampling equipment should be made of non-reactive materials that will neither add to nor alter the chemical or physical properties of the material that is being sampled. Table 2.1 lists some conventional equipment for sampling waste units/ phases and some potential limitations of the equipment. Another reference for selecting sampling equipment is the ASTM, standard guide for selection of sampling equipment for wastes and contaminated media data collection activities, d 6232, most recent version.

3.4 Laboratory Selection

Prior to submitting samples to a laboratory for analysis, the certification status of the laboratory must be determined. Laboratories submitting analytical data to the authority must hold current certification where applicable under the regulations governing the certification of laboratories and environmental measurements and/or under other relevant bodies. The offices concerned with quality assurance offers certification in the following categories:

- Drinking water program
- Oil spill and detection program
- Solid and hazardous waste programs etc.

The government certification program requires certification for the "analyse immediately" parameters under the safe drinking water, water pollution, and the solid and hazardous Water programs. Certification for those parameters can be obtained from the offices responsible with quality assurance.

Additionally, immunoassay methods that are considered laboratory or field methods require certification under the solid and hazardous waste program. Regardless of whether a company or organisation is or is not a laboratory, certification must be obtained. This includes but is not limited to responsible parties, contractors and facilities.

4.0 CONCLUSION

The fieldwork associated with the collection and transport of samples will account for a substantial proportion of the total cost of a monitoring programme. Sampling expeditions should, therefore, be planned and carried out in such a way that efforts are not wasted. If, for example, an essential piece of equipment is forgotten or an inadequately described sampling station cannot be found, the value of that particular sampling expedition is seriously compromised. Similarly, if unrealistic estimates of travel time are made and an expedition takes longer than intended, samples may be held longer than the maximum allowable storage time and the results of analyses will be of questionable value.

It is advisable to carry out a pilot programme before the routine monitoring programme begins. This can be used as a training exercise for new personnel and will provide the opportunity to make a final selection of sampling stations on the basis of whether they are representative of the whole site as well as readily accessible. Programme managers and laboratory personnel should accompany field personnel on field expeditions from time to time. This provides opportunities for field supervision as part of in-service training and for everyone working on the programme to appreciate the problems and needs of the field work.

5.0 SUMMARY

In this unit, you were exposed through the fascinating concept and practice of waste monitoring through environmental sampling for waste and laboratory analysis. In this you do appreciate the rationale for waste sampling and the rudiments of developing a waste sampling plan and checklist and indeed, determining the sample size and purpose of taking the sample. We have also gave a good outline of various waste sampling equipment and waste sampling procedures for different waste sites like waste piles, impoundments, drums, and tanks. Also highlighted are waste sample handling procedures including particle size reduction and finally the health and environmental considerations in waste sampling. Waste monitoring through regular sampling of waste sites is fundamental for the understanding of the nature, magnitude and management options for any category of waste.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the term sampling plan.

7.0 REFERENCES/FURTHER READING

Thompson, S. C. and Dore, G. J. (2003). Blood-borne viruses and their survival in the environment: Is public concern about community needle stick exposures justified? *Australian and New Zealand Journal of Public Health.* 27**(6)**: 602–607.

US Environmental Protection Agency. Priority PBTs: Dioxins and Furans Fact Sheet. Office of Pollution Prevention and Toxics, Washington, DC.

UNIT 2 EFFECTS OF BIOMEDICAL WASTE ON THE ENVIRONMENT AND HEALTH

CONTENTS

1.0 INTRODUCTION

In the last unit, you were given a good description of solid waste analysis and characterisation, including the rationale, procedure for analysing waste, waste analysis equipment and laboratory specimen handling. In this unit, we shall take you through a description that will improve your understanding of part of the reasons of waste sampling and analysis, that is, the effects of wastes on the environment, health and economy.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- outline the effects of biomedical waste on the environment
- describe the impact of biomedical waste on human health
- enumerate solid waste associated diseases
- identify economic effects of biomedical waste accumulation.

3.0 MAIN CONTENT

3.1 Background

Imagine what will happen if we all throw garbage, junk and rubbish away anyhow. Imagine there was no authority to supervise waste management activities from all the sources mentioned earlier. Imagine we all just sent our rubbish to the landfill, or just dumped them in a nearby river. What do you think will happen? A disaster!

3.2 Effects of Biomedical Waste on the Environment

Biomedical waste can pose serious effect on the environment if not properly managed. The proper management of solid waste from the point of generation to the point where it is finally disposed is very important to prevent environmental degradation. Below are some effects of solid waste on the environment:

- Global warming-change in climate and destruction of ozone layer due to waste biodegradable
- Air pollution
- Water pollution
- Pollution of soil by leaching i.e. a process by which solid waste enter soil and contaminating them
- Blockage of drainage leading to flood.

3.2.1 Air Pollution

Gases are generated through anaerobic decomposition of organic biomedical waste. If a significant amount of methane is present, it may be explosive and greatly lead to greenhouse effect. People who live near those sites may suffer from respiratory disorders occurring with toxic gases, dust, and fumes. When pollutants get mixed with air, this causes acid rain. Acid rain degrades the top soil.

3.2.2 Water Pollution

Rain can penetrate and pass through biomedical waste and can reach out and carry hazardous organic chemicals & inorganic chemicals such as heavy metals into the groundwater as well as nearby surface water sources. People who utilise the ground water or the surface water will absolutely expose to those pollutants and severe health problems may occur. Also elements such as N, P, leaching to surface water sources will be create eutrophication conditions. This will increase the biological oxygen demand of water sources and reduce the bio-diversity of water source.

3.2.3 Soil Pollution

Open dumps of biomedical waste or landfill pose serious threats to environment. One of the greatest environmental concerns associated with land filling is the generation of leachate. During degradation process, one tonne of land filled biomedical waste generates about 0.2 m3 of leachate, depending on the type of waste and seasonal climate. This wastewater primarily results from the degradation of the organic portion of the waste in combination with percolating rainwater and moisture that leaches out organic and inorganic constituents through the waste layer in the soil. A landfill site may still produce leachate with a high concentration of ammonia for over 50 years after filling operations have ceased. If not properly treated, leachate seeping from a landfill can enter the underlying groundwater, posing potentially serious hazards to the environment and to public health. For this reason, the generation of leachate has become a worldwide environmental concern in recent years.

3.2.4 Land Pollution

Land wasting damages microbial population and other soil fauna by releasing various toxic substances & disturbing their normal habitats. Garbage dumping, especially plastics, reduce the soil fertility as they are non-biodegradable. These waste change the soil texture and prepare artificial environment inside the soil. This will disturbs root movement of trees and habitats of the soil fauna.

3.2.5 Global Warming

Methane and carbon dioxide are two major gases produced from the decomposition of the organic fraction of solid waste in the landfill. Methane gas has a 21-fold global warming potential as compared to carbon dioxide. According to the Intergovernmental Panel on Climate Change, such emissions contribute to 18% of the total methane emissions to the atmosphere, ranging from 9 to 70 Tg (Mega Tonnes) annually.

Therefore, landfills have been implicated as the largest source of atmospheric methane in the world, leading to a natural phenomenon called "global warming" (Hansen, 2005a). Due to global warming, changing temperature and rainfall patterns will bring a variety of pressure upon plant and animal life. If temperature rises as projected, one-third of species will be lost from their habitat, either by moving elsewhere or by becoming extinct.

3.2.6 Flooding

Indiscriminate dumping of biomedical waste can lead to blockage of drainage thereby causing floods posing serious public health and environmental problems.

3.3 Health Impacts of Biomedical Waste

3.3.1 General

Modernisation and progress has had its share of disadvantages and one of the main aspects of concern is the pollution it is causing to the earth – be it land, air, and water. With increase in the global population and the rising demand for food and other essentials, there has been a rise in the amount of waste being generated daily by each household. This waste is ultimately thrown into municipal waste collection centres from where it is collected by the area municipalities to be further thrown into the landfills and dumps.

However, either due to resource crunch or inefficient infrastructure, not all of this waste gets collected and transported to the final dumpsites. If at this stage the management and disposal is improperly done, it can cause serious impacts on health and problems to the surrounding environment.

Waste that is not properly managed, especially excreta and other liquid and solid waste from households and the community, are a serious health hazard and lead to the spread of infectious diseases. Unattended waste lying around attracts flies, rats, and other creatures that in turn spread disease. Normally it is the wet waste that decomposes and releases a bad odour. This leads to unhygienic conditions and thereby to a rise in the health problems. Plastic waste is another cause for ill health.
Thus excessive biomedical waste that is generated should be controlled by taking certain preventive measures.

The group at risk from the unscientific disposal of biomedical waste include – the population in areas where there is no proper waste disposal method, especially the pre-school children; waste workers; and workers in facilities producing toxic and infectious material. Other high-risk group includes population living close to a waste dump and those, whose water supply has become contaminated either due to waste dumping or leakage from landfill sites. Uncollected biomedical waste also increases risk of injury, and infection.
In particular, organic domestic waste poses a serious threat, since they ferment, creating conditions favourable to the survival and growth of microbial pathogens. Direct handling of biomedical waste can result in various types of infectious and chronic diseases with the waste workers and the rag pickers being the most vulnerable. Exposure to hazardous waste can affect human health, children being more vulnerable to these pollutants. In fact, direct exposure can lead to diseases through chemical exposure as the release of chemical waste into the environment leads to chemical poisoning. Many studies have been carried out in various parts of the world to establish a connection between health and hazardous waste. Waste from agriculture and industries can also cause serious health risks. Other than this, co-disposal of industrial hazardous waste with municipal waste can expose people to chemical and radioactive hazards.

Uncollected solid waste can also obstruct storm water runoff, resulting in the forming of stagnant water bodies that become the breeding ground of disease. Waste dumped near a water source also causes contamination of the water body or the ground water source. Waste dumping in rivers, seas, and lakes results in the accumulation of toxic substances in the food chain of these areas. Through the plants and animals that feed on it directly or indirectly.

Disposal of hospital and other medical waste requires special attention since this can create major health hazards. This waste generated from the hospitals, health care centres, medical laboratories, and research centres such as discarded syringe needles, bandages, swabs, plasters, and other types of infectious waste are often disposed with the regular non-infectious waste.

Waste treatment and disposal sites can also create health hazards for the neighbourhood. Improperly operated incineration plants cause air pollution and improperly managed and designed landfills attract all types of insects and rodents that spread disease. Ideally, these sites should be located at a safe distance from all human settlement. Landfill sites should be well lined and walled to ensure that there is no leakage into the nearby ground water sources.

Recycling too carries health risks if proper precautions are not taken.
Workers working with waste containing chemical and metals may experience toxic exposure. Disposal of health-care wastes require special attention since it can create major health hazards, such as hepatitis B and C, through wounds caused by discarded syringes. Rag pickers and others, who are involved in scavenging in the waste dumps for items that can be recycled, may sustain injuries and come into direct contact with these infectious items.

3.3.2 Specific Effects of Biomedical Waste on Human Health

Poor biomedical waste management can pose a serious risk to human health.

The improper management of solid wastes represents a source of environmental pollution, and poses risks to human health. Below are some effects of biomedical waste on human health.

a. Spread of vector borne-diseases-Poor disposal of biomedical waste is associated with spread of vector borne-diseases like malaria and dengue fever. Malaria accounts for an estimated 300-500 million cases globally; which is an endemic disease in sub-Saharan Africa. It accounts for about 1.5-2.5 million deaths yearly, most of them among children under five years.
b. Respiratory diseases-Inhalation of poisonous chemicals can cause serious danger to human health. Chemicals inhaled may cause catarrh, cough, and bronchitis and may aggravate some health conditions such as asthma. Incineration of biomedical waste contributes to air pollution by

the release of gases into the air, which may cause ill-health. Malfunctioning incinerator can also cause fire outbreak.

c. Breeding ground for pest of public health importance decomposing organic materials can become breeding sites for pests, rats, flies and vermin that enhance the likelihood of disease transmission like diarrhea and Lassa fever. Lassa fever for example is a hemorrhagic fever common in four African countries: Guinea, Liberia, Nigeria and Sierra Leone. It is transmitted to humans from contacts with food or household items contaminated with rodent excreta.

d. Flooding to health risks-indiscriminate dumping of wastes in the streets can block water drains and channels which can cause flooding, posing significant environmental and public health risks. Water pollution can occur when rain water combines with decomposing waste and seep through permeable soil, finally contaminating surface and ground water with both lethal materials and pathogenic organisms; this is extremely dangerous as ground water is the main source of drinking water for most people in Nigeria.

e. Low birth weight- children of women exposed to hazardous solid waste materials may have low weight at birth.

f. Cancer- biomedical waste containing carcinogenic materials can pose danger to human health. Biomedical waste materials such as polyethylene may emit carcinogens during combustion and anybody expose to it will be at risk.

g. Congenital malformations-congenital malformations may occur as a result of exposure by pregnant women to some toxic constituents known as teratogens in biomedical waste.

h. Increase in neurological disease- biomedical waste may also impart negatively on human health by increase in neurological diseases due to handling of bulky materials

i. Nausea and vomiting-obnoxious odours emanating from indiscriminate waste disposal sites may cause nausea and vomiting to humans.

j. Increase in hospitalisation- biomedical waste containing hazardous materials if not properly managed may results toxicity to people that may be exposed to it leading to increased hospitalisation especially of vulnerable people e.g. of diabetic residents living near hazard waste sites.

k. Mercury toxicity-toxicity may occur as a result of consumption of fish containing high level of heavy metals such as mercury leading to mercury poisoning.

l. Accidents- improper disposal biomedical wastes may lead to accidents on road causing loss of human lives and economic properties.

3.3.3 Occupational Hazards Associated with Waste Handling

i. Infections

- Skin and blood infections resulting from direct contact with waste, and from infected wounds

- Eye and respiratory infections resulting from exposure to infected dust, especially during landfill operations
- Different diseases that results from the bites of animals feeding on the waste
- Intestinal infections that are transmitted by flies feeding on the waste.

ii. Chronic Diseases

- Incineration operators are at risk of chronic respiratory diseases, including cancers resulting from exposure to dust and hazardous compounds.

iii. Accidents

- Bone and muscle disorders resulting from the handling of heavy containers
- Infecting wounds resulting from contact with sharp objects
- Poisoning and chemical burns resulting from contact with small amounts of hazardous chemical waste mixed with general waste
- Burns and other injuries resulting from occupational accidents at waste disposal sites or from methane gas explosion at landfill sites.

3.3.4 Economic Effects

a. Municipal Wellbeing

Everyone wants to live and visit places that are clean, fresh and healthy. A city with poor sanitation, smelly and with waste matter all over the place does not attract good people, investors and tourists. Such cities tend to have poor living standards.

b. Recycling Revenue

Cities that do not invest in recycling and proper waste control miss out on revenue from recycling. They also miss out on job opportunities that come from recycling, composting and businesses that work with them.

4.0 CONCLUSION

The total effect of solid waste on the environment and consequently on public health must be considered so as to avert any danger that may arise. Poor solid waste handling poses serious health implications and hazards to man. Many problems have been associated with improper handling of waste in the environment like dumping of waste on land, indiscriminate disposal of waste into rivers and other surface waters, or into the air can cause environmental pollution and hazards to the living organisms resulting to destruction of life. Effective management of solid waste is therefore a key for sustainable development and environmental protection to ensure public health.

5.0 SUMMARY

Finally, in this unit we presented to you the effects of solid waste accumulation on the environment, the health of man and even his economy. You learned that solid waste not only pollute the soil, water and air in our surroundings, it is also a major cause of accidents, global warming and to a greater extend flooding and their associated health consequences. Solid waste accumulation also leads to spread of infections and chronic diseases as well as economic loss as it discourages tourism and its associated investment potential.

6.0 TUTOR-MARKED ASSIGNMENT

1. Outline the effects of biomedical waste in the environment.

7.0 REFERENCES/FURTHER READING

Soge, O. O., Giardino, M. A., Ivanova, I. C., Pearson, A. L., Meschke, J. S. and Roberts, M. C. (2009). Low prevalence of antibiotic-resistant gram- negative bacteria isolated from rural south-western Ugandan groundwater. *Water SA* 35: 343–347.

Solberg, K. E. (2009). Trade in medical waste causes death in India. *Lancet* 373: 1067.

UNIT 3 BIOMEDICALWASTE TRANSFER TRANSPORT

CONTENTS

1.0 INTRODUCTION

Waste transfer can take place by the collection car emptying the garbage into a container for collection by a larger container car that transports it to a place of final disposal.

2.0 OBJECTIVE

By the end of this unit, you will be able to:

- explain how waste are being transferred and transported.

3.0 MAIN CONTENT

3.1 Definition of Term

This is the process of shifting discarded resources from the point of generation or storage to the point of recovery or pre-disposal point by a pre-determined medium. The medium can be man, mechanical or nature. If the place of disposal is far away or if very small vehicles are used for collection, it can be appropriate to load the garbage unto a larger transport vehicle. Transport is thereby rationalised in that it takes fewer vehicles and crews. Waste transfer can take place by the collection car emptying the garbage into a container for collection by a larger container car that transports it to a place of final disposal.

There are certain factors to be considered when designing waste transport system aspect of waste management.

These include:

i) Location of disposal points
ii) Disposal facilities
iii) Available technology
iv) Prevailing climate
v) Route plans and road network and
vi) Waste quality and quantity

In the transportation of waste resources the following can be used:
i) Tippers
ii) Side loaders
http://www.unaab.edu.ng
iii) Skip vehicles and
iv) Roll over vehicle

These are useful in the transportation of compressible wastes.
A front-loading garbage truck in North America.

Transportation of liquid waste may take place through networking in which the effluent passes into soil pipes (a channel) or through the channel to the final storage point and this is regulated through the use of gauge valve.

4.0 CONCLUSION

Transportation of liquid waste may take place through networking in which the effluent passes into soil pipes (a channel) or through the channel to the final storage point and this is regulated through the use of gauge valve.

5.0 SUMMARY

Transport is rationalized in that it takes fewer vehicles and crews. Waste transfer can take place by the collection car emptying the garbage into a container for collection by a larger container car that transports it to a place of final disposal.

6.0 TUTOR-MARKED ASSIGNMENT

1. Define the term waste transport.
2. List five factors to be considered when designing waste transport System.

7.0 REFERENCES/FURTHER READING

Phillips, G. (1999). Microbiological aspects of clinical waste. *Journal of Hospital Infection.* 41**(1)**: 1–6.

Potron, A. and Nordmann, P. (2009). Nosocomial spread of ESBL-positive Enterobacter cloacae co-expressing plasmid-mediated quinolone resistance Qnr determinants in one hospital in France. *Journal of Antimicrobial Chemotherapy*. 64: 653–654.

UNIT 4 RESOURCE RECOVERY

CONTENTS

1.0 INTRODUCTION

Moving towards this objective is moving towards an utopian environmental view that there is no such thing as waste, only resources. Hence, everything considered useful for something even though a waste somewhere.

2.0 OBJECTIVE

By the end of this unit, you will be able to:

- discuss resource recovery.

3.0 MAIN CONTENT

3.1 Definition of Term

To some people, a perfect system for waste disposal system would be a technology that is capable of accepting an unlimited amount of waste and safety containing it forever outside the sphere of human life. This is an impossible dream and it is not environmentally sound.

The environmentally preferred concept with respect to waste management is to consider wastes as resources out of place. With increasing cost of raw materials, energy, transportation and land to reuse and recycle more resources will become financially feasible. Moving towards this objective is moving towards an utopian environmental view that there is no such thing as waste, only resources. Hence, everything considered useful for something even though a waste somewhere.

Resource recovery means obtaining some economic benefits from materials that has been regarded as waste by someone. It includes:

(i) Reduce: the objective here is to reduce the amount of urban and other types of wastes that must be disposed of in landfills, incinerators, or other waste management facilities. Reducing waste can be facilitated by better packaging establishment of recycling programs and large-scale composting programs.

(ii) Reuse: this suggests using the same materials for the same purpose again, rather than disposing of it. An example of this is the refilling of soft drink bottles.

(iii) Conversion: this involves the processing of materials to make something different (such as producing padding for clothing and steeping bags from plastic bottles or producing compost from food waste)

(iv) Recycling: this involves processing materials so that it can be used again as the same material, such as the processing of waste paper to make pulp and then new ones. Recycling refers to the collection and reuse of waste materials such as empty beverage containers. The materials from which the items are made can be reprocessed into new products. Material for recycling may be collected separately from general waste using dedicated bins and collection vehicles, or sorted directly from mixed waste streams. The most common consumer products recycled include aluminium such as beverage cans, copper such as wire, steel food and aerosol cans, old steel furnishings or equipment , polyethylene and PET bottles, glass bottles and jars, paperboard cartons, newspapers, magazines and light paper, and corrugated fiber board boxes. PVC, LDPE, PP, and PS are also recyclable. These items are usually composed of a single type of material, making them relatively easy to recycle into new products. The recycling of complex products (such as computers and electronic equipment) is more difficult, due to the additional dismantling and separation required. The type of recycling material accepted varies by city and country. Each city and country have different recycling programs in place that can handle the various types of recyclable materials

(v) Energy recovery (Waste-to-energy): The energy content of waste products can be harnessed directly by using them as a direct combustion fuel, or indirectly by processing them into another type of fuel. Recycling through thermal treatment ranges from using waste as a fuel source for cooking or heating, to anaerobic digestion and the use of the gas fuel (see above), to fuel for boilers to generate steam and electricity in a turbine. Pyrolysis and gasification are two related forms of thermal treatment where waste materials are heated to high temperatures with limited oxygen availability. The process usually occurs in a sealed vessel under high pressure.

Pyrolysis of solid waste converts the material into solid, liquid and gas products. The liquid and gas can be burnt to produce energy or refined into other chemical products (chemical refinery). The solid residue (char) can be further refined into products such as activated carbon. Gasification and advanced Plasma arc gasification are used to convert organic materials directly into a synthetic gas (syngas) composed of carbon monoxide and hydrogen. The gas is then burnt to produce electricity and steam. An alternative to pyrolisis is high temperature and pressure supercritical water decomposition (hydrothermal monophasic oxidation).

4.0 CONCLUSION

The environmentally preferred concept with respect to waste management is to consider wastes as resources out of place. With increasing cost of raw materials, energy, transportation and land to reuse and recycle more resources will become financially feasible. Moving towards this objective is moving towards an utopian environmental view that there is no such thing as waste, only resources.

5.0 SUMMARY

Resource recovery means obtaining some economic benefits from materials that has been regarded as waste by someone. It includes:

(i) Reduce: the objective here is to reduce the amount of urban and other types of wastes that must be disposed of in landfills, incinerators, or other waste management facilities. Reducing waste can be facilitated by better packaging establishment of recycling programs and large-scale composting programs.

(ii) Reuse: this suggests using the same materials for the same purpose again, rather than disposing of it. An example of this is the refilling of soft drink bottles.

(iii) Conversion: this involves the processing of materials to make something different (such as producing padding for clothing and steeping bags from plastic bottles or producing compost from food waste)

6.0 TUTOR-MARKED ASSIGNMENT

1.Explain the term resource recovery.

7.0 REFERENCES/FURTHER READING

Chauhan, M. S. and Kishore, M. (2002). Existing solid waste management in hospitals of Indore city. *Indian Journal of Environment and Science.* 6:43–49.

Collins, C. H. and Kennedy, D. A. (1992). The microbiological hazards of municipal and clinical wastes. *Journal of Applied Bacteriology.* 73: 1–6.