



NATIONAL OPEN UNIVERSITY OF NIGERIA

SCHOOL OF SCIENCE AND TECHNOLOGY

COURSE CODE: ESM444

COURSE TITLE: Industrial Waste and Industrial Water Treatment

**ESM 444: INDUSTRIAL WASTE AND
INDUSTRIAL WATER TREATMENT**

Dr (Mrs) M. S. Dauda
University of Abuja

**NATIONAL OPEN UNIVERSITY OF NIGERIA
(NOUN)**

TABLE OF CONTENT

UNIT 1: WATER COOLING SYSTEMS

1.0	Introduction -	-	-	-	-	-	1
2.0	Objectives -	-	-	-	-	-	1
3.1	Recirculation water system	-	-	-	-	-	1
3.2	Applications of closed recirculation water system-	-	-	-	-	-	2
3.3	Advantages of closed recirculating water system-	-	-	-	-	-	2
4.0	Conclusion --	-	-	-	-	-	3
5.0	Summary -	-	-	-	-	-	3
6.0	Tutor marked Assignment	-	-	-	-	-	3
7.0	References -	-	-	-	-	-	3

UNIT 2: BOILERS AND BOILER WATER TREATMENT

1.0	Introduction -	-	-	-	-	-	4
2.0	Objectives -	-	-	-	-	-	4
3.1	Boiler Water -	-	-	-	-	-	4
3.2	Boiler Water Treatment -	-	-	-	-	-	5
4.0	Conclusion -	-	-	-	-	-	5
5.0	Summary -	-	-	-	-	-	6
6.0	Tutor Marked Assignment -	-	-	-	-	-	6
7.0	References -	-	-	-	-	-	6

UNIT 3: INDUSTRIAL WASTEWATER TREATMENT

1.0	Introduction -	-	-	-	-	-	7
2.0	Objectives -	-	-	-	-	-	7
3.1	Sources of Industrial Wastewaters	-	-	-	-	-	7
3.2	Industrial Wastewater Treatment	-	-	-	-	-	8
4.0	Conclusion -	-	-	-	-	-	9

5.0	Summary	-	-	-	-	-	-	10
6.0	Tutor Marked Assignment	-	-	-	-	-	-	10
7.0	References	-	-	-	-	-	-	10

UNIT 4: INDUSTRIAL WASTES AND THEIR IMPACT ON THE ENVIRONMENT

1.0	Introduction	-	-	-	-	-	-	11
2.0	Objectives	-	-	-	-	-	-	11
3.1	Sources of Industrial wastes	-	-	-	-	-	-	11
3.2	Common Industrial wastes	-	-	-	-	-	-	12
3.3	Impact of Industrial waste on the Environment	-	-	-	-	-	-	12
4.0	Conclusion	-	-	-	-	-	-	13
5.0	Summary	-	-	-	-	-	-	13
6.0	Tutor Marked Assignment	-	-	-	-	-	-	13
7.0	References	-	-	-	-	-	-	13

UNIT 5: HANDLING OF WASTES AND TREATMENT METHODS

1.0	Introduction	-	-	-	-	-	-	14
2.0	Objectives	-	-	-	-	-	-	14
3.1	Waste Management	-	-	-	-	-	-	14
3.2	Disposal of Wastes	-	-	-	-	-	-	15
3.3	Reduction of Wastes	-	-	-	-	-	-	15
4.0	Conclusion	-	-	-	-	-	-	16
5.0	Summary	-	-	-	-	-	-	16
6.0	Tutor Marked Assignment	-	-	-	-	-	-	16
7.0	References	-	-	-	-	-	-	16

UNIT 6: RECYCLING OF WASTES

1.0	Introduction	-	-	-	-	-	-	17
2.0	Objectives	-	-	-	-	-	-	17

3.1	Recycling of wastes-	-	-	-	17
3.2	Biological Reprocessing	-	-	-	18
3.3	Advantages of Recycling	-	-	-	18
4.0	Conclusion -	-	-	-	19
5.0	Summary -	-	-	-	19
6.0	Tutor Marked Assignment	-	-	-	20
7.0	References	-	-	-	20

UNIT 1: WATER COOLING SYSTEMS

1.0	Introduction
2.0	Objectives
3.1	Recirculation water system
3.2	Applications of closed recirculation water system
3.3	Advantages of closed recirculating water system
4.0	Conclusion
5.0	Summary
6.0	Tutor marked Assignment
7.0	References

1.0 Introduction

Water cooling systems are of two types: One type involves discharging water to a sewer and another type involves recirculation of water, that is, the cooling medium is reused and recycled.

2.0 Objectives

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

- Know the main types of recirculation water systems
- Describe closed recirculation water system
- Know the applications of closed recirculation water system
- Know the advantages of closed recirculation water system

3.1 Recirculation Water System

Recirculation water systems are of three types:

- The additive systems
- The open systems
- The closed systems

In the additive cooling systems, make-up water is used to maintain a specific temperature or range of temperature for the cooling.

In open recirculation systems, evaporative cooling process is carried out using cooling tower, evaporative condenser and sump tank or spray pond to remove large amounts of heat with small amounts of water loss.

Closed recirculation system is the most popular method of controlled cooling of water treatment.

In closed recirculation water system, water is circulated in a closed cycle and subjected to alternate cooling and heating without air contact. The heat energy that is absorbed in the closed system is transferred to the recirculating water of an open recirculating system by water-to-water exchanger.

3.2 Applications of closed recirculation water system

Closed recirculation water system is used to control temperature in industry. It is also applied in the cooling of gas engines and compressors, diesel engines which use radiator systems, sample coolers in power plants, air conditioning chilled water systems to transfer the refrigerant cooling to air washers, etc.

3.3 Advantages of closed recirculating water system

- Better control of temperatures in heat-producing equipments
- Simplified control of potential waterside problems
- Make-up water not needed unless there is leakage or for repairs
- Very little evaporation occurs
- No problem of scale deposits
- No dangers of cracked cylinders, broken heads or other mechanical failures.
- Less susceptible to biological fouling from slime and algae deposits
- Reduced corrosion.
- Reduced wastage of water
- Very convenient.

Exercise 1.1

State the main types of recirculation water systems.

Answer Kit

The main types of recirculation water systems are the additive systems, the open systems and the closed systems.

4.0 Conclusion

Closed system is the commonest recirculation water system that is used for cooling. The closed recirculation water system has many advantages.

5.0 Summary

In this unit, you have learnt about closed recirculation water system. The applications and advantages of closed recirculation water system have also been stated.

6.0 Tutor Marked Assignment

Describe how closed recirculation water system operates. State the applications and the advantages of closed recirculation water system.

7.0 References

www.gewater.com/handbook/coolingwatersystems/ch32closed.jsp

UNIT 2: BOILERS AND BOILER WATER TREATMENT

1.0 Introduction

2.0 Objectives

3.1 Boiler Water

3.2 Boiler Water Treatment

4.0 Conclusion

5.0 Summary

6.0 Tutor Marked Assignment

7.0 References

1.0 Introduction

This unit focuses on problems associated with boiler system and the various means of treatment.

2.0 Objectives

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

- Know the use of boiler system
- Identify problems of boiler system
- Describe different types of boiler water treatment

3.1 Boiler Water

In industries, steam is used as a means of transferring heat energy. The steam is usually generated using water boilers that are heated under controlled conditions. This results in the production of energy which is then used for many different things such as cooking, heating, chemical reactions etc. The steam usually dissolves other materials thereby creating problems. The major problems are: scale, corrosion, boiler water carryover and sludge deposition. Therefore, there is need for boiler water treatment.

3.2 Boiler Water Treatment

Industrial boiler water treatment includes:

- (a) The use of oxygen scavengers to absorb oxygen thereby preventing oxygen corrosion.
- (b) The use of sludge conditioners to help prevent suspended solids baking onto heat transfer surfaces.
- (c) The use of pH control products to help prevent corrosion.
- (d) The use of antifoams to minimize boiler water carryover.

- (e) The use of amines to protect the condensate system from oxygen and carbondioxide corrosion.

Exercise 1.1

What are the major problems associated with the use of boiler system?

Answer Kit

The major problems associated with the use of boiler system are formation of scales, corrosion, boiler water carryover and sludge deposition.

4.0 Conclusion

The use of boiler system for heating results in problems such as scale and sludge deposition. These problems must be treated.

5.0 Summary

Boiler water system is used for heating under controlled conditions. The problems created from the use of boilers can be treated using oxygen scavengers, sludge conditioners, pH as well as antifoams.

6.0 Tutor Marked Assignment

Describe boilers and the different methods of boiler water treatment.

7.0 References

www.gewater.com/handbook/coolingwatersystems/ch32clsoed.jsp.

UNIT 3: INDUSTRIAL WASTEWATER TREATMENT

- 1.0 Introduction
- 2.0 Objectives
- 3.1 Sources of Industrial Wastewaters

3.2 Industrial Wastewater Treatment

4.0 Conclusion

5.0 Summary

6.0 Tutor Marked Assignment

7.0 References

1.0 Introduction

Many industrial processes produce wastewaters. These are waters that have been contaminated in some way by anthropogenic industrial or commercial activities.

2.0 Objectives

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

- Identity the various sources of industrial wastewaters.
- Describe the various ways of industrial wastewater treatment.

3.1 Sources of Industrial Wastewaters

The main sources of industrial wastewaters include: Food industry, water treatment plant, agricultural waste, iron and steel industry, mines and quarries, nuclear industry as well as chemical industries.

3.2 Industrial Wastewater Treatment

Industrial wastewaters are treated to obtain good quality water for demanding purposes. Treatment of industrial wastewater involves:

Removal of solids – This involves processes such as sedimentation, filtration, flocculation as well as the use of alum salts.

Removal of oils and grease- This involves recovering of the oils from water surfaces by skimming devices.

Removal of biodegradable organic matter- Biodegradable organic material can be treated using activated sludge or trickling filter. These are biochemical processes of treating industrial wastewater.

The activated sludge method uses oxygen and microorganisms to oxidize the organic material thereby producing a waste sludge which contains the oxidized material.

The activated sludge process requires aeration and settling tanks. The aeration tank is where air is injected and properly mixed into the wastewater. The settling tank is to allow the waste sludge to settle.

The trickling filter process of removing biodegradable organic material involves adsorption of the organic materials by microbial slime layer, diffusion of air into the slime layer to provide the oxygen required for the oxidation of the organic material.

Treatment of other organic materials- Industrial wastewaters are also treated for other synthetic organic materials such as pesticides, pharmaceutical products, paints, solvents, cooking products, etc. The treatment that is carried out will depend on the type of organic material being treated.

Treatment of acids and alkalis – Acids and alkalis in wastewaters are treated by neutralization. Further treatment is usually needed after the neutralization to remove toxic residues produced.

Treatment of toxic materials – Toxic materials in industrial wastewaters are difficult to treat because they are generally resistant to biological processes. Toxic materials such as metals can be treated by precipitation. This can be achieved by changing the pH or by using other chemicals to form precipitates

with the metals. Other toxic dissolved materials can be removed by incineration. Others may require concentration followed by landfilling or recycling.

Exercise 1.1

State the main sources of industrial wastewaters

Answer kit

The main sources of industrial wastewaters include: the water treatment plant, food industry, agricultural wastes, nuclear industry, chemical industry, etc.

4.0 Conclusion

Most industrial activities produce contaminated wastewaters. There are different ways of treating the industrial wastewaters.

5.0 Summary

In this unit, you have identified the different sources of industrial wastewaters. You have also learnt about the different methods of treating industrial wastewaters.

6.0 Tutor Marked Assignment

Discuss the different methods of treating industrial wastewaters.

7.0 References

Water Environmental Federation Report (1980). Wastewater

Treatment. Journal of Water Pollution Control Federation.

52(5):999 - 1007

API (1990). Management of Water Discharges. American Petroleum
Institute.

UNIT 4: INDUSTRIAL WASTES AND THEIR IMPACT ON THE ENVIRONMENT

1.0 Introduction

2.0 Objectives

3.1 Sources of Industrial wastes

3.2 Common Industrial wastes

3.3 Impact of Industrial waste on the Environment

4.0 Conclusion

5.0 Summary

6.0 Tutor Marked Assignment

7.0 References

1.0 Introduction

Waste that is produced by activities of industry is referred to as industrial waste. The industrial activities include the production process, the use and the disposal of the products.

Industrial waste is produced at every stage of the industrial activities.

2.0 Objectives

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

- know the meaning of industrial waste
- know source and types of industrial waste
- know the impact of industrial waste on the environment

3.1 Sources of industrial waste

Some of the source of industrial waste are building and road construction, lumber and paper mills, textile mills, chemical and drugs industries, petroleum industries, transport industries, agriculture, nuclear industry, iron and steel industry, water treatment, mines, quarries, food and beverage industries, metallurgy and appliances, etc

3.2 Common Industrial Wastes

Some of the industrial wastes include: inorganic salts, acids, alkalis, detergents, suspended particulate organic compounds, dissolved organic, surfactants, slurries of rock particles, ammonia, cyanide, hydraulic oils and grease, paints, dyes, plastics, pesticide residues, effluents from vegetables, fruits and meat products. Other industrial wastes include metals such as zinc, arsenic, lead and mercury.

3.3 Impact of Industrial Waste on the Environment

Some of the industrial wastes are toxic and hazardous. The main impact of industrial wastes on the environment is pollution.

- Pollution of the environment, that is:

Water pollution

Air pollution

Soil pollution

- Health Hazards / Risks

Exercise 1.1

What is the main impact of industrial wastes on the environment?

Answer Kit

The main impact of industrial wastes on the environment is pollution. That is: pollution of water, soil and air. The pollution of the environment leads to health hazards and/or risks.

4.0 Conclusion

Wastes are usually produced at every stage of an industrial activity. These industrial wastes lead to the pollution of the environment resulting to health hazards/risks.

5.0 Summary

In this unit, industrial wastes have been defined and their sources identified. The impact of industrial wastes on the environment has also been stated.

6.0 Tutor Marked Assignment

How are industrial wastes produced?

7.0 References

www.online.com/articles/50898

UNIT 5: HANDLING OF WASTES AND TREATMENT METHODS

- 1.0 Introduction
- 2.0 Objectives
- 3.1 Waste Management
- 3.2 Disposal of Wastes
- 3.3 Reduction of Wastes

4.0	Conclusion
5.0	Summary
6.0	Tutor Marked Assignment
7.0	References

1.0 Introduction

The best way of handling wastes is to handle in ways that will reduce their harmful effect on human health and the environment.

2.0 Objectives

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

- know what is involved in waste management practices
- know the different methods of wastes disposal
- know how to reduce wastes

3.1 Waste Management

The collection, transportation, processing, disposal and monitoring of waste materials are referred to as waste management. Waste management also involves the recovering of resources as well as the recycling of waste materials. Waste management practices depend on the type of wastes and differ from place to place.

3.2 Disposal of Wastes

The method used to dispose wastes will depend on so many factors. The methods of disposing wastes, include:

Integrated waste management method - This involves the separation and collection and then the reuse and recycling of non-organic portion of the waste as well as the production of fertilizer or compost.

Landfill method - This involves burying the wastes usually in abandoned or unused quarries, mining voids or borrow pits.

Incineration method - This method involves burning organic wastes to convert them to heat, steam, gas, ashes and other residues.

Incineration is used to dispose solid, liquid and gaseous wastes. This method of disposing wastes can be carried out on small scale by individuals and on large scale in the industry.

Incineration reduces the volume of wastes. The main disadvantage of incineration is the liberation of gaseous pollutants.

3.3 Reduction of wastes

Reduction of wastes is an important way of managing wastes. In the reduction process of wastes, the waste materials are prevented from being generated. This can be achieved by:

- the reuse of second-hand products
- repairing broken items instead of buying new ones
- designing products to be refillable or re-usable
- encouraging consumers to avoid using disposable products.
- removing any food or liquid leftovers from cans
- packaging and designing products that use less materials to achieve

the same purpose.

All these will help avoid and /or reduce waste which is far better than any management practice.

Exercise 1.1

State the aim of waste management practice.

Answer kit

The aim of waste management is to handle wastes in way(s) that will reduce or minimize their harmful effects on human health and the environment.

4.0 Conclusion

Handling of wastes include the collection, transportation, processing, disposal as well as monitoring and reduction of the waste materials.

5.0 Summary

In this unit, you have known the essence of proper handling of wastes. You have studied the different methods of wastes disposal and reduction.

6.0 Tutor Marked Assignment

Discuss any two methods of disposing wastes. State the various means of reducing wastes.

7.0 References

- Oskamp S. (1995). Resource Conservation and Recycling:
Behaviour and Policy. *Journal of Social issues*. 51(4):157-177
- Pratarelli M.E. (2010). Social Pressure and Recycling.
Journal of Applied Social Psychology. 21(8): 611-629.

UNIT 6: RECYCLING OF WASTES

- 1.0 Introduction
- 2.0 Objectives
- 3.1 Recycling of wastes
- 3.2 Biological Reprocessing
- 3.3 Advantages of Recycling
- 4.0 Conclusion
- 5.0 Summary
- 6.0 Tutor Marked Assignment
- 7.0 References

1.0 Introduction

Recycling of wastes is one of the methods of disposing wastes in waste management practice.

2.0 Objectives

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

- know the meaning of recycling
- know the wastes that can be recycled
- know the importance of biological reprocessing
- know the advantages of recycling

3.1 Recycling of wastes

Recycling refers to the re-use of waste materials.

Recycling is a method of processing used materials so as to convert them into new products.

Recycling starts with the collection of the waste materials, separation and clean-up of the wastes.

The collection of wastes vary from place to place and it also depends on the general composition of the wastes. The collection of wastes may be carried out separately from general waste or sorted out directly from mixed wastes. Generally, the main methods of waste collection are: Drop-off centres, Buy-back centres and Curbside collection.

The recycling process involves passing the cleaned waste materials through a system that enables the material to be re-used.

Wastes that are commonly recycled, include:

- Different types of glass bottles and jars
- Paper products such as newspapers, magazines, paperboard cartons, cardboards, corrugated fiberboard boxes, etc
- Metal such as beverage cans, aerosol cans, food cans, aluminum, copper wire, zinc, lead, metal furnishings or equipments, etc
- Plastic materials especially thermoplastics the easiest to recycle because they melt when heated and can be remoulded
- Textile materials

- Electronic materials such as computers and electronic equipment
- Energy from wastes can be harnessed by converting them directly to fuel through combustion or by processing into another type of fuel or source of fuel

3.2 Biological Reprocessing

Biological composting and digestion processes are used to recycle organic wastes such as plant materials, food scraps, etc. The biological decomposition is used in the management of organic wastes by controlling and accelerating the natural process of decomposing organic materials.

The biological method of decomposition of organic wastes is either aerobic or anaerobic.

3.3 Advantages of Recycling

- New products are obtained.
- Wastage of potentially useful materials is prevented
- Volume of waste materials is reduced
- Air and water pollution is reduced
- Provides new sources of fuel
- Saves energy
- Saves money.

Exercise 1.1

What is recycling?

Answer Kit

Recycling is the re-use of waste materials.

4.0 Conclusion

Recycling of wastes is a very important method of waste management in which waste are converted into new useful products.

5.0 Summary

In this unit, you have learnt about recycling and biological reprocessing of wastes. Also, the advantages of recycling of wastes have been stated.

6.0 Tutor Marked Assignment

State the main processes in recycling of wastes.

State the advantages of recycling of wastes.

7.0 References

Carl A. Z. (2005). Scrap Recycling in America.

New Brunswick, NJ: Rutgers University.

Oskamp. S. (1995) Resource Conservation and Recycling:

Behaviour and Policy. Journal of Social Issues. 51(4): 157-177

Pratarelli M.E. (2010). Social Pressure and Recycling. Journal of

Applied Social Psychology. 21(8): 611-629.

CHM 444: INDUSTRIAL WASTE AND INDUSTRIAL WATER TREATMENT

Course Writer: Dr (Mrs) M. S. Dauda

University of Abuja