KEMENTERIAN PENDIDIKAN TINGGI
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI

POLITEKNIK MALAYSIA
TUN SYED NASIR

ENVIRONMENTAL QUALITY AND POLLUTION CONTROL: AN INTRODUCTION

AZINI AMIZA HASHIM
DR. ANIS SAKINAH ZAINAL ABIDIN
NOR AZRIN AHMAD KURNIN

ENVIRONMENTAL QUALITY AND POLLUTION CONTROL: AN INTRODUCTION

AZINI AMIZA HASHIM
DR. ANIS SAKINAH ZAINAL ABIDIN
NOR AZRIN AHMAD KURNIN

Copyright page
eISBN

FIRST PUBLISHED ONLINE 2025

Editor

Noorizyan binti Asimat

Illustrated by
Azini Amiza binti Hashim
Dr. Anis Sakinah binti Zainal Abidin
Nor Azrin binti Ahmad Kurnin

Published in Malaysia by:
Politeknik Tun Syed Nasir Syed Ismail
Hab Pendidikan Tinggi Pagoh
KM 1 Jalan Panchor 84600 Pagoh, Johor
Tel: 06-9742266 Faks: 06-9742395
Website: www.ptsn.edu.my

Cataloguing-in-Publication Data

Perpustakaan Negara Malaysia

A catalogue record for this book is available from the National Library of Malaysia

eISBN 978-967-2736-41-7

PREFACE

The conservation and protection of the environment represent a critical priority in contemporary society. With escalating concerns regarding environmental degradation, it has become imperative for individuals to develop a comprehensive understanding of the fundamental principles and practices of environmental engineering. *Environmental Quality and Pollution Control: An Introduction* eBook is designed to equip students with essential knowledge to interpret, evaluate, and address the complex challenges associated with environmental sustainability and preservation.

This eBook offers a comprehensive introduction to key themes such as water and wastewater treatment, as well as air and noise pollution control, presented through interactive notes enhanced with Augmented Reality (AR) elements. By engaging with these topics, students gain a foundational understanding of the various aspects of environmental engineering. The book begins with an introduction to environmental quality and pollution control, highlighting the interaction between humans and the environment. This chapter also outlines major environmental issues alongside relevant laws and regulations established to mitigate them.

The chapter on water and wastewater treatment provides a clear yet detailed examination of water quality characteristics, the technologies applied in treatment processes, and the management of sludge treatment and disposal. Understanding these aspects is vital for ensuring access to clean and safe water for both human health and ecological sustainability.

Finally, the chapter on air and noise pollution examines the different types of pollutants that adversely affect both the environment and human health. It also explores the technologies available to mitigate and control these pollutants, while assessing their impacts on ecosystems, climate, and overall public well-being.

CONTENTS

1.1 Define the importance of environmental quality and pollution control

The **environment** can be described as one's immediate surroundings. However, for an environmental engineer, a more specific interpretation is required. To an environmental engineer, the "environment" can mean anything from the global scale to small, specific areas needing solutions. It also includes contained spaces, like small volumes of liquid, gas, or solids in a treatment plant reactor.

The **ecosystem** is a community made up of biotic and abiotic components. The interaction between **biotic** and **abiotic** components is through nutrient cycles & energy flows.

The environment fulfill **human's natural and acquired needs**

Natural needs- These unprocessed natural resources were easily found in the biosphere, and their waste was usually compatible with or easily absorbed by the environment (renewable resources).

Acquired needs- These are processed, manufactured, or refined items that produce complex waste, often not easily absorbed by the environment (non-renewable resources).

Figure 1.1 shows how biotic and abiotic components interact.

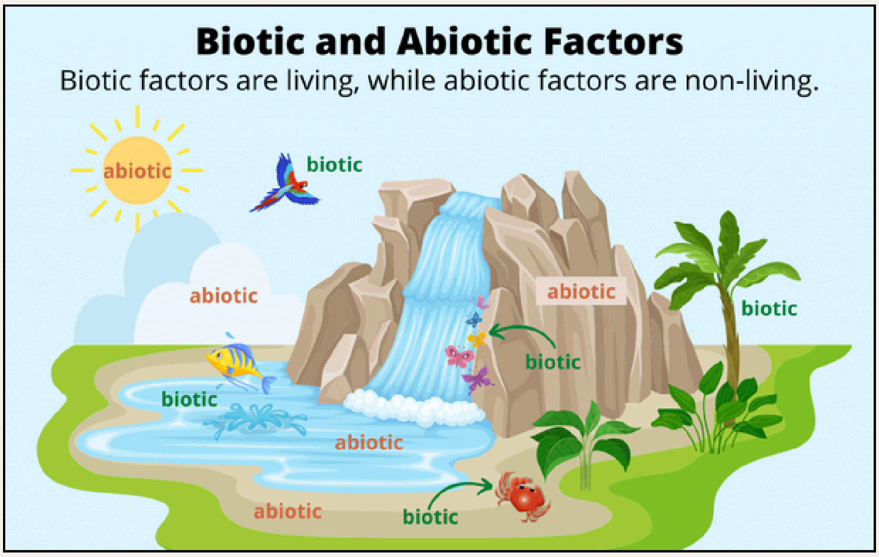


Figure 1.1: Interaction between biotic and abiotic components

Biotic factor

Example:

- Living organism like bacteria & plant.
- Dead organic matter

Abiotic factor

Example:

- Hydrosphere (ocean & lake)
- Atmosphere (air)
- Lithosphere (soil)

1.1.1 Identify the concepts and definitions of environmental quality and pollution control

Pollution refers to the buildup and harmful impacts of pollutants or other elements on human well-being and the environment. However, comprehending pollution requires us to identify and characterize potential pollutants.

These **contaminants** can arise from waste generated by living organisms, primarily humans. Yet, contamination can also arise from natural sources, such as arsenic leaching from bedrock into groundwater or smoke produced by natural fires leading to air pollution. Figure 1.2 shows the major categories of pollutants and their predominant routes of human exposure

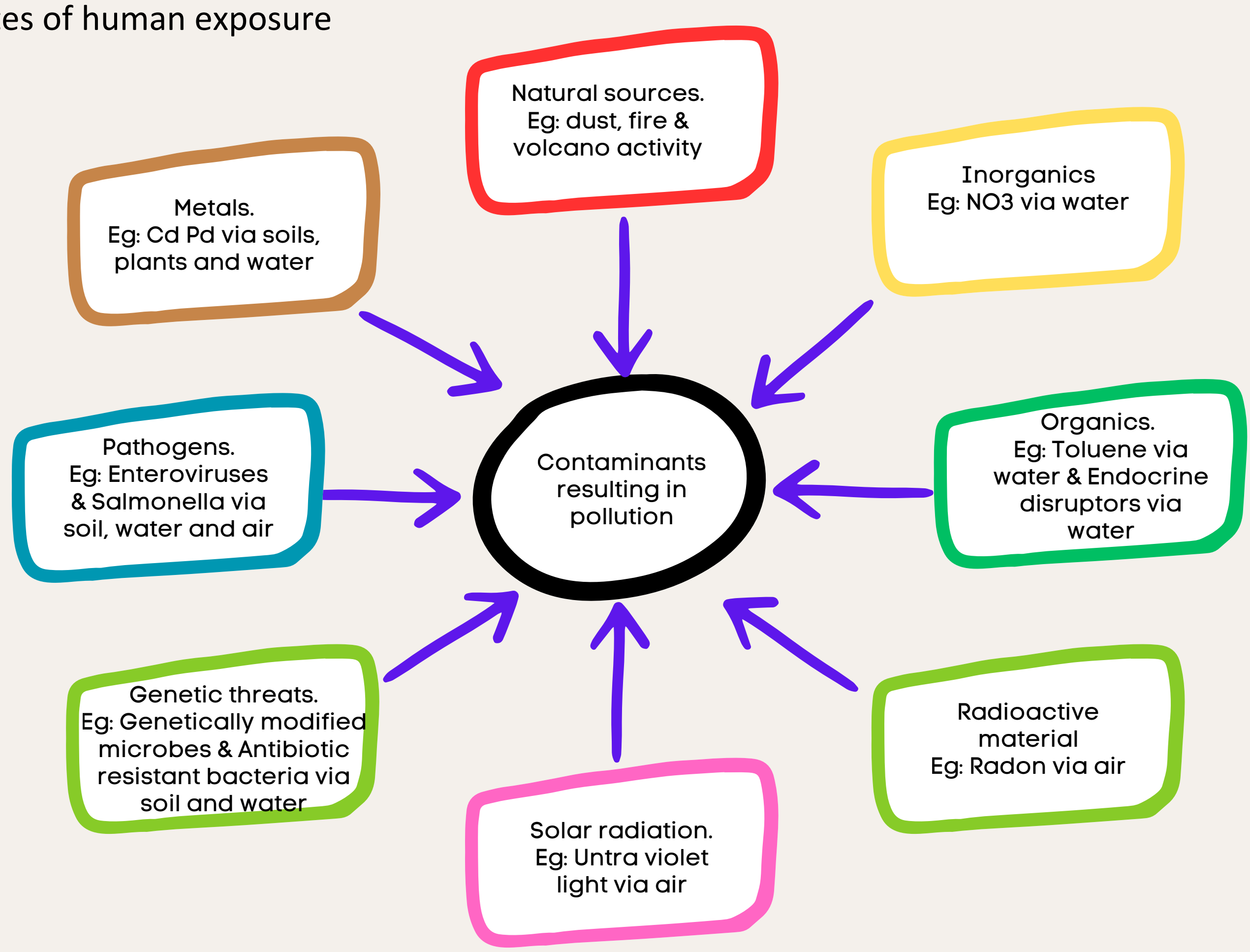


Figure 1.2: Major sources of pollutant

The environment includes land, water, air, and the biosphere, and is the first place where pollutants are released. These **pollutants** interact with the environment, change form, and eventually become part of it.

According to the **conservation** of mass, pollutants can't be destroyed, only transformed. So, the impact of a pollutant depends on how it's released, how fast, and how it changes in the environment, affecting both humans and other organisms.

1.1.2 Describe environmental impacts of human activities

The mismanagement of waste, excessive resource consumption, and uncontrolled development all have adverse **effects** on the environment. These effects ripple through the ecosystem, leading to degraded soil, water, and air quality, damaged habitats, and added pressure on wildlife populations.

Consequently, these impacts have numerous **direct and indirect consequences** for humans as well.

Direct effects

- Exposure to pollutants can result in illnesses and even fatalities among affected individuals, representing a direct consequence of pollution.

Indirect effects

- pollution diminishes the quality and availability of environmental resources for human use, potentially leading to scarcity and impacting human well-being indirectly
- overuse of specific resources can also lead to scarcity and indirectly affect human health and well-being.

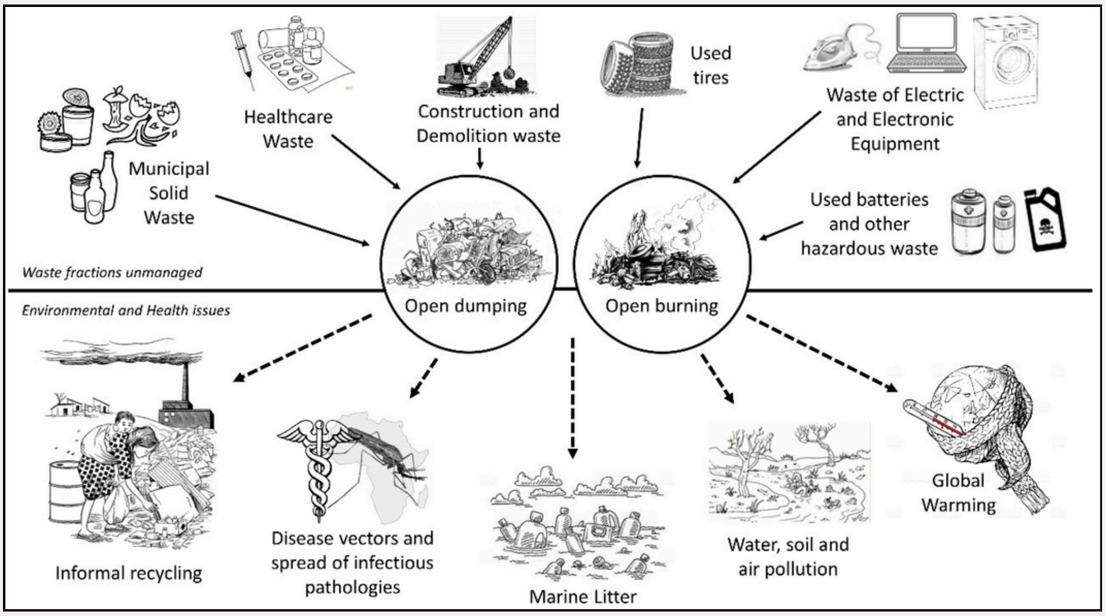


Figure 1.3: Source of contamination due to schedule waste mismanagement (Ferronato, N., & Torretta, V., 2019)

1.1.3 Outline importance of environmental quality and pollution control for human health and well being

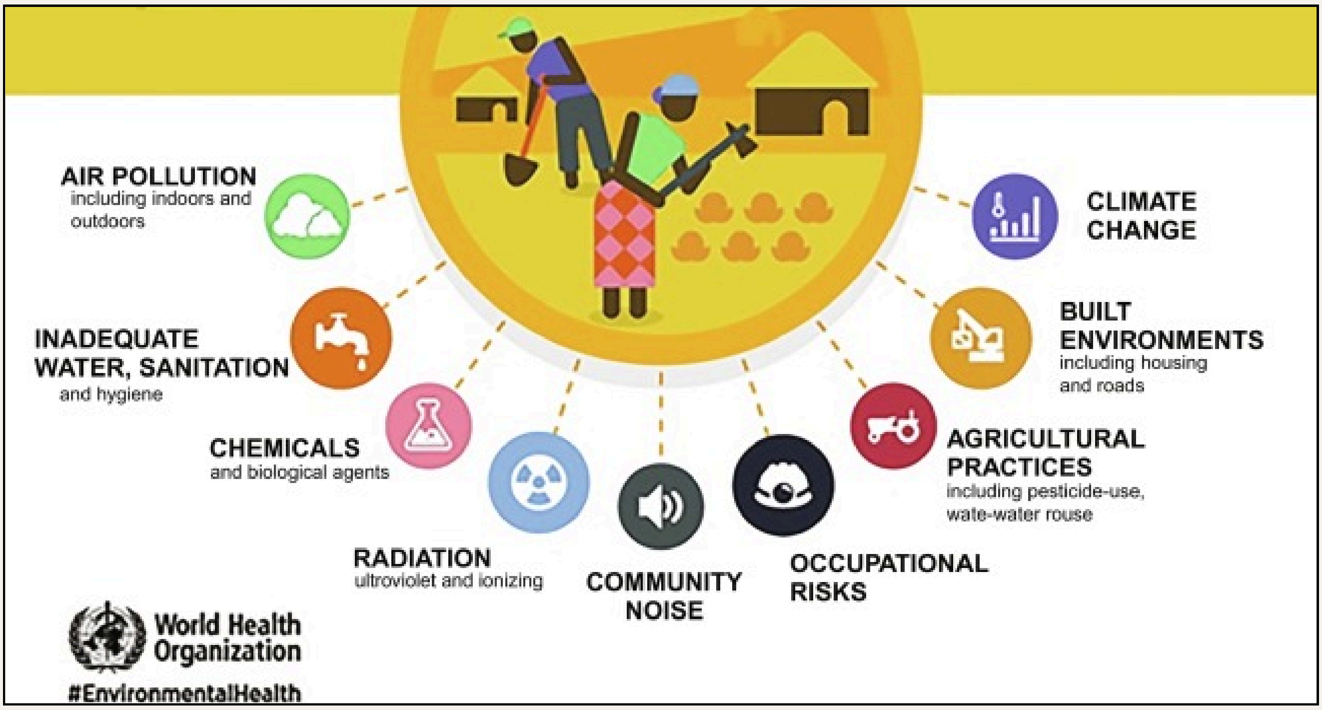


Figure 1.4: Environmental-related sources of risks to human health and well-being (World Health Organization)

Figure 1.4 shows the environmental-related human health impact can originate from pollution events and from environmental disturbance such as major global change issues. Global change issues represent challenges to human welfare and natural ecosystem.

Major global change issues

1) Climate issues

- Burning fossil fuels releases gases that trap heat, causing global warming. This leads to more extreme weather, rising sea levels, and threats to ecosystems and human health.

2) Coral reef destruction

- Coral reefs, home to 24% of marine life, are dying due to overfishing, pollution, disease, and climate change. Up to 70% could be lost soon.

3) Deforestation

- Cutting down forests for farming and housing destroys habitats, increases erosion, and adds to global warming. It also raises local temperatures and reduces biodiversity.

4) Desertification

- Fertile land is turning into desert due to overgrazing and poor farming. Over 70% of drylands are affected, especially in Africa, leading to hunger and displacement.

5) Drought

- Lack of rain, growing populations, and water pollution are causing water shortages for drinking and farming in many areas.

6) Species extinction

- Animals and plants are disappearing due to hunting, habitat loss, pollution, invasive species, and climate change. Over 19,000 plants and 5,000 animals are endangered.

7) Upper Atmosphere Ozone Depletion

Chemicals like CFCs from sprays and air conditioners damage the ozone layer, allowing harmful UV rays to reach Earth.

Figure 1.5 shows the summary of the biggest environmental problem.

Figure 1.5: The biggest environmental problem (Kain, 2023)

Lets take a look on
the effect of climate change!

1.1.4 Classify the relationship between environmental quality and economic development

The relationship between environmental quality and economic development can be complex and multifaceted. There are several possible classifications for this relationship, each representing a different perspective on how these two factors interact. Here are some common ways to classify their relationship:

Positive Correlation

This classification suggests that as economic development increases, so does environmental quality. The idea here is that as countries or regions become wealthier, they can afford to invest more in environmental protection, conservation, and sustainable practices. This positive correlation can be observed in certain cases where economic growth has been accompanied by improved environmental policies and technological advancements that reduce pollution and resource consumption (Shafik 1994).

Negative Correlation

In contrast to the previous classification, this perspective suggests that economic development often comes at the expense of environmental quality. The pursuit of economic growth may lead to increased pollution, habitat destruction, deforestation, and resource exploitation. Industries and businesses may prioritize short-term profits over long-term environmental sustainability, resulting in environmental degradation (Shafik 1994).

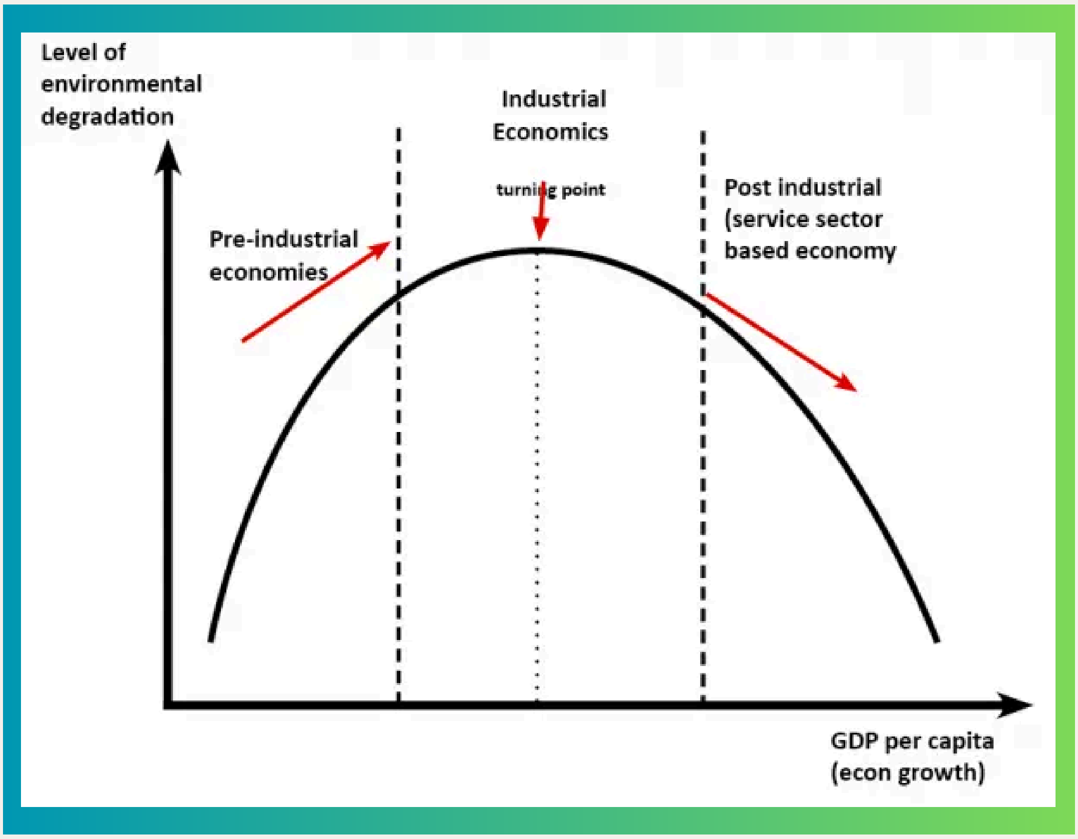


Figure 1.6: Diagram of Kuznet Curve

1.2 Describe environmental laws and regulations

1.2.1 State Malaysia Environment Quality Act EQA 1974

Introduction

EQA 1974 is an act relating to the prevention, abatement, control of pollution and enhancement of the environment. The Act restricts the discharge of wastes into the environment in contravention of the acceptable conditions. **Department of Environment (DOE)** is the body that administers and enforces EQ 1974. The EQA empowers the DOE to enforce environmental regulations and standards, monitor pollution sources, conduct inspections, issue permits and licenses, and take legal action against offenders. It sets out specific provisions, penalties, and enforcement mechanisms to ensure compliance with environmental standards and to address environmental pollution incidents.

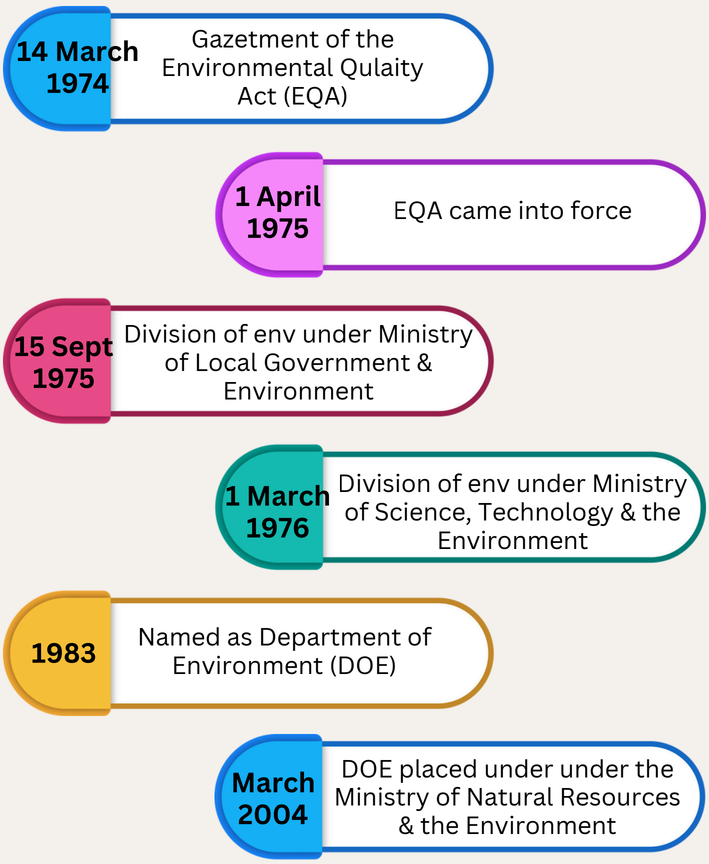


Figure 1.7: Flow of establishment of EQA 1974 and DOE

Principle adapted in the formulation of EQA 1974

- Premis/industry - Pollution should be controlled at source
- Pollulter pay principal - Polluters must pay or bear the cost of their pollution control.
- Standard sets - sets may be contravened in certain circumstances provided that it does not adversely affect the environment.
- Variable standards - may be specified if the uniform standards is inadequate to protect the environment

Objective of EQA 1974

- Prevention of pollution
- Enhancement of the environment
- Control of pollution
- Abatement of pollution

Regulations and orders under EQA 1974

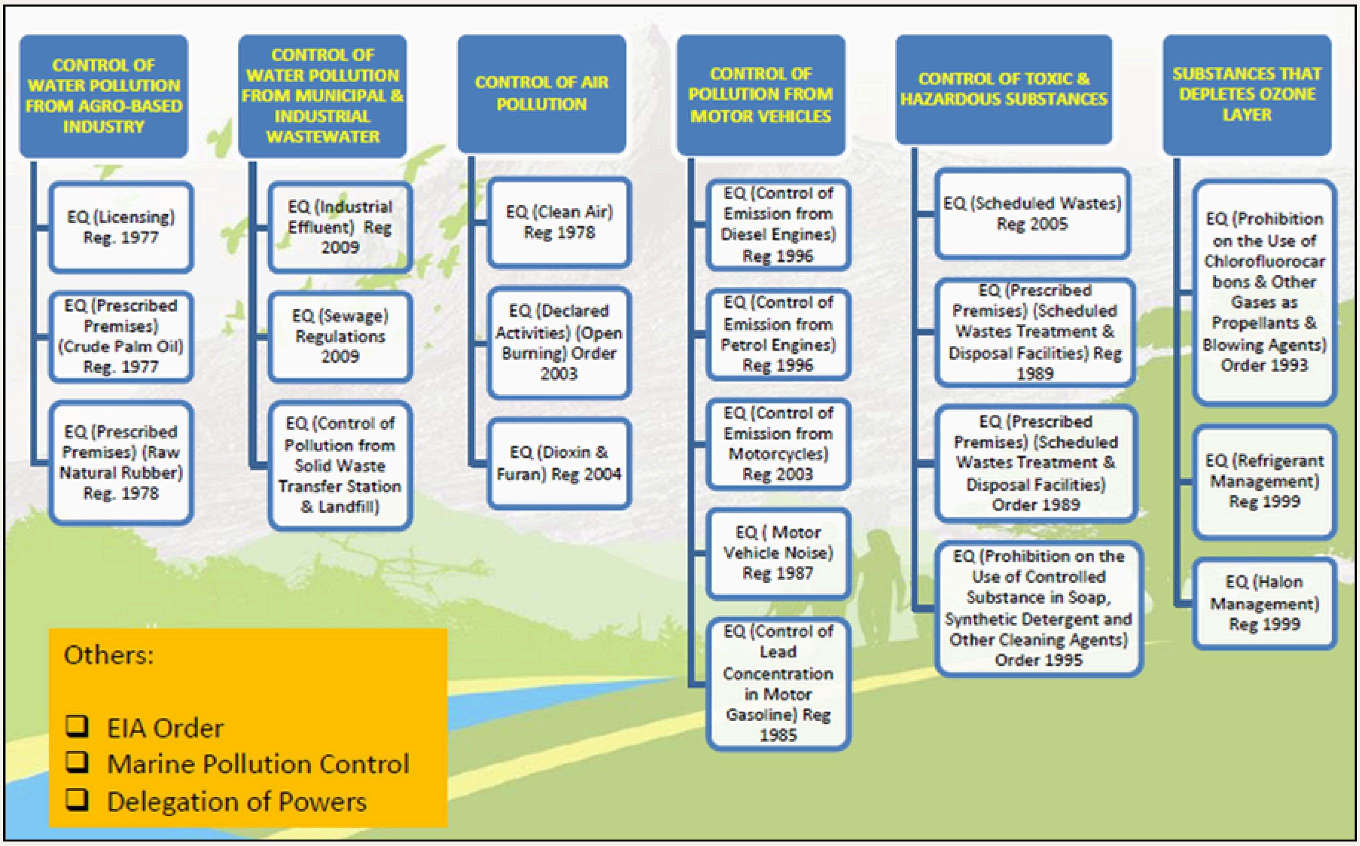


Figure 1.8: Regulations and orders under EQA 1974

1.2.2 Categorize EQA regulation

Categories of EQA Regulations

- Control of water pollution from agro-based industry
- Control of water pollution from municipal & industrial wastewater
- Control of air pollution
- Control of pollution from motor vehicles
- Control of toxic & hazardous substances
- Substances that depletes ozone layer

Control of water pollution from Agro-based industry

Agricultural pollution is the main sources of pollution in water and lakes. Chemical from fertilizers and pesticide make their way into groundwater that ends up in drinking water.

Regulations for Agro-based industry:
- -EQ (Licensing) Regulation 1977
- -EQ (Prescribed Premises) (Crude Palm Oil) Regulation 1977
- -EQ (Prescribed Premises) Raw Natural Rubber (Regulation 1997)

Control of water pollution from municipal & industrial wastewater

EQ (Industrial effluent) Regulation 2009

Apply to any premises which discharge or release industrial effluent or mixed effluent onto or into any soil, or into any inland waters, except those listed in First Schedule.

EQ (Sewage) Regulation 2009

Applicable to any premises which discharge sewage onto or into any soil, or into any inland waters or Malaysian waters, other than any housing or commercial development or both having a population equivalent (PE) of less than 150.

EQ (Control of Pollution from Solid Waste Transfer Station & Landfill) Regulation 2009

Applicable to solid waste transfer stations and landfills which discharge or release leachate.

Industrial effluent for mixed effluent has standard 'A' and standard 'B' as depicted in Figure 1.9. Figure 1.10 shows the example of acceptable conditions for discharge of effluent for mixed effluent for standard 'A' and standard 'B'.

Standard A is for discharge upstream of any raw water intake.

Standard B is for discharge downstream of any raw water intake

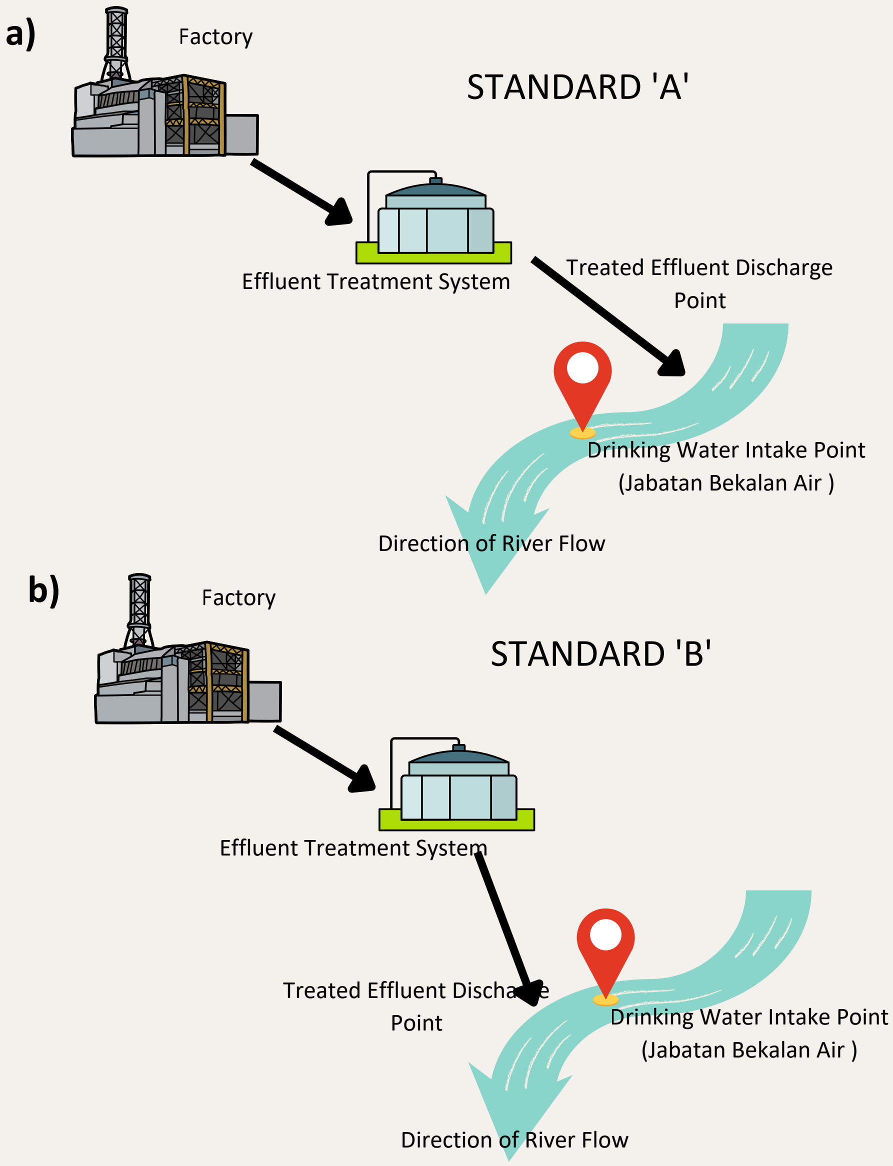


Figure 1.9: Difference between a) standard 'A' and b) standard 'B'

APPENDIX K2

Extracted from Environmental Quality (Industrial Effluents) Regulations 2009 (PU (A) 434)

FIFTH SCHEDULE
[Paragraph 11(1) (a)]

ACCEPTABLE CONDITIONS FOR DISCHARGE OF INDUSTRIAL EFFLUENT FOR MIXED EFFLUENT OF STANDARDS A AND B

	Parameter	Unit	Standard A	Standard B
	(1)	(2)	(3)	(4)
(i)	Temperature	°C	40	40
(ii)	pH Value	-	6.0-9.0	5.5-9.0
(iii)	BOD_5 at 20°C	mg/L	20	40
(iv)	Suspended Solids	mg/L	50	100
(v)	Mercury	mg/L	0.005	0.05
(vi)	Cadmium	mg/L	0.01	0.02
(vii)	Chromium, Hexavalent	mg/L	0.05	0.05

Figure 1.10: Example of acceptable conditions for discharge of effluent for mixed effluent for standard 'A' and standard 'B'

Control of air pollution

EQ (Clean Air) Regulation 1978

EQ (Clean Air) Regulation 2014

Applicable to:

- any premises used for any industrial or trade purposes, or on which matter is burnt in connection with any industrial or trade purposes, including burning of waste, whether or not the premises are prescribed under section 18 of the Act
- any other premises or process that discharges or is capable of discharging air pollutants into the open air
- any industrial plant
- any fuel burning equipment.

EQ (Dioxin and Furan) Regulation 2004

Applicable to:

- municipal solid wastes incinerator
- scheduled wastes incinerator
- pulp or paper industry
- sludge incinerator
- sewage sludge incinerator

Table 1.1 : New Malaysia Ambient Air Quality Standard (https://www.doe.gov.my/en/2021/12/15/air-quality-standards/)

Pollutants	Averaging Time	Ambient Air Quality Standard		
		IT-1 (2015) µg/m^3	IT-2 (2018) µg/m^3	Standard (2020) µg/m^3
Particulate Matter with the size of less than 10 micron (PM_{10})	1 Year	50	45	40
	24 Hour	150	120	100
Particulate Matter with the size of less than 2.5 micron ($PM_{2.5}$)	1 Year	35	25	15
	24 Hour	75	50	35
Sulfur Dioxide (SO_2)	1 Hour	350	300	250
	24 Hour	105	90	80
Nitrogen Dioxide (NO_2)	1 Hour	320	300	280
	24 Hour	75	75	70
Ground Level Ozone (O_3)	1 Hour	200	200	180
	8 Hour	120	120	100
*Carbon Monoxide (CO)	1 Hour	35	35	30
	8 Hour	10	10	10

*mg/m^3

Click! **HOW TO MEET AMBIENT AIR QUALITY STANDARD?**

Control of toxic & hazardous substance

EQ (Scheduled waste) Regulation 2005

- **Schedule Waste** is any waste falling within the categories of waste listed in the First Scheduled of the Environmental Quality (Scheduled Wastes) Regulations 2005.
- There are 77 categories of scheduled wastes listed which is divided into **FIVE parts:**

1. **SW 1** – Metal and metal-bearing wastes
2. **SW 2** – Wastes containing principally inorganic constituents which may contain metals and organic materials
3. **SW 3** – Waste containing principally organic constituents which may contain metals and inorganic material.
4. **SW 4** – Wastes which may contain either inorganic or organic constituents
5. **SW 5** – Other wastes

EQ (Prescribed Premises)(scheduled Waste Treatment And Disposal Facilities) Regulations 1989

- **Prescribed premises** means premises prescribed by the Environmental Quality (Prescribed Premises) (Scheduled Waste Treatment and Disposal Facilities) Order 1989.
- **SIX** categories of prescribed premises:

1. **Off-site storage facilities** – Premises occupied or used for storage, collection or transfer of any SW which is not produced on those premises.
2. **Off-site recovery facilities** – Premises occupied or used for the retrieval of material or product from any SW which is not produced on those premises.
3. **Off-site treatment facilities** – Premises occupied or used for the processing of material or product from any SW which is not produced on those premises.
4. **Land treatment facilities** – Premises used for the land treatment of any SW such as sludge farming
5. **Scheduled waste incinerators** – Premises used or occupied for the thermal destruction of any SW
6. **Secured landfills** – Premises used or occupied for the disposal of any SW on land

Control of substances that depletes ozone layer

EQ (Refrigerant Management) Regulations 1999

The provisions shall apply to a person handling a refrigerant environmentally hazardous substance in an existing or a new installation. Table 1.2 shows Refrigerant environmentally hazardous substances according to Regulation 2.

Table 1.2 : Refrigerant Environmentally Hazardous Substances

Group	Chemical Formula	Substance
1	$CFCl_3$	Trichhlorofluoromethane (CFC – 11)
	CF_2Cl_2	Dicholorodifluoromethane (CFC – 12)
	$C_2F_3Cl_3$	Trichlorotrifluoroethane (CFC – 113)
	$C_2F_4Cl_2$	Dichlorotetrafluoethane (CFC – 114)
	C_2F_5Cl	Chloropentafluoroethane (CFC – 115)

Table 1.3 : List of Halon from Schedule 1

Group	Chemical Formula	Common Name
Bromochlorodifluoromethane	CF_2BRC_1	Halon 1211
Bromotrifluoromethane	CF_3Br	Halon 1301
Dibromotetrafluorothane	$C_2F_4Br_2$	Halon 2402

CLICK HERE **Effect of Refrigerant to Environment**

Tutorial
Question

1. How do human activities contribute to pollution and what are some of the major environmental impacts of these activities?
2. Discuss the significance of pollution control in preserving ecosystems and biodiversity. Provide real-world examples to support your answer.
3. In your own words, define environmental quality and its relevance to sustainable development.
4. How do environmental factors affect human health and well-being? Discuss the interplay between a healthy environment and public health.
5. Describe the potential long-term consequences of neglecting pollution control and environmental quality for future generations.
6. Can economic development and environmental quality go hand in hand? Explain the relationship between these two factors and any potential trade-offs.
7. Assess the effectiveness of existing pollution control measures and environmental laws in your country or region. What improvements could be made?
8. Analyze the challenges faced in implementing and enforcing environmental laws and regulations. How can these challenges be overcome?

Activities

Case Scenario:

"A new chemical factory has been proposed in a town near a river and forest area. The factory promises jobs and economic growth but may increase air and water pollution. The town hall is being held to discuss whether the factory should be approved."

Instructions:

1) In a group of 4 to 6 students, assign each students a role of
   - Environmentalist
   - Factory Owner
   - Government Official
   - Local Resident
   - Scientist

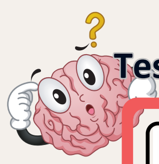
2) Prepare a short opening statement (1–2 minutes) to express your opinion.

3) Each student presents their viewpoint.

After everyone speaks, there will be a discussion or rebuttal session.

Try to persuade others, support your argument with facts, and stay in character.

As a group, vote or come to a consensus on whether the factory should be allowed.



Test Yourself!

SCAN HERE!

Tutorial

Answer

1. Human activities contribute to pollution through actions like industrial emissions, transportation, and deforestation. Major environmental impacts include air and water pollution, habitat destruction, and climate change.
2. Pollution control is significant in preserving ecosystems and biodiversity by reducing harmful pollutants. For example, limiting pesticide use helps protect beneficial insects and wildlife.
3. Environmental quality refers to the overall condition of the environment, affecting the well-being of all living organisms. It is crucial for sustainable development, ensuring a healthy planet for future generations.
4. Environmental factors can impact human health by affecting air and water quality, leading to respiratory diseases and waterborne illnesses. A healthy environment is vital for maintaining public health and preventing disease outbreaks.
5. Neglecting pollution control and environmental quality may result in severe consequences, such as loss of biodiversity, ecosystem collapse, and health problems for future generations.
6. Economic development and environmental quality can be balanced through sustainable practices. However, trade-offs may arise, requiring careful planning and decision-making to achieve both goals.
7. The effectiveness of pollution control measures and environmental laws varies. Improvements can be made by enforcing stricter regulations, investing in cleaner technologies, and raising public awareness.
8. Challenges in implementing and enforcing environmental laws can be overcome through better coordination between government agencies, public education, and active involvement of stakeholders.

2.1 Identify the characteristics of water quality

The Engineering Services Department of the Ministry of Health of Malaysia has set up drinking water quality guidelines. The purpose of this guideline is to ensure that drinking water and water used for domestic purposes is safe, pleasant-tasting, and visually appealing. Besides, its' also aimed to establish limits for substances in water that could be harmful to health or unappealing to the consumer's senses.

2.1.1 Types of water pollutants

Generally, there are two types of water sources: groundwater and surface water. Figure 2.1 shows the detail figure of groundwater.

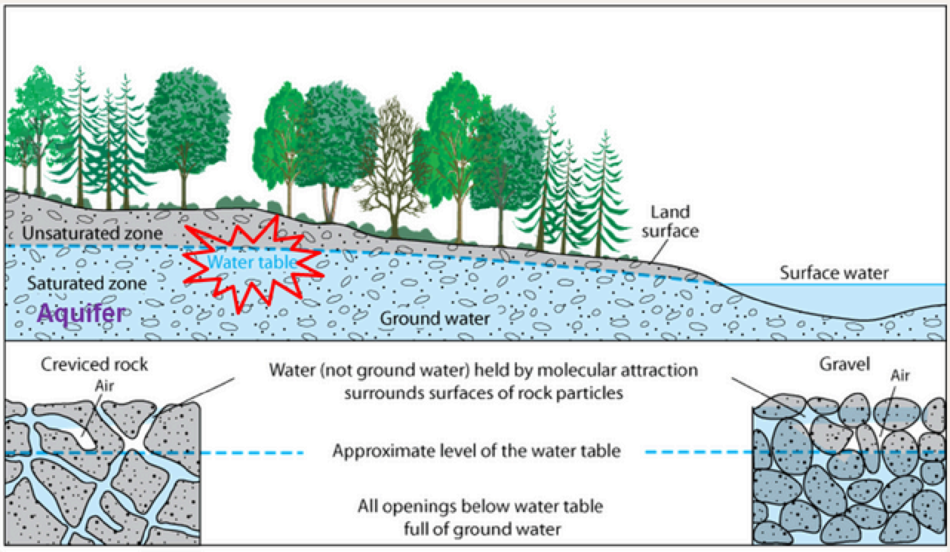


Figure 2.1: Parts in groundwater
(source: https://www.cdc.gov/healthywater/drinking/public/water_sources.html)

There are two zones: unsaturated and saturated zone. Groundwater can only be extracted out from the saturated zone (or known as aquifer) which lies below the zone of aeration. The boundary which both zones met is called as water table or phreatic surface. At this point, the hydrostatic pressure of groundwater at the surface is equivalent to atmospheric pressure. Meanwhile, surface water such as freshwater, seawater, streams and river are mainly contributed by hydrologic cycle as shown in Figure 2.2.

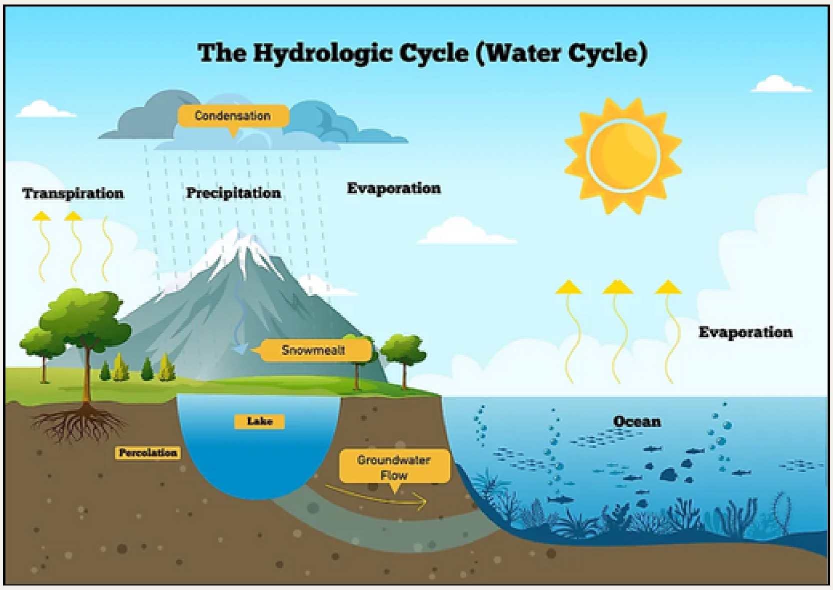


Figure 2.2: Hydrologic cycle
(https://www.worldatlas.com/the-water-cycle.html)

The water quality management are dependent on three primary parameters: physical, chemical, and biological. These critical components serve as the foundation for evaluating water health and sustainability in aquatic ecosystems. By comprehensively evaluating these parameters, we can determine the quality and usefulness of water resources, ensuring their preservation and optimal utilization for the benefit of all.

2.1.2 Physical water quality parameter

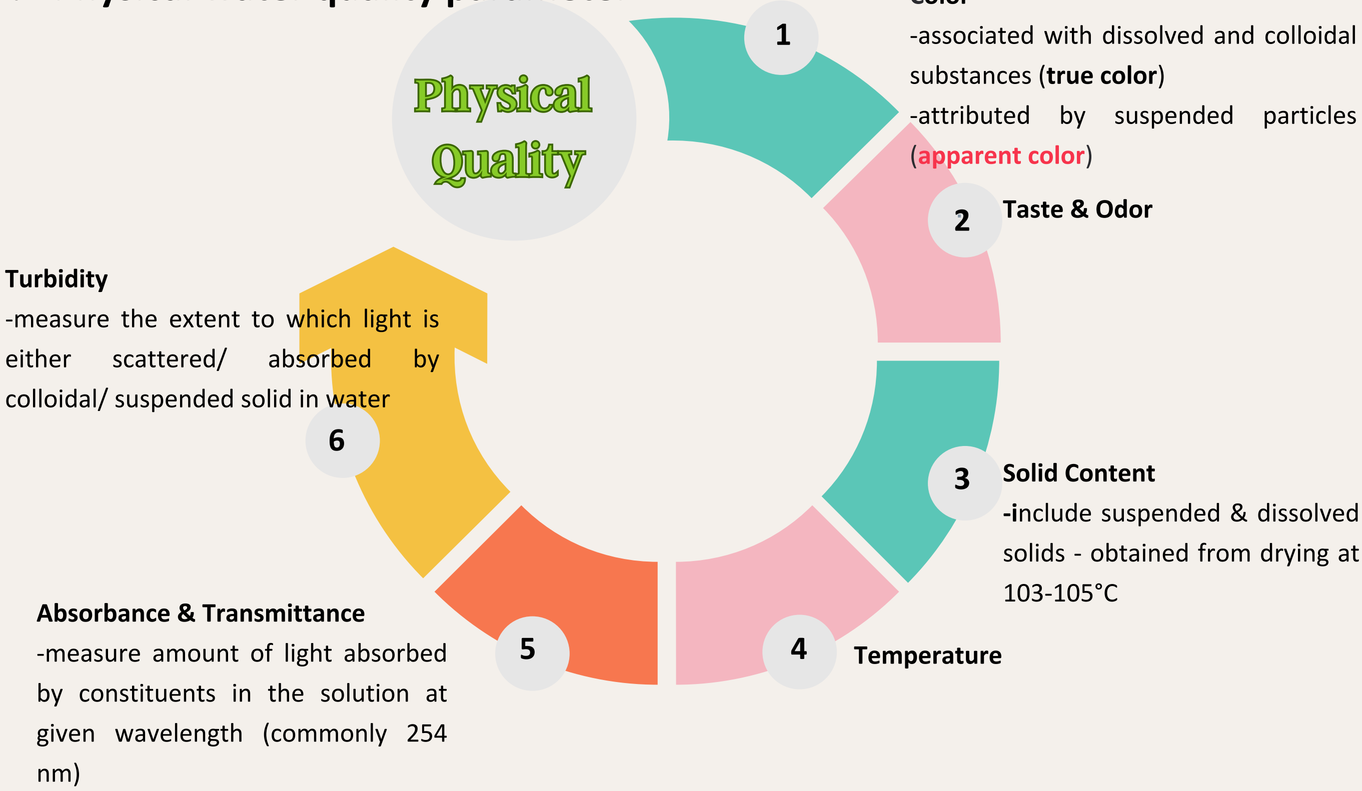


Figure 2.3: Physical quality of water

Based on Figure 2.3, there are 6 main physical qualities of water which includes color, taste, odor, solid content, temperature, absorbance, transmittance and turbidity. While most of the physical parameters have been described in Figure, third parameter which is solid content is described as follows. In water analysis, the solid content of water sample can be categorized into two subcategories, total dissolved and suspended solids. Total solids encompass all matter remaining after evaporation and drying of the sample, consisting of both suspended and dissolved solids. Total solid content can be calculated using Equation 2.1.

$$TS\ (mg/L) = \frac{W_{residue\ +dish} - W_{dish}}{V_{Sample}} \ldots\ldots\ldots\ldots (eq2.1)$$

Total Suspended Solid (TSS)

Solid content that can be determined through filtration using pores sized between 0.45 to 2 micrometers and then dried. TSS can be calculated using Equation 2.2.

$$TSS\ (mg/L) = \frac{W_{residue\ +filter} - W_{filter}}{V_{Sample}} \ldots\ldots (eq2.2)$$

Total Dissolved Solid (TDS)

Solid content which consisted of fixed and volatile dissolved solid that can pass through filter. TDS can be calculated using Equation 2.3.

$$TDS\ (mg/L) = TS - TSS \ldots\ldots (eq2.3)$$

2.1.3 Chemical Water Quality Parameter

Chemical parameter of water and wastewater can be divided into two categories which are inorganic and organic. Figure 2.4 depicts the inorganic chemical parameter with its' detail.

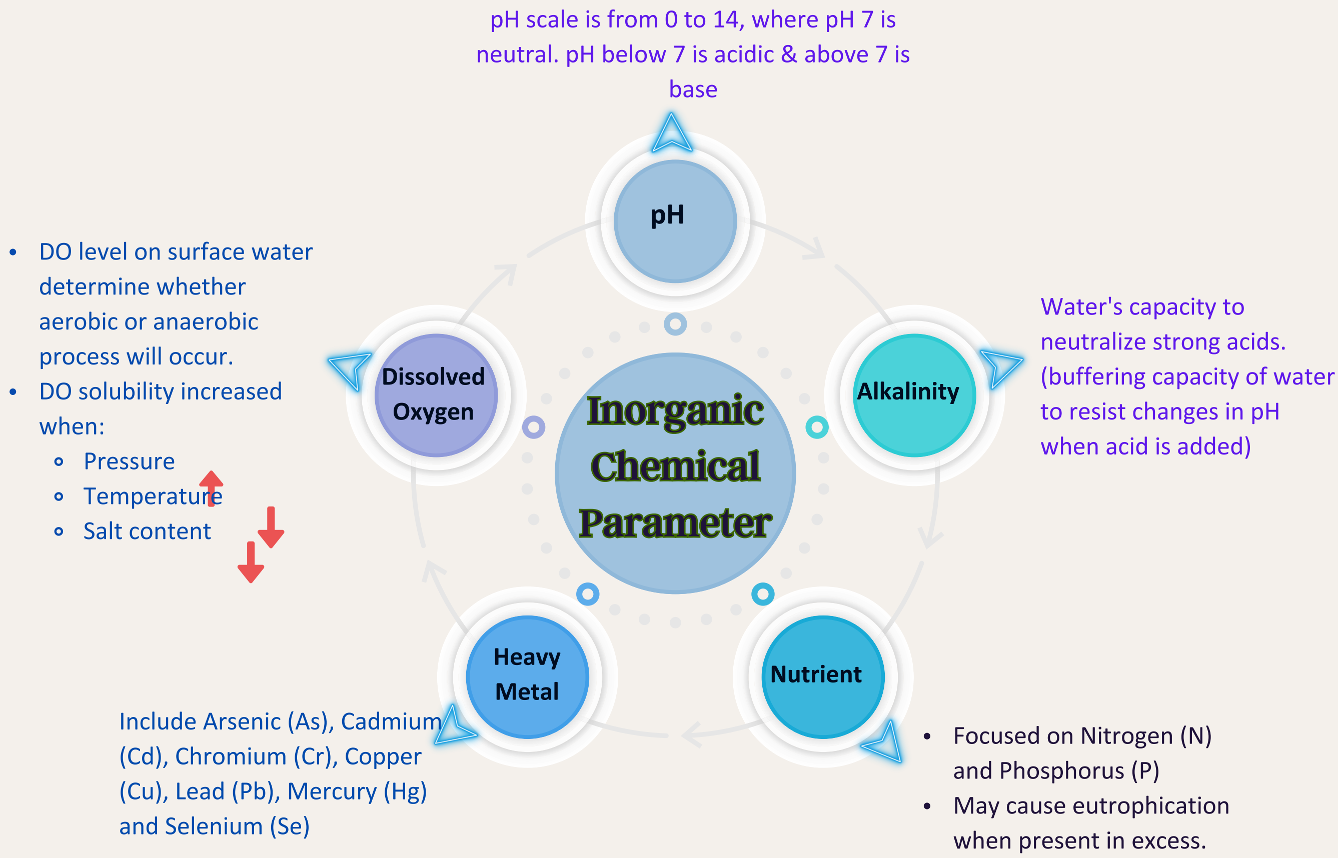


Figure 2.4: Inorganic chemical parameter of water

Besides inorganic chemical parameter of water, organic chemical parameter such as chemical oxygen demand (COD), total organic carbon (TOC) and oil and grease (O&G) are also essential in determining the water quality.

Total Organic Carbon (TOC)

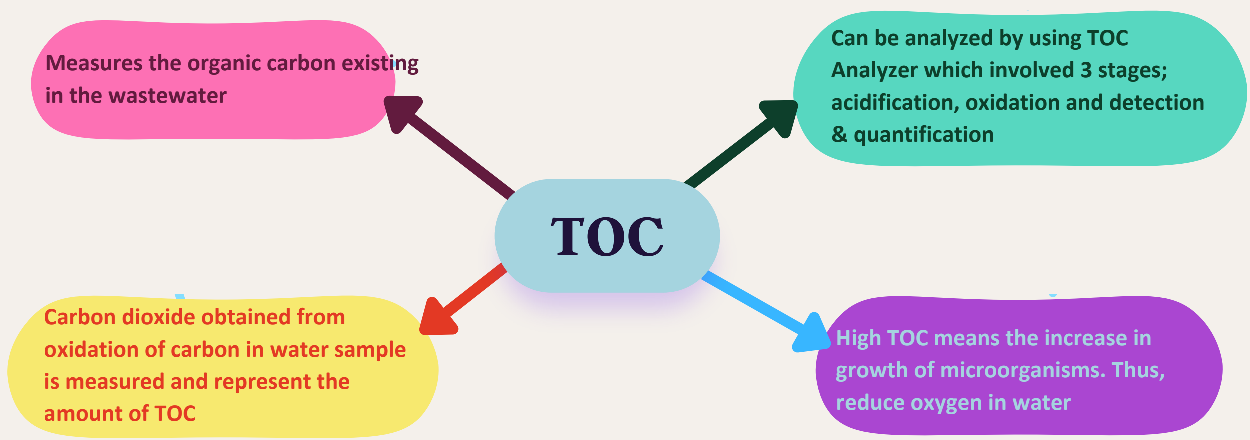


Figure 2.5: Information on TOC

Chemical Oxygen Demand (COD)

Chemical Oxygen Demand (COD) defined as the amount of oxygen required to chemically oxidize and decompose organic and inorganic matter in water. It's another vital indicator of water quality and pollution levels beside BOD, often used in wastewater treatment and environmental monitoring. By quantifying the oxygen demand of a water sample, COD provides valuable insights into the presence of contaminants and the potential impact on aquatic ecosystems, making it an essential tool for assessing and managing water quality.

$$COD >> BOD_u \geq BOD_5$$

COD results are typically higher than BOD values, as COD considers all oxygen-consuming substances. In summary,

2.1.4 Biological Water Quality Parameter

Biological Oxygen Demand (BOD)

Definition: Quantification of amount of oxygen used by microorganisms to oxidize dissolved organic and inorganic constituents in water.

BOD_5 : The amount of oxygen consumed (in mg/L)over a 5 days period at 20°C (in the dark). It is a measure of the bio-availability over 5 days period under controlled conditions.

BOD_u : The maximum amount of oxygen usage by microorganisms over a long period of time. A good measure of maximum bio-availability.

BOD level varies according to industries/ sources. Figure 2.6 shows the BOD level (mg/L) for different type of industries/ sources. Amount of organic & inorganic material presents in the discharge stream from the industries affect the BOD level. **Higher BOD level in water indicate that the water is polluted.**

Compound	BOD_5, mg/L
Domestic Wastewater	200
Ethylene glycol	400,000
Whole Milk	102,500
Skim Milk	73,000
Coke	67,400
Pepsi	79,500

Figure 2.6: BOD level in water from various industries

BOD consisted of:

Carbonaceous BOD (CBOD) is used to quantify the amount of oxygen used by microorganisms to oxidize dissolved organic constituents in water.

Nitrogenous BOD (NBOD) referred to amount of oxygen used by microorganisms to oxidize dissolved nitrogen in a water.

Figure 2.7 depicts the differences between CBOD, NBOD level for a sample.

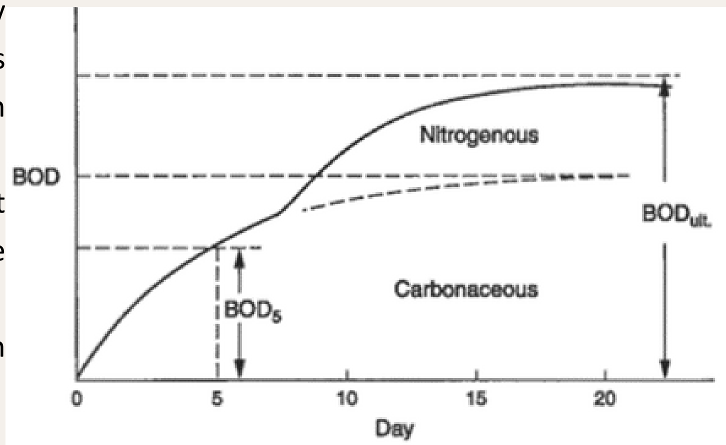


Figure 2.7: Type of BOD and its' level

Factors affecting BOD level are:

1. TEMPERATURE OF WATER BODY
2. pH OF WATER BODY
3. PRESENCE OF MICROORGANISMS
4. CONCENTRATION OF ORGANIC CONSTITUENTS IN WATER

Methods to calculate BOD

There are two methods to calculate BOD of water sample:

i. Theoretical method

By applying the first order reaction equation:

$$y = L(1-10^{-k1 \cdot t})$$

where ;

y = BOD value for 5 days incubation, BOD_5
L = ultimate BOD, BOD_u
k_1 = First order reaction constant, day-1
t = time in days

However, k_1 is affect by temperature. Thus the value may change according to the following equation:

$$k_{1T} = k_{1-20} 1.047^{T-20}$$ where T is in celcius

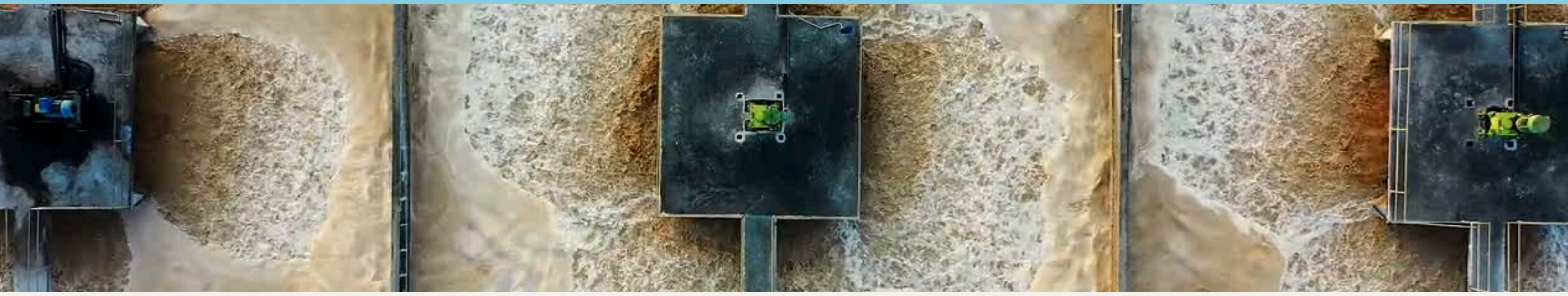
ii. Experimental/ Laboratory test method

Besides theoretical method, Biological Oxygen Demand (BOD) can also be measured by using the difference in dissolved oxygen (DO) concentrations before and after a specified incubation period. It can be expressed as:

$$BOD_5 = (DO_1 - DO_2) \times \left| \frac{\text{Vol.of diluted sample}}{\text{Vol.of raw sample}} \right|$$
$$= \text{DO consumed} \times \text{Dilution ratio}$$

where DO = dissolved oxygen, initial and final

This formula is used to determine the amount of oxygen consumed by microorganisms during the incubation period, reflecting the BOD of the water sample and indicating its pollution level.



2.2 Investigate water treatment technologies

Freshwater is a finite supply whereby readily available suppliers are becoming less abundant. With water scarcity becoming more significant with increasing in human population and impact from climate change, a lot of research are required to help overcome the issue especially in treating the waste or used water.

2.2.1 Categorize wastewater

There are mainly two types of wastewater in Malaysia, which are **SEWAGE** and **INDUSTRIAL WASTEWATER**. Sewage or also called as domestic/ municipal wastewater comes from housing or residential area. While industrial wastewater comes from various source depend on type of industry.

	SEWAGE	INDUSTRIAL WASTEWATER
PHYSICAL CHARACTERISTICS	Unpleasant odor - due to high amount of organic matter and pollutants	Unpleasant odor and various colors (depend on industry
COMPOSITION	Human/ animal excreta Run-off water from street	Chemicals Coloring agent Grease, sand and clay
MAIN POLLUTANT	Microorganisms Organic and inorganic matter	Organic and inorganic matter microorganisms

INDUSTRY (BOD)

Domestic wastewater (~200ppm)

Ethylene glycol (400,000ppm)

Skim milk (~73000ppm)

Different type of wastewater regardless from domestic or industrial sources, it has to undergo series of process before re-using or releasing it to the river or other discharge point. The type of treatment process whether single or series of many processes depend on the characteristic of the wastewater. For industrial discharge, one of the key parameter is the BOD and COD. The value varies according to the type of industry (manufacturing or processing goods).

Typical parameter of wastewater

SEWAGE

Parameter	Value (g/ capita.day)	Value (mg/ℓ)
Biochemical Oxygen Demand (BOD_5)	56	250
Suspended Solids (SS)	68	300
Chemical Oxygen Demand (COD)	113	500
Total Nitrogen (TN)	11	50
Ammoniacal nitrogen (AMN)	7	30
Total Phosphorus (TP)	2	10
Oil and Grease (O&G)	11	50

PALM OIL MILL EFFLUENT

Constituent	Range (ppm)
pH	3.3-5.7
BOD	18000-25000
COD	45800-54800
Suspended solid	24800-31000
Total solid	46300-63200
Ammonical Nitrogen	77-100
Total Nitrogen	670-780
Oil & Grease	5600-8800

2.2.2 Discover primary, secondary and tertiary water treatment

Both ground and surface water sources with high mineral concentrations may also contain contaminants or pollutants, often resulting from human activities and industrial processes. Thus, in order to provide clean water supply, raw water obtained have to undergo a series of treatment process to remove its odor, color, turbidity and bacteria.

Scan me to look at how typical water treatment plant look like.

Coagulation and flocculation

Coagulation followed by flocculation is a process of turning color, turbidity and contaminant (bacteria) into larger flocs, either as precipitate or suspended particles. It removes silt particles (which usually in negative charge) suspended in water. During coagulation, a positive ion is added to water to reduce the surface charge to the point where the colloids are not repelled from each other. A coagulant is the substance (chemical) that is added to the water to accomplish coagulation. Most common chemical used in this process is alum.

Settling/ Sedimentation

Sedimentation basins, also known as clarifiers, remove particles that settle over time. These basins come in rectangular or circular shapes with radial or upward water flow. The design comprises four zones: inlet, settling, outlet, and sludge storage. Figure 2.8 depicts the zone in a sedimentation tank. The design of inlet zone's role is to **allow uniform flow** and suspended particles, using inlet pipes and baffles and thus able to **minimize turbulence**. This is also aided by the well-designed of baffle system in the inlet zone.

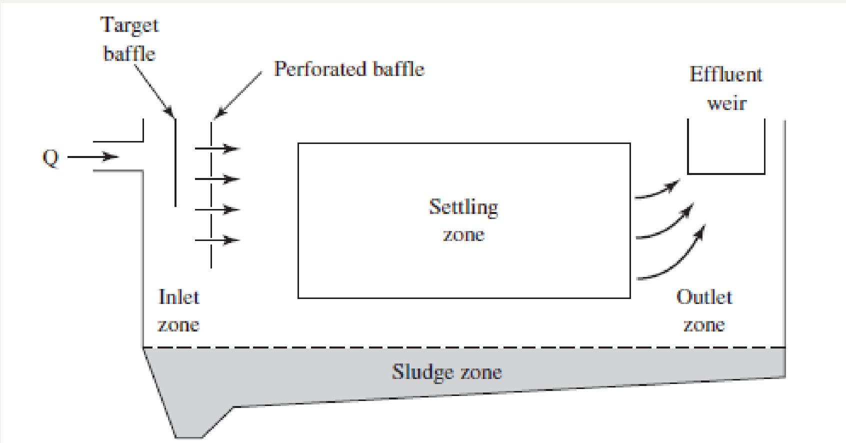


Figure 2.8: Design of settling tank (Davis and David, 2008)

Main **FACTORS** considered when designing the settling tank are :

i. Overflow rate (inlet flow of water/ wastewater into settling tank
ii. Retention time (average time that the water remained in the tank)
iii. Weir loading rate

Filtration

Water that leaves the settling tank are usually clearer than the raw with turbidity range from 1 to 10 NTU. However, small flocs and precipitated particles still remained in the water. Thus, filtration is used to further remove these particles. Granular media filters are the primary choice at many water treatment facilities, though membrane processes are increasingly being implemented as well.

Granular media filtration able to operate at either high (5- 15 m/h) or low loading rate (< 0.2 m/h) driven by gravity flow. Rapid filtration system is more favored in high loading water treatment facility where a dual-media granular media filter is used. The filter media used must be fairly uniform in size for an efficient high loading rate filtration. Common granular media used are anthracite, granular activated carbon, sand, and gravel. Figure 2.9 shows the diagram of dual-media filter unit.

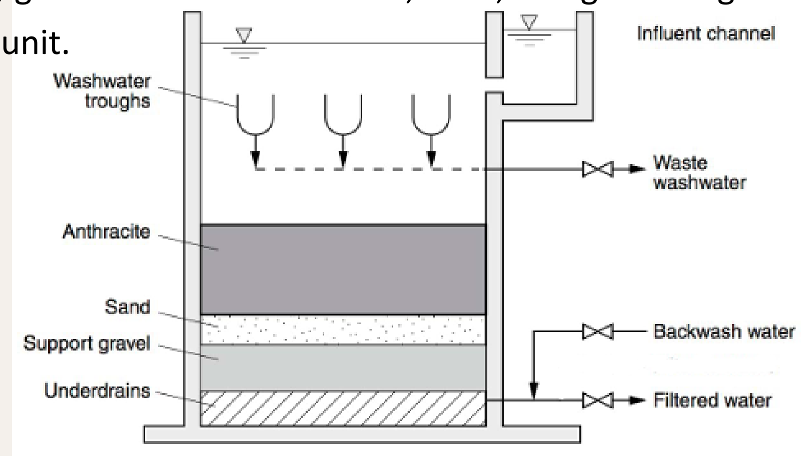
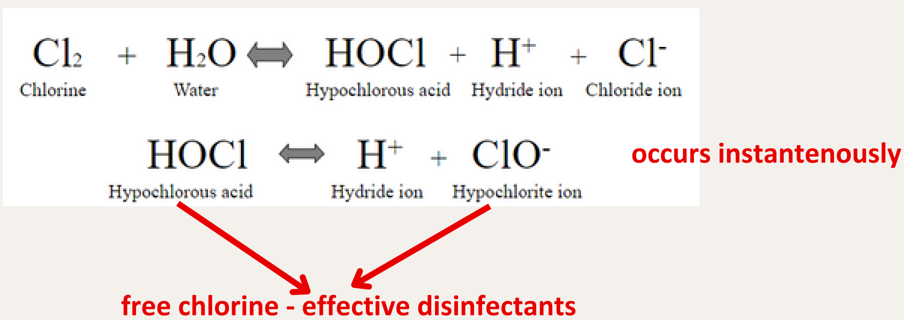


Figure 2.9: Dual-media granular filter
(Source: James and Julie, 2014)

Rapid filtration operates over a cycle of filtration and backwash stage. While filtration process occur gravitationally, backwash require the opposite flow direction which upwards. This is to help assist in flushing the particles up and away from the media. Filtration process may operate for several days, while backwashing takes about 15-30 minutes.

Disinfection

Disinfection is a process in which pathogens (disease-producing microorganisms) are reduced to an acceptable range. Common disinfectants or also known as oxidizing agents used are chlorine, ultraviolet light and ozone. Below shows the chemistry of chlorination process of water.



2.2.3 Explore wastewater disposal and reuse method

The design and operation of a wastewater treatment facility requires knowledge on the influent wastewater characteristics as well as the effluent requirement based on the guideline from Department of Environment (DOE). Major constituents that presents in wastewater are BOD, COD, suspended solid, oil and grease and others. The concentration varies based on the industry (refer to subtopic 2.2.1).

Figure 2.10 shows an example layout of wastewater treatment plant. Steps that are involved in a wastewater treatment plant are:

i. primary treatment **(Physical/ mechanical)**

ii. secondary treatment **(Biological)**

iii. tertiary treatment **(Advanced)**

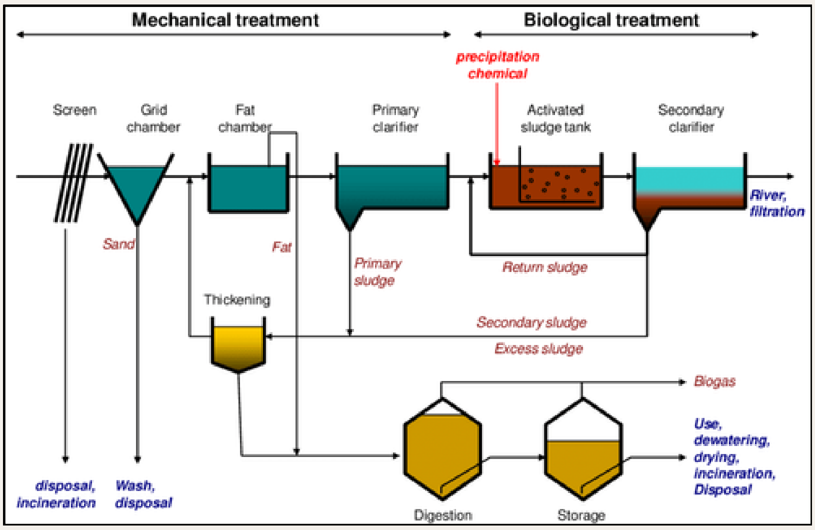


Figure 2.10: Layout of wastewater treatment plant
(Source: Neela and Prasad, 2011)

Let's watch how wastewater treatment plant work

i. Primary treatment

Primary treatment of wastewater is the initial steps in reducing any possible pollutants that either float or sink. Pre-treatment process is also considered as part of primary treatment. The primary treatment includes cooling process (for hot wastewater), physical screening/ filtration and sedimentation process. Typically, the treatment able to reduce about 60% of suspended solid and 35% of BOD. However, this does not apply to soluble/ dissolved solids in the wastewater.

ii. Secondary treatment

Though primary treatment is seen to reduce the amount of suspended solid and BOD to a lower level, the wastewater's parameter is needed to be further treated. Secondary treatment is where it can further reduce the BOD and suspended solids that escaped the primary treatment. The secondary treatment is designed to speed up the natural process of breaking down the organic pollutants in shorter time. It can be successfully achieved with the aid of biological processes like usage of microorganisms. Examples of secondary treatment includes application of aerobic, anaerobic, facultative and oxidation pond. Although secondary treatment is effective in eliminating over 85% of both BOD and suspended solids, it doesn't significantly reduce nitrogen, phosphorus or heavy metal levels, nor does it fully eradicate pathogenic bacteria and viruses.

Aerobic Pond - is a shallow pond which light can penetrate to the bottom allowing algal photosynthesis throughout the treatment process. Normally, there is presence of aerator on the pond surface. Stabilization of the organic material entering an aerobic pond is accomplished mainly through the action of aerobic bacteria.

Anaerobic Pond - is a biological oxidation of organic matter in the absence of oxygen. An anaerobic state in a pond can be sustained by introducing a BOD_5 load that is higher than the oxygen generated through photosynthesis. By reducing the pond's surface area and deepening it can reduce photosynthesis. Anaerobic ponds tend to become murky due to the presence of reduced metal sulfides, diminishing light penetration to the extent that algal growth becomes insignificant. The treatment of complex wastes involves two distinct phases. Initially, in the **ACID FERMENTATION** stage, complex organic materials are primarily broken down into short-chain acids and alcohols. Subsequently, in the **METHANE FERMENTATION** stage, these materials are converted into gases, primarily methane and carbon dioxide. Effective design of anaerobic ponds should establish environmental conditions conducive to methane fermentation. Anaerobic ponds are primarily utilized as a preliminary treatment method and are particularly suitable for managing high-temperature and high-strength wastewaters.

Facultative Pond - is a treatment process which involved both aerobic and anaerobic condition. The facultative zone lies just above the anaerobic layer, where molecular oxygen may not always be available. Typically, this zone is aerobic during daylight hours and anaerobic during nighttime. Above the facultative zone lies an aerobic region where molecular oxygen is consistently present. Oxygen is obtained from two sources: a limited amount diffuses across the pond's surface, while the majority is supplied through algal photosynthesis. Facultative ponds are favored in such treatment scenarios due to their extended retention times, enabling effective management of large fluctuations in wastewater flow and strength without significantly impacting effluent quality.

Furthermore, capital, operational, and maintenance costs are lower compared to other biological systems offering similar treatment efficacy. Figure 2.11 provides a schematic depiction of the operation of a facultative pond. Initially, raw wastewater is introduced at the pond's center. Suspended solids within the wastewater settle at the pond bottom, leading to the formation of an anaerobic layer.

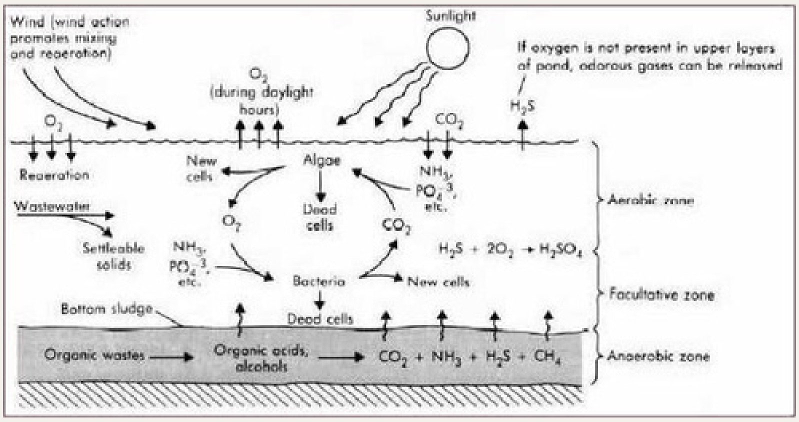


Figure 2.11: Schematic diagram of facultative pond (MND Liady et. al., 2009)

Microorganisms inhabiting this layer do not rely on molecular oxygen for energy metabolism but utilize alternative chemical species. Both acid fermentation and methane fermentation processes occur within the bottom sludge deposits.

iii. Tertiary treatment

While a series of secondary treatment able to reduce significant amount of degradable organic pollutants, and suspended solid which contributes to lower BOD, certain industry still require additional treatment which is also called as advanced wastewater treatment to further reduce the BOD as well as nitrogen and phosphorus of secondary effluent to the lowest level according to parameter set by the Department of Environmental (DOE) before discharged. This may include either application of ion exchange, granular filtration, membrane filtration, carbon adsorption and many more.

Once the wastewater have been completely treated to a level which its' BOD have reached the allowable limit set by DOE, then it is discharged or reused accordingly. For certain area/ district, all treated effluent is discharged into watercourse like river or used for land application. Besides, certain industries tried to utilized the treated effluent for other purpose like land irrigation. Water reuse involves reclaiming or recycling wastewater for various beneficial purposes, such as agricultural and landscape irrigation or replenishing groundwater. Recycled water utilized for these applications typically necessitates less treatment compared to water recycled for drinking purposes. Any residual pollutants remaining in the wastewater are safely assimilated into the soil structure. Water reuse represents a cost-effective and environmentally responsible approach to utilizing treated wastewater.

2.3 Examine Sludge Treatment and Disposal

During the wastewater purification process, an additional challenge emerges which is **sludge**. The volume of sludge generated for disposal increases with the level of wastewater treatment, with the exception of cases involving land applications or polishing lagoons. This sludge comprises materials settled from the raw wastewater and solids produced during the wastewater treatment processes.

2.3.1 Categorize sludge

There are FOUR types of sludge normally produced within industry of water treatment facilities. This include grit, primary, secondary and tertiary sludge.

i. Grit Sludge

Consists of materials such as sand, broken glass, nuts, bolts, and other dense items which are collected in the grit chamber. Though it do not constitute typical sludge as they lack fluidity, they still require disposal. Due to the ease of draining water from grit and its limited biological activity (non-biodegradable), it is usually transported directly to a landfill without additional treatment.

ii. Primary or Raw Sludge

Sludge that is obtained from the bottom of primary clarifiers or sedimentation tank. It contained 3-8% solids which approximately 60-80% organic. This sludge easily becomes anaerobic and highly odiferous (strong smell)

iii. Secondary Sludge

This sludge comprises microorganisms and inert materials discarded from the secondary treatment processes, making the solids approximately 90% organic. When air supply is removed, this sludge transitions to an anaerobic state, potentially leading to noxious conditions if not treated prior to disposal. The solids content varies based on the source; wasted activated sludge typically contains 0.5–2% solids, while trickling filter sludge ranges from 2–5% solids. In certain instances, secondary sludges may contain significant amounts of chemical precipitates due to the aeration tank doubling as the reaction basin for chemical addition step to eliminate phosphorus.

iv. Tertiary Sludge

It depends on the nature of the tertiary treatment process. For example, phosphorus removal sludge from activated sludge process and nitrogen removal sludge from denitrification process. This type of sludge is more difficult to treat due to its complexity.

2.3.2 Sludge Treatment Technology

With high amount of sludge produced within any water or wastewater treatment facilities, there is need to further treat the sludge. The objectives of sludge treatment are:

i. To stabilize the sludge
ii. To reduce the volume of sludge
iii. To kill pathogenic organisms
iv. To produce any value-added product from the sludge like fertilizer.

Figure 2.12 shows the schematic flow diagram of a general sludge-processing treatment.

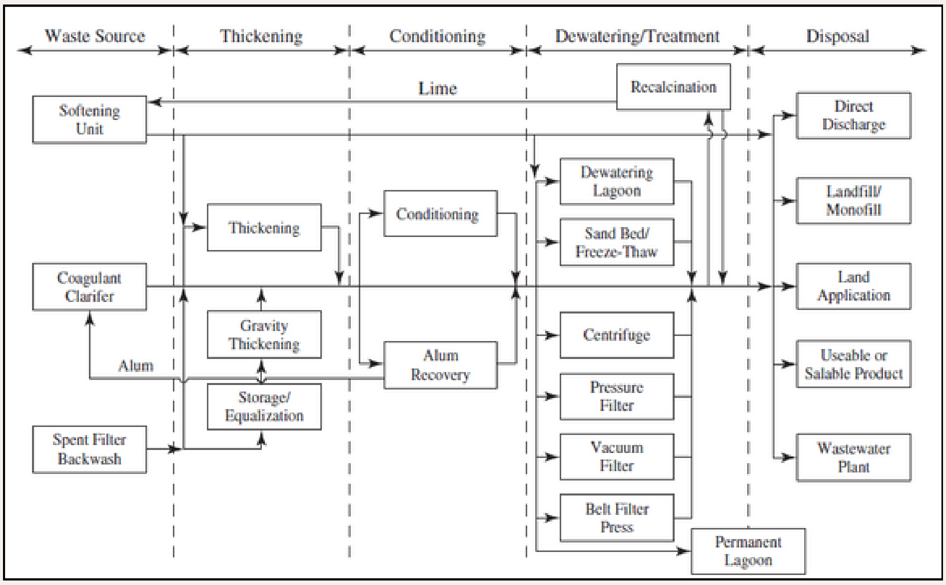


Figure 2.12: Schematic diagram of sludge treatment (Source: Mackenzie and Davis, 2013)

i. Thickening

Thickening is typically achieved through one of two methods. First is flotation, where solids rise to the liquid's surface, and second is gravity thickening, where solids settle at the bottom. The objective is to remove as much water as possible before final dewatering or sludge digestion. Gravity thickening is a straightforward and cost-effective process extensively used for primary sludges over many years. It involves a sedimentation process akin to that in settling tanks. Figure 2.13 depicts the schematic diagram of gravity thickener. Sludge is directed into a tank resembling the circular clarifiers used in primary and secondary sedimentation. In the tank, solids settle at the bottom, where a robust mechanism scrapes them into a hopper for further processing. The nature of the sludge being thickened significantly impacts performance. Optimal outcomes are observed with purely primary sludges. As the proportion of activated sludge increases, the thickness of settled sludge solids decreases. Purely primary sludges can be thickened from 1–3% to 10% solids.

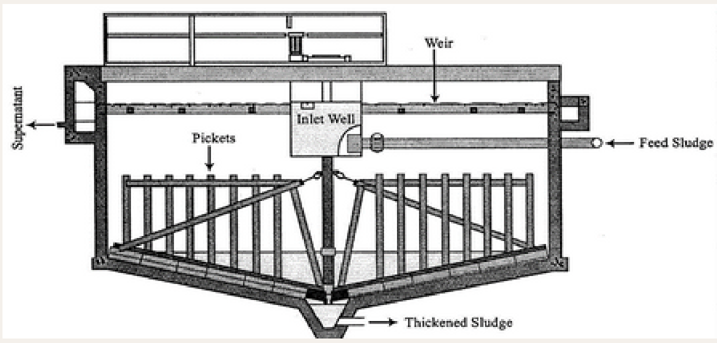


Figure 2.13: Schematic diagram of gravity sludge thickener (Mackenzie and Davis, 2013)

ii. Stabilization

Is a process to reduce odor and pathogens content in the sludge. by breaking down and converting the organic solids into more inert form. There are TWO typical processes used to stabilize the sludge. One is carried out in closed tanks without oxygen and is called **anaerobic digestion** whereby the flow of process is shown in Figure 2.14. The other approach injects air into the sludge to accomplish **aerobic digestion**.

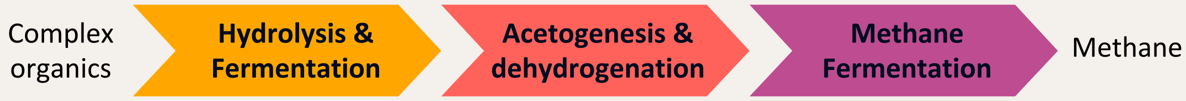


Figure 2.14: Steps in anaerobic digestion process

iii. Conditioning

Sludge conditioning refers to modification of sludge structure so that water can be easily separated/ removed. There are **TWO** types of conditioning which is **chemical** and **thermal conditioning**. Chemical conditioning mainly cause the sludge to coagulate and release the adsorbed water. Typical conditioning agent used are lime, alum, ferric chloride and polymers. Another method which is thermal conditioning means subjecting the sludge to heat at 175 - 230°C for 30 - 60 minutes.

iv. Dewatering

Dewatering is a crucial process in wastewater treatment, aiming to significantly decrease the volume of sludge by extracting water from it. Raw sludge typically contains an excess of 95% water by weight. Various methods are employed for dewatering, including the employment of **drying beds**, **vacuum filters**, **centrifuges**, and **belt filter presses**. Among these, sand drying beds are the most widely utilized unit for their efficiency. However, in scenarios where space is limited, vacuum filters equipped with a diverse range of fabric filters are preferred. The resulting sludge cake from this process is often subjected to incineration. Through dewatering, the water content in the sludge can be reduced to around 30%.

v. Reduction by incineration

If utilizing sludge as a soil conditioner is not feasible or if there's no available site for landfilling dewatered sludge, an alternative approach is sludge reduction. **Incineration** is employed to thoroughly evaporate the moisture content in the sludge and burn the organic solids into a sterile ash. Prior to incineration, it is essential to dewater the sludge as thoroughly as achievable to minimize fuel consumption. It is essential to carefully treat the exhaust gas from the incinerator to prevent air pollution.

2.3.3 Sludge Disposal Method

The final disposal of biosolids or residue (ash resulting from incineration) can be categorized broadly into three main groups: land application/composting, landfilling, and dedicated land disposal.

i. Landfilling

If there's a suitable and easily accessible location available, landfills are commonly chosen for the final disposal of biosolids, grit, screenings, and other solid waste. However, dewatering and stabilization are normally required before the landfill site can be utilized. Incorporating biosolids into the landfill may be encouraged, especially if methane recovery is implemented, as it can enhance gas production.

ii. Land Application/ Composting

If there's a suitable and easily accessible location available, landfills are commonly chosen for the final disposal of biosolids, grit, screenings, and other solid waste. However, dewatering and stabilization are normally required before the landfill site can be utilized. Incorporating biosolids into the landfill may be encouraged, especially if methane recovery is implemented, as it can enhance gas production.

iii. Dedicated Land Disposal

Dedicated land disposal involves applying significant amounts of sludge to specific areas of land that have limited public access and are designated solely for wastewater sludge disposal. However, this method does not allow utilizing the sludge in its original location. Typically, dedicated sites receive sludges in liquid form, although applying dewatered sludges is feasible but not commonly practiced. Moreover, disposing of dewatered sludge in landfills is generally more economically viable. One common location for dedicated land disposal is areas previously subjected to surface mining. The application of biosolids in such areas enhances land recovery by supplying organic matter and nutrients essential for plant growth.

Tutorial

Question

1. Identify the zone which groundwater can be obtained.
2. List out FIVE (5) physical parameters that can be measured.
3. 4 ml of raw sewage has been diluted to 200 ml and the D.O. concentration of the diluted sample at the beginning of the BOD test was 26 mg/l, and 10 mg/l after 5-day incubation at 20℃. Calculate the BOD of sewage.
4. State 3 condition of water body to increase the solubility of dissolved oxygen.
5. State the comparison between value of COD, BODu and BOD5.
6. The of a waste is 280 mg/L. The ultimate BOD is reported as 410 mg/L. At what rate is the waste being oxidizes?.
7. Draw a typical water treatment system with complete label.

Tutorial

Answer

1. Saturated zone/ aquifer.
2. Turbidity, Temperature, Solid Content, Absorbance and transmittance.
3. $$BOD_5 = (DO_i - DO_f)(\frac{diluted\ sample\ V}{raw\ sample\ V})$$

$$BOD_5 = (26 - 10)\left(\frac{200}{4}\right)$$

$$BOD_5 = 800\ ppm$$

4. High pressure, reduce temperature and reduce salt content.
5. COD >> $BOD_u \geq BOD_5$
6. Given: y = 280 mg/l, L = 410 mg/l

Sustitution in equation (5.8);

$$280 = 410\ (1 - 10^{-k_1 5})$$

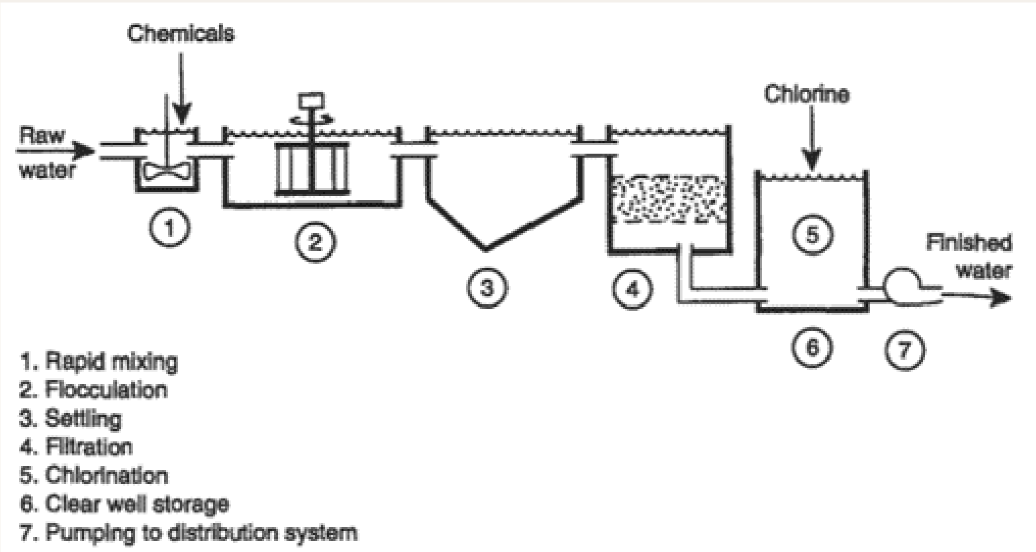
$$10^{-k_1 5} = 1 - \frac{280}{410} = \frac{130}{410}$$

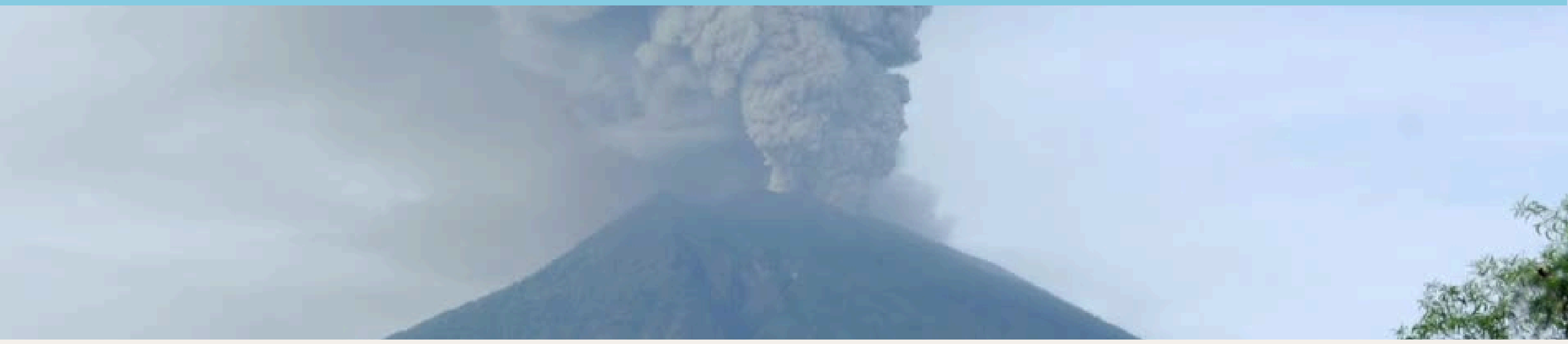
Taking log $-5k_1 \log 10 = \log 130 - \log 410$

Solving, $k_1 = 0.0998\ day^{-1}$

$\approx \underline{0.1\ day^{-1}}$

7.





3.1 Explain air pollution

Air pollution is the presence of solids, liquids or gases in the atmosphere that can endanger life, attack materials and reduce visibility. It is also defined as the presence of matter in atmosphere at concentrations, durations, and frequencies that adversely affect human health and environment.

3.1.1 Types of air pollutants and their sources

There are 6 major types of air pollutants commonly found in the air. The types and sources of these major air pollutants are depicted in Figure 3.1.

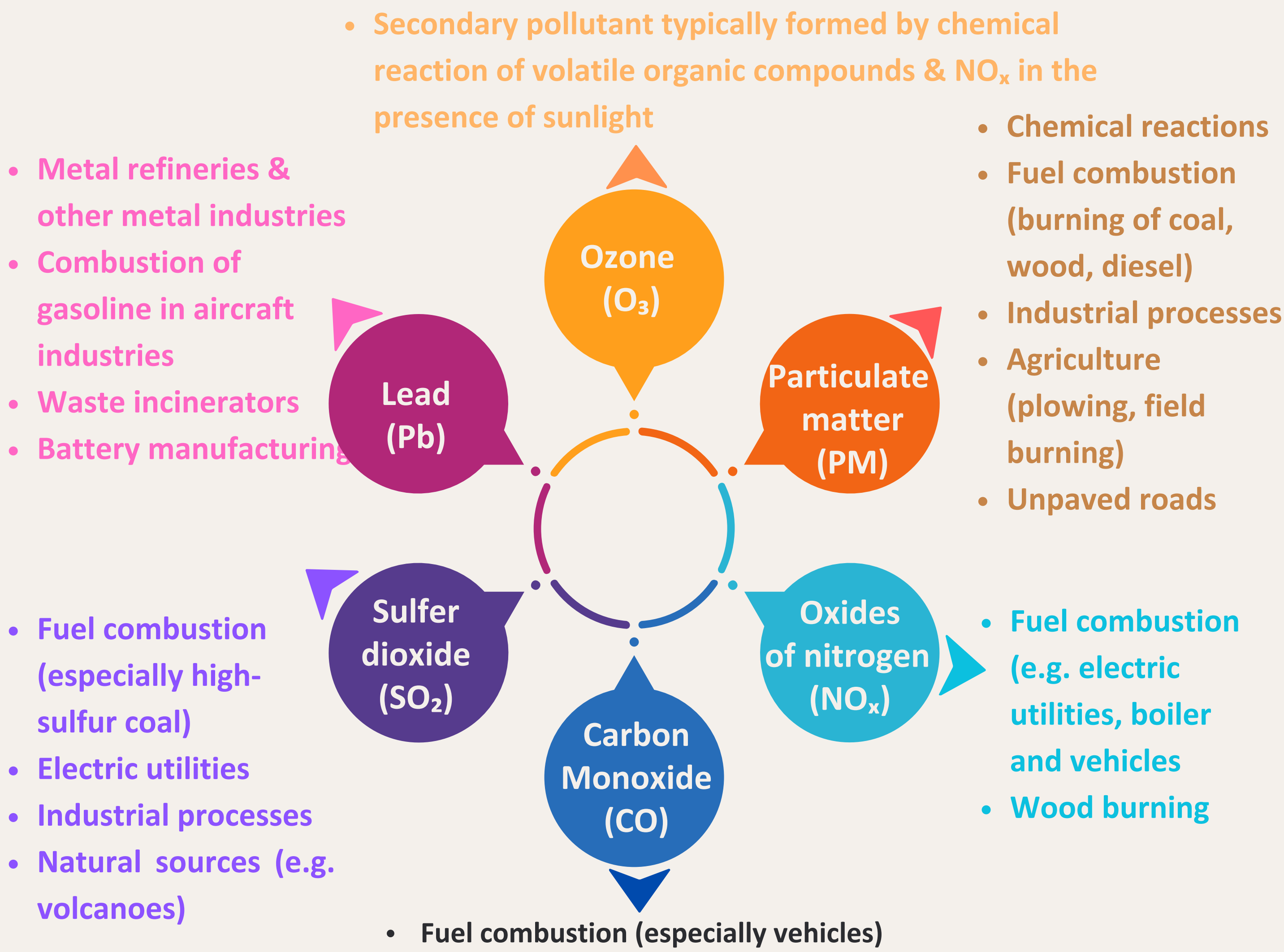


Figure 3.1: Major types of air pollutants and sources commonly found in the air. (Striebig, Ogundipe and Papadakis, 2016)

Sources of air pollution can be divided into TWO categories which are:

- Volcanoes
- Coniferous forests
- Forest fires
- Pollens
- Spores
- Dust storms
- Hot springs

- Fuel combustion
- Chemical plants
- Internal-combustion engines
- Power & heat generators
- Waste disposal sites
- Motor vehicles

Figure 3.2: Sources of air pollution

3.1.2 Effects of air pollution

The effects of air pollution are influenced by type and amount of pollutants as well as wind speed and direction, typography, sunlight, precipitation, air temperature change and photochemical reactions. Pollutants in the air cause numerous effects towards the quality of life and environment as summarizes in Figure 3.3.

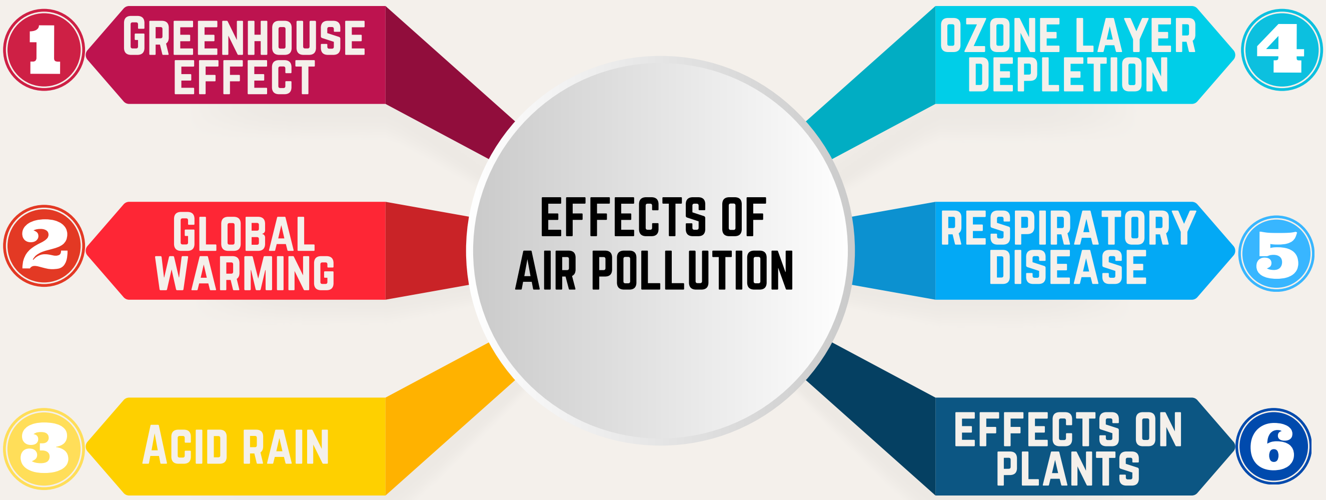


Figure 3.3: Effects of air pollution

1) Greenhouse effect

- Caused by excessive emissions of greenhouse gases (GHG).
  - Carbon dioxide
  - Methane
  - Nitrous oxide (fertilizers, burning of agricultural residue
  - CFC (aerosol sprays, refrigerant)
- Sunlight: 30% deflected to atmosphere & scattered back into space, 70% reach earth & reflected as infrared radiation.
- GHG absorbed heat from infrared & trap it like a heat blanket surround the earth.

Human activities that lead to the increase of greenhouse effect:

- Burning of fossil fuel
- Farming & land use change
- Industrial activities
- Deforestation
- Population growth

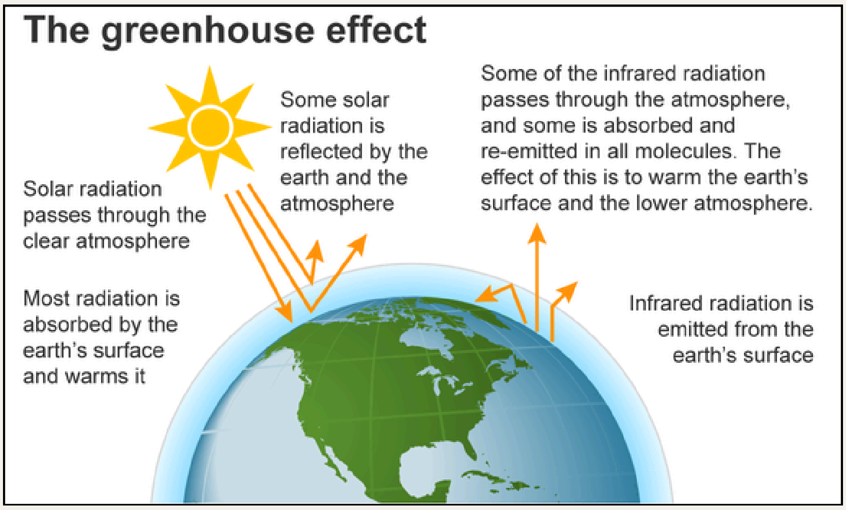


Figure 3.4: Greenhouse effect.
(U.S. Energy Information Administration, 2022)

2) Global warming

- Global warming is the warming of the earth through **carbon dioxide (CO_2)** being pumped into the atmosphere from tailpipes and smokestacks. Then, the gases trap heat like the glass in a greenhouse which contributes to "greenhouse effect".
  Figure 3.5 illustrates the relations between global warming and other effect of air pollution.
- When paper and other organic materials are burned, the heat produced from the burning contributes to the global warming.
- Apart from that, the **CO_2** production cause the greenhouse effect an contribute to the global temperature increase (global warming).
- The production of **sulphur dioxide (SO_2)** also contributes to acid rain occurrence.

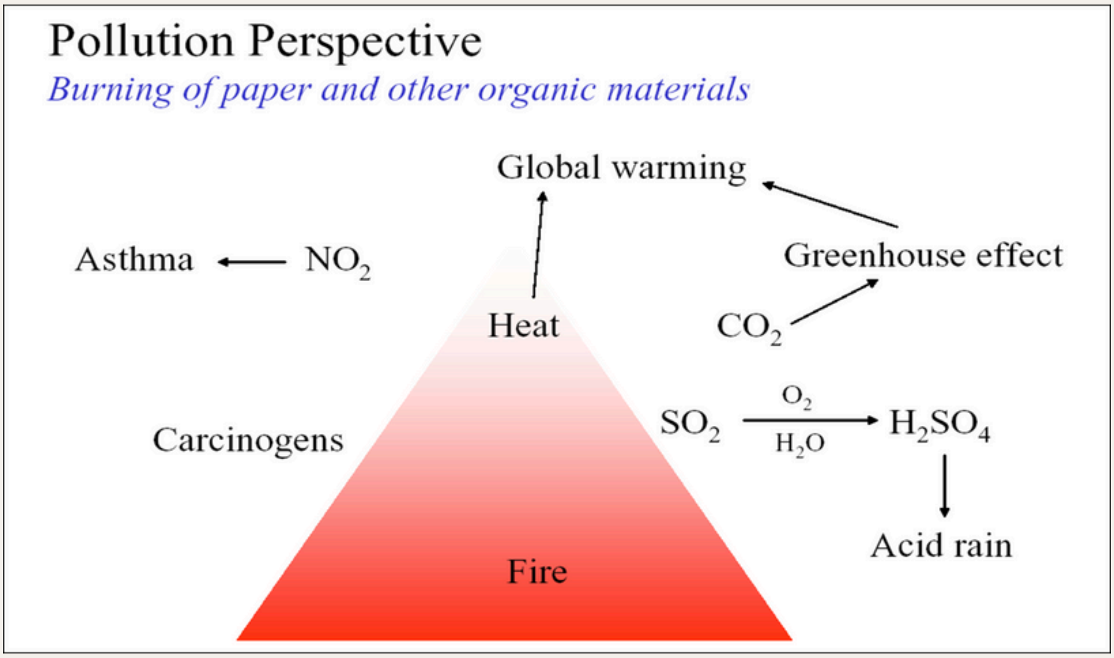


Figure 3.5: Relations between global warming and other effect of air pollution

- Global warming also brings detrimental effects to the agriculture as demonstrated in Figure 3.6.

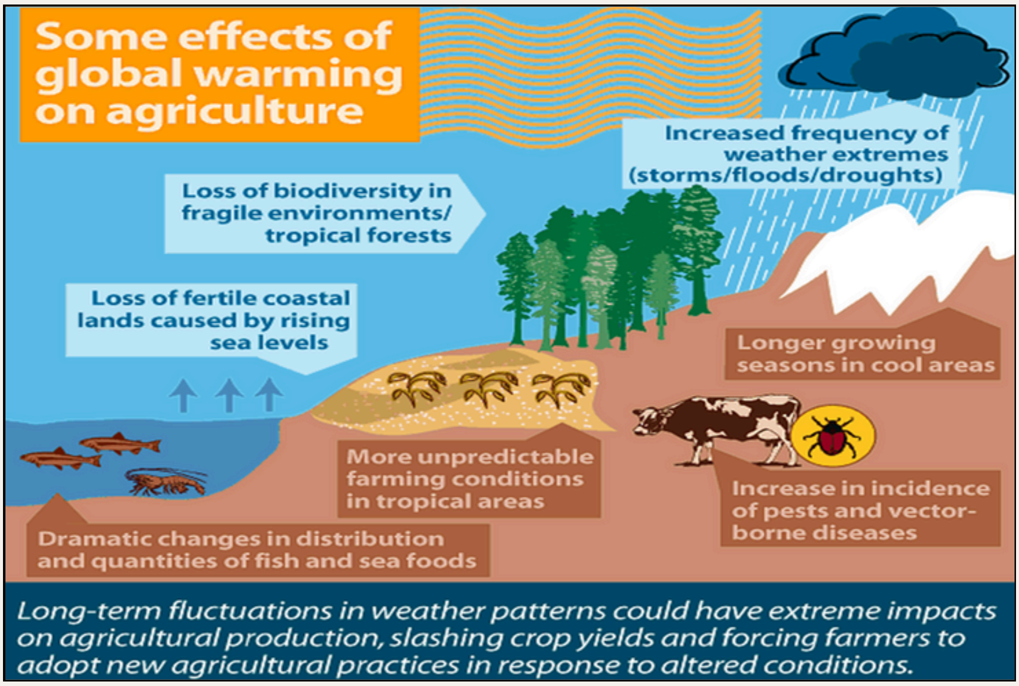


Figure 3.6: Effects of global warming on agriculture (Folnović, 2017)

3) Acid rain

- Normal rain is slightly acidic and has a pH of about 5.0 to 5.6.
- Any rainfall with a pH value less than 5.0 is defined as acid rain.
- Emissions of oxides of sulphur and nitrogen produce Acid Aerosols - **H_2SO_4 and HNO_3** (also regional pollutant).
- Main source: Coal fired (and oil fired) power plants.

  Figure 3.7 summarizes the occurrence of acid rain caused by human activities from vehicle emissions, factories and farm.

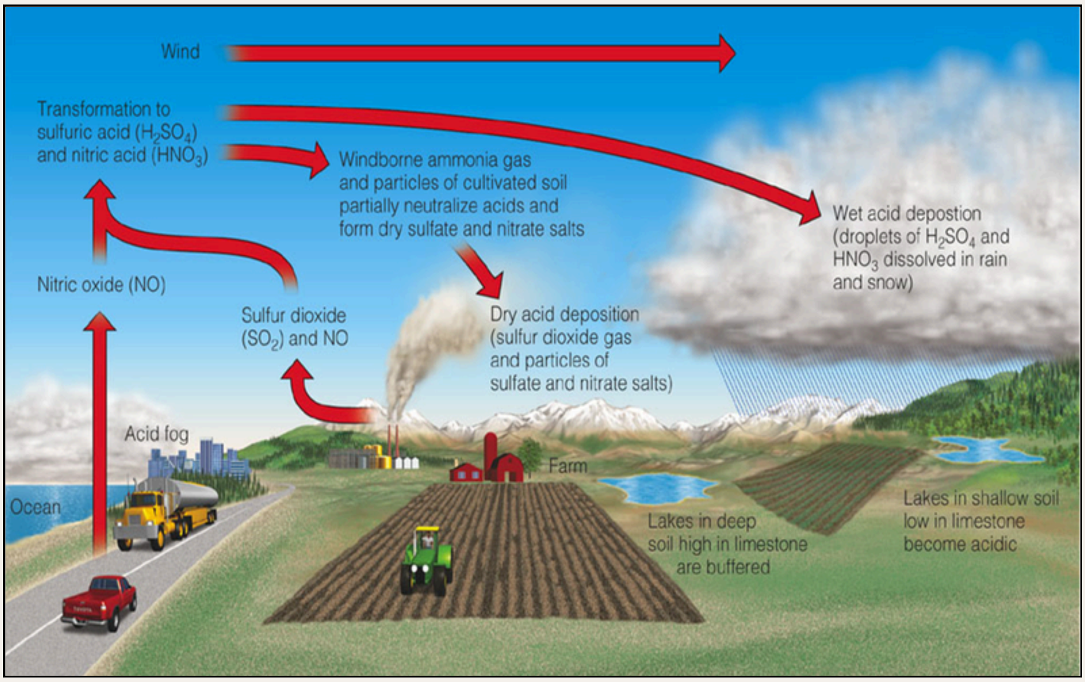


Figure 3.7: Acid rain

4) Ozone layer depletion

Figure 3.8 shows two types of ozone: stratosphere (upper atmosphere) and troposphere (ground level).

- Ozone's function is to shield earth from ultraviolet radiation (UV) from sun.
- Ozone depletion substances: CFCs, methyl chloroform, carbon tetrachloride, halons, methyl bromide (used in coolants, foaming agents, fire extinguishers, solvents, pesticides, and aerosol propellants).

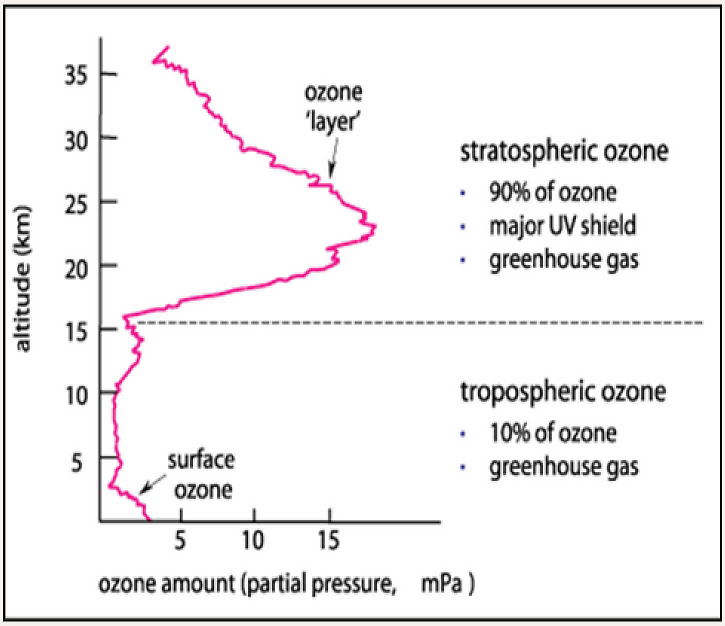


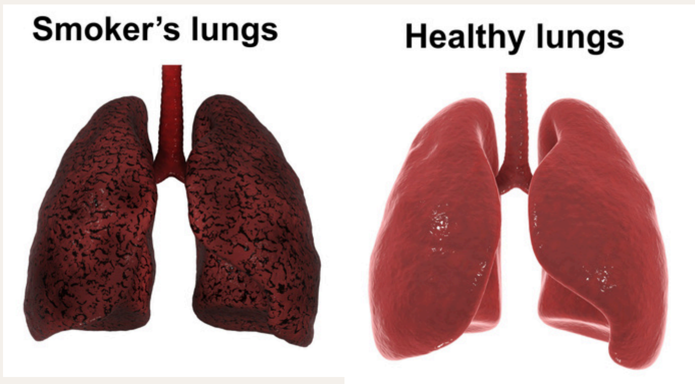
Figure 3.8: Stratospheric and tropospheric ozone

- The ozone depletion substances permits more solar radiation to reach earth, which would cause an increase in skin cancer, eye cataracts and changes in climate and animal and plant life.

5) Respiratory disease

Prolonged exposure to air pollutants can lead to:

- **Lung cancer**
- **Chronic bronchitis**
- **Emphysema**
- **Decreased lung function**
- **Acute shortness of breath**



6) Effects on plants

- Interferes with photosynthesis, carbohydrate production.
- Damage to leaf tissue, needles and fruit.
- Reduction in growth rate or suppression of growth.
- Increased susceptibility to disease, pests, and adverse weather.
- It reduces crop yields and makes fruit smaller, lighter and less nutritious.

3.1.3 Air pollution control strategies

Air pollution should be controlled to minimize its dreadful effects towards quality of life and environment. Air pollution can be controlled with or without the use of emission control devices.

Amongst the techniques used to control air pollution without emission control devices are as follows:

Air Pollution Control Techniques without Devices

1. Process Change
2. Use Wind, Geothermal, Hydroelectric, or Solar Unit Instead of Fossil Fired Unit.
3. Change in Fuel (e.g. Use of Low Sulfur Fuel Instead of High Sulfur Fuel
4. Good Operating Practices
   - Good Housekeeping
   - Maintenance
5. Plant Shutdown

Air Pollution Control Techniques with Devices

In industry, it is common to use air pollution devices or technology to minimize the release of pollutants into the atmosphere and improve the air quality within the work environment. Examples of common air pollution control devices are gravitational settling chamber, cyclone, fabric filter, electrostatic precipitator and scrubber.

1) Gravitational settling chamber

- Chambers in the gravitational settling chamber are divided into two parts (Figure 3.9):
  1) Settling chamber
  2) Baffled chamber (consists of baffle to spread the incoming flow evenly across the settling chamber)

- Working operation of gravitational settling chamber:
  - Settling chambers are effective for large and/or dense particles.
  - The carrier gas is made to pass inside the chamber through inlet provided at one end, with lower velocities.
  - The solid particulates having higher density than the surrounding gas, settle due to action of gravity on the base of the chamber.
  - The cleaned gas will come out through the outlet provided at another end.
  - The settled out particulates are then collected from the hopper for disposal.
  - Usual velocity – 0.5 to 2.5 m/s (best result obtained at uniform flow of < 0.3m/s).

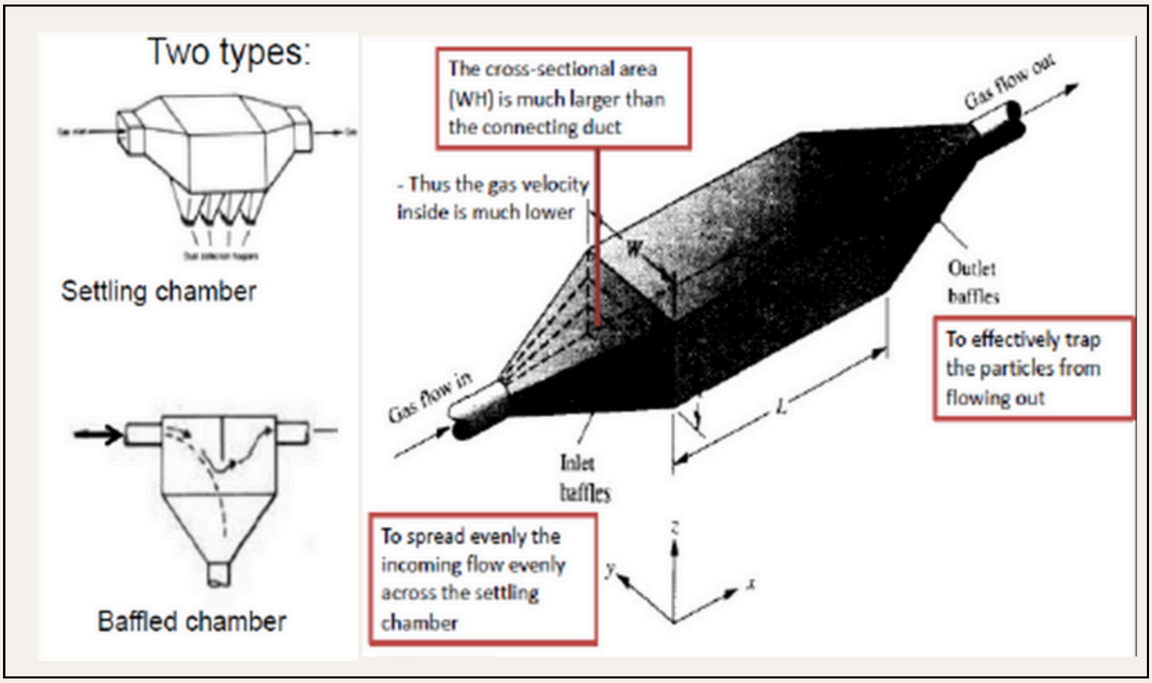


Figure 3.9: Schematic diagram of typical gravity settler

2) Cyclone

A cyclonic separation is a method of removing particulates from an air, gas or liquid stream, without the use of filters, through vortex separation. When removing particulate matter from liquid, a hydrocyclone is used; while from gas, a gas cyclone is used. Rotational effects and gravity are used to separate mixtures of solids and fluids. The method can also be used to separate fine droplets of liquid from a gaseous stream. A high-speed rotating (air)flow is established within a cylindrical or conical container called a cyclone.

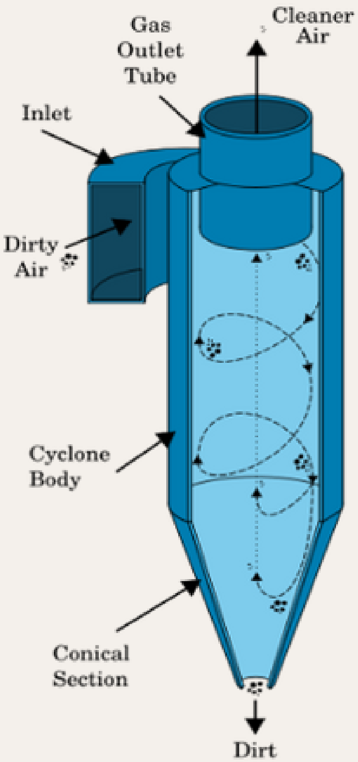
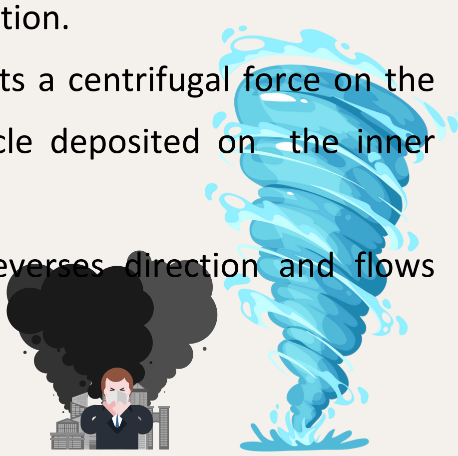


Figure 3.10: Schematic diagram of cyclone (Nakhaei *et al.*, 2020)

- Working operation of cyclone:
- The particle are removed by the application of a centrifugal forces and inertial mechanism.
- The polluted gas stream is forced into the cyclone by a vortex / circular / helical motion.
- The motion of the gas exerts a centrifugal force on the particle, and get the particle deposited on the inner surface of the cyclones wall.
- At the bottom, the gas reverses direction and flows upwards.



Advantages of cyclones

- Low capital cost.
- Reasonable high efficiency for specially designed cyclones.
- They can be used under almost any operating condition.
- Cyclones can be constructed of a wide variety of materials.
- There are no moving parts, so there are no maintenance requirements.

Disadvantages of cyclones

- They can only be used for small particles.
- High pressure drops contribute to increased costs of operation.

3) Fabric filter

- In industry, fabric filter is also known as bag house filter (Figure 3.11). Basically, the gas stream with particulate contaminant is filtered by passes through a woven or felted fabric.
- Working operation of fabric filter:
  - The filters retain particles larger than the mesh size.
  - Air and most of the smaller particle flow through. Some of the smaller particles are retained due to interception and diffusion.
  - The retained particles cause a reduction in the mesh size.
  - The primary collection is on the layer of previously deposited particles.

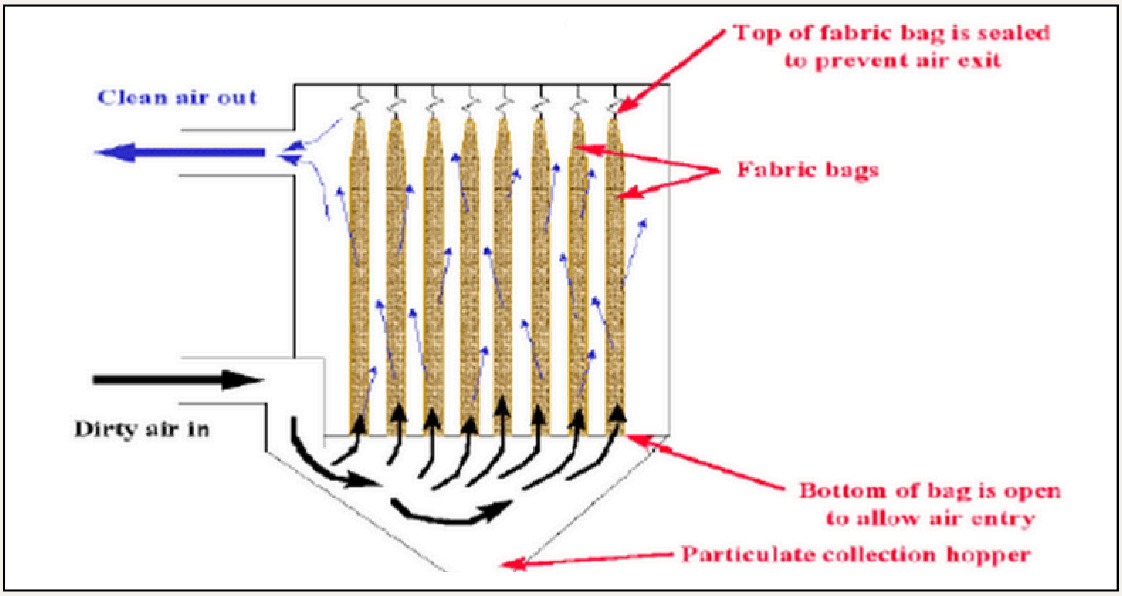


Figure 3.11: Schematic diagram of fabric filter

Advantages of fabric filter

- Modular & can be pre-assembled at factory
- Require low pressure drops
- Very high collection efficiency
- Can tolerate wide range of volumetric flow rates

Disadvantages of fabric filter

- Require large floor area
- Fabric is damaged at high temperature
- Ordinary fabrics cannot handle corrosive gases
- Cannot handle moist gas streams
- Fabric filtration unit is a potential fire hazard

4) Electrostatic precipitator (EP)

- Working operation of electrostatic precipitator (Figure 3.12):
  - The particles in a polluted gas stream are charged by passing them through an electric field.
  - The charged particles are led through collector plates.
  - The collector plates carry charges opposite to the particles.
  - The particles are attracted to these collector plates and are thus removed from the gas stream.
  - The particles are occasionally removed either by rapping or by washing the collector plates.

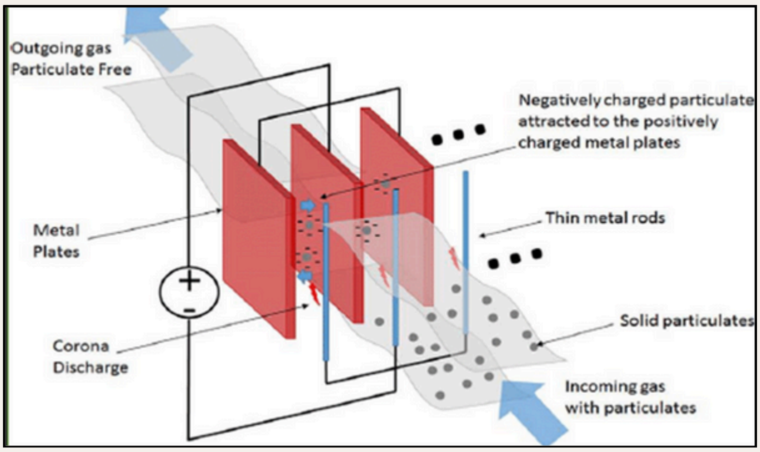


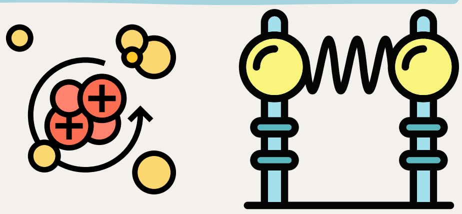
Figure 3.12: Diagram of electrostatic precipitator (Toppr Answer, 2022)

❋ Advantages of EP ❋

- Very high efficiency (from 99.5 to 99.9%)
- Able to handle higher loads with lower pressure drops
- Can operate at high temperatures
- Operating costs are generally low

❋Disadvantages of EP❋

- Not very flexible to changes in the operating conditions, once installed
- Initial capital costs are high
- Not suitable to collect particulate with the high resistivity



5) Scrubber

- There are many different types of scrubber which includes spray towers, ejector venturis, venturi scrubbers (Figure 3.13) and centrifugal wash collector (Figure 3.14).
- **Wet scrubbers** are used to remove gases such as hydrogen chloride, nitrous oxides and sulfur dioxide and particles (dust, fog or mist) while **dry scrubbers** are used mainly to remove acid gases from combustion sources.
- Working operation of wet scrubber:
  - The contaminated gas enters at the bottom and passes upward through the packed bed and downward-flowing solvent sprays.
  - The pollutants are collected in the solvent droplets, and before the gas leaves the scrubber, it passes through a mist eliminator to capture any droplets.
- Working operation of dry scrubber:
  - Emission gases are cooled to make it easier to remove pollutants and other toxins from the gas. Once the gas has been significantly cooled, the harmful components are removed from the gas.

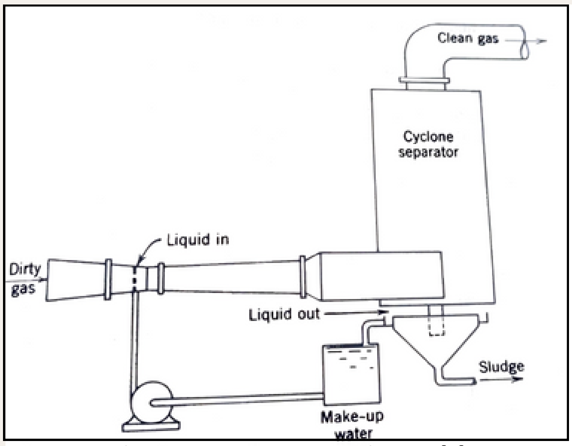


Figure 3.13: Venturi Scrubber (Nemerow *et al.*, 2009)

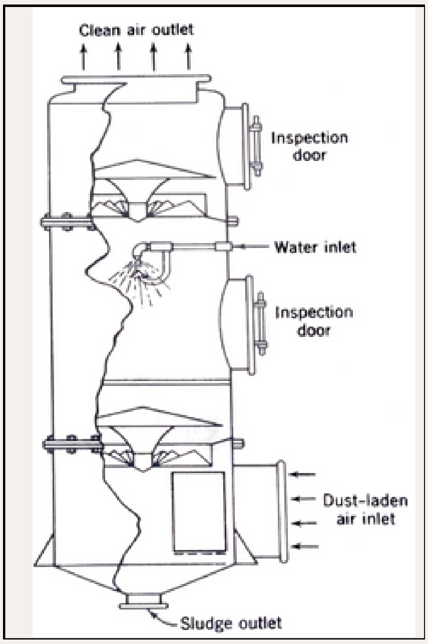


Figure 3.14: Centrifugal wash collector (Nemerow *et al.*, 2009)

3.2 Explain noise pollution

Noise pollution is the condition in which noise has characteristics and duration injurious to public health and welfare or interferes with the comfort of life and property. It is also defined as unwanted or excessive sound that can have detrimental effects on human health and environmental quality.

3.2.1 Sources of noise pollution

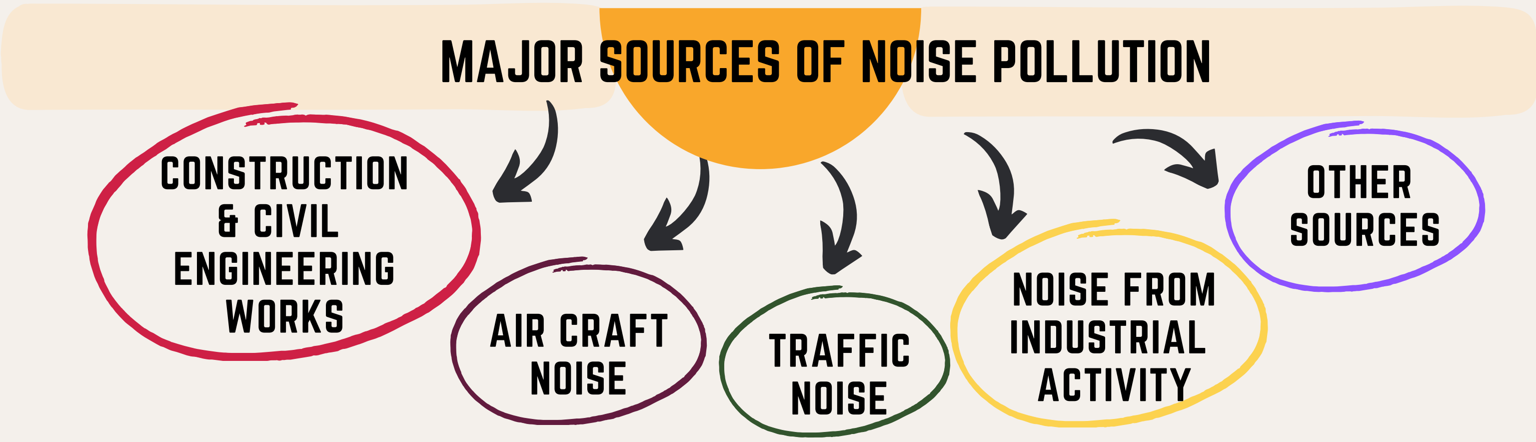


Figure 3.15: Major sources of noise pollution

The major sources of noise pollution includes the construction site, air craft, motor vehicles and industrial activity. Examples of other sources of noise are household appliances and equipment as well as commercial activities.

3.2.2 Effects of noise pollution

Noise pollution is amongst an environmental and workplace problem. A 24-hour exposure of 70 dBA is the maximum level of environmental noise that is safe for prevention of measurable hearing loss. For workers. the sound level above 90 dBa should be considered unsafe for daily exposure over a period of one month. The effects of noise pollution are as follows:

3.2.3 Noise pollution control strategies

Measurement of Noise

- Sound Level Meter (SLM) is used to measure noise at source to identify where noise may or may not be a problem.
- SLM measure SPL (Sound Pressure Limit), 1/1 and 1/3 Octave Band-Frequency (Hz).
- Measurement of noise level is often necessary for:
  - ✓ Assessing the noise climate
  - ✓ Assessing compliance to noise limits for noise source(s) and/or project development
  - ✓ Assessing environmental impact and potential community response

Figure 3.17: Sound Level Meter

Noise Control Method

Noise can be controlled at source, in its path of transmission or where it is received (Figure 3.17). Generally, the most preferable method is to reduce noise at source. However, most of the time, two or three ways in the path of noise travel from the source to the receiver are combined to ensure an effective noise control.

NOISE CONTROL METHOD	EXAMPLES
CONTROL AT SOURCE	Control at design stage Reduction of speed and pressure
REDUCTION AT PATH	Adding barriers or enclosing the equipment Adding sound-adsorbent materials
REDUCTION AT RECEIVER	Relocating employee from the sound field Limiting his working time in the area Use of hearing protective device

Figure 3.18: Noise control method and examples

Tutorial
Question

1. List THREE (3) hazardous air pollutants.

2. Choose FOUR (4) major air pollutants gases complete with the chemical symbol.

3. Provide FIVE (5) advantages of cyclone in air pollution treatment.

4. Write commonly used air pollution control methods for particulate emission.

5. Sketch the cyclone operation in air pollution treatment with complete label.

6. Examine TWO (2) sources of noise pollution.

7. List THREE (3) effects of noise pollution to marine life.

8. Provide THREE (3) examples of noise control method by the reduction at receiver.

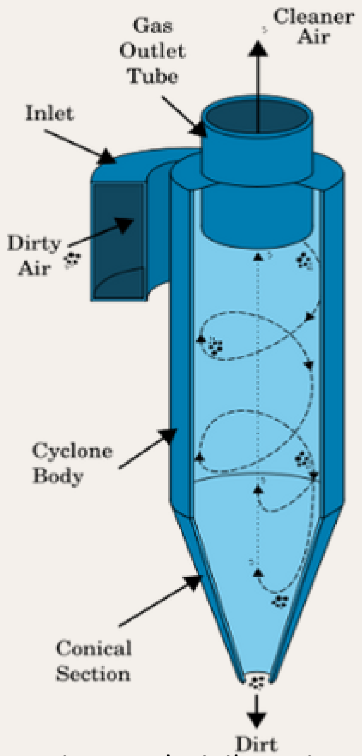
SCAN ME!

Tutorial

Answer

1. Ozone, Lead, Sulfur Dioxide, Particulate Matter, Carbon Monoxide, Oxides of Nitrogen (any THREE answers)
2. Ozone (O_3), Lead (Pb), Sulfur Dioxide (SO_2), Particulate Matter (PM), Carbon Monoxide (CO), Oxides of Nitrogen (NO_x) (any FOUR answers)
3. Low capital cost, reasonable high efficiency for specially designed cyclones, can be used under almost any operating condition, can be constructed of a wide variety of materials and there are no moving parts, so there are no maintenance requirements.
4. Gravitational settling chamber, cyclone, fabric filter, electrostatic precipitator and scrubber.

5.



6. Construction and civil engineering works, air craft noise, traffic noise, noise from industrial activity (any TWO answers)

7.

- Disorientate marine life
- Affect the marine's life ability to feed
- Affect the marine's life ability to communicate

8.

- Relocating employee from the sound field.
- Limiting his working time in the area.
- Use of hearing protective device

REFERENCES

1) Nemerow, N. L., Agardy, F. J., Sullivan, P. J., & Salvato, J. A. (2009). *Environmental engineering: environmental health and safety for municipal infrastructure, land use and planning, and industry*. John Wiley & Sons.

2) Striebig, B., Ogundipe, A. A., & Papadakis, M. (2015). *Engineering applications in sustainable design and development*. Cengage Learning.

3) Shafik, N. (1994). Economic development and environmental quality: an econometric analysis. Oxford economic papers, 46(Supplement_1), 757-773.

4) Dinda, S. (2004). Environmental Kuznets Curve hypothesis: A survey. Ecological Economics, 49(4), 431-455.

5) U.S. Energy Information Administration (2022). *Energy and the environment explained: Greenhouse gases*. Retrieved April 27, 2022 from https://www.eia.gov/energyexplained/energy-and-the-environment/greenhouse-gases.php

6) Tanja Folnović (2017). *Climate change impacts on agriculture*. Retrieved April 27, 2022 from https://www.agrivi.com/blog/climate-change-impacts-on-agriculture/

7) Munn, R.E. (1979). *Environmental impact assessment: principles and procedures*. New York: John Wiley.

8) Glasson, J., Therivel, R and Chedwick, A (2005). *Introduction to environmental impact assessment 2nd Edition*. UCL Press, Taylor & Francis Group.

9) Nakhaei, M., Lu, B., Tian, Y., Wang, W., Dam-Johansen, K., & Wu, H. (2020). CFD Modeling of gas–solid cyclone separators at ambient and elevated temperatures. Processes, 8(2), 228.

10) Toppr Answer (2022). *Solution to write a brief account of electrostatic precipitator with a neat labelled diagram*. Retrieved April 27, 2022 from https://www.eia.gov/energyexplained/energy-and-the-environment/greenhouse-gases.php

REFERENCES

11) International Organization for Standardization ISO (2006). *Environmental management - life cycle assessment - principles and framework ISO 14040:2006.* Retrieved September 12, 2023 from https://www.iso.org/standard/37456.html

12) United States Environmental Protection Agency (2023). Sustainable materials management: non-hazardous materials and waste management hierarchy. Retrieved September 1, 2023 from https://www.epa.gov/smm/sustainable-materials-management-non-hazardous-materials-and-waste-management-hierarchy

13) United Nations Development Programme (2016). *Goal 12 responsible consumption and production.* Retrieved October 1, 2023 from https://www.undp.org/sustainable-development-goals/responsible-consumption-and-production

14) O.Berk (2022). *What actually happens when you recycle*. Retrieved October 1, 2023 from https://www.oberk.com/packaging-crash-course/what-actually-happens-when-you-recycle

15) Jereme, I.A., Siwar, C., Begum, R.A. and Alam, M.M. (2015). An Assessment of Waste Management Operation in Malaysia: Case Study on Kuala Langat and Sepang. International Journal of Environment and Waste Management, 16(2), 133-144.

16) Shakil, N. S. M., Azhar, N. A. Z. M., & Othman, N. (2023). Solid Waste Management in Malaysia: An overview. Information Management and Business Review, 15(1 (I) SI), 86-93.

17) Zainu, Z. A., & Songip, A. R. (2017). Policies, challenges and strategies for municipal waste management in Malaysia. Journal of Science, Technology and Innovation Policy, 3(1), 10-14.

18) John, P. (2014). Waste Management Practices. Municipal, hazardous, and industrial. Second Edition. CRC Press. Taylor & Francis Group.

19) Rao, M. N., Sultana, R., & Kota, S. H. (2017). Solid and hazardous waste management. Science and engineering. Elsevier. BS Publications.

e ISBN 978-967-2736-41-7
9 789672 736417