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OIL & FAT INDUSTRY

ENVIRONMENTAL IMPACT AND WASTE MANAGEMENT

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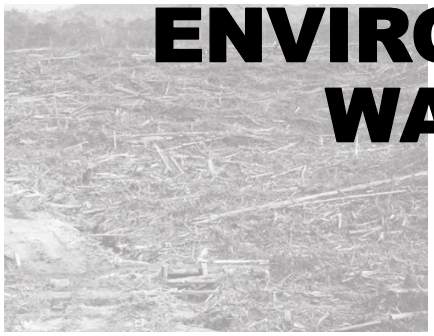

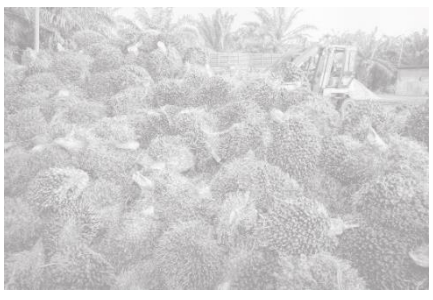

OIL & FAT INDUSTRY

ENVIRONMENTAL IMPACT AND WASTE MANAGEMENT

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Oil & Fat Industry
Environmental Impact and Waste Management

Dedicated to all lecturers and students.

PREFACE

OIL AND FAT INDUSTRY: ENVIRONMENTAL IMPACT AND WASTE MANAGEMENT is aimed to provide an overview of the environmental impact resulting from oil and fat industry with particular emphasis on palm oil production beginning from the processing of oil and fat to the production of the final product. It also discusses major processes and facilities as they are related to waste generation and control. This book addresses primarily waste water aspects of oil and fat industry, and briefly, air and solid waste aspects.

The background of the oil and fat industry including the waste generation from plantation to finished product in palm oil industry, the waste produced and the importance of waste management from this industry is introduced in chapter 1. As in chapter 2, 3 and 4, the sources of waste for air emission, solid wastes and wastewater and how these wastes could be managed effectively is detailed discussed. In the last chapter. The readers also exposed to environmental impact of oil and fat industry and current issues related to this industry.

CONTENTS

CHAPTER

01

INTRODUCTION TO WASTE MANAGEMENT IN OIL AND FAT INDUSTRY

LEARNING OUTCOMES

- Define waste and waste management emphasizing waste from oil and fat industry
- List the sources of wastes from oil and fat industry
- Discuss the impact of waste from oil and fat industry on the Environment
- Explain the need for waste management by fat and oil industries.

1.1 INTRODUCTION TO OIL AND FAT INDUSTRY

Fats and oils are used in both food and industrial applications all over the world. Both are contained in food like shortening, butter, salad oils, margarine, and cooking oils. In industrial application, they are used in animal feeds, personal care products, soaps, paints, biodiesel, greases, and lubricants. The sources of fats and oils include edible vegetable oils, palm oils, industrial oils, animal fats, and marine oils. Edible vegetable oils, palm oils, industrial oils, animal fats, and marine oils are all sources of fats and oils. Food applications account for the majority (about three-quarters) of global fat and oil consumption. However, there has been a steady movement in usage from food to industrial, particularly in biodiesel. In Europe and United States, there is an increase in usage of rapeseed (canola) oil and soybean oil for biodiesel production. As a result of country mandates, soybean oil use for biodiesel has surged in Central and South America. Other oil crops' industrial applications are also being researched and developed.

Structurally, fat and oils are esters of glycerol with three fatty acids (called either triacylglycerols or triglycerides), which give the functionality to fats. The fatty acids found in most widely ingested oils and fats are long carbon and hydrogen chains with between 8 to 20 carbon atoms, primarily with even numbers of carbon atoms, while animal fats contain large amounts of odd-chain fatty acids. On one end, they have a methyl (CH_3) group, while on the other, they have a carboxylic acid (COOH). This carboxylic acid group combines with the hydroxyl groups on the glycerol molecule to generate the triacylglycerol molecule's ester bonds.

Chemically, fats and oils can be divided into four main types:

- Saturated fatty acids
- cis-monounsaturated fatty acids
- cis-polyunsaturated fatty acids
- trans fatty acids

At room temperature, fat is classified as solid due to the structures of saturated and transfatty acids, while oil is classified as liquid due to the cis-unsaturated structure. There are no 100% saturated or unsaturated fatty acids, but rather a mixture of both. However, because one form of fatty acid predominates, fats are often referred to as "saturated" or "unsaturated."

Fats and oils physical and chemical specifications present special challenges in waste management. At low temperatures, fats and oils solidify, whereas at high temperatures, they dissolve. At the same time, the repeating used has a higher viscosity than the lessen, which can be semi-solid or solid at room temperature. The handling of this waste is not a straightforward process.

Fat waste has traditionally been disposed of in sewage, resulting in blockage of waste systems when fat is combined with other solid waste in a sewer. Waste fats and oils, on the other hand, are a valuable commodity feedstock that may be used to generate energy and recover materials. Before being used in cogeneration plants that produce thermal and electric energy, this feedstock requires modest pre-treatment. Therefore, this chapter will discuss the waste management in the fats and oils sector, as well as the sources of fats and oils waste, the environmental impact of waste from fats and oils industry and the importance of waste management in fats and oils industry.

1.2 WASTE AND WASTE MANAGEMENT

According to Cambridge dictionary, waste is unwanted matter or material of any type, especially what is left after useful substances or parts have been removed. Literally, fats and oils waste cause serious problems in the sewerage system. They cause sewage blockage when dumped down the kitchen sinks or dirty drains and pollute local waterways when discharged down rainwater pipes and gullies.

Globally, around 200,000 sewage clogs and pollution incidents occur in England and Wales yearly, with fat and oils being responsible for up to 75% of the incidents. The expense of removing these constraints is in the millions of pounds per year. Fats and oils industries are also at risk of having their drainage systems clogged, which would result in lost revenue owing to cleaning costs. These fats and oils blockages result in sewer flooding, odour problems and the risk of rat infestations near to the premises. This issue attracts the attention of waste management sector.

Waste management refers to the collection, transportation, processing (waste treatment), recycling, and disposal of waste products, most of which are generated by human activity, in order to decrease their impact on human health, local aesthetics, and amenity. The fundamental principles of waste management are to minimise and recycle the waste, recover the energy and finally dispose the waste (Abdullah & Sulaiman, 2013). In recent decades, a sub focus has been gone through on recovering resources of fats and oils waste as well as reducing waste materials impact on the natural world and environment.

There are several waste management's concepts that are used differently in different regions. For common examples are reduce, reuse, and recycle. According to the hierarchy, they are classified according to their desirability in waste management strategies. Over the last decades, the waste hierarchy has taken into many forms, but the basic concept has retained the cornerstone of most waste minimisation strategies. The intention of the waste hierarchy is to get the most practical value out of things while producing the least amount of garbage.

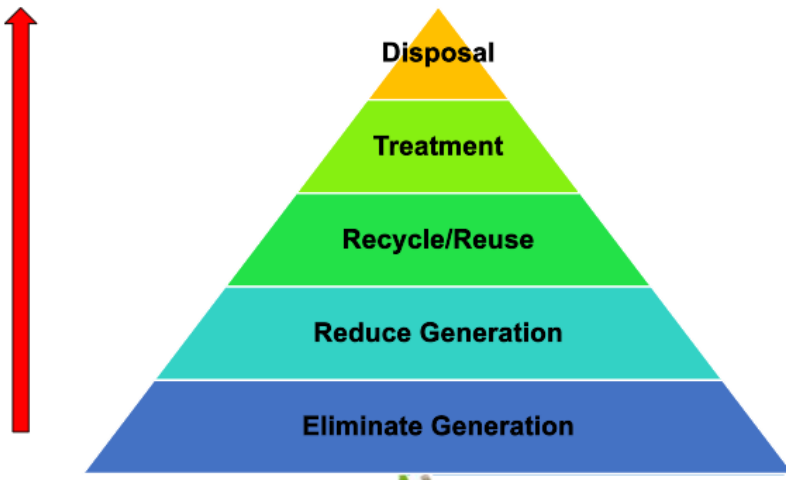


Figure 1.1 Priority approaches to hazardous waste reduction (Masters & Ela, 2008)

Figure 1.1 illustrates a priority system for rating different approaches to hazardous waste reduction. Overall, minimising, eliminating, and recycling hazardous substances lowers the cost of treatment and disposal. According to the hierarchy,

- The goal of eliminating generation is to find a way to totally remove the use of hazardous chemicals. Modifying production processes or changing items that suit the same need without producing hazardous waste are two ways to eliminate hazardous waste.
- Reduce generation refers to minimizing the amount of waste produced.
- Recycle/reuse means to maximize the recycling/reusing hazardous substances like solvents and acids before they need to be treated and disposed.
- Treatment is the process of reducing the volume and toxicity of hazardous chemicals.
- Disposal is considered only after all other options have been explored.

1.3 SOURCES OF WASTE FROM OIL AND FAT INDUSTRY

Asia is the world's largest consumer of fats and oils, accounting for about half of global consumption. China and India together contribute for over a third of global output. Soybean oil is the most popular in China, followed by palm and canola oils. Canola oil, as well as palm oil and butter, are heavily consumed in India. Both countries expect high growth to continue. Indonesia and Malaysia play a role in overall consumption, particularly in the demand for palm oil.

Indonesia and Malaysia are the primary producers of palm oil. Palm oil usage contributes for 30% of global consumption and is predicted to expand at a rate of 4% each year. India, Indonesia, and China, as well as the rest of Asia, Europe, and Africa, are the primary consumers. Because of its lower cost, edible characteristics, and abundant supply, palm oil has become increasingly popular.

Soybean oil is the world's second-largest producer and consumer of oil. It is widely produced and utilised in the US, Brazil, Argentina, and China. Its usage as a feedstock in biodiesel manufacturing has facilitated its expansion in North and South America. In 2018, soybean oil contributed for about a quarter of global fats and oils consumption, and it is predicted to expand at a rate of around 2.5 percent each year.

Animal fats, such as tallow and grease, butter, and lard, continue to account for a large segment of world fats and oils production and consumption, despite the fact that volumes have stayed relatively stable or only mildly increased in recent years due to higher saturated acids or cholesterol content, which related to health concern. Tallow and grease are generated in large quantities in the United States and rank second in terms of oil or fat consumption (after soybean oil). As a feedstock for biodiesel manufacturing, tallow competes with soybean oil.

Overall, global fats and oils consumption is predicted to expand at a rate of 2.5–3.0% per year, owing to strong growth in Asia and moderate increases in the US and Europe. In Asia, China and India will continue to develop their populations and economies, resulting in an increase in fat and oil consumption per capita. Fats and oils usage for non-food purposes, particularly biodiesel generation, is predicted to rise in the United States, Europe, and Central and South America.


Tallow and grease are produced in high volumes in the United States.
Soybean oil is made and used extensively in the United States, Brazil, Argentina, and China.
China ranks second in total world production of oil and fat in 2018, and is a larger producer of soybean and rapeseed (canola) oils.
India produces large volumes of canola and butter.
Malaysia ranks third in world production because of its place as the world's second-largest palm oil producer
Indonesia is the world's largest producer, and accounts for more than half of the global production of palm oil.
ASIA
RUSSIA
CHINA
INDIA
UNITED STATES OF AMERICA
MEXICO
BRAZIL
SOUTH AMERICA
AUSTRALIA
ANTARCTICA
ANTARCTICA
1
2
3
N
S
W
E

During the fats and oil processing, plantation is the first step, followed by primary and secondary processing. All these stages produce their own industrial waste as in Figure 1.2.

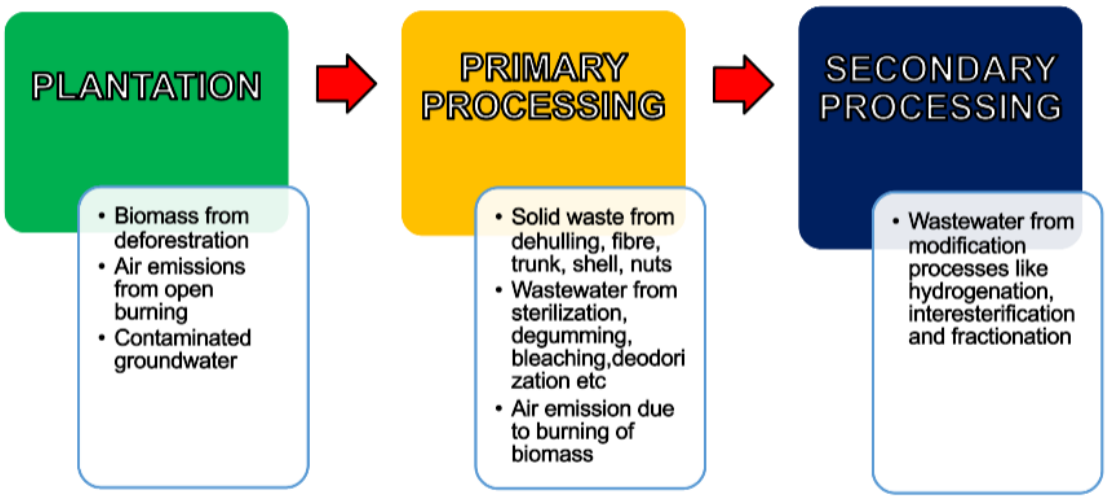


Figure 1.2 Oil and fat industrial waste.

Oilseeds processing, refining and processing of vegetable oils (primary processing), and further processing into edible products and oleochemicals (secondary processing), results in a range of waste products. Table 1.1 illustrates an example of waste products from the fat and oil industry. Hazardous and non-hazardous industrial waste exist both, however, have the potential to create serious environmental problems if not properly controlled. Understanding and control of the processes are required for proper waste management.

Table 1.1 The example of sources of waste from fat and oil industry

SOLID WASTES	AIR EMISSIONS	WASTEWATER
Refinery bleaching clay	Process dust particulates	Oilseed Plantation
Spent hydrogenation nickel catalyst	Solvent from extraction and meal processing	Oilseed Preparation and Extraction
Biomasses	Odors from meal cooling and oil deodorization	Crude Oil Refining
Oilseed meal/cake	Boiler emissions	Refined Oil Modification

Figure 1.3 depicts the primary processes of a typical fat and oil processing and refining facility, whereas Figures 1.4 depict different types of waste generated from palm oil.

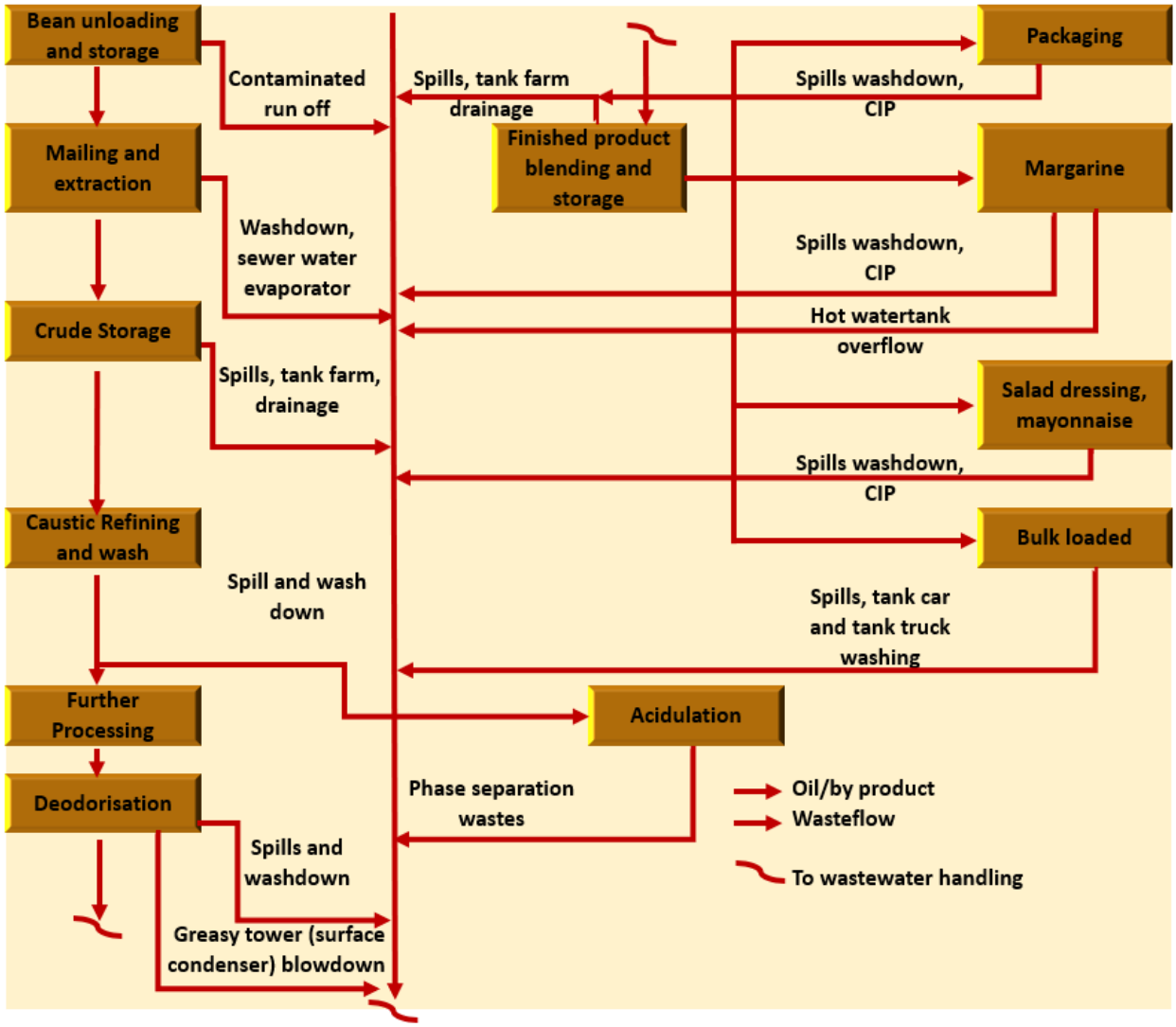


Figure 1.3 Conceptual diagram of fats and oil processing.

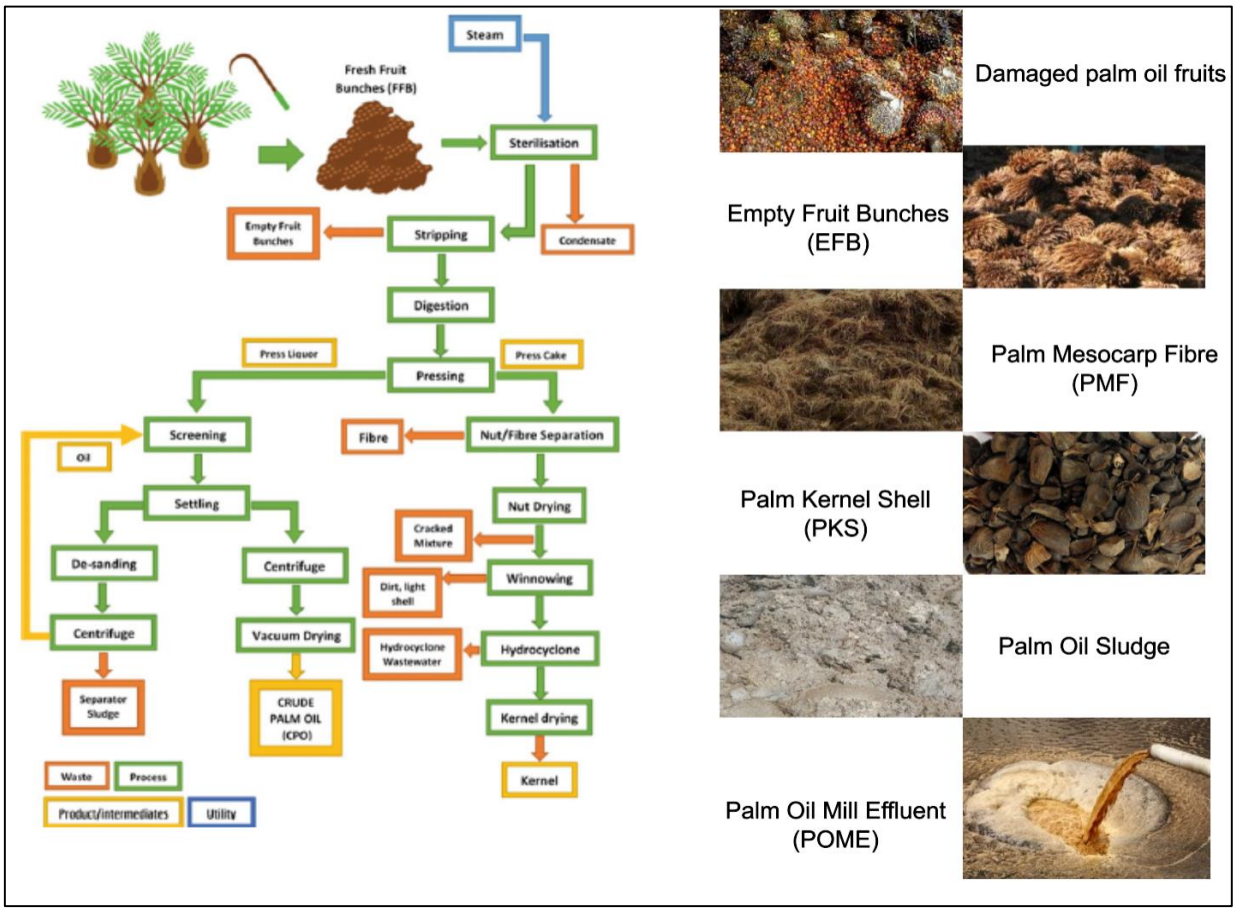


Figure 1.4 Different types of waste from palm oil processing

The environment is closely linked to waste. Waste is not only a concern for the environment, but it also costs money. Poor waste management leads to climate change and air pollution, as well as having a direct impact on a variety of ecosystems and species. In the next section, we'll learn more about how waste affects the environment.

1.4 IMPACT OF WASTE FROM OIL AND FAT INDUSTRY ON ENVIRONMENT

Since oil and fat processing is a land-intensive sector related, the oil and fat industry has always been linked to the environment. Any uncontrolled development will result in forest system deterioration, habitat loss (including plants and animals), excessive land degradation, and pollution (water and airborne) due to the use of enormous quantities of pesticides and herbicides required to sustain the plantation. Both the input and output sides of its activities contribute significantly to environmental degradation.

- **Input side:** The operations contribute greatly to environmental damage on both the input and output sides.
- **Output side:** Manufacturing processes generate enormous amounts of solid waste, wastewater, and air pollution

The following are some examples of environmental degradation:

- Oil spills are caused by the discharge of biomass such as hulls, fibres, trunks, shells, and leaves in the plantation site without retrieving any remaining oil. Incineration of biomass, on the other hand, wastes a renewable energy source and heat that could otherwise be used to heat the mill's boiler.
- Wastewater is formed when liquid waste from an extraction process is blended with waste from the cooling water and steriliser.
- During wastewater digestion, odour is discharged into the surrounding air, lowering air quality in the lagoons.
- Methane gas is one of the greenhouse gases that can deplete the ozone layer. However, at the moment, the methane produced by POME digestion in biogas is neither used or trapped, and it simply escapes into the atmosphere.
- Waste sludges are produced in the oilseeds wastewater treatment process from a variety of sources, including lime neutralisation, dissolved air flotation phase separators, and biological waste. Disposing of these items is getting increasingly complicated and expensive.
- The purification and elimination of colour bodies from refined oils require several bleaching clays. In majority, it contains 5 to 35 percent oil, which will spontaneously combust in the presence of excess heat generated by organic oxidation. This causes issues regarding to disposal in sanitary landfills and at industry sites. Other than spontaneous combustion, bleaching clay is not typically considered hazardous; nonetheless, some landfills are hesitant to accept this material due to combustion and/or oil content.
- Nickel catalyst is used in the hydrogenation of oil. After being used for many times, this waste is either recycled or disposed of in sanitary landfills (or onsite). Although the EPA has not yet identified nickel as a dangerous substance, nickel has been designated as dangerous in several states, and it is expected to be recognized that way globally soon.
- High levels of phosphorus are associated with acidification, but it can also be found in a variety of other waste streams. The impact of phosphorus on algal production in receiving streams, particularly at impounded lakes, is a pressing issue. The most difficult aspect of treating phosphorus is due to the existing as organic form. It becomes difficult to precipitate with lime or alum. If the wastes are biologically treated, the wastewater will contain mostly inorganic phosphorus, which can be precipitated easily.

- Phosphorus can also be found in crude oils, particularly soybean oil in the form of phosphatides. During refining process, phosphorous is from the oil phase. Then, if refinery washwaters and soapstock are acidulated, it is transported into the water phase.
- The acidulation of soapstock using sulphuric acid producing sulphate as by product. Sulphate is a source of concern because of its contribution to dissolved solids and its ability to create odour-causing chemicals in anaerobic circumstances.

1.5 THE IMPORTANCE OF WASTE MANAGEMENT IN OIL AND FAT INDUSTRY

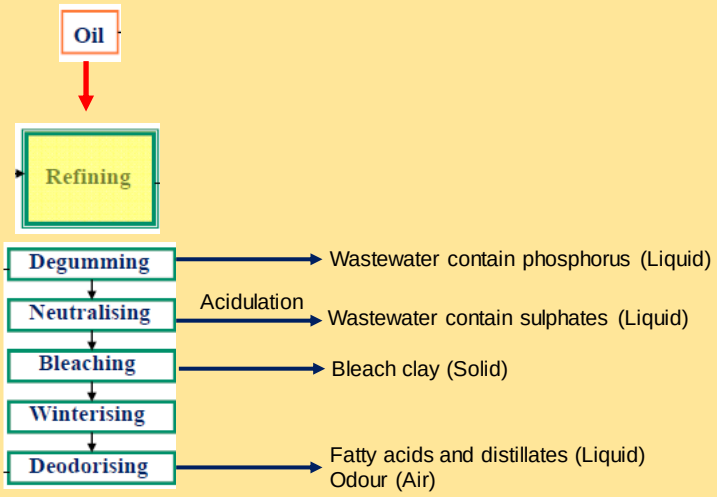
Processing oilseeds, refining vegetable oils, or any other subsequent processing into edible products and oleochemicals generates a variety of waste products. Understanding and control of the processes are required for proper waste management. Different types of waste management mechanisms have various degrees of complexity, logistics, and economic challenges. Waste management is a must for conservation of natural resources as well as for protecting the environment in order to approach sustainable development. All wastes have the possibility to cause serious damage to the environment if not properly managed. Major cost saving could be achieved through effective waste management program.

TUTORIAL

Sketch a schematic diagram of edible oil refinery processing stage together with the types of waste generated from each stage.

SOLUTION

1. List down the stage involved in oil and fat refinery process. You may refer to Figure 1.3.
2. Evaluate each stage and potential type of waste generated (solid, liquid or gas).



TEST YOUR CONCEPT

SECTION A

1. What is the function of combination between carboxylic acid group with hydroxyl groups on the glycerol molecule?
   A. To give the functionality to fats
   B. To generate the triacylglycerol molecule's ester bonds.
   C. To generate large amounts of fatty acids chain.
   D. To ingest oils and fats in long carbon and hydrogen chains.

2. How fats and oils waste cause serious problems in the sewerage system globally?
   A. They cause sewage blockage when dumped down the kitchen sinks or dirty drains
   B. They pollute local waterways when discharged down rainwater pipes and gullies.
   C. Fat and oils being responsible for up to 75% of 200,000 sewage clogs and pollution incidents
   D. Fats and oils blockages result in sewer flooding, odour problems and the risk of rat infestations near to the premises.

3. Waste management refers to the _____of waste products, most of which are generated by human activity
   I. Collection
   II. Transportation
   III. Management
   IV. Disposal

   A. I, II, III
   B. I, II, IV
   C. I, III, IV
   D. II, III, IV

4. What is the purpose of waste management?
   I. To decrease the waste impact on factory
   II. To minimise and recycle the waste
   III. To recover the energy
   IV. To dispose the waste

   A. I, II, III
   B. I, II, IV
   C. I, III, IV
   D. II, III, IV

5. Arrange the priority system for different approaches to hazardous waste reduction from least to most priority.
   I. Treatment
   II. Eliminate generation
   III. Disposal
   IV. Recycle/Reuse
   V. Reduce generation

   A. I, II, III, IV, V
   B. III, V, I, II, IV
   C. III, I, IV, V, II
   D. II, III, IV, I, V

6.

According to figure above, choose the correct industrial waste for secondary processing.
A. Contaminated ground water
B. Wastewater from modification process
C. Air emission due to burning of biomass
D. Solid waste from hydrogenation process

SECTION B

1. There are several waste management's concepts that are used differently in different regions. The intention of the waste hierarchy is to get the most practical value out of things while producing the least amount of garbage. Arrange reduce generation, recycle and eliminating generation by increasing the priority. Next, state the importance of each step.

2. Any uncontrolled development will result in forest system deterioration, habitat loss (including plants and animals), excessive land degradation, and pollution (water and airborne) due to the use of enormous quantities of pesticides and herbicides required to sustain the plantation. Explain THREE examples of biodegradable degradation.

CHAPTER

02

SOURCES OF WASTES FROM OIL AND FAT INDUSTRY:

AIR EMISSIONS

LEARNING OUTCOMES

- Describe air emissions
- Examples of wastes from air emissions of oil and fat industry
- Sources of wastes from air emissions.
- Control measures to manage waste from air emissions.

2.1 INTRODUCTION

The gases and particulates that pollute our atmosphere come from a variety of places. Primary pollutants are those that are emitted directly into the atmosphere, whereas secondary pollutants are those that are produced by numerous physical processes and chemical reactions that occur in the atmosphere. The processes that produce primary pollutant emissions can be used to categorise the sources of these emissions. Most primary pollutants enter the atmosphere as a result of combustion, evaporation, or grinding and abrasion. Automobile exhaust emissions and power plant stack gases are created during combustion; volatile substances such as gasoline, paints, and cleaning fluids enter the atmosphere by evaporation; whereas dust kicked up when land is plowed and asbestos fibers that flake off of pipe insulation are examples of grinding and abrasion. Of these, combustion accounts for the great majority of emissions, and the gases and particulate matter released when fuels are burned have been the focus of most of the technical and legislative pollution control efforts.

Air emissions are commonly linked to operations such as combustion, material storage, and other industry-specific processes. Emissions of air pollutants can occur in the oil and fat business from a range of operations such as feedstock cultivation, transportation, milling, and refining of the oil generated. Major sources of air emissions considered for this presentation include the following:

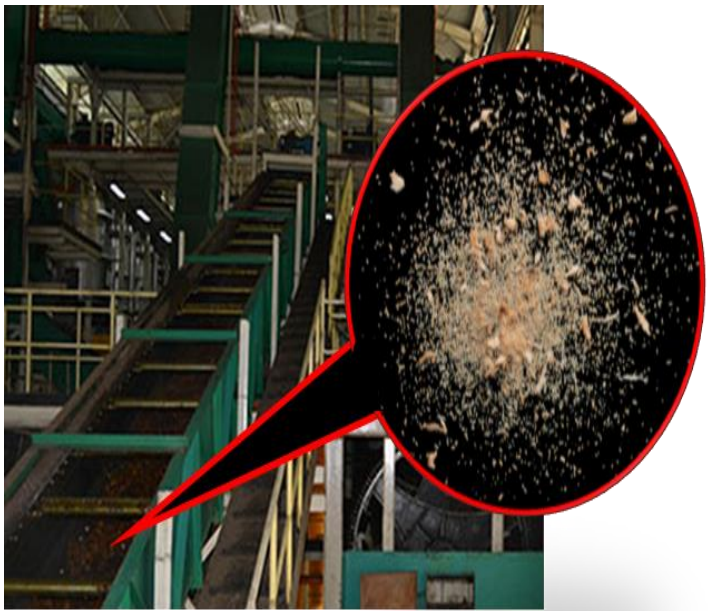
1. Process dust particulates
2. Solvent from extraction and meal processing
3. Odors from meal cooling and oil deodorization
4. Boiler emissionsworld consumption of fats and oils

Particulate Matter (PM):
Dust or particulate matter (PM) is released during certain operations such as the combustion of fossil fuels, open storage of solid materials, and from exposed soil surfaces, including unpaved roads.

2.2 SOURCES OF AIR EMISSIONS FROM OIL AND FAT INDUSTRY

PROCESS PARTICULATE MATTER

Production of particulate matter occurs as a result of a multitude of factors during the handling and processing of oil seeds and by-product meal. Elevator losses as a whole normally range between 2% and 3%. Moisture loss, seed spilling, and dust loss/emissions all contribute to this loss. Although the dust element of the loss is modest in absolute terms, when assessed as particle air emissions, it can pose significant issues. Additionally, a fraction of these losses may also emerge as water-borne pollutants in rainfall runoff from plant sites.



ODORS FROM MEAL DRYER AND OIL DEODORIZATION

Odour is a qualitative parameter from the standpoint of both measurement and control. Complaints from residents living near a facility are frequently the source of motivation for abatement. Meal driers and refined oil deodorization can also be sources of odour. In certain exceptional cases, acidulation has caused odours; however, this is most typically due to poor design and operation, which usually coincides with batch processing in open-topped kettles. The other two processes can also be odour generators on their own. The odours of meal drying vary depending on the seed used and the equipment used.

In deodorization, oil is subject to high temperatures to drive-off volatile fractions to strip odour-causing compounds from the oil. The control of these compounds has become an integral part of the process.

SOLVENT EXTRACTION

The facilities are regulated as major sources of solvent emissions. The industry controls itself to a certain degree because of the cost of the solvent—normally ‘‘commercial’’ hexane. The U.S. Federal Clean Air Act provides a basis for controlling solvent emissions as volatile organic compounds and, because a major constituent is typically n-hexane, as a hazardous air pollutant. The Federal Clean Air Act requires the U.S. Environmental Protection Agency to establish hazardous air pollutant emission criteria per unit of production. These standards have been promulgated and range from 0.2 to 0.25 kg for 100 kg of oilseeds processed, for specific categories of extraction and oilseed type. Attainment of this figure requires a properly designed vent and cooling water system with minimal interruptions to the operations.

How Does the Hexane Extraction Process Work?

In chemical extraction of oils, the seeds or other oil producing fruits are ground up and flattened into a round and then covered in a solvent that will extract oil from the subject. This mixture is then left to sit and the solvent will evaporate, leaving behind the extracted oils. This one method of chemical extraction while others use the help of heat and steam to aid the process. So why is hexane used for extraction? Because hexane evaporates quickly and will boil at 154.4 degrees Fahrenheit, in addition to having low toxicity levels, hexane is the preferred solvent for both methods of extraction.

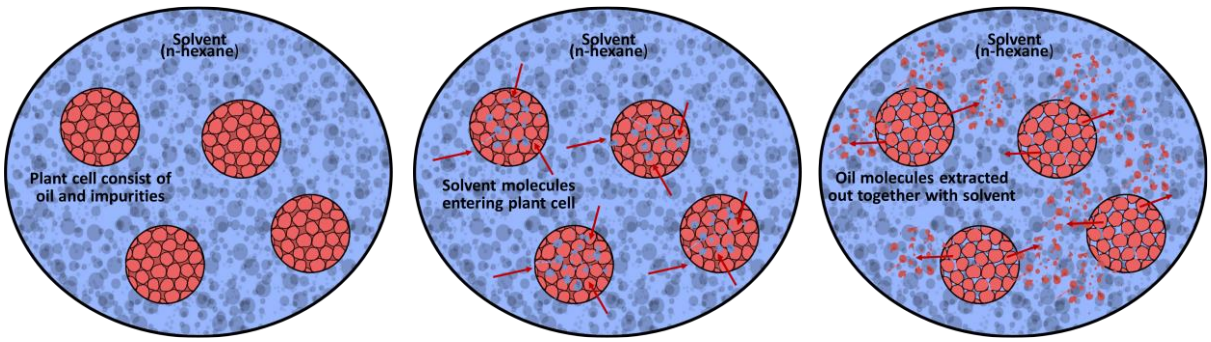


Figure 2.1 : Mechanism of solvent extraction of oil.

BOILERS

Steam generation is an integral component of oilseed processing facilities, sometimes coupled with the generation of electricity. Several processors operate coal-fired boilers as a hedge against fluctuating natural gas and fuel oil costs. Coal-fired boilers for steam and electrical generation are common in other areas of the world at oilseed plants. In palm oil industry in Malaysia, palm kernel chell (PKS) is a side product derived from the production of crude palm oil (CPO) and palm kernel oil (PKO). PKS is commonly used for power generation at respective mills or for third party use. PKS used as a replacement for coal and other fossil fuels in the generation of power creates a carbon offset in addition to increased air emission concerns for coal combustion. Concerns with boiler emissions now include oxides of nitrogen (NOx) and carbon monoxide (CO) irrespective of the fuel. For coal, the pollutants of concern include not only these constituents, but also ash particulate emissions and associated visual plumes, sulphur dioxide (SO_2), mercury (Hg), other trace metals, and hydrochloric acid (HCl). Certain oilseed processors use by-products of production as alternative fuels, which is particularly true in sunflower and peanut processing where hulls are burned as boiler fuel. This creates additional combustion challenges, but reduces solid waste.

2.3 AIR EMISSION MANAGEMENT IN OIL AND FAT INDUSTRY

The palm oil industry's commitment to increasing sustainability and decreasing greenhouse gas emissions has continued to grow. Many organisations are using a wide range of new and better management techniques that result in emission reductions. The Roundtable on Sustainable Palm Oil (RSPO) and Winrock International have cooperated to compile a compilation of best management practises to enable the broader palm oil sector evaluate what prospective practises may be put in place and the magnitude of GHG emission reductions (BMP). Plantation establishment, concession management, and mill management are among the practises investigated. Each BMP identified was evaluated against three criteria: financial feasibility, technical and operational challenges, GHG reduction potential, and technical and operational challenges, environmental and social co-benefits, and replicability.

PROCESS PARTICULATE MATTER

As mentioned earlier, the production of particulate matter in oil and fat industry is due to the mechanical manipulation of grain and meal particles. Depending on the size, capacity, technology, and cost of the mitigation process, there are numerous strategies to regulate and manage process particulate matter production in the oil and fat business. For example, dust minimization and control need proper design and maintenance of transfer and handling facilities. The use of enclosed and interconnected conveying systems with flow metres reduces speed spills and the accompanying dust emissions. In addition, facility designs must account for internal elevator dust build up, which must be controlled and cleaned to avoid fires and explosions. In addition, facility designs that minimise internal conveying equipment are typical when it comes to internal elevator dust generation, which requires control and cleanup to avoid fires and explosions.

Current industry trends are toward the installation of enclosed conveyors and the construction of enclosed areas with negative pressure aspiration for oilseed unloading and meal load-out. Highly efficient dust collection systems and control equipment (cyclones and bag houses) are used throughout the processes to control both fugitive and point source emissions.

A number of gas-cleaning devices can be used to remove particulates. The most appropriate device for a given source will depend on such factors as particle size, concentration, corrosivity, toxicity, volumetric flow rate, required collection efficiency, allowable pressure drops, and costs.

1) Baghouses

Fabric filtration is a prominent competitor for electrostatic precipitators in terms of efficient capture of tiny particles. The popularity of baghouse filters is rising, however, and they now rival precipitators in total industrial sales. As shown in Figure 2.2, dust-bearing gases are passed through fabric filter bags suspended upside-down in a large chamber called a baghouse.

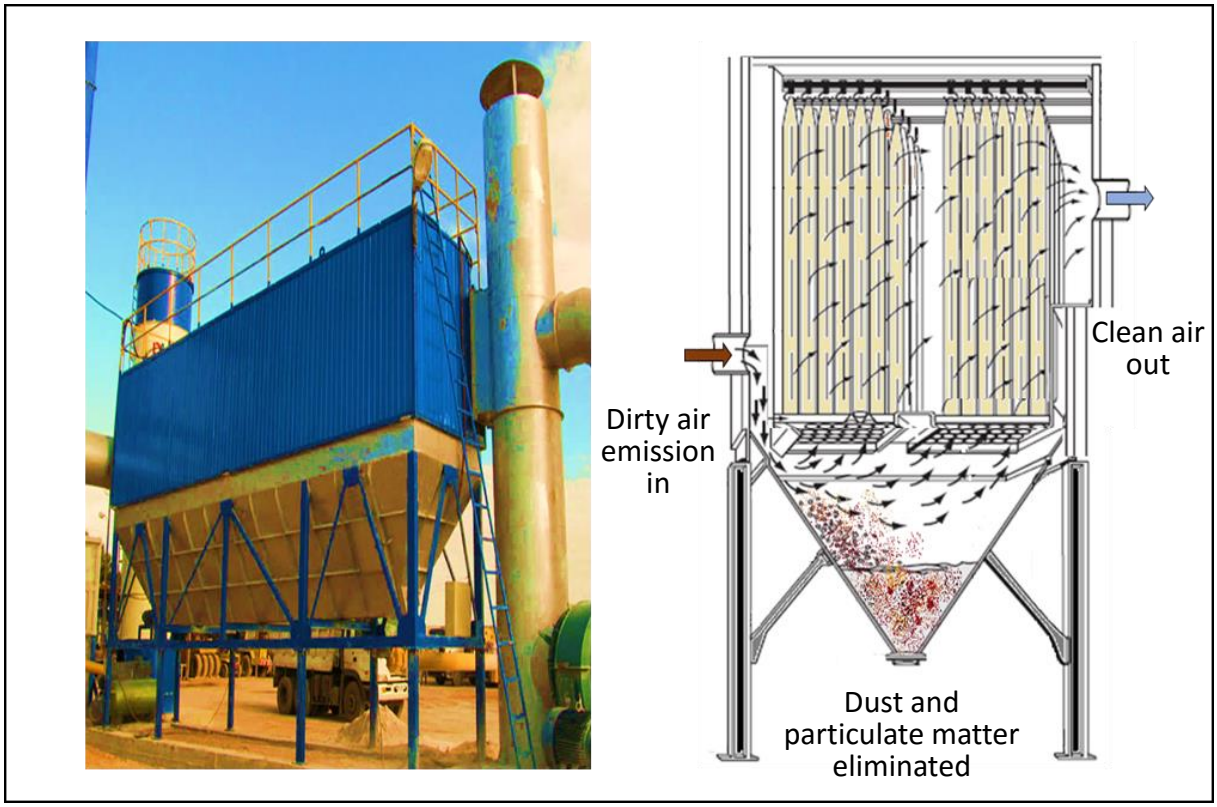
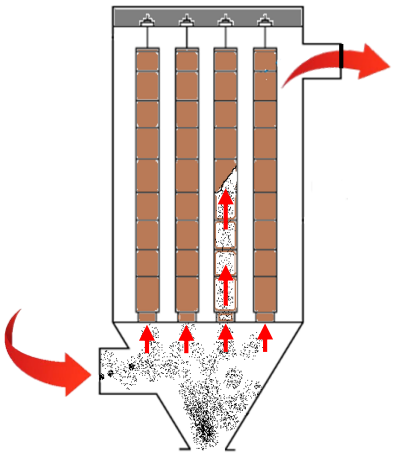


Figure 2.2 : Baghouse.

Thousands of bags may be stored in a baghouse, which are generally divided into many compartments. This enables for the cleaning of particular compartments while the others remain operational. Part of the filtering is performed by the fabric itself, but the dust that collects on the interior of the bags causes a larger portion of the filtration. Small particles are removed with near-100 percent efficiency, and large numbers of them are also eliminated. They do, however, have some drawbacks. Baghouses are enormous and expensive, just like precipitators. Corrosive substances in flue gases can injure them, and they can't work in humid situations. If the dust is flammable, there is also the risk of fires or explosions.



Working Principle of a Baghouse

- Through hoppers, dust-laden gas or air enters the baghouse and is guided into the baghouse compartment.
- The gas is sucked through the bags, either on the inside or outside depending on the cleaning procedure, and a coating of dust builds up on the filter media surface until air cannot pass through.
- The cleaning procedure begins when there is a significant pressure drop (P). Cleaning can be done either while the baghouse is active (filtering) or when it is turned off (in isolation). Normal filtration resumes after the container is clean.

2) Cyclone Collectors

The centrifugal, or cyclone, collector is the most often employed control device for moderately big particles. Particle-laden gas enters tangentially near the top of the cyclone, as seen in Figure 2.3. Centrifugal forces cause the particles to clash with the outer walls as the gas spins in the cylindrical shell, and gravity causes them to slide down into a hopper at the bottom. The spiralling gases then emerge out the collector's top. Cyclone efficiency can reach over 90% for particles greater than, but it quickly goes off for the small particle sizes that are the most dangerous to human health. While they do not fulfil emission regulations, they are generally affordable and require little maintenance, making them ideal as pre-cleaners for more expensive and crucial final control systems like baghouses and electrostatic precipitators.

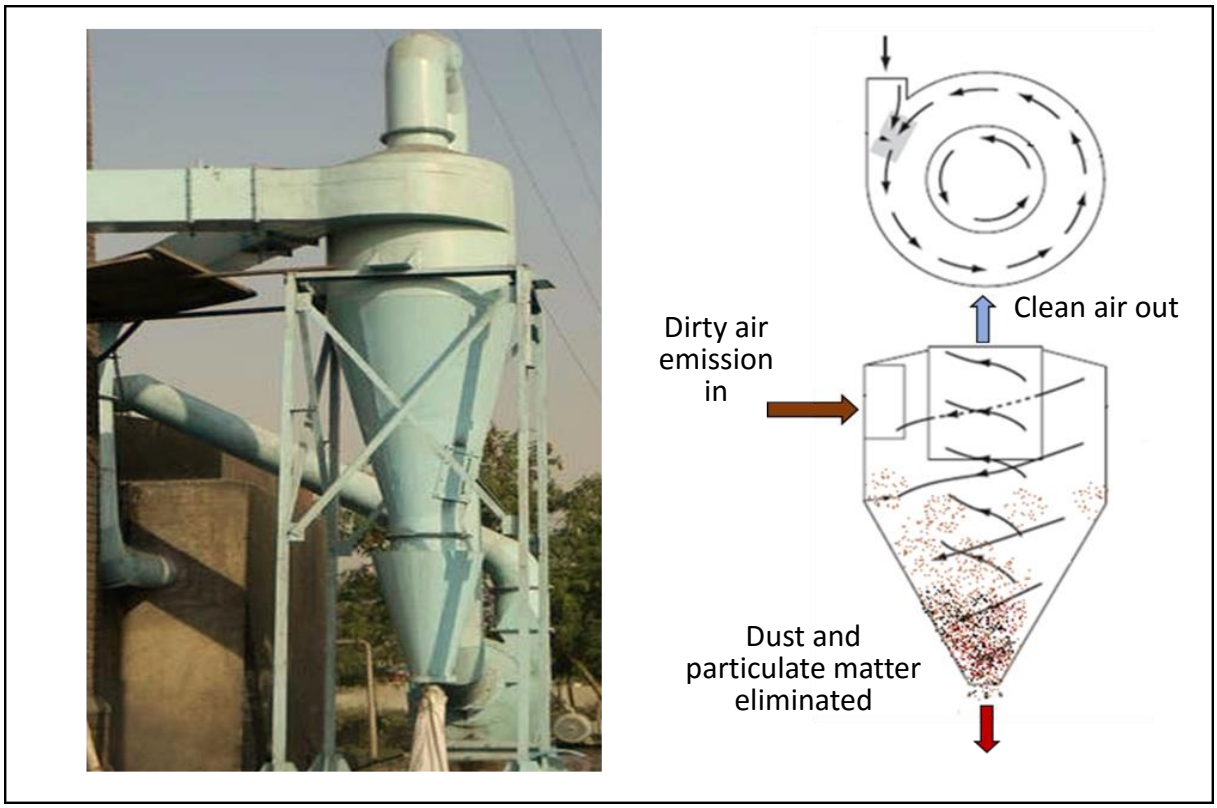


Figure 2.3 : Cyclone collector.

3) Electrostatic Precipitators

Electrostatic precipitators are used in most utility power plants to gather extremely minute particles. Figure 2.4 depicts one electrostatic precipitator setup, which consists of vertical wires placed between parallel collection plates.

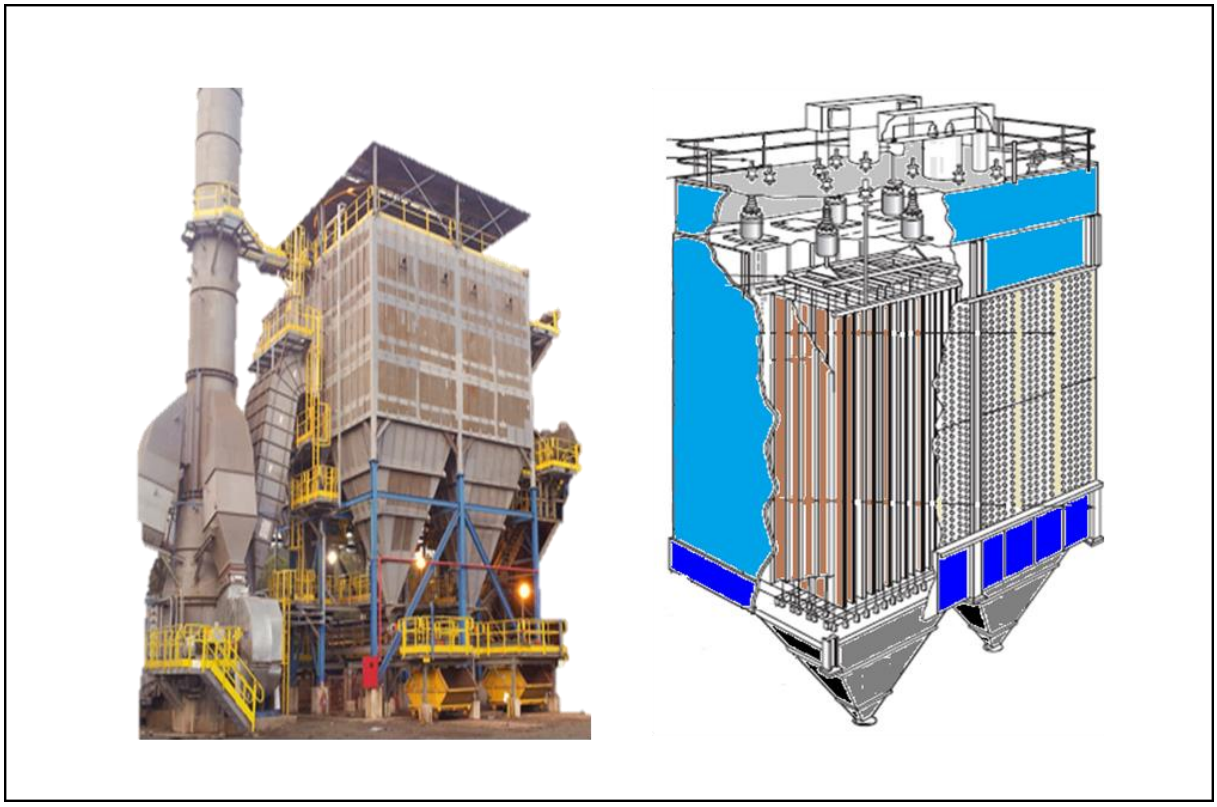
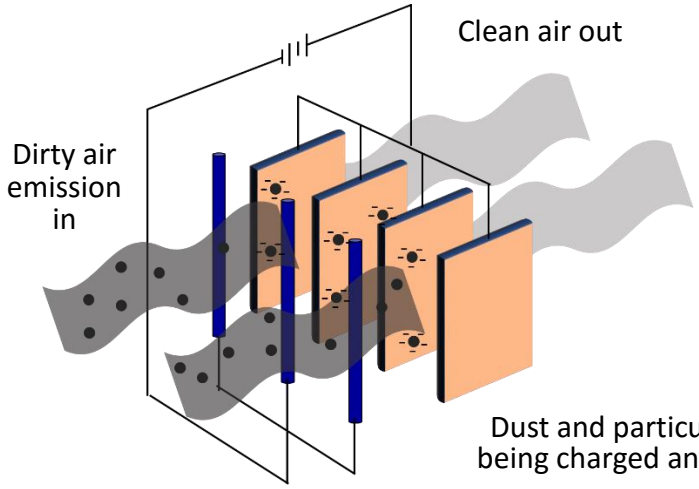


Figure 2.4 : Electrostatic precipitator.

The plates are grounded, and the cables have been charged to a very high (negative) voltage, possibly 100,000 V. The corona discharge caused by the high electric field near the wires ionises gas molecules in the air stream. Negative ions and free electrons are formed, and some of them attach themselves to passing particulate matter on their route to the grounded plates. The particles now have a charge, which leads them to travel to a grounded collecting surface under the influence of the electric field. Gravitational forces, tapping, or flushing the collecting plate with liquids are used to remove them from the collection electrode. Actual electrostatic precipitators, like the one depicted in Figure 2.4, can contain hundreds of parallel plates with total collection areas in the tens of thousands of square metres. Electrostatic precipitators can easily remove over 98 percent of particles travelling through them, including submicron-sized particles. Some companies have efficiency levels as high as 99.9%. They can handle large flue-gas flow rates with little pressure drop, and they have relatively low operation and maintenance costs. They are quite versatile, operating on both solid and liquid particles. Precipitators are very efficient, but they are expensive and take a lot of space.



Working Principle of an Electrostatic Precipitator

- Particles in the gas stream acquire negative charge as they pass through the corona and are then attracted to the grounded collecting plates.

ODOUR

As noted in Section 2 facilities to control odour have become essentially a part of the process. Deodorization of fats and oils is a necessary process for removing disagreeable flavour and odour components that are naturally present or created during processing. The deodorization of oils produces off-gases that historically have produced the greatest challenge to the industry for odor control.

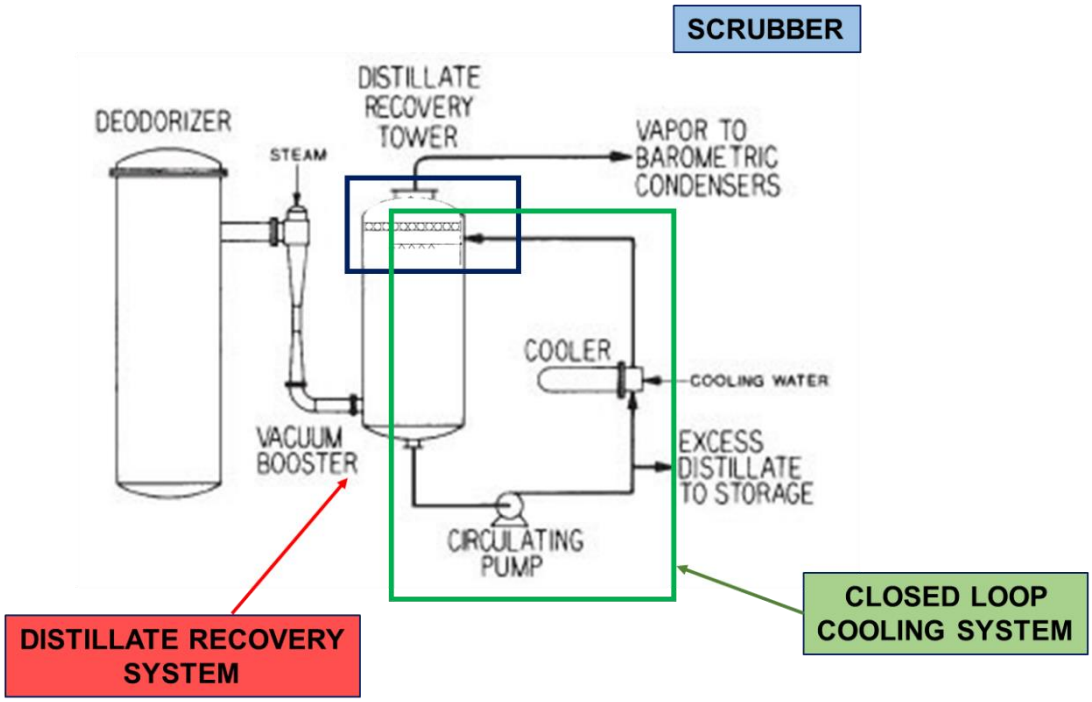


Figure 2.5 : Control mechanism for odour from deodorization of oil (Boyer, 2005).

In general, there are three methods to getting rid of these odour issues. The first is a distillate recovery system, which recovers the majority of the fatty acid as a byproduct, as well as many of the aromas associated with it, from the deodorizer vapour output. The second is a closed-loop cooling system that keeps the cooling tower free of fat-laden hot well water. The third stage is to use a vapour scrubbing or oxidation device to remove any remaining volatile organic chemicals from the previous two steps. A typical distillate recovery system consists of a scrub cooler located at some point in the deodorizer vacuum system. The deodorizer vapor effluent is stripped of about 95% of the condensable organic material by direct contact in the cooler. The circulating distillate is then cooled to remove the heat of condensation before being returned to the stripping tower. Several equipment companies offer design/equipment packages for this. The stripped steam and the leftover deodorizer vapours are then condensed in either barometric or shell-and-tube condensers. The condensate and cooling water from the direct contact condensers, as well as the air discharge from the final ejector, are discharged to a hot well when barometric condensers are utilised. The cooling water is pumped from the hot well to a cooling tower before being recirculated to the condensers. This system is the source of the typical oilseed processing odour seen in oil refineries. This system normally uses a condenser discharge directly to a hot well and then to a cooling tower, often by gravity. The cooling tower overflow and blow down is discharged to a wastewater treatment facility as part of the plant oily wastewater handling needs.

If odours from the cooling tower need to be controlled further, the hot well's cooling water is fed through plate heat exchangers, allowing for indirect cooling. However, due to fouling issues, an additional heat exchanger must be provided to allow for heat exchanger cleaning off-line. Cleaning is done with either steam or water and detergent. One advantage of using steam is that the fatty material may be reclaimed more easily. The closed-loop system is more expensive to build (more equipment) and uses more energy in the vacuum system to pump water and motive steam.When non-contact cooling water is used with shell and tube condensers, the deodorizer distillate not recovered in the scrubbing system will not build up and foul the cooling tower but is confined to the hot well. The insides of the tubes of the condensers require continuous scrubbing with caustic water to eliminate fouling, which also enters the hot well. The floating distillate is skimmed from the hot well into a recovery tank, whereas a portion of the high pH water is recirculated for cleaning the tubes and the excess water overflows to the wastewater treatment facility.

BOILERS

The control of combustion products varies depending on the type of fuel burned and the architecture of the boiler. The control mechanism for NOx and CO emissions in natural gas and fuel oil combustion is commonly a burner system that recirculates combustion gases to the burner to regulate combustion temperature. These burners can also be retrofitted into existing boilers; however, this may result in a loss in steaming capacity. Most coal-fired boilers have baghouse collectors for particle management. Fluid bed boilers can usually provide fire-box management where NOx and SO_2 control is a problem due to lower combustion temperatures and the use of a limestone bed. Another way to reduce SO_2 emissions is to burn low-sulphur coal. Air pollutants that are hazardous to human health, such as trace metals and HCl, are prohibited. Their concentrations can vary substantially inside a coal vein and from vein to vein. Control options include switching coals or chilling boiler exhaust gases, introducing a sorbent, and collecting the resulting particles using a baghouse collector.

SOLVENT

Sound extraction, distillation, vent, and cooling water component and system design, operation, and maintenance are principally responsible for adequate control of extraction solvent loss. Computer monitoring and control solutions can help you run your business more efficiently, resulting in better solvent management.

TUTORIAL

There are three common methods in mitigating the particulate matter produced from oil and fat industry e.g.: baghouse, cyclone filter and electric precipitator. Which method is the best in doing so. Explain your answer.

TIPS

1. List down all three methods in different table.
2. Evaluate each method in terms of their advantages and disadvantages in controlling particulate matter emission in oil and fat industry.
3. Present your findings and decide which method is the best.

TEST YOUR CONCEPT

SECTION A

1. Emissions of air pollutants can occur in the oil and fat business from a range of operations such as feedstock cultivation, transportation, milling, and refining of the oil generated. Choose the major sources of air emissions.
   A. Process solid particulates
   B. Solvent from extraction and meal processing
   C. Odours from meal cooling and oil deodorization
   D. Air emissions world consumption of fats and oils

2. Select the correct statement about palm kernel shell (PKS).
   A. PKS used as a replacement for coal and other fossil fuels in the generation of power.
   B. PKS is commonly used for power generation for first party use
   C. PKS is a main product derived from the production of crude palm oil (CPO) and palm kernel oil (PKO).
   D. PKS creates a carbon offset in addition to decrease air emission concerns for coal combustion.

3. Baghouse is a large chamber or room for holding bag filters used to filter gas streams from a furnace. Which of the statement is **NOT** referring to the drawback of baghouse.
   A. Enormous and expensive
   B. Corrosive
   C. High humidity
   D. Explosive

4. Which component is **NOT** responsible for adequate control of extraction solvent loss.
   A. Sound extraction
   B. Distillation Vent
   C. Cooling water component
   D. Design operation

SECTION B

1. Explain the working Principle of a Baghouse.
2. Explain why is hexane used for extraction?
3. Define fabric filtration.

CHAPTER

03

SOURCES OF WASTES FROM OIL AND FAT INDUSTRY:

SOLID WASTES

LEARNING OUTCOMES

- Describe solid wastes.
- Examples of solid wastes resulting from oil and fat industry
- Sources of solid wastes from oil and fat industry.
- Control measures to manage solid wastes from oil and fat industry.

3.1 INTRODUCTION

Generation and handling of solid and hazardous waste has not been a challenge in this industry on the same scale with wastewater or air emissions. However, several significant sources exist. In this chapter, the sources of solid waste from oil and fat industry are discussed, as well as some of mitigation approach being implied to reduce its impact to the environment. Solid wastes in oil and fat industry mainly contributed by the plantation of oilseed, extraction process and refinery.

Examples of solid wastes

- ✓ Biomasses (fibre, shell, hulls, leaves, wood, trunk etc)
- ✓ Meal and grain solid / oilseed cake
- ✓ Refinery bleaching clay/ bleaching earth/ activated clay
- ✓ Spent hydrogenation nickel catalyst

3.2 SOURCES OF SOLID WASTES FROM OIL AND FAT INDUSTRY

DEFORESTATION AND PLANTATION

- ❖ The oil and fat industry has always been linked to the environment because it is a land of intensive industry.
- ❖ Deforestation is inevitable for plantation of oilseed.
- ❖ Any unplanned development will lead to the degradation of the forest systems, loss of habitats including plants and animals, extreme land degradation and pollution to maintain the plantation.
- ❖ Most of solid wastes are biomasses produced during harvesting of oilseed such as wood, leaves, trunk.

OILSEED EXTRACTION

- ❖ The solid wastes may consist of biomasses including hulls, fibres, trunks, shells, leaves and much more.
- ❖ Disposal of biomasses without recovering remnant oil in it contributes to oil spills.
- ❖ Incineration of the biomass on the other hands, means wasting renewable energy source and heat which actually could be provided for boiler in the mill.
- ❖ Main process of biomass production are
- ✓ Dehulling – produced hulls
- ✓ Threshing – produced fibre and shell
- ✓ Mechanical/Solvent extraction – produced cake or stone like olive cake

REFINERY BLEACHING

- Bleaching is an adsorption process of removing color pigments (carotene, chlorophyll) and minor impurities like phosphatides, soaps, metals and oxidation products. These components are adsorbed on acid-activated clays or bleaching earth.
- Various bleaching clays purify and remove color bodies from refined oils. These wastes contain 5% to 35% oil. The oil will be extracted and the clay will be disposed as waste.
- The characteristics of these materials are such that they will combust spontaneously, which has created problems for disposal in sanitary landfills, as well as at factory locations.
- The spontaneous combustion is caused by excess heat generated from oxidation of organics.
- Methods to prevent contamination include addition of antioxidants or water sprays to the waste earth. The addition of lime is also reported to prevent the spontaneous combustion.

OIL HYDROGENATION

- Hydrogenation is a modification process of oil to harden the physical properties of oil by altering the unsaturation of bonding by adding hydrogen.
- Nickel catalyst is used in the hydrogenation of oil. Depending on the processor, catalyst may be recycled many times; therefore, waste generation rates differ.
- However, some refinery will generate about 100 kg of spent catalyst per day. This material has been either recycled or disposed of in sanitary landfills (or onsite).
- The recycling for nickel recovery has been spotty and not well organized.
- Although nickel has not yet been designated as hazardous by the EPA. Several states have classified nickel as hazardous and it is anticipated that it will soon be universally treated in that manner.
- Active facilities for spent nickel catalyst recycle are known to exist at this time in the United States, Mexico, and western Europe.

3.3 SOLID WASTES MANAGEMENT IN OIL AND FAT INDUSTRY

BIOMASSES

- Usually used as combustion materials for boilers in mill for electricity generation.
- Some are used in mulching and soil conditioning in plantation. Examples : palm oil fibre and cottonseed hulls.
- Mulch is used to retain moisture in the soil, suppress weeds, keep the soil cool, prevent frost heaving in winter, and make the garden bed look more attractive. Organic mulches also help improve the soil's structure, drainage, and nutrient-holding capacity as they decompose.

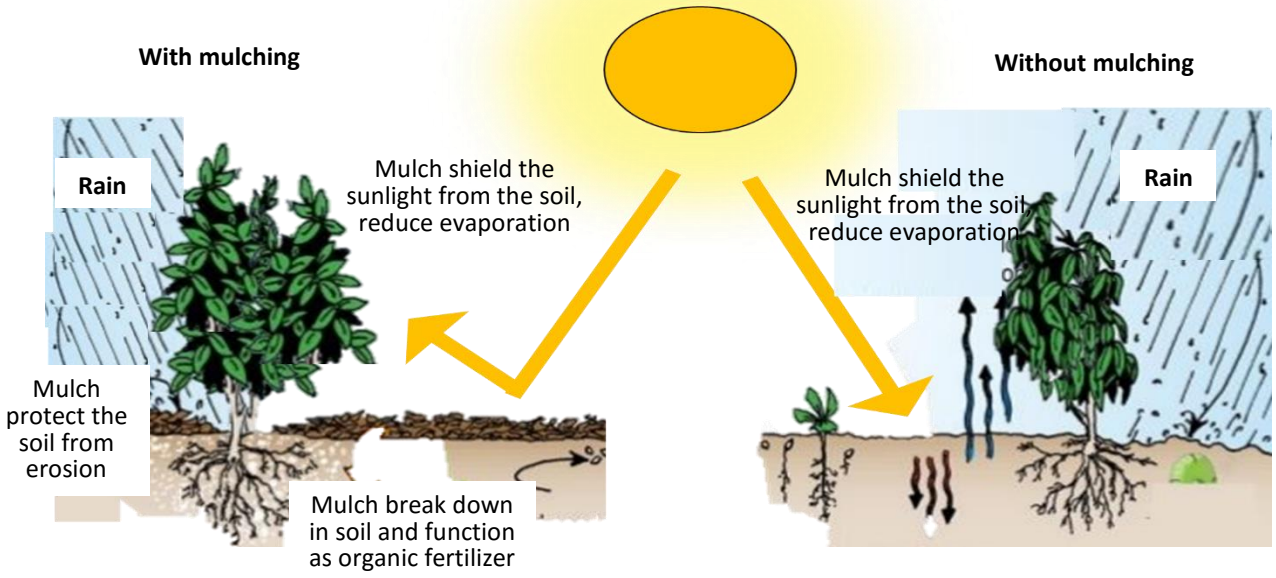


Figure 3.1 : Concept of mulching in protecting plant in extreme conditions.

Figure 3.2 : Example of mulching using biomass in landscaping.

OILSEED CAKES AND MEALS

- Oilseed cakes and meals are the residues remaining after removal of the greater part of the oil from oilseeds. The residues are rich in protein and most are valuable feeds for livestock.
- Produced during the extraction process of oilseed, either by mechanical or chemical (solvent) extraction.
- Oilseed meals contain significant quantities of protein, minerals and other necessary nutrients for microbial growth
- Extensively used as animal feed or supplement due to its high protein content.

Figure 3.3 : Example of animal feed from palm oil meal.

REFINERY BLEACHING CLAY

- Various bleaching clays purify and remove color bodies from refined oils.
- Used bleaching clays wastes contain 5% to 35% oil. The oil will be extracted and the clay will be disposed as waste.
- Some are added to poultry feed at 0.5-2.00 % that act as pallet binder in poultry diet.
- Most of bleaching clay wastes are disposed in sanitary landfill.
- The characteristics of these materials are such that they will combust spontaneously, caused by excess heat generated from oxidation of organics.
- To prevent contamination, include addition of antioxidants or water sprays to the waste earth. The addition of lime is also reported to prevent the spontaneous combustion.

Figure 3.4 : Bleaching clay or bleaching earth.

NICKLE CATALYST

- Nickel catalyst is used in the hydrogenation of oil. Used catalyst (or spent catalyst) are either recycled or disposed of in sanitary landfills (or onsite).
- The recycling for nickel recovery has been spotty and not well organized.
- These catalysts have environmental problems of their own because they are heavy metal-based.
- In order to reduce the production of spent nickel catalyst, catalyst may be recycled many times until it can no longer be used or not efficient.
- Active facilities for spent nickel catalyst recycle are known to exist at this time in the United States, Mexico, and western Europe.
- Some company mix spent nickel catalyst from industry to natural nickel in the production of stainless steel.

TUTORIAL

Explain how solid waste management in oil and fat industry contributes to energy sustainability.

SOLUTION

1. Some oil mill used the biomass from extraction as a feed source for boiler. Steam for boiler generates electricity for internal use in the mill.
2. Oilseed meal and cake are used as a protein source in livestock food formulation.
3. Mulching in plantation helps in slowing down the evaporation of water to the environment during the day, thus reduce the need of frequent watering and save energy.

TEST YOUR CONCEPT

SECTION A

1. The followings are examples of solid waste from palm oil mill **EXCEPT**:
   A. Palm kernel shell
   B. Empty fruit bunch
   C. Palm mesocarp fibre
   D. Activated carbon

- Used to purify and remove color bodies from refined oils.
- Can cause potential spontaneous combustion due to heat generated.

2. Both statements above are referring to
   A. Oilseed meal and cakes
   B. Oil hydrogenation
   C. Biomass
   D. Refinery bleaching clay

3. All statements below are correct **EXCEPT** :
   I. Palm kernel shell contain significant quantities of protein, minerals and other necessary nutrients for microbial growth
   II. Nickle catalyst can potentially combust spontaneously, caused by excess heat generated from oxidation of organics.
   III. Addition of antioxidants or water spray to the bleaching clay might cause contamination to the environment.
   IV. Biomasses are the main contributor for solid waste generation in oil and fat industry.

   A. I, II, and III
   B. I, II, and IV
   C. II, III, and IV
   D. All of above

4. Which approach below is **NOT** responsible for adequate control of solid waste in oil and fat industry
   A. Incineration
   B. Disposal at landfill
   C. Used as nutrient source in livestock food
   D. Fuel source for energy generation

SECTION B

1. Explain how mulching protects plant from dried out during hot weather.

2. Discuss the proper management of nickle catalyst to reduce the environmental impact to our surrounding.

3. Elaborate on environmental impact of oil and fat industry due to the plantation of the oilseed.

CHAPTER

04

SOURCES OF WASTES FROM OIL AND FAT INDUSTRY: WASTEWATER

LEARNING OUTCOMES

- Identify processes in oil and fat processing which produce wastewater.
- Describe the sources of wastewater from oil and fat industry.

4.1 INTRODUCTION

Oilseeds processing, refining and processing of vegetable oils, and further processing into edible products and oleochemicals, produces a variety of waste products. In no other industry is the proper handling of these wastes as dependent on the understanding and control of the processes. This article reviews major processes and facilities, particularly as they relate to waste generation and control.

Wastewater is defined as used water from any combination of domestic, industrial, commercial or agricultural activities, surface runoff or stormwater, and any sewer inflow or sewer infiltration". Therefore, wastewater is a byproduct of domestic, industrial, commercial or agricultural activities. The characteristics of wastewater vary depending on the source. Types of wastewater include: domestic wastewater from households, municipal wastewater from communities (also called sewage) and industrial wastewater. Wastewater can contain physical, chemical and biological pollutants.

In general, almost all processes involved in oil and fat industry produce wastewater. The amount of wastewater generated and its characteristic hugely affected by the type of process occur. Table 4.1 shows different type of processing in oil and fat industry with estimation of wastewater loading from each process.

Table 4.1 Average wastewater flow from different oil seed processing stage (Boyer, 2005).

NO.	PROCESS	AVERAGE WASTE LOAD FLOW (m^3/day)
1.	Milling and extraction	95
2.	Caustic refining	42
3.	Deodorization	19
4.	Acidulation	72
5.	Further processing	19
6.	Margarine production	265
7.	Salad dressing/mayonnaise	189
TOTAL		**701**

4.2 SOURCES OF WASTEWATER FROM OIL AND FAT INDUSTRY

OILSEED PLANTATION

A large-scale estate dedicated to farming that specializes in feedstock crops for the oil and fat industries is known as an oilseed plantation. Cottonseed, palm oil, canola, rapeseed, soy bean, sunflower, olive, coconut, and corn are among the crops produced. Because oilseed plantation is a land-intensive stage in the entire oil and fat business, it has always been tied to the environment. Aside from deforestation and forest degradation, loss of habitats including plants and animals, significant land degradation, and pollution, plantations are also a major source of worry due to the massive volumes of pesticides and herbicides required to sustain them.

Eutrophication, excessive nutrients in aquatic ecosystems resulting in algal bloom and anoxia, leads to fish kills, loss of biodiversity, and renders water unfit for drinking and other industrial uses. Excessive fertilization and manure application to cropland, as well as high livestock stocking densities cause nutrient (mainly nitrogen and phosphorus) runoff and leaching from agricultural land. These nutrients are major nonpoint pollutants contributing to eutrophication of aquatic ecosystems and pollution of groundwater, with harmful effects on human populations.

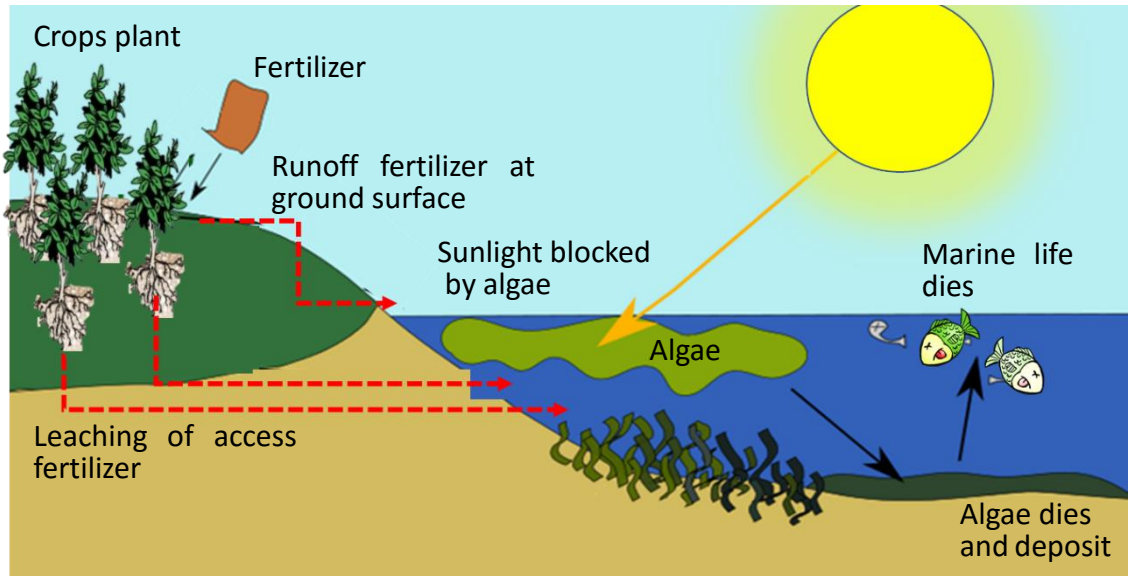


Figure 4.1 : Schematic diagram on how eutrophication occurs.

How eutrophication occurs?

- **STEP 1** - Leaching from the excessive use of fertilizers causes a nutrient build up in neighboring rivers or lakes.
- **STEP 2** - As a result of the increased nutrients plants within the lake or river grow rapidly, including algae on the surface of the water.
- **STEP 3** - The growth of algae is called an algal bloom, when this occurs it prevents sunlight from getting through the surface and down to the plant life on the riverbed, as a result they die.
- **STEP 4** - The death of this plant life results in reduced oxygen in the water, and the plant matter is broken down by decomposer bacteria which use up any remaining oxygen within the water.
- **STEP 5** - As a result of the lack of oxygen in the water any animal life - fish and other organisms - die.

OILSEED PREPARATION AND EXTRACTION

Once harvested, oilseed will be transported to mill for extraction process. Upon arriving to the extraction facilities/mills, they will undergo preparation prior to the extraction process. Oilseed will be cleaned or washed if necessary. Wash water from this process usually contain coarse biomass, particulates that can manifest in water runoff. In palm oil industry, the oilseed will be sterilized in pressurized vessel. The process is crucial to the final oil quality as well as the strip ability of fruits.

Wastewater generated at this stage mainly consist of mixture of oil from the extraction process and distillate from previous sterilization process. Crude oils, particularly soybean oil, contain significant quantities of organic phosphorus in the form of phosphatides. Trace amount of phosphorus might be found in wastewater in extraction process. Sterilization inactivates the lipases in the fruits and prevents buildup of free fatty acids (FFA). In addition, steam sterilization of the FFBs facilitates fruits being stripped from the bunches. It also softens the fruit mesocarp for digestion and release of oil, and conditions nuts to minimize kernel breakage.

CRUDE OIL REFINING

Crude oil refining process is the main contributor of wastewater in oil and fat industry. Operations of different size, and lacking some processes, will have different waste loads. Variations in refining process methods will greatly impact wastewater characteristics.

Crude oils, particularly soybean oil, contain significant quantities of organic phosphorus in the form of phosphatides. These compounds are removed to a large extent from the oil phase in the refining process. If refinery washwaters and soapstock are acidulated, the phosphorus is then carried into the water phase.

Sulfates are present from the use of sulfuric acid in the soap stock acidulation process. Concerns for sulfates are generated from their contribution to dissolved solids as well as their potential to form odor-causing compounds under anaerobic conditions.

REFINED OIL MODIFICATION

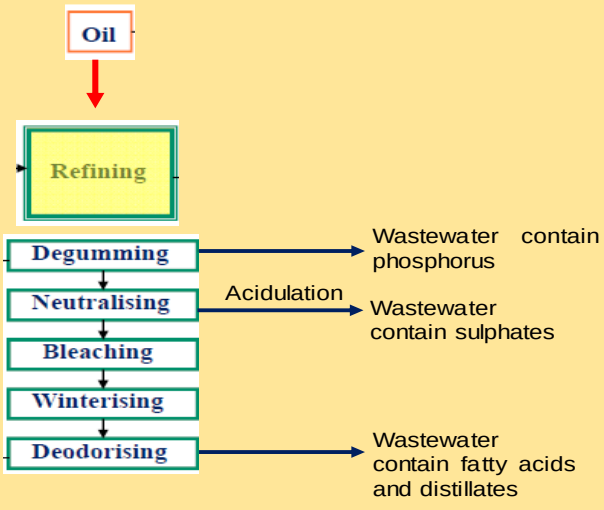
Oil modification process such as in the production of margarine and mayonnaise also contributes in wastewater generation from oil and fat industry. Nickel may enter the wastewater stream from clean up and minor losses in the hydrogenation process areas caused by nickel catalysts. Caustic cleaning of filter screens from the catalyst are a particularly significant source. Often, this problem can be controlled at the source.

TUTORIAL

Oil refining is one of main contributors in oil and fat industry. Sketch a schematic diagram of edible oil refinery processing stage together with the types of wastewater generated from each stage.

SOLUTION

1. List down the stage involved in oil and fat refinery process.
2. Evaluate each stage and potential type of wastewater produced based on each stage.



TEST YOUR CONCEPT

SECTION A

1. The followings are examples of sources of wastewater from palm oil refinery **EXCEPT**:
   A. Acidulation
   B. Particulate matter
   C. Degumming
   D. Deodorization

> Excessive fertilization and manure application to cropland, as well as high livestock stocking densities cause nutrient (mainly nitrogen and phosphorus) runoff and leaching from agricultural land.

2. The statement above is referring to
   A. Oilseed preparation and extraction
   B. Oilseed plantation
   C. Eutrophication
   D. Oil refinery

3. All statements below are correct **EXCEPT**:
   I. The main source of wastewater in the oil and fat business is the crude oil refining process.
   II. Nickel may enter the wastewater stream as a result of clean up and modest losses produced by nickel catalysts in the hydrogenation process regions.
   III. The majority of the wastewater generated in refinery processing stage is a mixture of oil from the extraction process and distillate from the preceding sterilisation phase.
   IV. Biomasses are the main contributor for solid waste generation in oil and fat industry.

   A. I
   B. II
   C. III
   D. IV

SECTION B

Figure 4.2

1. State the phenomenon as shown in Figure 4.2 above.

2. Discuss how the phenomenon causes the environmental damage to our aquatic ecosystem.

CHAPTER

05

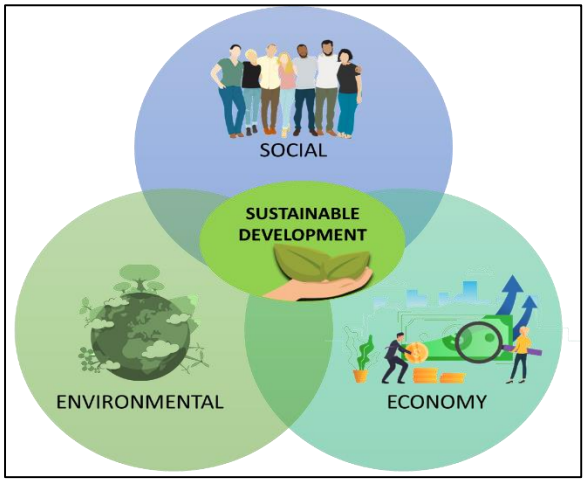
ENVIRONMENTAL IMPACTS OF OIL AND FAT INDUSTRY

LEARNING OUTCOMES

- Describe sustainable development.
- Discuss the current issues related to oil and fat industry, in particular palm oil industry

5.1 INTRODUCTION

SUSTAINABLE DEVELOPMENT



Sustainable development defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable development is a method of organizing society in order for it can exist in the long term. This includes taking into account both current and future imperatives, such as environmental or natural resource protection, as well as social and economic equality.

The oil and fat industry has always been linked to the environment because it is a land intensive industry. Any unplanned development will lead to the destruction of the forest systems, loss of habitats including plants and animals, extreme land degradation, water and airborne pollution as a result of the massive quantities of pesticides and herbicides required to maintain the plantation.

Management of the waste and other hazardous chemicals in oil and fat industry is a must for conservation of natural resources as well as for protecting the environment in order to approach sustainable development.

5.2 ENVIRONMENTAL IMPACT FROM OIL AND FAT INDUSTRY

DEFORESTATION

Deforestation occurs when a forest or stand of trees is removed from land and transferred to a non-forest use, such as conversion of forest land to farmland, ranches, or urban usage. Palm oil production has become the major cause of deforestation in the world due to high global demand for palm oil. 84% of the palm oil is produced in Indonesia and Malaysia and this industry deforests to make way for palm oil plantation which include building infrastructure such as mill, roadway and accommodation for workers (Hannah Ritchie & Max Roser, 2021).

Deforestation is driving the loss of species such as orang utan, and Asean rhinos. Besides that, it also threatening the livelihoods and cultures of millions of local people and contributing to climate change at an alarming rate.

Deforestation contributes about 4.8 billion tonnes of carbon dioxide per year or about 8- to 10% of annual human emissions of carbon dioxide (Anneka D., 2019). Trees and plants absorb CO_2 from the air and release oxygen. This is part of the photosynthesis process which trees and plants convert sunlight into energy. Forest is thus a “carbon sink,” creating a net reduction in atmospheric CO_2, as opposed to a “carbon source” such as fossil fuel combustion. Deforestation decreases the carbon sink, and the decay of the resulting dead plant matter contribute to a new carbon source. In many cases, deforestation is usually followed by burning the dead trees and plant matter, which releases most of the carbon that had been stored in them.

Figure 5.1 : Forest as carbon sink

CLIMATE CHANGE AND GLOBAL WARMING

Climate change is defined as a change in the average conditions such as temperature and rainfall in a region over a long period of time, whereas global warming is defined as the increase in mean surface temperatures on earth as a result of human activities, primarily fossil fuel burning, which increases heat-trapping greenhouse gas levels in Earth's atmosphere.

Climate change generally refers to all of the various long-term changes in climate, including sea level rise, extreme weather, and ocean acidification meanwhile global warming generally refers to the observed warming of the world due to human-caused greenhouse gas emissions.

CAUSE OF CLIMATE CHANGE AND GLOBAL WARMING

The trapping of excess carbon and other greenhouse gases in the Earth's atmosphere causes climate change. The trapped carbon pollution heats up, causing climate patterns to shift. The burning of fossil fuels like coal and oil for energy and transportation is the primary source of pollution.

The common greenhouse gases are summarized in Figure 5.2:

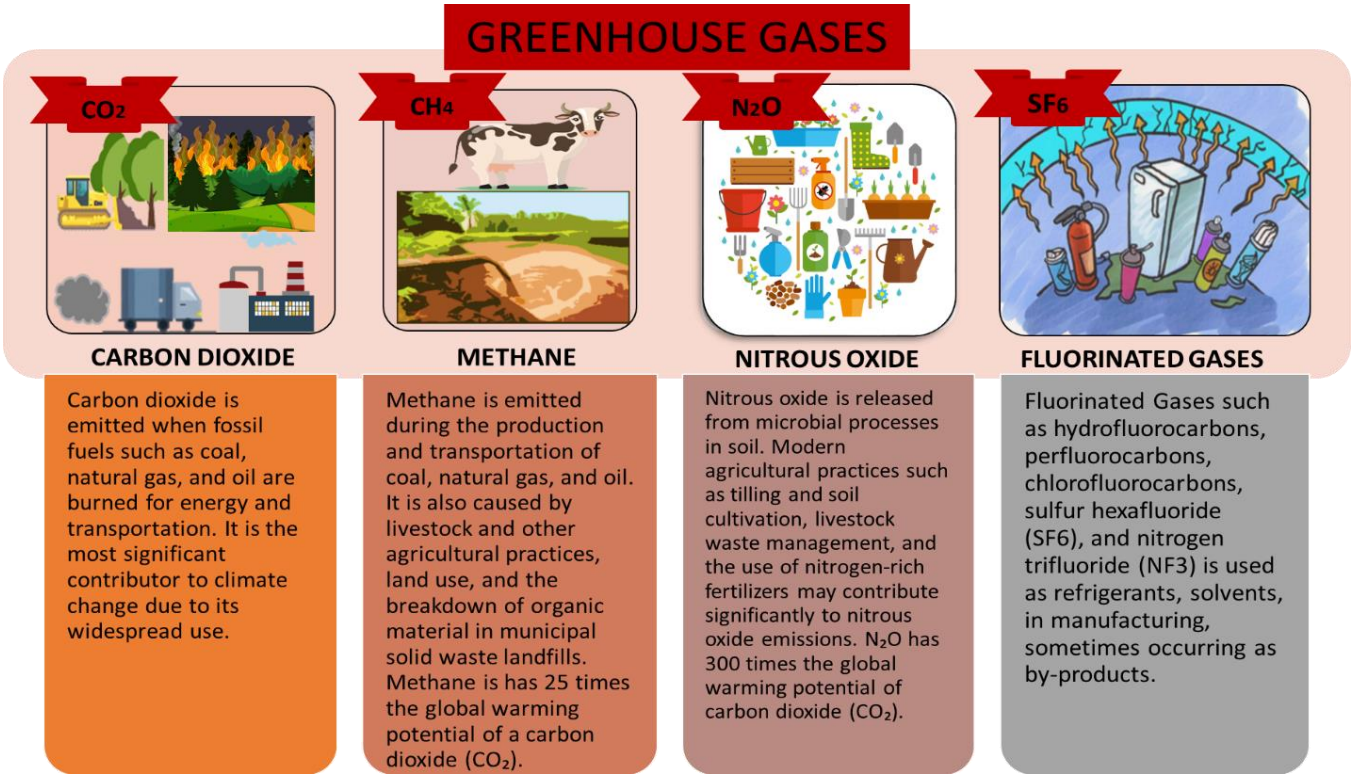


Figure 5.2 : Example of common greenhouse gases

Table 5.1 : Lifetime of Greenhouse Gases in the Atmosphere
Source: Romm, J. J. (2018)

Gas	Lifetime in the Atmosphere
Carbon dioxide (CO_2)	100 years
Methane (CH_4)	12 years
Nitrous oxide (N_2O)	114 years
Fluorinated Gases	45–1700 years

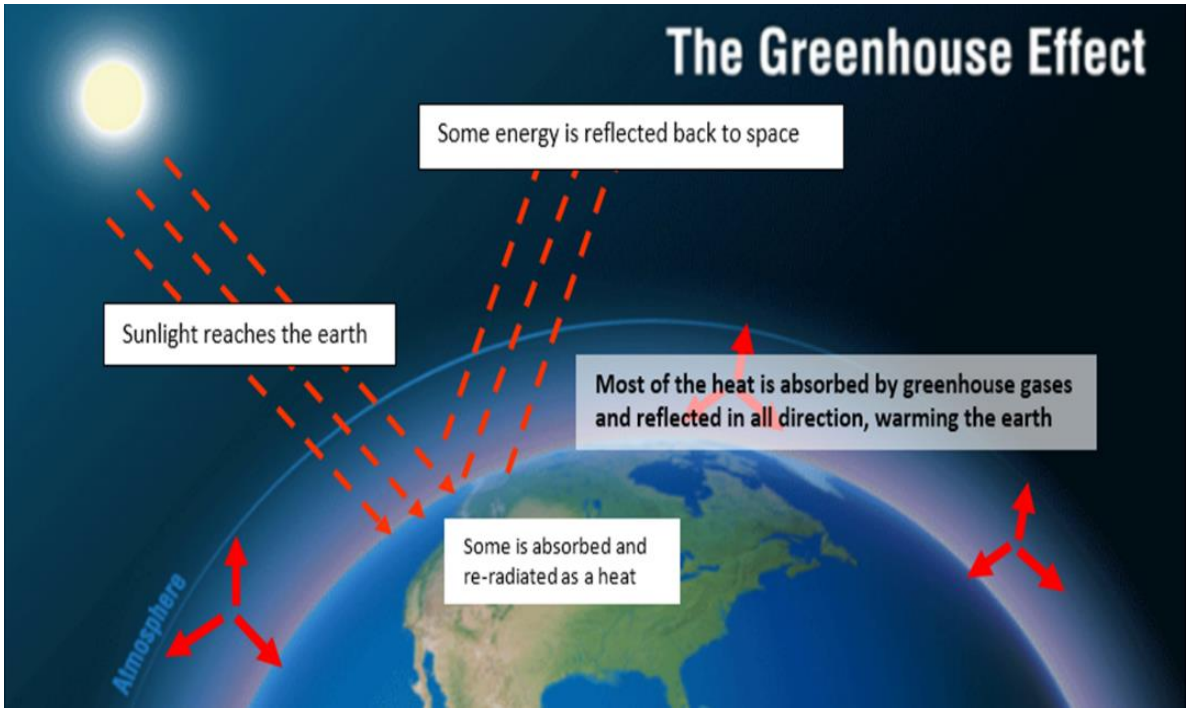


Figure 5.3 : The Greenhouse Effect

IMPACT OF CLIMATE CHANGE AND GLOBAL WARMING

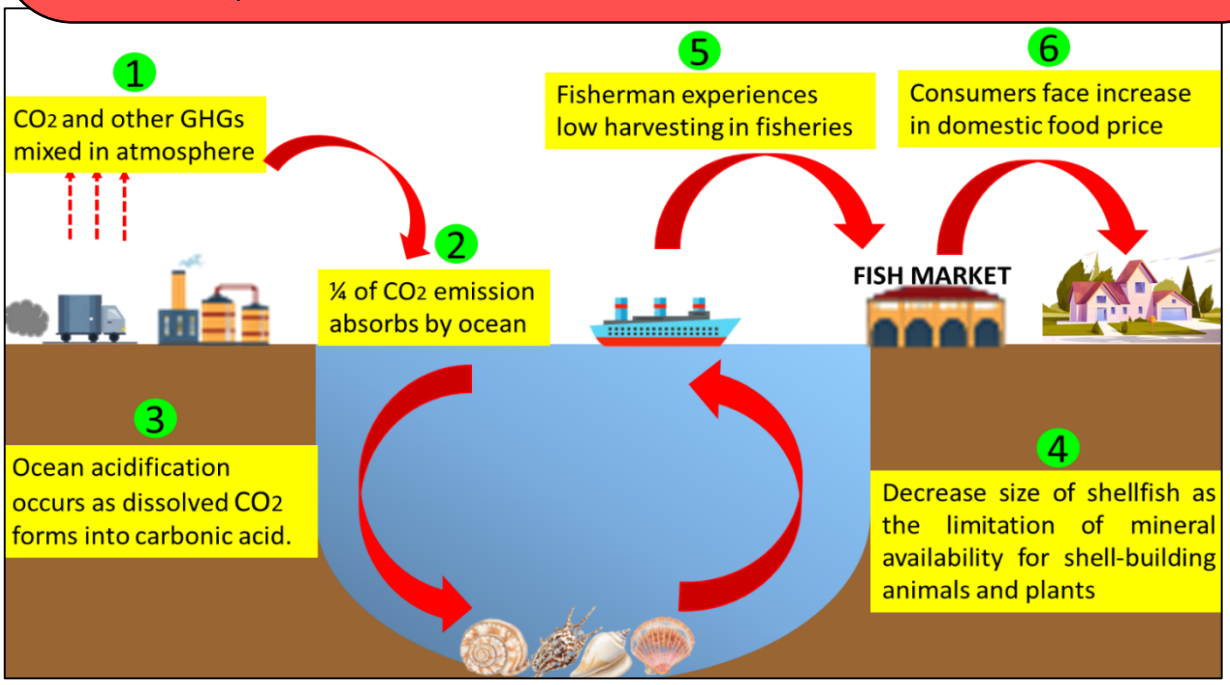
The gases trap heat in the atmosphere, causing a variety of environmental effects such as rising sea levels, extreme weather events, and drought, which makes the terrain more vulnerable to wildfires. An increase in temperature due to global warming and climate change is not only about a heat increase that can be felt by humans or glacial ice melting, it may have affected the planet's entire ecosystem.

RISE OF SEA LEVEL

- Thermal expansion - The ocean, like all water, expands as it warms up and thus takes up more space.
- Changes in groundwater storage - Groundwater is pumping out for farming and drinking. More groundwater is extracted than returns to the ground, which results of water ends up in the world's oceans.
- Glacier, Greenland and Antarctic ice loss – Melting mountain glacier cause frozen water that was trapped on land flows to the sea.

OCEAN ACIDIFICATION

One quarter of the emitted carbon dioxide into the air absorbed by the oceans. Carbonic acid is formed when carbon dioxide dissolves in seawater, acidifying the ocean. As carbon dioxide is absorbed in water, chemical reactions occur. It reduces the saturation states of biologically essential calcium carbonate minerals used by "calcifying organisms," such as corals, molluscs, and some plankton which serve as the building blocks for the skeletons and shells of many marine organisms. Ocean acidification may have impact on global food production as marine food source are likely to be reduced in area that rely on fish protein which lead to increase domestic food price.



ENDANGERED WILDLIFE

Rising temperatures are affecting weather and vegetation patterns around the world, leading animal species to migrate to new, cooler areas in order to survive. The rapid nature of climate change is expected to outpace many species' abilities to migrate in order to adapt.

REDUCTION OF AGRICULTURAL PRODUCTIVITY AND INCREASE FOOD SECURITY THREAT

Droughts, floods, and extreme temperatures are examples of climate extremes that can cause crop losses and affect agricultural producers' livelihoods as well as community food security around the world. Temperature rises may lead increase fungi, weed and pests which can contribute to food spoilage and contamination. Agricultural productivity may be harmed as a result of extreme weather events

ACID RAIN

Acid rain describes any form of precipitation which contains high levels of nitric and sulfuric acids that falls to the earth from the atmosphere in both dry and wet form. Normal rain is slightly acidic, with a pH of 5.6, while acid rain generally has a pH between 4.2 and 4.4. It can occur in the form of snow, dew, frost and fog, known as wet deposition. In the absence of moisture, acidic particles and gases deposit from atmosphere as dry deposition which quickly settle on the surface like water bodies, vegetation, and buildings or may react during atmospheric transit to form bigger particles that can be harmful to human health. When the accumulated acids are washed off a surface by the next rain, this acidic water flows over and through the ground, harming plants and wildlife, such as insects and fish

CAUSE OF ACID RAIN

Acid rain can be caused by both natural sources and man-made activity. Natural sources such as volcanoes and decaying of vegetation produce sulfuric acid (H_2SO_4), nitric acid (HNO_3), and hydrochloric acid (HCl) depending on the emissions associated with specific volcanoes. Man-made activity, mainly from fossil fuel combustion is used for transportation and energy generation. In some palm oil mill, natural gases or coal are used as combustion material for boiler to generate the electricity results in emissions of sulphur dioxide (SO_2) and nitrogen oxides (NOx). The burning of fossil fuels by industries releases sulfur into the air that combines with oxygen to form sulfur dioxide (SO_2). In addition, oil refining processes and transportation also contribute to the emission of SO_2 and NOx to the environment. Exhausts from the transportation cause the formation of nitrogen oxides(NOx) in the air. The SO_2 and NOx reacts with water, oxygen and other chemicals to form sulfuric acid (H_2SO_4) and nitric acid (HNO_3). These acids may dissolve in the water vapour in the air and carried by winds for miles before settling as acid rain.

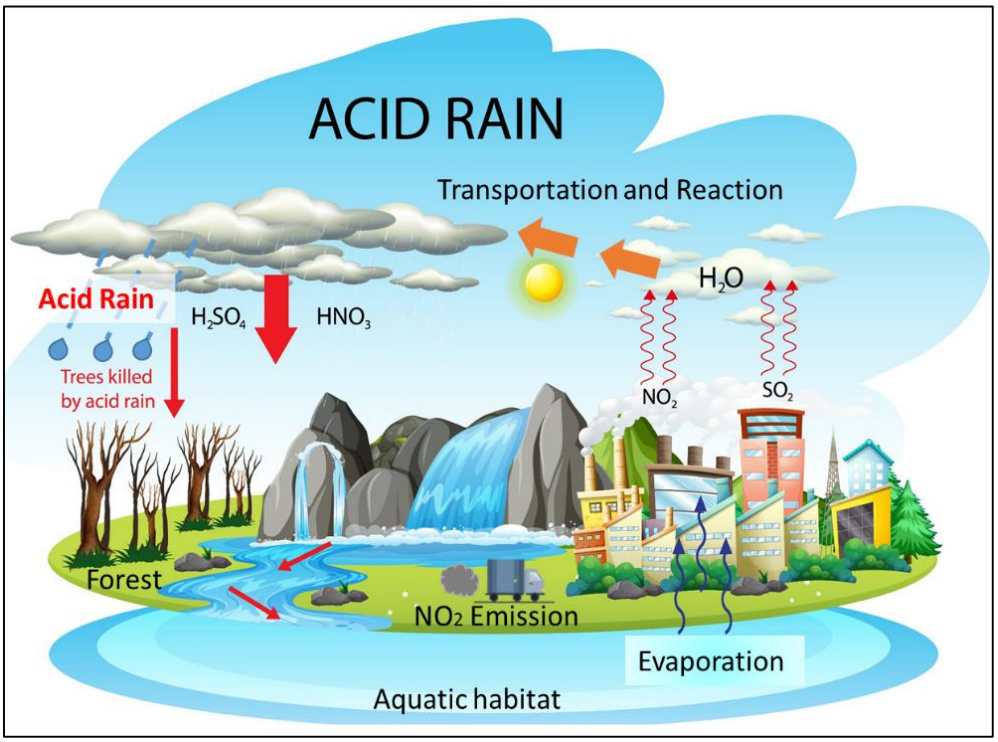


Figure 5.4 : Acid rain formation

IMPACT OF ACID RAIN

1. Acid rain has numerous ecological effects, especially for lakes, streams, wetlands, and other aquatic habitats. Acid rain causes such waters to become more acidic, resulting in increased aluminium absorption from soil, which is carried into lakes and streams. Waters become toxic to crayfish, clams, fish, and other aquatic species as a result of this combination.
2. Acid rain and fog also damage forests, especially those at higher elevations. The acid deposits deplete essential nutrients of soil like calcium and cause aluminium to be released into the soil, which makes it hard for trees to absorb water. Acids also harm the leaves and needles of trees.

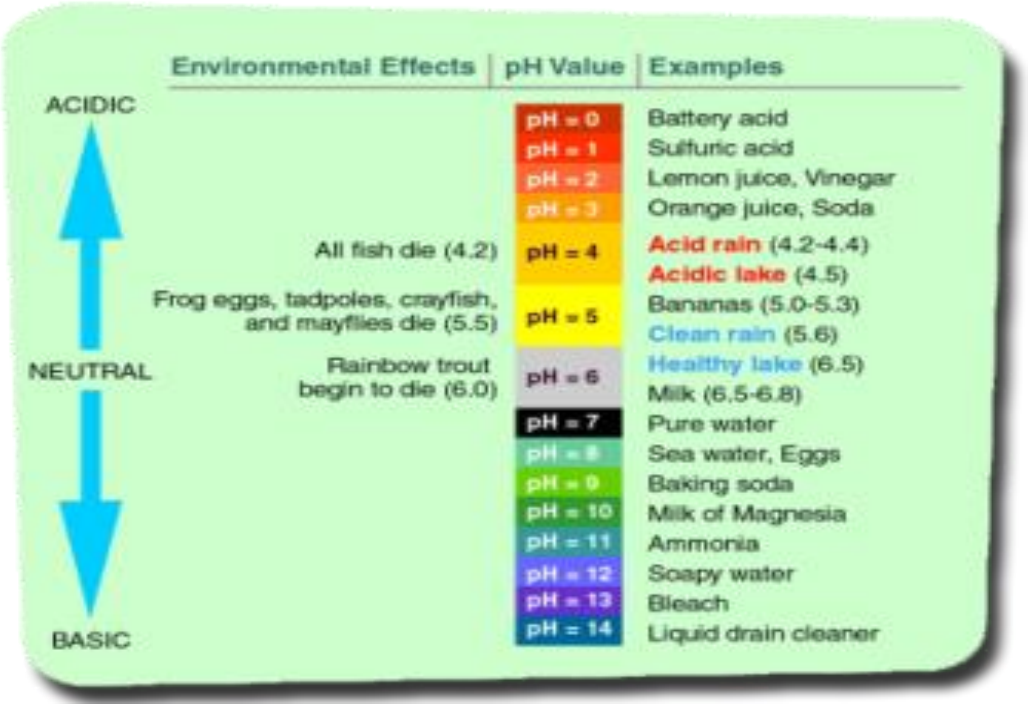


Figure 5.5 : Acid rain pH value impact to environment

Source: U.S. Environmental Protection Agency

3. Acid rain, in combination with other environmental stressors, causes trees and plants to become less healthy, making it more vulnerable to cold temperatures, insects, and disease. The pollutants may also make it difficult for trees to reproduce.
4. Acid rain, in the form inhalable fog can cause health issue including eye irritation and asthma. SO_2 and NOX react in the atmosphere to form fine sulfate and nitrate particles that people can inhale and cause breathing difficulties.
5. Acid deposits damage physical structures such as limestone buildings and cars. Calcite in marble and limestone dissolves when sulphurous, sulfuric, and nitric acids in contaminated air react with it. It resulted in roughened surfaces, material removal, and the loss of carved details in exposed portions of structures and statues.

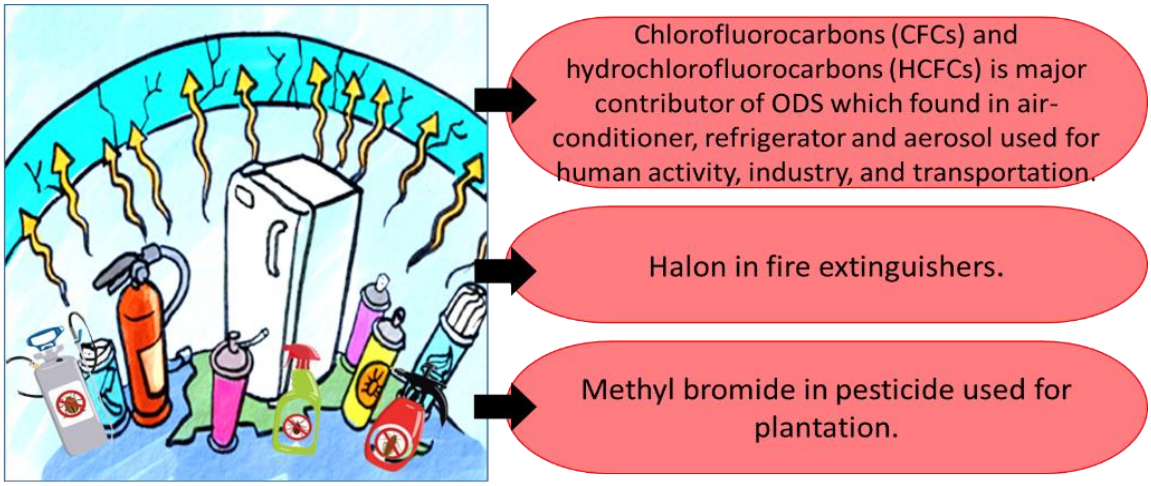
Figure5.6 : Statue eroded by acid rain

OZONE LAYER DEPLETION

Ozone (O_3) is a highly reactive gas, consist of three oxygen atoms. Atmospheric ozone absorbs ultraviolet (UV) radiation from the sun, particularly harmful UVB-type rays. The depletion of ozone is a deterioration of the ozone layer, the layer found in the lower portion of the stratosphere which located 0 to 30 km above the earth.

CAUSE OF OZONE LAYER DEPLETION.

Ozone depletion occurred due to ozone depleting substances (ODS) from human activity and industries is released to atmosphere. The main source of ODS are:



CFSs which consist of chlorine, carbon and fluorine molecules is released to atmosphere and reached the stratosphere layer. The UV rays split chlorine atom away from CFSs molecules. This chlorine atom breaks the ozone molecule, resulted in ozone layer hole and depletion. This depletion caused increases in the amount of UV radiation reaching Earth's surface.

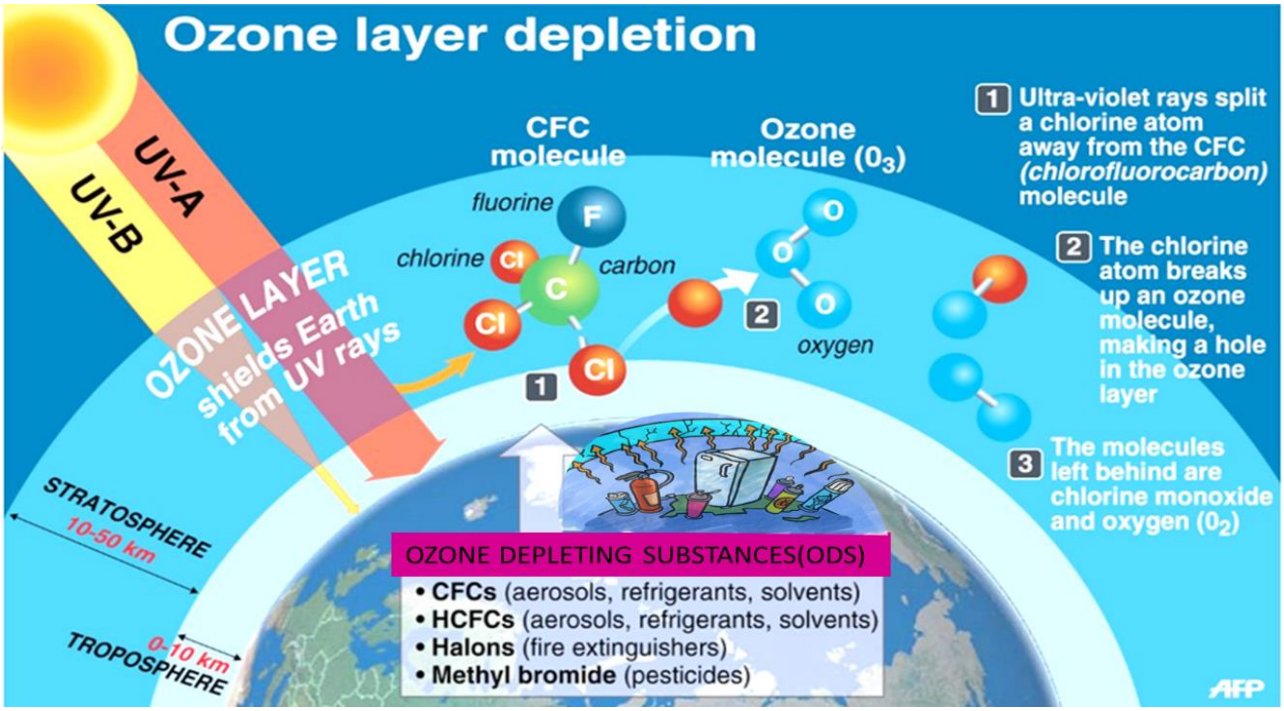
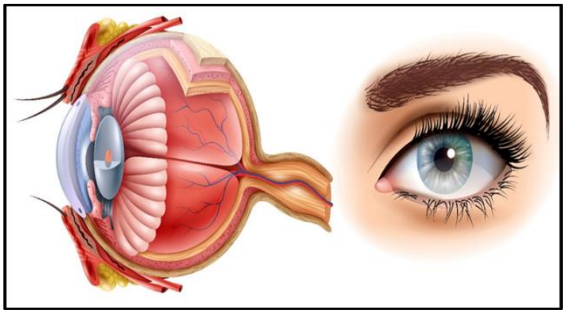


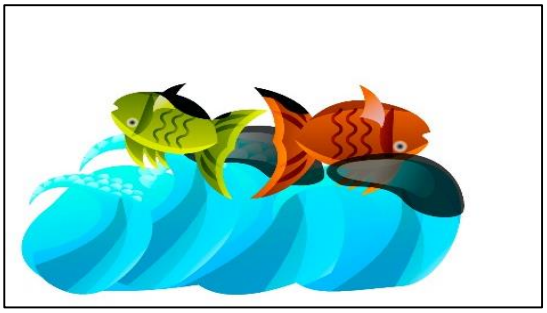
Figure 5.7 : Ozone layer depletion process

IMPACT OF OZONE LAYER DEPLETION



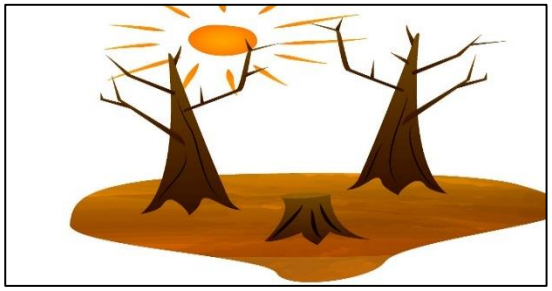
HUMAN HEALTH

High UV exposure may lead to serious effect to human health such as skin cancer, eye cataracts and weak immunity system.



MARINE ECOSYSTEM

Exposure to UV reduce the survival rate of phytoplankton which is key component of aquatic system. Implication of reduction phytoplankton may affect the whole marine ecosystem.



AGRICULTURAL

Plants may experience minimal growth, flowering, and photosynthesis as a result of high ultraviolet light.

5.3 CARBON FOOTPRINT

INTRODUCTION

A carbon footprint is defined as the amount of greenhouse gases, especially carbon dioxide emitted by something such as human activity, product manufacturing or transportation over a given time period, typically expressed in equivalent tonnes of carbon dioxide (CO_2). It can be calculated by adding greenhouse gases emissions resulting from every stage of a product manufacturing such as material production, production process, usage, until end-of-life or human activity. Careful monitoring of the CO_2 emission in each process or step might help to further decreasing of CO_2 production in every process involved in fat and oil industry thus reduce its contribution to global warming.

In crude palm oil industry, numerous greenhouse gasses (GHG) were produced in the process. The source of emissions is from the land clearing, palm oil plantation such as biomasses, chemicals, fossil fuels, and electricity, emissions from the transportation of the raw material to the palm oil milling, the fuel combustion in boilers, production processes, and palm oil mill effluent(POME) generation. 90% of GHG was released by POME, 6% by boiler and 1.3% by transportation from raw material to finished product (Hosseini, S.E. and Abdul Wahid, M. ,2013).

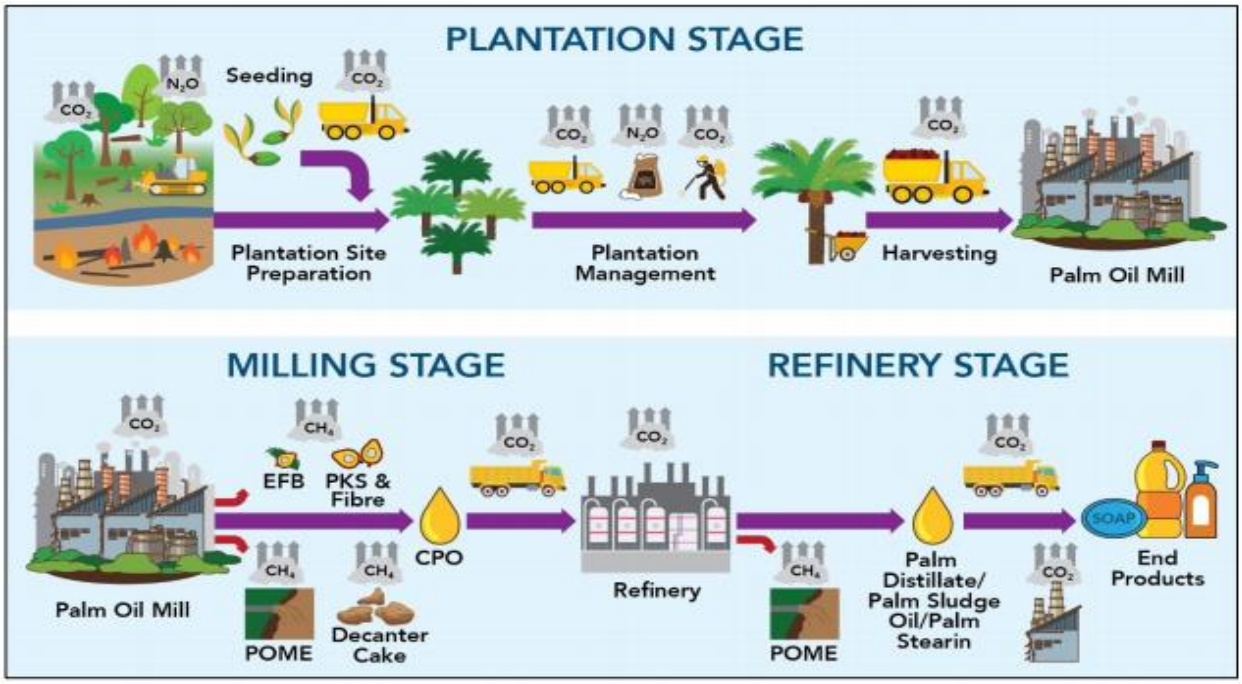


Figure 5.8 : Carbon footprint in palm oil processing industry (Walker, SM, A. McMurray, F. Rinaldy, K. Brown & D. Karsiwulan, 2018).

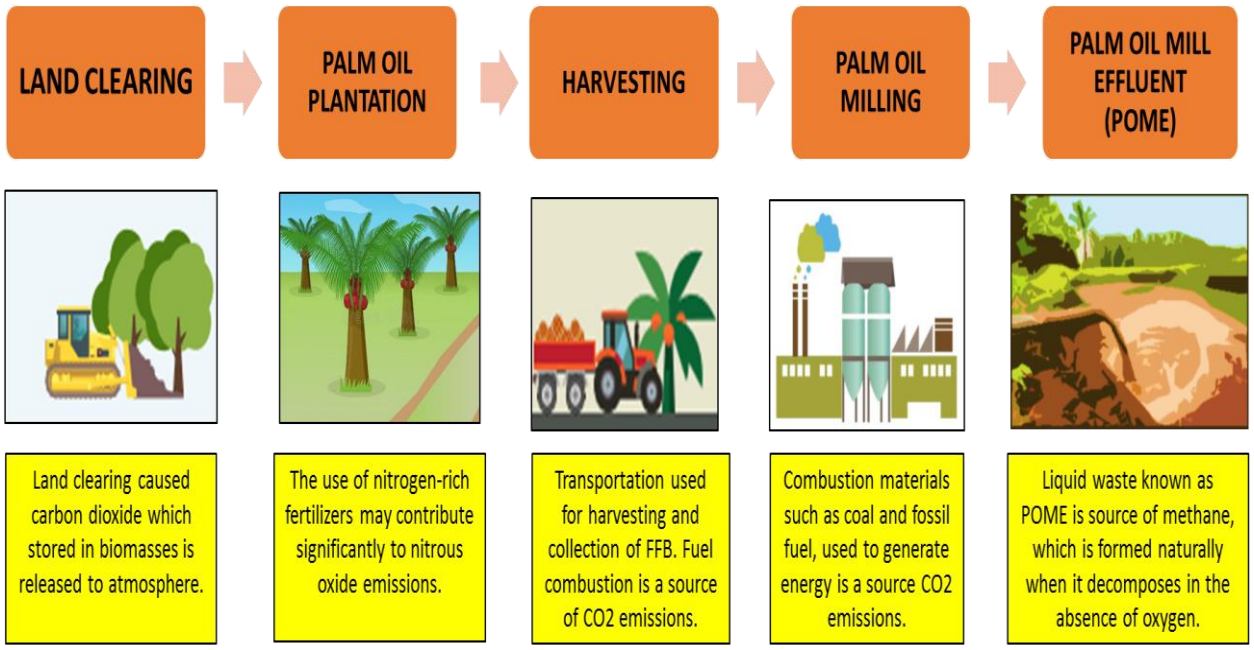
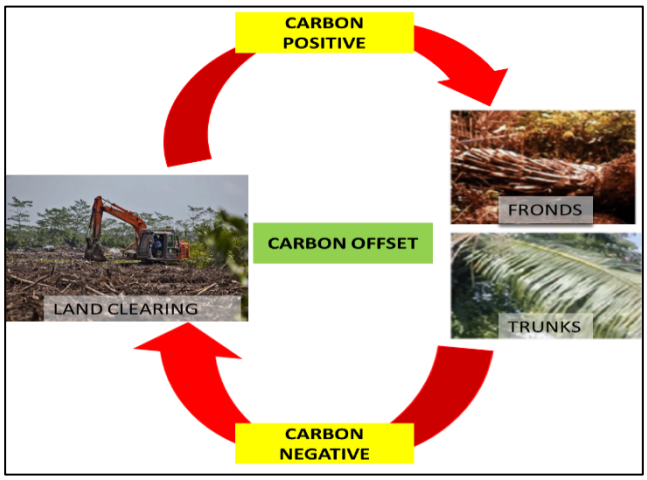


Figure 5.9 : Carbon footprint in crude palm oil processing industry.

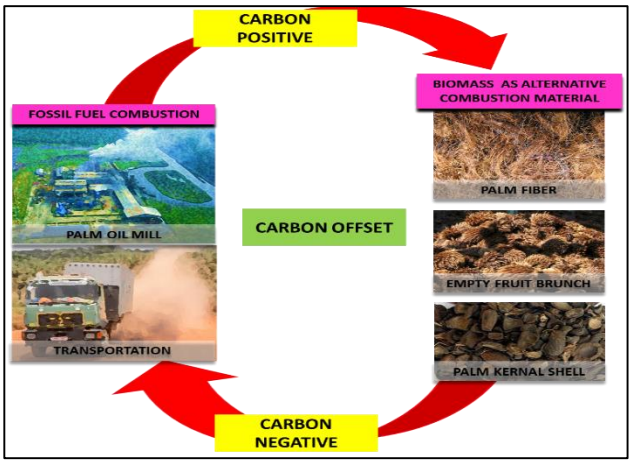
CARBON FOOTPRINT AS THE BASIS OF CARBON MANAGEMENT

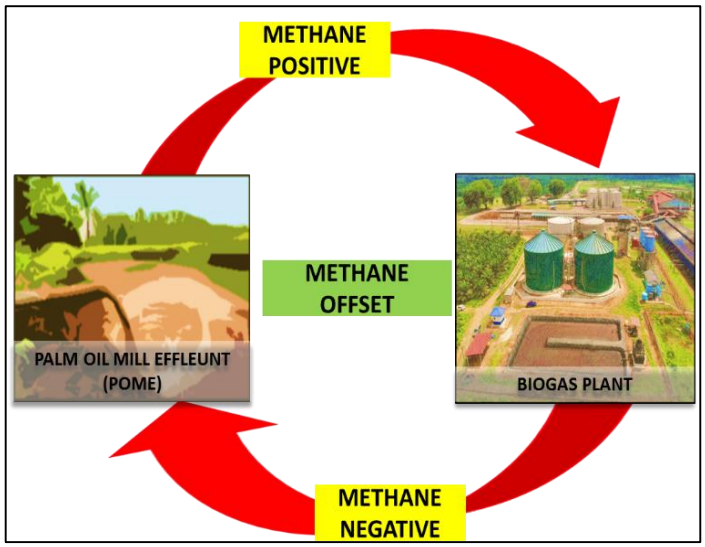
United Nation Framework for Climate Change (UNFCCC) has recognized carbon footprint as the basis for carbon management. The concept of recognising carbon management is important to address the phenomena of climate change and global warming issues that faced by the world. In crude palm oil processing industry, the carbon footprint has been recognized for carbon management whereas;



Palm oil plantation as carbon sequestration. Carbon sequestration is the process of capture atmospheric carbon dioxide (CO2). Carbon emission through land clearing has been offset by carbon sequestration of the palm biomasses which produced during land clearing. In addition, some of land in palm oil plantation is conserved instead of being used for oil palm cultivation to act as carbon sequestration.

Palm kernel shell (PKS) as an alternative combustion material. PKS is by-product from palm oil milling process. Carbon emission through combustion of coal and fossil fuels for power generation has been offset by the combustion of palm kernel shell and other biomasses like empty fruit brunch (EFB) and fibre.





Biogas plant as renewable energy source. POME, a source of methane emission is retained and captured for a period of time in biogas plant before being discharged into the stream. Methane emission through POME degradation has been offset as biogas produced. It can avoid methane release by about 82%. The biogas is used for power generation and other energy usage, preventing methane emission into the atmosphere.

TUTORIAL

Discuss ONE (1) impact of oil and fat industry to the environment

TIPS

1. Select any issue caused by oil and fat industry to the environment.
2. List down and elaborate on how the issue occurs.
3. Relate the issue with solution that have been, or could been implemented to resolve the issue.

TEST YOUR CONCEPT

SECTION A

1. Climate change is defined as
   A. a change in the average conditions in a region over a long period of time.
   B. a change in the average conditions in a region over a short period of time.
   C. increase in mean surface temperatures on earth as a result of human activities.
   D. the amount of greenhouse gases, especially carbon dioxide emitted by something.

2. Main contributor of greenhouse gases emission in crude palm oil industry is
   A. palm mill oil.
   B. land clearing.
   C. palm oi mill effluent (POME).
   D. transportation of raw material until finished product.

3. The following are greenhouse gases EXCEPT
   A. oxygen.
   B. methane.
   C. nitrous oxide.
   D. carbon dioxide.

4. 

The carbon footprint in Y can be offset by

   A. biogas plant.
   B. carbon sequestration.
   C. alternate burning material.
   D. NONE of above.

SECTION B

1. Explain how deforestation to fulfil high global demand for palm oil may give impact to environment.
2. Describe acid rain formulation by using diagram.
3. Discuss ozone depletion process and their impacts.

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PHOTO CREDITS

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ANSWERS

CHAPTER 1 : INTRODUCTION TO WASTE MANAGEMENT IN OIL AND FAT INDUSTRY

SECTION A

1. **B** 2. **C** 3. **B** 4. **D** 5. **C** 6. **B**

SECTION B

1. Arrangement by increasing priority:

Recycle ---> Reduce generation ---> Eliminate generation

Importance:

Reduce generation: to minimizing the amount of waste produced.
Recycle: maximize the recycling hazardous substances like solvents and acids before they need to be treated and disposed.
Eliminating generation: to find a way to totally remove the use of hazardous chemicals.

2. [Note: 1F + 1 E – 2 marks]

F1: Oil spills are caused by the discharge of biomass
E1-1: Examples are hulls, fibres, trunks, shells, and leaves in the plantation site
E1-2: Without retrieving any remaining oil
E1-3: Incineration of biomass wastes a renewable energy source
E1-4: Heat that could otherwise be used to heat the mill's boiler.

F2: Formation of wastewater
E2-1: When liquid waste from an extraction process is blended with waste
E2-2: from the cooling water
E2-3: and steriliser.

F3: During wastewater digestion, odour is discharged
E3-1: into the surrounding air
E3-2: lowering air quality in the lagoons.

F4: Methane gas is one of the greenhouse gases
E4-1: that can deplete the ozone layer.
E4-2: the methane produced by POME digestion in biogas is neither used or trapped
E4-3: it simply escapes into the atmosphere.

CHAPTER 2 : SOURCES OF WASTES FROM OIL AND FAT INDUSTRY : AIR EMISSIONS

SECTION A

1. **B** 2. **A** 3. **C** 4. **D**

SECTION B

1. In chemical extraction of oils, the seeds or other oil producing fruits are ground up and flattened into a round and then covered in a solvent that will extract oil from the subject. This mixture is then left to sit and the solvent will evaporate, leaving behind the extracted oils.
2. Because hexane evaporates quickly and will boil at 154.4 degrees Fahrenheit, in addition to having low toxicity levels, hexane is the preferred solvent for both methods of extraction.
3. Fabric filtration is a prominent competitor for electrostatic precipitators in terms of efficient capture of tiny particles.

CHAPTER 3 : SOURCES OF WASTES FROM OIL AND FAT INDUSTRY : SOLID WASTES

SECTION A

1. **D** 2. **D** 3. **A** 4. **A**

SECTION B

1. Mulch shields the sunlight from the soil, reduce evaporation
   Mulch shields the sunlight from the soil, reduce evaporation
   Mulch protects the soil from erosion
   Mulch breaks down in soil and function as organic fertilizer
   Mulching also used in landscaping to preserve the soil and protect the plant from extreme conditions e.g ; hot and rainy day.

2. Nickel catalyst is used in the hydrogenation of oil. Depending on the processor, catalyst may be recycled many times; therefore, waste generation rates differ. However, some refinery will generate about 100 kg of spent catalyst per day. This material has been either recycled or disposed of in sanitary landfills (or onsite). The recycling for nickel recovery has been spotty and not well organized.

3. The oil and fat industry have always been linked to the environment because it is a land intensive industry.

   Deforestation is inevitable for plantation of oilseed.

   Any unplanned development will lead to the degradation of the forest systems, loss of habitats including plants and animals, extreme land degradation and pollution to maintain the plantation.

   Most of solid wastes are biomasses produced during harvesting of oilseed such as wood, leaves, trunk.

CHAPTER 4 : SOURCES OF WASTES FROM OIL AND FAT INDUSTRY : WASTEWATER

SECTION A

1. **B** 2. **C** 3. **C**

SECTION B

1. Eutrophication

2. Step of eutrophication occur:

- STEP 1 - Leaching from the excessive use of fertilizers causes a nutrient build up in neighboring rivers or lakes.
- STEP 2 - As a result of the increased nutrients plants within the lake or river grow rapidly, including algae on the surface of the water.
- STEP 3 - The growth of algae is called an algal bloom, when this occurs it prevents sunlight from getting through the surface and down to the plant life on the riverbed, as a result they die.
- STEP 4 - The death of this plant life results in reduced oxygen in the water, and the plant matter is broken down by decomposer bacteria which use up any remaining oxygen within the water.
- STEP 5 - As a result of the lack of oxygen in the water any animal life - fish and other organisms - die.

CHAPTER 5 : CURRENT ISSUES RELATED TO OIL AND FAT INDUSTRY AND THE ENVIRONMENT

SECTION A

1. **A** 2. **C** 3. **A** 4. **A**

SECTION B

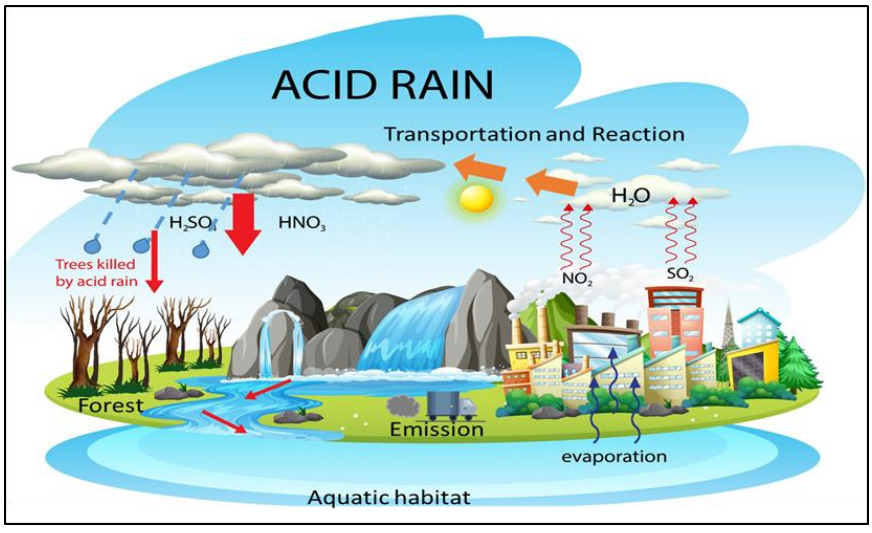
1. -Deforestation is removal of forest or stand tree which stores massive amount of carbon and act as carbon sink, creating a net reduction in atmospheric CO_2.

   -Deforestation decreases the carbon sink, and the decay of the resulting dead plant matter contribute to a new carbon source.

   - Deforestation is usually followed by burning the dead trees and plant matter, which releases most of the carbon that had been stored in them.

   - The trapping of excess carbon in the Earth's atmosphere causes climate change and global warming.

2. Acid rain formulation



-SO_2 and NOx from transportation and industry is emitted to atmosphere.

- The SO_2 and NOx reacts with water, oxygen and other chemicals to form sulfuric acid (H_2SO_4) and nitric acid (HNO_3). These acids may dissolve in the water vapour in the air and carried by winds for miles before settling as acid rain.

3. -Ozone depletion occurred due to ozone depleting substances (ODS) from human activity and industries is released to atmosphere.

   -CFSs which consist of chlorine, carbon and fluorine molecules is released to atmosphere and reached the stratosphere layer.

   -The UV rays split chlorine atom away from CFSs molecules.

   This chlorine atom breaks the ozone molecule, resulted in ozone layer hole and depletion which caused increases in the amount of UV radiation reaching Earth's surface.

   -Impact: human health such as skin cancer and eye cataracts. Effect marine ecosystem as the survival rate of phytoplankton which is key component of aquatic system is reduced. Effect to plant as may experience minimal growth, flowering, and photosynthesis as a result of high ultraviolet light.

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