WASTE DISPOSAL MANAGEMENT

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Preface

Since the beginning of recorded human history, waste has been a byproduct of human activity. If not managed appropriately, this garbage could harm the environment. Every year, the average citizen of a developed country produces about half a tonne of waste, thus waste management is an essential industry. Old waste management systems based on the collection of mixed/sorted waste and transporting it a long way to disposal sites has a significant negative impact on the environment and humans.

This book will review the available waste management systems that can be implemented in our house and community. Carrying out the 3R activities, namely reuse, reduce and recycle is a must in order to save the earth and environment from waste's impact. Promoting environmental awareness and the 3R program must starting from the elementary schools.

We thank all those who have helped in the preparation of this book. Thanks to Dr. Ari Setiawan and friends at CEL. Representing all the authors who wrote the chapters in this book, I hope that this book will be of benefit to readers.

Pekanbaru, June 6th 2023
Penyusun

Wetri Febrina

Contents

SUMMARY

Every year, the average citizen of a developed country produces about half a ton of waste, thus waste management is an essential industry. Old waste management systems based on the collection of mixed/sorted waste and transporting it a long way to disposal sites has a significant negative impact on the environment and humans.

The two most basic, and at the same time most important, types into which we can divide the waste are the biodegradable and the non-biodegradable. Sorting waste in this way can even reduce by half the amount of waste that must be taken to the recycling or incineration plants or to landfill. However, many consumers may have not the motivation to segregate waste, because they do not realize the importance of this practice. o, here academics play a role as a mover and motivator for the community in carrying out the 3R movement, namely reduce, reuse and recycle.

Waste problems and environmental problems are a shared responsibility. Awareness of environmental safety must be taught from an early age at the elementary school level.

This book explains how to handle waste from the household level before disposing it to landfills. This book also provides education to students and the public about the importance of managing waste, for the sake of environmental safety

CHAPTER I
MUNICIPAL WASTE

Wetri Febrina

A. I.1 Introduction

Every year, the average citizen of a developed country produces about half a tonne of waste, thus waste management is an essential industry. Old waste management systems based on the collection of mixed/sorted waste and transporting it a long way to disposal sites has a significant negative impact on the environment and humans. This chapter will review the available waste management systems for households. Biological methods (such as composting or anaerobic digestion) and physicochemical methods (such as burning or pyrolysis) of waste utilization will be considered from the householder's point of view. The most important features of each system will be discussed and compared. Municipal waste management systems for domestic use could eliminate or significantly reduce the stage of waste collection and transportation. Additionally, they should not require special infrastructure and at the same time should allow garbage to be changed into safe products or energy sources with no harmful emissions. The aim of the work is to identify the best available waste disposal systems for domestic use (Jouhara et al., 2017).

Waste generation in urban settlements comes from homes households, stalls, public buildings, and home industries. Population growth in Urban residential areas raise waste management problems ranging from waste generation problems, the need for final waste processing sites, and environmental costs generated. Waste management is a systematic, comprehensive and sustainable management which includes the reduction and handling of waste. Model Currently known waste management, among others; waste collection, handling in place, collection, transportation, processing and final processing (Setiadi, 2015).

Municipal waste requires proper handling based on quantities,, types and activities. Handling on site or handling waste on the source is more economic if done before the waste reaches the landfill. Waste handling in place has a significant influence on waste handling at the landfill. Handling activities include sorting, reuse and recycling aims to reduce the amount of waste generation. Waste collection is an activity carried out from homes or sources generated waste to the temporary shelter before transfer to the final processing location (landfill).

Globally, urban waste management experiences a process of collecting and processing carried out in three ways, namely independent waste management, communal waste management, and waste management managed by local governments.

1. Self-management, where the community manages their own waste by: first, collecting organic waste and processing it into compost. Second, burning flammable waste such as dry leaves. Third, selling recyclable waste such as paper, plastic and metal.

However, this independent waste management still has weaknesses, where collecting waste at home will invite rodents which can carry the risk of contracting infectious diseases.

2. Waste processing by local government

Waste processing by local governments is usually carried out by collecting waste in a place far enough from residential areas to prevent the spread of harmful viruses and bacteria from waste.

Even though this has been done since ancient times, this action is considered to have a considerable negative effect. The average final disposal site (TPA) is around 40-44 km from settlements, where garbage trucks travel considerable distances with average fuel consumption.

Elimination of waste collection can also prevent CO_2 emissions of 4.2 to 12 kg CO_2 per tonne of waste, depending on the type of vehicle used at the various stages of waste transport and the estimated payload and average mileage. He was told by Transport for London, that the waste generated in the city travels 44 million kilometers on London roads every year, releasing around 200,000 tons of CO2 into the atmosphere. In addition, this does not include the additional road miles traveled, and the resulting CO2 emissions, through the transport of waste, especially to landfill sites outside Greater London (Jouhara et al., 2017).

The waste management system by collecting waste and disposing it to landfills is actually outdated, but until now this system is still used in developing countries, even some developed countries.

Figure 2.1 Muara Fajar's Landfill, Pekanbaru, Indonesia

Figure 2.2 Lagoon System for Processing Leachate from Landfill

I.2 Technical Procedures for Operational Management of Municipal Waste

In Indonesia, urban waste processing already has standard procedures and procedures regulated in the Indonesian National Standard (SNI), namely SNI no 19-2454-2002 concerning Technical Procedures for Operational Management of Urban Waste. This standard is a review and revision of SN1 19-2454-1991 concerning Procedures for technical management of urban waste starting from container, collection, transfer, transportation, processing of waste accompanied by sorting activities with the 3R concept approach from the source, transfer to
final disposal.

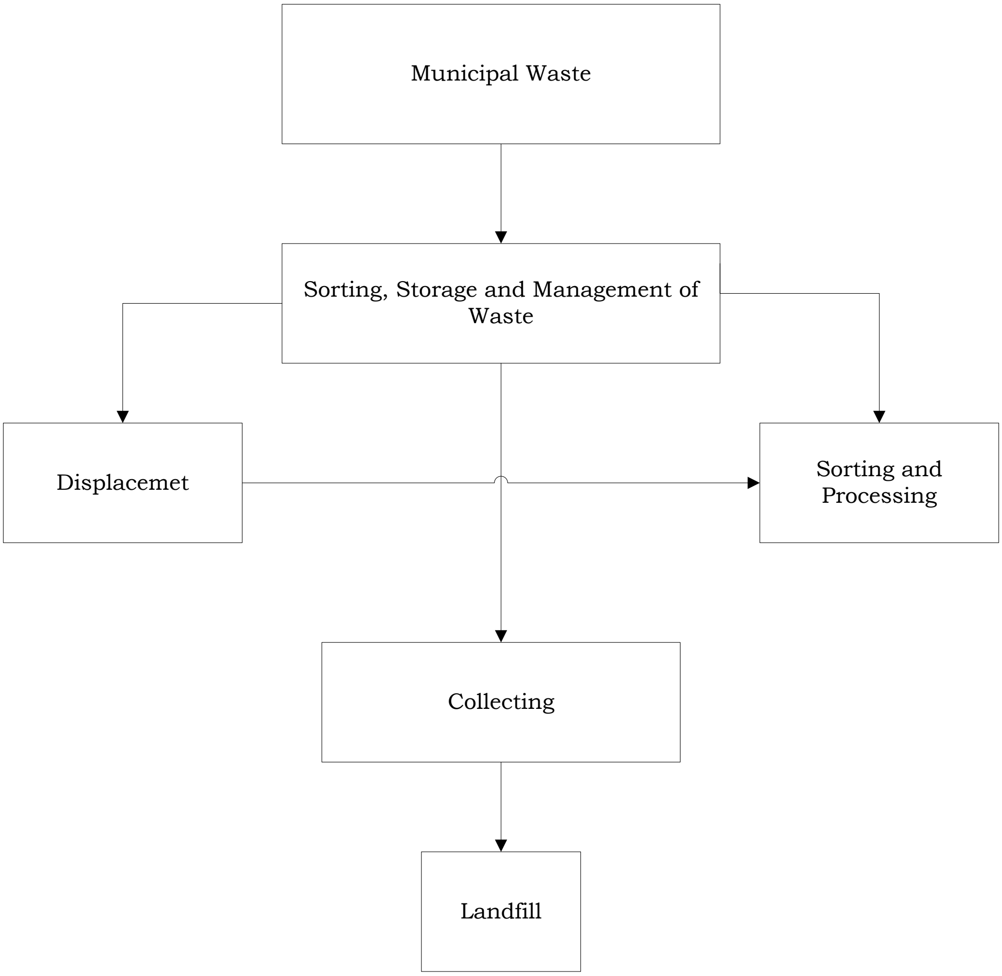

Figure 3. Operational Procedure of Waste Disposal Management
Source : (SNI 19-2454-2002 Tentang Tata Cara Teknik Operasional Pengelolaan Sampah, 2002)

Some factors that affect the municipal waste management system are:

1) population density and distribution;
2) physical environmental and social characteristics;
3) waste generation and characteristics;
4) cultural attitudes and behavior of the people;

5) the distance from the waste source to the final waste disposal site;

6) city spatial planning and development;

7) facilities for collecting, transporting, processing and final disposal of w waste;

8) available fees;

9) local regulations;

Municipal waste constitutes only around 10% of total waste generated. However, the political emphasis on municipal waste is very high because of its complex character due to its composition, its distribution among many waste generators and its link to consumption patterns ((Blumenthal, 2011).

Some of the waste treatment that is carried out at landfills today is landfill, incineration, recycling, and composting. Waste processing includes a physical transformation process in the form of component separation waste and compaction to facilitate storage and transport.

Incineration to convert waste into gaseous form so that the volume can be reduced by up to 95%. Making compost (composting) natural fertilizer from green waste and other organic materials to accelerate the process of decomposition, as well as transformation waste into heat and electricity. While the final processing of waste is the placement of waste in a certain place (open dumping and sanitary landfill) until the space capacity is no longer sufficient.

Figure 2.4 Composting Activities on Bantar Gebang's Landfill

1.3 Problem Solving

a. Reducing household waste. Reducing household waste is one way to reduce waste globally. Reducing household waste can be done by:

b. Process organic waste into fertilizer

c. Carrying out the 3R activities, namely reuse, reduce and recycle.

d. Promoting environmental awareness starting from the elementary/early years and promoting the 3R program, namely reuse, reduce and recycle.

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Biography

Wetri Febrina was born in Padang Pariaman, is a lecturer and writer. She has graduated bachelor on chemical engineering program of Universitas Sumatera Utara, and Master Program from Institut Teknologi Bandung. Right now she's still study doctoral program of Chemistry on Universitas Riau. Her email is wetri.febrina@gmail.com or wetrifebrina@sttdumai.ac.id

CHAPTER II
MEDICAL WASTE

Arif Munandar

II.1 Introduction

Waste is the rest of a business or activity. The Community Health Center is a health service organization that also produces waste, both medical and non-medical waste. Medical waste is waste produced by medical units, for example medical examination rooms, treatments, laboratories and others. This medical waste contains pathogenic germs, viruses, toxic chemicals, and radioactive substances which are harmful and cause health problems. Medical waste can be sharp objects, such as needles or infusion kits. There is also infectious waste related to infectious diseases and related laboratory waste microbiological examination. Body tissue waste includes organs, limbs, blood, and body fluids that are produced during use. This waste is hazardous and poses a high risk of infection. The waste generated by the health center is usually an infectious waste sharp, where waste from health care facilities such as health centers can be included in the category of Hazardous and Toxic Materials (B3) waste. Puskesmas medical waste can include needles, spet, sarongs hands, masks, etc. In 1999 WHO reported that in France there had been 8 cases of health workers contracting HIV through wounds, 2 of which happened to workers who handled medical waste. In Indonesia, in one report it is known that every month the use of syringes for treatment reaches 10 million services. In fact, apart from being used for treatment, syringes are also used in healthy diet programs for infants and children, which annually reach 4.9 million children and each child requires 8 losses. Thus the amount of sharp medical waste in Indonesia is very high (Affila, A., & Afnila, A. (2021). Waste generated from health service activities needs to be managed properly, especially medical waste which is infectious in nature because it can interfere with the health workers who handle it, puskesmas employees, visitors or pollute the surrounding environment. Most of the management of infectious medical waste originating from health care facilities such as puskesmas is still far below health standards

Figure 2.1 Medical Waste

The environment because it is immediately disposed of in a TPA using an open dumping system (Mihai, F. C. 2020). Inappropriate management of medical waste can reduce the degree of public health because it causes disease transmission and work accidents, both from patient to patient and from and to the public visiting the community Health centers. The diversity of medical waste demands a good management design. This is absolutely necessary to maintain public health. In carrying out good medical waste management, existing medical waste data is needed. For this reason, this study aims to measure the existing medical waste generated by the community Health centers so that a good medical waste management design can be determined Public health center. Medical waste management is carried out by various ways. The management What takes priority is sterilization, namely in the form of reduction (reduction) in volume, reuse with prior sterilization, recycling (recycle), and processing (treatment) (Slamet Riyadi, 2000). Better management of medical waste starting at the collection stage, sorting, transport and disposal end. Medical waste generated by This community Health centersincludes sharps waste, infectious waste, and body tissue waste. At the collection stage, garbage medical collected from each room health centers that produce medical waste by officers from each unit. The place the workforce must meet 39 namely the requirements of strong materials, have a lid and easy to open, covered in a plastic bag with certain symbols and colors, transported if it has been filled 2/3 etc. Collection there are not enough trash bins at the health center meet such requirements not all covered in a plastic bag and not closed.

The health center has done segregation of sources between medical waste and non-medical in each room. Sorting is mandatory for makes it easier to recognize the various types medical waste to be disposed of. The use of bags that are labeled as well color difference would be very helpful in the medical waste management process next. Trash dump medically inadequate. Garbage storage should be provided in each unit with the shape, size, the amount adjusted for the type and amount of waste and local conditions. There are several conditions for the place waste storage, among others, no become a source of odor and breeding ground vector, airtight, always closed otherwise being filled, easy to clean and easy affordable transport vehicles, easy emptied and cleaned. In the process of transport and collection, medical waste garbage transported by officers with using Personal Protective Equipment (PPE) such as masks, gloves, clothes protectors and shoes so it doesn't become source of disease transmission work accident. But here PPE is not used by collectors. Garbage hauling should be using a covered trolley that meets conditions to prevent disease transmission through medical waste. These terms include others will not become a nest of insects, easy to clean and dry, trash does not stick to the conveyance, garbage easy to load, cool and reload (MOH RI, 2004). Garbage transport this medical center is still not use a suitable trolley condition. The final stage of waste management medical is annihilation. the burners able to burn medical waste with temperatures up to 1200 °C are not owned by this puskesmas (Adisasmito, 2007). Therefore That's medical waste from the health center periodically transported to the General Hospital Local Regional Hospital (RSUD) for the next destroyed by incinerator. Transportation of medical waste use the means of transportation provided by the local hospital.

II.2 Medical Waste

Medical waste is one of the biggest challenges faced by provision of health services, hospitals, health centers and clinics. Waste Medical waste is waste originating from medical services, dental care, pharmaceuticals, research, treatment, care or education that uses materials that are toxic, infectious, dangerous or dangerous unless done certain safeguards, then from this there must be special handling or management of medical waste generated from service facilities health (Akmal, 2017). Health services are an important part of health, health services in the form of private medical practice (general and specialists), midwives and other health clinics, in every process that carried out will result in materials or waste from the organizers health service provided, in this case health services in the form of practice of private doctors, midwives and clinics as service providers health actually the loss is quite a lot of waste or very waste dangerous and can threaten public health and the balance environment (Olastri et al., 2018). The amount of medical waste sourced from health facilities is estimated the longer it will increase, the cause is the number of hospitals,health centers, clinics and medical laboratories that continue to grow. On Profile Indonesia Health in 2019 regarding health service facilities reach thousands. From the data released by the Ministry of Health, a total of 2 there are 2852 hospitals, 9909 health centers and 8841 clinics throughout Indonesia As for pratama clinics in Indonesia, there are 7641 pratama clinics and clinics pratama in West Java there are 810 pratama clinics with medical waste data reached 296.86 tons per day produced by health care facilities the largest in Indonesia (Ministry of Health, 2019). World Health Organization (WHO) World The Health Organization releases 40% of cases of death in hepatitis and HIV/AIDS patients in various countries due to poor management of home medical waste sick. therefore there is a need for special attention related to waste management especially good B3 (Hazardous and Toxic Material) waste from the facility health services Characteristics of medical waste and generated medical waste generation private practice in the city of Banjarbaru there is 39.1 kg/day of infectious waste, waste pathological 29.66 kg/day, sharps waste 2.68 kg/day, and pharmaceutical waste 3.07 kg/day (Mustika et al., 2014). The average weight of the composition of medical waste at clinic A are gloves 0.01 kg/day, masks 0.0005 kg/day, cotton 0.02 kg/day, needles/sharp objects 0.002 kg/day and teeth 0.0002 kg/day (Nandito, 2018). In research on the type and composition of medical waste used by medical doctors namely the type of infectious waste produced 0.81 kg/day, sharps 0.12 kg/day, chemicals 0.05 kg/day, pharmaceuticals 0.02 kg/day and radioactivity 0 kg/day (Rume, T., & Islam, S. M. D. U. 2020). Problems in waste management at service facilities growing number of health centers (hospitals, health centers, clinics, etc.) so that it will increase the generation of medical waste, the unavailability of facilities waste processing in several areas that meet the requirements independently or k-3 parties, difficulties in obtaining permits for wastewater treatment, costs and 3

Processing technology is quite high, assistance from the leadership/facility manager Health services have not been maximized, the emergence of related legal cases waste management in health service facilities (Rume, T., & Islam, S. M. D. U. (2020). Improper handling of medical waste is one of the problems Occupational safety and health that can have a negative impact on officers health, patients, and visitors, these problems can be injuries, infectious diseases and so on. Everyone exposed to hazardous waste from a medical facility is most likely to be a person at risk, incl who are outside the facility and have a job managing waste or risk due to carelessness in waste management. Nosocomial infection is one of the diseases caused by work in facilities health. Nosocomial infections are infections acquired in service facilities health by patients while being treated, can occur in patients, society surroundings, visitors and staff, an infection occurred after 72 hours since the patient start treating (Behera, B. C. 2021). Various types of medical waste provided by clinics can be dangerous and cause health problems for visitors and especially to officers who directly handle the medical waste as well as the community around the clinic, the waste needs good handling before being transported to a landfill or destroyed with the unit local extermination. Management of medical waste is one sanitation aspect of a clinic is an integral part of quality clinical services and will support the process of healing and prevention 4 secondary infection so what is the purpose of people coming to the clinic will be achieved.

Figure 2.2 Medical Waste Treatment

II. 3 Medical Waste Management

Medical waste is considered as a link in the chain of spread o infectious diseases, waste can be a place for diseases to accumulate and become a nest for insects and rats. Besides that, medical waste also contains various toxic chemicals and sharp objects that can cause health problems. The management of B3 waste from Health Service Facilities is meant to produce as little B3 waste as possible and even try to reduce it to zero, which is done by reducing and/or eliminating its hazardous and/or toxic properties. Waste generated from health service facilities includes solid waste, liquid waste, and gas waste, which includes waste: with infectious features; sharp object; pathological; expired chemicals, spills, or leftover packaging; radioactive; armation cytotoxic; medical equipment with high heavy metal content; and gas tanks or pressurized containers.

Procedures and Technical Requirements for Hazardous Waste Management from health care facilities:

1. Subtraction

Reduced activities can be carried out by eliminating all hazardous materials or materials that produce less waste. Some things that can be done include: improving environmental governance (good house keeping) through eliminating the use of chemical air fresheners (which only aim to eliminate odors but release hazardous and toxic materials in the form of formaldehyde, petroleum distillate, p-dichlorobenzene, etc.); replacing mercury thermometers with digital or electronic thermometers; cooperate with suppliers to reduce product packaging; substitute the use of hazardous chemicals with non-toxic materials for cleaners; and use of less hazardous cleaning methods, such as using pressurized steam disinfection instead of using chemical disinfection.

2. Sorting

Sorting will reduce the amount of waste that must be treated as hazardous waste or as medical waste because non-infectious waste has been separated; Segregation will reduce Waste as it will result in easy, safe, cost effective flow of solid Waste for recycling, composting or subsequent management; Sorting will reduce the amount of hazardous waste that is disposed of along with non-hazardous waste to the media environment. For example, mercury is not wasted with other non-B3 waste; and Segregation will facilitate the assessment of the amount and composition of the various waste streams (waste streams) enabling health care facilities to have baseline data, identify and select cost-effective waste management measures, and evaluate the effectiveness of waste disposal strategies.

Figure 2.3 Sorting

3. Storage

Effective management of hazardous waste from health care facilities must consider the main elements of waste management, namely waste reduction, segregation and appropriate assistance. Appropriate handling, treatment and disposal will reduce waste management costs and improve environmental protection and management. B3 waste must be stored in packages with clear symbols and labels. With the exception of sharps and liquid waste, B3 waste from health service facility activities is generally stored in plastic packaging, containers that have been given waste plastic, or packaging with certain standards such as leak-proof. The most appropriate way to identify waste according to its category is to sort waste according to the color of the packaging and labels and symbols. The basic principles of handling medical waste include:

a. Waste Placed in containers or bags according to the category of waste.

b. The highest volume of waste that is put into a waste container or bag is 3/4 (three-fourths) of the volume of waste, before it is safely closed and carried out further management.

c. Waste handling must be done carefully to avoid being stabbed by sharp objects, if sharps waste is not disposed of in a waste container or bag according to the waste group.

d. Compaction or placing of Waste in a Waste container or bag by hand or foot must be absolutely avoided.

e. Manual waste handling should be avoided. If this must be done, the top of the waste bag must be closed and the handler should be as far away from the body as possible.

f. The use of multiple waste containers or bags must be carried out, if the waste container or bag leaks, tears or is not completely closed

4. Freight

Waste transportation at the location of health service facilities can use a trolley or wheeled container. Waste filling equipment must meet the following specifications:

a. easy to carry out loading and unloading of Waste

b. Trolleys or containers used for scraping the waste with sharp differences

c. easy to clean.

In-situ waste transport equipment should be cleaned and disinfected daily using appropriate disinfectants such as chlorine, formaldehyde, phenolic and acid compounds. Personnel carrying out waste transportation must be equipped with clothing that meets occupational safety and health standards.

5. Management

Hazardous waste treatment is a process to reduce and/or eliminate hazardous and/or toxic properties. In practice, the processing of B3 waste from health service facilities can be treated thermally or non-thermally. Thermal processing includes using tools in the form of:

a. autoclave;
b. microwaves;
c. irradiation frequency; and/or

Non-thermal processing includes:

a. encapsulation before stockpiling;
b. inertization prior to stockpiling; and
c. chemical disinfection

For liquid waste, this can be done at the Wastewater Treatment Plant (IPAL) of a health care facility. The purpose of medical waste treatment is to change the characteristics of biological and/or chemical waste so that the potential hazard to humans is reduced or absent. Some of the terms used in medical waste treatment and indicating the level of processing include: decontamination, sterilization, disinfection, render harmless (render harmless), and kill (kill). These terms do not indicate the level of efficiency of a medical waste treatment process, so the level of efficiency of a medical waste treatment process is determined based on the level of microbial destruction in each medical waste treatment process.

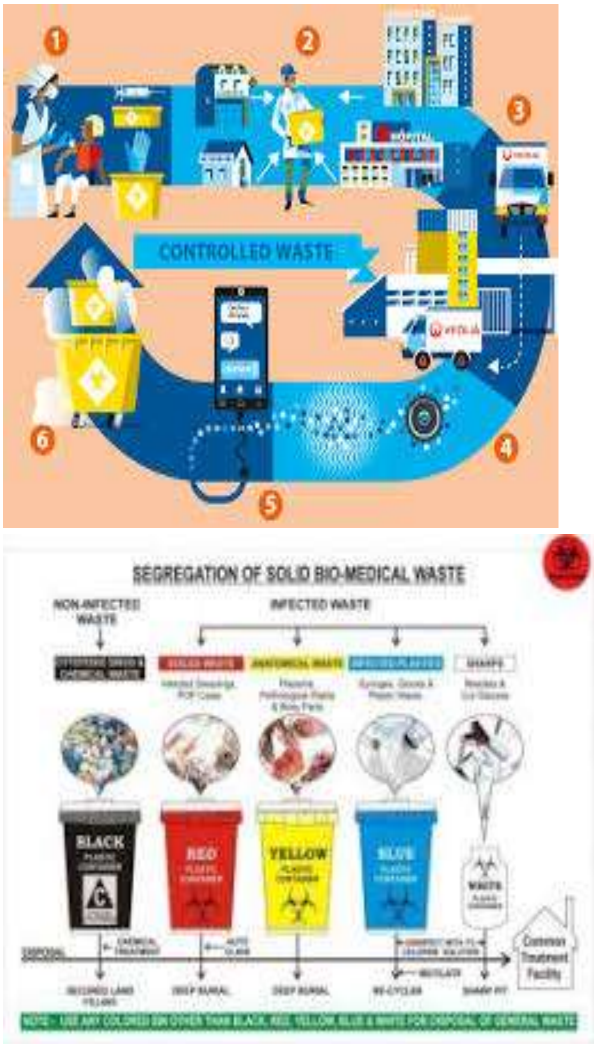

Figure 2.4 Medical Waste Management

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Biography

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CHAPTER III
AGRICULTURAL WASTE

Ade Sumiahadi

3.1 Introduction

Agriculture is one of the oldest human activities that began when humans knew civilization. Agriculture "broadly" is interpreted as agricultural activities, including plant cultivation, animal production, fisheries, forestry, and product processing. Agriculture is one of the most important sectors in the world because it produces food for the world community and supplies raw materials for several industrial sectors. In Indonesia alone, in 2021, more than 28% of people carried out agricultural activities as their main livelihood. In addition, the agricultural sector also contributes around 13% of Indonesia's GDP and is the second largest contributor to GDP after the manufacturing industry (BPS, 2022).

Apart from producing food, agricultural activities also produce large amounts of waste. Agricultural waste is the residue or by-product of the main agricultural products such as food and horticultural crops, plantation crops, and livestock manure. In general, the amount of waste generated from agricultural activities is enormous and varies depending on the type of commodity cultivated (Koopmans & Koppejan, 1997; Saleh & Hassan, 2020). For example, the production of one ton of rice produces 1-3 tons of straw, depending on the type of variety used (Bradshaw, 2016), the production of one ton of cotton produces 3-5 tons of waste (Maragkaki et al., 2015), and the production of one ton of sunflower seeds produces more than 4 tons of waste (Torma et al., 2017). Animal husbandry activities also produce no less numerous wastes and vary depending on the type of livestock produced and the area of the livestock business. For example, cows produce 1.4-5 kg of dung, while goats and sheep produce 0.3-0.6 kg daily. In total, agricultural waste in the world is estimated at 2000-5000 million tons per year (Saleh & Hassan, 2020). This amount does not include waste from the agricultural processing industry (processing industries made from the agricultural sector) (Sumiahadi & Acar, 2020), which, if added up, will reach a fantastic amount.

Managing agricultural waste is important to do well so as not to impact the environment negatively. The main problem in agricultural waste management is finding the right solution so that the waste is not immediately disposed of into the environment and, as much as possible, is reprocessed into materials that have added value and can be used for other activities. Solutions for handling agricultural waste must be appropriate, efficient, inexpensive, and economically viable so that it is easy to implement and effective in minimizing the negative impact of agricultural waste. Appropriate waste management methods not only reduce environmental problems but can also increase the added value of the waste and increase the income of farmers or the community.

The community has made various efforts to find solutions to the problem of agriculture, including:

1) Immediately use it as animal feed ingredients and fuel.
2) As a raw material for the manufacture of food products.
3) Processed simply into fuel or as a mixture of building construction materials and other products.
4) Processed into fertilizer (Obi et al., 2016; Yunita et al., 2016; Mulasari et al., 2018; Duque-Acevado et al., 2022).

These efforts are basically human efforts to utilize or process agricultural waste so that the waste can provide benefits and does not cause environmental, health, or aesthetic problems.

3.2 Types and Sources of Agricultural Waste

Agricultural (including livestock) waste is defined as residue from producing and processing raw materials for agricultural products such as fruits, vegetables, meat, poultry, dairy products, and other plant products. This waste is a by-product of the production and processing of agricultural products, which can contain useful materials but has a lower economic value than the costs of collection, transportation, and processing. Agricultural waste, which is also referred to as agro-waste, includes dairy waste (manure, urine, animal carcasses, bedding, unconsumed feed), food processing waste (fruit skins, seed coats, bran, egg shells, husks, corn husks, etc.), plants (straws, corn stalks, litters and drops, sugarcane tops and bagasse, prunings, etc.), and hazardous-toxic agricultural waste (pesticides, herbicides, insecticides, etc.) (Obi et al., 2016).

Mainly agricultural waste are organic and can be in the form of liquids, slurries, or solids from plant cultivation, livestock production, and agro-industry (Obi et al., 2016). However, solid and semi-solid waste are agricultural waste types with a greater amount and impact than liquid waste types, so they are the main focus in agricultural waste management (Saleh & Hassan, 2020). Some of the main characteristics of agricultural waste are having a fairly high organic content such as carbohydrates, proteins, lipids, and mineral salts, containing microbes, having a high water content (70-95%), can undergo rapid autoxidation and decomposition, causing a foul odor, and contains remnants of chemicals used in the production and processing of products and by-products (Madrini, 2017).

Based on the source, Al Saedi and Holm-Nielsen (2004) classify agricultural waste into two categories, namely agricultural waste originating from agricultural output and by-products from agricultural products and waste originating from input residues from agricultural activities, as explained in Figure 1. Meanwhile, Weiland (1999) classifies agricultural waste into different categories, namely waste originating from crop production (including the food industry and agro-industry) and waste from animal production (including slaughterhouses and processing of meat products), as presented in detail in Figure 2.

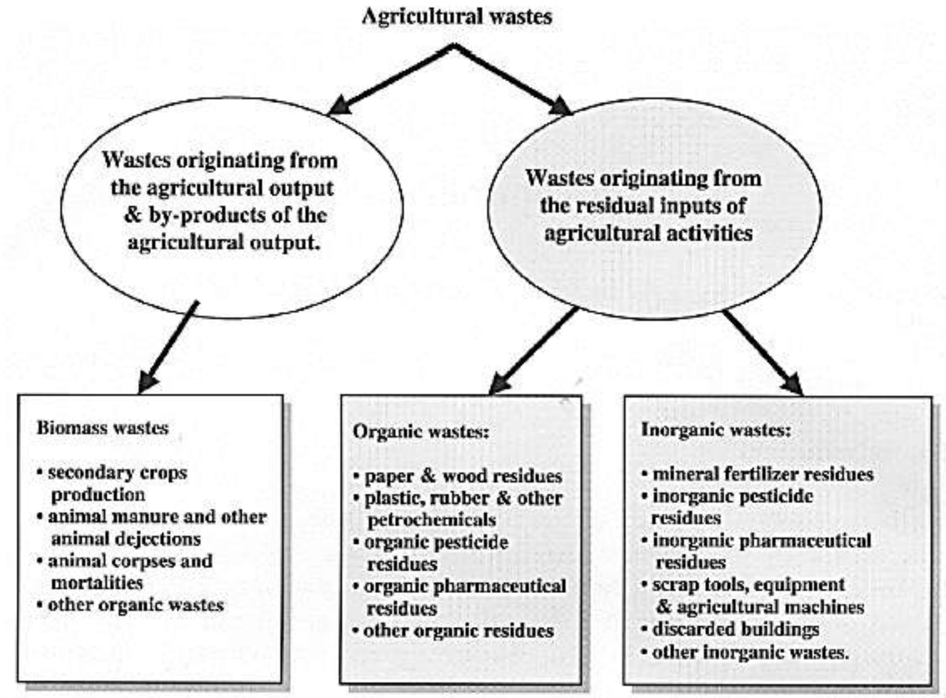

Figure 3.1. Agricultural wastes

Based on the explanation above, agricultural waste is generally grouped into two major groups, namely organic and non-organic waste. Organic agricultural waste consists of waste from the production and processing of plants and livestock production and processing, while inorganic agricultural waste is non-natural waste originating from equipment, materials, and packaging used during the production and processing of crops and livestock.

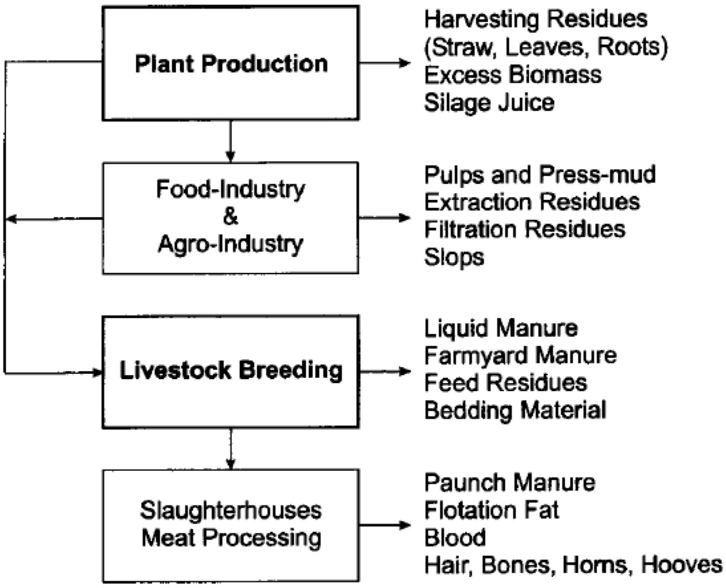

Figure 3.2. Origin of agricultural wastes

3.3 Waste from crop production and processing

In crop production and processing activities, a very large amount of waste is generated. The waste is in the form of residues and by-products from crop production and processing activities. The amount of waste generated from these activities varies depending on the type of crop being managed and the region (area and climate) of the location of the business being carried out (Obi et al., 2016). Some of the waste that falls into this category include:

a. Harvest residues

Residues from harvesting are in the form of unharvested (abandoned) plant biomass, most of which are cultivated plants leaving very large amounts of residue, and some plants even produce more residue than the harvested part of the plant. The residue is usually in the form of leaves, straws and stalks of cereals, tops of sugarcane and beets, green parts of potatoes and legumes, etc. The production of crop residues from several crops is presented in Table 1 (Drackley et al., 1985; Weiland, 1999; Tobia et al., 2008; Torma et al., 2017).

Table 1. Production of residues from several crops

Residue	Yield (t ha^{-1})	Dry matter (%)
Sugar beet leaves	40	16
Fodder beat leaves	30	10
Potato green parts	13	25
Cereal straws	3-6	86
Maize stalks	3-10	86
Rape green parts	5-14	86
Pea and bean green parts	3-6	86
Soybean green parts	3.89	25
Sunflower green parts	8.78	65

b. Crop residues from the maintenance process

This type of agricultural waste refers to solid waste resulting from the cultivation and maintenance of horticultural or plantation crops and the maintenance of landscape or garden crops. This type of waste includes litter, pruning, weeds and grass cuttings (Adejumo & Adebiyi, 2020).

d. Crop processing waste

Processing of crop products such as grains, fruits, and vegetables into food ingredients, agro-industry raw materials, energy sources, or chemicals produces various solid and liquid wastes in large quantities with varying characteristics depending on each type of plant being processed and the final product produced. Crop processing waste is generated from washing, peeling, trimming, blanching, extraction, juicing, pasteurization, and biological conversion processes (Weiland, 1999). Food processing wastes are rich in organic materials and thus are often easily degraded biologically. Generally, these wastes contain sufficient nitrogen, phosphorus, and trace elements for biological growth. The volume and strength of solid and liquid wastes from food processing depend on the type of process, the size and age of the crops, and the season (Hansen & Cheong, 2019). Table 2 shows several types of waste from crop processing activities (Weiland, 1999; Akhadiarto, 2010; Nursanti, 2013; Rosenfelder et al., 2013; Suhendro et al., 2018; Hambali & Rivai, 2017; Ojaba et al., 2021).

Table 2. Several types of crop processing waste

*COD: Chemical Oxygen Demand

Processing Activities	**Solid Waste**		**Wastewater**	
	Type	**DM (%)**	**Type**	**COD* (g l-1)**
Breweries	Spent grain	22-24	Total wastewater	1.5-3.0
Canneries	Sorting residue, fragments	18-25	Blanching water	2.0-5.0
Distillaries	Thick stillage	16-27	Stillage	20-90
Fruit juices	Sorting residue, pulps	21-23	Processing water	4.0-6.0
Wheat mills	Chaff	84-86	-	-
	Bran	83-95	-	-
	Middling	86-87	-	-
Oilseed mills	Oilseed cakes	88-94	-	-
Potato processing	Sorting residue, peels	20-25	Processing water	2.0-8.0
Potato strach production	Potato pulp	18-20	Potato fruitwater	7.0-10.0
Sugar production	Beet pulp	20-30	Washing water	5.0-9.0
Palm oil production	Sludge	24-90	Palm oil mill effluent (POME)	1.6-43.1
	Palm kernel cake	95.17	-	-
	Mesocarp fiber	92.16	-	-
	Palm kernel shell	91.51	-	
	Empty fruit bunch	91.95	-	-

3.4 Waste from Animal Production and Processing Processes

Waste from the production and processing of livestock generally comes from farms for slaughterhouses and milking houses. The types of waste generated from these activities are manure, milkhouse waste, slaughterhouse waste, and by-products from dairy food production (Yeck, 1981; Weiland, 1999).

a. Waste from livestock production

The main waste from the livestock production process is manure, a mixture of feces, urine, bedding, and unconsumed feed (Yeck, 1981), and a small portion is pure urine. Animal manure is the most important organic waste because it is produced in large quantities, both in liquid and solid manures. A farm can produce around 230 Mt of manure annually, consisting of 65% liquid manure, 30% solid manure, and 5% urine (Weiland, 1999). The manure produced from a farm will vary depending on the type of livestock produced (Barth et al., 2008). Manure production from different livestock is presented in Table 3 (Weiland, 1999).

Table 3. Production of manure from different livestock

Animal Species	**LU***	**Manure/Year (m^3 LU^{-1})**
Dairy cow	1.2	17
Beef cow	0.7	12
Calf	0.2	7
Fattened pig	0.12	13
Layer/Poultry	0.004	146

*LU (live weight unit) = 500 kg

b. Waste from milk production and processing

Milk production and processing waste are in the form of liquid waste from the washing process of milking machines, milking places and cow udders. Liquid waste produced by one cow ranges from 17-46 l per day (Weiland, 1999). This liquid waste contains milk, excrements, cleaning and disinfecting agents with a chemical oxygen demand (COD) of between 2,200-3,700 mg l^{-1} and a biological oxygen demand (BOD) of between 350-650 mg l^{-1} (Hornig & Scherping, 1993). More liquid waste is produced and highly loaded in the milk processing process. For example, in the cheese production process, the main liquid waste generated comes from whey, followed by wash water and pasteurization mater. Production of one kg of cheese can produce 4-10 kg of whey. Whey contains about 6-7% dry matter with a BOD ranging from 32,000-60,000 mg l^{-1} (Weiland, 1999).

c. Wastes of slaughtering and meat processing

The waste generated from slaughtering and meat processing in slaughterhouses is generally categorized as hazardous waste, requiring special handling and disposal methods and places. Approximately 25% of the total weight of slaughtered animals consists of residue and waste, resulting in significant waste loads. The main wastes originate from killing, hide removal, dehairing, punch handling, processing, and cleanup operations. The wastewater is high in dissolved and suspended organic matter and contains feces, urine, blood, fat, grease, bowel contents, cleaning and disinfection agents, and solid wastes. The solid waste consists of paunch manure (undigested feed from paunches of slaughtered animals), hides, bristles, hair, horns, bones, hooves, and feathers (Weiland, 1999; Hansen & Cheong, 2019). The amount and composition of the waste produced from each slaughterhouse will vary according to the livestock type produced. Table 3 presents the amount of solid and liquid wastes from pig and cattle slaughtering (Weiland, 1999).

Tabel 4. Amount of solid and liquid wastes from pig dan cattle slaughtering

Wastes	**Pig*** **(kg LU^{-1})**	**Cattle**** **(kg LU^{-1})**	**DM (%)**	**COD (g l^{-1})**	**BOD (g l^{-1})**
Solid wastes					
Bones	70-75	60-65	57	-	-
Bristles/claws	3-5	1.5-2.5	76	-	-
Stomach contents	3-12	40-80	11-15	-	-
Fat	2-4	2-3	30-70	-	-
Liquid wastes					
Blood	30-45	20-35	-	375	150-200
Fat flotate	5-35	4-25	5-24	95-400	-
Total wastewater	1,500-4,000	1,000-1,500	-	3-17	2-5

* 1 LU = 7.7 pigs
** 1 LU = ~1 cattle

3.5 Non-natural wastes

The agricultural industry widely produces various kinds of non-natural wastes. The main sources of this type of waste relate to inputs in agricultural production, such as agrochemicals, seeds, animal health products, machinery, and equipment for producing and processing other products and by-products. In general, this waste is smaller than the waste generated from the production and processing of crops and animals. However, this amount has a greater negative impact on the environment and human health, especially concerning agrochemicals, animal health products, and the visual impact of plastic waste. Figure 3 describes the sources and types of non-natural wastes (Okuniewski, 2001).

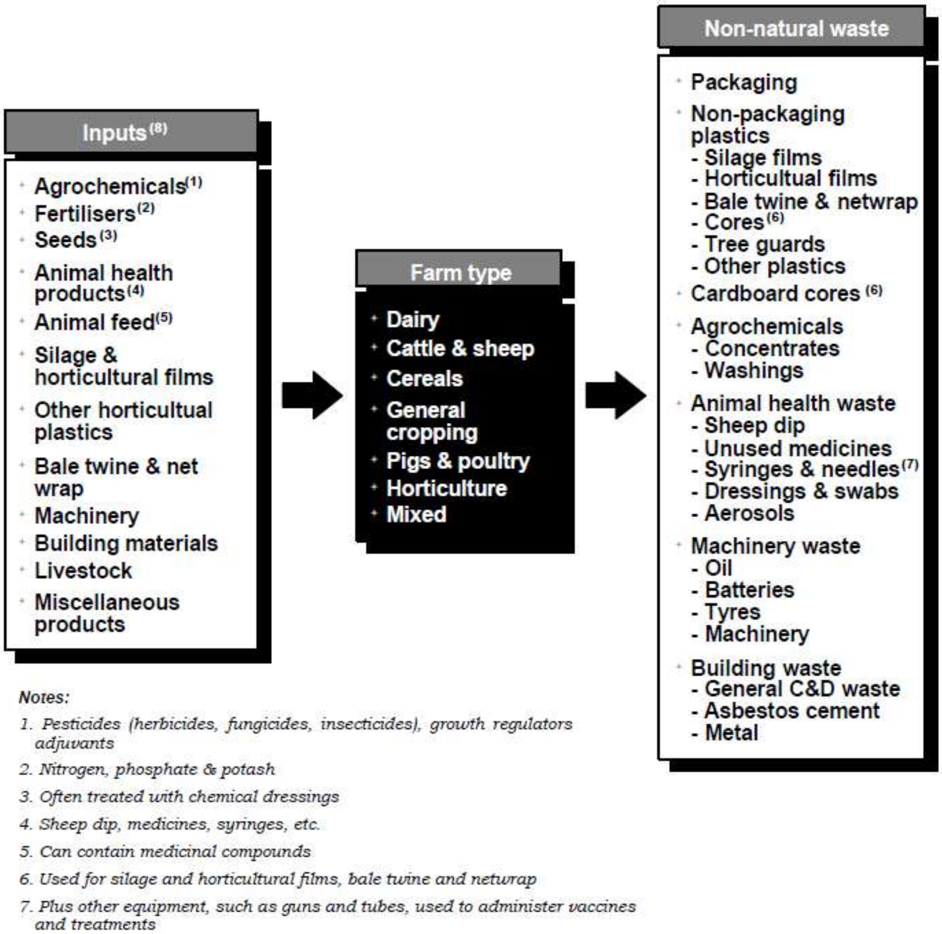

Figure 3. Sources and types of non-natural agricultural wastes

3.6 Management of Agricultural Waste

Agricultural waste management is an effort to manage agricultural waste that is carried out to reduce and reuse agricultural waste to minimize or eliminate its negative effects. Processing and utilization of waste is an alternative that can be done to increase the economic value of the waste. In the process of managing agricultural waste, a system is needed that can guarantee that the process is carried out in a directed manner and under applicable regulations and plans that have been made. According to Safley et al. (2011), agricultural waste management system (AWMS) is a planned system in which all necessary components are installed and managed to control and use by-products of agricultural production in a manner that sustains or enhances the quality of air, water, soil, plants, animals, and energy resources.

1. Function

Safley et al. (2011) also stated that an agricultural waste management system consists of six basic functions: production, collection, transfer, storage, treatment, and utilization. In certain systems, the six functions are combined, repeated, omitted, or rearranged according to needs. However, in general, the flow of the six functions is described in Figure 4.

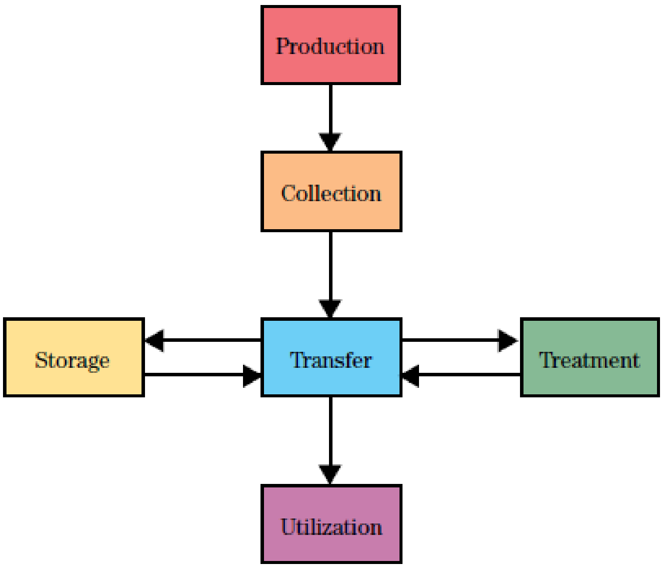

Figure 4. Waste management functions

a. Production or generation

Production is the function of the amount and nature of agricultural waste generated by an agricultural enterprise. The waste requires management if the quantity produced is sufficient to become a resource concern. A complete production analysis includes the kind, consistency, volume, location, and timing of the waste produced. Some major principles in waste production are: the waste management system may need to accommodate seasonal variations in the rate of production; the production of unnecessary waste should be kept to a minimum; a record should be kept of the data, assumptions, and calculations used to determine the kind, consistency, volume, location, and timing of the waste produced; and the production estimates should include future expansion.

b. Collection

Collection refers to the initial capture and collection of the waste from the point of origin or deposition to a collection point. The AWMS plan should identify the method of collection, location of the collection points, collection schedule, labor requirements, necessary equipment or structural facilities, management and installation costs of the components, and the impact that collection has on the consistency of the waste.

c. Transfer

Transfer refers to the movement and transportation of waste throughout the system. It includes transferring the waste from the collection point to the storage facility, treatment facility, and utilization site. The waste may be transferred several times before utilization.

d. Storage

Storage is the temporary containment of the waste. The storage facility of a waste management system is the tool that gives the manager control over the scheduling and timing of the system functions. The waste management system should identify the storage period; required storage volume; type, estimated size, location, and installation cost of the storage facility; management cost of the storage process; and impact of the storage on the consistency of the waste.

e. Treatment

Treatment is any function designed to reduce the pollution potential or modify the physical characteristics of the waste, such as moisture and total solid content, to facilitate more efficient and effective handling. Manure treatment is comprised of physical, biological, and chemical unit processes. It also includes activities that are sometimes considered pretreatment, such as separating solids. The plan should include an analysis of the characteristics of the waste before treatment; a determination of the desired characteristics of the waste following treatment; selection of the type, estimated size, location, and installation cost of the treatment facility; and management cost of the treatment process.

f. Utilization

Utilization includes reusing and/or recycling of waste products. Agricultural wastes may be used as a source of energy, bedding, mulch, organic matter, or plant nutrients. Properly treated, they can be marketable. A common practice is to recycle the nutrients in the waste through land application. A complete analysis of utilization through land application includes selecting the fields; scheduling applications; designing the distribution system; selecting necessary equipment; determining application rates and volumes, the value of the recycled products, and installation and management costs associated with the utilization process.

2. Disposal treatment

The availability of waste from each activity of agriculture and animal husbandry varies significantly from activity to activity. However, in general, the availability is very abundant, so it requires good waste management to reduce the adverse effects of this waste. Most agricultural wastes have good values as soil conditioners due to their organic matter and nutritional contents. Some of these wastes and byproducts still have high economic values for use in agricultural and animal husbandry activities, such as animal feed, so some opinions say that this type of waste is not included in the waste category. In general, agricultural waste can be managed by using it directly (for example, as feed or fuel) or through prior processing (for example, into biogas, fertilizer, building raw materials, etc.). Organic waste management from agricultural and livestock activities can be divided into anaerobic and aerobic processes.

a. Anerobic process

Anaerobic treatment is widely used to treat wastewater and solid waste from agriculture and livestock activities. This process simultaneously overcomes pollution problems and can produce products that have economic value, such as biogas and compost. This anaerobic process is also capable of reducing the presence of pathogenic seeds or weed seeds, removing foul-smelling materials, increasing the fertilizing effect because the process of converting complex organic matter becomes simpler and readily absorbed by plants, and improving the handling properties of manure and other sludges (Weiland, 1999).

Anaerobic waste treatment is more widely applied because it is considered more efficient economically because it uses a cost-effective operation, does not require aeration equipment, lower excess sludge, and relatively does not require large land areas. In addition, the anaerobic waste treatment also has high energy production prospects through the utilization of the main product of the process, namely methane (Arvanitoyannis & Giakoundis, 2014). Anaerobic waste treatment involves a microbiological process with three stages that occur simultaneously or separately, which consist of:

1) Hydrolysis and fermentation of polymer compounds and complex organic compounds,

2) Production of organic acids, especially acetic acid, from smaller dissolved organic molecules,

3) Formation of methane and carbon dioxide (biogas).

At least three groups of microbes are involved in each process, capable of converting solid and dissolved compounds from agricultural waste, such as carbohydrates, lipids, and proteins, into biogas. The process can run well in the presence of sufficient amounts of microorganisms, a balanced C:N ratio, and some trace elements such as Fe, Ni, Co, and Mn. In addition, the type of waste can also affect the success and efficiency of the process. Wastewater and slurries are treated in one- or two-stage processes using digesters with or without biomass accumulation. In the two-stage mode of operation, hydrolysis and acidification occur in the first stage and methanation in the second stage. In contrast, in the one-stage operation, all process steps simultaneously occur in the same reactor. Solid wastes are treated in wet or dry fermentation processes, which differ in the solids content of the influent digester. Another type of process, co-fermentation, treats a mixture of liquid manure and solid wastes, making waste management more economical and efficient (Weiland, 1999). Some of the different anaerobic processes of agricultural wastes are shown in Figure 5.

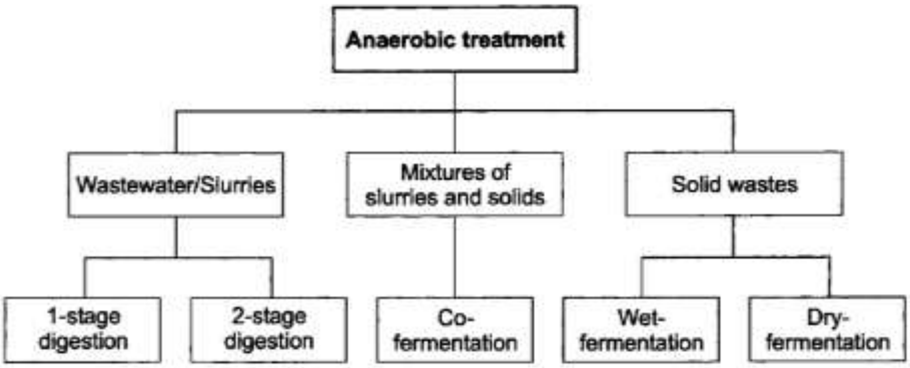

Figure 5. Classification of anaerobic treatment processes

Anaerobic treatment processes are operated under mesophilic (30-38°C) or thermophilic (55-65°C) conditions. Under thermophilic conditions, the degradation will occur faster, allowing smaller reactor sizes due to shorter necessary residence times and sometimes higher biogas yields. The higher process temperature results in a complete destruction of pathogenic germs and weed seeds. Nevertheless, most anaerobic processes operate under mesophilic temperature conditions because lower quantities of heat must be supplied to maintain the process temperature. Several times better process stability has been observed under mesophilic conditions because the inhibiting effect of some components, such as ammonia, is lower under mesophilic temperature conditions (**Wellinger,** 1991).

The amount of methane generated during anaerobic digestion is a function of the biodegradable fraction of the total waste available to the anaerobic bacteria and the operating and environmental conditions of the process. The anaerobic degradability depends on the waste type and its pretreatment and handling before digestion. Soluble organic compounds, e.g., sugars or volatile fatty acids, are almost entirely biodegradable. In contrast, the degradability of solid waste from crops decreases at increasing maturity and senescence due to increased lignin and lignocellulose content.

b. Aerobic process

Aerobic biological treatment involves microbial degradation and oxidation of waste in the presence of oxygen (Kushwaha et al., 2013). Aerobic processes are generally helpful for COD and nitrogen removal as well as odor control. Aerobic processes are used relatively seldom to treat slurries and highly loaded wastewater because the aeration is problematic, a high energy input is necessary, and the process is often disturbed by the formation of foam or scum layers. Aerobic treatment processes are well established in agriculture for composting solid organic wastes in simple heaps, forced aerated windrow systems, or closed composting reactors to produce a stable humified end product that can be used as fertilizer or soil conditioner. The complex microbial population of composting processes can degrade sugars, lipids, proteins, hemicellulose, and cellulose to carbon dioxide and water. The process needs a well-balanced C:N ratio of 25:1-30:1, a **50-60% moisture content,** and a free air space of about 30%. Many agricultural wastes, such as manures and vegetable wastes, have a lower

C:N-ratio, a higher moisture content, and are hard to aerate. They must be mixed with an adsorbent solid matrix, such as straw or bulking agents, like wood chips, which can provide extra carbon and an appropriate bulk structure. The heat produced during the biological oxidation is high enough that sizeable composting mass temperatures of 60-70°C can be reached for several weeks. Most disease and parasitic organisms, including weed seeds, are killed at these temperatures within a few days, and only a few aerobic spore-forming *Bacillus* species can survive. Dependent on its nutrient content, quality, and structure, the compost can be used as a soil conditioner, fertilizer, mulch, or peat replacement (Weiland, 1999).

3. Utilization

The implementation of handling and controlling waste must be accompanied by efforts to utilize it to save operating costs, and it is even expected to have advantages in the form of added value. Agricultural product waste, as well as from agro-industry, livestock, and humans, can be used to help meet the needs for food, feed, energy, and fertilizer. Ways of disposing of less productive waste can be replaced with ways that can help increase agricultural productivity, save energy, improve the environment, and strengthen the independence of farmers.

a. Waste utilization for food

The utilization of agricultural waste for food cannot be done directly, but this waste can be used to produce several food ingredients through biotechnology processes. Various countries have developed the use of straw, sawdust, and animal dung to produce edible mushrooms (common mushrooms). Several types of common mushrooms can be grown on different agricultural waste base growing media. For example, oyster mushroom (*Pleorotus* sp.) can be grown on the medium from rice straw, wheat straw, cotton straw, tea leaves, and banana leaves; button mushroom (*Agaricus bisporus*) can grow on the medium from wheat straw; shiitake mushroom (*Lentinula edodes*) can grow on the medium from rice bran and coffee pulp; straw mushroom (*Volvariella volvacea*) can be grown on the medium from rice straws and tea leaves, and Chinese mushroom (*Ganoderma* sp.) can be grown on sawdust (Kamthan & Tiwari, 2017). Some types of mushrooms also can grow better on a medium made from a combination of some agricultural wastes; for example, *Pleurotus eryngii* can grow better on medium form combination of wheat straw, wheat bran, soybean powder, rice bran, and wood chips; *Pleurotus sajorcaju* grows better on medium form combination of soybean straw, wheat straw, and sawdust; while *Pleurotus ostreatus* and *Pleurotus cystidiosus* show better growth on the medium from a combination of corncob and sugarcane bagasse (Elahe et al., 2016).

Several types of yeast that can be consumed by humans (food grade) can be grown in drops or molasses on sugar cane, sugar beets, potato, and cassava processing wastes, rice straw, vegetable and fruit processing waste, whey, rice bran, oats bran, rice husk, and some agro-industrial wastewater (Dimova et al., 2010; Bekatorou et al., 2016). In addition, tofu processing wastewater and tapioca processing wastewater can also be processed into *nata de soya* and *nata de cassava* through a fermentation process with the help of *Acetobacter xylinum* (Yuwono & Armando, 2016).

b. Waste utilization for animal feed

The needs of the animal feed industry cannot be fulfilled optimally. This phenomenon is caused by insufficient raw materials. On the other hand, a lot of agricultural waste still has not been utilized. The nutritional value of agricultural wastes such as straw and husks can be improved through processing, either chemically, physically, or biologically. Until now, most animal feeds still use primary agricultural products, the same as food for human consumption. Using waste or by-products from agricultural activities is an alternative to fulfill the demand for animal feed without competing with human food needs.

The utilization of agricultural waste for animal feed usually comes from production, maintenance, and plant processing industries. Waste handling into fodder can be carried out using simple technology and, therefore, only requires relatively little time and capital, and the result can be a significant increase in additional value. Agricultural waste in the form of crop maintenance and harvest residues such as rice straw, wheat straw, corn straw, sugar cane tops, legume greens, corn husks and cobs, cassava peels, fruit and plantation prunings, and grass or weed cuts can be given to livestock directly without prior processing (Yuwono & Armando, 2016). Several types of plant processing wastes such as palm oil, soybean, sunflower seeds, rapeseed and cottonseed oilcakes, sugar cane and sugar beet press meals, cassava starch processing waste, rice, wheat or other cereals brans, and tofu production waste can also be fed directly to livestock (Mahro & Timm, 2007; Lamascolo et al., 2012; Yuwono & Armando, 2016).

These wastes can also be used as animal feed after processing. Processing is usually in the form of hay and silage making or fermentation. The purpose of hay and silage making is to store feed for a longer time so that it can be fed to livestock in the future when the feed supply is low. In comparison, fermentation is carried out to break down cellulose and lignin into simpler compounds so that the digestibility of waste materials can be increased for both ruminant and non-ruminant feeds. Fermentation is carried out with the help of cellulase-producing fungi such as *Pleurotus flabelatus, Marasmius* sp., *Aspergilus niger*, and *Trichoderma virideae* (Yuwono & Armando, 2016).

c. Waste utilization for energy

Agricultural waste can be processed as a source of energy. Waste has different compositions, densities, calorific values, and other properties. The calorific content of agricultural waste is the same as that of other conventional fuels. The prospect of the value of waste as an energy material is highly dependent on price, ease of availability, and the conversion process. In principle, energy in the form of gas, liquid, or solid can be produced from agricultural waste. These biofuels then have the potential to be converted into electrical energy in a biomass power plant (Haryanti et al., 2014).

Anaerobic treatment of agricultural waste will produce biogas in the form of methane. As previously explained, biogas production through the anaerobic process can be carried out in several ways depending on the type of waste used and requires several suitable conditions such as the number of microorganisms, the balance of C:N ratio, COD, several trace elements, humidity, pressure, pH, temperature, and retention time (Weiland, 1999; Devi et al., 2022). Almost all types of agricultural waste can be converted into biogas in the form of liquid waste such as and not limited to livestock urine (Anuradha & Sharma, 2019), POME (Pambudi et al., 2021; Wiharja et al., 2021), tofu liquid waste (Anoi, 2021), baverage industrial wastewater (Admasu et al., 2022), and tapioca wastewater (Yuwono & Armando, 2016); semi-solid waste such as slurry (Weiland, 1999) and sludge (Demirbas et al., 2016; Oladejo et al., 2019; Periyasamy et al., 2022); as well as solid waste such as and not limited to manure (Atandi & Rahman, 2012; Anuradha & Sharma, 2019) plant-based municipal waste (Ciaoabla et al., 2012), banana plant waste (Hidayat et al., 2012), coconut processing waste (Khaidir, 2016), fruit and vegetable waste (Romli et al., 2010; Aworanti et al., 2016; Soeprijanto et al., 2021), rice husks (Syafrudin et al., 2017; Syafrudin et al., 2018), rice straw (Romli et al., 2014), and sorghum stalk (Romli et al., 2015).

Agricultural waste containing high sugar and starch can be converted into an energy source in the form of bioethanol through a fermentation process. Nowadays, the interest in producing ethanol from cellulose is increasing. Ethanol production from cellulose can be done through a two-stage reaction. Crude cellulose (oligosaccharides or polysaccharides) is first hydrolyzed into monosaccharides through separate reactions before fermentation. The hydrolysis process can be carried out either chemically using acids or biologically with enzymatic methods and using bacteria and fungi. The monosaccharides produced from the hydrolysis process are then fermented to produce ethanol (Hansen & Cheong, 2019).

Bioenergy production from solid agricultural waste can be done by converting the waste into biobriquettes. Briquettes are charcoal in a certain shape made by certain pressing techniques and using certain adhesives as hardeners. Biobriquettes are fuel briquettes made from charcoal from agricultural biomass (plant biomass). Biobriquettes are made from agricultural waste, which has a woody structure, such as tree branches and twigs, coconut shells, sawdust, rice husks, wood charcoal, corn cobs, etc. The calorific value of biobriquettes fuel is greater than biomass without being processed into briquettes and is not significantly different from coal (Vachlepi & Suwardin, 2013).

d. Waste utilization for ferlizer or soil conditioner

Most agricultural wastes have a high organic matter that is a high potential for soil organic matter addition and soil properties improvement. These materials will increase organic matter and plant nutrient contents in soil and reduce the application of chemical fertilizers. The utilization of these residues for soil organic matter addition is also one of the solutions to overcome the problem of organic waste management and to reduce pollution and harmful impacts from chemical fertilizer residues. Agricultural waste in any form (liquid, semi-solid and solid) is not only high in organic matter but also high in nutritional values, so it has the potential to be used as organic fertilizer or soil conditioner. Organic fertilizers not only increase soil nutrients but can also improve the physical and biological properties of the soil, resulting in increased plant growth and yield. The amendment of plant residues into the soil is also an effort to recycle nutrients that plants have used. The recycling process can reduce fertilizer inputs, making it more economically and environmentally sustainable.

The application of organic wastes as fertilizer or soil conditioner can be made directly or through processing before use. Organic waste can be used directly by amending the organic matter into the soil as fertilizer or spreading it on the soil's surface as mulch. Meanwhile, organic materials can be processed through fermentation, composting, or making biochar and then applied to the soil.

The application of undecomposed plant residues into the soil is known as green manure. Legume and non-legume crops can be used for green manure, but legume crops are used. Using legume green manures has advantages, such as having a relatively high nitrogen content and generally more easily decomposed due to their low C:N ratio and higher water content (Ranjan & Sow, 2020). The use of organic mulch from plant residues is also commonly practiced as an alternative to more environmentally friendly mulching. Using organic mulch can maintain soil temperature and moisture stability, control weeds, reduce soil erosion rates, and add organic matter and nutrients to the soil when this organic mulch is weathered.

The fermentation process is usually carried out for organic water waste from agricultural activities, and the end product of this process is liquid organic fertilizer. Some liquid wastes that have the potential to be used as liquid organic fertilizers are POME (Maharani, 2017), coconut water (Sari et al., 2021), rice cleanse water (Lalla, 2018; Dewi et al., 2021), livestock urine (Herlianawati, 2019), tofu liquid waste (Marian & Tuhuteru, 2019), as well as liquid waste from other food processing industries. The nutrient content of the liquid waste varies depending on the chemical oxygen demand (COD), total dissolved solids (TDS), and other chemical properties contained in the waste.

The composting process is carried out on solid organic waste to produce compost. Almost all types of organic solid waste from agricultural activities can be composted, and the end product is compost with varying qualities. Composted organic waste has better properties than raw organic waste because organic matter has been degraded into simpler compounds that are easier to decompose in the soil, and nutrients become more readily available to plants. The composting process can be accelerated by adding decomposer agents. These decomposer agents can be bacteria, fungi, or macrofauna, such as worms and insects (larvae/maggots).

Manure also needs to be composted before application. This process results in manure stabilization, mass and moisture reduction, and the reduction of pathogen levels. Compared to raw manure and synthetic fertilizers, composted animal manures can reduce nutrient leaching when applied to agricultural fields. Manure composting is usually done by adding other waste, such as straw, sawdust, leaves, and sand. Adding these wastes into the manure composting process resulted in better manure compost chemical and physical properties than that without the addition (Michel et al., 2004).

The incorporation of undecomposed agricultural wastes, such as residues and processing by-products from certain plants, is not always beneficial for plant growth. Some plants produce allelochemical compounds that have phytotoxic properties, so using waste from these plants can inhibit the growth of crop plants (Sumiahadi & Acar, 2020). One of the plants that have been proven to produce allelochemicals, among others, is the sunflower plant, which can synthesize allelochemical compounds, mostly phenolic, including sesquiterpene lactones and flavonoids (Fernandez-Luqueno et al., 2014). Sunflower seed meal also had a phenolic content range from 2.54 to 4.61% (Bau et al., 1983). Other plants that produce allelochemicals are rapeseed or canola, producing glucosinolate compounds in almost all plant organs, including oil seed cake (Brown et al., 1991). One of the legume plants that is capable of producing allelochemicals is soybean, which produces allelochemical compounds in the form of coumarins and isoflavonoids (Huang, 2001; Iman et al., 2006). Waste originating from these plants should be used after a proper composting process. The decomposition process can degrade these toxic compounds into simpler and non-toxic compounds.

Another processing product made from agricultural waste is biochar. Biochar is a highly porous carbon-rich substance obtained after the pyrolysis of organic biomass. Biochar contains 50% of the original carbon that is highly recalcitrant in the environment; therefore, its production helps in carbon sequestration by locking the carbon in the plant biomass. Incorporating soil with biochar can increase soil pH and electrical conductivity (EC) due to the presence of ash residue that is dominated by carbonates of alkali and alkaline earth metals and some amount of silica, heavy metals, and organic and inorganic nitrogen. Biochar has a large surface area that helps increase water holding capacity, cation exchange capacity (CEC), microbial activity (act as its habitat), and reduces nutrient leaching by providing nutrient binding sites. This reduces the total fertilizer requirement of biochar-amended soil, thereby reducing environmental pollution caused by the leaching of inorganic fertilizer. It also plays a vital role in increasing crop productivity (Narzari et al., 2015).

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Biography

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CHAPTER IV
SOLID INDUSTRIAL WASTE

Satya Darmayani

4.1 Definition of Solid Waste

According to Law Number 18 of 2008 concerning Waste Management, solid waste is the residue of daily human activities and natural processes in solid form. Meanwhile, based on SNI 19-2454-1991, updated in SNI 19-2454-2002 concerning Operational Technical Procedures for Urban Waste Management, solid waste consists of organic matter, and the inorganic matter is considered useless. It must be managed not to harm the environment and protect development investment. Then based on the Environmental Term for Management, Ecolink 1996, solid waste is a material that is wasted or disposed of from sources resulting from human activities and natural processes that do not yet have economic value. Thus, solid waste is the residue/result of human activities, which are organic and inorganic, that can harm the environment, so good management and processing are needed.

The definition of solid waste is also adjusted to the source, such as the meaning of solid waste generated from organic and inorganic solid waste office activities that require good management and treatment. Office solid waste includes commercial-type solid waste. This is because office activities are one of the activities of the city centre.

5.1 Regulations on solid waste

With the increasing population of Indonesia, which can result in an increase in the volume of solid waste generation, a legal arrangement for solid waste management is needed based on the principles of responsibility, sustainability, benefits, justice, awareness, togetherness, safety, security, and economic value. The regulations underlying the management and treatment of solid waste consist of the following:

1. Law Number 18 of 2008 concerning Waste Management
2. SNI 19-2454-2002 concerning Procedures for Operational Techniques for Urban Waste Management
3. SNI 19-3694-1994 on Methods of Retrieval and Measurement. Example: Generation and Composition of Urban Waste
4. Guidelines for The Management of Office and Residential Waste within the Ministry of Public Works.

5.2 Solid Waste in General

Solid waste generation is the amount or amount of solid waste produced by humans in an area. The resulting solid waste can be distinguished by its composition and source. It is expressed by the percentage (%) of the weight or volume of the solid waste. Based on its composition, solid waste is divided into two, namely (Artiningsih, 2008):

1. Wet solid waste

Wet solid waste is a solid waste in the form of organic materials that are easily decomposed by microorganisms. The decomposition process will occur when solid waste is left wet and is at an optimum temperature of around 200-300 C. In general, wet solid waste is used as compost. Examples of wet solid waste, namely food waste, vegetables, soft fruit skins, and leaves.

2. Dry solid waste

Dry solid waste is a solid waste in the form of organic and inorganic matter. In general, dry solid waste does not decompose quickly by microorganisms, making it difficult to decay. Inorganic dry solid waste can be reused into other useful products. Examples of dry solid waste, namely paper, plastic, food or beverage wrapping containers, cans, wood, metal, and glass or glass.

Meanwhile, when viewed from the source, urban solid waste is categorized into several groups, namely (Tchobanoglous et al., 1993):

1. Residential solid waste

Residential solid waste comes from the results of household activities. This group includes residential houses occupied by a family or a group of houses located in a residential area, as well as residential units in the form of flats.

2. Commercial solid waste

Commercial solid waste comes from the results of downtown activities, such as offices, shops, restaurants, markets, hotels, motels, and workshops. In general, solid waste from this source is similar to domestic solid waste but has a different composition.

3. Institutional solid waste

Institutional solid waste comes from institutional activities, such as government centres, schools, prisons, and hospitals. Especially for hospitals, solid waste is handled and processed separately from other solid waste.

4. Construction solid waste

Construction solid waste comes from the results of construction activities, such as solid waste from construction sites, road repairs, and building repairs.

5. Public service solid waste

Public service solid waste comes from the results of public service activities, such as cleaning and sweeping roads, recreational areas, sports venues, places of worship, parking lots, parks, and city drainage channels.

6. Solid waste treatment plants

Solid waste from treatment plants comes from the results of treatment plant activities, such as clean water treatment plants, dirty water, and industrial waste that produce sludge. The characteristics of the processing plant depend on the processing process.

7. Industrial solid waste

Industrial solid waste comes from the results of the activities of factories, construction, light and heavy industry, chemical installations, and power generation centres.

8. Agricultural and livestock solid waste

Agricultural and livestock solid waste comes from the results of agricultural and livestock activities, such as planting and harvesting activities and slaughtering activities. At present, disposal of agricultural and livestock solid waste is not yet the responsibility of these solid waste producers. Thus, the disposal of animal residues becomes a problem in some areas.

Table 1. Sources and Types of Solid Waste

Sources of Solid Waste Generation	**Types of Solid Waste**
Settlement	Food waste, paper, cardboard, plastics, textiles, garden solid waste, wood, glass, cans, aluminum, other metals, and dust.
Commercial	Paper, cardboard/cardboard, plastic, wood, food waste, glass, metal, and hazardous waste.
Institutional	Paper, cardboard/cardboard, plastic, wood, food waste, glass, metal, and hazardous waste.

Construction	Wood, steel, concrete, and earth.
Public Service	Sweeping roads, parking lots, beaches, and recreational areas.
Processing Plant	Treated sludge.
Industry	Material waste, food waste, dust, construction solid waste, and hazardous waste.
Agriculture and Animal Husbandry	Agricultural and livestock solid waste, as well as hazardous waste.

(Source: Tchobanoglous et al., 1993)

5.5. Operational Engineering Aspects

A. Solid Waste in General

Based on SNI 19-2454-2002 concerning Procedures for Operational Engineering of Urban Waste Management, operational techniques for urban solid waste management consisting of storage activities up to final disposal must be integrated by sorting from the source.

Operational techniques for urban solid waste management, including (SNI 19-2454-2002):

1. Container

Container is the activity of temporarily collecting solid waste in an individual and communal Container at the source of solid waste. Seeding begins with sorting. Thus, the storage of solid waste, according to the type of disaggregated solid waste, consists of the following:

a. Organic solid waste, such as leaves, vegetable waste, soft fruit peels, and food waste, using dark-coloured containers.

b. Inorganic solid waste, such as glass, plastic, metal, and others using light-coloured containers

c. Household toxic, hazardous solid waste using red containers with a special emblem.

This pattern of housing is divided into individuals placed in the front and back yards, as well as communal placed as close as possible to sources of solid waste, not disturbing road users or other public facilities, outside traffic lanes, at the ends of small alleys, around parks, and crowd centres. Requirements for the sealing material are as follows:

Table 2. Characteristics of Solid Waste Containers

No	Characteristic	Pewadahan Pattern	
		Individual	**Communal**
1	Shape	Boxes, cylinders, containers, and barrels. Where all these containers are sealed and plastic bags	Boxes, cylinders, containers, and barrels. Where all these containers are covered
2	Characteristic	Lightweight, easy to move, and easy to empty	Lightweight, easy to move, and easy to empty
3	Kind	Metal, plastic, fiberglass, wood, bamboo, and rattan	Metal, plastic, fiberglass, wood, bamboo, and rattan
4	Procurement	Personal, agency, manager	Agencies and managers

Source: SNI 19-2454-2002, concerning Procedures for Operational Engineering of Urban Waste Management

Table 3. Examples of Containers and Their Uses

No	Container	Capacity	Service	Container	Information
1	Plastic bags	10 – 40 L	1 KK	2 – 3 days	Individual

2	Barrel	40 L	1 KK	2 – 3 years	Maximum tak time
3	Barrel	120 L	2 – 3 KK	2 – 3 years	Shop
4	Barrel	140 L	4 – 6 household	2 – 3 years	
5	Container	1,000 L	80 KK	2 – 3 years	Communal
6	Container	500 L	40 KK	2 – 3 years	Communal
7	Barrel	30 – 40 L	Pedestrians, pa	2 – 3 years	

Source: SNI 19-2454-2002, concerning Procedures for Operational Engineering of Urban Waste Management

2. The collection is a handling activity that not only collects solid waste from individual and/or communal containers but also transports it to a specific place, either by direct or indirect Transportation. The operational planning of the collection is as follows:

- Irritation between 1-4 per day
- Periodization between 1 day, two days, or a maximum of once every three days, depending on the condition of the solid waste composition, namely:

- The greater the percentage of organic solid waste, the maximum service periodization once every day
- For dry solid waste, the collection period is adjusted to a predetermined schedule; it can be done more than three days one time
- For B3 solid waste adjusted to the applicable provisions
- Have a specific and fixed service area
- Have a permanent and periodically transferred implementing officer
- The loading of work is attempted to be evenly distributed by the criteria of the amount of solid waste, mileage, and regional conditions.

Disaggregated types of solid waste of economic value can be collected by the authorities at a time that has been mutually agreed upon between the collection officer and the solid waste-producing community.

3. TransferTransferRemoval is the activity of moving collected solid waste into a means of transport to be taken to a landfill. Sorting at the transfer site can be done manually by cleaners and/or interested communities before being transferred to a solid waste transporter. The way to move can be done as follows:

a. Manual

b. Mechanical

c. Combined manually and mechanically, container filling is done manually by the collection officer, while the Transportation of containers onto the truck is carried out mechanically.

4. Transportation Transportation is the activity of carrying solid waste from the removal site or directly from the source of solid waste to the landfill. The transport process can be distinguished into:

a. Transportation of solid waste by the door-to-door individual collection system- Solid waste transport truck from the pool to the first solid waste source point to pick up solid waste

- Next, take solid waste at the next solid waste source points until the truck is full according to its capacity

- Further transported to TPST solid waste

- After emptying at TPST, the truck heads to the next solid waste source site until it is complete.

b. Solid waste collection through a transfer system at transfer depots type I and II

- Solid waste transport vehicles exit the pool directly to the transfer site at the transfer depot to transport solid waste to TPST

- From TPST, the vehicle returns to the transfer depot for pickup at the next rit. There are several types of transportation patterns, such as:

Table 4. Transport Patterns Through Transfer System

Way 1	Way 2	Way 3
- Vehicles from the pool to the first container to transport solid waste to TPST - Empty containers are returned to their original place - Go to the next container for transport to TPST - Empty containers are returned to their original place - And so on until the last route	- Vehicles from the pool to the first container to transport solid waste to TPST - From the TPST the vehicle is an empty container to the second location to unload the empty container and bring the filled container to be transported to the TPST - And so on until the last rit - At the last rit with an empty container, from TPST to the location of the first container, then the truck Back to the pool without a container	- Vehicles from the pool carrying empty containers go to the location of the container contents to replace / pick up and directly take it to TPST - Vehicles carrying empty containers from TPST to the next container - And so on until the last route

Source: SNI 19-2454-2002, concerning Procedures for Operational Engineering of Urban Waste Management

5. Processing is a process of reducing the volume/of solid waste and/or changing the form of solid waste to a useful one. Solid waste treatment techniques can be:

a. Composting

b. Environmentally sound incineration

c. Recycling

d. Reduction of the volume of solid waste by enumeration or compaction

e. Biogasification (utilization of energy from solid waste treatment)

6. Final disposal

The landfill is a place where activities are carried out to isolate solid waste so that it is safe for the environment. General and technical requirements for solid waste landfill sites in accordance with SNI 03-3241-1994 on TPST Site Selection Procedures.

2. Definition of Industrial Solid Waste

Industrial solid waste is any type of waste material or waste material that comes from the by-products of an industrial process. Industrial solid waste can be very hazardous waste for the environment and humans (Palar, 1994).

Solid waste from industry is one of the serious problems in the era of industrialization. Therefore, the regulation of environmentally friendly industrialization is an important issue (Basaran, 2013; Wilson et al., 2012). The underlying reason is that waste comes not only from the production process but also survival. Therefore, waste treatment must be carried out from an early age when the production process occurs. That is, waste treatment must be carried out from upstream to downstream because if this is not done, the threat of pollution will be fatal (Xue et al., 2013; Mohanty, 2012).

The urgency of handling and managing solid waste from the industry is that production results cause waste that is vulnerable to the environment, whether in the form of liquid, solid or other forms of waste. Therefore, education for small industry business actors related to the problem of handling and managing business waste is very important (Nasir & Fatkhurohman, 2010). The fundamental problem of waste handling and management is the lack of knowledge of business actors, especially from small industrial groups. This then becomes a justification for the low awareness of small industry business actors towards waste management and management.

Another related problem is that there is no meeting point between those who can use waste and industries that produce waste. Whereas economically, all waste can actually be processed to provide benefits so as to provide economic value and benefits, namely not only for industry players but also parties who are interested in the waste (Achilles et al., 2013). Of the various waste problems and their relevance to waste utilization, one of the issues is the handling and management of waste from small industries making tofu (Nasir & Fatkhurohman, 2010). Liquid waste generated from small tofu industries in various regions has the potential to be developed into alternative energy to meet the needs of Households and other activities (Darsono, 2007; Damayanti et al., 2004).

Handling and management of industrial waste can provide benefits and vice versa. If not managed, it causes pollution, reduces water quality and also harms the quality of life (Director General of Small and Medium Industries, 2007).

2.1. Classification of Industrial Solid Waste

According to Lestiani et al. (2010), the categories for solid waste in the industry are:

a. Non-B3 Solid Waste (Hazardous and Toxic Materials)

Non-B3 solid waste is in the form of sludge, boiler ash, heavy equipment spare parts, gloves, and so on.

b. B3 Solid Waste (Hazardous and Toxic Materials)

B3 solid waste includes radioactive materials, chemicals, oil, and so on. According to PP No. 18 of 1999, hazardous and toxic material waste, abbreviated as B3 waste, is the remainder of a business or activity that contains hazardous and toxic materials that, due to their nature and concentration and their amount, either directly or indirectly, can pollute the environment, can harm the environment, k health, survival of humans as well as other living beings. Waste that is included as

B3 waste if it has one or more of the following characteristics: explosive, flammable, reactive, toxic, infectious and corrosive.

2.2. Characteristics of Industrial Solid Waste

To be able to manage industrial solid waste well, it is necessary to know the characteristics possessed by each of these industrial solid wastes.

The characteristics of solid waste can be distinguished into three types, namely (Tchobanoglous et al., 1993):

1. Physical characteristicsPhysical characteristics are important in terms of the selection and operation of equipment and processing facilities. Included in the physical character of Industrial solid waste is:

a. Specific gravity

Specific gravity is necessary to assess the total mass and volume of waste that needs to be treated.

b. Water or moisture content

Water or moisture content is a comparison between the weight of water and the wet weight of total solid waste or the dry weight of industrial solid waste. The value of the water content is expressed in per cent. Knowing the water content or humidity can be determined the frequency of solid waste collection. In addition, the humidity of industrial solid waste is affected by the composition of solid waste, seasons, and precipitation.

c. Particle size and distribution

Determination of the size and distribution of solid waste particles is used to determine the type of solid waste treatment, mainly to separate large particles from small particles. Particle size and distribution are important considerations in material recovery efforts, especially by mechanical means and magnetic separators.

d. Field capacity

Field capacity is the total amount of moisture that can be stored in a sample that moves down by gravity.

e. Permeability

Permeability is an important physical characteristic in regulating the movement of liquids and gases in industrial solid waste disposal sites.

2. Chemical characteristicsDetermining

Chemical characteristics is necessary to evaluate alternatives to a process or recovery in solid waste. Included in the chemical characteristics of industrial solid waste are:

a. Volatile levels

The determination of the volatile content of solid waste aims to estimate how effective the reduction (reduction) of solid waste is using high-tech combustion methods.

b. Ash content

The ash content is the residue of the combustion process at high temperatures. By determining the ash content can be seen the effectiveness of the combustion process performance can be improved.

c. Energy content

The determination of the energy content of solid waste is required in the process of solid waste treatment, especially thermal processing.

3. Biological characteristics

The biological characteristic used is the number of flies in solid waste samples. The presence or number of flies is carried out by placing a fly grill tool on a pile of solid waste according to each of its classifications. The average presence of flies in the sample is seven heads. Thus, the greater the generation of solid waste and its composition, the greater the presence and number of flies.

2.3. Industrial Solid Waste Management System

After knowing the type, generation, and characteristics of industrial solid waste produced, an industrial solid waste management system is needed starting from the source to the final disposal site, to reduce the generation of industrial solid waste. The solid waste management system consists of 5 aspects that support each other and are related to each other. The five aspects are operational engineering aspects, institutional aspects, legal and regulatory aspects, financing aspects, and community participation aspects.

2.4. Industrial Solid Waste Treatment

The kinds of industrial solid waste treatment can be based on several criteria, that is, they are based on the process of occurrence, nature, type, and characteristics of such solid waste. The classification of solid waste is known as the basis for handling and utilizing solid waste.

a. Process of occurrence

The process of occurrence of dense industrial limbah is distinguished as follows:

1. Natural solid waste

Is solid waste derived from natural processes.

2. Non-natural solid waste

Solid waste comes from all human life activities.

b. Properties of Industrial Solid Waste

According to Ircham (1992) in Astidwiningsih 2006, Based on its nature, industrial solid waste can be classified into:

1. Organic solid waste.

Organic solid waste is solid waste that contains organic compounds, which are composed of carbon, hydrogen and oxygen elements. This organic solid waste is easy to decompose by microbes, for Example: leaves, wood, vegetable remains, and cardboard.

2. Inorganic solid waste.

Inorganic solid waste is solid waste that is difficult for microbes to decompose, for Example: plastic, cans, iron, glass, and metal.

c. Types of Industrial Solid Waste

Based on the type of solid waste (Ircham, 1992 in Astidwiningsih, 2006), it can be classified as follows :

1. Whether or not it can be burned

- Flammable solid waste, Examples: paper, rubber, wood, plastic.

- Solid waste is difficult to burn, for ExampleExample, scraps of iron, cans, broken glass, and metal.

2. Whether or not it can rot

- Solid waste is easy to decompose, for ExampleExample, food waste, leftover leaves, pieces of meat, fruit residue and shredded paper.
- Solid waste is difficult to decompose; examples: are plastic, cans, broken glass, rubber, and iron.

2.5. Industrial Solid Waste Management

1. Hoarding Open

There are two commonly known methods of landfilling, namely, the open dumping method and the sanitary landfill method, the open method of stockpiling. In open stockpiling fields, various disease-causing pests and germs can multiply. Methane gas produced by the decay of organic waste can spread to the surrounding air and cause a foul odour and flammability. Liquids mixed with the soil can seep into the soil and contaminate the soil and water (Ali et al., 2014).

2. Sanitary Landfill

In the sanitary landfill method, garbage is deposited in holes that are covered with clay and plastic sheets to prevent sewage from seeping into the ground. In more modern landfills, a double fire system (plastic – clay – clay) and duct pipes are usually made to collect methane liquids and gases formed from the process of decay of garbage. The gas can then be used to generate electricity (Nissim et al., 2005).

3. Incineration

Incineration is the incineration of solid waste using a device called an incinerator. The advantage of the incineration process is that the volume of waste is reduced very much (it can reach 90 %). In addition, the incineration process generates heat that can be utilized to generate electricity or for heating the room (Yuliani, M., 2016).

4. Solid and liquid composting

This method is to process organic waste such as vegetables, dry leaves, and animal waste through a decomposition process by certain microorganisms. Composting is one of the best ways to handle organic waste. Based on the form of compost, there are solid and liquid. Its manufacture can be done using microorganism cultures, namely using ready-made compost and can be obtained in the market such as EMA effective microorganism 4. EMA is a mixed culture of microorganisms that can increase the degradation of waste or organic waste (Hamoda et al., 1998).

5. Recycling

Recycling is the process of turning a used material into a new material with the aim of preventing waste that can actually become something useful, reducing the use of new raw materials, reducing energy use, reducing pollution, land damage, and greenhouse gas emissions when compared to the process of making new goods. Recycling is one of the solid waste management strategies consisting of sorting, collecting, processing, distributing and manufacturing used products/materials, and the main component in modern waste management the third part is the hierarchical process of 3R waste (Reuse, Reduce, and Recycle). Recyclable materials and their processes include (Diaz et al., 2020) :

a. Building materials used building materials that have been collected are destroyed by a shredder, sometimes together with asphalt, bricks, soil, and stone. Rougher results can be used in road coatings such as asphalt, and finer results can be used to create new building materials such as bricks.

b. Battery

The large variety and size of batteries make the process of recycling this material relatively difficult. They must be sorted first, and each type has special attention in its processing. For ExampleExample, older batteries still contain mercury and cadmium, which must be taken more seriously to prevent damage to the environment and human health. Car batteries are generally much easier and cheaper to recycle.

c. Electronic Goods

Popular electronics such as computers and mobile phones are generally not recycled because it is not yet clear what the economic benefits are calculated for. Materials that can be recycled from electronic goods, for ExampleExample, are metals contained in these electronic items (gold, iron, steel, silicon, etc.) or parts that can still be used (microchips, processors, cables, resistors, plastics, and others). However, the main purpose of the recycling process, namely environmental sustainability, can clearly be the purpose of implementing the recycling process on this material, even though the economic benefits are still unclear.

d. Metal

Iron and steel are the most recycled types of metals in the world, including one of the easiest because they can be separated from other garbage by magnets. Recycling includes metal processes in general, smelting and reprinting. The result obtained does not reduce the quality of the metal. Another example is aluminium, which is the most efficient recycled material in the world. But in general, all types of metals can be recycled without compromising the quality of the metal, making the metal an indefinitely recyclable material.

e. Other Ingredients

1. Glass: can also be recycled. The glass obtained from the bottle and so on is cleaned with contaminants and then melted together with the new glass material. It can also be used as a building and road material. There is already Glassphalt, which is a road coating material using 30% recycled glass material.

2. Paper: can also be recycled by mixing waste paper that has been made into pulp with new paper material. However, the paper will always experience a decline in quality if it continues to be recycled. This makes the paper have to be recycled by mixing it with new materials or recycling it into lower-quality materials.

3. Plastic: recyclable just as much as recycling metal. It's just that there are various types of plastic in this world. Currently, in various plastic products, there are codes regarding the types of plastics that make up the material, making it easier to recycle. A code on the package that is a 3R triangle with a number code in the middle is an example. A certain number indicates a certain type of plastic and is sometimes followed by abbreviations, for example, LDPE for Low-Density Poly Ethylene, PS for Polystyrene, and others, making the recycling process easier (Diaz et al., 2020).

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CHAPTER V
INDUSTRIAL LIQUID WASTE

Nyimas Yanqoritha

5.1 Introduction to water pollution

Liquid waste is the residue from a business and/or activity that is liquid (Hawali Abdul Matin et al., 2022; Hilkiah Igoni et al., 2008; Thiounn & Smith, 2020).

The kind and size of the industry, the production process, the recycling rate, and pre-treatment all affect how much industrial wastewater flows. The wastewater flows can vary significantly when two industries produce virtually the same product. A thorough analysis of the corresponding flows is necessary when a sizable industry contributes to the public sewage system and subsequently to the wastewater disposal plant (WWTP). Industrial wastewater has a significant impact on the design and management of WWTPs.

An industry's liquid waste or pollutants must be carefully handled to ensure they don't deviate from the government's quality standards (Hawali Abdul Matin et al., 2022; Shih et al., 2015; Ahmed et al., 2017). Waste water that will be disposed of into water bodies has the following requirements: a. obligation to treat waste; b. standards for waste water quality and amount that can be disposed of in environmental media; c. requirements for how to dispose of waste water; d. requirements to provide facilities and procedures for dealing with emergencies; e. criteria for evaluating waste water quality and disposal; f. other requirements determined by the results of an analysis of environmental impacts g. prohibition of disposal all at once in one moment or sudden release; h. prohibition to dilute wastewater and efforts to comply with the required level limits. Protection and management of water quality is regulated in government regulations (PP No. 22 of 2021), annex six Environmental Protection and Management Implementation Government Regulation of the Republic of Indonesia Number 22 of 2021. The following are the enterprises and/or activities whose wastewater quality standards are governed by Regulation of the Minister of Environment of the Republic of Indonesia Number 5 of 2014: a. metal coating and galvanizing industry; b. industry of tanning leather; c. palm oil sector; d. the rubber industry; e. industry of tapioca; f. Industry for inosine monophosphate and monosodium glutamate; g. plywood industry; h. industry of processing milk; i. beverage industry; j. Industry producing vegetable oils, soaps, and detergents; k. industry of beer; l. industry for lead-acid batteries; m. processing of fruits and/or vegetables; n. industry processing fishery products; o. industry that processes seaweed; p. industry that processes coconuts; q. industry of processing meat; r. industry that processes soybeans; s. processing industry for herbal or traditional medicines; t. Farming of cattle and pigs; u. industry for frying oil using either a wet or dry procedure; v. sugar industry; w. industry for cigarettes and/or cigars; x. the electronics sector; y. industry of processing coffee; z. sector of refined sugar; aa. petrochemical industry upstream; bb. the rayon sector; cc. ceramic industry; dd. industry for terephthalic acid; ee. polyethylene terephthalate; ff. petrochemical industry upstream; gg. fundamental oleochemical industry; hh. Industry of caustic soda and chlorine; ii. the pulp and paper sector; hh. ethanol industry; kk. industry for dry batteries; ll. paint industry; mm. industry of pharmaceuticals; nn. pesticide industry; oo. fertilizer industry; pp. textile industry; qq. hospitality; rr. facilities for health services; ss. slaughterhouse.

The following details regarding water usage and wastewater production should be at least gathered for the primary industry (Hilkiah Igoni et al., 2008):

Water consumption

- Amount consumed overall (per day or month)
- The amount used for each stage of the process.
- Recirculation within the body
- Water supplies (public supplies, wells, etc.)
- Internal water treatment system

Wastewater Production

- Overall flow
- The quantity of discharge points (with appropriate industrial processes associated with each point)
- The discharge pattern at each discharge site (continuous or intermittent;
- length and frequency).
- Disposition location (sewerage system, drains)
- Periodic mixing of home trash, wastewater, and water storms

Industrial activities that create a good or service have a variety of favorable effects on Indonesia's economic activity. Nonetheless, each production process used by the sector undoubtedly has a negative effect, with waste being a byproduct of the process. Trash, which is often referred to as a contaminant, is an integral component of all industries, big and small. The effects of the trash produced might undoubtedly disturb the balance of the environment. Types of waste originating from industry consist of organic waste and inorganic waste. Organic waste that smells like textile factory waste or paper factory waste, while inorganic waste is in the form of hot, frothy and colored liquid, and contains sulfuric acid, which has a pungent smell. Such as steel factory waste, gold factory waste, paint factory waste, organic fertilizer factory waste, pharmaceutical factory waste, and others. If the industrial waste is discharged into waterways or rivers, it will cause water pollution and damage or destroy organisms in the ecosystem. Types of heavy metals are mercury, lead, and cadmium where all three are very dangerous for humans when consuming them, for example the mercury pollution that occurred in Minamata, Japan.

In the chemical industry, process water is one of the biggest environmental problems. Process water can be divided into two groups: input water and output water which is called process wastewater and used solvent. Chemicals must be recycled into our natural environment. So, when planning waste management, avoid choosing options for disposal, but opt for methods of reducing the amount of waste or offering options for recycling (figure 1.)(József et al., 2015).

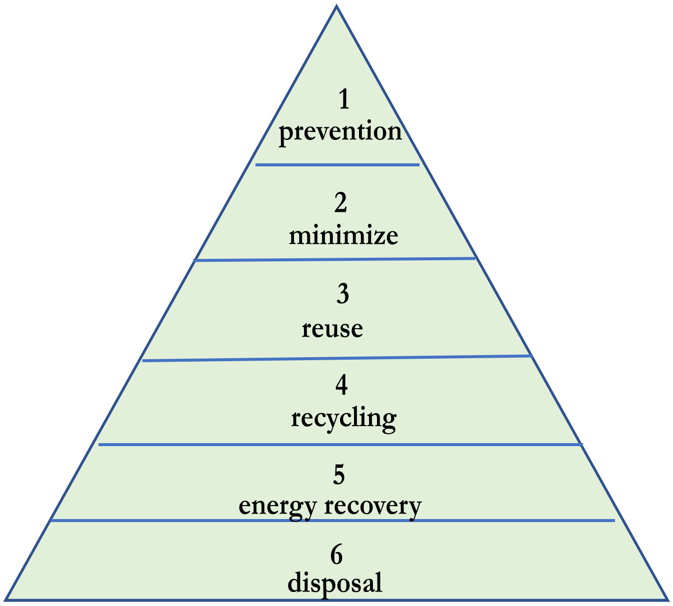

Figure 1. Diagram of Waste Management (József et al., 2015)

Figure 1. Diagram of stages of waste water management (József et al., 2015): **1. prevention**, organic solvents are urgently needed. **2. minimize**, if the volume can be reduced, can the process be optimized? Solvents can be replaced which

are more effective, so that the amount is minimized; the solvent is more selective, so less waste is produced; less volatile solvents, so less air pollution. From the point of technology and the problem is solvent specific. The detailed manufacturing process must be analyzed and changed. If replacement of the solvent is not possible, how and at what cost can the solvent be extracted from the waste and - channeled back into the original technology, so that less new solvent is used. **3. Reuse,** used in other areas, if the solvent does not meet process purity requirements and specifications. **4. Recycling,** this stage there are still a number of options. Solutions that are proven to be effective include mass transfer processes: adsorption, stripping, extraction, membrane process, distillation, or a combination thereof (hybrid operation). This treatment means end-of-pipe technology in the wastewater process. **5. Energy recovery,** if the waste material cannot be recycled, the amount of waste can be reduced by concentrating the pollutant components.

6. Disposal, all types of combustion produce hazardous by-products, which must be disposed of. Solid incineration residues (flue ash and slag) must be transported to the final disposal site (TPA). Legal standards limit recovery, because in these situations the solid residue qualifies as hazardous waste.

5.2 Industrial Wastewater Composition

Water use determines the makeup of wastewater, which allows for adaptation of the implementation method to the local environment, society, economics, and cultural practices. Determining the various components that make up the wastewater is often not of interest in the design of a WWTP due to the challenges of carrying out several laboratory tests and the fact that the data itself cannot be used as considerations in design and operation. Hence, it is frequently preferable to select illustrative characteristics that reflect the nature or possibility for contamination of the relevant effluent. Physical, chemical, and biological characteristics are used to determine the factors that determine the quality of industrial effluent. These parameters are determined using a variety of laboratory tests, although the results themselves

Parameter of Quality

Tabel 1. Specific average flows of several industries

Type Unit	Activity		Water consumption per unit (m^3/unit) (*)
Food	Fruits and vegetables in cans	1 tonne product	4–50
	Sweets	1 tonne product	5–25
	Sugar cane	1 tonne sugar	0.5 – 10
	Slaughter houses	1 cow or 2,5 pig	0.5–3.0
	Dairy (milk)	1000 L milk	1–10
	Dairy (cheese or butter)	1000 L milk	2-10
	Margarine	1 tonne margarine	20
	Brewery	1000 L beer	5-20
	Bakery	1 tonne bread	2-4
	Soft drinks	1000 L soft drinks	2-5

Textiles	Cotton Wool Rayon Nylon Polyester Wool washing Dyeing	1 tonne product 1 tonne product 1 tonne product 1 tonne product 1 tonne product 1 tonne wool 1 tonne product	120–750 500–600 25–60 100–150 60–130 20–70 20-60
Leather /tanneries	Tannery Shoe	1 tonne hide 1000 pairs of shoes	20–40 5
Pulp and paper	manufacture of pulp bleaching pulp paper manufacturing Paper and pulp together	1 tonne product 1 tonne product 1 tonne product 1 tonne product	15–200 80–200 30–250 200–250

Chemical industries	Paint Glass Soap Acid, base, salt Rubber artificial rubber gasoline refinery Detergent Ammonia Carbon dioxide Petroleum lactic sulfate pharmacological substances (vitamins)	1 employee 1 tonne glass 1 tonne soap 1 tonne chlorine 1 tonne product 1 tonne product 1 barrel (117 L) 1 tonne product 1 tonne product 1 tonne product 1 tonne product 1 tonne product 1 tonne product	110 L/d 3–30 25–200 50 100–150 500 0.2–0.4 13 100–130 60–90 7–30 600–800 8-10 10–30
Manufacturing products	optical and electronic precision mechanics superior ceramic machine sector	1 employee 1 employee 1 employee	20–40 L/d 40 L/d 40 L/d
Metallurgy	Foundry Lamination Forging Electroplating	1 tonne pig iron 1 tonne product	3–8 8–50 80 1–25

	Iron and steel plating industry	1 tonne product 1 m^3 of solution 1 employee	60 L/d
Mining	Iron Coal	1 m^3 mineral taken 1 tonne coal	16 2–10

∗ Consumption in m^3 per unit produced or L/d per employee

Source: CETESB (1976), Downing (1978), Arceivala (1981), Hosang and Bischof (1984), Imhoff & Imhoff (1985), Metcalf & Eddy (1991), Der´ısio (1992) in Marcos von Sperling, 2007 ditulis ulang oleh Nyimas Yanqoritha

5.3 Characteristics of industrial wastewater

Physical, chemical, and biological features can be found in industrial wastewater. The physical characteristics of industrial wastewater can be seen from the temperature, solids, odor, color, and also the turbidity of the water. **The temperature** of industrial wastewater has a relatively higher temperature than the room temperature where it is located. Higher water temperatures result in less dissolved oxygen. This makes aquatic organisms die from lack of oxygen. **Solids** are dissolved solids, namely total dissolved solids (TDS) and non-dissolved suspended solids, namely total suspended solids (TSS). Insoluble solids can be seen easily in water, but dissolved solids are only visible when the water is heated to 103°C or 105°C. **Odor,** the characteristic of industrial wastewater indicates the presence of waste in the water, because the characteristic of clean water is that it does not smell. Water can have a foul, metallic, or pungent smell depending on the pollutants it contains. The color of clean water is colorless or clear. **The color** of the water indicates the presence of pollutants in it. Wastewater can be of any color, from yellowish, brownish, reddish, blackish, to a bright green color, depending on the type of waste. **Turbidity** as a physical characteristic contains dissolved substances, colloidal substances, suspended solids, and microbes in it. Turbidity can be seen clearly when light is scattered through the wastewater. Light will be scattered according to the nature of the colloid. The more turbid the wastewater, the less light will be transmitted by the water. **Chemical** characteristics of wastewater from the organic matter industry are usually capable of causing an unpleasant odor. This is because the chemical nature of wastewater consumes oxygen in the water. In general, the chemical characteristics of wastewater can be seen from the substance content in it. These substances can be organic, inorganic, to gaseous substances. The chemical characteristics of wastewater containing organic substances are as follows (Shon et al., 2007): the organic composition of wastewater contains approximately 50 percent protein, 40 percent carbohydrates, 10 percent fats and oils. Organic substances are usually divided into 2 groups, namely compounds that contain nitrogen, for example proteins, nitrates and nitrites and the second is compounds that do not contain nitrogen, for example oils, fats and carbohydrates. Inorganic substances Wastewater can contain inorganic substances such as alkaline, chlorine, nitrogen, phosphorus, sulfur, to heavy metals such as lead and mercury. The dissolved inorganic substances make the wastewater alkaline or acidic which is indicated by changes in the pH of the water. Dissolved oxygen Wastewater has low levels of dissolved oxygen. Some wastes do not even have dissolved oxygen at all. This makes aquatic organisms such as fish die if they are in wastewater. Biological oxygen demand (BOD) is the oxygen required for aerobic bacteria and microorganisms to decompose organic matter in water. High levels of BOD indicate highly polluted and hazardous waste water. Biological characteristics consist of bacterial microorganisms in industrial wastewater which are used to balance dissolved oxygen DO, chemical oxygen demand

(COD) and biochemical oxygen demand (BOD) and eliminate pathogenic bacteria (Abdallh et al., 2016; Aderibigbe et al., 2018; Noukeu et al., 2016; Shruti Danve, 2015). The **biological** characteristic of wastewater is the presence of microorganisms that are harmful to health in the water. The presence of viruses, bacteria, protozoa, and pathogenic worms is an indicator of water contamination. Wastewater can contain enteroviruses which can cause inflammation of brain and spinal cord tissue, difficulty breathing, and even polio. Wastewater can also contain bacteria such as E. coli, Salmonella sp., Shingella spp, to Vibrio chloerae which can cause various health problems.

In general, the characteristics of typical industrial wastewater are difficult to determine because of the wide variability from time to time and from one industry to another. The concept of biodegradability is the process by which the capacity of wastewater is stabilized through biochemical processes by microorganisms. The biological treatment of industrial wastewater can be treated with conventional biological processes and the concentration of biodegradable organic matter, waste water BOD, can:

- higher than household waste (especially biodegradable organic wastewater, which can be treated biologically), or
- lower than domestic wastewater (the majority of inorganic wastewater is biodegradable, where the need to remove BOD is less, but pollution load can be expressed in terms of other quality parameters).

Nutritional availability: a balance between C, N, and P nutrients is necessary for biological wastewater treatment. Domestic garbage typically contains this equilibrium.

Toxicity: Certain industrial wastewaters contain toxic or inhibitive components that could interfere with biological treatment or render it impossible.

5.4 Sampling of Food Industry Waste Treatment

A collecting tank is used to collect industrial waste water from the food industry process that has a high organic load and filter out fibrous and solid particle materials. Waste treatment generally involves three stages of the treatment system namely primary, secondary and tertiary. **Primary processing** is carried out to remove suspended solids. Physical primary treatment is only able to remove floating material content and can be precipitated by gravity. The pollutant content that cannot be processed primary is followed by secondary processing whose function is to remove suspended or dissolved pollutant content. **Secondary processing** is carried out by biological processes (aerobic or anaerobic). Processing of food industry waste water from processed soybeans, for example wastewater from the tofu industry. Processing is done by anaerobic biology and nitrification-denitrification process. This is due to the characteristics of industrial wastewater containing a high organic load (Nyimas Yanqoritha, 2023a, 2023b), where processing is carried out using an anaerobic reactor and a nitrification-denitrification reactor (Nyimas Yanqoritha, Kuswandi, 2022). **Tertiary processing** is a process if needed, the aim is to improve the quality of the effluent. These processes include sand filtration, nitrogen elimination (nitrification and denitrification), and phosphorus elimination (chemically and biologically) (Ramesh et al., 2018). Each stage of the process, influent water and process effluent will be analyzed manually. Water samples are taken and sent for examination to the laboratory which is a process that takes time, costs and human resources (Das & Jain, 2017).

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Biography:

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CHAPTER VI HAZARDOUS AND TOXIC MATERIAL WASTE

Lukman Handoko

Hazardous and toxic materials, hereinafter abbreviated as B3, are substances, energy, and/or other components that, due to their nature, concentration, and/or amount, can directly or indirectly pollute, damage, or endanger the environment. Humans and other creatures are alive, healthy, and surviving. Hazardous and toxic waste, hereinafter referred to as B3 waste, are the remains of companies and/or operations that contain B3 compounds.

Any solid or liquid waste that (1) can cause or significantly contribute to the growth of hazardous substances by virtue of its quantity, concentration, physical or chemical properties, or infectious qualities is considered hazardous waste (or a combination of solid and liquid waste). (2) If handled, stored, transported, disposed of, or otherwise disposed of inappropriately, they constitute a substantial current or potential risk to human health or the environment.

6.1 **Control of Hazardous and Toxic Waste**

In recent years, there has been a remarkable advancement in the technologies available for the control of hazardous and toxic wastes. In this section, a few of the more significant control types are discussed.

1. Minimization

The interest in waste minimization grows along with the quantity of bulk garbage. Every recent study has found that waste reduction is both technically possible and economically advantageous using current technologies. Waste minimization aims to reduce the amount of hazardous waste produced so that less needs to be processed, stored, or disposed of in the future. In order to lessen current and potential risks to both human health and the environment, minimization entails a generator reducing waste in both quantity and toxicity.

Waste Reduction

The majority of hazardous wastes can be reduced in a wide range of ways. Process modifications, feedstock substitutions, feedstock purity improvements, housekeeping and management procedure implementation, machinery efficiency improvements, use or reclamation within a process, and any other action that lowers the amount of waste leaving a process are all examples of reduction measures in the industrial process. There are many valuable goods connected to hazardous waste. Reclamation is the process of getting rid of the usable product and reducing the amount of harmful elements overall. The direct and efficient replacement of trash for a component or raw material utilized in an industrial process or for a commercial chemical product is also an option in some operations. Dewatering is an example of a treatment that is exclusively meant to prepare hazardous waste for disposal and is not typically seen as waste minimization.(Piervandi *et al.*, 2021)

Doing a waste reduction evaluation is a crucial first step, according to engineers who have researched waste reduction implementation (WRA). These are the steps involved in this process:

1. Determine the types and quantities of hazardous materials present in garbage.

2. Determine the precise sources of the waste's creation.

3. Set waste reduction goals based on factors like prices, environmental advantages, risks to one's health and safety, and production constraints.

4. Decide on an economically viable technology.

5. Assess the economics of waste management control choices that are currently available and those that will be available in the future.

6. Assess the effectiveness and progress of the selected waste reduction strategies.

The waste generator must take into account both the technological and human components of waste reduction if waste reduction is to reach its full potential. Economic effects, the decrease in health risks, and the impact on the environment should all be taken into consideration. A significant amount of research and development must go into this.

Benefits

The main goal of hazardous waste minimization is to reduce expenses while also lowering dangers to human health and the environment. Maximizing the relationship between technology and the usage of a resource is the modern manager's strategy. Hence, a non-waste technology that conserves resources and lessens pollution must be created.

The minimization of hazardous waste has advantages for producers beyond just reducing waste production itself, such as lower costs for handling, treating, storing, and/or disposing of the trash. Savings may also be realized as the regulatory costs of waste in general decrease or if regulated treatment or storage facilities are eliminated. Savings may also be realized from the reduction of long-term liabilities that should come with decreased handling of waste, though these are difficult to quantify. Building goodwill with the communities where they operate is another advantage that businesses may experience.

Progress

Although technology exists, practice has lagged behind theory when it comes to the advantages of waste reduction, which dates back to roughly 1980. At the federal regulatory level, there hasn't been much enthusiasm for promoting waste minimization. Because they are concerned about losing support for current regulatory initiatives, environmental organizations have likewise been rather passive in their advocacy for waste reduction. A federal waste reduction program has also not received the support of the private sector due to uncertainty regarding potential side effects. The industry worries about onerous waste reduction regulations. Waste management and pollution control businesses worry about losing customers. These worries have prevented the federal policies needed to create effective waste reduction programs from being developed.

2. Incineration

It has long been debatable whether hazardous waste should be burned as an alternative to processing and disposal. There are many different points of view; some consider incineration to be the only viable option, while others consider it to be one of the most destructive and risky engineering methods ever. Significant developments in recent years have shed light on the advantages and drawbacks of incineration. The general population is still skeptical, nevertheless, because of worries about contaminated local air. Because of this, it is now politically challenging to build, operate, and secure a permit for an incinerator. (Buekens, 2013)

Characteristics

Waste that cannot sustain combustion has been added to the list of materials that are considered incinerable trash. Any waste that is dangerous when it contains toxic organic chemicals, regardless of the poisonous concentrations or the matrix in which they occur, is now regarded as eligible for burning. Today, it is common practice to incinerate even contaminated water, soil, and several other solids and liquids that contain trace amounts of organic chemicals.

Only two categories of hazardous trash are still deemed unsuitable for incineration today. Any dangerous substance that includes poisonous heavy metals is the first. Heavy metals cannot be destroyed by incineration; while burning can lessen their toxicity, it cannot get rid of the metals themselves. The fly ash or the bottom of the incinerator still contain the heavy metals.

Wastes with a high halogen content are another category that cannot be burned. The generation of extremely corrosive gases makes it challenging to incinerate wastes with a chlorine and/or fluorine content over roughly 30%. The incinerator could be harmed by these fumes.

Principles of Incineration

The fundamental idea behind incineration is that it is a carefully planned and managed procedure for obliterating organic materials using high-temperature thermal oxidation. All organic waste is transformed into carbon dioxide and water during this process. Incinerators for both solid and liquid wastes have an efficiency rate of at least 99.99 percent when they are correctly constructed and run.

The three variables of time, temperature, and turbulence are essential in the creation of an effective incineration process. Here, the term "time" refers to the length of time that a chemical must be heated to a high temperature in an incinerator before its toxicity is eliminated. It is referred to as residence time. The amount of waste molecules destroyed increases with exposure time. The majority of contemporary incinerators have residence times exceeding two seconds.

Temperature is the measure of how much heat is necessary to destroy organic materials. The majority of contemporary incinerators are built to function at temperatures higher than 2,000 °F. The process is more efficient at higher temperatures, just like it is with time.

The amount of mixing between the hot gases around the incinerator and the trash within is referred to as turbulence. The waste materials receive more heat from the incinerator flame when there is more turbulence. In the destructive process, this is a crucial factor. An effective incineration system strikes a balance between these three elements.

Incinerator Technology

There are many different kinds of incinerators that have been developed, each with a unique feature. The rotary kiln incinerator is the most typical form of incinerator used in the commercial burning of hazardous waste due to its extreme versatility. Tars, organic and aqueous liquids, sludges, uniform granular solids, and irregular bulk solids can all be burned in this kind of unit. Rotating kilns can also burn garbage that contains a lot of fusible ash. A rotary kiln incinerator's temperature ranges from 60 million Btu per hour on average to 90 million Btu per hour.

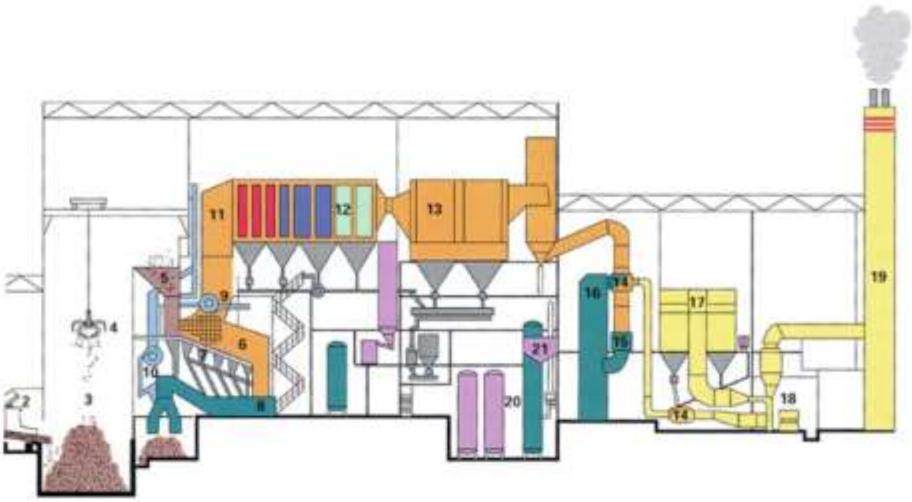
Fixed-hearth incinerators can be made to burn liquid, organic, and aqueous wastes, but their main uses are for the burning of homogenous granular solids, irregular bulk solids, and heavy tars. When it comes to the types of garbage that can be burned, fluoridated-bed incinerators are a little more flexible than fixed-hearth incinerators. Homogeneous granular particles, heavy tars, aqueous and organic sludges, and aqueous and organic liquids can all be burned in these incinerators. They are not intended to burn abrasive or dense substances. The petroleum and chemical industries frequently use liquid waste incinerators to destroy the liquid waste that is produced at these facilities on-site. Every kind of solid or sludge waste can be burned in these kinds of incinerators. There are also cyclonic, auger, infrared, and plasma incinerators.

Regulatory Requirements

The Resource Conservation and Recovery Act regulates hazardous waste incinerators, with the exception of when they burn polychlorinated biphenyls (PCBs). The Toxic Substance Control Act regulates the burning of PCBs. All trash disposed of via incineration must comply with these criteria and be destroyed with an efficiency of at least 99.99 percent (99.9999 percent for PCBs). A lengthy trial burn test program run by the

Environmental Protection Agency is required to show this efficiency.

The emission of particles and hydrogen chloride are two additional requirements for hazardous waste incinerators. When the exhaust is corrected to a level of 7.0 percent oxygen, the particulate matter content in emissions cannot be more than 0.08 grams per dry standard cubic foot of exhaust. There are certain states with stricter rules. The amount of hydrogen chloride that can be released into the environment is restricted by federal rules to 4.0 pounds per hour, or, if greater, no more than 1.0 percent of the amount of hydrogen chloride existing in the exhaust before the emission control equipment. Operators of incinerators must also maintain continual observation.



1. Unloading hall	1. Under-grid hoppers	13.Dust collector filter	19. Chimney
2. Bulk waste cutter	2. Bottom ash channel	14.Heat exchanger s	20. Chemical reagent trays
3. Garbage pit	3. Pilot burner	15. water injection (Quench)	21. Water treatmen t systems

4. Crane grapple	4. Combustion air fan	16. Flue gas washing tower
5. kiln feed tank	5. Afterburner chamber	17. Bag filter
6. Combustion chamber	6. Recovery boiler	18. Draft fan

Figure : An Incinerator with a Motorized Grate's Operating Diagram (Buekens, 2013)

Safety Aspects

Swiss Re offered a thorough analysis of a few safety issues and mishaps at incinerator facilities. Many unexpected actions occur on site during incinerator installation and yearly maintenance, posing a number of risks. Although these risks are reduced to more manageable levels during normal operation, several safety issues could arise around incinerator plants, to name a few. (Dörrie, Struve and Spillmann, 2010)

1. Fires in waste bunkers
2. Explosions that occur while shredding trash
3. Flame flashback into the feeding locking system
4. Explosive combustion is caused by the simultaneous ignition of a huge amount of garbage, which places the furnace under excess pressure and causes the flames to separate the trash.
5. Explosions of hydrogen caused by the breakdown of water in contact with heated metal in a wet ash extractor
6. Pressure containers (boilers).
7. insufficient boiler feed water levels
8. Tube collapse and boiler rust
9. Mishaps caused by on-site chemicals, such as acids and bases used in boiler feedwater treatment and ammonia used in DeNOx operations
10. Moving and rotating machinery

11. Transformers catch fire.

12. Fires during shutdown in the wet scrubber

Relevant ideas in industrial safety approaches include pool burning, boiling liquid expanding vapor explosions (BLEVEs), and vapor cloud explosions (VCEs). The complexity and diversity of the waste streams that could be treated mean that even complete waste treatment facilities may not achieve the volume of operations or storage needed to qualify under COMAH eligibility requirements. The storage, mixing, and feed preparation facilities in front of a chemical waste incinerator are subject to such incidents because fires at chemical storage sites are often impressive.

3. Landfills

Historically, landfills were one of the most common places in the United States to dispose of waste. The method was created as a location to keep fresh sanitary waste. Hazardous waste contamination in landfills, however, appears to have spread over time. 90 percent of the municipal landfills in the Midwest are thought to contain poisonous and hazardous waste. There is a widespread understanding that garbage is harming the ecosystem and that landfills are no longer reliable storage facilities. (Tammemagi, 1999)

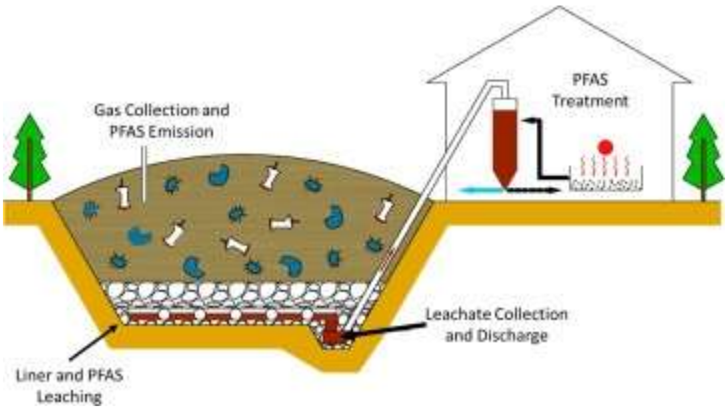


Figure : Poly-and Perfluoroalkyl Substances (PFAS) in Landfills (Zhang *et al.*, 2023)

4. Biological Treatment

The individual microbial cells used in the treatment of biological waste can be seen as tiny chemical reactors that can change a waste component into a less dangerous one. Chemical energy is changed as a result of their conversion in the system of reactants and products. In essence, wastes are gradually broken down through a series of chemical reactions throughout biological treatment processes. The bacteria use a portion of the free energy that is released for metabolic purposes.

The activated sludge process for sewage treatment, which was established around the turn of the twentieth century, is where the technology for microbial dispersal of wastes first emerged. The chemical structure of the wastes that needed to be treated changed as industry advanced, and new methods of treatment were also created. Yet, the incredible capacity of life to adapt to environmental changes has allowed the microbial process to continue working. The majority of organic chemicals produced by industry have been assimilated by microbial organisms, albeit slowly and in small amounts. The ability of microorganisms to handle inorganic materials through either direct or indirect metabolic pathways has also been established. As a result, a variety of substances found in household or industrial wastes that are poisonous, carcinogenic, or otherwise generally unwelcome in the environment are metabolized by microbes. Science has advanced quickly, and now we have the ability to help nature with the adaptation process by altering minor characteristics of microbes to increase their efficacy in removing contaminants.

The rate of microbial conversion is influenced by a variety of variables. The reason why the reaction takes so long to complete is because the reactants must first get past an activation barrier in order to transform into products. One method to get beyond the activation energy barrier is to raise the temperature of the reactants. One method is to utilize a chemical agent known as a catalyst to lower the activation energy barrier. The best biological activity occurs when this process is used. The microorganisms' internal metabolic processes result in the production of enzyme catalysts, which speed up the degradation of trash.

Proteins and nonproteins both make up enzymes. The apoenzyme, the protein component of an enzyme, is thought to be in charge of the chemical specificity of catalytic action. The pro-factor is the name given to the enzyme's nonprotein part. Pro-factors are thought to be in charge of influencing chemical processes like oxidation and hydrolysis transfer.

Because they can process wastes on-site, microbial methods have emerged as particularly appealing for treating solid industrial waste. Also, such treatment might do away with the requirement for significant capital investments at processing facilities like incinerators. For more than 50 years, the method has been successfully used in a variety of businesses. Examples include the petroleum business, where oily spills have been treated using the microbial method by carefully applying it to water or dirt when there is a dense population of microorganisms. With more study, it might be possible to apply these methods to organic pollutants including dioxin, pesticide residues, and chlorinated biphenyls.

There are numerous research projects underway that attempt to increase the application of biological technology. Both the technological components of engineering and biology offer opportunities for process improvement. The advances in engineering will happen soon. The biological advancements, however, that is, it taking more time to do research and development to identify the optimum organisms to attack a certain waste, Genetic engineering may have a significant influence. Yet, there are several political, emotional, and technical issues about environmental safety that must be resolved by the courts and the general public, as there are currently no clear legal precedents for the use of recombinant mutant organisms in open areas. Even though genetic engineering has many issues, it is a fast-expanding field for the remediation of hazardous pollutants.

5. Biological Treatment

The individual microbial cells used in the treatment of biological waste can be seen as tiny chemical reactors that can change a waste component into a less dangerous one. Chemical energy is changed as a result of their conversion in the system of reactants and products. In essence, wastes are gradually broken down through a series of chemical reactions throughout biological treatment processes. The bacteria use a portion of the free energy that is released for metabolic purposes.

The activated sludge process for sewage treatment, which was established around the turn of the twentieth century, is where the technology for microbial dispersal of wastes first emerged. The chemical structure of the wastes that needed to be treated changed as industry advanced, and new methods of treatment were also created. Yet, the incredible capacity of life to adapt to environmental changes has allowed the microbial process to continue working. The majority of organic chemicals created by industry have generally been assimilated by microbial organisms, albeit occasionally slowly and in low quantities. The ability of microorganisms to handle inorganic materials through either direct or indirect metabolic pathways has also been established. Hence, a variety of substances found in household or industrial wastes that are poisonous, carcinogenic, or otherwise generally unwelcome in the environment are metabolized by microbes. Science has advanced quickly, and we are now able to help nature with the adaptation process by selecting and altering minor characteristics of microbes to increase their efficiency in removing toxins.

6. Chemical Treatment

Chemical treatment is a frequently used method for disposing of hazardous waste when it is desirable to change the composition of materials. As an example, the pesticide ethylene dibromide (EDB) can be chemically changed into a salt, potassium bromide (which has economic value), or the gas acetylene, or it can be made harmless by removing a chlorine atom from 2,3,7,8-dioxin using reagents based on glycol. Some of the most significant chemical treatment procedures include oxidation, reduction, neutralization, chlorinolysis, and dechlorination.(Intrakamhaeng, Clavier and Townsend, 2020; Thakur *et al.*, 2023)

Ions or compounds can undergo chemical oxidation as part of the oxidation process to make them nonhazardous. The oxidizing chemical agent is changed as a result. Many different forms of hazardous pollutants can be treated using this method. The treatment of organic and inorganic pollutants in aqueous solutions is one of its main applications. For instance, one important use has been the removal of cyanide from metal plating wastes. Slurries and sludges, which may contain a large number of oxidizable components, are not well suited for this procedure since oxidation is relatively nonselective in oxidizing pollutants. It works best when diluted with aqueous waste.(Ali *et al.*, 2022)

7. Physical Treatment

While treating hazardous waste, a variety of physical treatment procedures are employed. Techniques like sedimentation and filtration are frequently employed to separate particulates from liquids. Water solids are routinely removed using sedimentation basins. A cost-effective approach to liquid-solid separation is provided by the separation of chemically coagulated materials. Microscreens, diatomaceous earth filters, sand filters, and mixed-material filters can all be used for filtering. As an illustration, vacuum filters or sand beds are used to filter sludge. (Ya *et al.*, 2023)

The processes of distillation and evaporation are used to divide waste streams into two or more groups. Many methods have been created. As an example, air is driven through garbage during a stripping procedure in order to gather vaporized materials. Trace amounts of volatile solvents have been eliminated from contaminated groundwater using air stripping.

In waste oil recovery, lighter hydrocarbons can be recovered by evaporating them from heavier oil wastes.

Concentration of organics dissolved in water is also possible through activated carbon or absorption. Several hazardous waste facilities allow suspended solids and a range of organic components to settle as sludge before being separately disposed of. Hence, a large range of organic compounds can be concentrated.

8. Stabilization

By making wastes less soluble or mobile, stabilization is a way for lowering the risk that they pose.The wastes are enclosed in a solid with a high degree of structural integrity during stabilization operations.While the solidification may involve the mechanical binding of the waste into a solid, it need not alter the waste's physical or chemical characteristics. The smaller surface area exposed to leaching considerably slows the migration of harmful substances. (Wei *et al.*, 2022)

The majority of the stabilization techniques used today include adding absorbents and solidifying agents to wastes. The majority of the procedures fall under one of four general categories: vitrification, thermoplastic microencapsulation, lime- and/or cement-based approaches, and sorption.(Xiong *et al.*, 2022)

9. Underground Burial

Throughout the 1960s and 1970s, there was a surge in hazardous waste, which led to the practice of burying waste at shallow depths. Very frequently, this kind of disposal consisted me Throughout the 1960s and 1970s, there was a surge in hazardous waste, which led to the practice of burying waste at shallow depths. Very frequently, this kind of disposal consisted merely of hiding rather than complete isolation from human interaction. As a result, the biosphere was exposed to several toxins that threatened the entire ecosystem. This indirect impact on people typically took months or years to become apparent, making it more challenging to identify the problem's root cause and far more difficult and expensive to take corrective action.(Dörrie, Struve and Spillmann, 2010)

New burial methods, including well injection, deep mines, and naturally occurring and man-made caves, were developed in the 1970s as a result of rising public awareness and more stringent government restrictions. The most important conditions for the successful disposal of waste have been found to be adequate surface and subsurface water control. Such a burial site must exhibit the traits listed below:

1. Enough depth to allow for the buried garbage
2. A water regime to prevent the spread of toxins in the area
3. sufficiently uniform and impermeable soil or bedrock to facilitate gradual, predictable groundwater migration away from the location.
4. A geological environment that is sufficiently stable to guarantee that conditions favorable for waste disposal at the time of burial won't be significantly altered over the site's estimated useful life
5. Appropriate slope, seismic activity, lithology, temperature, and other important variables that affect the performance of a site are particularly important as they relate to one or more of the aforementioned fundamental qualities.

Many studies have been conducted recently on the challenging issue of choosing a burial site for waste, not only for hazardous and poisonous chemicals but also for radioactive waste. Despite having a variety of origins and compositions, the rocks that make up the earth's crust have formed over intervals of thousands to millions of years. It goes without saying that some places are not appropriate for storing hazardous materials. Unsuitable areas include those where tectonic change occurs quickly due to earthquakes or volcanic eruptions. Both places that experience rapid erosion and areas that frequently flood are inappropriate. The majority of these areas are simple to locate.(Xin *et al.*, 2023) rely of hiding rather than complete isolation from human interaction. As a result, the biosphere was exposed to several toxins that threatened the entire ecosystem. This indirect impact on people typically took months or years to become apparent, making it more challenging to identify the problem's root cause and far more difficult and expensive to take corrective action.

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CHAPTER VII
REDUCE, REUSE, RECYCLE

Gregorius Prima Indra Budianto

7.1 Overview of Risk Assessment Concept

Wastewaters are nearly oriented to environmental risk. In order to quantify the impact of the risk, a risk assessment is needed. It is familiar to the effort to identify the type and magnificent of toxicants that potentially damage the environment (Allen & Shonnard, 2001).

1. Hazzard Assessment

In this step, the potential danger posed by the waste is evaluated. Consider if an irritant, allergen, or cancer-causing substance is present in a waste product.

2. Dose-Response

The next stage is quantifying the compounds' harmfulness in the wastewater. The term "dosage" refers to the maximum quantity of a substance that a human body can process.

3. Exposure Assessment

This stage measures who is exposed to the hazard and how many living things are exposed.

4. Risk Characterization

The last step in this process involves determining the severity of the hazard posed by the chemical and the associated analytical uncertainty.

7.2 Progress in Pollution Control Regulations: Moving Beyond "End of Pipe" Measures

After assessing the risks, efforts to reduce pollution risks must be accomplished. As time goes by, the "end of pipe" concept starts to be abandoned because it is considered only oriented toward the generated waste from an industrial process. Pollution Prevention is a new concept that reflects an endeavor to control and prevent pollution.

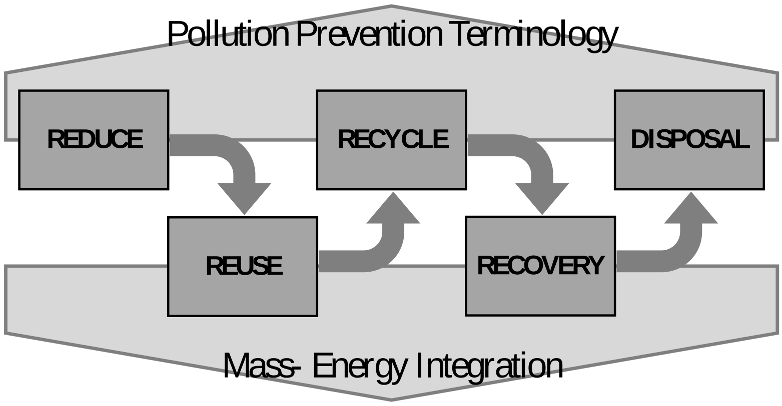

Figure 1. The concept of wastewater minimization

Pollution prevention is a design for minimizing liquid waste implemented from the outset of the process by reducing or preventing the generation of liquid waste, repurposing byproducts, and disposing of any remaining waste securely. Pollution Prevention Concepts and Terminology include:

1. Source reduction

In order to restrain pollution, the design of a chemical manufacturing process requires the selection of feedstock, the selection of solvents, catalysts, and other materials, and the selection of reaction paths. Green Chemistry familiarly calls this method. The following concerns are specifically addressed in this section:

a. Feedstocks

A renewable source of the feedstock's raw material is required. For instance, Only 8% of crude oil is utilized to make chemicals, while 90% is burned to generate electricity. The major reasons to utilize renewable feedstocks and reduce fossil fuel consumption are:

- To preserve fossil fuels for future generations (a key sustainability concept).

- Reduce global greenhouse gas emissions, particularly carbon dioxide (renewable resources are CO_2-neutral).

Reducing fossil fuel consumption for chemical manufacturing may save some resources and reduce CO_2 emissions, but renewable energy generation will do more. Hence, chemicals made from renewable resources should lower the danger, cost, pollution, and market demands (Doble & Kruthiventi, 2007).

b. Green chemicals and solvents

Green chemicals and solvents rely on their usage and destiny throughout the chemical process. In green chemistry, determining solvent consumption may include any of the following.

- Redesign of the precise chemical nature of the solvent by synthesis;
- Discovery of similarly effective but less hazardous replacements of another chemical class for use instead of a "conventional" solvent; or
- Reduction/elimination of solvent usage in certain chemical processes.

It must be an eco-friendly solvent that completes the work. Solvents are chosen based on environmental toxicity. These chemicals should be safe for humans and the environment and not pollute. A safe solvent should clearly define environmental toxicity, fate, and absorption (Sheldon et al., 2007).

a. Synthesis pathways

The implementation of this part is to select the shorter process pathways in order to reduce the possibility of wastewater leakage. This is also directly tied to the choice of chemicals and solvents. For instance: the urea production process compares the combination Haber-Bosch method and industrial urea synthesis with Electrocatalytic. In fact, Nitrogen interacts with hydrogen to generate ammonia, which then reacts with carbon dioxide to form urea at high temperatures and pressures. The Haber-Bosch process of ammonia synthesis requires around 2% of world energy yearly; Moreover, hydrogen feedstock is produced from fossil fuel reforming, which produces hundreds of millions of tonnes of CO_2 annually. As a result, a more ecologically friendly procedure that produces waste of moderate quality and quantity is necessary. Protons may be created from water splitting rather than hydrogen gas, indicating that electrocatalytic processes are possible options for sustainable movement (Chen et al., 2021).

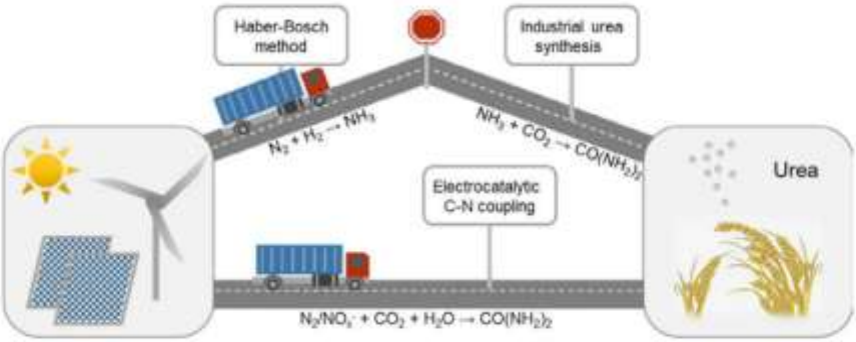

Figure 2. Pathways to urea synthesis (Chen et al., 2021)

2. Recycle

After contemplating the aspects of Green Chemistry, it is possible to recycle the pollution caused by a process's byproducts, particularly wastewater. There are three methods to recycle (Allen & Shonnard, 2001):

a. In-Process recycle

This type attempts to reuse waste or unreacted feeds back to the reactor.

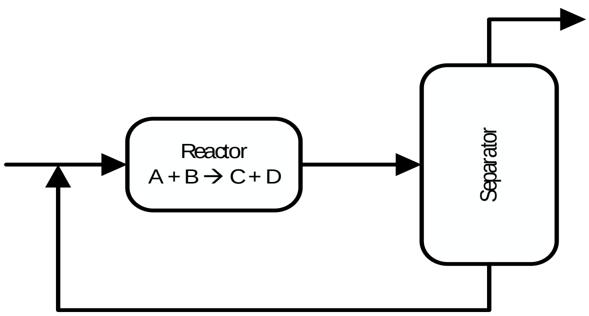

Figure 3. In-process recycle scheme

b. On-site recycle

This type seeks to convert waste into a commercial product through a second reactor within the facility.

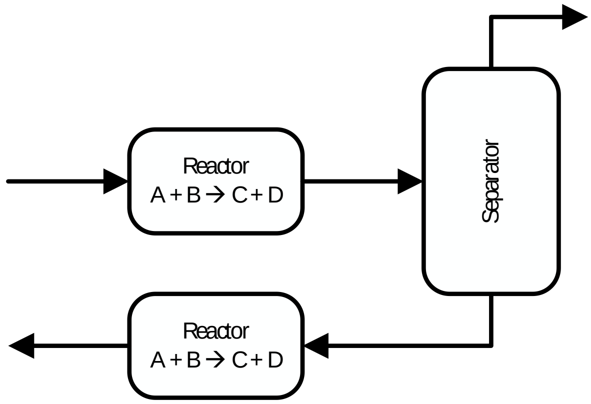

Figure 4. On-site recycle scheme

c. Off-site recycle

This segregated waste is moved off-site where it is converted into commercial products at other facilities.

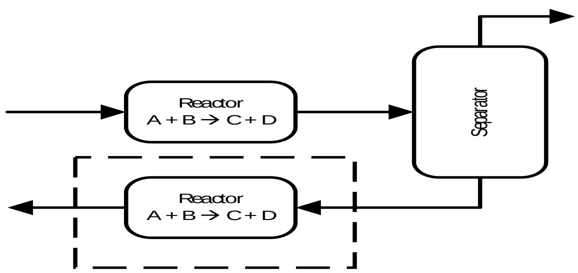

Figure 5. Off-site recycle scheme

3. Treatment and Disposal

The final step is disposal treatment. This step is carried out if wastewater can no longer be reduced and recycled. Wastewater treatment technology can be selected according to the amount and characteristics of wastewater. After that, water that has met the quality standards can be disposed of securely and directly released into the environment.

Mass-Energy Integration is a mechanism of reusing residual mass and energy by integrating them into the process. Two standard methods are source-sink mapping and the pinch method, which are intended for mass and energy integration.

1. Source-Sink Mapping for Mass Integration

Source-sink mapping is performed to identify whether waste streams may be utilized as feedstocks. Because it is one of the simplest and most visible techniques for finding potential streams for mass integration, it is the first quantitative instrument for mass integration.

Procedure:

The first step in building a source-sink diagram is identifying the material's sources and sinks for which integration is sought. For example, if water integration is desired, wastewater streams (the "sources" of water) are identified. It is also necessary to identify the processes that demand water (the "sinks" of water). The flow rates of the sources and sinks must be known, as many sinks can accept a wide range of flow rates. Substances present in the source streams that may cause an issue for the sinks must be identified, and each sink's tolerance for these contaminants must be determined (Allen & Shonnard, 2001).

Example:

Consider the sources and sinks in Figure 6 as an example of building a source-sink diagram. Figure 6 depicts the acrylonitrile production process, which employs oxygen, ammonia, and propylene as raw substances.

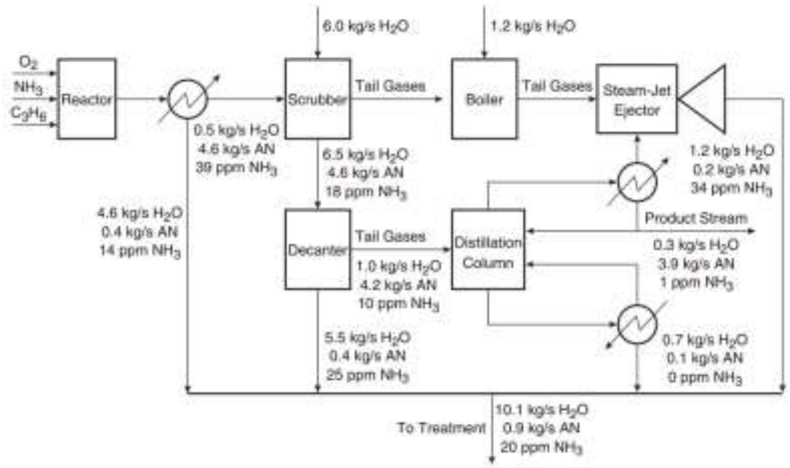

Figure 6. Process flow diagram for production of acrylonitrile (Allen & Shonnard, 2001)

In this idealized scenario, the integration of water and acrylonitrile is desired, and ammonia is the only pollutant of concern. The scrubber's liquid input rate must be between 5.8 and 6.2 kg/s and may consist of either water or a water-acrylonitrile mixture. The feed to the scrubber must contain no more than ten parts per million of ammonia. On the contrary, the boiler's feed cannot contain ammonia or acrylonitrile, and its velocity must be 1.2 kg/s.

Solution:

In order to reduce the quantity of wastewater, there are four sources: condenser, decanter, distillation column, and ejected. On the other hand, the scrubber and the boiler are the sinks. The amount of those can be seen clearly in Table 1.

Table 1. Stream data for Source-Sink Method (Allen & Shonnard, 2001)

Source				**Sink**			
Tag	**Water kg/s**	**AN kg/s**	**[NH_3] ppm**	**Tag**	**Water kg/s**	**AN kg/s**	**[NH_3] ppm**
Condenser	4.6	0.4	14	Scrubber	6		
Decanter	5.5	0.4	25	Boiler	1.2		
Distillation column	0.7	0.1	0				
Ejected steam	1.2	0.2	34				

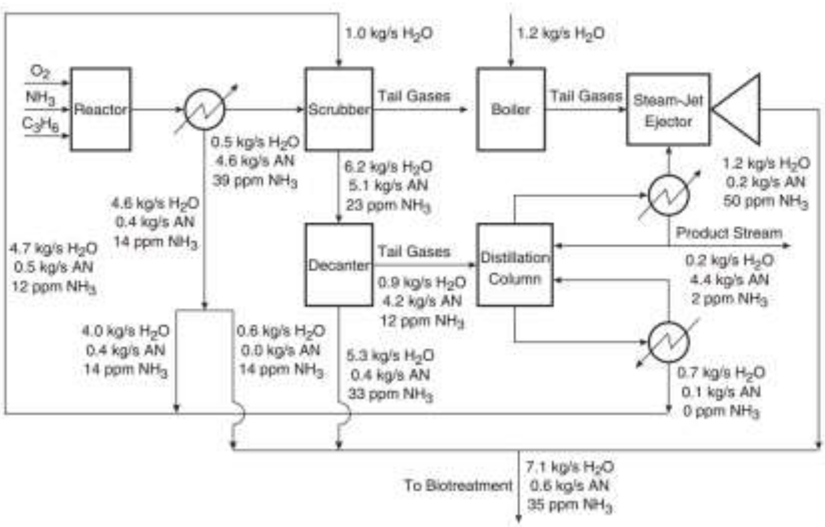

Figure 7. Flowsheet for acrylonitrile following Source-Sink Mapping revealed water integration potential (Allen & Shonnard, 2001)

Figure 7 depicts the finished flowchart, and Table 2 details the changes between the outputs (wastewater and product stream) of the original configuration and the version with wastewater reuse. The need for freshwater input is 30% of the actual process, whereas the material flow rate is 60% of the initial procedure. The mass fraction of acrylonitrile in the stream submitted for treatment has decreased by 15%, but the ammonia concentration has increased by roughly a factor of two. In addition, the ammonia content in the product stream is double what it was before wastewater reuse. Yet, the rise in acrylonitrile synthesis from 3.9 kg/s to 4.4 kg/s may be more significant than any of these alterations. Given a market value of $0.60 per kilogram and 350 production days per year, this product growth is worth $9,000,000 annually.

Table 2. Output characteristic (Allen & Shonnard, 2001)

Effluent characteristic	**Wastewater reuse**	
	Before	**After**
Fresh water feed	71 kg/s	21 kg/s

Acrylonitrile in the product stream	31 kg/s	4.4 kg/s
Flow rate to treatment	13.1 kg/s	7.7 kg/s
Acrylonitrile mass fraction in the treatment stream	0.092	0.078
Ammonia concentration in the treatment stream	20 ppm	35 ppm
Ammonia concentration in the product stream	1 ppm	2 ppm

2. Pinch Method for Energy Integration

Consider the straightforward procedure of a counter-current heat exchanger shown in Figure 8. A heat balancing diagram is shown in figure 8 for a stream that has to be heated from 50 ^{O}C to 200 ^{O}C and another stream that needs to be cooled from 200 ^{O}C to 30 ^{O}C. For the purpose of simplicity, we will assume that the heat capacity of both streams, in this case, is one kJ/kg. ^{O}C. The flow rate of the stream that needs to be chilled is one kilogram per second, whereas the flow rate of the stream that needs to be heated is two kilograms per second.

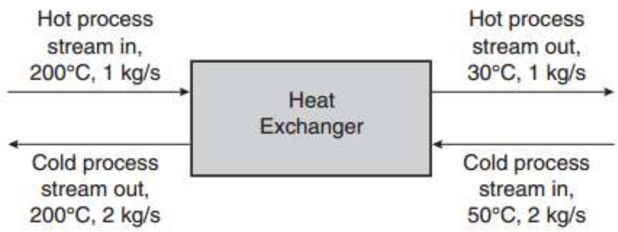

Figure 8. A schematic of the Heat Exchanger (Allen & Shonnard, 2001)

A stream is defined as any flow that must be heated or cooled but does not change composition during its movement. A cold stream is a name given to the feed with a frigid initial temperature that must be warmed up. On the other hand, the hot product or stream that must be cooled down is referred to as a hot stream. A steam heater could be installed on the cold stream, and a water cooler could be installed on the hot stream so that the heating and cooling functions could be carried out. The flows may be seen by looking at Figure 8. In order for the process to run, it is obvious that we will be required to deliver 300 kW of heating through steam and 170 kW of cooling via water (Allen & Shonnard, 2001).

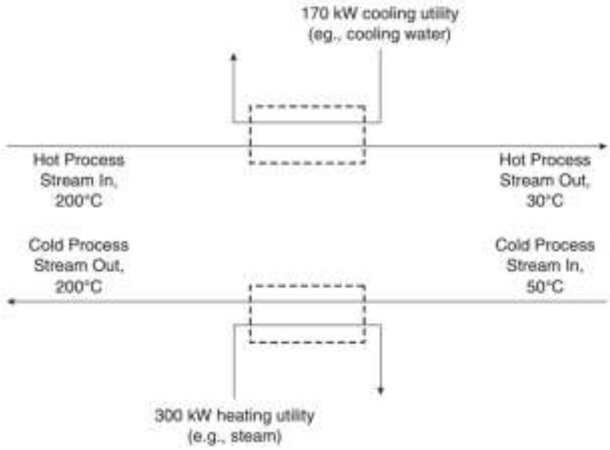

Figure 9. The energy needs of the cooler and heater (Allen & Shonnard, 2001)

The best-case scenario would be if we were able to recover all 300 kW from the hot stream and use it to heat the cold stream. Nevertheless, due to temperature restrictions, this is not going to be achievable. However, one alternative method to integrate the two sub-systems is utilizing the Heat Exchanger to transfer heat between the hot (200 ^{O}C) and cold (50 ^{O}C) streams, resulting in hot and cold stream outputs of 60 and 120 ^{O}C, respectively. Furthermore, to attain the appropriate temperature, each current must be connected with a cooling and heating utility with lesser power of 30 kW and 160 kW, respectively.

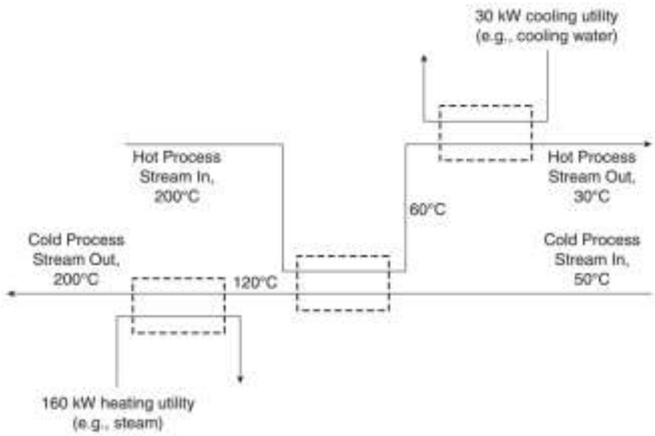

Figure 10. Energy integration to reduce energy consumption (Allen & Shonnard, 2001)

C. Industrial Ecology

The phrase "Industrial Ecology" refers to the study of industrial systems attempting to replicate natural ecosystems' mass conservation characteristics. There are numerous approaches to compare and contrast natural ecosystem evolution with the potential growth of industrial systems. Industrial ecology is a relevant scientific discipline concerned with the knowledge of how to utilize, chemically alter, and recycle effluent, as it permits the transmutation of refuse into raw materials.

For instance, before Techno-Ecological Synergies (TES), the solar energy production life cycle proceeded without considering inventory and needs for ecosystem goods and services, resulting in excess environmental degradation worsened by a lack of financial and management inputs. Solar energy development with TES, on the other hand, begins with a comprehensive accounting of the inventory and needs for ecosystem products and services at appropriate spatiotemporal scales, generates electricity and various technical outputs while simultaneously maximizing favourable ecological outcomes, which are reinforced by capital investment in and management of ecosystems (for example, restoration). Compared to solar energy without TES, solar energy with TES results in a beneficial change in the direction and quantity of flows between the 'natural system' (for example, desert and woods) and the 'technical system' (solar energy improvement) (Hernandez et al., 2019).

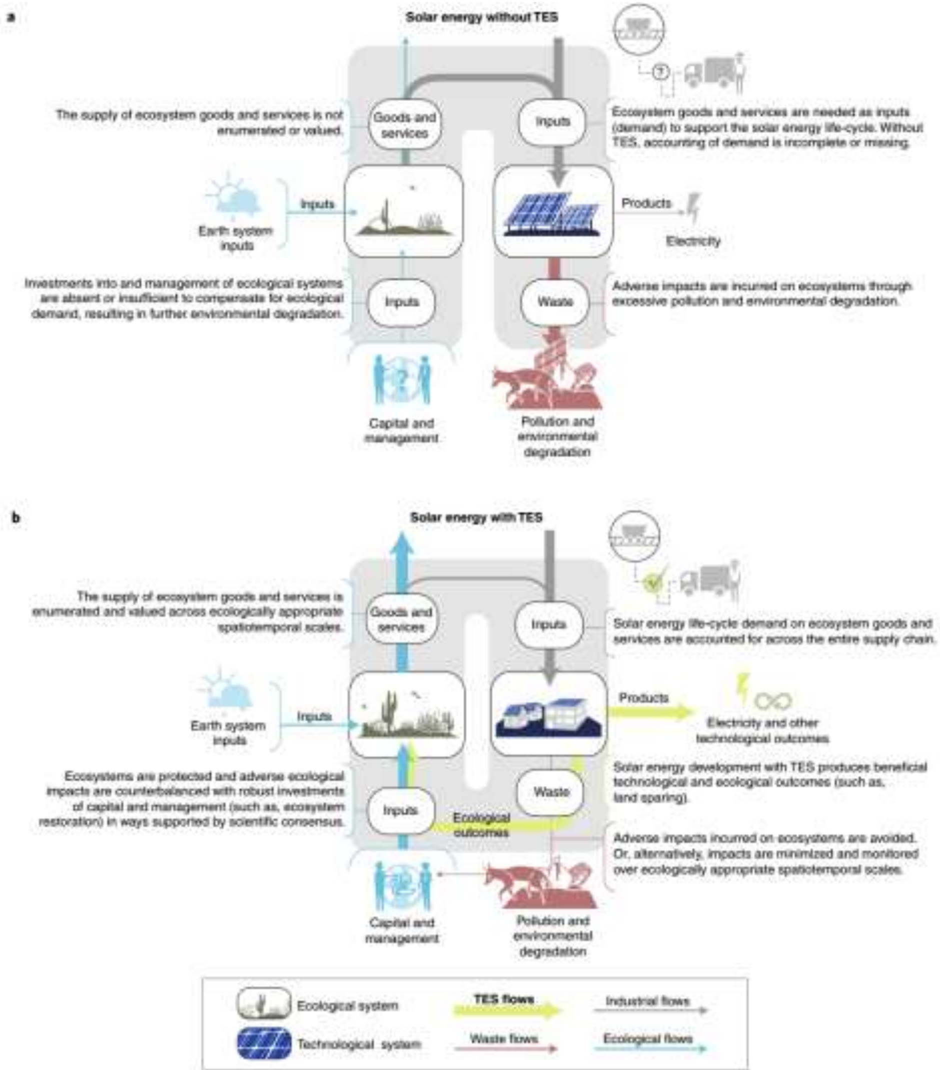

Figure 11. Conceptual model of TES application (Hernandez et al., 2019)

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CHAPTER VIII
WASTE MANAGEMENT EDUCATION FOR INDUSTRY

Elfarisna

8.1 Introduction

The most pressing issue currently facing global national and municipal governments is environmental management. Urban areas are where the majority of the newly constructed industrial estates are situated. This is mostly caused by elements like the accessibility of trained labor, closeness to administrative centers, transportation hubs, communication infrastructure, financial markets, and other auxiliary services. Large quantities of hazardous waste have been produced as a result of rapid industrial expansion. The previously substantial issues with trash disposal have been made worse by these "new" sorts of waste.

In reality, more than 50.000 chemical compounds are employed daily in one million different combinations in industrial, domestic, and agricultural processes. There are many chemical products and by-products that are extremely poisonous and harmful, despite the fact that the majority of them are not dangerous. Numerous industrial, commercial agricultural, and even home activities produce hazardous waste. It could take the shape of a solid, liquid, sludge, or gaseous substance. However, mining, metallurgical, chemical, refining, electroplating, and other processes produce the majority of the hazardous wastes.

As well as causing long-term environmental damage, hazardous wastes have an immediate and short-term negative impact on public health. They might have severe effects on the food and life cycles, which would then have an influence on human health and the natural system. Although evidence implies that certain groups are exposed to significant risk when they are close to particular hazardous-waste sites, the distribution and frequency of these exposures cannot be determined since the necessary data have not been acquired.

In order to prevent contamination from one ecological medium to another, it is vital to develop appropriate disposal and storage techniques. While proper hazardous waste management has a cost, lessons learned from many industrialized nations indicate that the long-term cost of clearing up "past sins" is significantly higher. For instance, in the United States, it is projected that cleaning up incorrectly managed trash will cost 10-100 times more than doing so early on. Therefore, it is crucial that all emerging nations implement controls over hazardous wastes to prevent later incurring such high remediation expenditures.

The government must give the business community instructions on how to handle these hazardous wastes and chemicals. To safely manage and dispose of these wastes and substances, stringent regulatory enforcement and legislative action are essential. The federal and state agencies that now oversee hazardous-waste sites do not have the necessary laws, regulations, or procedures in place to adequately safeguard the public's health. The creation and implementation of safe manufacturing techniques, safe manufacturing processes, and techniques for recycling these wastes and substances into useful resources for reuse may all be encouraged. Hazardous waste management is essential for the sector from the perspective of business firms' social duty as well as the need to adhere to ISO standards, which will impact their ability to compete in international markets.

8.2 Industry Waste

Since the beginning of recorded human history, waste has been a byproduct of human activity. Waste that is both solid and liquid as well as gas will be produced as a result of industrial activity. If not managed appropriately, this garbage could harm the environment. According to the "waste disposal statute," garbage is either "general" or "industrial." "General (Non-hazardous) industrial waste" and "hazardous industrial waste" are further classifications for industrial trash. To identify between the latter two groups, the Environmental Protection Agency (EPA) published " Identification criteria for Hazardous Industrial Wastes." The EPA simultaneously released "Methods and Facilities Standards for industrial Waste Storage, Removal, and Disposal" to improve waste management. Strict management guidelines for the operation of industrial waste that is both general and hazardous are part of these criteria.

Taiwan's regulations give producers of hazardous industrial waste only two options for disposal: self-disposal or contracting with waste management companies (either publicly or privately operated). The government issued a set of "Regulations Governing the Management and Guidance of the Waste Haulage and Treatment Business" under the Waste Disposal Act in order to promote and manage a thriving contractual waste disposal industry.

The rising amount of waste produced by all industrial societies is a part of the modern legacy. Additionally, there is a never-before-seen level of worry about how exposure regimes can affect the environment and public health. Large amounts of trash have been created since the beginning of industrialization, and sometimes it has been disposed of in ways that could be problematic for future generations.

The shift to a green economy is greatly assisted by the trash sector. If we are to achieve the technical and behavioral changes necessary for a sustainable, resource-efficient future, we must continue to provide our society with a fundamental grasp of core competencies. The sector needs young workers who are proficient in science and mathematics and approach problems in a methodical, "can-do" manner.

Numerous well-publicized events of pollution in various industrialized nations have demonstrated that contaminants can move in complicated and poorly understood ways. As a result, a number of laws now demand that better garbage disposal procedures be included in public policy. However, the legacy of previous practices presents a number of challenging problems for decision-makers and scientists regarding how to evaluate the effects of outdated disposal methods on public health and the environment, how to establish the best possible policies to minimize harm in the future, and how much funding should be allocated to these problems.

In Asia, industrial, agricultural, and hospital waste are the three main sources from which hazardous waste is produced. Hazardous wastes typically exhibit poisonous, infectious, corrosive, reactive, and ignitable properties. Only the Republic of China and Singapore among the survey participants have comprehensive records on the amounts of hazardous waste produced. It's possible that the techniques suggested by published literature to calculate the number of hazardous wastes are not always applicable. Based on industrial outputs, the majority of Asian nations assess and forecast the amounts of hazardous waste.

A. Waste Management Education for the Industry

"Generation, prevention, characterization, monitoring, treatment, handling, reuse, and residual disposition of solid wastes" are all parts of waste management. Solid waste comes in a variety of forms, including municipal, agricultural, and special. The process is typically carried out to lessen the impact of the materials on health, the environment, or aesthetics. The word typically refers to materials produced by human activity.

This is a major driving force behind the city's continued development of integrated waste- and environmental initiatives that not only make use of the cutting-edge technology the nation is recognized for but also put a strong emphasis on involving residents in the environment around them. Without community involvement and long-term citizen education, even the best waste management technology and systems will not be sustainable.

A hazardous waste management strategy is a road map that specifies the types of hazardous waste to be handled, how they should be managed, and who should manage them. It should include instructions on how to transport and dispose of this hazardous material, as well as administrative and statutory controls. The strategy must also include additional supporting measures including training, information, and laboratory services.

Developing such a strategy entails identifying and quantifying the issue, developing waste management policies and controls, creating standard terminologies, and correctly classifying hazardous wastes. Meanwhile, efforts should be made to inform companies and the general public about the significance of such a strategy, as well as activities should be launched concurrently to generate political support for a hazardous waste management strategy. In addition to helping to refine the strategy and accompanying measurements, the opinions shared during these initial meetings may also be used to enlist their support and participation in the implementation process.

The specifics of the plan and how the various legal, technical, organizational, and financial components interact would depend on the local conditions present in each nation. The priority should differ from location to location depending on local circumstances and limits as well as natural challenges. In the early stages of formulating the strategy, the roles and duties of the various parties involved should also be determined.

The "known" volumes of hazardous wastes are far smaller than those of wastewater and municipal solid trash because they are mostly produced by industries. The majority of governments cannot afford to use their meager funds to address this "less serious" issue. The government hasn't offered much aid to the companies while adopting the "Polluter Pay Principles" and pressuring them to find solutions for the disposal of hazardous wastes on their own.

A nation's cultural, institutional, technological, political, and economic circumstances will determine whether it should implement a national strategy for managing hazardous waste. The speed at which these nation-specific issues will affect the formulation and implementation of their hazardous waste management legislation. For industries like the ones listed below, there are a number of waste management education initiatives that can be used:

1. Collection, Storage, Treatment, and Disposal of Hazardous Wastes

Two key components of managing hazardous waste are collection and transportation. One of the key components of industrial waste management is an effective collecting network. More emphasis should be put on creating legal frameworks that clearly define the obligations and obligations. Asian nations have not yet implemented appropriate storage practices and regulations in their regions. In addition, only Japan and Singapore may use the manifest system to collect and transport hazardous materials on a regular basis. Practically speaking, the collection bins serve as sporadic storage areas. There is routine lifting.

There are numerous, well-documented hazardous waste treatment systems available. Prior to final disposal, these methods seek to alter the chemical and/or physical characteristics of hazardous wastes. They lessen the amount of waste produced while immobilizing or detoxifying the poisonous elements. However, small and medium-sized firms (SMEs), which make up more than 90% of industries in Asian nations, typically lack the technical and financial resources necessary to process these hazardous wastes on their own before disposal.

The industrial process can be changed so that the raw material is used as efficiently as possible and the hazardous waste produced is kept to a minimum. For instance, in the process of electroplating zinc, the cyanide issue can be resolved by changing the sulfate salt from the chloride compound to the sulfate salt. Evaporation, precipitation, or the decapitation technique can all be used to concentrate wastes. The waste volume is significantly decreased in these methods. Waste disposal often involves incineration. The volume of garbage is also reduced by separating hazardous wastes from non-hazardous wastes.

It is crucial to properly manage hazardous waste, which may entail I physical treatment (ii) chemical treatment (iii) solidification (iv) incineration (v), and (v) biological treatment. Hazardous chemical waste needs to undergo treatment to detoxify and neutralize it. The physicochemical characteristics of the trash will determine which treatment method is used. Physical treatment options include sludge drying in beds, long-term storage in tanks, and phase separation techniques like lagoons. Particulate contaminants can be separated using these techniques. Hazardous waste can be completely broken down with the help of chemical treatment, which also balances acidity and alkalinity. This entails processes including oil/water separation, chemical reduction, heavy metal precipitation, and oxidation.

Facilities for the comprehensive and central disposal of hazardous waste are widespread in Asian nations. Even safe landfills are rare in many poor nations. In Thailand, Hong Kong, and Malaysia, there are centralized facilities for the treatment of hazardous waste. A few of the member nations are now designing and building suitable facilities for disposing of hazardous waste. In some nations, incineration is used to treat medical waste.

Policies and regulations must be implemented for the storage, collection, and transportation of hazardous wastes in Asian nations, notably in the application of the manifest system. Furthermore, in order to prevent the careless dumping of hazardous wastes, adequate disposal facilities are urgently required.

The Environmental Protection Agency (EPA) currently supports a hierarchy for pollution prevention that places an emphasis on lowering the production of hazardous waste. This calls for the following tactic:

1. Cut back on pollution at its source.
2. When feasible, recycle garbage.
3. Wastes should be treated to lessen their volume or risk.
4. As a last option, burn rubbish or dispose of it on land.

2. Green Productivity for Hazardous Waste Management

Green productivity is a technique to improve environmental and socioeconomic performance while increasing productivity. In addition to saving money on treatment and disposal expenses, many industries that had adopted green productivity programs also saw financial gains from lower manufacturing costs and higher product yields. The Republic of China and Singapore actively promote green productivity, and their industries profit from reducing, recycling, and reusing hazardous waste. With the adoption of the green route, an industry's environmental performance is increasingly seen as a crucial component of its national commitment to environmental protection.

For the decrease of hazardous wastes in terms of quantity and/or toxicity, Asia's green productivity is a crucial hazardous waste management method. Green productivity practices strive to lessen the production of hazardous wastes at the point of generation and during the subsequent stages of their reduction, storage, and disposal. If it is both technically possible and financially practical, reducing the generation of hazardous waste provides benefits in and of themselves.

However, there would be barriers in the cultural, institutional, technological, political, and economic contexts that would prevent the successful implementation of green productivity techniques. Therefore, strategies should be developed in each nation to get over these limitations.

The ability to recycle and reuse their industrial wastes on-site is often inadequate in SEMs. With the development of commercial recycling facilities and/or the direct transportation of these wastes to other consumers, the off-site recycling facility is growing in popularity. As one of the key elements of its hazardous waste management program, the government should offer incentives to encourage green productive initiatives.

It is commonly acknowledged that in order to achieve sustainable development in business and industry, we must shift to a "Green Economy." To accomplish this goal, consumers and the business community must change what is generated, how it is created and utilized, how it is disposed of, and/or how it is recovered. Society, in both rich and developing nations, must fully comprehend the effects of this transformation.

3. Human Resources Development

A team of skilled employees is necessary to put hazardous waste management policies into practice and oversee them. The technological proficiency of Asian nations in managing hazardous waste has not yet attained the expected requirements. Most nations depend on the technical assistance of developed nations to train their labor force. Asian nations need additional training in the creation and application of technologies that are suitable for their unique circumstances. The majority of environmental training that was previously funded by international organizations used methods and fixes that were common in wealthy nations, few of which were appropriate for solving issues in developing nations. Such instruction could prove ineffectual.

The senior government officials who may attend these training sessions hosted by international organizations benefit greatly from the exposure they receive. There is an urgent need for national training programs for engineers, industrialists, and other government officials to advance the technological capabilities of Asian nations in handling hazardous waste. The developed nations should help transfer technologies for managing hazardous waste, and their investments in Asian nations should also include proper environmental protection measures.

Non-governmental organizations (NGOs) and international organizations and financial agencies can act as catalysts in advancing hazardous waste management technology transfer operations. These organizations and agencies might offer financial support for the recruitment of regional or worldwide experts with knowledge of local or regional issues who can train the staff in these developing nations on the promotion of hazardous waste management.

The region's nations should work together to achieve the same goal of reducing pollution and environmental deterioration. The management of hazardous waste and its features are influenced by factors such as living standards, culture, climate, technology, and industrialization level. Instead of importing technology from developed nations with distinct environments, it is more acceptable to learn from nations with similar historical backgrounds. The developing nations in the same region might more actively exchange knowledge and experiences on the management of hazardous waste.

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CHAPTER IX
WASTE MANAGEMENT EDUCATION FOR STUDENTS

Iin Arianti

9.1 Definitions

This book about waste management education for students. It is a commendable initiative. It's an important topic that can help create awareness and inspire positive environmental actions.

According to Julia K. Steinberger and Maurie J. Cohen (2019), waste management is the set of processes and actions required to minimize the adverse environmental and social impacts associated with waste generation and disposal. It involves the implementation of strategies for waste reduction, reuse, recycling, and appropriate treatment technologies. [1]

Waste management is one of the most important environmental problems of our time,

posing a great danger to both the environment and the present and future generations. This is an urgent issue for the world community in the framework of the concept of sustainable development and conservation of ecosystems of the sea and land. To solve the problem of the generation and use of waste means to find a way out of the growing environmental crisis in which humanity is currently living and which can lead to the destruction of society [2].

Why waste management education for students is important? Waste management education for students is crucial for several reasons:

1. Waste management education raises students' awareness about the environmental impacts of waste. It helps them understand how improper waste disposal, excessive consumption, and lack of recycling contribute to pollution, resource depletion, and habitat destruction. By educating students, we can cultivate a sense of environmental responsibility and encourage sustainable practices.

2. Education plays a pivotal role in fostering behavior change. By teaching students about waste management, we can in still lifelong habits and attitudes that promote waste reduction, recycling, and responsible consumption. When students understand the consequences of their actions, they are more likely to make informed choices and actively contribute to waste reduction efforts.

3. Waste management education emphasizes the importance of resource conservation. Students learn about the value of materials and resources and how waste reduction, reuse, and recycling can help preserve natural resources, reduce energy consumption, and minimize the need for raw material extraction. This knowledge encourages a shift towards a circular economy mindset.

4. By educating students about waste management practices, we empower them to become active participants in waste reduction efforts. They learn how to minimize waste generation, adopt practices such as composting and recycling, and make conscious choices to reduce packaging and single-use items. Students can also become advocates for waste reduction within their families, schools, and communities.

5. Waste management education extends beyond the individual level. It encourages students to engage with their communities, raise awareness, and actively participate in waste management initiatives. By involving students in community clean-up campaigns, recycling programs, or composting projects, we foster a sense of ownership and collective responsibility towards waste management.

6. Waste management education nurtures responsible and sustainable citizenship. It equips students with the knowledge and skills to become environmentally conscious citizens who understand the interconnectedness between their actions and the well-being of the planet. By educating students, we prepare them to make informed decisions and contribute positively to a sustainable future.

Ongoing environmental education programs for pre-schoolers are scarce. Those that do exist tend to be affiliated with either early childhood education settings or environmental education settings [3].

I. Discussion

Waste management education empowers students to become agents of change in creating a more sustainable and environmentally friendly society. It equips them with the knowledge, skills, and mindset necessary to make conscious choices, promote waste reduction, and actively participate in creating a cleaner and healthier world [4][5][6]. There are several things that need to be done so that waste management education for students can be successful, as follows:

A. The Target Audience

Students who will be given education about waste management are divided into 3 groups. Educating students in primary, middle, and high schools requires an understanding of their developmental stages and learning abilities [7]. Here are some strategies to effectively educate students in each of these age groups:

1. Primary School Students (Ages 6-11):

- Keep it interactive: Utilize hands-on activities, experiments, and games to engage young students. Incorporate visual aids, such as colourful illustrations and diagrams, to facilitate understanding. Here are some examples of interactive methods to educate primary school students about waste management:

- Sorting Game: Create a hands-on sorting game where students categorize different items as recyclable, compostable, or landfill waste. Provide bins or containers labeled with these categories and have students place the items in the appropriate bins. This activity helps them understand the importance of proper waste segregation.
- Recycling Relay Race: Organize a relay race where students form teams and compete to correctly sort and recycle a set of waste items. Each team member takes turns running to a sorting station and placing the items in the correct recycling bins. This activity combines physical activity and waste management education, making it engaging and fun.
- Waste Audit: Conduct a waste audit in the classroom or school. Students can collect and sort waste for a specified period, record the types and amounts of waste generated, and analyse the results. This activity allows them to observe firsthand the amount of waste produced and explore ways to reduce it.
- Recycled Art Project: Encourage students to create art projects using recycled materials. Provide a variety of recyclable items like paper rolls, plastic bottles, and cardboard boxes. Students can let their creativity shine by transforming these materials into artwork, emphasizing the concept of reuse and upcycling.
- Waste Reduction Pledge: Have students make personal commitments to reduce waste. Ask them to write or draw their pledge on a large chart or poster, and display it prominently in the classroom. This activity reinforces the idea that everyone can make a difference by adopting simple waste reduction practices.
- Field Trip to Recycling Center: Organize a field trip to a local recycling center. Students can observe the recycling process, learn about different types of recyclables, and understand how recycling helps protect the environment. This first-hand experience creates a lasting impact and reinforces the importance of recycling.

- Guest Speaker or Environmental Expert: Invite a guest speaker, such as a waste management professional or environmental expert, to talk to students about waste management. They can share their experiences, provide practical tips, and answer students' questions. This interaction exposes students to real-world expertise and motivates them to take action.
- Storytelling approach: Use storytelling techniques to convey waste management concepts. Create relatable characters or narratives that highlight the importance of waste reduction, recycling, and environmental conservation.
- Simplify the language: Use simple and concise language to explain waste management practices. Break down complex ideas into smaller, easily understandable parts.
- Focus on practical actions: Emphasize practical actions they can take, such as sorting recyclables, composting organic waste, and reducing single-use items. Encourage participation in recycling programs at school and home.

2. Middle School Students (Ages 12-14):

- Connect with their interests: Relate waste management education to their interests and daily lives. Discuss the impact of waste on the environment, climate change, and sustainability.
- Promote critical thinking: Encourage students to think critically about waste-related issues. Foster discussions and debates on topics like consumerism, waste generation, and the importance of responsible consumption.
- Project-based learning: Assign projects or group activities that allow students to research and propose solutions to waste management challenges. This can include designing recycling campaigns or exploring innovative waste reduction ideas.
- Field trips and guest speakers: Organize field trips to recycling facilities, waste management centers, or invite guest

speakers from environmental organizations to provide real-world experiences and insights.

3. High School Students (Ages 15-18):

- In-depth exploration: Provide more comprehensive information about waste management practices, including waste hierarchy, landfill management, waste-to-energy technologies, and circular economy principles.
- Encourage research and analysis: Assign research projects or essays on waste management topics. Encourage students to analyse the environmental, social, and economic impacts of waste and propose sustainable solutions. Foster leadership and activism: Empower students to take a leadership role in waste management initiatives. Encourage them to organize awareness campaigns, initiate recycling programs, or advocate for sustainable practices within their school or community [8].
- Collaboration with experts: Collaborate with waste management professionals, environmental scientists, or sustainability experts to provide guest lectures or mentorship opportunities. This can offer students insights into real-world waste management challenges and potential career paths.

Here are some examples of interactive methods to educate middle and high school students about waste management:

Waste Reduction Challenge: Organize a waste reduction challenge where students compete to reduce waste in their classrooms or schools. Provide them with tools and resources to track and measure their progress, such as waste audit sheets and monitoring charts. Encourage creative solutions and reward the most effective waste reduction efforts.

Waste-Free Lunch Campaign: Initiate a waste-free lunch campaign where students are encouraged to pack lunches with minimal packaging and waste. Conduct awareness sessions, provide tips for waste-free lunch options, and recognize students who consistently bring waste-free lunches. This campaign can be accompanied by discussions on the impact of single-use plastics and alternatives.

Upcycling Workshop: Organize an upcycling workshop where students learn to repurpose and transform waste materials into useful or decorative items. Provide a variety of materials like fabric scraps, old CDs, or bottle caps. Students can work individually or in groups to create upcycled products and showcase their creativity and innovation.

Waste Management Debate: Divide students into groups and assign them different waste management topics to debate. Examples of topics could include the effectiveness of recycling programs, the pros and cons of waste-to-energy technologies, or the responsibility of manufacturers in reducing waste. Encourage critical thinking, research, and evidence-based arguments during the debate.

Design a Recycling Campaign: Have students work in teams to design a recycling campaign for their school or community. They can create posters, videos, or social media campaigns to raise awareness about the importance of recycling and proper waste management. This activity promotes teamwork, creativity, and leadership skills.

Waste Management Simulation Game: Develop a waste management simulation game where students make decisions regarding waste management practices and observe the consequences of their choices. This interactive game allows students to understand the complexities of waste management and explore the impact of different strategies on the environment.

Guest Speaker Series: Organize a series of guest speakers from various waste management sectors, such as recycling facilities, composting centers, or environmental organizations. These experts can share insights, success stories, and challenges related to waste management. Students can engage in Q&A sessions, learn from real-world experiences, and gain inspiration for their own waste management initiatives.

These interactive methods for middle and high school students foster active learning, critical thinking, and engagement. They encourage students to think beyond the classroom and apply their knowledge to real-world situations, empowering them to become environmental advocates and agents of change [9].

B. Learning from Countries Have Implemented Waste Management Education

Several developed countries have implemented waste management education initiatives targeted at students. Here are some examples from Australia, the United States, England, Japan, and China:

Australia

Clean Up Australia Schools Program: This program encourages schools to participate in clean-up activities, waste audits, and recycling initiatives. It educates students about waste management, litter prevention, and environmental conservation.

Resource Smart Schools: An initiative in Victoria that promotes sustainability education, including waste management. It offers resources, tools, and support to schools to implement waste reduction programs, composting, and recycling initiatives.

United States

Eco-Schools USA: This program, run by the National Wildlife Federation, focuses on sustainability education in K-12 schools. It includes waste management education, recycling programs, energy conservation, and ecological projects.

Zero Waste Schools Program: Various cities and states have launched zero waste programs in schools, aiming to reduce waste sent to landfills through recycling, composting, and waste reduction strategies.

England

Eco-Schools Programme: Managed by Keep Britain Tidy, this program empowers students to lead environmental action in their schools. Waste management education is a key component, with schools working towards reducing waste, increasing recycling, and promoting sustainability.

Waste and Resources Action Programme (WRAP): WRAP offers resources and guidance for schools in England to implement waste reduction initiatives, including composting, recycling, and food waste prevention.

Japan

Environmental Youth Ambassadors Program: Run by the Ministry of the Environment, this program aims to cultivate environmental leaders among students. It includes waste management education, with a focus on recycling and waste reduction.

Waste Management Education in Schools: Local governments in Japan often incorporate waste management education into school curricula. They provide educational materials, conduct waste separation workshops, and organize waste-related events [10].

China

Environmental Education Programs: China has implemented various environmental education programs, including waste management education in schools. These programs emphasize waste sorting, recycling, and responsible waste disposal practices.

Green Schools Initiative: This initiative encourages schools to adopt sustainable practices, including waste reduction and recycling. Schools are encouraged to develop waste management plans and implement waste separation and recycling systems.

South Korea

South Korea has also implemented waste management education initiatives targeting students. South Korea integrates environmental education, including waste management, into the national curriculum. Students learn about waste reduction, recycling, and responsible waste disposal practices through textbooks and classroom activities. South Korea has a comprehensive waste separation and recycling system. Students are educated about the importance of waste separation and how to properly sort recyclables, food waste, and general waste. Schools often have separate bins and educate students on the appropriate use of each bin. The South Korean government organizes environmental youth camps where students learn about various environmental issues, including waste management. These camps include educational workshops, hands-on activities, and field trips to waste treatment facilities, promoting a better understanding of waste management practices. South Korea hosts environmental competitions and contests for students, encouraging them to showcase their knowledge and ideas on waste management. These competitions often involve projects related to waste reduction, recycling, and environmental conservation. Waste Management Education Campaigns: Non-governmental organizations and local governments in South Korea launch waste management education campaigns targeting schools. These campaigns include interactive presentations, workshops, and events to raise awareness about waste-related issues and promote sustainable waste management practices among students.

South Korea's waste management education initiatives aim to develop environmentally conscious citizens and promote a culture of waste reduction and recycling from a young age. By integrating waste management education into the curriculum and providing practical experiences, South Korea emphasizes the importance of responsible waste practices among its students.

These examples demonstrate how developed countries have taken proactive measures to educate students about waste management. The initiatives often include a combination of curriculum integration, practical activities, community engagement, and partnerships with relevant organizations to promote environmental awareness and sustainable waste practices among students. A zero-waste strategy needs to ensure everyone has access to tools to reduce, reuse and recycle waste where they live, work and play. This will let individuals to participate in saving the environment [11].

9.2 Conclusion

Indonesia is a waste-producing country, maybe because the population continues to increase every year, so several efforts must be made. What should Indonesian do now?

Waste management education is vital for students in primary, middle, and high schools. It helps raise awareness about the environmental impacts of waste, fosters responsible behavior and attitude towards waste reduction, recycling, and proper waste disposal, and promotes resource conservation and sustainable citizenship.

Interactive methods can be employed to engage students in waste management education. For primary school students, activities like storytelling, games, and hands-on projects can be used. Middle and high school students can benefit from interactive workshops, discussions, case studies, and field trips to waste management facilities.

Several developed countries such as Australia, the United States, England, Japan, and China have implemented various waste management education initiatives targeting students. These include educational programs, campaigns, competitions, and practical projects aimed at promoting waste reduction, recycling, and environmental awareness among students.

In Indonesia, efforts are being made to educate students about waste management. The country has integrated waste management education into the curriculum, implemented waste separation programs, organized campaigns and workshops, and encouraged community participation in waste management initiatives. However, further actions are needed, including strengthening waste management infrastructure, promoting recycling and composting, raising awareness, and fostering collaboration between government, private sector, and civil society.

Indonesia, as a waste-producing country, can take steps to address the waste management challenges. Individuals can reduce waste generation, practice proper waste segregation, support recycling and composting, advocate for improved waste management, participate in clean-up initiatives, and embrace circular economy principles. Collectively, these actions can contribute to a cleaner and more sustainable environment.

Overall, waste management education and proactive efforts at individual, community, and national levels are essential to tackle the waste management issues in Indonesia and create a more sustainable future.

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BAB X
WASTE REGULATION AND ENVIRONMENTAL PROTECTION

Andiyan

The living environment is everything that surrounds humans and is mutually related. The opposite of the living environment is the artificial environment, which includes areas and their components that are heavily influenced by humans. This study is based on various laws and regulations, especially Law Number 32 of 2009 concerning Environmental Protection and Management, as well as other references(Angga & Suat, 2019; Firmansyah & Rahayu, 2021; Labetubun & Taufik, 2021; Listiyani & Said, 2018; Saepudin, Rachmawati, Kuncoro, & Angretnowati, 2022; Usman & Saleng, 2022). And the results of interviews with community representatives in the Barugbug Dam environment in Karawang Regency. The problems raised in this study are what are the factors that cause environmental pollution due to hazardous and toxic (B3) industrial waste and how is law enforcement against environmental pollution due to hazardous and toxic (B3) industrial waste to Law Number 32 of 2009 concerning Environmental Protection and Management. Law Number 32 of 2009 concerning Environmental Protection and Management states that the declining quality of the environment has threatened human survival and increasing global warming has resulted in climate change(Angga & Suat, 2019; Belladona, 2017; Firmansyah & Rahayu, 2021; Hendrawan, Andersen, & Dewi, 2020; Labetubun & Taufik, 2021; Listiyani & Said, 2018;

Saepudin et al., 2022; Usman & Saleng, 2022). So that before the environment is increasingly damaged and cannot be replenished, it is important for humans to keep the environment alive and not just extinct due to the actions of humans themselves.

10.1 What are the local government's efforts in handling environmental pollution control due to industrial waste

Before entering into the implementation of article 13 of Law Number 32 of 2009 related to Environmental Protection and Management of environmental pollution due to industrial waste the law is law that was drafted to protect or overshadow all the rules under it related to the environment(Angga & Suat, 2019; Firmansyah & Rahayu, 2021; Labetubun & Taufik, 2021; Listiyani & Said, 2018; Saepudin et al., 2022; Usman & Saleng, 2022). That the principle of several regulations related to environmental management must be based on the Law on Environmental Protection makes this law always be implemented, one of which is implementing article 13. In the explanation of the article, environmental pollution control with the prevention, control, and recovery efforts. From the description above, if we adapt it to the problem, it can be said that environmental pollution due to industrial factory liquid waste is caused by humans themselves who carry out industrial activity business activities. The river is aware of one of the most polluted rivers, the source of river water pollution stems from industries that produce high BOD COD TSS pollutant parameters which often dispose of by-products of their production activities exceeding the quality standards flow into the river stream river. BOD and COD are key parameters to determine water quality. According to the Department of Environment, the industry is the main cause of river pollution as follows;

Table 1. Types of Watershed Pollution Sources

No	Pollutant Source Type	Percentage
1	Industry	60%
2	Food processing	45%
3	Household	38%
4	Agriculture and irrigation channels	43%
5	Laundry	38%
6	Hotel	25%
7	Health services	40%

The problem of river pollution has occurred since several years ago, but until now pollution is still a complex problem that has not been able to be resolved(Saputra & Dhianty, 2022). Thus, the Environmental Service as an agency must have the authority to carry out control efforts by Article 13 of Law No. 32 of 2009 concerning environmental protection and management(Angga & Suat, 2019; Firmansyah & Rahayu, 2021; Labetubun & Taufik, 2021; Listiyani & Said, 2018; Saepudin et al., 2022; Usman & Saleng, 2022; Wildan, 2022).

While quality standards are a measure of the limits or levels of living things energy substances components that exist or must exist which are elements of pollutants that are tolerated by the truth of their existence in a particular resource as an element of the environment(Leo & Nainggolan, 2022). According to the law, waste by-products from industrial activities should not be directly released into the environment even into the river flow without a waste management process according to the provisions of quality standards, if this is not considered then the waste will exceed the quality standard threshold resulting in various river ecosystem problems and adversely affecting the surrounding community who use river water as a daily necessity. Therefore, as humans, it is necessary to have the awareness to pay attention to events that have the potential to damage the environment(Indrastuti & Saputra, 2022). The environment that we have damaged, can be immediately rehabilitated to prevent further damage. The provisions of wastewater quality standards for those found in the pulp and paper industry are as follows;

Table 2.Wastewater quality standards contained in the pulp and paper industry

Wastewater quality standards for the pulp and paper industry						
Product Type		Volume Maks (M3/ton)	Parameters			
			Maximum Level (mg/L)			
			BOD_5	COD	TSS	pb
A	Pulp Products					
	Kraft bleached	80	100	300	100	-
	Soluble Pulp	90	100	300	100	-
	Unbleached Kraft	50	75	200	60	-
	Mechanical and Ground Wood Chemistry	60	50	120	75	-
	Semi-chemical	70	100	200	100	-
	Soda Pulp					
	Deinking Pulp (from waste paper)	80	100	300	100	-
B	Till Paper Products					
	Smooth Paper	130	100	250	100	0.1
	Rough Paper	90	80	200	80	-
	Cigarette Paper	170	60	185	70	-
	Other papers that are stretched	95	80	160	80	0.1
pH		6-9				

Article 13 of the Law on Environmental Protection provides a systematic effort in controlling environmental pollution or damage, it must be carried out utilizing prevention, control, and recovery of the 3 aspects carried out by the central government, local government, and the person in charge of the business who has the authority of their respective roles and responsibilities(Saepudin et al., 2022). That way the legal product should be applied effectively and efficiently in all forms of any problems that have a relationship to environmental damage. There are many instruments for preventing factory waste pollution that is accommodated and regulated in the law, but there are several important issues that must be underlined regarding pollution control due to industrial factory waste, where the impact of pollution damages the quality of the environment, especially waters as one of the needs of mankind and other living things. Rivers can be a source of disaster if the ecosystem is not maintained, both in terms of benefits and protection. We can see what is happening in the river kali, along with efforts to improve the economy and welfare of citizens, the development of industrial areas for national economic development in the current era of globalization is increasing rapidly(Prasetyo & Murtini, 2022). The number of people in charge of businesses violates the rules in the disposal of by-products of their business production activities, business actors neglect to dispose of waste from production into waters, the waste indicates organic pollutants (has a foul odor) and inorganic pollutants (bubbly and has color) resulting from its production, this causes environmental pollution, the intended environmental pollution is water pollution. Supposedly, to avoid water pollution, the by-products of industrial discharges should be processed in advance with waste management techniques according to the standard quality standards of liquid waste, after meeting the standard quality standards of new waste water can flow into several sewers or rivers(Wildan, 2022). Therefore, the community needs to strive to prevent and deal with water pollution.

The implementation of article 13 of Law No. 32 of 2009 related to Environmental Protection and Management related to industrial waste pollution cases is not fully implemented alone, of course, there are other supporting laws and regulations or separate regulations that complement the environment in organizing environmental pollution control caused by industrial waste(Angga & Suat, 2019; Belladona, 2017; Firmansyah & Rahayu, 2021; Harahap, Gunawan, Suprayogi, & Widyastuti, 2021; Labetubun & Taufik, 2021; Listiyani & Said, 2018; Risdawati, 2022; Saepudin et al., 2022; Usman & Saleng, 2022).

Following PP No. 82 of 2001 related to water quality management and water pollution control article 21 paragraph (1) for activities that have the potential to establish national wastewater quality standards set following the decision of the Minister of population and environment Number: 122 of 2004 concerning Amendments to the decision of the minister of the state of the environment Number: KEP-51 / MENLH / 10/1995 concerning Liquid Waste Quality Standards for Industrial Activities the decision lists the procedures for granting liquid waste disposal permits which are determined based on the maximum level of each parameter and the maximum liquid waste discharge that must not be exceeded(Angga & Suat, 2019; Firmansyah & Rahayu, 2021; Harahap et al., 2021; Labetubun & Taufik, 2021; Listiyani & Said, 2018; Risdawati, 2022; Saepudin et al., 2022; Usman & Saleng, 2022; Yusni & Melati, 2020). Each parameter or maximum effluent discharge is only allowed to be exceeded as long as the maximum pollution load is not exceeded. Because every industrial activity can trigger environmental pollution, it is, therefore, necessary to control the disposal of liquid waste by determining effluent quality standards. Not only that, juridically in handling industrial wastewater pollution, other regulations support Law Number 32 of 2009, namely the Minister of Environment Regulation Number 5 of 2014 concerning Wastewater Quality Standards(Angga & Suat, 2019; Firmansyah & Rahayu, 2021; Labetubun & Taufik, 2021; Listiyani & Said, 2018; Saepudin et al., 2022; Usman & Saleng, 2022). The regulation of the Minister of the Environment contains implicitly the handling of wastewater quality standards for businesses / or activities(Pramulya, Bantacut, Noor, & Yani, 2019). This Ministerial Regulation aims to clear references regarding wastewater quality standards to first, the Governor in determining wastewater quality standards must guarantee the carrying capacity and capacity of the environment based on its designation, second as a guideline for the preparation of environmental documents such as AMDAL, UKL-UPL or study documents for wastewater discharges to water bodies by producing more specific wastewater quality standards(Kotijah, 2018). If the results of the study show that the wastewater quality standards set by this Ministerial regulation result in the carrying capacity and capacity of the pollution load already exceeding, the governor following his authority is obliged to determine the value of wastewater quality standards specifically and strictly from the wastewater quality standards in this Ministerial regulation. This shows that the Law on Environmental Protection is a general regulation that is a benchmark in formulating ministerial regulations, government regulations, and regional regulations where each of its considerations will be a reminder in formulating the regulations below it, including in handling pollution due to industrial factory wastewater.

Article 13 of Law No. 32 of 2009 related to Environmental Protection and Management that the control of pollution and environmental damage is carried out to preserve the function of the environment includes 3 important aspects of prevention, control, and recovery(Angga & Suat, 2019; Firmansyah & Rahayu, 2021; Labetubun & Taufik, 2021; Listiyani & Said, 2018; Saepudin et al., 2022; Usman & Saleng, 2022; Wildan, 2022). Thus, if we look at the phenomenon of pollution that takes place in the conscious river in Sukoanyar village due to the presence of industrial waste, it is included in water pollution which should currently be carried out to overcome and restore water quality even though it is substantially ineffective and efficient. Pollution due to industrial factory waste that occurs in the river kali has also violated article 20 paragraph (3) of Law No. 32 of 2009 related to Environmental Protection and Management explaining that "every person is allowed to dispose of waste into environmental media with the requirement to meet environmental quality standards and obtain permission from the regent following his authority"(Angga & Suat, 2019; Firmansyah & Rahayu, 2021; Harahap et al., 2021; Labetubun & Taufik, 2021; Listiyani & Said, 2018; Saepudin et al., 2022; Usman & Saleng, 2022). From the findings, there are media reports or complaints from the public about a company that has problems with its waste, that the company has problems with its wastewater disposal installation. From the findings, the factory's problems began with the exhaustion of aerobic anaerobic nutrient nutrients from the oxidation system as waste decomposing bacteria, so finally the biological process was not perfectly processed as a result there was water seepage from the final settling basin of wastewater collection from the circulation pump channel. The processing of anaerobic aerobic nutrient raw materials from abroad is also without being balanced In this case the person in charge of the business has violated Article 8 of the governor's regulation Number 72 of 2013 jo Number 52 of 2014 proven not to carry out wastewater management properly so that wastewater discharges in the discharge of water quality standards. They have tried to fix any problems in the management of the liquid waste, the company has made improvements to the WWTP by adding a settling basin and giving a special substance to neutralize odors in organic chemicals but the claims of the person in charge have not been proven even more the substance still exceeds the quality standards. Based on the monitoring conducted, it was found that several rivers have organic and inorganic parameters that are outside the predetermined quality standards, due to industrial activities. Based on the results of laboratory tests of liquid waste quality, it is known that liquid waste in several industrial factories shows pollutant parameters (TSS, DO, BOD, COD, N, P, and Fe), which indicates that the pollutant parameters are caused by pollutants from the parameter Organic and inorganic chemical wastewater resulting from industrial business activities that do not comply with the quality standards that have been determined. If these problems are not addressed immediately and the carrying capacity of the environment is reduced, the damage to river water quality will be even worse in the future(Firmansyah & Rahayu, 2021).

Environmental control and management are consistent and consequent efforts to prevent, overcome and restore the environment polluted by waste. In terms of the impact of river functions, it can lead to a decrease in water quality, extinction of species, and disruption of environmental balance(Juniah, Dalimi, Suparmoko, & Moersidik, 2018). actually environmental pollution prevention activities are indeed our field but we are limited by whether the prevention activities appear or not, so we cannot carry out prevention activities but there is no phenomenon of pollution this depends on the budget as well, in general prevention is carried out with the prokasih program or commonly called clean production with the implementation of mobile sewage suction for small industries that do not have IPAL to reduce waste from the source, then conduct socialization of waste management and domestic waste, socialization of laws and regulations, socialization of wastewater management, socialization of B3 waste management for the awareness of the surrounding community as well as business actors which is very difficult so it takes a long time, not to mention that the community does not know the complaint procedure in the event of pollution and the regulations in the law Not only that, the village government invites the local community to require mutual cooperation in cleaning the river regularly if the river is polluted, the best step is to clean and neutralize the river.

Based on the explanation above, various prevention efforts have been made related to water pollution as follows;

1. Prevention

a. Implementation of cleaner production

The implementation of the mobile sewage suction program is done only for small-scale industrial companies where the industry does not have a wastewater management installation. This program aims to reduce waste from its source by reducing the volume of discharge to reduce the volume of waste and increase the amount of waste that can be treated again. Efforts to reduce waste from the source according to the scheme that can be practiced include saving water use, saving the use of chemicals, modifying the wastewater management process, and maintaining factory cleanliness. The program includes the efforts of the Environmental Agency which aims to produce clean and environmentally friendly products in small and large-scale industrial activities.

b. Extension/socialization

Along with the increase in economic activity and development has an impact on pollution, the selection of industrial development locations makes the industry's dependence on rivers as a medium for disposing of waste higher, thus increasing the burden of pollution on rivers, several things to prevent this, the environmental service office has made several efforts, namely socialization of waste management and domestic waste, socialization of laws and regulations, socialization of wastewater management, socialization of hazardous waste management, not only that in efforts to prevent the community from being involved in the form of rapid response to pollution complaints, then as a preventive effort in the implementation of the Law-PPLH, the environmental service office develops easy tools in efforts to monitor water quality. As a curative effort, the local village government requires cooperation in cleaning the river regularly if the river is polluted, the best step is to clean and neutralize the river. This is done to provide knowledge so that the community can oversee the supervision and law enforcement of water pollution.

c. Industrial effluent management

Liquid waste management can be done in 3 ways, namely physical management carried out by precipitation, filtration, and absorption chemical management carried out by neutralization, and biological management carried out by biofilters and activated sludge, three liquid waste management must require a lot of water so that the need for water in the waste management process will be very high in outline to reduce the levels of polluting substances (organic and inorganic pollutants) in paper industry wastewater, efforts are made to reduce the volume of wastewater by using chemicals that provide low levels of pollution and reduce the use of hazardous materials in the production process of environmentally friendly industrial activities.

d. Enactment of Strategic Environmental Assessment (SEA)

As an instrument to prevent environmental pollution. The preparation of SEA is aimed at implementing the principle of sustainable development in the development of an area. SEA was enacted to prove that instruments that were previously available but could not prevent and overcome the emergence of environmental problems such as Amdal were seen as not solving various environmental problems to the fullest, considering that environmental problems exist in the order of policies and activities. Noting that the use of natural resources must be in harmony, harmony, and balance with environmental functions.

2. Countermeasures

To overcome the consequences of industrial activities, various local government officials and the Environmental Agency as policy implementers are involved in both the supervisory function, but the environmental agency is more competent in this control problem, especially in monitoring and supervising whether industrial companies are following the provisions of government regulations and laws as follows;

a. Coaching

Coaching is carried out to socialize the quality standards of liquid waste to industrial companies so that they can carry out their liquid waste management according to the quality standards that have been determined and the reporting system(Patmawati & Alwathan, 2018). In addition, the environmental service takes corrective action if the company continuously violates the rules without any initiative to correct mistakes, by freezing environmental permits or revoking permits from related parties that issue licenses, the environmental service only provides recommendations on these issues to the person in charge of the business, usually, the revocation of the permit temporarily lasts for 3 months, the company is closed and no activity is allowed(Saepudin et al., 2022).

b. Surveillance

Supervision is an action taken to monitor or assess the level of compliance with business activities that cause environmental impacts in the form of pollution or environmental damage to applicable regulations. Supervision is carried out to inspect environmental documents so that environmental permit recommendations during business activities take place are evaluated periodically and supervise the compliance of medium and large-scale industrial companies in the region with environmental permits, environmental impact analysis, RKL / RPL, and UKL-UPL this is done to minimize the ongoing violations of business activities in the Mojokerto Regency area. The prerogative scale of supervisory officials in business activities that have environmental permits, especially companies that meet the provisions related to liquid waste disposal permits, structuring points, wastewater quality standard parameters, and data reporting in each parameter.

There are two methods of supervision, namely direct supervision, and indirect supervision, if it comes directly to the company based on laboratory tests if indirect supervision is through written and periodic company reporting, the company is obliged to report to the environmental service to the regent and then to the minister for 3 months, while the implementation of environmental documents is 1 semester or usually said to be 6 months. In addition, there are two types of supervision, routine supervision that we have planned at least once a year, then incidental supervision concerning if there are complaints from the public there are environmental issues that occur, and supervision based on the company's proper. Our supervision team conducts supervision according to the SOP because if there is no SOP the supervisory official and his members may violate the rules in carrying out supervision, this supervision is carried out solely to ensure that there is pollution, their supervision team also provides direction and guidance to business actors such as the importance of protecting the environment according to the provisions that have been made(Faujiah & Marzuki, 2021).

supervisory officials and their members carrying out this supervision may violate the rules to carry out SOP supervision are very important to be used as a guideline in carrying out activities. supervision efforts carried out by the Environmental Service to deal with environmental pollution prevention caused by industrial activity waste. Based on the explanation of the data above, in detail, supervision by nature is divided into two, namely;

a) Direct Supervision

1) Field verification

This supervision is carried out when there are environmental issues or suspected violations, it is necessary to carry out field checks in an intensive manner. Based on the explanation above, field verification is carried out if there are complaints of environmental issues from the community, NGOs, and even fellow business actors, etc., this complaint is carried out by two procedures, first direct complaints by coming to the complaint post at the environmental service then the complainant must fill out a complaint form. At the time of direct scouting, it is recommended that the complainant bring relevant supporting evidence in the form of data and information on the facts of the incident and if there is evidence of the completeness of environmental documents, secondly, complaints indirectly submit complaints via sms, WA, letters, telephone, and other media only after that the agency as the person in charge manages complaints with the stages of receiving, reviewing, verifying, formulating reports on the results and following up on the results of complaints. To carry out verification, data collection, and information in the field are carried out. In collecting data, supervisory officials or members of the supervisory team must submit facts in the field which include the results of analysis, samples, photos/images, copies of documents, statements from witnesses, and personal observations, this stage is carried out within 40 working days.

2) Laboratory test

The Environmental Service provides a laboratory to make it easier for the environmental service to test the quality of waste so that the waste tested has accurate results and makes waste testing more efficient, this is used as a supporting tool in carrying out supervisory policy tasks carried out by the Environmental Service.

b) Indirect supervision

1) Routine supervision

Based on interview data, the supervision has generally been scheduled at the beginning of the year through supervision targets according to the time set by the Environmental Agency. The Environmental Agency conducts supervision once a year for each company and can even be done twice a year. This form of supervision is carried out through written company reports. A written report is accountability related to the work that has been carried out by examining the environmental management document report by the person in charge of a business that has licensed environmental documents to the Environmental Service per semester(Angga & Suat, 2019; Firmansyah & Rahayu, 2021; Labetubun & Taufik, 2021; Listiyani & Said, 2018; Saepudin et al., 2022; Saputra & Dhianty, 2022; Usman & Saleng, 2022).

Based on Law Number 32 of 2009 concerning Environmental Protection and Management Article 63, one of the obligations of the Regional Government is to provide guidance and supervision of the obedience of the person in charge of the business/activity to the provisions of environmental licensing and laws and regulations as well as to determine and implement supervision regarding environmental impacts(Angga & Suat, 2019; Firmansyah & Rahayu, 2021; Labetubun & Taufik, 2021; Listiyani & Said, 2018; Saepudin et al., 2022; Usman & Saleng, 2022). The supervision that has been running in the Environmental Service for businesses/activities is the supervision of the implementation of AMDAL, RKL RPL/UKL-UPL licenses, for liquid waste management.

2) Supervision based on PROPER (Company Performance Improvement Program)

The form of this supervision is that if the company wants to improve the quality of the company to be better and higher, the company must report the matter to the Environmental Agency so that it immediately carries out supervision of the company for inspection of the company's quality improvement.

The main goal proper is to improve the structuring of the industrial world for stakeholders. The basic principles of company performance assessment generally include the above:

a. Implementation of environmental permits such as UKL/UPL, AMDAL, and RKL/RPL
b. Potential environmental damage
c. Water pollution control
d. Air pollution control
e. Management of hazardous waste and non-hazardous solid waste
f. Utilization of waste and resources
g. Environmental management system and;
h. Community development

The following aspects of water pollution control assessment;

a. Adherence to technical requirements
b. Compliance with liquid waste management license
c. Adherence to the fulfillment of quality standards
d. Adherence to parameterized data reporting
e. Adherence to wastewater quality standard parameters
f. Obedience point compliance

3) Incidental supervision

The implementation of supervision is carried out at any time based on needs, meaning without prior scheduling based on complaints from residents if there are environmental issues that occur. Not only supervision of the Environmental Service when guidance is needed, but the environmental service also conducts guidance by conducting socialization.

3. Recovery

Restoration of environmental functions is carried out if the location of the pollution is not known to be the source of the pollution and the party committing the pollution is not known. Recovery is carried out when the closure or revocation of hazardous waste management license facilities and due to environmental pollution, both business activities that have a waste management license and do not have a waste management license. The stages of recovery are outlined in the environmental function recovery plan document and must obtain approval from the minister before the implementation of recovery. Restoration of environmental functions must be carried out by first planning the mapping of the location of land contaminated with hazardous and toxic materials, the volume of land, and the area of contaminated land in the form of data from laboratory test results. Second, the implementation of contaminated land management refers to the direction of the recovery agency/directorate and does not require a waste management license because land recovery is part of the mechanism for revoking hazardous and toxic waste management licenses so it does not require a license. Third, evaluation by referring to the soil, groundwater, and waste test data, the success rate of recovery is declared successful with quality standards, reference points, and risk base screening level, fourth soil monitoring at upstream and downstream monitoring points and reference points then the relevant parties issue a status letter for handling land contaminated with hazardous waste.

In addition, the infrastructure used in the supervision process has limited transportation, for example, special vehicles such as official vehicles are felt to be lacking, as a result, supervisory officials use private vehicles for the supervision process, for example carrying out field reviews at each company, thus causing the slow performance of supervisory officials of the environmental service, therefore it is hoped that the government will pay more attention and strive for facilities and infrastructure for smooth supervision so that such problems are no longer an obstacle factor in carrying out supervision. Second, external factors, is the commitment of the person in charge of the paper industry business, the person in charge of the business still does not fully follow every regulation that has been set, for example in reporting every semester such as UKL-UPL and the AMDAL, RKL and RPL assessment mechanism, this is because the person in charge of the business actor is only concerned with the profit point that can be obtained without seeing the impact reaped from his production activities(Angga & Suat, 2019; Firmansyah & Rahayu, 2021; Labetubun & Taufik, 2021; Listiyani & Said, 2018; Saepudin et al., 2022; Usman & Saleng, 2022).

The industry has been running well, this can be seen based on performance achievements and clear standard operating procedures for implementation, but it has not run optimally because, in the implementation of these policies, there are still obstacles in the form of human resources, This is due to the lack of compliance of the person in charge of the business in carrying out the implementation of a good and adequate WWTP(Saepudin et al., 2022). Thus the problem of company violations is due to the person in charge of the business who is not well accompanied by how the function of the person in charge of the business/activity in controlling environmental pollution even though the law mandates the role and authority of the person in charge of the business in achieving the preservation of environmental functions properly(Angga & Suat, 2019; Firmansyah & Rahayu, 2021; Labetubun & Taufik, 2021; Listiyani & Said, 2018; Saepudin et al., 2022; Usman & Saleng, 2022). Although the local government has made various law enforcement efforts against violations of industrial companies, these efforts have not been able to reduce environmental pollution problems.

If we adopt from a policy implementation theory, in this case, the implementation of article 13 of Law No. 32 of 2009 according to Edwards III, in his book Subarsono explains the factors that influence the implementation of policies seen from the first 4 variables of communication, if we look at communication for the success of policy implementation implementors must know what should be implemented in implementing the policy so that it can be transmitted to the target targets as an example of the community and business actors to increase public awareness of obeying the law and supporting the implementation of the law so that they know the importance of protecting the environment because this law is substantially very good. Second, resources, although the content of the policy has been communicated clearly, the implementer lacks resources to carry out the policy will not take place effectively as resources can take the form of human and non-human resources, for example, the lack of personnel of supervisory officials, this is proven to hinder the implementation. Fourth, the bureaucratic structure is the task of policy implementation implementors because this has an important influence on policy implementation. This means that of the four variables from Edwards' theory, there is one variable that is not fulfilled so the implementation of article 13 has not been able to run well because in terms of human resource factors and non-human resources including facilities and infrastructure so related to the implementation of article 13 has been implemented properly as a reference for solving environmental pollution problems caused by industrial waste, but there are inhibiting factors from the implementation of these rules which are a problem to find a solution. The regulation can be effective if it is supported by tools of Law enforcement. Environmental law enforcement is related to the ability of the apparatus and the compliance of citizens with applicable regulations.

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CHAPTER XI
WASTE WATER

Yoshephine D.R & Ari Setiawan

A. Definition of waste water

The definition of waste water in Government Regulation of the Republic of Indonesia Number 82 of 2001 concerning Management of Water Quality and Control of Water Pollution is the residue from a result of a business and or activity in liquid form. In addition, based on the Ministry of Environment and Forestry. Regulation of the Minister of Environment and Forestry No. 68 of 2016 concerning Domestic Waste Quality Standards, waste water is residual water from a business and/or activity.

According to Abduh (2018) The remaining water released by homes, factories and other public places is known as waste water, and usually contains toxins or compounds that are harmful to human health and the environment. Another definition of wastewater is waste water produced by human activities, both originating from domestic and non-domestic activities such as industry, hotels and airports, and includes compounds that can damage human health and the environment. Even though it is waste water, the volume is large because about 80% of the water used in daily activities is dirty (polluted) water. This effluent will eventually flow into rivers and seas, which will be utilized by humans.

B. Sources of Waste water

Abduh (2018) states that sources of wastewater can come from various sources, including household, urban and industrial waste.

1. Domestic Waste Water

Water used for washing, cooking water and bathing water is included in the waste generated from the daily activities of the community (settlements). Organic materials make up the majority of household wastewater.

2. Municipal Waste Water

Wastewater from cities, workplaces, commerce, hotels, restaurants, public spaces, sewers, and other sources. The chemicals included in this form of wastewater are similar to those found in domestic wastewater.

3. Industrial Waste Water

As a result of the manufacturing process, wastewater from various sectors. Ink factories, steel factories, paint factories, rubber factories, coffee factories, and tapioca flour factories are just a few examples. The chemicals in them are very different depending on the raw materials used by each business. Nitrogen, sulfides, salts, colors, minerals, heavy metals, solvents and other substances are examples.

C. Characteristics of Waste water

It is necessary to know the characteristics of wastewater, because this will determine the proper processing method so that it does not pollute the environment. Broadly speaking, there are 3 characteristics of wastewater, namely physical characteristics, chemical characteristics, and biological characteristics.

1. Physical Characteristics

It consists mostly of solids and suspensions. Domestic wastewater, in particular, looks hazy and has a mild odor, similar to soapy water. It may contain bits of paper, colorful washings of rice and vegetables, shards of dirt, and other items. (Irwan 2021).

The physical characteristics of liquid waste include:

1) Temperature / temperature

The temperature of wastewater is greater than ordinary water, ranging between 40 and 50 degrees Celsius. The high temperature of wastewater reduces the amount of dissolved oxygen in the water, which causes spoilage. (B 2006).

2) Color

The presence of contamination in liquid waste is indicated by the color of the waste. The color of wastewater is determined by the composition of the waste. The breakdown of organic matter causes the appearance of color. (Al Amin 2018).

3) Smell

The smell of wastewater is determined by its source. The decomposition of organic compounds in waste, chemicals, plankton, or aquatic plants and animals, both living and dead, causes odors. The smell of fresh sewage is similar to the smell of soap or grease. It smells of sulfur in a septic state, which is unpleasant. (RJ and Syarief 2010).

4) Total Suspended Solids (TSS)

Total suspended solids or total suspended solids are the amount of particles that will settle over time or solids that produce turbidity but cannot settle immediately.

5) Total Dissolved Solids (TDS)

Total dissolved solids or dissolved solids are solids that have not been suspended which are smaller than that. Organic and inorganic substances such as calcium, magnesium, sodium, potassium, carbonates, sulfates and chlorides form dissolved solids. (Al Amin 2018).

2. Chemical Characteristics

In most cases, wastewater consists of a combination of inorganic chemicals produced from clean water and organic compounds formed by the breakdown of feces, urine and other wastes. Organic matter in wastewater consists of two types of compounds, namely (Irwan 2021):

1) Combinations containing nitrogen, for example: urea, protein, amines, and amino acids.

2) Combinations that do not contain nitrogen, for example: fat, soap, and carbohydrates, including cellulose.

Liquid waste chemical parameters include pH, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO).

1) pH

pH or degree of acidity is a unit of measurement used to determine the amount of acid or base in a solution. A pH value of 7 indicates that the waste is neutral; a pH value of less than 7 indicates that the waste is acidic, and a pH value of more than 7 indicates that the waste is alkaline. The pH of water has an impact on aquatic plants and animals, and is commonly used to judge water quality. Microorganisms cannot survive in water with a pH value that is less than or more than the typical pH range. (Al Amin 2018).

2) Biological Oxygen Demand (BOD)

BOD is Microorganisms requiring a certain amount of dissolved oxygen to decompose organic matter in the trash. Organic waste contains carbon, hydrogen, oxygen, nitrogen, sulfur and other components that easily absorb oxygen. This causes the oxygen levels in the wastewater to drop, making it cloudy and smelly. In order to evaluate the pollutant load generated by wastewater and to construct a biological water treatment system, BOD inspection is required. At 20°C and 5 days, good breakdown occurred.

3) Chemical Oxygen Demand (COD)

The amount of oxygen required for chemical breakdown is referred to as COD. The oxygen concentration required to oxidize the organic compounds contained in a 1 liter water sample uses oxidant K2Cr2O7 as a source of oxygen is determined by COD. The COD value is a measure of naturally oxidized organic chemicals and can contaminate water by reducing dissolved oxygen in water through microbial activity. COD analysis is different from BOD analysis, although both can be compared using COD and BOD numbers. COD testing is a chemical test that takes less time than BOD testing. Bacterial activity has no effect on the results of COD analysis.

4) Dissolved Oxygen (DO)

The amount of dissolved oxygen in water produced by photosynthesis in aquatic and air plants is referred to as DO. Aerobic processes require oxygen for the oxidation of organic and inorganic components. DO is also needed by microorganisms for respiration, metabolic activity, and the exchange of chemicals that provide energy for growth and reproduction. Creatures living in water will die if their oxygen demand drops. Changes in water temperature, photosynthetic rate, light intensity, and organic matter content all affect dissolved oxygen levels throughout the day. (Al Amin 2018).

Bacteria play an important role in the wastewater treatment process, as certain bacteria are effective decomposers of organic compounds found in wastewater. Algae also contribute to the production of oxygen through photosynthesis and the decomposition of nitrogen in wastewater. Algae, on the other hand, have a defect that can lead to eutrophication if the effluent contains too much nitrogen. (Abduh 2018).

D. Waste water Problems

The following are wastewater problems (Sulistia and Septisya 2020):

1. Wastewater temperature is over 50˚C.
2. The pH level or high degree of acidity is more than 9, because the threshold value for pH levels in domestic wastewater is 6-9.
3. The level of total suspended solids or total suspended solids is more than 30 mg/liter.
4. Biological Oxygen Demand (BOD) levels are more than 30 mg/liter.
5. Chemical Oxygen Demand (COD) level is more than 100 mg/liter.
6. Oil and fat content is more than 5 mg/liter
7. Ammonia in domestic wastewater is more than 10 mg/liter.
8. Total coliform in domestic sewage is more than 3000/100 ML.

E. Community Empowerment in Waste water Management

Examples of community empowerment in waste water management, namely (Medawaty 2015):

1. Communal Septic Tank Type of Settlement Research and Development Center

The process of selecting the best technically, socially and ecologically acceptable appropriate technology at the lowest feasible cost is known as sanitation program planning. It is very important to first understand the features of a wastewater treatment system before developing one. The aim of wastewater treatment is to reduce the concentration of hazardous components in wastewater so that they can be safely released into receiving water bodies.

2. Pond Sanita (Public Sanitation) Type Puskim

Sanita (garden sanitation) is a pool made of masonry, then filled with gravel and aquatic plants, then accommodated in a receiving water body or used as a fish pond.

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WASTE DISPOSAL MANAGEMENT

The two most basic, and at the same time most important, types into which we can divide the waste are the biodegradable and the non-biodegradable. Sorting waste in this way can even reduce by half the amount of waste that must be taken to the recycling or incineration plants or to landfill. However, many consumers may have not the motivation to segregate waste, because they do not realize the importance of this practice. o, here academics play a role as a mover and motivator for the community in carrying out the 3R movement, namely reduce, reuse and recycle. Waste problems and environmental problems are a shared responsibility. Awareness of environmental safety must be taught from an early age at the elementary school level.This book explains how to handle waste from the household level before disposing it to landfills. This book also provides education to students and the public about the importance of managing waste, for the sake of environmental safety

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