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# **WATER AND ENVIRONMENTAL ISSUES (VOL 2)**

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**UTHM**

# **Water and Environmental Issues (Vol. 2)**



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# Water and Environmental Issues (Vol. 2)

**SYAZWANI MOHD. ASHARUDDIN**

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## **PREFACE**

Water is a precious and finite part of the environment which is vital for socioeconomic development, sustainability of the environment and survival. Malaysia is fortunate that it is located in a humid tropical area rich in rainfall and water resources. The rapid economic growth of Malaysia in the past decades is also mainly attributed to its ability to exploit abundant natural resources including water. The exploitation of water resources is an important catalyst of economic growth but continuous exploitation without proper management and conservation may cause the depletion of water supplies, rendering water resources unsustainable. In recent years, water problems have escalated in Malaysia due to climate change, urbanization and population explosion. Therefore, effective water conservation, efficient waste water and sewage management integrated with recent technologies are important for fostering the tandem development of economic growth and the sustainability of environmental resources.

This second volume of Water and Environmental Issues is based on current research works and didactic activities on water and environmental issues by researchers at the Micropollutant Research Centre (MPRC), Universiti Tun Hussein Onn Malaysia (UTHM). Readers can find a wide range of information related to water and environmental issues as well as the latest techniques to overcome environmental problems.

Water and Environmental Issues (Vol. 2) comprises of ten chapters; chapter 1 describes the necessity and challenges of nature conservation to ensure that the environment and biodiversity around the world can be maintained and protected. Chapter 2 highlights the effectiveness of combined techniques including conventional coagulation and electrocoagulation in treating leachate. Chapter 3 reviews the influence of water quality on human health. Chapter 4 discusses the strategies, methods and challenges in food waste composting as an approach to reduce waste volume. Chapter 5 focuses on a case study on ablution water consumption and proposed approaches for saving ablution water. Chapter 6 presents successful attempts on the application of food waste composting in a cafeteria. Chapter 7 focuses on the effects of personal care products towards humans and the environment. Chapter 8 gives an overview on the application of the electrocoagulation method for biodiesel wastewater treatment. Chapter 9 presents the outstanding properties of activated carbon produced from agricultural waste as a potential bio-absorbent.

We would like to express our appreciation to all authors for their cooperation and contribution of the book chapters. We are also deeply grateful to all the reviewers for their insightful and valuable comments which helped improve the manuscripts selected for this book. Our gratitude also goes to Nur Shahirah Abd Rahim and Syarifah Nur Fahirah Tuan Besar who helped us with the editing and formatting of this book. We also wish to express special thanks to our Deputy Vice Chancellor, Prof. Dr. Ruzairi Bin Abdul Rahim, who has encouraged us to embark on this meaningful project.

**Radin Maya Saphira Radin Mohamed,  
Head of Micropollutant Research Centre (MPRC),  
Universiti Tun Hussein Onn Malaysia**

## SYNOPSIS

### NECESSITY AND CHALLENGES OF NATURE CONSERVATION

Nature conservation is the key towards sustainable development. The responsibility of conserving the nature must be fulfilled by all members of the society to ensure that the future generation will continue to live in a clean and healthy environment. This chapter discusses the reasons why nature conservation is important so that every living thing can have an improved quality of life. Nature conservation is vital in protecting biodiversity, preventing and decelerating the endangerment of animals and plants and conserving rainforests as the regulator of a balanced ecosystem. Emerging issues and challenges faced in nature conservancy such as overharvesting and explosion of the human population are also addressed in this chapter.

### LEACHATE TREATMENT BY CONVENTIONAL COAGULATION, ELECTROCOAGULATION AND TWO-STAGE COAGULATION (CONVENTIONAL COAGULATION AND ELECTROCOAGULATION)

Conventional coagulation involves the use of cationic salts to destabilize colloidal material and cause the agglomeration of small particles into large stable flocs. This is the most widely adopted method for the treatment of wastewater but the high volume of sludge production has become the biggest constraint. Electrocoagulation is a new method developed to overcome the drawbacks of the conventional method. It is effective and has a lower sludge production. This chapter provides sheds light on the potential of integrating the conventional coagulation method with the electrocoagulation method to achieve optimized leachate treatment.

### A REVIEW ON THE INFLUENCE OF DRINKING WATER QUALITY TOWARDS HUMAN HEALTH

Clean drinking water is a basic necessity for maintaining human health and its importance has been recognized early in history. But while it helps to keep people, homes, and cities clean, water itself can also carry harmful microbial or chemical contaminants. A large array of synthetic organic chemicals has been released into the environment, and from there these chemicals can eventually find their way into drinking water supplies. Many water quality regulations have been outlined as a protective measure to ensure that drinking water is adequately treated, monitored, and managed to protect public health. This chapter points out the standard of water parameters that is safe and clean to be consumed on a daily basis and the potential effects on human health if the water quality does not meet the water quality regulations.

## **IMPLEMENTATION OF FOOD WASTE COMPOSTING IN MALAYSIA**

Expanding and developing city areas have led to rapid urbanization. In consequence, available landfill space decreases while the cost of building new landfills increases. This is one of the struggles in waste disposal management faced by municipal governments. In the search of new alternative methods to overcome the challenge, waste composting emerges as a viable option for solid waste management. This chapter presents the advantages of waste composting, strategies to ensure effective waste composting and challenges involved in the process of waste composting.

## **ABLUTION WATER CONSUMPTION AND POSSIBLE SOLUTIONS: A CASE STUDY**

Ablution is a mandatory religious routine for all Muslims before performing prayers. The amount of water used for this ritual usually differs from person to person but many perform ablution under fast flowing water which can lead to excessive water consumption. This chapter provides the output of a water consumption survey during ablution at the UTHM Mosque. It also suggests water conservation approaches during ablution to prevent wastefulness during ablution.

## **FOOD WASTE COMPOSTING IN CAFETERIAS: A CASE STUDY**

Food composting can be a great solution to reduce large amounts of food waste discarded from cafeterias. Implementing food composting in cafeterias can reduce environmental impacts by diverting waste from landfills and reducing the cost of waste management. It is also beneficial for gardeners since organic compost is incredibly rich in nutrients. This chapter describes methods employed for food composting at a cafeteria where leftover food was successfully converted into nutritious organic compost.

## **THE USE PERSONAL CARE PRODUCTS AMONG STUDENTS AND THEIR POTENTIAL EFFECTS TO THE ENVIRONMENT**

Pharmaceuticals and personal care products (PPCPs) are essential regimes for humans to maintain cleanliness and health. PPCPs are able to reach the wastewater system as they are directly washed down the drain during and after use. The chemicals that are able to penetrate the body and are then excreted are also able to enter the wastewater system through the toilet. This chapter presents the survey output conducted on college residents to determine the chemicals or ingredients contained in personal care products used by students. The potential hazards and harmful effects the chemicals can have on environmental ecosystems or organisms that are exposed to them are also discussed.

## **THE APPLICATION OF ELECTRO-COAGULATION IN BIODIESEL WASTEWATER TREATMENT**

The production of biodiesel by biodiesel production plants generates a large amount of wastewater that contains high levels of chemical oxygen demand (COD), oil and grease (O&G), and soap and alkali. This type of wastewater requires treatment prior to environmental discharge. Conventional

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methods such as gravity separation and skimming, air flotation, coagulation and de-emulsification possess several drawbacks including the inability to remove micron- or submicron-sized oil droplets efficiently. Such drawbacks can be overcome using the electrocoagulation method. This chapter reviews the application and advantages of using electrocoagulation for biodiesel wastewater treatment.

### **WASTE TO WEALTH: PRODUCTION OF ACTIVATED CARBON FROM AGRICULTURAL WASTE**

Agricultural and forestry waste products represent unused resources. They are also abundantly available and environmentally friendly which make them suitable to be considered as a precursor to produce activated carbon for water treatment. This chapter begins with the process of activated carbon production and continues to describe the characteristics of activated carbon. The comparison of activated carbon performance derived from various literatures was also supplemented to provide insights on the potential of activated carbon developed from agricultural waste.

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# CHAPTER 1

## NECESSITY AND CHALLENGES OF NATURE CONSERVATION

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### Abstract

Nature conservation is the preservation of resources that are produced naturally for example wild animals and plants, ecosystem and biodiversity especially from the effects of human activities for example exploitation and industrialization. Nature conservation is necessary in protecting the biodiversity for example to prevent animal species from endangering or extinct, protection for natural ecosystem and human's freshwater sources for drinking purposes. Moreover, nature conservation is important in maintaining a long-life natural environment as well as an environment that is sustainable towards development. However, nature conservation is not an easy task as it requires a lot of manpower as well as money. Therefore, nature conservation is challenging as well. The challenges of nature conservation include human's overpopulation, global warming and overharvesting. Human's overpopulation is one of the most challenging factors that influences the practice of nature conservation.

**Keywords— preservation, environment, challenge**

## 1. Introduction

Nature can be seen as harmonious, beautiful, peaceful and inspiring. Meanwhile, when human started to be ignorant towards nature, then nature could bring disaster as well. Therefore, nature had to be conserved from human's ignorance activities in order to prevent disasters that are brought by nature to happen. Nature conservation can be defined as the preservation of resources that are produced naturally for example wild animals and plants, ecosystem and biodiversity especially from the effects of human activities for example exploitation and industrialization [1].

Nowadays, the earth is facing a lot of problems including poverty, wars, famine, depletion of natural resources, emergence of transmitted diseases as well as the destruction of natural environment [2]. Most of these problems are caused by human's ignorance and arrogance as well as the destructive and unsustainable use of the natural resources. According to United Nations, the world human population is going to be doubled every 41 years [3]. As results from human's overpopulation, an estimation about 40-50% of inhabitable land including forest had been transformed into housing area or used as agricultural purposes [4]. Thus, developed area such as cities is required to transform from being only consumers of food and other products into resource-conserving and sustainable generators of food and other products.

Due to the high demand of fresh drinking water, about 50% of the run-off freshwater all over the world had been used by human [5]. Naturally, water is circulating resources that is constantly recharged. However, due to human population, source of fresh drinking water is reduced. Although, the consumption of fresh drinking water is well below the upper limit, more than 2 billion human population live in highly water-stressed areas due to uneven distribution of renewable freshwater resources [5].

As a source of protein towards human, about 74% of the marine fisheries had been overexploited by human and some species even endangered or extinct at this point [6]. In order to overcome the high demand towards foods for human, intensive factory farming had been introduced. Therefore, an estimated of 38 billion metric tons of organic wastes were produced by the crops industry throughout the world [7].

Due to the effects caused by human overpopulation onto the environment, nature conservation is necessary in conserving and protecting the natural environment. Human is just part of the huge life-supporting system which is the biodiversity, therefore sustainable use of the natural resources is the only way to conserve the natural environment, so that the future generation will not be suffering in the end. Therefore, natural conservation in the past is served as an optional discipline or interest for a group of certain people. For example, organizations that influence by foundation of national parks in USA which focus on protection of species for human use [8]. Before 1900, societies for bird protection were founded in Netherland and England. At the end 1900, these organization for bird protection was recognized the importance of international co-operation. In 1902, international agreement on the bird

protection was signed by the European countries and Wild Bird Directive 1979 was developed [9]. This history of bird protection also implemented in other sector in nature conservation.

For now, nature conservation has become a global concern and mandatory disciplines and it is vital for society as well as the preservation and conservation of life on earth. Nature conservation can be characterised into two parts which is conservation biology and restoration ecology [10]. Conservation biology is mainly for animals and short-term goals in terms of durability, while restoration ecology focused on plant communities and it is long term goals. Conservation biology emphasizes on the genetic population and species level while restoration ecology emphasizes towards the communities and ecosystem. Lastly, conservation biology is conducted descriptively and theoretically while restoration ecology is conducted experimentally [11].

Nature conservation is the management on long term and large space-scales based on the principles of systems ecology. As a result, nature conservation is the key towards sustainable development. Even though nature conservation is a hard task, but preservation of existing natural environment will deliver long term values as well as will ensure that the future generation is having a great environment and ecosystem to spend their life on.

## 2. Necessity of Nature Conservation

Nature conservation is important for the protection of biodiversity. Biodiversity is the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystem and the ecological complexes where they are part of. It includes the diversity within species, between species and ecosystems. Therefore, biodiversity is a fundamental of life support system and it forms the foundation of ecosystem service to which human actions is intimately linked. Biodiversity is consisted of many elements including living things for example animals and plants, non-living things (soil, sunlight, water, air) ecosystem and the interactions between living things and non-living things. Therefore, none of the organism can live in the earth when they are under isolation from the biodiversity [12].

Nature conservation can prevent and decelerate the endangering of the animal species. Every organism plays an important role in balancing the global ecosystem and the survival of the earth. Many animals like tiger used to be plentiful in the past [13]. Due to humans' ignorance and greediness, many animals are hunted down. Humans eat or use these animals without being worried about the consequences raised when all of these animals are endangered. Humans should have a stronger sense regarding nature conservation and the importance of every organism in the ecosystem as well as their importance to human, not until when the number of particular animals such as Malayan tiger, Malayan Tapir, Orang Hutan, Borneo Pygmy Elephant, Proboscis Monkey and other endangered species in Malaysia dropped to a critical number until they became extinct or endanger.

There are several human activities that cause the endangering of tiger namely illegal hunting and excessive logging. Tigers are being hunted down for their high economic value skin. In some countries, tigers are being hunted to be consumed as they thought that tiger's meat has high medical value. For these cases, Malayan tiger and Indochinese tiger are the examples. According to World Wide Foundation for Nature (WWF), the primary threats to the survival of Siberian Tiger are intensive illegal logging and development which cause the loss of habitats for Siberian Tiger [13]. The total number for tiger's population in 2016 is approximately 3890 which is higher than 2010 tigers' estimate population which is 3200 [13]. It was the first time the tigers' population is on the rising trend after decades of declining. This happened when the government works together with local communities and nature conservationists. It shows that the importance of nature conservation in preventing the endangering and extinction of animal species.

Besides, nature conservation is also important to protect the ecosystem especially rainforests. Rainforests play an important role in maintaining the balancing of the global ecosystem and environment [14]. Rainforests help to regulate the surrounding temperature. This is because rainforest is also known as the 'lungs' of the earth as rainforest absorbs huge amount of carbon dioxide and releases huge amount of oxygen. Carbon dioxide is heat trapped gas [15]. Therefore, when the plants in rainforest used up carbon dioxide in photosynthesis, it helps to reduce the composition of carbon dioxide in air and thus reduces the surrounding temperature. Therefore, destruction of rainforest may cause the production of greenhouse gases which causes the surrounding temperature to rise. This will result in the melting of the ice cap in Arctic and Antarctic which causes the rising of sea level. As a result, floods may occur in the low land all over the world.

Rainforest also acts as a water reservoir in global ecosystem. This is because one of the criteria to be recognized as rainforest, an area must receive at least 80 inches of rain every year [16]. Therefore, rainforests help to maintain the water cycle by producing large amount of rain every year. Water produced by rainforest makes its way all over the world. Hence, the destruction of rainforest may affect the water cycle system which leads to droughts in different areas all over the world. Rainforests also act as the habitats for half of the plants and animals. Thus, destruction of rainforest may cause the loss of habitats for the flora and fauna. Thus, nature conservation helps to maintain and reserve the natural resources that can be found in rainforest.

Nature conservation is also necessary in protecting the natural water resources. Even though more than 70% of the earth is consisted of water, however most of it is salt water, which can only be consumed by human after it undergoes desalination process [17]. Conservation towards the natural water resources is important in protecting the hydrosphere and to meet the current and future human demand towards the fresh water usage. Nowadays, climate change has been increasing the pressure on the demand towards fresh water especially in the manufacturing and agricultural industries [18]. Source water is basically what human relies on daily for drinking purposes. Therefore, the main purpose of protecting source water is to protect water source from being contaminated or overused. In other words, source water protection is similarly protecting human health. Besides, protection natural water resources also protects aquatic life. Most of the aquatic organisms for example fish and prawn

cannot live under contaminated or polluted water. Thus, nature conservation towards natural water sources is essential in protecting aquatic organisms. This will eventually ensure that aquatic life which acts as one of the humans' food source will not die due to water contamination and pollution.

Due to the rapid population growth, safe-drinking water shortage is happening right now. According to World Wide Fund for Nature (WWF), water shortages will be more prevalent among poorer countries such as Middle East, Africa and part of Asian countries in 2025 [19]. As a result, it is expected that 1.1billion will lack access to water, approximately 2.7 billion people will undergo water scarcity in one month of a year. About 2.4billion people will be exposed to infectious diseases like cholera and typhoid fever due to inadequate freshwater resources which cause them to drink contaminated water.

### 3. Challenges of Nature Conservation

Overharvesting is also one of the challenges in nature conservation. Marine living organisms is believed to be one of the largest source for protein. It's expected that global demand for proteins is on an upper trend for the following decades. In order to fulfil the high global demand for marine living organisms, people in the aquaculture industry will choose to use the easiest and cheapest method for example fish bombing in order to obtain huge amount of fishes [20]. Fish bombing will eventually interrupt the marine ecosystem as it will cause pollution towards the marine and the most importantly it will damage the coral. Thus, marine living organisms like fish, prawn and lobster will undergo loss of habitats and food source. As a result, the marine ecosystem is interrupted and polluted. In overcome of this problem, local authority and government such as Department of Fisheries Malaysia can develop and implement regulation on prohibition of using fish bombing.

To sustain the marine living organism, Marine Stewardship Council (MSC) is the best certification body to measure the sustainable of marine living organisms [21]. MSC is the world's leading certification for wild caught and sustainable marine living organisms. However, consumers have less willingness to buy products that are certified by MSC due to expensive, which are mostly imported from Europe. Thus, Asian population may not be willing to buy these products. In addition, product's availability in supermarket is very low, limited in canned and frozen. Whereas, Asian population prefers their product fresh rather than canned and frozen.

Human's overpopulation is one of the most challenging aspects in nature conservation. Human's overpopulation is the phenomena when the ecological footprint of a human population in a specific geographical region exceeds the carrying capacity of the place occupied by the group [22]. Basically, human's overpopulation can result an increase in human's births and increase in immigration. Overpopulation will cause the increased demands for food and water resources. Demand for fresh water and foods will be increased due to increasing of human population. Thus, the inadequate of fresh water and foods will eventually take place.

Thus, it results in increasing of deforestation for agricultural purposes. In addition, water scarcity will take place due to the high demands of freshwater for drinking purposes. In overcome of this problem,

small countries such as Singapore, the government established the “Stop-at Two” programme, which allowed only two children for a family. The implementation of the policy caused a population decline in Singapore [23].

Therefore, intensive factory farming will be conducted to support the high demands for foods all over the world. The fertilizers used in intensive factory farming will increase the nitrogen and phosphorus level in freshwater sources like rivers and lakes [24]. This will eventually cause algae blooming to be happened in rivers and lakes. Algae blooms require sunlight, slow moving water and nutrients which are phosphorus and nutrients [25]. This situation is worsened due to the run-off water from the industrial farming especially during rainy seasons. Algae blooms might lead to the death of the aquatic organisms in freshwater and also pollution of freshwater. This is because some of the algae might release toxins and also it reduces the oxygen level in the freshwater. In addition, the pH level of the freshwater might be altered due to intensive factory farming due to the release of phosphorus and nitrogen into the freshwater sources. The alteration of pH level in freshwater sources will also affect the safety of humans’ drinking water.

Moreover, depletion of energy natural resources such as fossil fuel will also take place due to the overpopulation of humans. As a result, fossil fuels like petroleum, natural gases and charcoal will undergo depletion if the exploitation towards these fossil fuels are not controlled well. Not only will the fossil fuels, natural resources like air will also undergo pollution as well. The increase in using vehicles that require fossil fuel will cause the emission of pollutants towards the surrounding including carbon dioxide, sulphur dioxide, nitrogen dioxide, carbon monoxide and other pollutants [26]. High population (1.4 billion) such as in China produce the highest carbon dioxide emissions, i.e., 9040 million metric tons. Second highest produce carbon dioxide emissions is United States, i.e., 5000 million metric tons in population of 325 million [27]. These kind of air pollutants are hard to be controlled as the government cannot restrict the amount of vehicle on the road as well as ban the residences from using vehicles. The only way to reduce the air pollution caused by vehicles is by improving the country’s public transport system and encourages the people to use them.

Global warming is also one of the challenges that nature conservation is facing at this moment. Global warming is the observed century-scale rise in the average temperature of the Earth’s climate system and its related effects [2]. The increasing of the global temperature causes the pH value of the ocean will be altered due to global warming. The bleaching of coral reef will occur as well due to the increase of global temperature. As a result, aquatic organisms like fish or prawn will suffer from loss of habitats as well as good sources. Global warming will also lead to other consequences for example heat waves, droughts, heavy rainfall as well as floods which will eventually lead to climate change for some places. This situation will probably lead to the death of some animal species and affects in decreasing of crop yields. It is believed that the main cause for global warming is the increase in the atmospheric greenhouse gases. Thus, reforestation should be conducted as well as preventing deforestation to be happening. In small scale, global warming is likely to have an impact on turtle nesting beaches. The increase in nest temperature could produce 100% female turtle hatchlings, resulting in unbalanced

marine turtle population. Thus, monitoring the temperature during turtle's incubation period is required to balance the turtle population [28].

In addition, local authorities can implement the green building such as through programme UI Greenmetric World University Ranking. Based on this programme, educational institution, i.e., university, required to comply a few criteria such as Energy and Climate Change, Solid Waste, Water Consumption and other criteria to achieve the high ranking. From the criteria being used, the university was identified to reduce their carbon footprint and thus help to overcome problem of global climate change [29].

#### 4. Conclusion

Nature conservation is necessary in maintaining and protecting the natural environment. The necessity of nature conservation should be spread throughout the community all over the world as to remind that nature conservation should be done by human to prevent damage towards to natural environment that is caused by human's activities as well as human's ignorance and greediness.

Nature conservation can prevent and decelerate the endangering or extinction of a particular animal species. Human hunts down wild animals for their skin or meat which is high in economic value. Therefore, national park is set up in nature conservation in order to prevent wild animals from human's hunting. Nature conservation is necessary in protecting the rainforest. The logs in rainforest is in high demand. Threats to rainforest include illegal hunting, conversion of land use like from rainforest area to agricultural purpose causes the disappearing of rainforest. Rainforest is also important in maintaining the global temperature. Therefore, nature conservation is important in maintaining the global temperature. Nature conservation is also necessary to protect the natural freshwater resources. Once the natural freshwater resources are contaminated, it brings negative effects towards human's health as well.

One of the challenges of nature conservation includes overharvesting. High demand towards the source of protein including fishes causes overharvesting to be occurring. Overharvesting causes the depletion or extinction of a particular animal species which may cause the unbalancing of the ecosystem. Human's overpopulation is the most challenging aspect in nature conservation. This is because the increase in human's population will eventually increase human's activities. This increases the chances for pollution to be happening. Moreover, increase in human's population will increase the demand for freshwater sources and also increase the release of wastewater production. Lastly, global warming is one of the factors that is hard to be controlled by human in nature conservation. In conclusion, nature conservation should be carried out even though it is challenging. This is because nature conservation can ensure that the biodiversity all around the world can be protected.

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## CHAPTER 2

### LEACHATE TREATMENT BY CONVENTIONAL COAGULATION, ELECTROCOAGULATION AND TWO STAGES COAGULATION (CONVENTIONAL COAGULATION AND ELECTROCOAGULATION)

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#### Abstract

Leachate is widely explored and investigated due to highly polluted and difficult to treat. Leachate treatment commonly involves advanced, complicated and high cost activities. Conventional coagulation is widely used in the treatment of wastewater but the sludge production becomes the biggest constraint in this treatment. Electrocoagulation is an alternative to conventional method because it has the same application but produce less sludge and requires simple equipment. Thus, combination of conventional coagulation and electrocoagulation can improve the efficiency of coagulation process in leachate treatment. This article is focusing on the efficiency of single and combined treatment as well as the improvement made by combined treatment. Based on review, the percentage reduction of current density and dose of coagulant was perceptible. As much 50% reduction of current density, duration of treatment, and dose of coagulant able to be obtained by using combined treatment. This combined treatment is able to reduce the cost and at the same time reduce the duration of treatment. Hence, the combined treatment offers an alternative technique for landfill leachate treatment on the removal of pollutants.

**Keywords—landfill, leachate treatment, coagulation-flocculation, electrocoagulation**

## 1. Introduction

In Malaysia the common solid waste disposal comprises of open dumping, controlled dumping, and sanitary landfill. Landfill is a place for disposal of residue solid wastes in the surface soils of the earth. Sanitary landfill is the best and safe method option for solid waste management but the constraint for sanitary landfill is lacking funds. In Malaysia, there are only 11 sanitary landfills out of 155 landfills [1]. Thus, the government accounted an action by increasing the number of sanitary landfill. Landfilling is one of the best method for disposal of solid waste. However, it produces the hazardous liquid known as leachate.

Leachate is the result of the percolation of precipitation, uncontrolled runoff, irrigation water into the landfill, and the water content in the waste [2]. Based on Rodriguez (2004), leachate is a dangerous liquid that harm the environment if not treated properly [2]. The quality of leachate depends on the age of landfill, refuse composition, site condition, and degree of compaction, temperature, and depth of waste [2, 3]. Landfill leachate is divided into three group which is young, intermediate and stabilized. Young leachate is produced at the acidogenic phase while, mature leachate produced at methanogenic phase [4, 5]. At the acidogenic phase, the large amount of acid will produce but at the methanogenic phase the acid will convert into methane gas [4, 5]. The characteristic of leachate is measured through concentration of biological oxygen demand (BOD), chemical oxygen demand (COD), ammoniacal nitrogen ( $\text{NH}_3\text{-N}$ ), suspended solid (SS), organic compound, heavy metals, biodegradability and pH (Table 1).

**Table 1:** Characteristics of different types of landfill leachate [6]

Parameter	Young	Intermediate	Stabilized
Age (years)	<5	5-10	>10
pH	6.5	6.5-7.5	>7.5
COD (mg/L)	>10 000	4000-10000	<4000
BOD <sub>5</sub> /COD	>0.3	0.1-0.3	<0.1
TOC/BOD	<0.3	0.3-0.5	>0.5
NH <sub>3</sub> -N (mg/L)	<400	-	>400
Organic compounds	80% VFA	5-30% VFA+ HA and FA	HA and FA
Heavy metals	Low-medium	Low	Low
Biodegradability	Important	Medium	Low

\*VFA – Volatile fatty acid

\*HA – Humic acid

\*FA – Fulvic acid

## 2. Treatment of Leachate

The treatment of leachate is depending on the type of leachate. Class of leachate (young, intermediate or stabilized) determine the suitability of the treatment that can be applied (Table 2) [3, 4]. For young leachate, the age of landfill is below 5 years and it contains large amount of biodegradable organic matter [7]. The suitable method for high biodegradable organic matter is biological treatment method [8] such as aerobic and anaerobic treatments. Leachate requires more than 10 years to stabilize. At this stage, the organic fraction in the leachate dominated by non-biodegradable compound and physical-chemical treatment is the suitable method for this condition [9]. The method such as coagulation-flocculation, chemical precipitation, chemical oxidation, and electrocoagulation is an example of physical-chemical treatment that can be applied [10, 11]. Suitable treatment for stabilizing leachate is physical-chemical treatment due to its less organic matter [10, 11]. However, with the increasing ages of landfill the composition of leachate became more complex and difficult to treat [4]. Single treatment is properly not sufficient to treat leachate up to permissible discharge standard [12]. Therefore, combined treatment becomes the new alternative treatment for leachate [4, 10].

**Table 2:** Landfill leachate treatment [13, 14]

Processes	Treatment efficiency		
	Young	Intermediate	Stabilized
Biological treatment	Good	Fair	Poor
Chemical oxidation	Fair-poor	Fair	Fair
Activated carbon	Fair-poor	Good-fair	Good
Coagulation-flocculation	Fair-poor	Good-fair	Good
Electrocoagulation	Poor	Good-Fair	Good

## 3. Conventional Coagulation

Based on study by Lee, Robinson and Chong (2014), conventional coagulation and direct flocculation is a different process [16]. Conventional coagulation involves the use of coagulating agents such as  $\text{Al}^{3+}$  and  $\text{Fe}^{3+}$  salts to destabilize the colloidal material, which caused the small particles to agglomerate into large stable flocs [16]. Conventional coagulation is more effective by using cationic inorganic metal salts with the help of coagulant aid that have long chain ionic polymer [16]. For conventional coagulation, the operating parameters are rapid and slow mixing intensities, rapid and slow mixing duration, dose of coagulant, pH, and settling duration [15]. Coagulant aid is used to help the reaction in coagulation-flocculation process by enhancing the floc-settling rate [16]. The coagulant will be added at the beginning of rapid mixing, while the coagulant aid will be added at slow mixing

[22]. The function of this mixing is to mix the coagulant in the solution uniformly and to attach the suspended particle to grow in size that easily settle by gravity [17].

The direct flocculation process does not involve the addition of coagulant and pH adjustment, it only uses the medium charge density with high molecular weight of cationic polymers [15]. This method will produce less sludge and workable at any pH range and only suitable for organic based wastewater [18]. Thus, the conventional method is still preferable and widely used to treat wastewater due to workability to treat organic-based and inorganic wastewater. The inorganic metal salts need to be added in large quantities to obtain high efficiency. Furthermore, metal salt has an adverse effect if it has been used excessively. The application of coagulant aid can reduces the amount of coagulant used and at the same time improves the flocculation process in wastewater treatment. Types of coagulant aid that has been used are synthetic and natural ones [19]. The use of coagulant aid in industrial effluents treatment become popular due to their natural inertness to pH changes, used of low dosage, easy to handle, and have high treatment efficiency [20]. Synthetic polymeric coagulants have problems of non-biodegradability and unfriendly to environment compared to natural coagulants aid. However, natural coagulant aid has moderate efficiency especially for landfill leachate treatment [21]. Thus, the combination of coagulant aid with chemical coagulant will produce better coagulation and flocculation process [22].

Table 3 shows the efficiency of primary coagulant and coagulants aid for leachate treatment. Based on Table 3, the efficiency of conventional coagulation with the help by coagulant aid shows different results. The performance of the treatment depends on the composition of leachate and several factors such as pH and dose of coagulant. Based on a study by Tatsi [15], Hamidi [23] and Wang [24], the use of ferric chloride as coagulant shows high efficiency of pollutants removal. It also proved that, a conventional coagulation treatment is unsuitable to treat young leachate. Physical-chemical method is insufficient to treat high concentration of COD but it can remove colour effectively [24]. The initial pH of the wastewater plays the important role for conventional coagulation performance. Based on Zhang (2002), the lower the pH value, the higher the efficiency of the treatment [24]. Addition of acid (HCl) will increase the positive charge in the solution then adsorb the negative charge from the leachate [25]. The removal of colour shows high removal efficiency due to the effectiveness of coagulants to entrap the colloidal particle, which is directly increase the removal of colour [26].

The selection of coagulant aid is important because the suitable coagulant aid will improve the flocculation process. Study by Zhang (2002) shows low removal of COD and colour because the use of unsuitable coagulant aid [24]. Hamidi (2007) had stated that sometime coagulant aid is not necessary if the wastewater is categorized as low range [23]. Application of coagulant aid can affect the treatment performance by destabilization of colloidal particles. Thus, for low range wastewater no addition of coagulants aid is needed. However, for high strength wastewater such as leachate addition of coagulant aid is advisable. Conventional coagulant is established treatment method as it has been applied since ages. There are many studies have been done to improve this method with aimed to reduce the dose consumption, simplified the method, and utilization of new coagulant.

#### 4. Electrocoagulation Treatment

Electrocoagulation (EC) method becomes popular especially among the researcher [13]. This method is developed to overcome the drawbacks of conventional wastewater treatment process. It is also widely used in several wastewater treatment such as mill paper wastewater, textile wastewater, restaurant wastewater, and sanitary landfill leachate [27, 29]. EC is a direct current source that transfers to metal electrodes, which are immersed in wastewater. The electric current cause the dissolution of metal electrodes commonly iron or alum into wastewater [30]. The dissolution metal ions, at the suitable pH can form wide ranges of coagulant and metal hydroxides that destabilize and merge the suspended particles [21]. EC is an effective method in removing organic pollutants and producing less generation of sludge compared to the conventional coagulation [21, 28]. However, the effectiveness of EC is depending on several factors such as current density, duration of current flow, conductivity, and pH.

**Table 3:** Application of conventional coagulation for landfill leachate

Coagulant(s)	Coagulants aid	Type of landfill leachate	Characteristics	Optimum result	References
Ferric chloride and aluminium sulphate  Dose : Alum – 3 g/l Ferum – 2 g/l	Natural (N200), two cationic (K1370) and K506 and an anionic (A321) polyelectrolytes	Landfill leachate (young)	pH - 6.2  Colour - 10550 pt-Co  COD - 70900 mg/l  NH <sub>3</sub> -N - 950 mg/l	<i>Alum Sulphate</i>  COD – 40% (raw pH)  Colour– 100% (pH 7)	[15]
				<i>Ferric chloride</i>  COD -25% (pH 10)  Colour – 95% (pH 10)	
Ferric chloride and aluminium sulphate  Dose : Alum – 3 g/l Ferum – 2 g/l	Natural (N200), two cationic (K1370) and K506 and an anionic (A321) polyelectrolytes	Landfill leachate (stabilized)	ph - 7.9  Colour - 7600 p-tCo  COD - 5350 mg/l  NH <sub>3</sub> -N - 940 mg/l	<i>Alum Sulphate</i>  COD – 70% (pH 10)  Colour – 97% (pH 10)	[15]

				<i>Ferric chloride</i> COD – 75% (pH 10) Colour – 100% (pH 10)	
Ferric chloride Dose : 0.97 g/l	Polyacrylamide grafted Gum Ghatti (GGI-g-PAM)	Landfill leachate (stabilized)	pH - 7.7 $BOD_5$ - 11 mg/l COD - 2475 mg/l $NH_3-N$ - 200 mg/l	COD – 79% Turbidity – 90% TSS – 90%	[42]
Ferric chloride Dose : 1.0 g/l	Sodium oxalate Dose : not stated	Landfill leachate (stabilized)	pH – 7.6 COD – 5800mg/l $BOD_5$ – 430mg/l	COD – 31% Colour – 70%	[24]
Ferric sulphate Dose : 1.2 g/l	-	Landfill leachate (young)	pH – 8.6 COD – 2567 mg/l Turbidity – 250 NTU SS – 640 mg/l Colour – 5305 pt-Co	Colour – 92% Turbidity – 95% SS – 94% COD – 51%	[23]
Polyaluminium silicate chloride (PASiC) Dose : 0.2 g/l	Anionic polyacrylamide Dose : not stated	Landfill leachate (stabilized)	pH - 8.5 COD - 2456 mg/l Turbidity - 103 NTU	Colour – 80% Turbidity – 95%	[43]
Lateritic soil Dose : 14 g/l	-	Landfill leachate (stabilized)	pH – 8.38 COD – 3500 mg/l Colour – 4750 pt-Co $NH_3N$ – 2040 mg/l	COD – 65.7% Colour – 81.8 $NH_3N$ – 41.2	[44]

\*COD-Chemical oxygen demand

\*SS-Suspended solid

\*TSS-Total suspended solid

\* $NH_3N$ -Ammonical nitrogen

**Table 4:** Application of electrocoagulation for leachate treatment

Optimum reading	Time taken (min)	Type of electrode (Al/Fe)	The volume of sample (ml)	Dimension of plate (mm)	No of electrode	Spacing (mm)	Effective area (cm <sup>2</sup> )	pH	Percentage of Removal (%)	Reference
Current density (mA/cm <sup>2</sup> )										
1.0	30	Fe (Rod)	1500	Length = 150 Diameter = 3	2	8.7	491	4.6	73.3 (Cr(VI))	[31]
5.62	30	Fe	1000	130x50 Thickness = 4m	2	50	142.40	2.91	70 (COD) 96.7 (Turbidity)	[32]
60	30	Fe	500	100x50 Thickness = 1mm	2	65	50	6.00	80.0 (COD) 42.0 (Colour)	[33]
63.1	30	Fe	500	150x50 Thickness = 2.0mm	2	65	45	6.9	32.0 (COD) 11.0 (NH <sub>3</sub> -N)	[34]
63.1	30	Al	500	150x50	2	65	45	6.9	59.0 (COD) 14.0 (NH <sub>3</sub> N)	
10	15	Al and Fe	650	45x75 Thickness = 3mm	6	10	-	3.0	100% (Cu) 100% (Cr) 100% (Ni)	[35]
20	120	Fe	900	75x45	6	9	202	6.54	53.4 (COD)	
4.96	90	Fe and Al	1000	120x70 Thickness = 1mm	10	10	560	6.7	49.8 (COD) 38.6 (NH <sub>3</sub> N) 69.7(Turbidity)	

Table 4, shows the performance of EC in the landfill leachate. The mechanism of EC extremely depends on the chemistry of the aqueous solution especially the conductivity. Conductivity helps the performance by enhancing the reaction of current in the solution. Based on Ilhan (2008), higher conductivity of leachate leads the metal ions to be dissolved easily while lower conductivity needs longer duration of current flow to fully reacted [34]. The longer retention time will increase the cost of treatment. In order to increase the conductivity, addition of sodium chloride has been suggested in some studies [38, 39]. Based on this table, the relationship between current density, effective surface area, and number of electrode need to be designed properly because it will affect the performance of EC. The performance for removal of COD by Orkun (2012) and Li (2011) shows slight differences [36, 37]. The more electrode used, the higher the treatment performance because the effective area is larger. However, the current density that has been supplied will be divided into each electrode. Thus, each electrode will be supplied the small value of current charge. Thus, the use of many electrodes requires high current density that increase the treatment cost. Most of the studies prefer to use two electrodes to reduce the cost of treatment and equipment.

Based on the Table 4, two electrodes show good removals performance of COD, turbidity, and heavy metals as described by Yehia (2015), Faiqun (2007), Moayerikashani (2012) and Feryal (2010) [31, 32, 33, 35]. Leachate that has high concentration of COD and NH<sub>3</sub>N is difficult to treat by single EC treatment. As found by Ilhan (2008), high concentration of COD and ammonia NH<sub>3</sub>N in leachate were difficult to treat [34]. The composition of leachate plays the important role in EC performance. The high amount of current density can increase the removal of COD but it can interfere the colloidal particles stabilization which caused the reduction of colour and turbidity removals. Thus, the proper design of EC treatment must be emphasized due to the mechanism in EC is complex.

##### **5. Two Stages Coagulation (Conventional Coagulation and Electrocoagulation)**

To date, combined treatment becomes the popular subject to be investigated especially in leachate treatment due to the complex composition of the leachate. Single treatment is not sufficient to treat the leachate. Examples of combine treatment are electro-photooxidation [40], electro-Fenton and SBR [41], and chemical coagulation-electrocoagulation [42]. Conventional coagulation treatment combined with EC treatment is still in research stage especially for leachate treatment. This method is expected to be effective in removing the inorganic matter. It is due to the use of current adsorb high volume of metal hydroxide and the coagulant absorb micro-colloidal particle in the leachate. Table 5 shows the application of combine treatment in the treatment of various type of wastewater.

**Table 5:** Application of combined treatments for various type of wastewater

Dose of coagulant (g/l)	Mixing intensity (rpm) and minute	Current density (mA/cm <sup>2</sup> )	Duration of current flow (min)	Type of electrode and number	Type of wastewater	pH	Percentage of removal (%)	Reference
PACl = 0.1	Rapid = 150 2min  Slow = 50 20min	17.8	15	Alum and 4 plates	Slaughterhouse wastewater	7	BOD <sub>5</sub> = 99% COD = 99% TSS = 80%	[40]
Iron sulphate = 1.2  Alum sulphate = 0.35	Not stated	10 - 15	30	Alum and iron and 6 plates	Stabilized leachate	3	Iron COD = 88% Colour = 90%  Alum COD = 86% Colour = 99%	[41]
Coagulant Iron Sulphate = 1.0  Coagulant aid = 2.5	Not stated	20.0	25	Alum and 2 electrodes	Intermediate leachate	4	SS = 80% Colour = 95% COD = 82% NH <sub>3</sub> N = 65%	[28]
PACl = 3.0	Not stated	40.0	240	Iron and 2 electrodes	Palm oil mill	3.6	COD = 90%	[45]

\*BOD<sub>5</sub>-Biochemical oxygen demand

\*SS-Suspended solid

\*COD-Chemical oxygen demand

\* NH<sub>3</sub>N-Ammoniacal nitrogen

\*PACl-Poly-aluminium chloride

Based on Table 5, combined treatment shows an effective removal and at the same time reduce dose, current density, and duration of current flow. The combined treatment offers an alternative technique in dealing with leachate treatment. In the combined treatment, there are two types of experimental design. Firstly, the treatment is conducted independently in optimum conditions for each treatment. Secondly, the treatment is conducted simultaneously at all optimum condition. This combined method is still new and difficult to get referrals. Studies by Hanafi (2015) shows the reduction of current density and duration of current flow with the high removal of suspended solid, colour, COD, and NH<sub>3</sub>N by using two stages coagulation [41]. EC produced fragile floc compared to conventional coagulation. Fragile floc is it too sensitive to physical forces and easily breakable and reduced back the removal efficiency [41]. Thus, the addition of coagulant helps floc strength and increases the positive charge in the solution. At the same time, EC helps coagulation by increasing the pH after treatment and reduces dose of coagulant because EC also produces coagulant by in situ. EC also reduced the sludge production. Table 6 shows the advantages and disadvantages of conventional coagulation and electrocoagulation that simultaneously facilitate when conducted together.

**Table 6:** Advantage and Disadvantage of conventional coagulation and EC method

Method	Advantages	Disadvantages
Coagulation-flocculation	<ul style="list-style-type: none"> <li>- easy operation</li> <li>- low cost</li> <li>- high efficiency in the removal of the pollutants</li> <li>- various type of wastewater</li> </ul>	<ul style="list-style-type: none"> <li>- high sludge production</li> <li>- the sludge gives adverse effects to human health</li> <li>- increase cost of sludge treatment</li> </ul>
Electrocoagulation	<ul style="list-style-type: none"> <li>- easy operation</li> <li>- the equipment easy to get</li> <li>- no need addition of chemical</li> <li>- high efficiency in removal the pollutants</li> </ul>	<ul style="list-style-type: none"> <li>- the layer of permeable oxide form at the cathode and reduce the efficiency of electrode</li> </ul>

## 6. Conclusion

Landfill leachate become the most difficult wastewater to treat because it contains a large amount of organic, inorganic, and heavy metal. If leachate is not treated properly, it will affect the environment. Thus, a proper and effective treatment to treat the leachate becomes the most popular subject to be investigated. Physical-chemical treatment is one of the methods applied for leachate treatment especially for partially stabilized and stable leachate. Conventional coagulation and electrocoagulation have been used in leachate treatment. Previously it is used as single treatment. However, for high strength wastewater such as leachate, the combination of these two methods are proven to be able to improve the treatment process by combining the strength of each method that compensate the weakness of both methods. However, this method is still in laboratory scale stage. Thus, intensive research study must be conducted especially for pilot scale study to ensure the applicability of this combined conventional coagulation and electrocoagulation in landfill site.

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# CHAPTER 3

## A REVIEW ON THE INFLUENCE OF DRINKING WATER QUALITY TOWARDS HUMAN HEALTH

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### Abstract

An adequate supply of safe drinking water is one of the major prerequisites for a healthy life. Inadequate of safe drinking water produce waterborne disease and a major cause of death in many parts of the world, particularly in children. Therefore, it must be treated properly before it can be used and consumed. This chapter provides the guidelines of important parameters for drinking water standard in order to ensure the safeness of drinking water. All the selected parameters were elaborated on the effect of high concentration if human consume the drinking water directly.

**Keywords— water resources, tap water, drinking water parameters**

### 1. Introduction

Water is imperative to individuals. All can live for some time without sustenance yet can't make due without water as there is around 70 % of water in our bodies. There is about 75% of the fresh water locked up as ice-caps and glaciers, 24% of it shows up as groundwater and under 1 % of the aggregate volume is found in lakes, streams and the dirt [1]. Since water is firmly identified with our life, in this way we are worried about the nature of our provided drinking water [1]. Drinking water or consumable water can be characterized as the water conveyed to the buyer that can be securely utilized for drinking, cooking, washing and other household applications [2].

In general, people living in developed countries have proper water supply at home. The quality of water received is clean and safe for consumption and can be consumed directly from the tap without threatening health and life. Be that as it may, there are still around one billion individuals need safe drinking water and more than six million individuals pass on from looseness of the bowels consistently because of utilization of dirty water [2].

## **2. Water Resources**

Water supply in Malaysia originates from two primary assets in term of surface water and groundwater. Surface water is any water which is discovered streaming or remaining at first glance, for examples waterway, streams, lakes, lakes and supply. Nature of surface water is needy upon the geographical factor. In Malaysia, surface water is promptly accessible consistently, its preoccupied essentially for the water system and residential employment. Surface water represents 97% of the total water use [3]. Pollution of surface water inevitable, therefore it needs to be treated carefully before being supplied to the consumers.

Groundwater is the precipitation that leaks down through the dirt until achieves shale material that is soaked with water. Groundwater for most part has better quality surface water, normally free from suspended soils, microscopic organisms and different pathogens with the exception of in zones where it has been influenced by contamination. Groundwater only represents 3% of the total water use [4]. In Malaysia, the potential aquifers might be found in alluvium and hard shale. In solidified residue, the aquifer happens in openings frame as a result of substance disintegration and in fractures in the stone body.

## **3. Tap Water**

Drinking water for human utilization ordinarily originates from two sources, tap water and mineral water. Whereas tap water usually comes from water treatment plants and is originally from rivers or artesian wells, mineral water is usually spring water that is bottled untreated [5]. The taste of water may be related to organic compounds found dissolved in it. Organic matter dissolved in water is a concern from the safety point of view, both for human consumption and environment.

In Malaysia, tap water is at first treated by an incorporated water treatment framework before being distributed to the consumer. In any case, the tap water quality isn't as agreeable as different angles due to the low quality of crude water because of unfit soil and water conservancy thusly, propelled water treatment ought to be developed to supplant the regular elucidation [6]. Drinking water or tap water, as devoured at home is a wellspring of minerals in the eating routine even though the sums are far lower than from other dietary sources.

## **4. Malaysian National Drinking Water Standards**

A drinking water quality rule esteem speaks to the centralization of a constituent that does not bring about any critical wellbeing danger to the customer over a lifetime of utilization. At the point when a rule esteem is surpassed, the reason ought to be researched, and a restorative move made. The amount by which, and for to what extent, any rule esteem can be surpassed without jeopardizing human wellbeing relies upon the substance included [7].

The quality of tap water and drinking water is frequently described by the minerals composition, color, taste and odor. According to Azlan [8], the result of the selected minerals found in the tap water samples were below the international standard limits, except for iron and manganese that were higher. The source from the tap water is an important source of minerals intake in the rural areas. The higher concentrations of heavy metals must be monitored from Ministry of Health Malaysia in term of safety and health which may poses the adverse health effects to the populations. Treated water from water treatment plant in Malaysia is required to meet the drinking water standard and can be consume directly. However during collection, distribution and storage, low level of hygiene and infrastructure failure may occur and will affect the quality of the water [9];[10].. Contaminants in tap water usually include aluminium, chlorine, calcium, magnesium, sodium, zinc, ammonia, arsenic, copper, lead, chromium, nitrate, cadmium, iron, and manganese. The most source pollutants in tap water are come from the distribution system. There are the issues in drinking water distribution systems such as microbial in nature, including biofilm growth [11], nitrification [12], microbial mediated corrosion [13] and the steadiness of pathogens [14]. The issue is expected under influence of water temperature, residence time and pipe material the drinking water quality may change while the water passes the domestic drinking water system [15]. Table 1 shows the benchmark for the drinking water quality status are usually determined using the National Guidelines for Drinking Water Quality Standard from the Ministry of Health.

**Table 1:** Malaysia National Guidelines for Drinking Water Quality Standard [16].

<b>Parameters</b>	<b>Maximum permitted proportion</b>
Turbidity	2 NTU
Color	15 TCU
pH	6.5-8.5
Aluminium	0.2 mg/l
Ammonia	0.5 mg/l
Anionic Detergent	1 mg/l
Sulphate	250 mg/l
Hardness	500 mg/l
Nitrate	10 mg/l
E.coli or Coliform	Must not detected in any 100ml sample
Manganese	0.1 mg/l
Fluoride	0.6 mg/l
Magnesium	150 mg/l
Chromium	0.05 mg/l
Residual Chlorine Free	Not less than 0.2
Cyanide	0.07 mg/l
Zinc	3 mg/l
Arsenic	0.01 mg/l

Selenium	0.01 mg/l
Chloride	250 mg/l
Phenol	0.002 mg/l
Iron	0.3 mg/l
Copper	1 mg/l
Lead	0.01 mg/l
Silver	0.05 mg/l
Sodium	200 mg/l
Cadmium	0.003 mg/l
Mercury	0.001 mg/l

## **5. Drinking Water Quality from Tap Water**

Several parameters must be considered when evaluating the quality of drinking water. The parameters that involved are described below.

### **5.1 Bacteriological quality**

The bacteriological quantity will be affecting the taste and colour of the water. Coliforms are the major microbial indicators for microbial indicators for water quality monitoring [18]. Coliform bacteria are the absolute most regular bacterial species, going from harmless to pathogenic and are discovered broadly in soil and in the defecation of warm blooded creatures [19]. Total and fecal coliforms count is the most prominent method used to assess the bacteriological quality of drinking water and surface water [19]. *Escherichia coli* as *E.coli* is a solitary types of fecal coliforms bacteria organisms that happens just in fecal issue from people and other warm-blooded creatures [20].

The bacterial infection transmitted through water and presented is concentrating on science and environment of the causal specialists and the malady qualities. Over two billion individuals have no entrance to enhanced sanitation, and in excess of 1.5 million youngsters bite the dust every year from diarrheal infections [21]. Children under five, fundamentally in Asian and African nations, are the most influenced by microbial sicknesses transmitted through water [22]. Tainting of water has been every now and again discovered related with transmission of malady causing bacteria organisms and parasitic loose bowels because of *Salmonella* and *Vibrio* or intense contamination the runs caused by *Escherichia Coli* [23].

### **5.2 Colour**

Colour in drinking water is caused primarily attributable to natural issue, generally humic material and colloidal forms of iron and manganese. Colour is derived from the dissolved and suspended matter. It's from metallic ions, chemical pollutants, plankton, plant pigments from humus and peat. Pure water is colourles but the presence of foreign substances frequently tints the water. Coloured water can

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affect laundering, dyeing, papermaking, dairy production, and other food processing, textile, and plastic production [24].

### **5.3 Turbidity**

Turbidity is a measure of water capacity to retain or scattered light. Turbidity is caused by the nearness of particulate issue in water, for example, mud, sediment, colloidal particles, tiny fish and other microscopic organisms [25]. The filtration method is an effective method for reducing turbidity in water caused by the presence of suspended solids such as sand, silt, or clay [26]. Turbidity is usually measured in Nephelometric Turbidity Unit (NTU) [27]. The utilization of exceptionally turbid water may constitute a wellbeing danger. Other than that, when turbidity is higher in drinking water sources may constitute a health risk as excessive turbidity can protect pathogenic microorganisms from the effects of disinfectants and also stimulate the growth of bacteria during storage [28]. The effect shield pathogenic microorganisms from disinfectants of improvement bacteria organisms amid capacity [29].

### **5.4 pH**

The carbon dioxide-bicarbonate-carbonate equilibrium phenomenon is the principal system regulating pH in natural waters. The pH is defined as the negative 10-logarithm of the hydrogen ion activity in the water, which therefore provides the indication of the amount of the hydrogen ions in the water. The erosion may not be critical, the cleansing would be less powerful at pH 7. Water with pH value below 7.0 is considered as acidic whereas water with pH value over 7.0 is considered basic or alkaline, while pH 7.0 indicates a neutral condition [30].

The pH from the tap water can be changed using electrolysis. The electrolysis is a process that takes place in an electrolytic cell, cathode and anode. The process at cathode is called reduction, and the process that takes place at the anode is called oxidation [31]. The reduction and oxidation have taken place and produce the alkaline and acidic water. The production water has some advocates of alkaline water believe it can neutralize the acid in your body [32].

### **5.5 Metals**

Metals refer to any metallic element that has relatively high density and are often toxic when accumulated in food chain and persistence nature [33]. Heavy metals are risky in light of the fact that they tend to bioaccumulate. The characteristic process and anthropogenic exercises would releases metals into the environment. In further, can enter a water supply by mechanical and buyer squander, or even from acidic rain separating soils and discharging substantial metals into streams, lakes, waterways and groundwater [34].

The effect of metals is high risk due to contaminated water consumption. Studies have reported various chronic and sub chronic effects from exposure to heavy metals. The heavy metals in drinking water linked most often to human poisoning are lead, iron, cadmium, copper, zinc, chromium and

other. According to the International Agency for Research on Cancer [35], Arsenic (As) is related to cancer risk and skin damage, Cadmium (Cd) is linked to kidney damage and cancer. Other effects such as Anemia from Lead (Pb), kidney and liver damage from mercury (Hg), Alzheimer's disease, brain disorder through nervous system, kidney and digestive system from Aluminium (Al), kidneys, liver, cardiovascular damage from Iron (Fe) and gastrointestinal disorder from Copper (Cu) are also reported [36].

### **5.6 Hardness**

Water hardness is caused by calcium (Ca) and magnesium (Mg) compounds. The two chemicals are not effortlessly identified, but rather the various negative impacts can be upsetting and expensive. The vital wellspring of hardness in water is dissolved polyvalent metallic ion from sedimentary rocks, drainage and run-off from soils. Water with the hardness over 200 mg/l may cause scale affidavit in the conveyance framework and also expanded cleanser utilization. Interestingly, with hardness not exactly around 100 mg/l, has a more noteworthy inclination to cause erosion of funnels, bringing about the nearness of certain substantial metals, for example, cadmium, copper, lead, and zinc in drinking water [37].

Hard water contributes calcium and once in a while magnesium to the eating routine, however the fixations and relative sums shift generally as per levels of water utilization through drinking and sustenance planning and the wellsprings of water [38]. Other than that, water hardness causes antagonistic health impacts in people other than expanded danger of kidney stone [39].

### **5.7 Nitrogen Ammonia**

Nitrogen is basic for every single living thing as it is a part of protein. It exists naturally in numerous structures and it travels through the cycle. Ammonia is present in nature as part of the nitrogen cycle. When all aquatic organisms excrete wastes and aquatic plants and organisms die, these may create presence of ammonia. However, infants and pregnant women are the most affected with the higher concentrations of ammonia [40]. Exposure to ammonia at any stage of pregnancy would not usually be regarded as medical grounds for termination of pregnancy. Where maternal toxicity is evident, additional fetal monitoring may be warranted, particularly if exposure is associated with maternal hypoxia. Other risk factors may also be present in individual cases which may independently increase the risk of adverse pregnancy outcome. Other than that, healthy person's liver converts ammonia into urea, a nonpoisonous substance excreted in urine. Several conditions and disorders that afflict children disrupt this process, known as the urea cycle, resulting in excessive levels of ammonia in the blood that can cause brain damage, coma and even death [41]; [42].

## 5.8 Anionic Surfactant (Detergents)

A surfactant intended for commercial sale, either as such or as a component in a detergent or cleaning formulation, should first undergo exhaustive tests to establish that there is no direct hazard to the health of the user. The detergent industry is particularly careful in this regard because many of its products come into intimate contact with the skin and are also used in the washing of wearing apparel, food, and food utensils. Delayed ingestion of hundreds or thousands of milligrams for each day has been discovered innocuous to people, a great many circumstances the sums which would enter through utilization of municipal drinking water. The exposure to the trace amounts of surfactants which may enter our environment via sewage which might be ingested by the individual in the normal course of events [43].

## 5.9 Phenol

Phenol is a dull to white solid when unadulterated. Commercial phenol is a fluid that dissipates more gradually than water. It has a particular scent that is sickeningly sweet and tarry. The common phenols are described pentachlorophenol, 4-chloro-3-methylphenol, 2,4,6-trichlorophenol, 2,4-dichlorophenol 2,4-dinitrophenol, 2-methyl-4, 6-dinitrophenol, 4-nitrophenol, 2,4-dimethylphenol, 2-nitrophenol, 2-chlorophenol and phenol have been included in the lists of priority pollutants [44].

Phenol is both manufactured chemical and a natural substance. There are the products of many industrial processes include coking plants and intermediates in the production of plastics, drugs, dyes, weed control agents and other pesticides [45]; [46]. Phenol can be found in air and water after discharge from fabricate, utilize, and transfer of items containing phenol. This in soil is going likely to move to groundwater. The potential health effects are cardiovascular disease, gastrointestinal damage, even death, and skin damage. Even though, potential health effects to children are contribute from vomiting, lethargy, birth defects and breast milk [47].

## 5.10 Cyanide

Cyanide is a carbon-nitrogen chemical unit which combines with many organic and inorganic compounds. Additionally, created by the deterioration of a few plants, can be available in a few nourishment for example, green almonds and dishonorably arranged cassava and can be delivered by a few microorganisms. The most ordinarily utilized form hydrogen cyanide is principally used to make the mixes expected to make nylon and other manufactured filaments and resins.

However, the health effects in term of short-term with the Environmental Protection Agency (EPA) has found when individuals are presented to it at level over the greatest contaminant level for moderately brief time may cause quick breathing, tremors, and other neurological impacts. Other than that, cyanide can possibly cause impacts to weight reduction, thyroid impacts and nerve harm from a lifetime presentation at levels over the most extreme contaminant level [49].

### 5.11 Residual Chlorine

The contaminant of chlorine is among the important process in water treatment plant. In Malaysia, chlorine is broadly used to refine drinking water. It is a basic chemical to control the centralization of free chlorine in the water, as any free chlorine antagonistically influences the taste and smell of water [50]. Chlorine residuals are maintained in drinking water distribution systems to prevent microbial contamination and microorganism regrowth [51]. High chlorine measurements at chlorination focuses for keeping up cleaning energy of tap water may prompt taste and odor issues [52].

The utilization of chlorine postured potential health dangers because of the formation of carcinogenic halo-organic compounds, as sanitization by-products [53] and major of which is trihalomethane (THM). These compounds could cause by evaluating ingestion by means of the gastrointestinal tract, skin contact and inward breath risks, premature birth or teratogenic infants, and kids with asthma from breathing in THMs vapor through the respiratory tract [54]. The centralization of all types of THMs slowly expanded as per the separation from water treatment plant to the sampling point [55]. This may be due to the more extended contact time amongst chlorine and natural issue in pipeline. Other than that, the best strategy to lessen the issue of sterilization by items THMs are to decrease natural levels previously cleansing with chlorine and to confine the utilization of chlorine prechlorination.

### 5.12 Nitrate

Nitrate is an inorganic aggravate that happens under an assortment of conditions in the environment, both normally and synthetically. It happens regularly in soil and water a wealth level of nitrates can be a contaminant of ground and surface waters. A large portion of the sources originate from human activities such as farming, human squanders or industrial pollution. Nitrate is an essential source of nitrogen for plants. Nitrate is one of the most widespread contaminants that can get into water and the typical sources including wastes from livestock operations, septic tank, crop and lawn fertilizers, municipal wastewater sludge application and natural geologic nitrogen.

Large amounts of nitrate in drinking water can cause serious illness in infants under six months of age. Nitrate in drinking water begins influencing the wellbeing of the general masses at levels in the scope of 100 to 200 mg/l nitrate, however the impact on any given individual relies upon numerous elements, including different sources of nitrate and nitrite the eating routine [56]. If the drinking water sources come from the wells, the level of nitrate should be monitored first in order to avoid the high nitrates that can contribute the ability of red blood cells to transport oxygen and difficulty in breathing since bodies are not receiving enough oxygen.

### 5.13 Sulphate

Sulfate occurs naturally in drinking water in numerous minerals, including barite, epsomite and gypsum. Sulfate minerals can cause scale buildup in water pipes like other minerals and may be associated with a bitter taste in water. Sulfates products are used in the production of fertilizers,

chemicals, dyes, glass, paper soaps, textiles, fungicides, insecticides, astringents and emetics. They are also used in the mining, wood pulp, metal and plating industries, in sewage treatment and in leather processing. Health concerns regarding sulfate in drinking water have been raised because effect of high levels of sulfate [57]. Particular concern are groups within the general population that may be at greater risk from the laxative effects of sulfate that can lead to dehydration especially for infants.

## 6. Conclusions

Overall, it can be concluded that in Malaysia, problem of water is unquestionably. One of the primary factors that are related with the human improvement considering its effect on human lives. The contaminants in tap water especially inorganic contaminants that arise from the geological strata through which the water flows and to a varying extent anthropogenic pollution by both microorganisms and chemicals. The all parameter stated above is more concern in drinking water guidelines by Ministry of Health. The parameters must be checked and sustained for below the value standard to make sure the drinking water supply from the tap water is free from hazardous chemicals that may affect human lives. As water pollution is getting worse, the most common use to treat tap water for houses is about equipped with water filter system.

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# CHAPTER 4

## IMPLEMENTATION OF FOOD WASTE COMPOSTING IN MALAYSIA

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### Abstract

As urbanisation continues to occur, waste management is becoming one of the major environmental problems around the world, including Malaysia. The generation of Municipal Solid Waste (MSW) in Malaysia has increased more than 91% over the past decades. Based on waste composition, food waste was indicated as the main waste component. Thus, recycling of food waste through composting had emerged as a potentially viable means that local governments can reduce the waste volume that is entering the landfills. Furthermore, MSW management in Malaysia can be considered as relatively poor and disorganized. The most preferred of MSW disposal method is through landfill due to various factors. This article elaborates on composting that gives benefits to Malaysian. This paper also exposes strategy to implement the composting in Malaysia by focusing on Food Waste Management Development Plan for the Industry, Commercial and Institution Sector. The current methods of food waste composting that are applied in Malaysia are also discussed in this paper. Finally, this paper reveals the challenges towards food waste composting in Malaysia.

**Keywords— challenges; composting; management; Municipal Solid Waste**

## 1. Introduction

Developed areas such as cities play a significant role in environmental and social sustainability. Developed areas require more spaces than what is inside their political boundaries in order to produce sufficient plants and animals for consumption, renewable energy for operation and space to absorb the air, water and waste disposal of their citizens. For instance, the largest city in Malaysia is Kuala Lumpur which covers an area of 243 km<sup>2</sup> (94 sq mi) and has estimated a population of 1.73 million [1]. The solid waste generation for any person in Kuala Lumpur was estimated to 1.5 kg a day, which produced to an estimated of 30,000 tonnes per day [1]. Based on the area, the waste required more spaces for disposal. Furthermore, due to lack of integrated waste management system, approximately 95% of the MSW is sent to landfills or dumps.

Nowadays, solid waste disposal has become a serious issue for municipal governments throughout the nation. As the available landfill space decreases and the cost of siting and building new landfills increases, the local authorities are struggling to develop alternative means of meeting the waste disposal challenge [1]. In Malaysia, the average waste composition results indicated that food wastes serve as the main waste component with 32%, followed by paper and plastics, 21% and 14% respectively as shown in Figure 1. From 32% of food waste, 44.5% was generated by household and balance was generated by industry, commercial or institution [2]. Composting of food waste has emerged as a potentially viable means that local governments can reduce the waste volume that is entering the landfills by diverting the organic fractious.

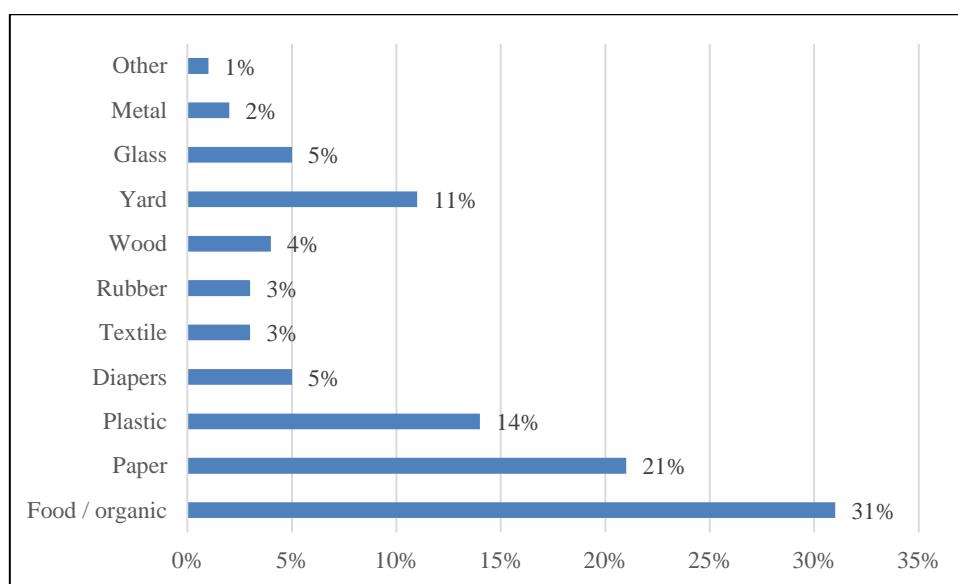


Figure 1: Waste composition in Malaysia [4]

The significant of volume reductions that are associated with composting and the possible uses of compost make MSW composting attractive as a potential alternative to divert waste from landfills. On the other hand, MSW composting requires considerable pre-sorting of the incoming waste and

screening of the finished product to remove the intolerable materials such as glass, plastic and metal which involve the relatively costly procedure [3]. Composting of food waste coupled with municipal solid waste is extensively implemented in India which has more than 70 composting facilities [4]. Every year, there are approximately 4.3 billion tonnes of compost produced from the food waste which stands at 5.9% of their municipal solid waste in India. Taiwan government also practices composting to utilize food waste to produce bio-fertilizers through their national programme named “Total Recycling for Kitchen Garbage” [5]. In Thailand, 15% of food waste from municipal solid waste was decomposed into bio-products such as biogas and bio-fertilizer [6]. However, it is noted that composting of food waste is less effective in developing countries due to reasons of improper segregation of food waste from other solid waste and poor food waste management framework [5,6].

Usually, the major contribution of the increasingly organic solid waste comes from human activities especially those from low income residential households. It can be proven as shown in Table 1, the characterization of municipal solid waste by different levels of income of the residents in Malaysia [7]. Residential households with low income showed the highest percentage of organic and food waste produced. This is because, residents in a low income tend to cook or prepared food at home as compared to the residents in high and medium income who likely to buy or eat at a restaurant.

This article is elaborating on food waste composting, which emphasize on strategy, methods and challenge in Malaysia. With this review, local authorities, government, NGO or researchers from other countries have an idea and knowledge in provide proper management in food waste composting.

**Table 1:** Typical Malaysia municipal solid waste characterization

<b>Source</b>	<b>Residential high income (%)</b>	<b>Residential medium income (%)</b>	<b>Residential low income (%)</b>
Food/Organic	30.84	38.42	54.04
Mix paper	9.75	7.22	6.37
News print	6.05	7.76	3.72
High grade paper	-	1.02	-
Corrugated paper	1.37	1.75	1.53
Plastic (rigid)	3.85	3.57	1.90
Plastic (film)	21.62	14.75	8.91
Plastic (foam)	0.74	1.72	0.85
Pampers	6.49	7.58	5.83
Textile	1.43	3.55	5.47
Rubber/leather	0.48	1.78	1.46
Wood	5.83	1.39	0.86
Yard	6.12	1.12	2.03
Glass (clear)	1.58	2.07	1.21
Glass (colour)	1.17	2.02	0.09
Ferrous	1.93	3.05	2.25
Non-ferrous	0.17	0.00	0.18
Aluminium	0.34	0.08	0.39
Batteries/hazards	0.22	0.18	-
Fine	-	0.71	2.66
Other organic	0.02	0.00	-
Other inorganic	-	0.27	0.25
Others	-	-	-

## 2. Composting

Composting is a natural process that converts food wastes into compost that is rich with nutrients and good for the soil. Composting converts several components in organic waste and turns into relatively stable humus-like substances that can be used as soil rectification or organic fertilizer. Li et al., [8] stated that composting helps to improve the soil structure and fertility. Composting is a convenient, easy, economical and natural biodegradation process that takes organic waste such as food waste which will eventually turn into new form with rich in nutrients as the food for plants [9].

According to Chang and Hsu [5], the chemical changing process and the complex metabolic processes of various microorganisms vary with the composition of the material composting. Specifically, the outcome of food waste composting is depending on the waste characteristics itself. Food waste has unique properties and characteristics as a raw compost agent. This is due to the high moisture content and low physical structure [9]. It is crucial to mix fresh food waste with a bulk agent which will eventually absorb some of the excess moisture as well as adding structure to the mix.

There are two composting types in which the differences are by the nature of the decomposition process; namely as aerobic and anaerobic [10]. The characteristics of these composting types are listed in Table 2. Oxygen is present in aerobic composting mainly to break the organic matter in the waste into a stable organic end product such as carbon dioxide, ammonia, water and heat. Anaerobic composting mainly develops an intermediate compound such as methane, organic acid and hydrogen sulphate.

**Table 2:** The characteristics of aerobic and anaerobic composting [10]

Characteristic	Aerobic	Anaerobic
Oxygen	Process occurs in the presence of oxygen	Process occurs in the absence or in limited of oxygen supply
Microbe used	Aerobic microbe breaks the organic matter. Stable organic end product produces with Carbon dioxide, ammonia, water, heat and humus	Anaerobic microbe dominates and develops intermediate compounds including methane, organic acids, hydrogen sulphide and other substances.
Risk	Little risk of phytotoxicity.	Has strong odors and some presence of phytotoxicity.
Temperature	The heat generated accelerates the breakdown of organic matter.	Low-temperature process
Duration	The processing time is short, depends on the mechanism used (maximum 4 months)	Longer than aerobic composting (6-8 months)
Nutrient value	Nutrients are lost from the composting process	Nutrients are not lost during the process of composting.

### 3. Benefits of Food Waste Composting in Malaysia

Composting of organic solid waste is seen as an economical way in treating waste. Currently in Malaysia, the composting process is recognized as the most adequate pre-treatment in order to obtain a composted material which may respond more efficiently and safely than the raw material to the soil [12]. As mentioned before, composting the food wastes enables the reduction in the amount of food wastes being disposed to landfill. Composting also could help the food industry in country to manage their wastes. As a result, the new and high quality organic fertiliser can be produced.

Compost definitely brings benefit for water and soil conservation. It also protects the quality of groundwater, minimises odours from agricultural areas, facilitates reforestation, wetlands restoration and wildlife habitat revitalisation efforts any amending contaminated and marginal soils [11]. Composting is a method of restoring organic matter to nature, which means the food taken from the plant will be returned to the ground. Other than that, composting also prevents methane and other greenhouse gasses production due to burning or dumping into landfill. In addition, leachate formation in landfills can be reduced by diverting organics from landfills into compost [11].

Food waste produced from within the campus of Universiti Sains Malaysia (USM) was used as compost fertilizer for the growth of plants around the campus. The compost fertilizer produced through the programme had indirectly saved the university's budget as the fertilizer produced is in equal quality with fertilizers sold in the external market [12]. Other public university in Malaysia, namely, Universiti Malaysia Perlis (UniMAP) was also conducted the similar programme with USM. Furthermore, UniMAP also extends their knowledge on composting to schools around the campus. For example, Sekolah Menengah Kebangsaan Sanglang was able to dispose approximately 300 kg of food waste and sold approximately 200 kg to public within six months [13]. Composting techniques have various ways, starting from easy process by using simple equipment until to a complicated process that is using modern equipment. Generally, composting can be done manually with the low cost and if composting using new technology, cost will be increased but resulting in high quantity and quality of the compost.

The benefits of compost in agriculture are it has long-term stable organic matter source, reduces the use of fertiliser, increases yield and size in some crops, increases soil nutrient content and water holding capacity of sandy soils and also water infiltration by clay soils [14]. Other than that, compost has the ability to buffer soil pH levels and able to restore soil structure after natural soil microorganisms have been reduced by the use of chemical fertilisers because compost is soil inoculant. Moreover, it also can increase length and concentration of roots in some crops [15]. Compost also helps close the food wastes loop by returning it back to agriculture and also puts an end to wasting large quantities of recyclable raw ingredients.

The benefits of compost in food industry are compost reduces solid waste disposal fees and educates consumers on the benefits of food waste composting. Moreover, reduced food waste generation will create clean and healthy environments. The composting process runs at high temperatures so that it

can turn off various sources of disease in the trash. In addition, by implementing composting, more employment opportunities will be existed.

#### 4. Strategy in Food Waste Composting in Malaysia

Food Waste Management Development Plan for the Industry, Commercial and Institution Sector (2016-2026) (PPPSM ICI) was developed to achieve an effective and efficient waste management. PPPSM ICI was developed in accordance with the Management Policy Solid Waste (2006) and the Solid Waste Management Department's Strategic Plan Country (2016-2020) [16].

This plan focuses on increasing responsibility from waste generator by implementing six (6) major strategies. First strategy is development of food waste generation database, which covers aspects such as the amount and type of food waste generated according to day, month and year, waste storage, waste collectors and delivery location. Systematic planning can be developed based on the database.

Second strategy is establishment of food recycling regulations. The regulation is given an emphasis on aspects such as waste generator responsibility to data reporting, waste separation, food waste reduction and waste treatment. Systematic management of food waste can be controlled based on the regulation. Reduced food waste at cause as referred to 3R concept is included in third strategy. Target of food waste generation in 2026 according to sectors is tabulated in Table 3.

**Table 3:** Estimate food waste generator sector in 2026

Food Waste Generator Sector	2011	2026
Restaurants, Food Court, Supermarket	100%	20%
Wet Market, Night Market	71%	10%
Hotels, Resorts, Institutions	93%	25%
Food and Beverage Industry	63%	25%

Food waste treatment at the source involves in altering in food waste to reusable resources is included in the fourth strategy. For example, production of fertilizer, compost, electric power or generating alternative fuel from food waste. This treatment facility can be done locally at food waste generation. Fifth strategy is developing an efficient system for food waste treatment, which involves the waste collections on a scheduled basis and convenience centralized treatment of food waste. Schedule collection system allows food waste to be exiled from the premises. Last strategy is methane recovery of the disposal site in which the approach is similar to landfill gas to energy.

#### 5. Food Waste Composting Methods in Malaysia

One of the methods that was applied in Kuching, Sarawak is heat method (stack method). Food waste is lumped and left to decay within certain period. To speed up the decay process, composting

agent is watered to the food waste within 3 to 5 days [17]. This method is suitable to apply in area that receives moderate rain fall. In large volume, approximately two acres is required to implement this method.

Shallow compartment method was applied in Georgetown, Pulau Pinang. This method is suitable for area that has moderate waste generation rate. In this method, brick is developed in 3 feet × 3 feet × 3 feet (27 feet<sup>3</sup>) under roof or inside the building [17]. Three months is required to produce the compost by using this method.

New technology such as mechanical method was applied in Putrajaya which was organised by Syarikat Alam Flora Sdn. Bhd. By using the machine, food waste is processed to make the compost within two weeks compared to conventional method that required up to three months. This technology is operated automatically in which sensor is used to determine the condition of composting process. In addition, this technology is equipped with odour filter which uses activated carbon as media in odour filter [18]. Furthermore, this method do not require a large space to implement.

In Bayan Baru, Pulau Pinang, Bio-Regen method was also applied to make the compost. This method using chopped machine and liquid compost is produced after keep for 28 days. Beside compost, food waste is also processed to produce mudball. Mudball is a product that is used to reduce the quantity of pathogen in surface water such as in Sungai Sebulong, Johor Bahru [17].

## 6. Challenges of Food Waste Composting in Malaysia

One of the challenges that is related to food waste composting is finding the space for the bins that is required to collect the food scraps. This is because the amount of space required will be dependent on material collected and the times it is picked up by the third-party organisation. Generally, the more the types of product being collected, the greater the number and size of bins required. Furthermore, the lesser the frequency of the collection, the greater the space needed for storage of full bins.

Other than that, public awareness, environmental education and technical skills also become challenges for food waste composting. The way human responds and co-operates this waste management issue is affected by their education which also shows that in Malaysia, environmental awareness among the citizens is still not requisite [19]. In 2001, a recycled campaign has been organised in Penang State with the aim to encourage Penang residents to recycle at least 1% of their daily waste. Sadly, the campaign with the motto of “Kembalikan Sinar kepada Pulau Mutiara” (Restore the Shine to the Pearl of the Orient) did not make a positive impact on Penang’s waste management problem [20]. Generally, Malaysians still have very low awareness on the importance of this kind of programmes.

On the other hand, professionalism in Malaysia solid waste industry is relatively weak and inferiorly represented. Malaysia is still not capable of organising, designing, constructing and managing of solid

waste management facilities and services due to insufficient number of personnel and technical capabilities [21]. As a result, this issue has led to poorly operate facilities.

Moreover, current solid waste management becomes problem to food waste composting. Many cities in Malaysia are unable to practice good waste management because of the shortcoming in financial. The main challenge in MSW management in developing country such as Malaysia is landfill tipping fees is relatively cheap. Thus, technical problem in landfill such as difficult to handle leachate recirculation and gas attraction occur in landfills. Besides, waste collecting almost covers all communities in urban areas, but only 66% of the populations in rural areas of Malaysia is covered. As the bad effect is waste is being dumped on the streets and drains in rural areas, this situation will eventually lead to breeding of insects and flash flood due to blocked drains. Table 4 shows the percentage of waste treatment method applied in Malaysia [20].

**Table 4:** Waste treatment methods practiced in Malaysia

Treatment Methods	Percentage (%)		
	2002	2006	Target 2020
Recycling	5.0	5.5	22.0
Composting	0.0	1.0	8.0
Incineration	0.0	0.0	16.8
Inert landfill	0.0	3.2	9.1
Sanitary landfill	5.0	30.9	44.1
Other disposal sites	90.0	59.4	0.0
<b>Total</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>

## 7. Conclusion

Malaysia experienced expeditious industrialisation and urbanisation over the past few decades. This scenario has increased the generation of the MSW. The fundamental aspect that needs to be inspected in designing a sustainable MSW management system is the accessibility of information on the characteristics of waste generated. Based on the characteristics, food waste shows the highest composition. Thus, recycle the food waste by composting may reduce the waste volume to landfill. Strategy of food waste composting was developed to initiate in food waste composting. Furthermore, several countries In Malaysia had implemented variety methods of composting and mostly were organized by city council. However, there is still lacking data in small scale composting such as from household. In order to achieve the successful of food waste composting, proper training needs to be conducted for all Malaysian and adequate space and funds must be allocated for MSW management. In addition, environmental awareness and education should be emphasized by organising a continuous campaign and programmes.

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# CHAPTER 5

## ABLUTION WATER CONSUMPTION AND POSSIBLE SOLUTION: A CASE STUDY 1

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### **Abstract**

Ablution water from mosques in Malaysia is commonly discharged untreated into drainage channels. Running water during the ablution leads to high wastage of water. Thus, this study makes attempt to identify how much ablution is produced during peak hours followed by treatment method for reusing the ablution water in order to promote water saving for UTHM mosque. Underground tanks are recommended to be built to store the ablution water for plant irrigation around mosque.

**Keywords—; conservation, groundwater; groundwater treatment, water protection**

### **1. Introduction**

Ablution is a must for one Muslim before he or she can perform the prayer. However, despite doing it in the proper way, which should be able to save water, many are taking it by granted with high volume of running water. This attitude causes wastage of water, especially when it is left to flow into drainage. Therefore, a team from UTHM has made an attempt to study on the ablution water to know how much is produced and what can be done to save the water. The team had started the survey on 16<sup>th</sup> November 2017 in UTHM mosque at 11.30 p.m. Assessment on the ablution water being wasted into drainage was measured by using bucket technique. It is calculated as per head and estimated how many of liters being wasted into drainage.

After the estimation on how much of water being wasted into the drainage, a survey is performed by asking the people at the mosque about their opinion on the ablution water awareness. From the interview, 90 percent of respondents have strictly agreed with the idea to build a filtered underground tank as water storage. This project is conducted to achieve several objectives ; to develop the ability to analyze the environmental issues, to analyze the perspective (include interview, data collection, auditing and survey) and critically evaluating the environmental issue. Then solutions can be proposed to enhance the creativity for Ablution Water Consumption, Treatment and Reuse in UTHM Mosque.

## **2. Description of the Case Study**

The mosque is located at a strategic area. It is near to the faculties. It is also located near to other buildings such as Curriculum Center, Stadium, University Health Center, and Office of Students Affair (HEP). As it becomes the place where most people come to pray and for other activities, this mosque was chosen as the study area. Moreover, they were using water for ablutions and other purposes, making the mosque as the right place to study.



**Figure 1:** Location of the Masjid Sultan Ibrahim on Google Maps

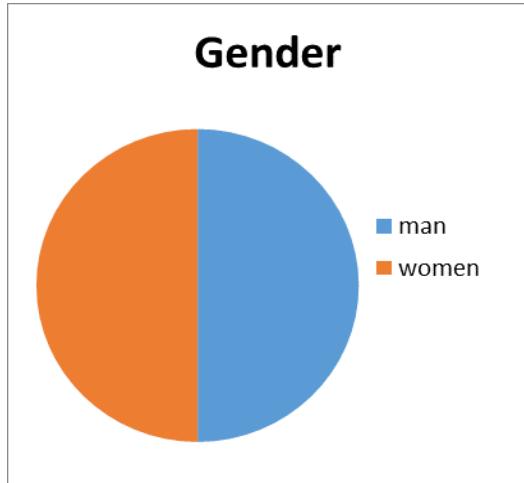


**Figure 2:** Front view of Masjid Sultan Ibrahim, UTHM

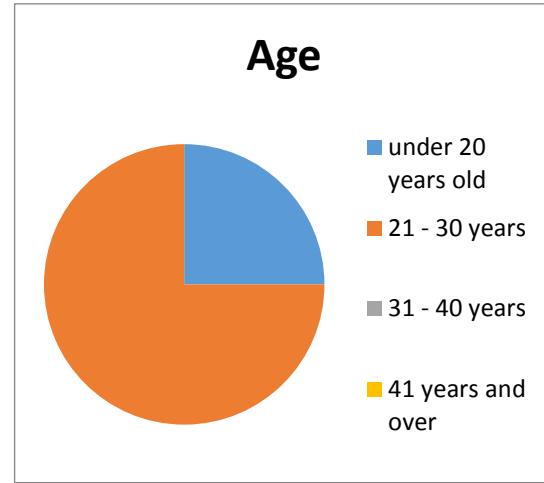
### 3. Results of the Case Study

#### 3.1 First Method Using Questionnaire

Figure 3 shows 20 respondents which consist of 10 men and 10 women. Meanwhile, Figure 4 shows their ages ranging from under 20 years to 40 years and above. Majority of the respondents' age is between 21 and 30 years, with percentage of 75%. This frequency is followed by age over 20 years (25%), and no respondents for age 21 to 40 years and 40 years old.

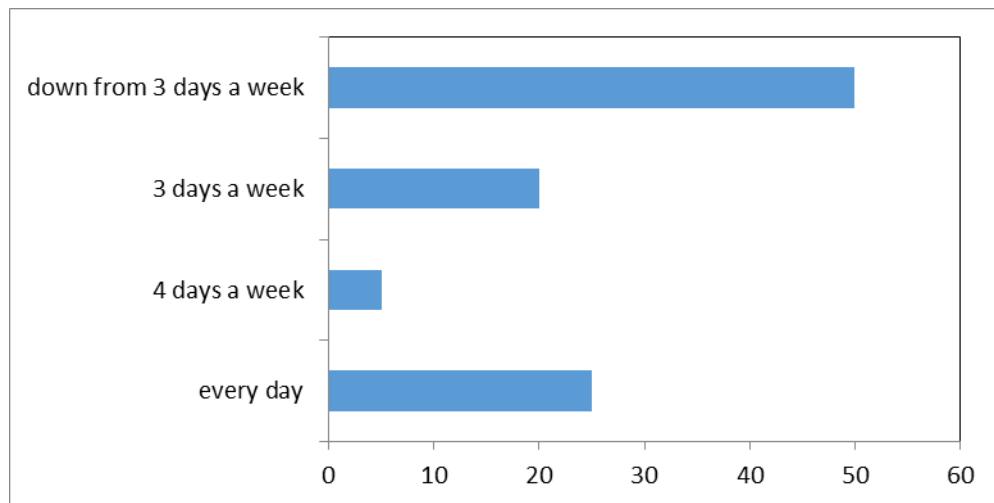


**Figure 3:** Gender of respondents



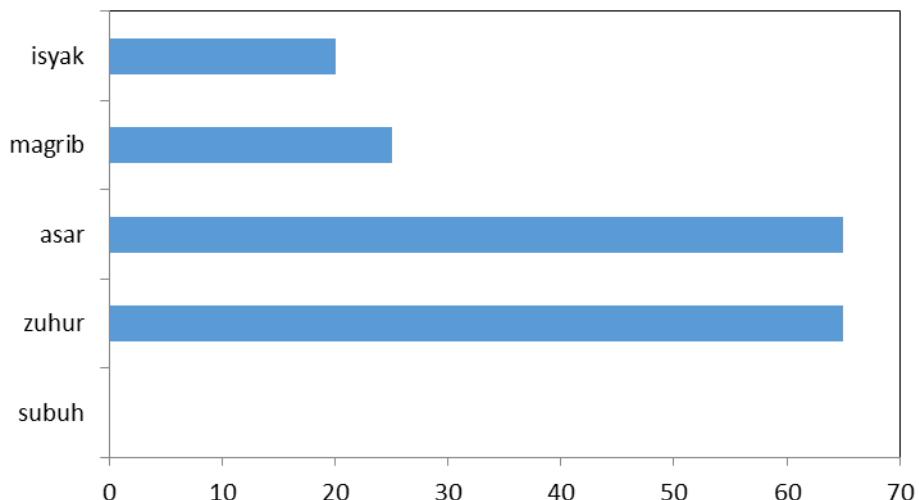
**Figure 4:** Age of respondents

Figure 5 shows the number of respondents against the frequencies of people going to UTHM mosque within a week. From the chart, the most visits were below 3 days a week shown by 50% while less than 4 days a week at 5%. For moderate amounts are 3 days a week and below 3 days a week shown by 20% and 25% respectively.



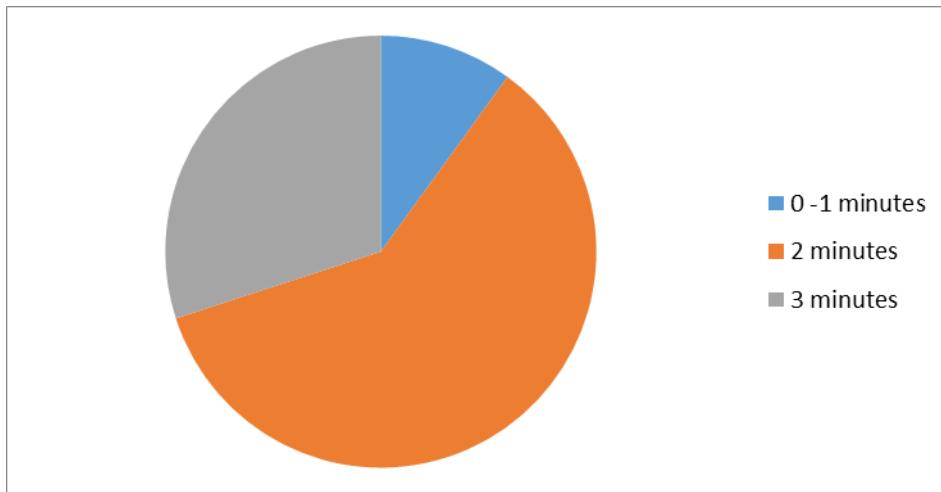
**Figure 5:** Response regular visit in a week to attend the UTHM mosque

Figure 6 shows the number of respondents against the frequency of people that come to UTHM mosque within a day. From the chart, the most frequent people go to mosque is during zohor and asar prayer time with percentage of 65% for each prayer. Meanwhile, for Maghrib and Isyak prayer time, the percentage for people frequency is 25% and 20% respectively.



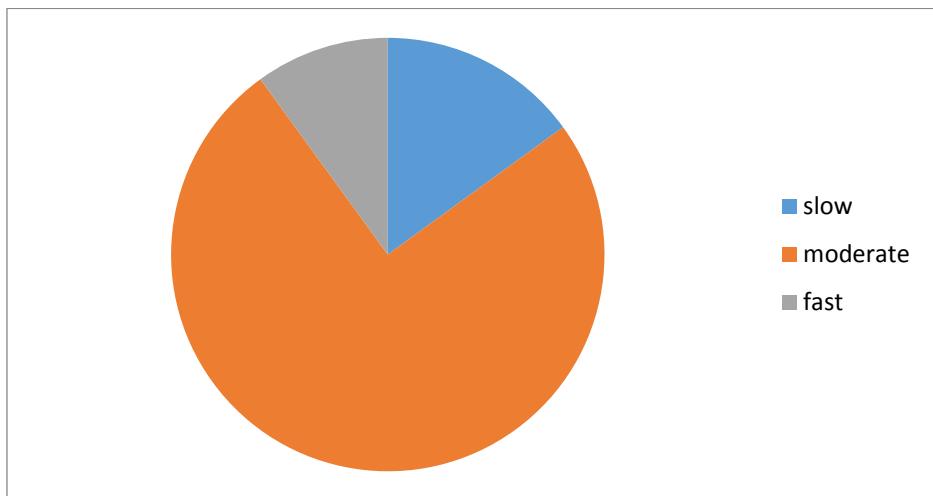
**Figure 6:** Response for “In a day, when do you frequently go to the mosque?”

Figure 7 shows how long it takes for one respondent to take ablution water. From the results most of the respondents took 2 minutes and above (60%) for an ablution while the fastest is 0 to 1 minute (10%).



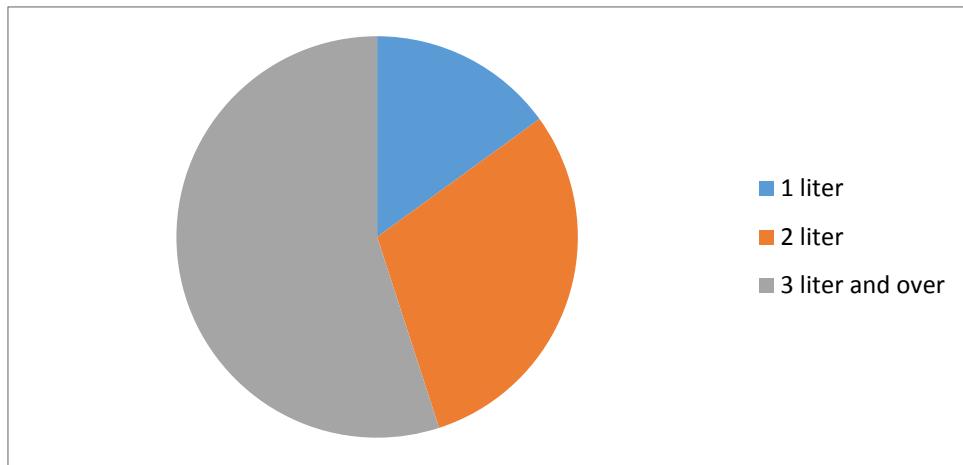
**Figure 7:** Response for “How long will it take for you to take ablution?”

Figure 8 shows the response for “how much your water speed is open”. The highest response for water speed was moderate (75%) followed by fast speed (10%) and slow speed (15%).



**Figure 8:** Response for “How much is your water speed estimated when taking ablution?”

Figure 9 shows the response for “how much water estimates are used” by respondents when taking ablution. The highest estimation is 3 liters (55%) while the lowest is 1 liter, which is approximately 15%, and 30% for two liters estimation.



**Figure 9:** Response for “How much water do you use”

### 3.2 Measuring the Water Used by Calculation

Measurement of water used was done by getting a sample of ablution water using tools such as one (1) liter drink bottle, a five (5) liter drink bottle, a bucket, and a filter funnel. The collection of ablution water was done on Friday during the Friday prayer. First, the water was collected in a bucket. Then, it was poured into a 1 liter bottle. Filter funnel was used to ease the transfer. Once full, the water was transferred into a 5 liters bottle. The calculations from this procedure are shown in Table 1 and 2. From the table, we can assume that the usage of ablution water is 5 liters per person.

**Table 1:** The Usage of Ablution Water per Person

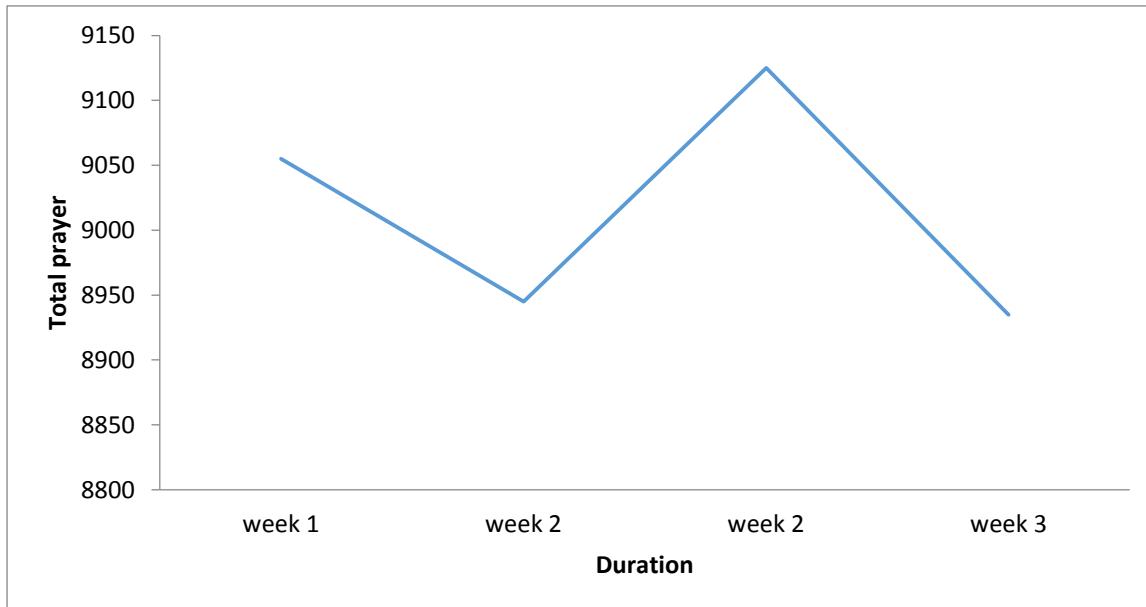
Person	Duration (minute)	Liter (l)
1	2.7	4.8
2	3.6	3.5
3	4.2	5.0
4	3.8	4.6
5	3.2	5.0
		Total average = 4.58

**Table 2:** Weekly Usage of Ablution Water for 5 Total Prayer a Day

Duration	Total prayer (x)	Litre (l)	$x \times l$
Week 1	1811	5	9055
Week 2	1789	5	8945
Week 3	1825	5	9125
Week 4	1787	5	8935
			36060

Figure 10 shows the total volume of water consumption (in liter) for the prayer against time duration. Only Friday prayer was collected because there were many people using water for ablution. Furthermore, it occurred in one hour, which is from 12.30 p.m. to 1.30 p.m. The total assumption

made from ablution water from week 1 to week 2 was 36060 L. This result shows that the sum from total prayer multiplied by the assumed ablution water was consistent from week 4 (8935L) and the highest value was from week 3 (9125).



**Figure 10:** Total prayer X liter against time duration

#### **4. Factor and Effect of Using Ablution Water to Environment**

##### **4.1 Wastage of water**

Based on the research conducted, each individual uses a different percentage of water according to their respective requirements. There are individuals who take ablutions by opening the water at high speed, causing the wastage of water compared to individuals who open water at low speeds.

##### **4.2 Water was not reused**

The ablution water used has not been reused or treated for prevent wastage. Water abatement can be recuperated or recycled to prevent wastage as used for spraying of plants or use in the toilet.

##### **4.3 Water pollution**

Quality of ablution water is still unkown. The quality may reduce based on the person used it. For an example, individuals with a skin disease will disseminate bacteria on the skin to be discharged into the river and cause other species in the river to have a negative effect. Thus, ablution water may effect

aquatic species in river or lake due to the water is normally discharged directly without treatment to drain and finally to lake or river.

#### 4.4 Change of Color, Odor and Feel

A healthy water is guaranteed by its purity so that it remains clear, odorless, and the quality is well within the standard. If the color of the water has changed, it shows that the water could be potential contaminated with certain substances. For example, brownish water might indicate that it has been contaminated by Fe and Mn elements. Likewise, taste and smell can be used as an indicator for water pollution. For example, a person attending a mosque may not be clean. They might carry dirty objects such as mud or animal waste.

### 5. Proposed Approach for Ablution Water Saving in UTHM Mosque

Many people opened the tap water at high speed when taking *wudhu* (ablution) and waste a great deal of water. Even worse, some people opened the tap in advance as soon as they reach the ablution site, and then only they roll their sleeves up while leaving the water to waste. However, Islam teaches us to avoid such wastage because we have to take account for each drop and will be held on the judgement day. There are many guidelines to avoid the wasteful use of ablution water.

1. Nozzle should be moderate in size, not too narrow to ooze water late or too wide to splash water consumed more than needed. To know its difference, if *wudhu* is made using a bucket, excessive water will be consumed. Similarly, wide tap will cause excessive consumption. In another method, when using a tap, open it a little to allow a small flow of water. Letting water flow strongly from the tap will waste unnecessary water. (refer Figure 11)



**Figure 11:** *Wudhu* using a bucket

2. Ablution water is stored by using pump and storage tank. The primary source of water for the system is the ablution area, where that grey water from the ritual is collected in a temporary storage under the washing bay. The grey water is then filtered to remove sediments and other fine particles before being pumped into an elevated storage tank. Filtration is an essential pretreatment to remove large suspended solids, ensuring the pump efficiently working and to avoid clogging. Once transferred to the storage tank, sedimentation would take place to further cleanse the water of finer particles. At the same time, disinfection of the water can be performed through chlorination using an automated dispenser fixed to the tank. The treated water is now ready to be reused indoors or outdoors such watering plant, wash floor of mosque, and so on. (refer Figure 12)



**Figure 12:** Water reused for watering plant and washing mosque floor

3. From the Al-Quran, the rainwater is pure water purification and it is known as *air mutlaq*. Rainwater can be used in medical, *mandi junub* (ghusl) and *wudhu* (ablution). Rainwater harvesting is the accumulation and deposition of rainwater for reused in watering plant or in toilet, rather than allowing it to run off. Rainwater can be collected on the roof as there is no pump in the storage tank to supply. Therefore, it just needs the gravity force from upper to lower distribution section. This solution will reduce the water usage and improve the efficiency of the water system.

## 6. Conclusion

In conclusion, the team had come up with an idea to build an underground tank that will produce water to the plants. This practise can promote water saving and efficient water management for water resource security. It is better if Malaysians can be aware of water wastage that can be reused. The

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water wasted form ablution water can be collected, treated and used for watering the plants and vehicle washing.

### **Acknowledgment**

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# CHAPTER 6

## FOOD WASTE COMPOSTING APPLICATION IN CAFETERIA: A CASE STUDY

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### **Abstract**

Excessive waste has become the environmental issue that cannot be neglected. Food wastes are among the waste that filled up the landfill sites and they are abundance. The impacts of massive mountains of food waste in the landfills affect the local community surrounding the area. They do not only cause unattractive sight but also produce bad odour and gas such as methane gas. This gas is dangerous than any greenhouse gasses because it can easily explode. Another problem is leachate, which can affect the clean ground water. Thus, this project proposes a conventional method to reduce the food waste by composting. The proposed approach is made because the compost materials will breakdown and can be used as fertilizer for gardening. As the project reached the end, it is found that composting is a very effective way to reduce food waste and it gives more benefits.

**Keywords—; Food waste, leachate, compost**

### **1. Introduction**

What is food waste? Food waste or food loss is a food that is discarded or lost uneaten. The causes of food waste or loss are numerous. It can occur at the stages of production, processing, retailing and consumption. The increasing of food waste could bring environmental issues which affect the solid waste management framework. Research by Solid Waste Corporation Management (SWCorp) stated that almost every year, an average Malaysian household throws away more than one month's salary

on food they do not eat. Daily, Malaysian produces around 15,000 tonnes of food waste which are 3,000 tonnes daily avoidable food waste that edible before it thrown. These 3,000 tonnes of food could feed 2.2 million people, in which this number is more than the population in Kuala Lumpur. Research also found that 12,000 tonnes of the unavoidable food waste were produced daily. Furthermore, research also showed that an average Malaysian household of five peoples spend around RM 900.00 on food where RM 225.00 of food worth value were thrown away per month. This amount of RM 225.00 could buy seven of 10 kg bags of rice, 132 litres of RON 95 petrol, and wireless internet (WIFI) 30Mbps plan cost RM 199.00/month. If we calculate RM 225 per month change, it is equal to RM 2,700 per year.

Other alternative to reduce food waste disposal besides conventional landfill and incineration is nature-friendly food waste handling method which is composting. Composting using food waste can be categorized as an organic composed. It can give an advantage to agriculture sector. Organic composed are made up from one or more combination of organic matters such as vegetables or animal matter. Composed are produced from a decaying of an organic matter such as dry leaves or dry grass, food waste (cannot contain oily, fat and meat), and others. There are many of the natural elements can be used to produce organic composed such as animal manure, rotten produce, bone meal, and decomposing plants. Organic compost gives benefit to the soil including organic matter, providing food for beneficial life, enhancing the soil's water holding capacity and gradually releasing plant nutrients. Compost made with high quantities of manure or bio solids may be high in salts and nutrients, but compost made with primarily plant residues do not generally contain troublesome quantities of salt. Compost that smells like ammonia or is not yet fully decomposed should be allowed to finish breaking down to avoid it from damaging plants. Compost also contains micronutrients needed for plant growth. There are many advantages that users could gain from composting, especially to reduce food waste from being thrown to garbage, for agricultural, and to maintain our nature to an organic agricultural. A few types of composting include conventional method by using dry leaves and vegetables waste; Bokashi is composed by using food and kitchen wastes that will produce leachate; vermicomposting by using worm, and Takakura composting. Figure 1 and 2 shows the example of dry leaves and organic composed that have been decayed by microorganisms.



**Figure 1:** Dry leaves



**Figure 2:** Organic compose that have

been decayed by microorganisms

Food waste is an important issue in food service industry, and it is related with our environmental issue. This is because food waste can give negative effect to our environment. Usually, the type of food waste is produced by the quality of the food, quantity of food and also the mixed product in the food. Food waste if it is dumped into water area may cause the water in that area to get nutrients and eventually lead to algae growth and pollute the water. Excessive amount of food wastes dumped on earth might cause odour pollution, which can bring negative effect to our ecosystem. There are a lot of uneaten foods that thrown away at university cafeteria each year. Mostly, people who throw away the food waste are among university students. This is because this food waste issue is related with university student behavior. Besides that, the students are likely to waste food and caused a lot of wastage including money, and this can result in their high daily expenses. This study presents the awareness on food waste management survey, food waste amount, and food waste composting application in UTHM cafeteria.

## 2. Methodology

This study of food waste composting application in cafeteria was conducted at G3 Cafe. It was located at Universiti Tun Hussein Onn Malaysia (UTHM), Parit Raja, Johor. G3 Cafe is the suitable place to be observed because there are many students and lecturers are eating there. The G3 Cafe has 5 five food courts and the food waste used in this study was taken from three food courts. This study was carried out to determine if the combination of food waste and soil were suitable to be used as a fertilizer. The food waste that involves were vegetables, fruits, dry leaves, and egg shells. Conventional method was used in preparing this food waste composting. Composting is a simple and easy technique. The food waste will be stored in a box together with a soil. The soil will be in as base medium. The design included 3kg bags of soil and food wastes. The process of composting was started by putting the soil and food wastes layer by layer and the same process was repeated into the box. Then, the tea water was used to moisturise the soil content. The tea was prepared by leaving it for one or two days. It was prepared in the spray bottle as it completed left for specific days.

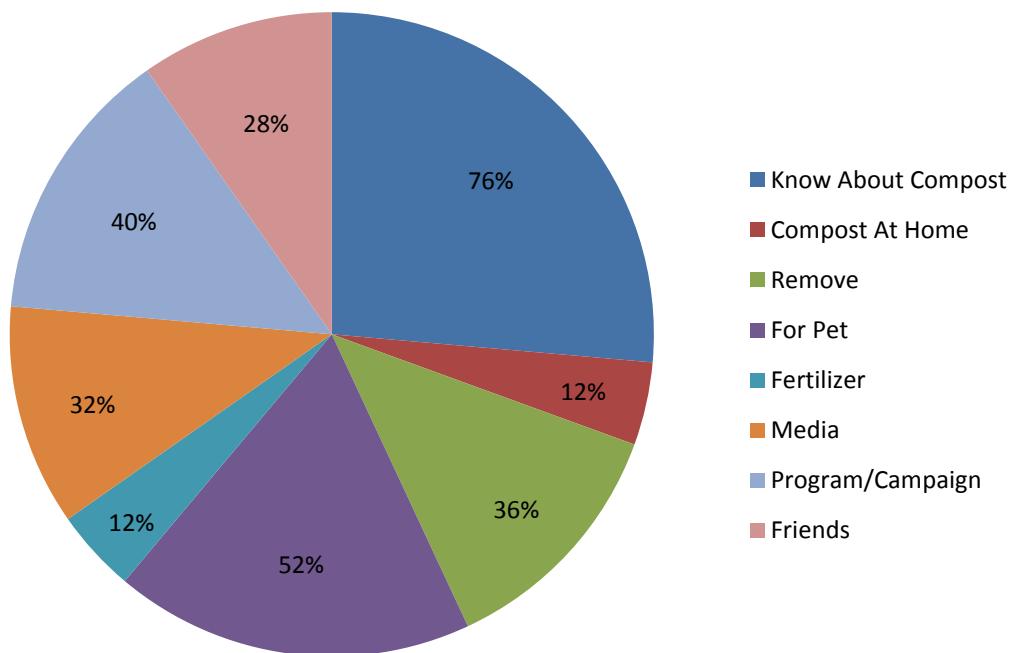
## 3. Results and Discussion

Table 1 shows the data collected from questionnaire survey on 25 students in UTHM from different faculty and gender. From this data (Figure 3), it can be concluded that most of the students know about composting, which is 76% and 9 students are from the faculty of FKAAS (Faculty of Civil and Environmental Engineering). Most of the students get the information about composting through programs or campaign which is 40% and media 32%. This is because 88% the number of the students do not make a compost at home. Besides that, most students give the foods waste for pet to eat which is 52% and the rest just throw it immediately to waste bin. Only 12% of students who make fertilizer from composting the food waste. From the data, it can be concluded that most student in

UTHM know about composting and it is not a new thing that they have heard, but they do not apply the knowledge about composting at home due to the lack of information on how to make organic compost fertilizer using an easy method. It can also be concluded that it is not merely because of lacking information but their lack of awareness on the benefits of converting food waste into beneficial materials. Figure 3 shows percentage on students' thought on food waste and composting.

**Table 1:** Data Collection from Student UTHM

Faculty	Know About Composting		Composting at Home		What they do with food waste			Find About Composting		
	Yes	No	Yes	No	Remove	For Pet	Fertilizer	Media	Program/Campaign	Friends
FKAAS	9	0	0	9	3	6	0	2	5	2
FPTV	2	2	0	4	2	2	0	2	1	1
FPTP	1	0	0	1	0	1	0	1	0	0
FSKM	1	1	0	2	1	1	0	1	1	0
FKMP	4	0	2	2	1	1	2	2	2	0
FKEE	2	3	1	4	2	2	1	0	1	4
Total	19	6	3	22	9	13	3	8	10	7
Percentage (%)	76	24	12	88	36	52	12	32	40	28



**Figure 3:** Percentage on students' thought on food waste and composting

Table 2 shows data collection from one of the UTHM cafeterias. Data on food waste were collected from three different shops at the G3 cafeteria. The collection was conducted from 3:00 pm to 4:00 pm because it is the time that all the food waste is being collected, before all shops are closed. From the data, we could see that the weight of food waste that had been thrown by students is approximately 4 kg to 12 kg, giving the total average of the food waste to be around 8 kg. These figures indicate that there were a lot of food waste that had been thrown away. In Monday, the weight of food waste was 17.8 kg and Tuesday was 22.9 kg. Meanwhile, in Wednesday the total weight of food waste was 27.7 kg. These again can be concluded that the food waste is increasing from day to day. Interview with the workers at G3 cafeteria revealed that most of them did not know about compost fertilizer; and therefore, they just threw all the food waste. Given that all the food waste is disposed in the same waste bin and it mixed with other wastes such as oily food, plastic cup, food packing, fish and chicken bones, these food wastes are not good for our environment.

**Table 2:** Data Collection from the G3 Cafeteria

Shop	First Day (Monday)	Second Day (Tuesday)	Third Day (Wednesday)	Total Average
1	6.0 kg	12.3 kg	7.6 kg	8.63 kg
2	4.5 kg	6.3 kg	7.5 kg	6.10 kg
3	7.3 kg	4.3 kg	12.6 kg	8.10 kg
Total weight	17.8 kg	22.9 kg	27.7 kg	22.83 kg

#### 4. Food Waste Composting Media

There are many proposed methods that can be used to reduce food waste in UTHM. Spread awareness to UTHM students about nature conservation is one of the solutions. That is why nature and conservation is an important subject for civil engineering students. The knowledge obtained can be used and practiced to help the community in UTHM. Moreover, the 3R system, which is reduce, reuse and recycle can be practiced at an early stage.

Furthermore, food service industry should control the production of food by demand only. Producing large batches always result in high in food wastage. The food service industry should reduce the menu by producing in small batches or cook-to-order system. Besides that, composting can be an easy and fast solution to help reduce the food waste. Composting can help to reduce food waste and enhance the soil. This study aims to determine whether composting food waste is efficient in reducing food waste or not. Based on requirement needed, the team decided to use conventional method. The needed materials were box, trash paper, and soil and food waste as shown in the figure below. Before start, sorted the food waste into different waste such as vegetables and fruits. The steps are shown in Figure 4-9 as follows:



**Figure 4:** Step 1 - A plastic bag was used for the compost materials



**Figure 5:** Step 2 - Black soil was filled as the first layer



**Figure 6:** Step 3 - Food waste and dry leaves as the second layer



**Figure 7:** Step 4 - Third layer was soil while food waste and dry leaves in fourth layer



**Figure 8:** Step 5 - Tea and teabags were used to moisturized the soil and composting materials



**Figure 9:** Step 6 - The compost material were sun-dried on the next day

##### 5. Rationale of the method

Conventional method of composting is via natural process of recycling decomposed organic materials into a rich soil. The process of natural decomposition is very important to one type of waste disposal. Conventional method is one of the composting methods from waste disposal, where organic waste decomposes naturally under oxygen rich conditions. Food waste such as vegetable and fruit peels,

coffee grinds, and eggshells are great items to compost. Adding meat products to compost should be avoided because as it decomposes, it will attract large animals and it will produce bad odour. Cooking oil and fat also must be avoided because the oils can form water resistant barriers around other material, displace water and reduce air flow in a heap thus slowing down the composting process.

Conventional method of composting also economically beneficial because this method can reduce the need for water, fertilizers, and pesticides. It serves as a marketable commodity and is low cost alternative to the standard landfill cover and artificial soil amendments. Composting also extends municipal landfill life by diverting organic materials from landfills and provide less costly alternatives to conventional method of remediating contaminated soil.

## 6. Conclusion

For conclusion, the compost does not make any bad odor and all the food waste were well decomposed and the compost was ready to be used as an organic fertilizer at home. Therefore, this finding indicates that odour pollution and other related pollutions such as land pollution and water pollution can be reduced. Inspite, composting can also help to prevent global warming by reducing emission of methane, which is a greenhouse gas that is produced when organic waste decomposes when buried in landfill sites. Organic composting also can reduce landfill waste, improve soil fertility which can help to break up heavy clay soils and keep moisture and nutrients in light and sandy soils. By using a compost, the need for water and fertilizer can be reduced, and thus making the soil healthy and led to healthy plants.

It is well-known that the environmental issues are created by individual actions. However, changes can me made towards a sustainable environment. For example, by composting, the use of peat-based compost or chemical fertilizer which causes destruction of our peat bogs can be reduced. In spite, human-made peat-free and chemical-free compost can be prepared from materials that commonly put in a garbage can and stop unpleasant odor. In fact, composting is a satisfying activity since many people are positive about it.

## Acknowledgement

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<http://www.wwf.org.my>

# CHAPTER 7

## A SURVEY OF THE USE PERSONAL CARE PRODUCTS AMONG STUDENTS AND THEIR POTENTIAL EFFECTS TO ENVIRONMENT

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### Abstract

The presence and fate of pharmaceutical and personal care products (PPCPs) in the environment is undergoing increasing scrutiny. PPCPs entering the environment causes detrimental effects on environment and health. It contains diverse organic groups, such as antibiotics, hormones, antimicrobial agents, synthetic and musks. It raised significant concerns in recent years for their persistent input and potential threat to ecological environment and human health. A group of UTHM students have done a survey on the personal care products used by students in "Kolej Kediaman Bestari" UTHM, profile and their potential hazard to environment and health. From the survey, the mostly commonly used products by both male and female students have been identified.

**Keywords— pharmaceutical, personal care products, environment, hazard**

### 1. Introduction

Pharmaceuticals and personal care products (PPCPs) comprises numerous chemical classes. Pharmaceuticals are used primarily to prevent or treat human and animal disease, whereas personal care products are used to improve the quality of daily life and include products such as moisturizers, lipsticks, shampoos, hair colors, deodorants and toothpastes [1]. Personal care products are an essential ingredient for humans to maintain the cleanliness and health of the people themselves. However, PPCP can have a negative impact on the environment and ecosystems through the waste

that has been generated through baths and washers called greywater. Personal care products comprising a mixture of chemicals have certain side effects that can affect environmental perfection and can negatively affect human health when the quality of greywater is contaminated by chemicals which comes from personal care products used by humans. Unlike pharmaceuticals which are intended for internal use, PPCPs are products intended for external use on the human body and thus are not subjected to metabolic alterations; therefore, large quantities of PCPs enter the environment unaltered through regular usage [2]. The environmental effect of pharmaceuticals and personal care products is largely speculative. PPCP have been detected in water bodies throughout the world. The term pharmaceuticals and personal care products contains as well environmental persistent pharmaceutical pollutants. The European Union summarizes pharmaceutical residues with the potential of contamination of water and soil together with other micro pollutants under "priority substances". Chemicals found in PPCPs such as as polychlorinated biphenyls (PCBs), organochlorine pesticides (OCPs), polycyclic aromatic hydrocarbons (PAHs), polychlorinated dibenzofurans (PCDFs) and dibenzop-dioxins (PCDDs) have caused risks for aquatic and terrestrial ecosystems [3]. Impaired reproduction and sexual anomalies have been observed in some fish species (Rahman *et al.*, 2009). Triclocarban (TCC) is one of XOCs has been proved to interrupt the gut microbiome in animals and humans which can cause myriad effects on health [4].

The personal care industries recognized the concerns raised by stakeholders regarding the presence of personal care products in the environment (PCPE). The major source of personal care products entering the environment is via use of products and removal from the body during bathing activities. Therefore, this study was conducted to do a site survey about the personal care products used by students and their potential hazard to environment and health. The students have been chosen as the respondents since the students are mainly young people who tends to use variety of personal products available in the market. Questionnaires were distributed to students residing in Kolej Kediaman Bestari to collecting data on various type of personal care product used by students at the college. The aim of the study is to determine the chemicals or ingredients contain in personal care products used by students and their potential hazard that can affect the quality of greywater for our environment and health.

## 2. Methodology

### 2.1 Project Location

Survey of the personal care products was distributed to students that stayed in "Kolej Kediaman Bestari UTHM". About 50 students were volunteer as the respondents to determine the type of personal care products used.

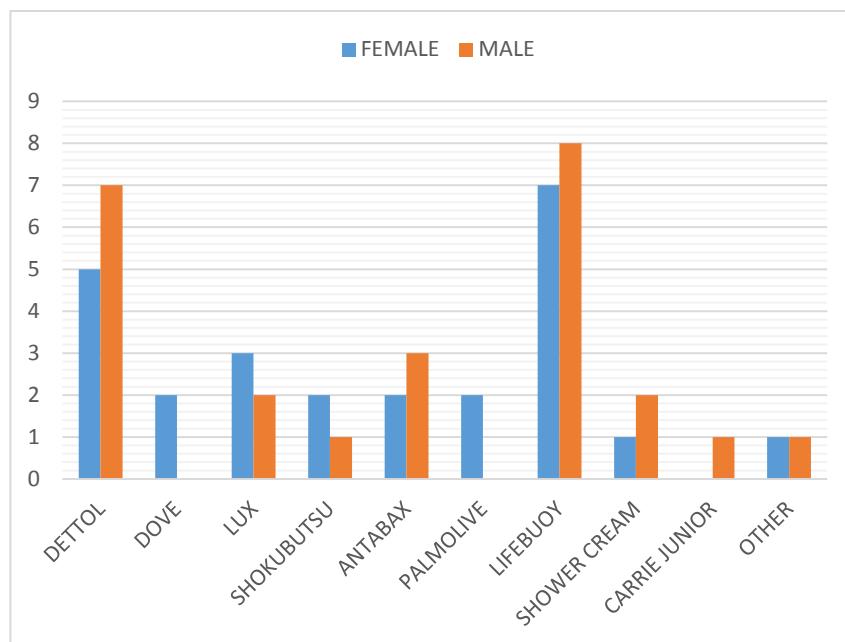
## 2.2 Implementation of the project

About 50 respondents were used in this study, which consist of 25 men and 25 women. Respondents were asked the brands of personal product used by them. Based on the brands, the ingredients of top five chemicals from the results are Laureth Sulfate, Formaldehyde, Fluoride from toothpaste, Nonylphenol ethoxylate and NPE. These chemicals were identified as toxic that will bring affect to aquatic life.

## 3. Results and Discussion

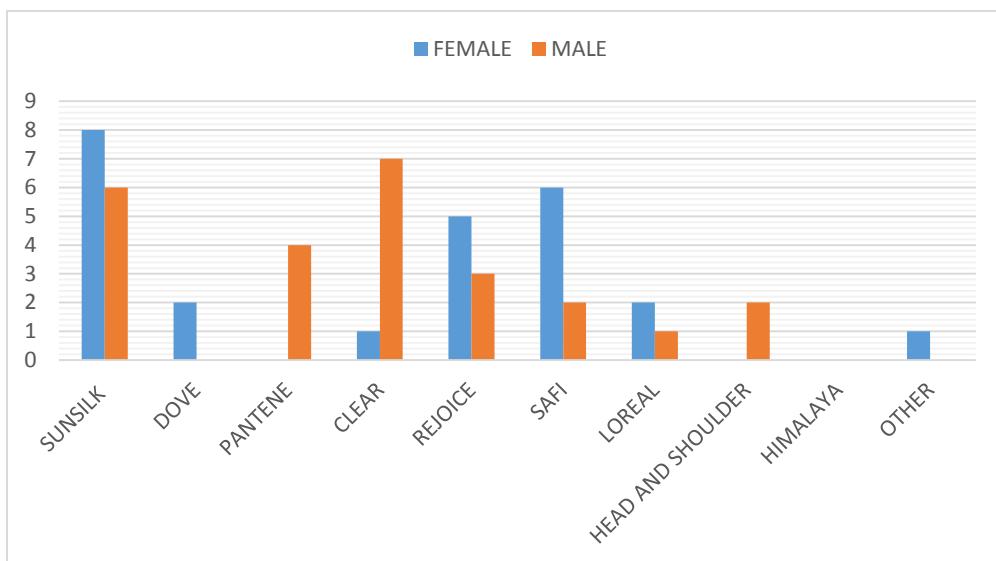
Figure 1 shows the most prefer of shower cream brands of respondent. Based on the result Lifebuoy brand is the highest selection. Second choice is Dettol brand, whereas carrie junior brands only use by one respondent.

**Table 1: Q2:** Numbers of student based on shower cream brands



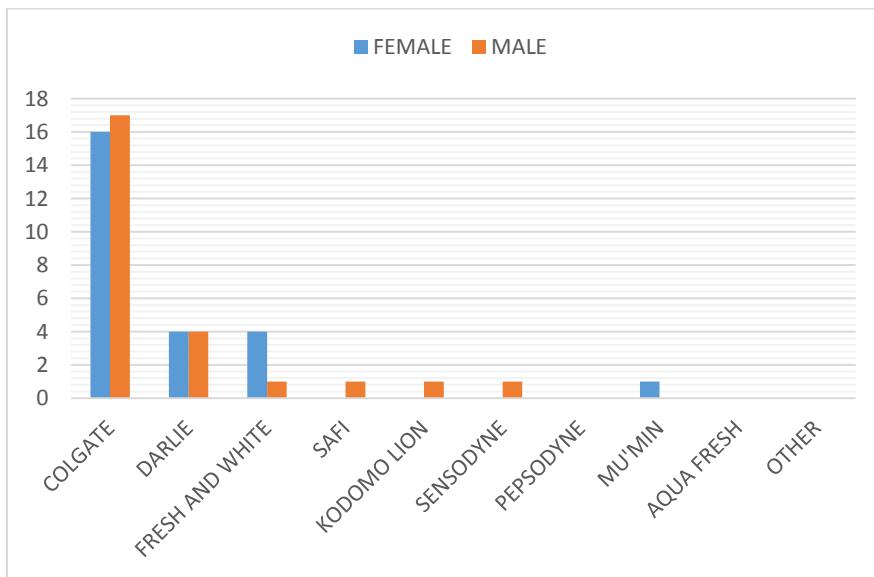
**Figure 1:** Shower cream brand used by respondents.

Based on the Figure 2, it can be seen that the male students prefer using Clear brand, while most of the female students prefer Sunsilk brand. The Himalaya brands shows the lowest users by both gender.



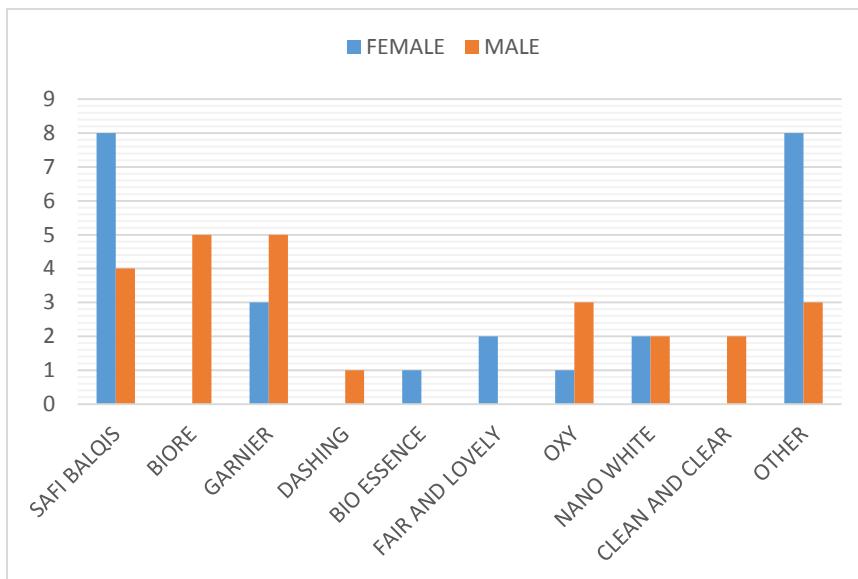
**Figure 2:** Shampoo and hair conditioner brand used by respondents

Figure 3 shows the toothpaste brand used by respondents. Based on figure, both gender prefer used Colgate brand while Pepsodyne, Aqua Fresh and other brand shows the lowest number.



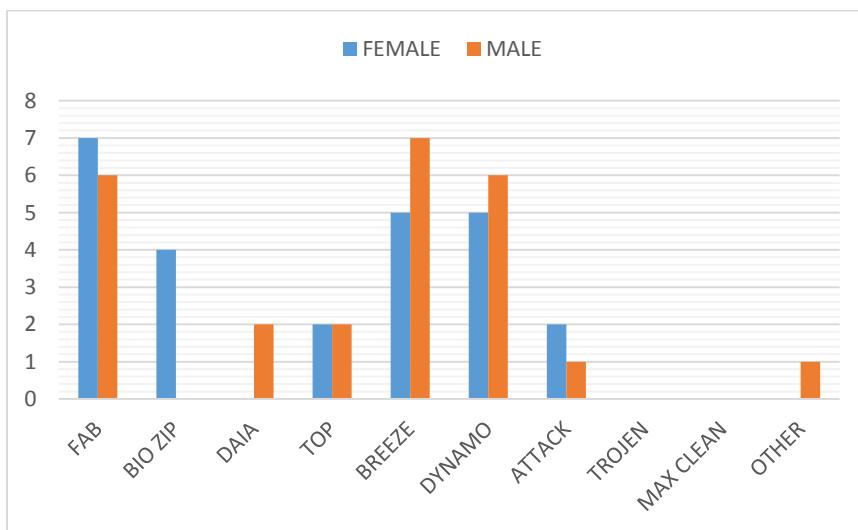
**Figure 3:** Toothpaste brand used by male and female students

Based on Figure 4, it shows that most of the male students preferred Biore and Garnier brand, while most of the female students prefer Safi Balqis brand and Others brand. Bio Essence and fair lovely shows the lowest user for male students, while dashing shows the lowest user for female students



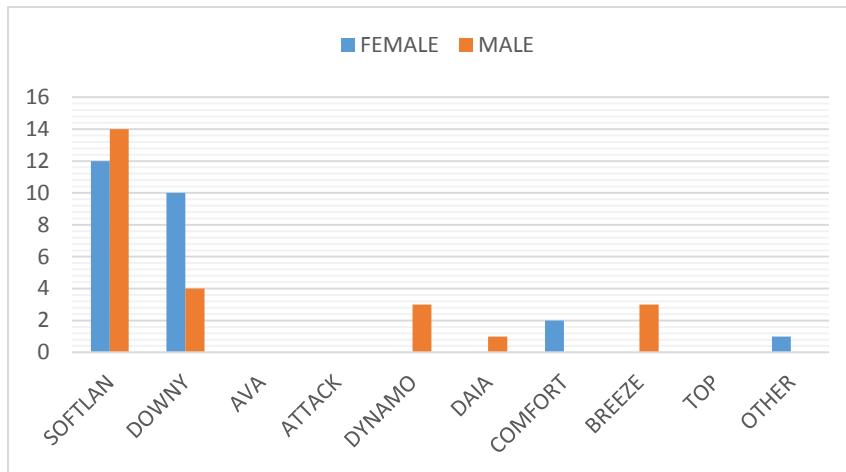
**Figure 4:** Face cleanser brand used by male and female students

Based on Figure 5, most of the male students prefer Breeze brands, while most of the female students prefer Fab brand. Trojen and Max Clean brand shows the lowest users for both gender. Generally, it can be said that the students prefer to used Fab brands, Trojen while Max clean brand shows the lowest users.



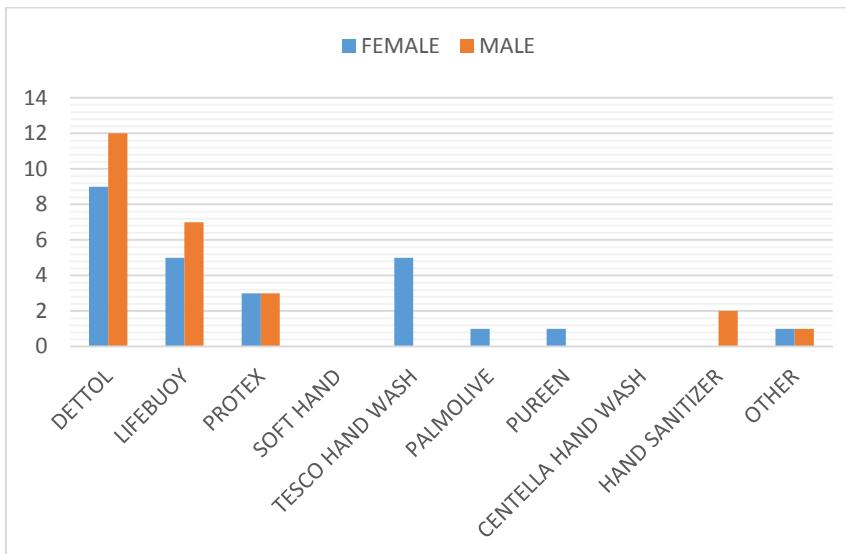
**Figure 5:** Detergent brand used by male and female students

Based Figure 6, it shows that most of the male and female students used Softlan brands. Ava, Attack and Top brand shows the lowest number of user for both male and female students.



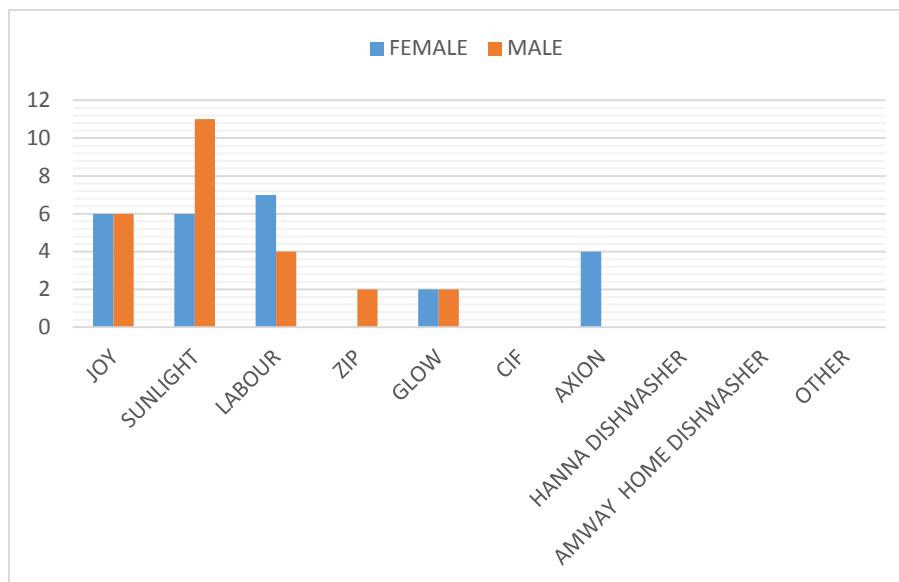
**Figure 6:** Softner brand used by male and female students

Figure 7 shows that most of male and female students used Dettol brand, while Soft Hand while Centella Hand Wash brand are not preferred by them.



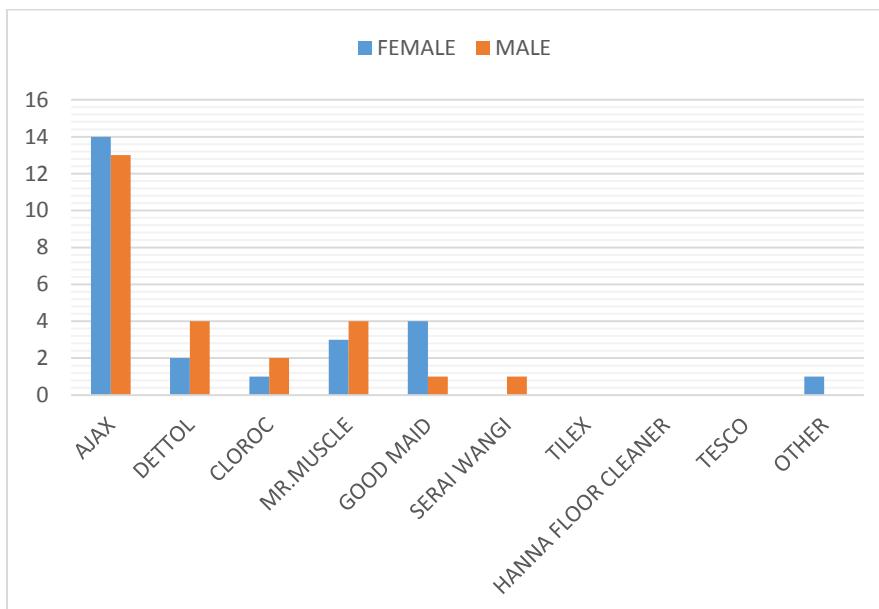
**Figure 7:** Hand wash brand used by male and female students

Figure 8 shows that most of the male student prefered Sunlight brand, while most of the female student prefer Labour brand. Cif, Hanna, Amways and other are not preferred by male and female students.



**Figure 8:** Dish washer brand used by male and female students

Based on Figure 9, it shows that most of male and female students used Ajax brands, while Tilex, Hanna and Tesco brands are not preferred by both male and female students.



**Figure 9:** Floor cleaner brand used by male and female students

### 3.1 Effects of personal care products to human

The scope of human exposure to pharmaceuticals and personal care products from the environment is a complex function of many factors. These factors include the concentrations, types, and distribution of pharmaceuticals in the environment; the pharmacokinetics of each drug; the structural

transformation of the chemical compounds either through metabolism or natural degradation processes; and the potential bioaccumulation of the drugs. More research is needed to determine the effects on humans of long-term exposure to low levels of pharmaceuticals and personal care products. The full effects of mixtures of low concentrations of different pharmaceuticals and personal care products is also unknown.

### **3.2 Effects of personal care products to environment**

While the full effects of most pharmaceuticals and personal care products on the environment are not understood, there is concern about the potential they have to harm because they may act unpredictably when mixed with other chemicals from the environment or concentrate in the food chain. Additionally, some pharmaceuticals and personal care products are active at very low concentrations and are often released continuously in large or widespread quantities. PPCP and their active metabolites may enter the aquatic environment via septic systems, spray irrigation of treated wastewater, leachates from waste disposal sites, wastewater from sewage treatment plants and the use of sludges in agriculture. Because of the persistence of many PPCPs in the environment, there may be potential for these chemicals to negatively affect aquatic organisms. Pharmaceuticals are designed to have a biological effect and therefore these substances may cause similar effects in nontarget organisms. Simvastatin, clofibric acid, diclofenac, carbamazepine, fluoxetine, and triclosan represent some of the most commonly used and/or detected PPCPs in aquatic environments [6].

### **3.3 PPCP that causes the environmental problem**

#### **i) Shampoo and hair conditioner**

Shampoos, shower gels and other cosmetic products along with a burgeoning number of other chemicals, are finding their way into the environment and are posing a risk to sea life, plants as well as people's health. The substances found include parabens, which have been linked to a rise in breast cancer and are used as a preservative in a range of cosmetic products. One of the chemicals causing environmentalists concern is triclosan which is in washing-up liquids, plastic kitchen utensils, toothpastes, deodorants and soaps. Triclosan is an antibacterial agent and an estimated 90 tonnes of it goes into domestic products every year. Triclosan is known to build up in the environment and is toxic to aquatic life; it has been found in the bodies of fish and in human breast milk.

#### **ii) Toothpaste**

Over 300 people in Panama died in early 2007 due to toothpaste tainted by substance called diethylene glycol. It's a chemical used in anti-freeze. Ingestion causes kidney failure, paralysis and often death. The diethylene glycol issue is somewhat extreme, but it raises many questions about

many everyday products we use that seem to be able to get around health and environmental regulations. Toothpaste and similar items are not a food and not a drug, therefore in many countries they escape close scrutiny. Triclosan is a registered pesticide, used as an antibacterial and antifungal agent and can destroy fragile aquatic ecosystems. Potassium nitrate is also an aquatic environmental nasty, parabens can disrupt the hormones in animals and so on and so on. The artificial flavors and sweeteners (more toxic chemicals) are there to cover up the taste of the other chemicals.

### **iii) Detergent**

The phosphorus and nitrogen compounds in detergents get concentrated in rivers. These two nutrients enable increased growth of aquatic plants (algae) that invade the entire aquatic area. When plants die, their decomposition consumes oxygen from the aquatic environment. Added to this is the consumption of oxygen due to the decomposition of the surfactants present in the detergents. Fish and invertebrates do not find adequate oxygen and die by asphyxiation. All this contribution of organic matter continues to decompose nevertheless but this time without oxygen.

### **iv) Softener**

Many fabric softener may contain phthalates, which disperse the scent; synthetic musks such as galaxolide, which accumulate in the body; and much more. Fragrance mixes can cause allergies, skin irritations such as dermatitis, difficulty breathing and potential reproductive harm. Research indicates that scents also cause irritation when vented outdoors, especially for asthmatics and those sensitive to chemicals.

### **v) Dish Washer**

Most mainstream brands still contain chlorine bleach. Over time, this strong chemical can cause some serious respiratory troubles. Chlorine fumes are often released into the air during the drying cycle of the dishwasher. With so many safer alternatives out there, there's just no good reason to expose your children to toxic indoor air. Regular detergents also add sulfuric acid. Not only is it highly corrosive, but it can also cause burns and trigger asthma.

### **vi) Floor Cleaner**

The major concern is the chemicals which cleaning products contain. There are thousands of chemicals in common use and many have not been tested for safety, though the effects of many are known. They may pollute streams and rivers and may take a long time to degrade into harmless products. Some may not break down at all but may persist in the environment. These may enter the food chain, being eaten by aquatic creatures and perhaps eventually by us. When consumed or

absorbed through the skin, they may have harmful effects, be toxic, cause cancer or cause birth defects.

### **3.4 Effects to environment**

#### **i) Contaminate water**

The water that has been dissolve with product are not suitable to drink and it can cause harm to the consumers. It is because all of this product contain a harmful chemical contents such as fluoride, triclosan and sodium bicarbonate. This type of chemical has been proven can affect an environment if it is exposed in large dosage.

#### **ii) Kill soft aquatic creatures and affect microbiological process**

Some of the aquatic creatures are too fragile and sensitive which may affect the growth of the consumers in long terms.

#### **iii) Effect the growth of plant**

Causing the leaf of the plant turn to yellow decrease the ability of plant to grow.

#### **iv) Contaminate soil**

The soil that absorbs the contaminate water are not suitable for some plant especially in the early growth of the plant. The living organism that live in the soil unable to live in a which are has been contaminate. Example of living organism is an earthworm which is one of the natural agent needed in soil fertility and helping in plant growth. Contaminate water will affect the nutrient in the soil also.

## **4. Conclusion**

Water pollution is caused by the intentional or unintentional release of toxics, chemicals or materials that contaminate and harmful compounds into various bodies of water such as rivers, lakes and the ocean. In addition to harming animals, water pollution can also affect plants, trees, the soil and other natural materials and resources of the earth. From the questionnaire that have been distributed to the students in Kolej Kediaman Bestari, it can be concluded that there are various chemicals that produced in different personal care product. Without proper disposal or filtration of these pollutants they can spread throughout the water and effect all living animals and organisms that come into contact with it by contaminating any living thing that requires water for survival.

## Acknowledgement

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# CHAPTER 8

## THE APPLICATION OF ELECTRO-COAGULATION IN BIODIESEL WASTEWATER TREATMENT

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### Abstract

A large quantity of oily wastewater is generated by biodiesel refineries which results in terrible environmental pollution and resource utilization problems. This wastewater must be treated before being released into the environment due to it normally rich in biological oxygen demand (BOD) and chemical oxygen demand (COD) which usually have damaging and harmful effects on plants, sea, river as well as surface and groundwater sources. Conventional biodiesel wastewater treatment methods such as gravity separation and skimming, air flotation, coagulation, de-emulsification and flocculation, posses several disadvantages including high operation cost, low efficiency, corrosion and recontamination problems. Indeed, most of these conventional methods unable to remove the micron or submicron sized oil droplets efficiently. Currently, new processes for efficient and adequate treatment of various industrial wastewaters with relatively low operating costs have been developed to meet the strict environmental regulations. At this point, the electrocoagulation process has attracted a great deal of attention in treating industrial wastewaters because of its versatility and environmental compatibility. Therefore, in this chapter, the advantages and application of electro-coagulation techniques were reviewed and discussed.

**Keywords— biodiesel wastewater, electro-coagulation (EC), aluminium electrodes**

## 1. Introduction

The demand of energy sources nowadays makes many of researchers has developed biofuel as alternative fuels. Biodiesel have many advantages such as biodegradable, non-toxic, burns with low content of sulfur, free carbon monoxide, better characteristics in terms of smell and environmental friendly since it can be produced through recycle oil and fats [1]. In Malaysia, the government has encouraged the using and producing biodiesel product as alternative fuels by introducing National Biofuels Policy of Malaysia. The aim of the mission is to reduce dependant on fossils fuel, encouraging palm oil demand and stabilize the price.

Biodiesel can be produced through a number of methods such as transesterification using alkaline catalyst, acid catalyst and supercritical methanol, ultrasonic irradiation and thermal decomposition of oil using alkaline catalyst [2]. Most of biodiesel production in Malaysia uses reaction method of transesterification using alkaline catalyst. This process is widely used in commercial production because it can produces more oil (triglycerides) on biodiesel (methyl esters) through simple chemical reaction [3]. Purification is the final process in production of biodiesel. The process normally use water since water is more effective in removing impurities. Purification process will be repeated depending on the quantity of impurities. The amount of wastewater produced is about 20-120 liters for each 100 liters of biodiesel [2]. Numerous studies reported biodiesel wastewater has high content of alkali, oil and grease, chemical oxygen demand (COD) and suspended solids (SS) [4]. Moreover, biodiesel wastewater also contributes to the changing of colour in water sources. Therefore, biodiesel wastewater produced can give a negative impact towards environment especially water sources and aquatic lives if it is not treated or not treated effectively. Electro-coagulation process provides an alternative method for treatment due to its flexibility and environmental friendly. Electro-coagulation process includes the application of electric current where metals dissolved at anode and at the same time hydroxyl ions and hydrogen gases produced at cathode. The techniques are widely used in solid waste wastewater treatment, municipal wastewater treatment such as dying wastewater, olive oil wastewater and wastewater that have high content of organic waste such as phenol. There are many advantages in electro-coagulation process compared to conventional method in terms of simple equipment, easy operation, less or not using chemical additive [3].

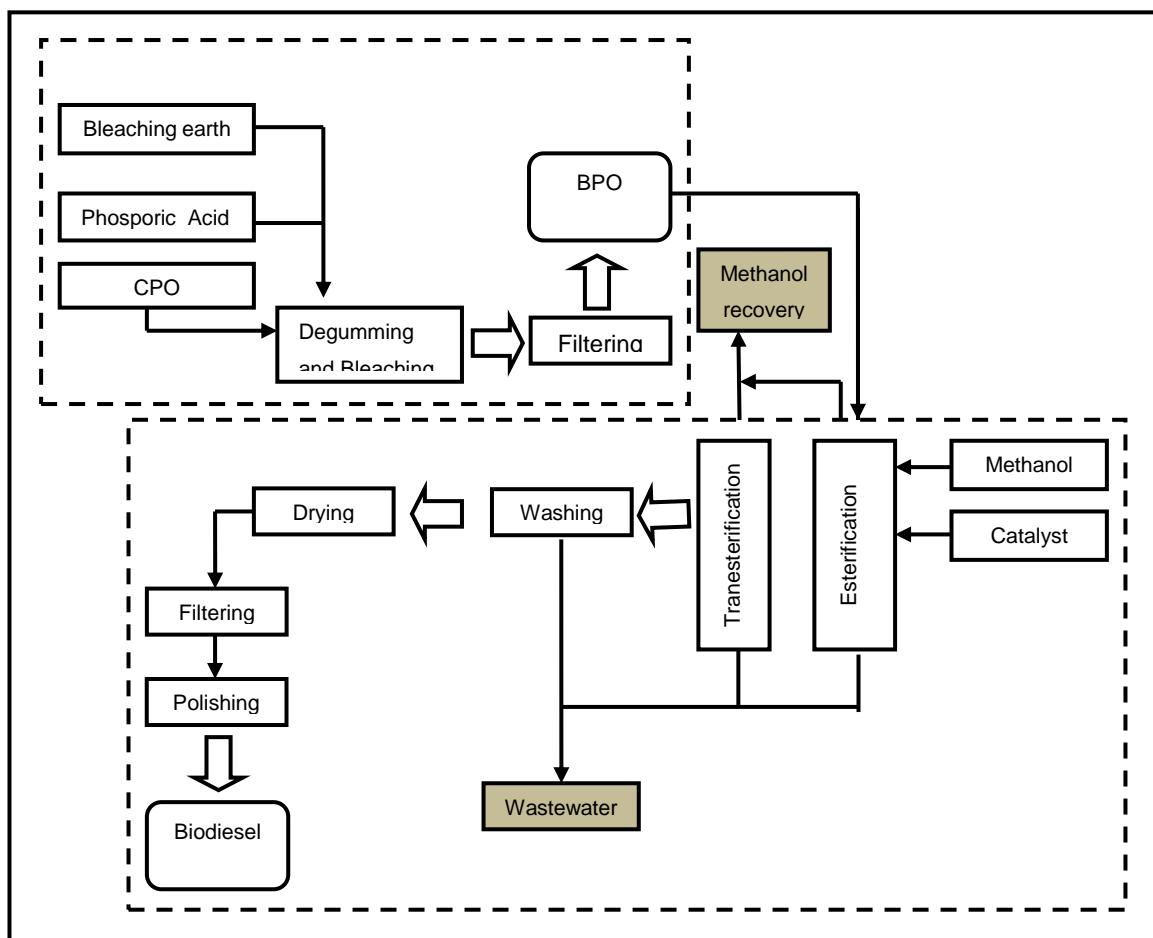
## 2. Biodiesel Production Process

The most common way of biodiesel production is through transesterification, especially alkali-catalyzed transesterification [5]. This is because the method offers the lower cost and able to change triglycerides (oil) to biodiesel with high volume of production compared to other method [2].

The process of biodiesel production can be divided in two blocks as shown in Figure 1. The aim in Crude Palm Oil (CPO) pretreatment is to prepare the raw materials quality to be fit for the second block. In this stage, CPO will be converted into Bleach Palm Oil (BPO). The process starts with degumming step to remove phospholipids. To remove phospholipids, phosphoric acid is used and

then followed by bleaching with activated earth vacuum to remove the colour and also any metals ions content. Dirt, solid particles or any impurities are separated using bleaching earth filter.

The second block processes include esterification and transesterification of BPO with methanol under presence of acid and base catalyst, respectively. Methyl esters are produced in esterification process. These products are then transferred into transesterification reactor with methanol to produce fatty acid methyl ester (FAME) or biodiesel. FAMEs then were washed, filtered, and vacuum dried before sending to storage. Wastewater is produced in washing stage.



**Figure 1:** Process of biodiesel production

### 3. Current biodiesel wastewater treatment

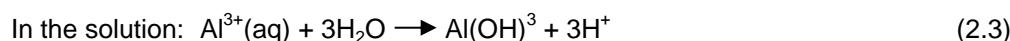
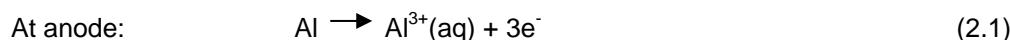
The biodiesel wastewater has a very high content of oil and grease, and low content of nitrogen and phosphorus. There were several options available to reduce pollution problem created by biodiesel wastewater. For instance, common treatment of oily wastewater in Thailand is through dissolved air floatation technique (DAF) and oil and grease (O&G) trap unit or other commercial O&G removal units [6].

The high content of BOD makes biodiesel wastewater easily amendable to biodegradation. Therefore, biological treatment is the best process to breakdown the organic pollutants in biodiesel wastewater. Biological wastewater treatment process uses microorganisms as nutrients substrates contaminating the water. The biological treatment system can be divided into three (3) types; anaerobic (absence of oxygen), aerobic (presence of oxygen) and/ or facultative (aerobic and anaerobic) [7]. The pH adjustment is often needed to prepare the effluent for subsequence treatment process, especially in biological treatment. In addition to pH control, chemical treatment also is required to reduce the total fatty matters prior to the separation by floatation and sedimentation processes.

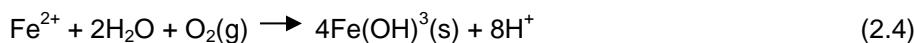
The other types of biodiesel wastewater treatment is sequencing batch reactor (SBR). Mode of SBR operation includes fill, react, settle, draw and idle. SBR treatment plant consist one holding tank and two reactors. The effluent is collected to recover oil and fatty matter before it is pumped into holding tank where nutrients and pH adjustment were carried out. Then, it is fed to the one of the reactors where air supplied by a compressor installed at the bottom of the reactor. All the operations are controlled by microprocessor-based sequencing controller [7].

#### 4. Principles of Electro-coagulation

In electro-coagulation, metal salts are used to destabilize colloidal particles and coagulants are produced in situ without direct addition of any chemicals. Coagulants are generated by electrolytic oxidation of appropriate anode materials, such as aluminium and stainless steels electrodes. Iron electrodes usually employed for wastewater treatment whereas aluminum electrodes commonly used for water treatment due to its economic viability [8]. Aluminium and iron cations were generated by dissolution of sacrificial anodes upon the application of a direct current. The metal ions generated were hydrolyzed ions according to reaction equation (2.1) - (2.3) below [9]:



The electro-coagulation with stainless steel electrodes, within the first period of process, will depleting oxygen during oxidation of ferrous iron to ferric ion as shown in reaction equation (2.4) below [10]:



When the cell is connected to an external power source, oxidation reaction will governs the process which driving the anode material to undergo electrochemical corrosion, while the cathode will subjected to passivation [11].

An arrangement of electro-coagulation cell can be manipulated into two; monopolar electrodes in series and bipolar electrodes in parallel. Cells that were connected in a series mode need a higher current flow because series mode has higher resistance due to current will flow through electrodes. While, cells connected in parallel mode have their electric current divided between all the electrodes in relation to the individual resistance of the cell [11].

The cell maintenance during use become easier because of simple set up. The mechanism of bipolar electrode are the neutral sides of the connected plate will be transformed to charged sides which have opposite electrodes when the electric current is passes through the electrodes. During operation, the positive side undergoes an anodic reaction, whereas a cathodic reaction take undergoes on the negative side [11].

## 5. Overview of different types of wastewater recently treated by electrocoagulation

Electro-coagulation has been successfully applied on various wastewaters, has been found to be at promising for solid/liquids separation [12]. Orathai and Maneerat [13] reported the level of COD, oil and grease (O&G) and SS was reduced by 55.43%, 98.42% and 96.59% respectively, at the optimum conditions of pH 6.06, applied voltage 18.2 V, and reaction time 23.5 minutes. Electro-coagulation duration that is preferred by many researchers is between 15 minutes to 30 minutes due to good removal efficiency of many pollutants [14]; [15].

In the electro-coagulation process using aluminium as anode and graphite as cathode, results show the removal efficiency for COD, SS and O&G were 55.7%, 97.5% and 97.8% respectively where the current density, retention time and initial pH value was 8.32 mA/cm<sup>2</sup>, 25 minutes and pH 6 respectively [3].

Another study about electro-coagulation using aluminium as electrodes and sodium hydroxide as supporting electrolyte in treating palm oil mill effluent reported that the COD level was reduced from 36,800 mg/L to 25,600 mg/L which corresponding to a 30% removal. The pH of the sample was increased from 4.30 to 7.63 after the electro-coagulation process. The BOD also was reduced from 23,400 mg/L to 14,000 mg/L which corresponding to a 38% removal [14].

Zodi et al [16] deduced that the usage of aluminium as electrode generating higher amounts of coagulants either by high current densities or long electro-coagulant periods. However, the process does not permit rapid settling of flocs, probably because of the gel-like structure of Al hydroxide. The study also reported that the supernatant layer contained significant level of suspended solids with moderate amounts of electro-generated Al species, whereas lower turbidity was reported in such conditions. Sedimentation time was observed to be more rapid when Fe electrode was employed for electro-coagulation due to the presence of iron hydroxide particles that having higher density compared to Al hydroxides.

The most common electrode used in the electro-coagulation were aluminium and iron in either bipolar or monopolar electrode modes [4]. However, Mahvi et al [17] had claimed that iron electrodes were easily corroded after several times of electro-coagulation process. Therefore, instead of iron electrode, stainless steel was also chosen as electrodes in treating the metal plating effluent.

## 6. Advantages of Electro-coagulation

Electro-coagulation method had been widely used since it was introduced to treat many types of wastewater such as including biodiesel wastewater, municipal wastewater, leachate from solid wastes, textile wastewater and wastewater containing organic species such as phenol [18].

In terms of sludge formation, electro-coagulation produced less sludge compared to conventional coagulation system. Electro-coagulation also produced flocs which are similar to chemical flocs. However, flocs produced by electro-coagulation contain less water and more stable [19]. This condition make flocs can be separated easily through filtration process.

Mollah et al. [11] had claimed that electro-coagulation has the ability to remove smallest colloidal particles because the applied electric fields set them in faster motion thereby facilitation the coagulation. Moreover, electrolysis will produce gas bubbles that carry the pollutants to the top of the treated solution where it can easily remove [20]. Electro-coagulation also provides no chemicals used, and there is no problem of neutralizing excess chemical and no possibility of secondary pollution [11]. Since this technique consumed low power of operation, it can be conveniently used in rural area where electricity is not available, because a solar panel attached to the unit may be sufficient to carry out the process [11]; [21].

## 7. Conclusions

From the current review, electrocoagulation method shows its high potential to be one of the most effective methods in treating biodiesel wastewater to ensure harmful pollutants are alleviated prior their discharge into receiving bodies.

## Acknowledgment

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# CHAPTER 9

## WASTE TO WEALTH: PRODUCTION OF ACTIVATED CARBON FROM AGRICULTURAL WASTE

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### Abstract

Adsorption is the main process for wastewater and drinking water treatment. The ability of activated carbon as an absorbent was proven by many researchers. Agriculture waste can be produced as an activated carbon based on availability, cost, and purity. Physical and chemical activations are the main process in activated carbon (AC) development. Both processes have its own advantage. Before proceeding with the activation process the precursor must be characterized for metal element and surface functional group by doing (X-Ray Fluorescence) XRF and Fourier transform infrared (FTIR). TGA will determine the exact carbonization temperature. Adsorbent pore will be analyzed using BET. Activating agent and carbonization temperature gives the main effect for surface area and total pore volume of AC. This chapter will review the AC development process and the exact characterization method in preparing the AC.

**Keywords— physical activation, chemical activation, activating agent, media characterization, precursor**

### 1. Introduction

Activated carbon (AC) is well known for its potential for the filter material to remove hazardous components in exhaust gases, as the purification system for drinking water purpose and wastewater treatment. Due to the high demand of AC, there is a need to identify new precursors that are cheap, accessible and available in an abundant quantity that has the potential for significant economic benefits to developing AC [1]. Reviews have documented the replacement of agricultural wastes as

inexpensive and effective metal ion adsorbents, for existing commercial AC's material result in relatively higher adsorptive efficiency [2]; [3]; [4]. The adsorptive efficiency of AC refers to capability in adsorption process due to AC surface which highly microporous form with both high internal surface area and porosity. They also often serve as catalysts and catalyst supports[5]. Several suitable agricultural byproducts as AC precursors have been investigated in recent years and continue to receive renewed attention. These include honeydew peel [6], cocoa pod husk [7] , cotton stalks [8], rice husks [9], Parkia Speciosa (Petai) [10], Camellia oleifera shell [2], reedy grass leaves [11], Areca nut waste [12], almond shell [13], apple waste [14], mango nuts [15],waste tea [16], cherry stones [17], grape seed [18], papaya peels [19]. Therefore, the objective of this paper is to review and evaluates the production process in preparing the AC through recycling of different types of agricultural waste materials via chemical method conventional heating.

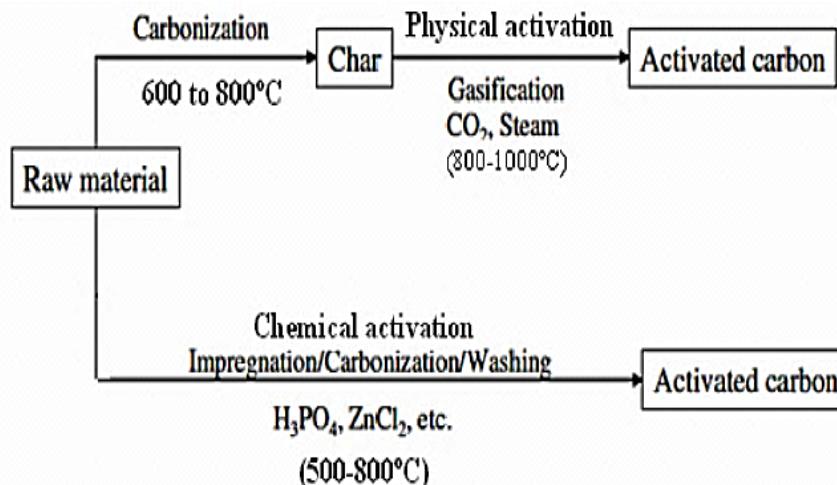
## 2. Production of AC

Pretreatment process for all precursor is required, to remove dirt or any impurities on the surface area, in this process, the precursor will be soaked and washed with distilled water and oven dried at 110°C for 24 hours. The dry precursor can then be proceed for AC production. Production of AC involves two main method as in Figure 1: Physical activation and Chemical activation.

In physical activation, there are two steps involved. Firstly, the dried precursor was crushed and sieved before carbonized by heating in an inert atmosphere such as flue gas. Dehydration and de-volatilization of the carbon occur in this process. For this stage temperatures usually do not exceed 800° C. Carbonization reduces the volatile content of the source material to fewer than 20%. The second stage is activation stage which enlarges the pore structure, increases the internal surface area and makes it more accessible. Then the carbonized product is activated with the steam temperature between 800°C – 1000°C [20]. This activation stage will enlarge the pore structure, increases the internal surface area and makes it more accessible.

Chemical activation involves mixing the raw material with an activating agents such as phosphoric acid ( $H_3PO_4$ ) [21], potassium carbonate ( $K_2CO_3$ ), Zinc chloride ( $ZnCl_2$ ) [21] and nitric acid ( $HNO_3$ ) [22], then heat-treatment at moderate temperatures in a one-step process between 500°C – 800°C. Then the AC was washed with hot distilled water at 70°C and rinsed several time with distilled water to remove residual chemicals from the material to the nearest neutral pH value of (5.0 – 6.0) [23]. Chemical activation is usually carried out if the raw material is wood or peat [24].

Each process leads to materials with specific properties so that the procedure to be employed has always based on the final application the AC. Chemical activation will take place at the lower temperature and less time for AC development compared to physical activation process [25].



**Figure 1:** Scheme of the process of activated carbon manufacturing [26]

### 3. AC characterization

Characterization of physicochemical properties has revealed both significant chemical compounds and physical behavior of AC and it will describe the effectiveness of AC as an absorbent. X-Ray Fluorescence (XRF) an analytical tool for elemental analysis and chemical compound of materials. Table 1 shows the element contains in different agricultural waste. Carbon is the main element and it is proven that agricultural waste suitable for AC development. It also can predict the adsorbate which suits the chemical element of the precursor.

**Table 1:** XRF for agricultural waste

Formula	Agricultural waste		
	Cassava peel (%)	Banana peel (%)	Coconut shell (%)
Carbon (C)	10	10	10
Calcium oxide (CaO)	4.6	2.45	1.03
Potassium oxide (K <sub>2</sub> O)	3.43	13.70	1.03
Silicon dioxide (SiO <sub>2</sub> )	1.73	0.94	-
Aluminum oxide (Al <sub>2</sub> O <sub>3</sub> )	1.11	-	-
Ferrum oxide (Fe <sub>2</sub> O <sub>3</sub> )	0.90	-	0.76
Sulfur trioxide (SO <sub>3</sub> )	0.55	1.05	-
Chloride (Cl)	0.50	4.60	0.28
Magnesium oxide (MgO)	-	0.19	-
Bromide (Br)	-	0.15	-

Thermogravimetric analysis (TGA) is commonly used to determine the decomposition reactions of materials and weight change against temperature which basically permits quantitative composition analysis [8]. From thermal analysis by TGA, it will indicate several stages of temperature drop where removal of moisture and gases occur also the final degradation process where it will indicate fixed carbon content and suitable carbonization temperature [16].

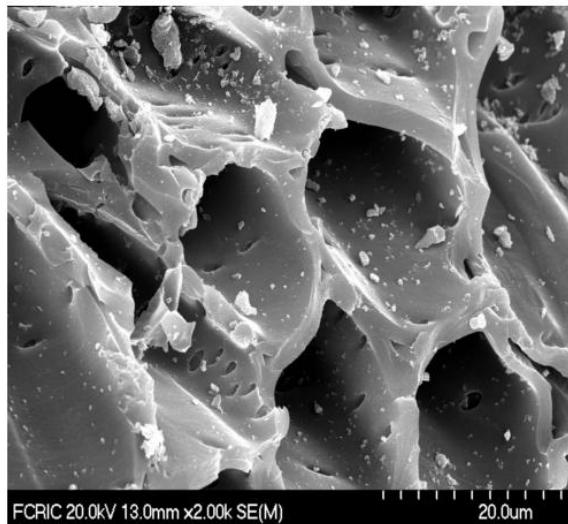
Fourier transform infrared (FTIR) was employed to determine the presence of functional groups in AC. The FTIR spectra were used in parallel for the evaluation of the amount and the type of the surface functional groups. and it will indicate the involvement of the alcohol, carboxylic, alkanes, amines that play the important role to reduce ions [27]. It was established that the amount of surface functional groups determined by potentiometric titration positively correlates with the intensity of the peaks of hydrophilic functional groups in the FTIR spectra. A comparison between the FTIR spectra before and after adsorption process will reveal the various chemical groups and bands in accordance with their respective wavenumbers ( $\text{cm}^{-1}$ ). Different groups corresponding to the properties of adsorbents influenced the adsorptive properties of AC differently [28].

The surface characteristics, namely specific surface areas( $S_{\text{BET}}$ )  $\text{m}^2/\text{g}$  and total pore volume  $\text{cm}^3/\text{g}$  and were determined from nitrogen adsorption isotherms [29]. Large surface area and high pore volume are widely used in liquid and gas separation, medicine and catalyst while the total surface area may support the accessibility of active site with relating to the catalytic activity. Field emission scanning electron microscopy (FESEM) equipment observed the changes of pores on top of the surface of AC weather well-developed pores are formed or the pores are ruptured. According to International Union of Pure and Applied Chemistry (IUPAC), the adsorbent pores were classified into three groups as in Table 2.

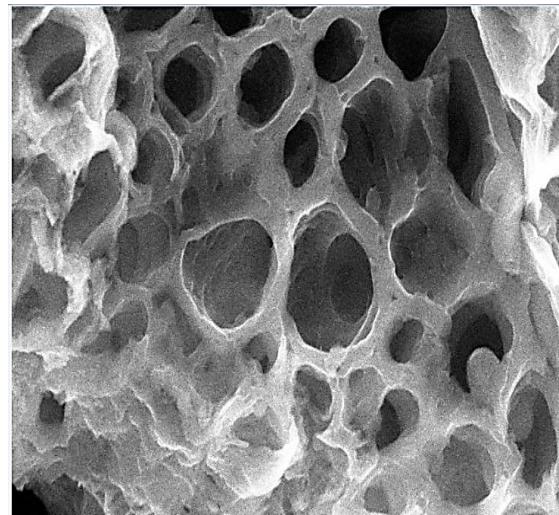
**Table 2:** Pore classification [11]

Type of Pore	Pore Diameter
micropore	<2nm
mesopore	2–50 nm
macropore	>50 nm

Figure 2 and Figure 3 are SEM images for AC from areca nut and rice husk. Both pictures revealed the adsorbent pores developed.



**Figure 2:** SEM image for AC from Areca nut [12]



**Figure 3:** SEM image for AC from rice husk [9]

#### 4. Activated carbon performance

The Iodine number (IN) will reveal the activated carbon performance by measure micropores content of the activated carbon and gives the indication of the internal surface area of AC. IN was obtained by the adsorption of milligrams of iodine adsorbed from an aqueous solution by 1 gram of activated carbon sample.

Table 3 shows various agro-waste sources as activated carbon and its characterization which can be used in the different application. Different acids were used as an activating agent in impregnation process with various concentration and ratio. Activating agent in impregnation process will modify surface functional groups of ACs precursor. The specific adsorption characteristics of an activated carbon strongly depend on the composition of the surface functional groups. Activating agents and AC precursors would play different roles in the activation process, leading to different porosity and morphology [31].

**Table 3:** Performance of activated carbon [2]

Source	Activating agent	Carbonization temperature (°C)	Surface area (BET) m <sup>2</sup> /g	Total pore volume cm <sup>3</sup> /g	Reference
Rice Husk	NaOH/KOH	700 - 900	29.6 – 63.4	0.35-0.49	[9]
Cotton stalk	H <sub>3</sub> PO <sub>4</sub>	500-800	300-1720	0.15-1.23	[8]

Parkia Speciosa (Petai)	H <sub>3</sub> PO <sub>4</sub>	500-800	190	0.0950	[10]
Camellia Oleifera shell	H <sub>3</sub> PO <sub>4</sub>	450	1608	1.17	[2]
Grass leaves	KOH	800	1100	0.601	[11]
Areca nut waste	H <sub>2</sub> SO <sub>4</sub>	400	367.30	0.016	[12]
Honey dew peel	H <sub>3</sub> PO <sub>4</sub>	470-550	997		[6]
Cocoa pod husk	K <sub>2</sub> CO <sub>3</sub> KOH ZnCl <sub>2</sub>	500-800	780	0.58	[7]
Almond shell	H <sub>3</sub> PO <sub>4</sub>	400-600	798- 1408	0.253- 0.4	[13]
Apple waste	H <sub>3</sub> PO <sub>4</sub>	110	854	0.13	[14]
Tea waste	ZnCl <sub>2</sub>	105	118-1141	0.13 – 0.34	[16]
Grape seeds	H <sub>3</sub> PO <sub>4</sub>	350-550	1139	0.24	[17]
Papaya peel	HNO <sub>3</sub>		26.56	0.086	[19]

KOH = Potassium hydroxide, H<sub>3</sub>PO<sub>4</sub> = Phosphoric acid, NaOH = Sodium hydroxide, K<sub>2</sub>CO<sub>3</sub> = Potassium carbonate, ZnCl<sub>2</sub> = Zinc chloride, HNO<sub>3</sub> = Nitric acid

ACs texture characteristics and surface properties depend on the precursor and the method used for its preparation [33]. Previous researchers have found that contact time, pH, temperature and metal concentration are the factors that will influence the adsorption capability by ACs [34]; [35]; [3].

## 5. Conclusion

The results of the numerous studies on the adsorbent efficiency of these agriculture wastes as AC demonstrate the ability in wastewater and drinking water treatment. The manipulation of agriculture waste material helps to improve up cycling of the waste and providing a potential alternative to

activated carbon precursor. The main advantage of AC is the ability to modify the AC surface to change its characteristic and to customize ACs for the particular application.

The surface area and total pore volume are the main factors in describing. The effectiveness of absorption process by AC, to maximize the surface area and total pore volume not only depends on the type of precursor but also on the appropriate method for AC development.

AC characterizations are very important to optimize the condition of the precursor. Comparison of AC characterization should be done as a benchmark to know the AC performance before and after the adsorption process. Agriculture wastes are promising alternatives precursor for AC to be used as an environment pollution control due to the abundant and availability of it source.

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