# INVESTIGATION OF ORGANIC COMPOSITION OF POTENTIAL PLANTS AS ALTERNATIVE FIBER IN PAPER MAKING INDUSTRY

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**Material:** **Pineapple leaf**
**Corn stalk**
**Napier grass**

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# ABSTRACT

Malaysia was known as a country that rich with a source of agro waste material. Three different crops had been studied which include the pineapple *(Ananas Comosus)* leaf, corn *(Zea mays)* stalk and Napier grass *(Pennisetum purpureum)*. Those crops were characterized as agro waste material in Malaysia and have a high potential to become an alternative fiber. The objective of this work was to analysis the chemical composition which are pineapple leaf, corn stalk and Napier grass; to investigate the properties of hand sheet made from those crops; to determine the influence of different pulping process and process variables on the physical and chemical properties. Every chemical components analyse; Cellulose, Hemicellulose, Ash and Lignin content by TAPPI Test Method. All of three samples were undergo acidic and alkali pulping process. Fiber Analyser was used for fiber analysis and SEM use for observation on sample. From pulping process, the step will continue for papermaking. Lastly, tensile, bursting, folding, and tearing tester machine will test paper production. Result shows that pineapple leaf gives high cellulose content (66.2%) and lower lignin content (4.2%) compared corn stalk and napier grass. Alkaline pulping shows a quality of pulp rather than acidic pulping process due to the pulp strength and colour of fiber. Corn stalk gives a high potential to be an alternative for mechanical properties viewed. High tensile index (90.99 Nm/g), burst index (6.64 kPa*$m^2$/g) and fold index (3.51 Nm) by corn stalk paper rather than pineapple leaf and napier grass but lower in tear index (2.85 $Nm^2$/g). This wass due to the long fiber length by pineapple leaf about 13.36 mm from SEM images. This arrangement form and effect a structure of fiber. Based on all tests, corn stalk materials have high potential to be fiber substitution but pineapple leaf and napier grass have their own characteristic to be alternative fiber. This research also promote green technology where one of the solid waste material technology for waste from agricultural residue.

# ABSTRAK

Malaysia dikenali sebagai sebuah negara yang kaya dengan sumber bahan buangan pertanian. Tiga tanaman yang berbeza akan dikaji termasuk nanas (*Ananas Comosus*) daun, batang jagung (*Zea Mays*) dan rumput *Napier* (*Pennisetum purpureum*). Tanaman ini telah disifatkan sebagai bahan sisa pertanian di Malaysia dan mempunyai potensi yang tinggi untuk menjadi gentian alternatif. Objektif penyelidikan ini adalah untuk analisis komposisi kimia daun nanas, batang jagung dan rumput *napier*; untuk menyiasat sifat-sifat kimia tanaman; untuk menentukan pengaruh proses pulpa dan proses pembolehubah yang berbeza ke atas sifat fizikal dan kimia. Setiap komponen kimia menganalisis; Selulosa, Hemiselulosa, dan kandungan *Lignin* oleh ujian kaedah *TAPPI.* Semua tiga sampel menjalani proses pulpa berasid dan alkali. *Fiber Analyzer* akan digunakan untuk analisis serat dan SEM digunakan untuk pemerhatian ke atas sampel. Dari proses pulpa, langkah akan terus untuk pembuatan kertas. Akhir sekali, tegangan, pecah, lipatan, dan mengoyak mesin penguji akan menguji pengeluaran kertas. Hasil kajian mendapati daun nanas memberikan kandungan selulosa tinggi (66.2 %) dan lignin (4.2%) rendah daripada batang jagung dan rumput *napier*. Pulpa alkali menunjukkan pulpa berkualiti daripada pulpa proses berasid kerana kekuatan pulpa dan warna gentian. Batang jagung memberikan potensi yang tinggi untuk menjadi alternatif kepada sifat mekanik dilihat. Indeks yang tinggi tegangan ( 90,99 Nm / g ), indeks pecah (6.64 kPa * m2 / g ) dan lipat indeks ( 3.51 Nm ) daripada daun nanas dan rumput *napier* tetapi rendah bagi koyak index (2.85 Nm2 /g) . Ini adalah kerana panjang serat panjang dengan nanas daun kira-kira 13.36 mm daripada imej SEM. Susunan ini akan membentuk dan menentukan struktur serat. Berdasarkan semua ujian, batang jagung mempunyai potensi yang tinggi untuk penggantian serat tetapi daun nanas dan rumput *napier* mempunyai ciri mereka sendiri untuk menjadi serat alternatif. Kajian ini juga mempromosikan teknologi hijau di mana salah satu daripada teknologi bahan sisa.

# TABLE OF CONTENT

## CHAPTER 2 LITERATURE REVIEW

## LIST OF TABLES

**NO. TITLE** **PAGE**

| | |
|---|---|
| Nm/g | Newton meter per gram |
| $mNm^2/g$ | Mili newton meter square per gram |
| $kPa.m^2/g$ | Kilo Pascal meter su=quare per gram |
| cm | centimetre |
| mm | milimetre |
| µm | Micrometre |
| ga/kga | Gram per kilogram |
| v/v | Volume over volume |
| $^0C$ | Celcius |
| ml | Militre |
| g | Gram |
| w/w | Weight over weight |
| % | Percentage |
| $H_0$ | Hyphotesis |
| L | Litre |
| NaOH | Sodium hydroxide |
| $HNO_3$ | Nitric acid |
| $H_2SO_4$ | Sulphuric acid |
| $NaClO_2$ | Sodium chlorite |
| C2H402 | Acetic acid |
| $C2H_5OH$ | Ethanol |
| C3H5OH | Acetone |
| SEM | Scanning Electron Microscopy |
| ANOVA | One Way Varians Analysis |
| $H_2SO_3$ | Sulphurous acid |
| $HSO_3$- | Bisulphite ion |
| $SO_2$ | Sulphur dioxide |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background of the Study.

Malaysia is one of the countries that has a larger tropical forest in the world. The use of tropical tree as a source of pulp creates a significant problem to Mother Nature. Every day, the news about on depleting forest tree activities and a problem that were

produced by depleting tree activity can be seen (Mmom *et al.,* 2013). The paper industry is one of the main industries that requires a forest tree for their beneficial and pulp production. Without them, the industry cannot do well in their production process and it will affect the whole economy especially the country where the main industry uses wood industry.

Wood had become a large conventional raw material for pulp and paper production in the world with more than 90% of the world production is being produced in the develop countries (Mmom *et al.,* 2013). From this increasing used of wood, develop country had found the use of recycled paper to become one of the solution to reduce depleting of forest trees; hence contribute to the sustainable development of Mother Nature. However, recycled paper cannot be used directly to become another option of paper production. It is because the strength of recycled fiber is subject to degradation after consecutive cycles (Aziz and Zhu, 2006). Most paper mill industry adds a certain amount of imported virgin pulp to restore the strength of recycled paper to make paper production more quality.

The aim of this study was to investigate the potential of alternative crop as fiber substitution to the conventional imported virgin pulp. Three different crops had been studied which are characterized as being the agrowaste in Malaysia (Ansah *et al.,* 2010; Aziz and Zhu, 2007; Khalil *et al.,* 2006). This investigation include corn stalk, pineapple leaf, and napier grass. All of these crops were investigated with regards to their chemical composition related to paper production. Among the chemical composition in those crops, fibre was the main component that were took as a research study. All non-wood material contain fiber component but the percentage of the fiber will act as the main factor in paper making (Khalil *et al.,* 2006).

Pineapple is a tropical plant that can be found in Malaysia due to suitable climate. Besides the fact that the fruit is rich in nutrition like protein, the leaves from this fruit consists of cellulose that is essential in paper making (Banik *et al.,* 2010). From early on, corn had been used as human consumption and is fed to livestock, primarily in the form of silage. Textile, chemical and pharmaceutical industries uses corn starch as the main of their production and the properties of corn starch makes it capable to be another uses product especially wheat (Thmae *et al.,* 2009). Meanwhile, corn stalks contain hemicelluloses which have potential as alternative fiber in paper making. Corn stalk offer a highly content of hemicelluloses that can be

partially extracted prior to pulping without reduce the quality of paper (Aziz and Zhu, 2007).

Another crop that had been studied was napier grass which in scientific term is called *Pennisetum purpureum*. This plant grows to 2 – 4.5 meters tall and only grow in tropical or sub-tropical regions (Aganga *et al.,* 2005).This study were undergoing three stages where the first part will investigate the chemical composition of each crops. The investigation of this crop chemical includes cellulose, hemicelluloses and lignin contents. Then, the crops were determine the properties of hand sheet made with several ratios of crop pulp; recycled paper. The last stage will evaluate the variables during processing period such as temperature, time and active alkali percentage.

TAPPI (Techninal Assicoation of the Pulp and Paper Industry) method was the standard method that were being used for pulp and paper making method. Wood and non wood material needed this method which include in physical (mechanical and fiber analysis) and chemical (composition of analysis) analysis (Aziz and Zhu, 2007). Both analysis had been standardise in this TAPPI method. Many researcher in this field of this study used this method as their guidelines.

## 1.2 Problem of Statement

Nowadays, the use of wood material had become more commercialized and it has become one of the main productions in Malaysian industry. Pulp and paper production industry is one of the industries which conventional uses the wood material. However, deplete on forest tree to get the wood material has made an impact on the environment and human consequently. The environmental effects will eventually lead to erosion, air pollution, flood and decreases of habitat an animals and also plants. This problem has become worse from day to day. Demand on paper production has made this problem persits and it need to overcome a new solution as this affect for our world.

In order to overcome this problem, recycled paper and alternative fiber given a solution to the problem that have determorated from day to day. Alternative fiber

from non-wood material can reduce the use of wood material. Thus, people can use a non-wood material that has no use or use only in specific ways on this will maximize the potential from that non-wood material or agro-waste material. Like pineapple leaves, cornstalk and naper grass, these non-wood material has no specific ways for use in this industry. Those three material were being classified as an abundances of agro waste materials. Abundance of agro-waste material in Malaysia leads to the environmental effects and the production of paper. This is because of the high demand of paper production in Malaysia. Paper has become the main need in our daily lives and to avoid the depletion of forest, alternatively it is the best solution for the problem that have been created from depleting phenomena.

In this study, three crops of non-wood material have high potential to become an alternative fiber and as one of the alternative choice of pulp production. Besides that, this experiment will identify whether this alternative fiber is suitable to make paper will have to undergo the method above.

## 1.3 Objective

The main objectives of this research include:

1) To investigate the chemical composition and fiber properties of pineapple leaf, corn stalk and napier grass to be used as alternative fiber for paper making.
2) To determine the effects of different pulping process and process variables during pulping process on the physical and chemical properties of the pulp yielded.
3) To investigate the properties of handsheet made with tensile test, tearing test, folding test and bursting test for three different alternative fiber selected (pineapple leaf, corn stalk and napier grass).

## 1.4 Scope

This research covered the preparation of raw material, analysis and parameters. The preparation was obtained locally pineapple leaf, corn stalk and napier grass. Analysis and parameters were conducted for pulp preparation, fiber analysis, surface observation and hand sheet making by obtaining paper strength test. The scope of this study also includes the investigation of the chemical composition which is include cellulose, hemicellulose, lignin, ash content, 1% NaOH solubility and hot water solubility content. The influence by the variables of pulping process (soda and acidic pulping) gave a significance to physical characteristic on the paper strength and formation. Those mechanical properties (tensile, tear, fold and burst) were determined by TAPPI method test where this could shown the good and quality of pineapple leaf, corn stalk and napier grass paper production in this study.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

Over the past twenty years, the issue of forests have given an impact on the international policy debates. In 2007, The United Nations Environment Programme (UNEP) had launched a worldwide campaign about the danger of the illegal activity

on our forest (Nellemann, 2012). Forestation indeed has emerged on an issue where it concerns every human being in the world, include all ethnicities, culture, location or subsistence means. Forest have become overused because of the increase of many industries that use the trees to make their product.

Forests have become the main source which include trees, plant and leaves for commercial products. There are many reasons why forests need to be cleared for human accommodation. Agricultural purpose is to develop a small and large area of forests needed to provide nutrients and soil products (FAO, 2001). This occurs on a much larger scale for intensive or modern agriculture. Next is the commercial logging, of the cutting down of the trees for sale as timber or pulp. Then, the timber and pulp will be sent to industies that needed the source.

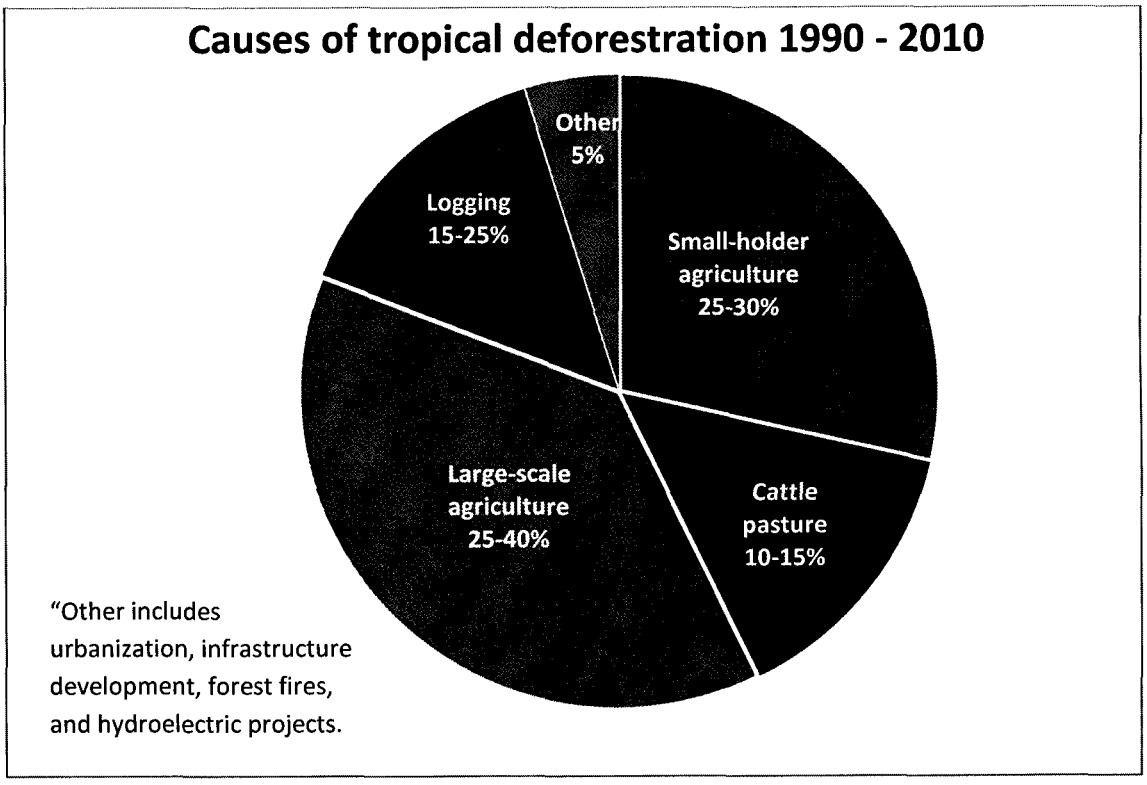



**Figure 2.1:** Causes of tropical deforestation in year 1990 – 2010 by all country in the world (Stibig *et al.*, 2014).

This industrial production is one of the obvious effects of our forest. From Figure 2.1, 15-25% of our forest has been cleared because of the high demand of

wood source in this area of industry. The next reason is constructions by the developer to make new scale side of commercialization of the places. Development of new city can needed to forest cut their trees to make new living life for people from demand of the population by people in the world. Deforestation can give many global effects that leads to the unsustainable structure of world environments. These changes affect all scopes from the environment to humans. Deforestation essentially gives significance to the microclimates, regional climate and global climate (Gupta *et al.,* 2005). Deforestation can affect the global change of energy not only through the micrometeorological processes but also by the increasing the concentration of carbon dioxide in the atmosphere (Chakravarty *et al.,* 2012). It is because carbon dioxide absorbs thermal infrared radiation in the atmosphere. Subsequently, deforestation can lead to the increase in the albedo of the land surface and hence affects the radiation budget of theregion (Gupta *et al.*, 2005; Rowntree, 1988).

The next effect from the loss of trees in our forest is water and soil resources which will be lost through flooding. According to Bruijnzeel (2004), deforestation also disrupts the global water cycle where the removal part of the forest cannot hold as much water which creates a drier climate. Deforestation gives an effect to the water resources which include drinking water, fisheries and aquatic habitat (Gupta *et al.,* 2005). Once the trees are gone in a large scale, too much water can result in downstream flooding, which is why many incidents of such have caused disaster in many parts of the world. This downstream flow causes soil erosion and this in turn causes a faster response of stream flow to rainfall and flash flooding (Chomitz *et al.,* 2007). The floor of the forest has become easily porous because of the strength of the soil of the forest has depleted due to the loss of trees and this will lead to the soil erosion.

Forests, support two thirds of all known species and contain 65 per cent of all world endangered species (Myers and Mittermeir, 2000). The biodiversity loss can lead to critical problems due to the increase of logging activities. The biodiversity can affect the climate change and the cycle of animals that live in the forest. This negative effects of deforestation can also increase the human-animal conflicts where it's hitting hard on the success of the conversation in a way alienating the people who participates in that conversation (Mangave, 2004).

This problem also effects the economic losses of some countries that face deforestation. Each year, tropical forest have been deplete into disaster in US $45

billion each year amount according loss in forest capital valued (Chakravarty *et al.*, 2012). This will give significance to all potential revenue and employment which could derive from the sustainable management of timber and non timber product (Ahenkan and Boon, 2011). However, there are many problems in the future that people will be faced if this overuse of our forest sources proloug and it will not recover immediately but it takes a long time to heal.

## 2.2 Solid Waste

Solid waste can be defined as non-liquid and non-gaseous of all wastes arising from human and animal activities where it was normally soliditied and is discarded as useless or unwanted waste (Babayemi and Dauda, 2009).There are many types of sources for solid waste can be seen from Table 2.1. Agriculture also includes the source of solid waste. This agriculture plays an important role in solid waste because it also affects the process of the industries that uses main raw materials from this agricultural. However, industrial waste is very important to be managed well because it involve chemical and the environmental safety. That is why solid waste management is very important to make sure our environment get the precaution needed from us.

Human population becomes larger, so on to the waste that is from humans that they use in daily life. The population will accumulate and increase the solid waste from their activities. That is why the recycled system is being done to make our world not being full of waste. Hence, the waste that cannot be recycled will be disposed in the place of where the wastes are being stored through the disposal process.

In Asian developing countries, population, urbanization and industrialization which contribute to solid waste have increased 16% to 17% in year 2011 (Dhokhikah

and Trihadiningrum, 2012). These consequences also affect the agricultural waste from the farm activities which is one of the property countries for export and import (Shekdar, 2009).India has a solid waste range between 0.2 kg/capita/day and 0.5 kg/ capita/ day with 27 million people in that country (Sharholy et. al, 2008). It shows how much solid is needed to be disposed and recycled in a day. That is why govermant and people need to decrease the abundance of solid waste and use it for another alternative by product.

Agamuthu (2011) stated that the waste generation in peninsular Malaysia has increased from 16,200 tonnes per day to 19,100 tonnnes per day. Assuming a 3.6 percent growth, in 2020 the amount is expected to be 31,000 tonnes/day where it can contribure the increasing of solid waste in Malaysia (NSP, 2005). Thus, Malaysia was definetely increasing in generated solid waste proportional with India country.

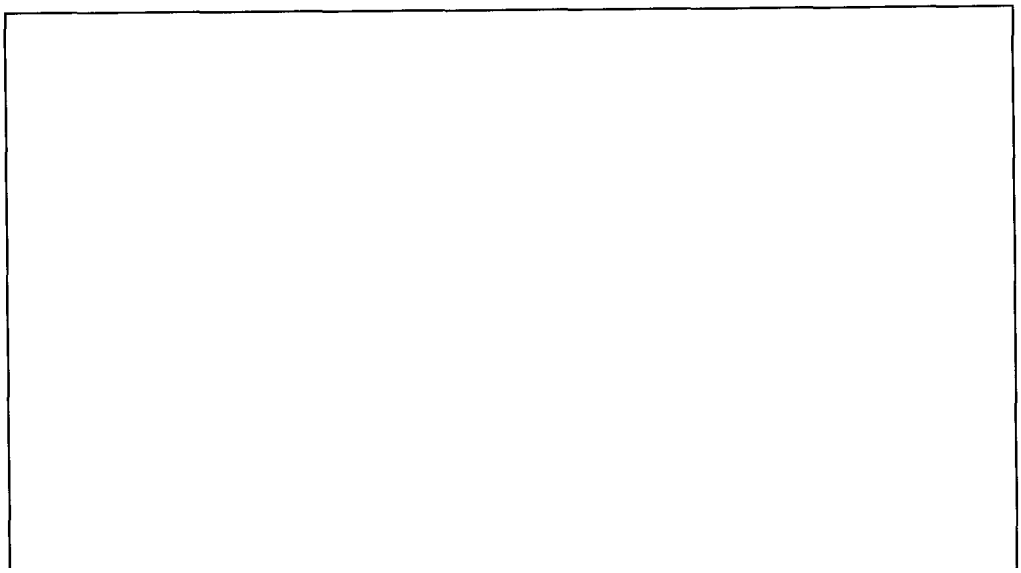
**Table 2.1:** Source and type of solid waste.

| Source | Typical waste generators | Type of solid wastes | References |
|---|---|---|---|
| Residential | Single and multifamily dwellings. | Food wastes, paper, cardboard, plastics, glass and household hazardous. | Fakere *et al.*, 2012; Ventour *et al.*, 2008 |
| Industrial | Light and heavy manufacturing, fabrication, construction sites, power and chemical plants | Housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes and textile | Mladenov and Pelovski, 2010; Babu *et al.*, 2007; Pap *et al.*, 2004. |
| Commercial | Stores, hotels, restaurants, markets, office buildings, | Paper, cardboard, plastics, wood, food wastes, glass, | Sharholy *et al.*, 2007 |

| | | | |
|---|---|---|---|
| | etc. | metals, special wastes, hazardous wastes | |
| Construction and demolition | New construction sites, road repair, renovation sites, demolition of buildings | Wood, steel, concrete, dirt, etc. | Kamala and Rao, (2012). |
| Agriculture | Crops, orchards, vineyards, dairies, feedlots, farms | Spoiled food wastes, agricultural wastes, hazardous wastes | Sabiti, 2011; Bundela *et al.*, 2010 |

The public needs it solving this problem where the improvement in living standard has changed the lifestyle and solid waste composition. The recycled system had increased from back this year where the recycled materials such as plastic, metal, glass and others have increased for recycling.

This has happened because of the increasing consumption of packaged products (Dhokhikah and Trihadiningrum, 2012). Solid waste generation in Asian developing countries show an increase in plastic components (Daniel and Perinaz, 2012). Another problem is the dominance of biodegradable organic waste (more than 40% of total weight), which is potential to emit greenhouse gases (GHGs) (EPA, 2002). Therefore, appropriate strategies should be determined for solving these problems.



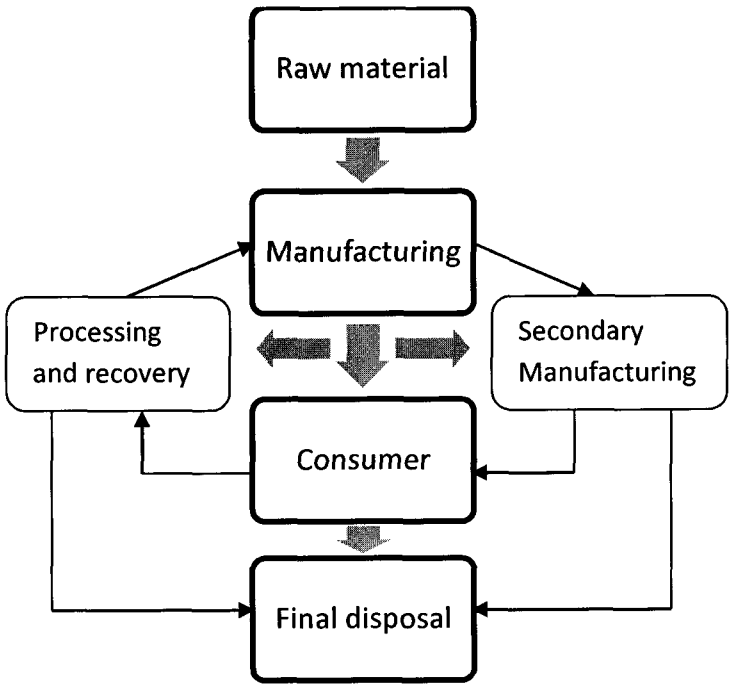



**Figure 2.2:** Flow of solid waste in technological society (Tchobanoglous *et al.*, 1993).

From Figure 2.2, solid waste were generated as a starter from the process. Beginning with raw material; those materials go through to manufacture the solid waste before converting for good consumption. However, the goods can be processed and recovered back to the same or different manufacturing item. Lastly, the best way to reduce the amount of solid waste from the consumer is to dispose the solid waste. Improper management of this waste attributes to the water and air pollution. For example, liquid from the dumps and a poor engineering landfill will contaminate the ground and surface of the water.

It would affect the marine life form in the water which includes plants and marine life. The liquid may contain toxic elements (cooper, arsenic and uranium) which can easily contaminate the water making it polluted. From previous research, the water has the ability to dilute disperse, degrade, absorb or reduce the unwanted residue (Tchobanoglous *et al.*, 1993). However, those unwanted maerials had exceeded from the assimilative capacity where the imbalance of ecological nature will occurr.

## 2.3 Solid Waste Management

In the Resource Conservation and Recovery Act (RCRA) the term solid waste management is defined as the discipline associated with the control of generation, storage, collection, transfer and transport, processing and disposal of solid wastes in a manner that was in accord with the best principles of public health, economics, engineering, conservation, aesthetics and other environmental considerations.

Waste generation (materials that no longer used) were handled for storage, separation and processing. Then, all of the solid waste will be transferred for disposal where the waste will not be abundant for human livehood. Disposal process will be made directly to a landfill site where residual material or other substances from various solid wastes are processed (Dhokhikah and Trihadiningrum, 2012). The amount of solid waste in Malaysia collected for final disposal about 70%, whereas 20% to 30% is dumped or thrown into a river (Ngoc and Schniter, 2009).

A land filled was the main method for disposal in Malaysia. It is because other ways disposal of method have high costs in operation and maintenance, and weaknesses in the maintenance and operation of facilities, incomplete separation of non – compostable material. This will lead to the poor management of solid waste and subsequently lead to pollution in the country. Thus, it would affect the llife style of man whereby needed free to be of pollution and save our nature. Solid waste management in Asian developing countries has less financial resource and lower enforcement of environmental regulations (Visvanathan and Glawe, 2006).

Therefore, composting is applied in India only 10-12%, and other countries like Nepal, Pakistan, Bangladesh and Sri Lanka less than 10% (Khajuna *et al.*, 2010). Solid waste like Figure 2.2 needs to be managed appropriately and follow the steps that has been guide because the financial and time to build the landfill are very precious and this process responsibility for the world and human life.

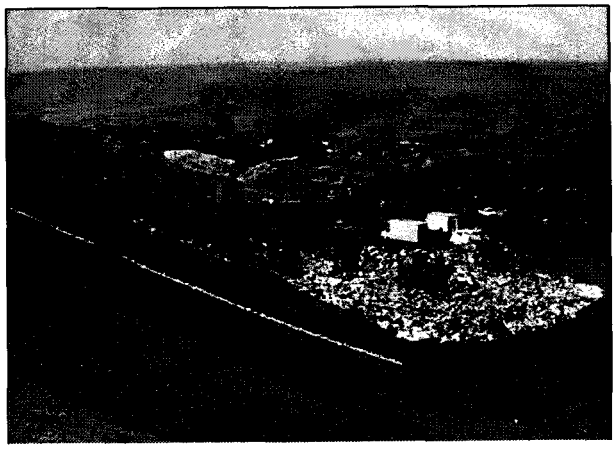


**Figure 2.3:** Landfill for disposal waste in Malaysia (retrieved from www.greengroup.com).

Table 2.2 shows the solid waste and composition in some of the developing countries in Asia. From the paper by Urban Development Sector unit East Asia and Pacific region (Visvanathan and Tränkler, 2003) urban areas of Asia expectedly spend about US$25 billion on solid waste management per year where it is a quite large of unit of waste that had been produced in Asia country.

In Table 2.2, Asian countries are among the countries that have a high of waste production per day. Malaysia is one of the country that was in a position of high composition of solid waste produce compared to other countries. From previous study, Malaysia produces 3798.9 tons per day of waste generation after Indonesia, Thailand and Bangladesh country (Liamsanguan and Gheewala, 2008).

**Table 2.2:** Solid waste generation and composition by Asian country.

| **Country** | **Waste generation** | **Composition (In Percentage)** | | | | **References** |
|---|---|---|---|---|---|---|
| | **Tons/ day** | **Paper** | **Plastic** | **Textile** | **Wood/ Agricul-ture** | |
| Indonesia | 6000 | 7.26 | 10.09 | 2.68 | 2.39 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | Kardono,2007 |
| India | 500 | 45.3 | 3.6 | 2.86 | na | Mangkoedihardjo *et al.*, 2007 |
| Nepal | 523.8 | 7.5 | 12 | 0.9 | na | Dangi *et al.*, 2011 |
| Thailand | 8778 | 12.09 | 10.88 | 4.68 | 6.9 | Udomsri *et al.*, 2011 |
| Malaysia | 3798.9 | 16.5 | 15.3 | 1.3 | 0.4 | Liamsanguan and Gheewala, 2008 |
| Iran | 420 | 8.7 | 9 | 0.4 | 0.4 | Moghadam *et al.*, 2009 |
| Bangladesh | 5340 | 10.7 | 4.3 | 2.2 | na | Alamgir *et al.*, 2005 |

n.a. not available

Besides Malaysia, Thailand also shows the high produce of solid waste coolection in a day; about 8778 tons per day (Udomsri, *et al.*, 2011). This waste generation include the paper, plastic, textile and wood or agricultural waste which all have a high of source of solid waste. Therefore, solid waste management is important to manage the solid waste where the abundance of this waste will lead to another problem will affect man and nature. The agricultural waste like agricultural plant has a high potential to be reused for others products that can benefit man.

Generation of waste especially agricultural waste to new products is also one of the management of waste where it is not just disposed in landfills but generated to be something new that can be used in our daily lives. There are many products that can be made from waste and transformed into new products like pineapple leaf textile, rice husk paper and many more (Sridach, 2010). Thus, reuse and creating new products are one of the solid waste management to conserve the use of wood and also reduce the disposal of high waste from everyone in the world.

## 2.4 Agricultural Waste

Agricultural waste defines the crop residues (animal excreta, plant residue, solid water and silage effluent) as no edible plant parts that are left in the field after harvest and remains that are generated from crop-packing plants or discarded during the crop process (EEA, 2006). The expansion of production by agriculture has naturally resulted in the increase of livestock waste, agricultural crop residues and agro-industrial by-products (Gregory, 1996).

The abundances of agricultural waste proportional of largest livestock farm will lead to a new problem which was environmental problem (Li *et al.,* 2013). Agriculture wastes was also one of the wastes that need to manage for disposed or manage by arising another method. Waste from a plant that were used in industries or daily lives might be decomposed with the soil but if it's in a large quantity, it takes time to decompose. On the other hand, the application of compost to soil from agriculture waste could raise environmental risks mainly related to excessive or unbalanced supply of nutrients, organic pollutants and present of heavy metal, and also the spreading of pathogens (EC, 2003). This environmental problem were led to the pollutant of the soil and the nutrients inside the land. However, biodegradable waste like vegetables and plant waste do not have a high contribution to this pollutant problem but huge abundances of quantity of this waste can also a slightly effect a little to the environment.

The rapid increase in the worlds population coupled by urban migration has resulted in the increase in the demand for food which has in turn lead to the production of large amounts of agricultural wastes, both for the farmer, municipality and city levels. The bulk of the agricultural food in developing countries is transported to cities in its raw form, thus compounding the net effect on large deposits of waste in urban markets, around homes and in slums as well as in various dumping grounds. (Sabiti, 2011).

Globally, about 998 million tonnes of agricultural waste is produced in a year and this waste needs to be disposed in a landfill without being used for other production except to vanish it (Agamuthu, 2003). Rejected agricultural materials will

be burned, dumped and disposed to reduce the amount of rejected materials (Gregory, 1996). That is because there are some parts of agriculture that will continue to become a product but the rejected were eliminated. Improper solid waste management will cause air, soil and water pollution. Indiscriminate dumping of wastes contaminates the surface and ground water supplies (Tyagi *et al.*, 2014). Figure 2.3 shows the developing countries have more agricultural losses and the production of waste from agricultural

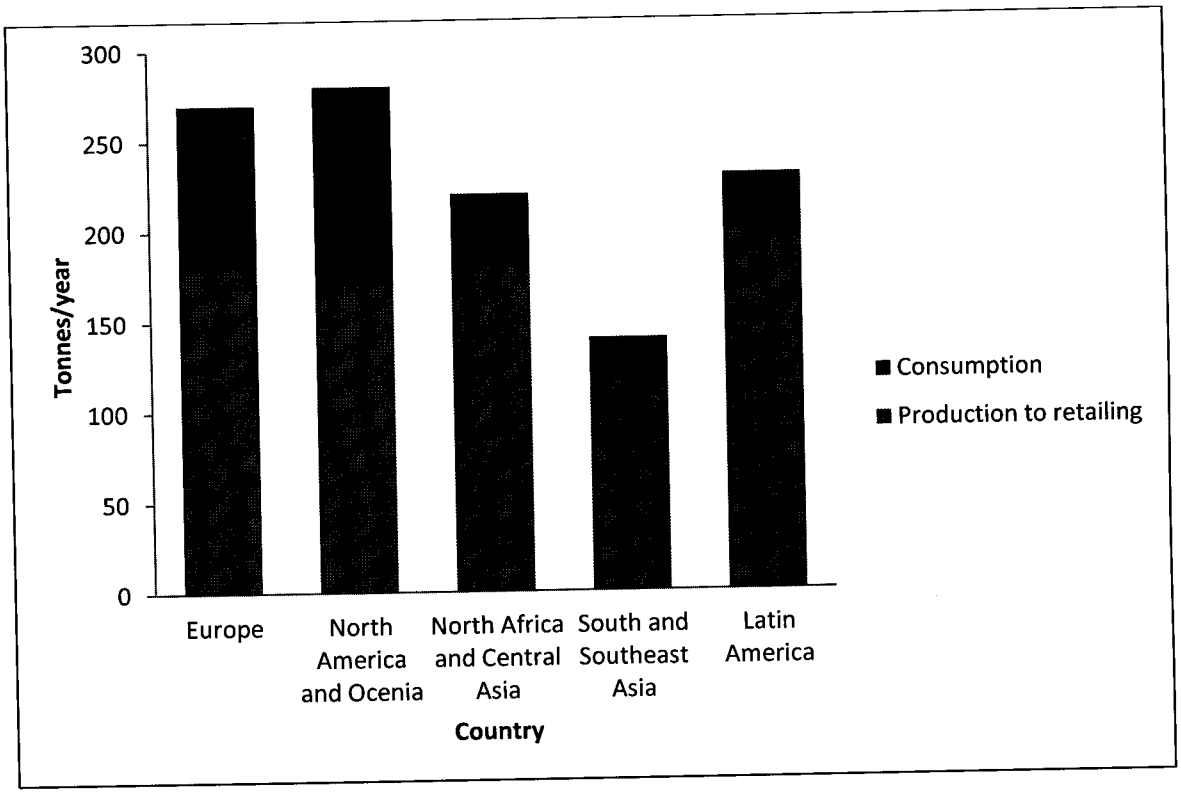



**Figure 2.4:** Per capita production and consumption agriculture waste in different region from 2008 to 2011 (Jenny *et al.*, 2011).

About 40% of Latin America country had come out with a huge production of waste compared to another region. It shows that agro industry have made an impact for an abundance of waste that yields from this agricultural residue. Beside agro waste industry, plantations on agricultural plant also contribute in the generation for abundance of agricultural waste. The plantation of agriculture plant like pineapple leaf or oil palm plant were lead to the waste that were not being used for agro

industry like leaf and trunk. Those part not have an interisting product that could be used. Those, with the opputunity on the branding a new product from those agriculture plant, this abundance part could be used in the maximum ways.

These abundances of waste produce from existing part that are not being used in this industry or plantation where it was called as crops or residue from agriculture plant (Pathak *et al.,* 2012). A high consumption from North America and Oceania country on agricultural waste rather than other region (Jenny *et al.,* 2011). Therefore, Southeast Asia countries like Malaysia also have a big production of agricultural waste. Malaysia country was rich with a source of forest and plant because of the coordinate in tropical region (Khalil *et al.,* 2006). Thus, it was not surprised that Malaysia is one of the Southeast Asian countries which can become one of the waste generation in agricultural residue. This abundance of waste will lead to a non profitable impact for the economy and it's become a disadvantage for the farming sector if not used in a completely beneficial ways (Jenny et. al, 2011).

At present, the disposal of these wastes is not the responsibility of most municipal and county solid waste management agencies. However, there were many issues in the area of the disposal of animal manure especially from feedlots and dairies (Tchobanoglous *et al.,* 1993). Animal source from agricultural waste is needed to be managed properly because of the pollution that will be produced from the waste. It has been estimated that about 10 to 25 percent of the agricultural organic waste from animal effluents, mostly from pig farms adjacent to rivers, dumps into our coastal waters (Agamuthu, 2003).

Environmental quality regulations have somewhat controlled the waste from the agriculture which is the most polluted industry. Not only for the animals, agricultural waste also include plants, biodegradable, and crops (Bundela *et al.,* 2011). This environmental regulation for agriculture waste under of Environmnetal Quality Act (1974), which were very useful for agriculture waste management (Ishak et al., 2010). Those, the management from the agriculture waste could be organise with complete and act with accordingly. This waste needes to be disposed approximately to avoid the affect from the abundance of waste becoming pollutant which can pollute the environment and damage the surrounding surface.

Figure 2.4 shows the agricultural residue from three types of agricultural plant that is rarely used for industrial purpose. Those high agricultural wastes are corn, coconut shell and carrot residue.

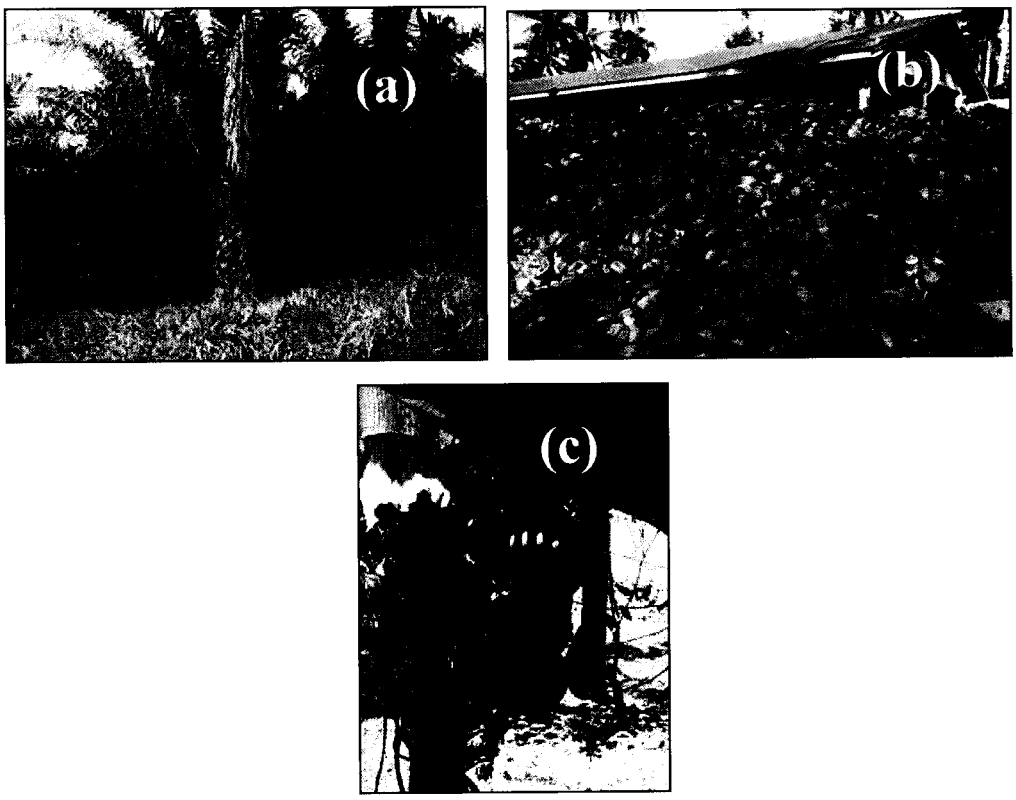



**Figure 2.5:** Agriculture plants waste (a) Oil palm stalk (b) Coconut shell (c) Banana (Khalil *et al.,* 2006).

Faridah (2001) conclude that organic plant wastes such as oil palm, coconut shell and banana were annually renewable, very abundances and limited value can be get from those three plants. It was because lack of priority and demand in industrial scrap, those agricultural waste residue would only be disposed and turned out to be waste that had no function to the economy. However, the Malaysian government especially had seen a very fair view of this problem and come out with a research to make this abundantly residue to become a new product that could make this as one of the financial support for the small entrepreneur especially. MARDI, FAMA and FRIM had seen the potential of this abundance residue; agriculture not useful to become product to become a great waste wealth in the future.

Table 2.3 shows estimation of annual production of agricultural waste among selected Asia countries. China lead the highest of agriculture waste of about 587 million tonnes per year which shows a high volume of production of waste in solid waste generation (Koopman and Koppejan, 1997). However, Malaysia also follows other developing country with having a 30 million tonnes per year of production of agriculture waste. This estimation of annual production by agro wastes shows how developing of plantation industries develop in this recent years. However, it is also related to the abundance of farm waste which can be developed as a pollutant in our environment (EC, 2003).

**Table 2.3**: Estimation of Annual production of Agricultural waste in selected residue Asia countries (Hsing et al., 2004; Gang, 2013).

| **Country** | **Agricultural waste, crop residue (Million tonnes)** |
|---|---|
| Japan | 170 |
| India | 320 |
| Indonesia | 140 |
| Malaysia | 122 |
| Thailand | 96 |

Faridah (2010) estimated a raise in total export earnings of the agricultural sector especially high production of agricultural waste like Malaysia. Thus, it will continue to be a strong segment of the Malaysian economy. Malaysia is a rich land of agricultural farm, which is why many researchers have studied from the use of waste from this agricultural product, can be recycled and be used for another good product. There are many sources of agricultural waste that might be generated to the abundances of this waste. These wastes must have a large farmed land and planted in a quite large area. Many industries are involved in this Agro-industry because of the high impact on the economy and it will generate abundances of waste from this industrial scrap

China is one of the Asian countries that has the largest farm land and largest stockholder for agro by-product. Each year, China produces about 4.6 million tonnes of paddy husk, 35 million tonnes of rice straw, 7 million tonnes of bagasse and more than 25 million tonnes of animal waste (Gang, 2013).

In addition to this, other countries such as Australia, Cambodia, Japan, Lao People's Democratic Republic, Nepal, New Zealand, Republic of Korea, Viet Nam and Small Island States in the South Pacific also generate huge quantities of agricultural waste and residues (Koopman and Koppejan, 1997). All these countries generate agricultural product for their economy. It is because this agricultural product can be commercialized to another country and the managements or processes are very easy. The lower financial commitment encourages the entrepreneur like to endorse it in the farming industry.

From Figure 2.5, there are five types of agriculture in Malaysia that have a higher number of quantities that is produced from waste of very plant. As statistical of world, Malaysia is one of the tropical forests that is rich with their mother nature of plant and animal. In 2009, Malaysia government has narrow their scope of making Malaysia as a farming country and leads Asian countries in the export and import farming materials.

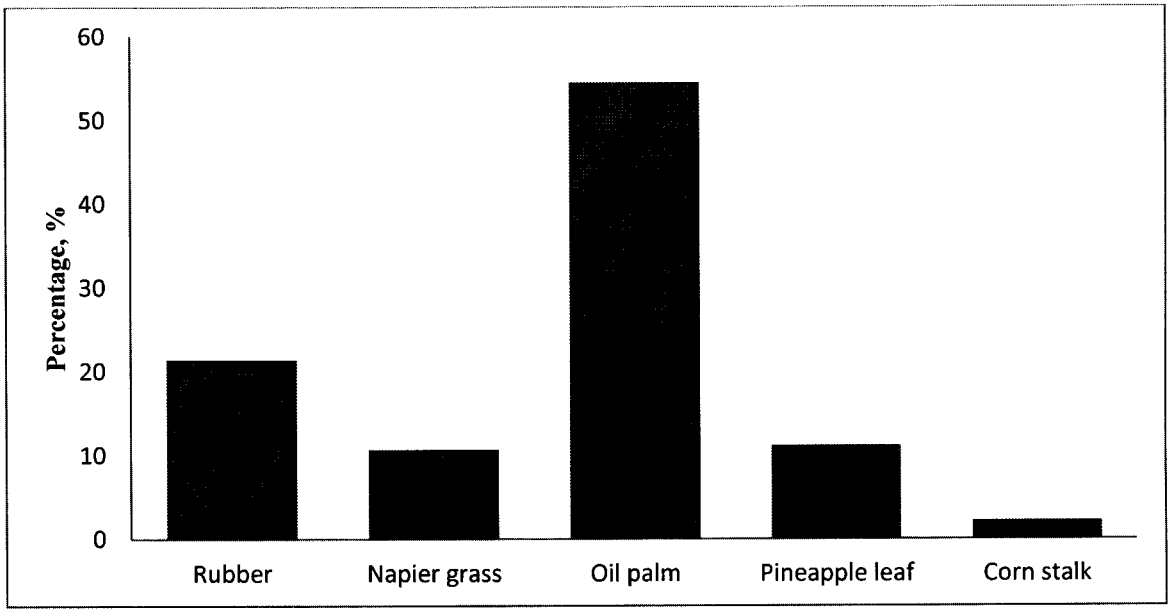



**Figure 2.6:** Annual Production of Agricultural Waste In Malaysia in 2010 (Khalil *et al.*, 2010).

Oil palm wastes make for greater production rather than other agricultural plant. About 16.77 million tonnes per year had been produced by the oil palm waste and this is a quite large number of waste (Khalil *et al.,* 2010). There are many institutions that had carried out done a research to make this waste more useable for our daily live sand for industrial purpose. Malaysia has a greater production of oil palm. Many countries had import our oil palm which has a high quality of oil derived from this plant.

Thus, the residue from this plant must be used for any form of product because the residues have a greater aspect of composition to make new products like paper. Beside oil palm, rubbers had high quantity agricultural waste production. Rubber industry has involved about six million people in rubber plantation (TRA, 2009). This high involvment of people makes the increasing of demanding of rubber industry in the world. Thus, informally the waste from this agricultural plant was increased too. Rubber is only used from their mills but the tree was not being used, so paper mill productions have created opportunities to make pulp and paper production (Jawjit *et al.,* 2010). The consequences of tree lost can be save with this pulp and paper making industry by agriculture waste materials.

Generally, pineapple leaf, corn stalk and napier grass had become one of the finest agricultural wastes, where about 45% of our country in the farming sector depends on it. It shows how many trees were being cut to make a product from it and it also leads the increasing of the waste from wood. Wood had produced waste of about 6.58 million of tonnes and it is a large scale for waste where management is required to fully prepare for disposal it (Roda and Rathi, 2006). Thus, recycling method or reuse of waste are needed to make sure all this source will not be able loss which have a benefit to economy country in industry.

In Sri Lanka, agricultural waste comprises animal waste, paddy husk, straw, coir fibre and coir dust, bagasse, as well as the waste from the timber industry, which comprises sawdust, off-cuts and charcoal. Commercial rice milling generates around 2 million tonnes of paddy husk per annum; whilst coir (the fibres from coconut husks) processing generates an annual 700 000 tonnes of coir dust (ESCAP, 1997). Beside Sri Lanka, Phillipines also has overcome of the abundances of pineapple leaf

in their country to make a quality product from it (Sridach, 2010a). The textile industry has seen a brighter future from this waste where it can be used for clothing.

However the percentage of this plant is not quite great because of lack of machine and specialists in this textile method from this pineapple leaf waste (Khiari *et al.*, 2011). In Malaysia, about 56.22 million tonnes of different crop residues are generated of which 12.46 million tonnes originate from cotton, 2.90 million tonnes of maize, 12.87 million tonnes of sugarcane, 8.16 million tonnes from rice and 19.83 million tonnes from wheat (ESCAP, 2007). That is why Malaysia should be fully committed in the reuse of this source to make new products that will give benefit to us. Table 2.4 shows a group of ariculture waste with their utilization.

**Table 2.4:** Agro waste utilization from different agriculture waste.

| Agro waste | Utilization | References |
|---|---|---|
| Ash and Charcoal | • Additive in cement mixes<br>• Water glass manufacture<br>• Active carbon | Paul and Rolf, 1993 |
| Rice Husk | • Electricity production | Islam and Modal, 2013 |
| Banana Peel and Sugarcane fibers | • Paper making pulp | Sun *et al.*, 2011;<br>Hemmasi *et al.*, 2011; Mohapatra *et al.*, 2010; |
| Oil Palm Empty Fruit Bunch<br>(EFB) | • Mulching, Organic Fertilizer | Ghehsareh,2013; Khalil *et al.*, 2010 |
| Oil Palm stems, Rubber wood | • Particleboards<br>• Softwood furniture | Kala *et al.*, 2012; Jawjit *et al.*, 2010 |
| Onion skin, Groundnut husk | • Heavy metal removal | Paul and Rolf, 1993 |
| Husk, Bagasse | • Mushroom cultivation | Frimpong-Manso *et al.*, 2011 |

| | | |
|---|---|---|
| Bagasse, Banana Fruit Reject | • Ethanol production<br>• Animal feed | Sun *et al.*, 2011;<br><br>Mohapatra *et al.*, 2010 |
| Husk, Straw, Cow Dung | • Biogas production<br>• Electricity generation | Bakar *et al.*, 2012; Gamage *et al.*, 2010. |
| Sunflower stalk, and<br><br>Bagasse Fibers | • Reinforcement for thermoplastics | Ashori *et al.*, 2014; Kaymakci *et al.*, 2013; |

Agro waste product had become one of the industrial scopes for their substitution for the main products. Table 2.4 shows the waste from agricultural that had been designed in making a new production from their basis. All of these agricultural wastes become an alternative production for their own sector. The accumulation of waste had enormous ill effects on humans and the environment, such wastes, if properly managed could be considered an important bio resource for enhancing food security in the smallholder farming communities that would not afford the use of expensive inorganic fertilizers. These organic wastes contain high levels of Nitrogen, Phosphorus, Potassium and organic matter like protein important for improving nutrient status of soils in urban agriculture (Sability, 2011).

There are certain agricultural wastes that has become an additive composition which makes a product become more quality rather than before. From those table, rice husk ash, charcoal, sunflower stalk, corn stalk and bagasse fibers becoming an additive for certain products like additive in cement mixture and thermoplastic reinforcements (Ashori *et al.*, 2014; Islam and Modal, 2013; Kaymakci *et al.*, 2013; Paul and Rolf, 1993). From those previous researches, these products are important in help in our daily work and lives like production of plastic or building.

However, Oil Palm stems, Rubber wood, Bagasse, Banana Fruit Reject, Banana Peel and Sugarcane fibers, Husk, Straw, and Cow Dung had been designed to make new product especially in the world of industry. These products that have been produced are like pulp for paper making, soft board, ethanol chemical production and also biogas production (Ghehsareh, 2013; Kala *et al.*, 2012; Bakar *et al.*, 2012; Khalil *et al.*, 2010; Jawjit *et al.*, 2010; Gamage *et al.*, 2010). Many

industries have used this waste to make their specific product and many demands from other make this industry develops with fast.

Agricultural waste can also be designed for biological process and treatment where this scope is popular among the industrial countries. Onion skin, Groundnut husk, Husk and Bagasse designed to be a heavy metal removal and mushroom cultivate (Frimpong-Manso *et al.,* 2011; Paul and Rolf, 1993). This biological process is highly designed and lower financially where there are many industries which really loves to include and create opportunities for their industries. So, this waste had a high demand and the problem of abundance of waste would not occur again.

The agricultural waste problem amplify the various factors especially in developing countries due to limited waste recycling (Jenny *et al.,* 2011). The impact of the environmental from this agricultural waste depends on the amount generated but also on the method of disposal like some of the agricultural waste burning in the some large places where it leads to the atmospheric pollution (Sability, 2011). Besides burning method, there are other methods of disposal practices which pollute the environment which are dump and recycle method(Tumuhairwe *et al.,* 2009; Sability *et al.,* 2004).

Water pollution could also occured when the abundance from this agricultural do nott manage to properly (Sibility, 2011). Excessive animal wastes on land as fertilizer and soil conditioner were subject to surface runoff and leaching that may contaminate ground or surface waters. For that reason, nitrate leaching was considered a major nitrogen (N) pollution concern on livestock farms (Tumuhairwe *et al.,* 2009; Mackie *et al.,* 1998) According to Mackie *et al.,* (1998) besides generating revenue from the energy produced waste-to-energy schemes offer an alternative and environmentally acceptable means of waste disposal.

## 2.5 Paper

Paper is a material that has a thin thickness mainly used for writing, printing, and drawing or for packaging. The paper had been produced by the most of fibers, or can

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