ASSESSMENT ON THE POTENTIAL OF PLASTICS BIODEGRADATION BY IMMATURE BLACK SOLDIER FLY LARVAE *Hermetia illucens*, (DIPTERA: STRATIOMYIDAE)

by

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A report submitted in fulfillment of the requirements for the degree of Bachelor of Applied Science (Natural Resources Science) with Honours

FACULTY OF EARTH SCIENCE

UNIVERSITI MALAYSIA KELANTAN

2024

DECLARATION

I declare that this thesis entitled "Assessment On The Potential Of Plastics Biodegradation By Immature Black Soldier Fly (*Hermetia illucens* (Diptera: Stratiomyidae))'' is the result of my own research except as cited in the references. The thesis not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date: 15 AUGUST 2024

ACKNOWLEDGEMENT

I would like to express my heartfelt thanks to all who helped me whether it is a coincidence or not until my thesis is successfully completed. I would like to thank Allah s.w.t for making me complete my thesis smoothly without any distractions.

Firstly, I am so thankful to my beloved supervisor Dr Norashikin Fauzi because of her guidance and advice, I finally accomplished my research thesis. Even though I was new to studying like this, she was very kind to give me lots of tips and advice. She taught me how to complete this thesis successfully.

Not to forget, I am so grateful to my family. The moral support they gave me, drove me until the end of my study. Other than moral support, they also supported me financially to complete my thesis.

Assessment on The Potential of Plastic Biodegradation by Immature Black Soldier Fly Larvae *Hermatia Illucens*, (Diptera: Stratiomyidae)

ABSTRACT

Immature black soldier fly (*Hermatia illucens*) is an important indicator in carrying out this study. This study was conducted to see the extent to which the black soldier fly (BSF) larvae interacted with some selected types of plastic. There are five types of plastic used, including Polyethylene Terephthalate (PET), Polyvinyl Chloride (PVC), Polypropylene (PP), Polystyrene (PS), Polyethylene Terephthalate (PET), and Polyethylene (PE). During that period, it was noted that the percentage of each plastic was recorded. The distribution of plastic consumption by BSF larvae was as follows: Polystyrene (PS) exhibited the highest level of consumption, with 22% of this plastic type having been consumed, with larvae. Polyethylene Terephthalate (PET) was the next most consumed, with larvae having ingested 21% of this plastic. Polyethylene (PE) followed, with 20% of this plastic type consumed. Polyvinyl Chloride (PVC) saw a lower consumption rate, with 19% of this plastic being eaten. The least consumed plastic among those tested was Polypropylene (PP), with only 18% having been ingested by the BSF larvae.

Penilaian terhadap Potensi Biodegradasi Plastik oleh Lalat Askar Hitam Larva Tidak Matang *Hermatia Illucens*, (Diptera: Stratiomyidae)

ABSTRAK

Lalat askar hitam yang belum matang (*Hermatia Illucens*) merupakan petunjuk penting dalam melaksanakan kajian ini. Kajian ini dijalankan untuk melihat sejauh mana lalat askar hitam (BSF) berinteraksi dengan beberapa jenis plastik terpilih. Terdapat lima jenis plastik yang digunakan, termasuk Polyethylene Terephthalate (PET), Polyvinyl Chloride (PVC), Polypropylene (PP), Polystyrene (PS), Polyethylene Terephthalate (PET), dan Polyethylene (PE). Dalam tempoh tersebut, diperhatikan bahawa peratusan setiap plastik telah direkodkan. Taburan penggunaan plastik oleh larva BSF adalah seperti berikut: Polisterina (PS) menunjukkan tahap penggunaan tertinggi, dengan 22% daripada jenis plastik ini telah digunakan, dengan larva. Polyethylene Terephthalate (PET) adalah yang paling banyak digunakan, dengan larva telah menelan 21% daripada plastik ini. Polietilena (PE) diikuti, dengan 20% daripada jenis plastik ini digunakan. Polivinil Klorida (PVC) menyaksikan kadar penggunaan yang lebih rendah, dengan 19% daripada plastik ini dimakan. Plastik yang paling kurang digunakan antara yang diuji ialah Polipropilena (PP), dengan hanya 18% telah ditelan oleh larva BSF.

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LIST OF ABBREVIATIONS

UMK	Universiti Malaysia Kelantan
g	gram
BSF	Black Soldier Fly
PP	Polypropylene
PET	Polyethylene Terephthalate
PVC	Polyvinyl Chloride
PS	Polystyrene
PE	Polyethylene
HDPE	High-density Polyethylene
LDPE	Low Density Polyethylene

LIST OF SYMBOLS

%	Percentage
°C	Celsius
mm	Millimeter
g	gram
x	Multiply

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The first reports of tiny plastic fragments found in the open ocean date back to the 1970s. Nevertheless, the phrase "microplastics" was not first used until 2004 in a publication that discussed the gradual build-up of particles with a diameter of only a few microns. Microplastics were mainly disregarded in the monitoring of plastic pollution until recently. Since information about the effects and ramifications of this kind of debris has been gathering over the past ten years, there has been a growing interest in this area of study. When describing the size of plastic contamination, three categories are commonly used: macroplastic (diameter >20 mm), mesoplastic (diameter 5- 20 mm), and microplastic (diameter <5 mm).

Plastic composed of synthetic or semi synthetic organic polymers. These polymers had a unique molecular structure that resembles longed chains since they were made up of repeated molecular structural units. Hydrocarbons, which make up the structural components, are usually obtained from feed stocks like gas or fossil oil. Numerous polymers exist, including polyethylene, polyvinyl chloride, polystyrene, and polypropylene. To improve their functionality and appearance, a broad range of additives (including fillers, plasticizers, flame retardants, thermal stabilizers, antibacterial agents, and colorings) can also be added.

The gut microbiota of Black Soldier Fly (BSF), *Hermetia illucens* (Diptera: Stratiomyidae), is greatly influenced by the composition of the rearing substrate. The Black Soldier Fly may develop on a wide range of organic substrates, including wastes and side streams. The intimate connection between diet and gut microbiota—which, among other things, supports host fitness by providing vital nutrients and aiding in food digestion—raises the exciting possibility of precisely sculpting the microbiota through dietary manipulation to target particular biological processes. The idea of using this insect for degrading and/or bio converting plastic waste is encouraged by the selection of particular plastic-degrading Black Soldier Fly, even if their remarkable eating flexibility and high bioconversion capacity are garnering more and more attention. The current study set out to find out if the Black Soldier Fly might provide functions that break down plastic. When plastics are consumed, the gut microbiota of the affected species and strains is drastically altered, and the microbiome becomes more abundant in functions that break down plastic.

1.2 Problem Statement

From the New Straits Times newspaper, Malaysia is among the top 10 nations that dump the most garbage and plastic debris into the ocean. The remaining nations in the top 10 are from South America and Africa, with the exception of the Philippines and Malaysia, which are all located in Southeast Asia. Based on available data, each Malaysian disposes approximately 2.29 kilogram of plastic waste into the ocean each year. According to a study summary, it is concerning when plastic waste and other trash are dumped into the ocean because they endanger marine life.

Plastics could not be totally eliminated from the environment by merely allowing them to decompose in landfills, unlike paper and food wasted, a place that biodegrades. This was one of the fundamental problems with disposal of polymers in the management of solid wasted cycled. The breakdown of plastics into smaller particles, or microplastics (i.e., plastics smaller than 5 mm in length), takes hundreds to thousands of years. As a result, plastic waste will build up on Earth, reducing the amount of landfill space available while also adding to an essentially irreversible environmental damage.

To address various waste management issues in Malaysia, the Malaysian government has launched a number of projects. Cutting returned to single-used plastics was one of the topics covered in more detail in the sections that followed. The No Plastic Bag Day (NPBD) campaign, launched in 2011 by the Ministry of Domestic Trade Cooperatives and Consumerism (MDTCC), led to a statewide ban on the giving out of free plastic bags at grocery stores. The goal of NPBD's introduction was to decrease Malaysia's usage of single-use plastics and increase public awareness of them. In an effort to alter customer behavior, a 0.20 MYR fee was also introduced for each plastic bag used in supermarkets and grocery stores throughout this campaign. Research has indicated wildly disparate degrees of support for the campaign: 66% of people in Selangor are eager to engage, compared to just 35% in Kuala Lumpur. According to Asmuni et al., 2015 higher income locations like Kuala Lumpur could require the application of a larger charge.

1.3 Objectives

The objectives of this study are:

i. To assess the potential of plastics biodegradation among the insects

ii. To compare the plastics preferences and biodegradation rates by the selected insects.

1.4 Scope of Study

This study focuses on the plastic in black soldier fly (BSF). This investigation was located in the Laboratory Faculty of Earth Science. The black soldier fly (BSF) is typically found near decomposing organic materials, such as plant debris or animal manure, and is frequently connected to the outdoors and cattle.

The scope of this study strictly follows the proposed main objectives for this study, to know the potential of plastic biodegradation among the black soldier fly (BSF) and focus to compare what plastics that are preferences black soldier fly (BSF) to biodegradation rates.

1.5 Significance of Study

These investigations provided preliminary baseline data of the assessment potential biodegradation by immature black soldier fly. Plastics have been discovered everywhere on Earth. The wind disperses these little particles, depositing them in raindrops. In this manner, they find themselves in seemingly immaculate places. Plastic concentrations rise because they degrade very slowly. The likelihood of insects coming into contact with plastics is rising. In fact, even the smallest species of insects are unable to resist it.

Black soldier fly are a useful chemical source for creating plastic that the same kind of insects may break down naturally. The black soldier fly gather their component plastics after using the waste plastic as their food source. Thus, the researchers might use the discarded plastics as references in addition to using the black soldier fly as the source for this assessment.

Through this studied, it could have been seen that black soldier fly (BSF) larvae was one that could used as examples of decomposers that can destroyed or had the potential for biodegradable plastics. It was also important to knew which ratio of plastics was among plastics that was easy for black soldier fly (BSF) to decomposing.

CHAPTER 2

LITERATURE REVIEW

2.1 Plastics

"Pliable and easily shaped" was the original meaning of the word "plastic." It was only recently used as the name for a class of materials known as polymers. Since polymers are composed of lengthy chains of molecules, the word polymer signifies of many parts. Nature is filled with polymers. One of the most prevalent natural polymers was cellulose, which is found in planted cell walls.

Long chain molecules of polymers made up the majority of synthetic or semisynthetic organic compounds with high molecular mass that were used as plastics. The standard components of plastics included an organic main chain link, side-connected molecular groups, and other natural and synthetic compounds provided as fillers, plasticizers, and other additives. Elements including carbon, hydrogen, nitrogen, oxygen, chlorine, and bromine are found in plastics. Because they are inexpensive, lightweight, and pliable, plastics are durable despite being inert and resistant to breakdown. Because they could have molded into a variety of sizes and formed, they had a wide range of applications. Every year, plastics are used more and more in every facet of life and technology.

Due to its properties, plastic was a substance that we encountered on a regular basis. Plastic was only ever used once in some applications, like plastic bottles. Furthermore, PET (polyethylene terephthalate) bottles were the most widely used kind of plastic bottles. Over time, the amount of plastic garbage would rise due to the ongoing usage of plastic. Plastics took decades or more to break down; some varieties may require hundreds of years. Pollution would result from the ongoing accumulation of plastic garbage if appropriate processing was not done to balance it out. Since pollution may have an impact on many facets of life, it would have been extremely harmful. In addition, it had the potential to pollute water, soil, and other living things.

Recycling was a practical method of turning plastic trash into something somewhat functional. Because of their intricate qualities, plastic blends were among the materials that were challenged to recycle (Wang, 2015). Up until then, sorting had been done using at least two methods: the human approach and the automatic sorting method. The types of resin that formed the wasted plastic determines how to sort it. It was necessary because pure resin from each type of plastic must be obtained for the sorting procedure.

2.2 Types of plastics

Based on figure 2.1 below show that different types of plastics identified by number are seven such as polyethylene terephthalate, also known as (PET), polyvinyl chloride (PVC), polypropylene (PP), polystyrene (PS), and polyethylene (PE). In addition, code seven, "other," designates a different kind of resin that used to denote plastic in addition to the previous six. Mixed plastic resins could have detrimental effects on the environment. For example, mixed PVC with PET might result in the production of HCl gas. Plastic garbage categorized according to the substance that made up the resin. Nevertheless, the manual approach has become less and less common these days as automated technologies become more common and easier to use.

Figure 2.1: Types of Plastic

2.2.1 Polyethylene terephthalate (PET)

Due to its excellent mechanical performance, thermal stability, nontoxicity, low processing energy requirements, and chemical resistance for a variety of applications, polyethylene terephthalate, also known as PETE or PET, was one of the most widely used semi-crystalline thermoplastic polyesters in both industrial and everyday applications.

Third placed in the world plastics market went to PET. PET is used worldwide to make a wide range of goods, including bottles, yarn, film, and fiber. Being the most ecologically benign form of synthetic polymer, PET manufacturing has grown rapidly, which is mostly due to this factor. As watered is the only byproduct of the manufacturing process. The industrial process's primary phases are completed in a vacuum. As a result, the environment is nearly completely free of emissions.

2.2.2 Polyvinyl Chloride (PVC)

Transparent and frequently amorphous, polyvinyl chloride (PVC) was a thermoplastic. One of the most extensively used commercial polymers worldwide, PVC is used in the built, electricity, automotive, healthcare, and packaging sectors due to its affordability, exceptional mechanical properties (strength and impact strength), resistance to chemicals, and longevity. Given its considerable melted viscosity, PVC may have used the majority of melted processing methods, including extrusion, via injection, and blow molding. Nevertheless, PVC had several drawbacks, included as notable thermal degradation (yellowing) around its processing temperature of 170 ◦C, which may had extended to greater extents with the utilization of thermal stabilizers.

2.2.3 Polypropylene (PP)

A cheap thermoplastic polymer with remarkable qualities like dimensional solidity, fired resistance, simplicity, and a high heat distortion temperature called polypropylene (PP). 16 percent of the global plastics market was made up of polypropylene (PP), a plastic that is extensively employed to create final goods for consumers, such as plastic packaging. Because of their mechanical and thermal qualities, as well as the potential to create novel products that could have manufactured used PP, a number of PP combinations with natural and synthetic fibers became more and more significant. Chemically speaking, PP is a downstream petrochemical product made from propylene, an "olefin monomer." Furthermore, because of its excellent mechanical strength, chemical resistance, thermal stability, and affordability, polypropylene (PP) is one of the most often used polymers in the creation of microporous membranes.

2.2.4 Polystyrene (PS)

Styrene monomers from liquid petrochemicals are used to make polystyrene (PS). It was made up of a lengthy hydrocarbon chain that connected to alternating carbon atoms by phenyl groups. Because polystyrene might have been difficult to separate and clean. Polystyrene wasted was mostly dumped in landfills instead of being recycled. This endangered the ecosystem and hurt humans, animals, and marine life. Pyrolysis became essential as a result for turning polystyrene into usable products. Plastic cooked to extremely extreme levels (in the range of 300 and 900 °C) within an oxygen free atmosphere during the pyrolysis process. This caused the lengthy polymeric chains to break down into low-molecular-weight liquid and gaseous molecules that were useful.

Polystyrene (PS), a durable and inexpensive plastic, was one of the most significant and often used materials. Although transparent, colorants could have been added to change its color. This polymer was suitable for many applications since it is heated resistant, lightweight, and had high strength and durability. A variety of products, such as toys, packaging, and home appliances and computer housing, were among the used. PS went in two forms: expanded and solid, and they might Have Been recycled in both. Nevertheless, during recycling, leftover expanded polystyrene foam lost its foam properties. Regassing recovered polystyrene is feasible, although the result is more expensive than with virgin material. For this reason, it is used in molding procedures in its solid state.

2.2.5 High-density polyethylene (HDPE)

Out of the three polyethylene's, high-density polyethylene, or HDPE, was the most widely used petroleum thermoplastic in a variety of applications. High-density polyethylene was an incredibly resilient material that was used, among other things, to make playground equipment, shampoo bottles, Milked jugs, recycling containers, and agricultural pipes. It is far stronger and thicker than PET because it is composed of long, unbranched polymer chains. In addition, it could withstand heat of as high as 120 °C without losing its strength or resilience to impact. Being one of the most easily recycled plastic polymers, HDPE is accepted for disposal at the majority of recycling facilities worldwide.

2.2.6 Low Density Polyethylene (LDPE)

Low Density Polyethylene (LDPE) was a type of thermoplastic polymer that was 100% recyclable, odorless, transparent, and flexible. It is widely used in items liked juice containers, cling wrapped, and shopping and trash bags. Due to its toughness, flexibility, and resistance to corrosion, together with its low cost and high efficiency of manufacturing, LDPE is preferred for engineering applications, which drove annual manufacturing of millions of tons of the material.

On plastic items, LDPE is denoted by the numbered "4" inside an arrow triangle. A thermoplastic polymer that is 100% recyclable, odorless, transparent, and flexible is called LDPE. It is frequently found in goods like cling wrap, juice containers, and grocery/garbage bags. The distinctive qualities of LDPE within the polyethylene material family could be attributed to its strongly branched, tree-branch-like bonding structure. Due to its reduced crystallinity, this branch gave LDPE its distinctive flexibility and ductility, setting it apart from more linear polyethylene variants including high density polyethylene (HDPE) and linear low-density polyethylene (LLDPE).

2.2.7 Other Types of Plastic

Plastic would have placed in the category of 7 if it could not be classified into any of the six categories listed above. Polycarbonates (PC) were the most well-known plastics in this category; they were used to make durable, robust items. Polycarbonates are frequently utilized to create lenses for safety, sports, and sunglasses that protect the eyes. However, smartphones and, more commonly, compact discs (CD) also included them.

2.3 Plastic properties

According to Ilyas et al. (2018) and Pan et al. (2020), among their many advantageous qualities was their low weight, resilience, high durability, and good stiffness, adaptability in construction, design potential, good insulation, low electrical and thermal conductivity, and resistance to corrosion. Polyethylene terephthalate (PET) and polybutylene terephthalate (PBT) were two examples of synthetic semi-aromatic polymers with outstanding physio-chemical qualities. These included intense heated distortion temperatures to the point of strong mechanical strengths, exceptional chemical resistance, and insulation of electricity. Their capacity to retain strength and form at high temperatures demonstrated by characteristics such high melted and glass transition temperatures (Tm and Tg, respectively) (Wu et al., 2015). Elasticity, processing capabilities, and inexpensive cost of production all contribute to plastic's emergence as a vital component of daily life.

As a result, those qualities made polymers more useful, particularly after nylon developed during World War II (Kedzierski et al., 2020). According to Oehlmann et al. (2009) and Pan et al. (2020), plastics offered a wide range of applications in the fields of the agricultural sector, built, transported goods, heated insulation, stored, manufacturing, electronics, furniture, toys and leisure products, vehicles, and medicine. Nowadays, plastics used in the production of 85% of medical products, included sterile packaging, intravenous bags, disposable syringes, and joint replacements, because of their biocompatibility and lightweight nature (Ilyas et al., 2018).

2.4 The Effect of plastic to Environment and living biota

Plastics ingested by marine biota physically entangle and harm fish stocks, hence reducing their productivity and efficiency in commercial fisheries and aquaculture. This had repercussions for fish stocks across the food chain, both directly and indirectly. Fish, which made up almost 20% of the weight of the diets of 1.4 billion people worldwide (19% of the total population), was the primary source of animal protein.

When feeding, animals were frequently exposed to plastic debris in the water or on the ground, which could occasionally cause the animals to perish. In comparison to terrestrial streams, plastic trash in aquatic environments was hydrophilic and had a high charge. The presence of microorganisms may cause the polymers to break down into plastic. Due to their adherence and aggregation, bacteria may grow into microcolonies on plastic garbage and injure aquatic life. Particles may enter the digestive tract by tainted food or mucociliary clearance after inhalation. Once within the body, they may alter the composition and metabolism of gut microbes, induce an inflammatory response, and increase permeability. It is believed that skin contact with microplastics presented a less dangerous exposure pathway. Microplastics were formerly thought to be harmless particles, but depending on an organism's susceptibility and exposure, they might have been harmful.

Plastics and microplastic items derived mainly from crude oil derivatives have increased in the last six decades partially because of continual scientific improvement, relatively low cost of production, and “incomparable” usage attributes. After its useful life, most plastic waste—regardless of how it was made—was burned, landfilled, discarded, or recycled, all of which eventually released carbon or methane emissions. Because of this, it was not shocking that scientists had projected that fish would become scarce by 2050 due to plastic pollution in the oceans. This prediction is based on the fact that over 100,000 aquatic animals were thought to have died each year from the estimated thirteen million tons of plastic bags that ended up along the shoreline.

Methane and ethylene, two harmful greenhouse gasses, are released when plastics weather on the ocean's surface. The accessible source of plastic garbage impacted by the population's rapid growth, and this could ultimately lead to environmental contamination as seen by the depletion of the environment's resources, the death of aquatic life, and sewage system blockages. Plastic waste interfered with the humus and reduced the effectiveness of organic phosphate and nitrogen. Furthermore, the pores in the cell walls of planted roots were blocked by plastic debris in the soil. As a result, the absorption of water and nutrients was reduced. Plastics' semi-permanent stability in aquatic environments raised the possibility of marine contamination, which could have an impact on aquatic life.

2.5 Previous Studies

Year	Author	Previous Studies
2020	Shashi Bahl, Jigmat Dolma, Jashan Jyot Singh, Shankar Sehgal	Biodegradation of Plastic: A State of the Art Review
2020	Yani, D Rosiliani, B Khona'ah and F A Almahdini	Identification and Plastic Type and Classification of PET, HDPE, and PP Using RGB Method
2021	Mikail Olam, and Huseyin Karaca	Optimization of Process Parameters at Direct Liquefaction of Waste PETs
2017	Yu-Shiang Wang and Matan Shelomi	Review of black soldier fly (*Hermetia illucens*) as animal feed and human food
2020	Tabish Wani, Syed Afsar Quadri Pasha, Sanskar Poddar, Balaji H V	A Review on The Use of High Density Polyethylene (HDPE) in Concrete Mixture
2021	Hasdianty Abdullah, Nurul Shafiqah Othman, Nor Suhaila Yaacob, Mohd Fadzli Ahmad, Marini Ibrahim, Maegala Nallapan Maniyam, and Hazeeq Hazwan Azman	Low-density Polyethylene (LDPE) Degradation by Malaysian Rhodococcus spp. Using Weight Reduction Test

2022	Davood Rahmatabadi, Kianoosh Soltanmohammadi, Mohammad Aberoumand, Elyas Soleyman, Ismail Ghasemi, Majid Baniassadi, Karen Abrinia, Mahdi Bodaghi, Mostafa Baghani	Development of Pure Poly Vinyl Chloride (PVC) with Excellent 3D Printability and Macro- and Micro-Structural Properties
2021	Ibrahim M. Maafa	Pyrolysis of Polystyrene Waste: A Review
2021	Rakesh Kumar, Anurag Verma, Arkajyoti Shome, Rama Sinha, Srishti Sinha, Prakash Kumar Jha, Ritesh Kumar, Pawan Kumar, Shubham, Shreyas Das, Prabhakar Sharma, and P.V. Vara Prasad	Impacts of Plastic Pollution on Ecosystem Services, Sustainable Development Goals, and Need to Focus on Circular Economy and Policy Interventions
2021	Ilker S. Bayer	Characterization of Low-Density Polyethylene and LDPE-Based/ Ethylene-Vinyl Acetate with Medium Content of Vinyl Acetate

2.6 Black Soldier Fly

Hermetia illucens, the black soldier fly, belongs to the family Stratiomyidae and is a true fly (Diptera). Although it originated in the Americas, it is now found throughout the world in tropical and temperate zones. It cannot invade non-native regions like Northern Europe because it is not cold hardy. The mature flies' color—black with metallic reflections—is the source of the name. The holometabolous stage of life of the black soldier flew insects consisted of four stages. The life cycle of the Black Soldier Fly was 40–45 days, depending upon the substrate that used to raise it. Adults simply drank water, stayed away from people, refrain from being attacked or stung, and did not spread any specific illnesses. When it came to the range of substances they could digest and the effectiveness with which they did it, they might have been the most productive fly species.

Black soldier flies are essential for alternative protein sources. Both people and animals can benefit greatly from them as a source of animal protein. They have up to 50% high-quality protein when dried. Animal feed is next. Animals adore them, hens in particular. Larvae of the black soldier fly offer both sustenance and a lively, natural activity. Insect foraging has a beneficial effect on hen welfare. And lastly, composting and waste management. Because they can consume nearly any organic waste, they are ideal for handling food scraps and agricultural waste. In order to handle food waste from their homes, many homeowners are also drawing BSF to their compost containers. Additionally, the fragrance of a compost bin containing BSF larvae will be superior to that of a bin home to houseflies.

About four days pass after the female lays between 200 and 600 eggs before the eggs hatch. The larvae begin as little as 1 mm in length, but their ravenous eating will cause them to grow to a maximum size of 25 mm very quickly. For around 10 to

28 days, the larvae will grow, depending on the nourishment supplied. After that, they will develop into pupae and become adult flies. It is evident that the black soldier fly has a brief life cycle. It takes longer for many of the popular species in the insect farming industry to reach adulthood, such crickets.

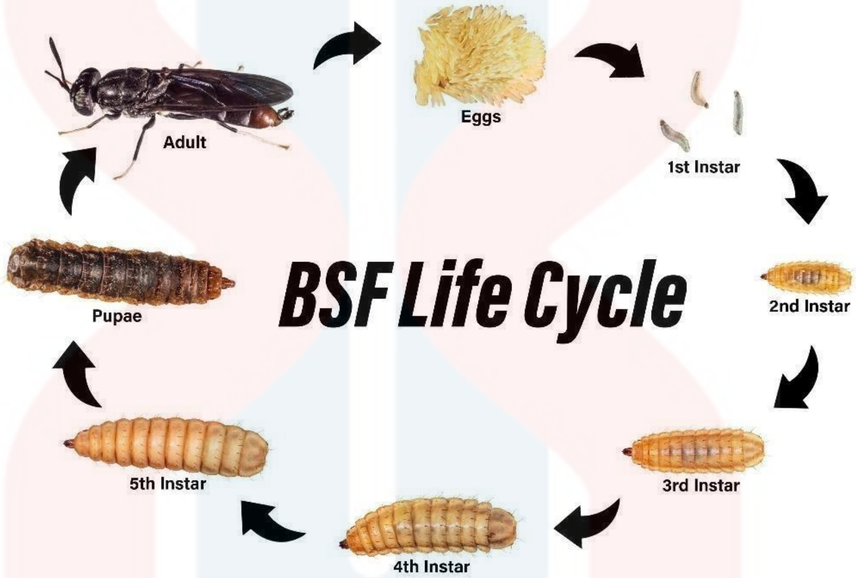


Figure 2.2: The live cycle of Black Soldier Fly

Although the black soldier fly is one of the approximately 2000 insect species that humans have already eaten in entomophagous societies, it is neither common nor popular, with modern consumption restricted to a single ethnic minority that is gradually giving up the habit. This is consistent with reports for insects worldwide: entomophagy is more common among more traditional and rural cultures (referred to as "primitive" people) than among urbanites, and it is becoming less common among these people as Westernization and urbanization take hold.

Black soldier fly (BSF) was additionally known to reduce the mass and nutritional value of pig manure, just like poultry dung did. Better farm cleanliness, fewer pest fly populations, and reduced nutrient contamination in runoff were all benefits of this. If there weren't sufficient flies to feed the pigs, the remaining manure residue might be utilized for landscaping, which would enable plants to thrive in otherwise unsuitable grounds or even sand. The flies may also be diverted for other uses, such as fish feed.

Compared to mealworms and crickets, they were known to have superior feed conversion rates, and their level of nitrogen and phosphorus contents, as well as their BSFL survival rate, was less affected by diet. They're not regarded as harmful. In order to be used as energy by the non-feeding adult, BSFL gathers lipids from their diet to the point where they can be transformed into biodiesel. Their nitrogen-rich grass and everything they don't eat can be combined to make fertilizer. Their larval growth takes longer than that of house and carrion flies—more than three weeks.

CHAPTER 3

MATERIALS AND METHODS

3.1 MATERIALS

In this study, the sampling of plastic biodegradation by immature black soldier fly will be observed at Laboratory Faculty of Earth Science using the following materials and equipment:

Laboratory materials and apparatus	• Black soldier fly • Petri dish • Glass jar • Aquarium • Forceps • Biodegradable gloves • Biodegradable disposable polypropylene lab coat • Polyethylene (PE) • Polyethylene terephthalate (PET) • Polyvinyl Chloride (PVC) • Polypropylene (PP) • Polystyrene (PS) • Aluminum foil

	• Spatula

Table 3.1: List of materials

3.2 METHODS

3.2.1 Collection and Rearing of Black Soldier Fly

Alive Black soldier fly (larvae) was brought from the company Ecolution Sustainability Hub in Batu Arang, Selangor. This samples were stored in glass storage. The used of plastic storage containers was not allowed because it would interfered with this studied to obtained the necessary results.

Figure 3.2: Collection black soldier fly (larvae) in glass jar

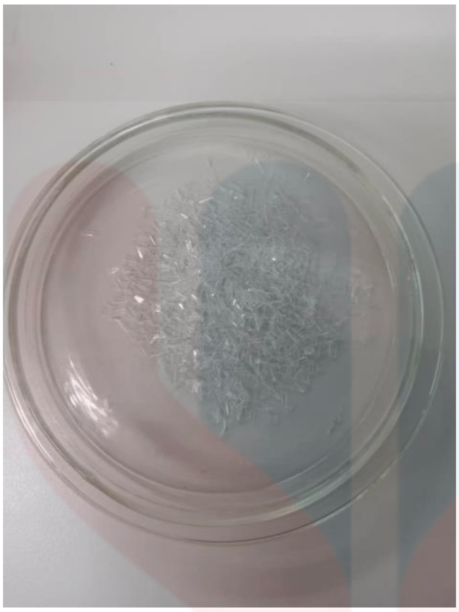
3.2.2 Plastics Preparation

For the use of plastics, it was only necessary to provide five different types of plastics. The use of plastics should be readily available and easy to operate. Plastic is used daily in human life in terms of employment, nutrition, purchasing, and so on. The plastics used were polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), polyvinyl chloride (PVC), and polystyrene (PS). This plastic was chosen because this looked at the obvious differences of the plastic that was the choice of the black soldier flew species. These five types of plastics were an option in conducting this experiment because they did not involve any capital while the experiment ruined. The purchase of these plastics did not take a significant expense when the experiment was to be carried out. Additionally, it is easy to find. The purchase or search of various types of plastics is easily available on various platforms such as online or can be found in any nearby store.

In this study, the plastic materials were categorized as follows: bubble wrap was utilized for Polyethylene (PE), waste plastic was designated for Polypropylene (PP), beverage containers were used for Polystyrene (PS), and book covers were employed for Polyvinyl Chloride (PVC). Each plastic type was systematically cut into small fragments to optimize the consumption process by black soldier fly larvae (BSF).

a) Polyethylene (PE)

b) Polypropylene (PP)



c) Polyethylene Terephthalate (PET)

d) Polystyrene (PS)

e) Polyvinyl Chloride (PVC)

Figure 3.3: The type of plastic that are cut

3.2.3 Test Optimization

To guarantee the success of this experiment, sample preparations such as black soldier fly larvae, glass jar, dirt, light-sealing containers, and other plastics were prepared. Up to 2 grams of black soldier fly (BSF) larvae were used for each of the five distinct kinds of petri dish. Only five different types of plastic should be used for plastic use: 1 gram each of polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), polyvinyl chloride (PVC), and polystyrene (PS). Black soldier fly and earth will be combined with crushed plastic. All that is needed for this experiment to compare which plastic the black soldier fly will eat is to observe the chosen species. This experiment must run for the entire amount of time needed for the black soldier fly (BSF) to consume the chosen plastic.

Based on figure 3.4 below the use of an aquarium is an important procedure for conducting this experiment. In the aquarium, five petri dishes should be placed to accommodate five different types of plastic. The aquarium was partitioned into five compartments and each compartment was divided with a barrier using aluminum foil. Black soldier fly (BSF) larvae were subsequently introduced into each compartment.

Figure 3.4 indicates the first petri dish contained Polystyrene (PS) plastic. The second petri dish was designated for Polyethylene Terephthalate (PET). The third petri dish was allocated for Polypropylene (PP) plastic. The fourth petri dish was used for Polyethylene (PE) plastic and the final petri dish contained Polyvinyl Chloride (PVC) plastic.

Figure 3.4: The aquarium was partitioned into five compartments, each containing a different type of plastic placed in Petri dishes.

3.3 RESEARCH FLOW

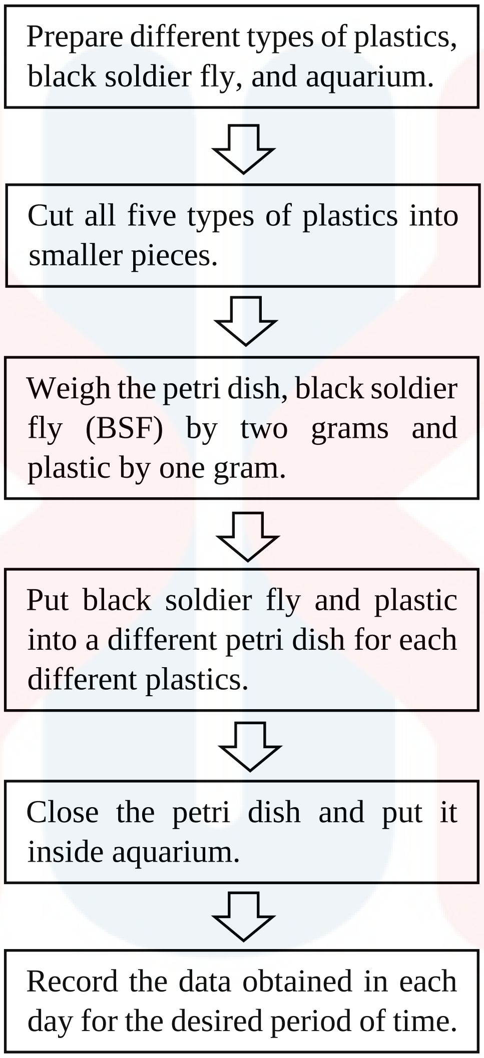


Figure 3.5: Research Flow

CHAPTER 4

RESULTS AND DISCUSSION

This experiment was done to pay attention to (BSF) larvae eating plastic. The weight of each type of plastic have been recorded for five consecutive days. The table below (Table 4.1) showed the weight of plastic for five different types of plastic, namely Polypropylene (PP), Polyethylene Terephthalate (PET), Polystyrene (PS), Polyvinyl Chloride (PVC), and Polyethylene (PE) for a period of five days.

Days	**Types Of plastics (g)**				
1	**PP**	**PET**	**PS**	**PVC**	**PE**
	0.909	0.992	0.994	0.985	0.974
2	**PP**	**PET**	**PS**	**PVC**	**PE**
	0.906	0.988	0.973	0.984	0.972
3	**PP**	**PET**	**PS**	**PVC**	**PE**
	0.901	0.979	0.965	0.982	0.933
4	**PP**	**PET**	**PS**	**PVC**	**PE**
	0.894	0.969	0.964	0.982	0.928
5	**PP**	**PET**	**PS**	**PVC**	**PE**
	0.802	0.92	0.96	0.86	0.89

Table 4.1: The total weight of plastic remaining within five days

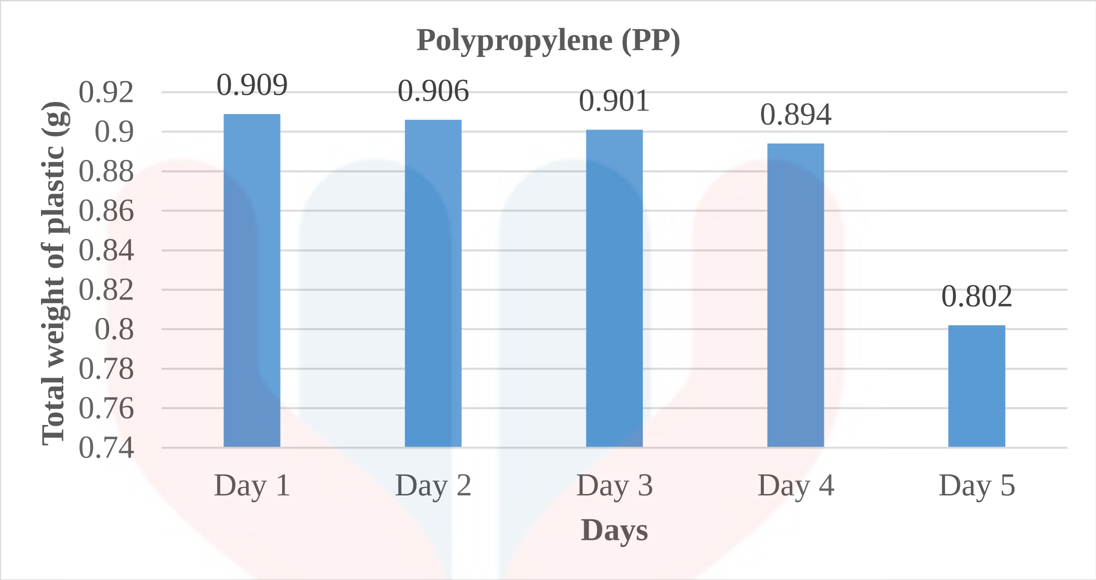


Figure 4.2: The total weight of Polypropylene (PP)

For Polypropylene (PP) the table above shows a decrease of 0.198 grams from one gram of plastic weighed. On the first day it recorded as much as 0.909 grams of plastic that was consumed by the black soldier fly (BSF) recording a decrease of 0.091 grams. On the second day it recorded as much as 0.906 grams which is a reduction of 0.094 grams. On the third day it was 0.901 grams where the reduction was 0.099 grams. On the fourth day, a total of 0.894 grams was recorded, which is a decrease of 0.106 grams.

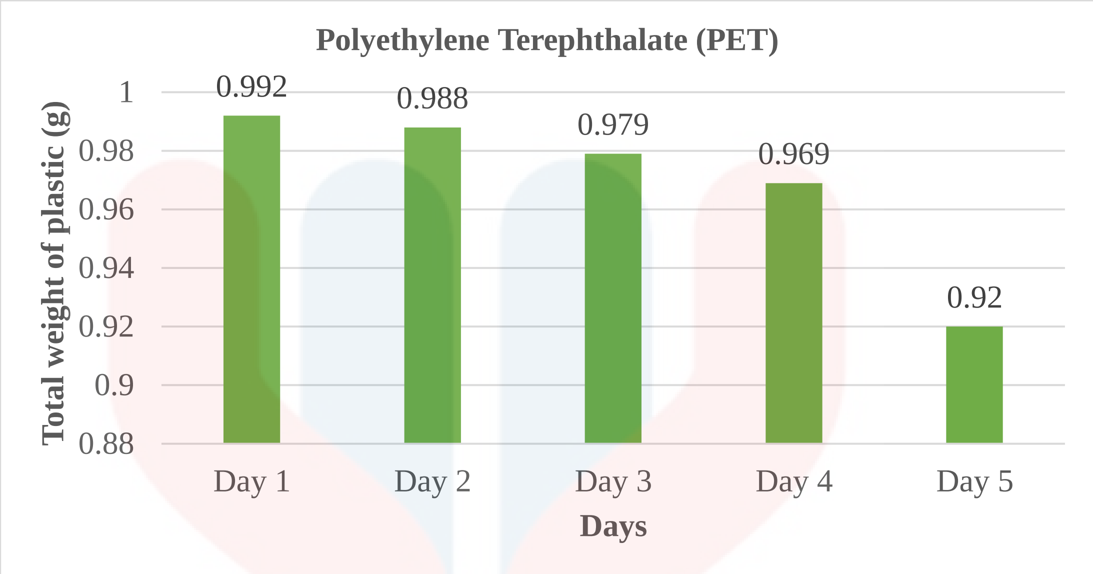


Figure 4.3: The total weight of Polyethylene Terephthalate (PET)

For Polyethylene Terephthalate (PET) the table above shows that the reduction in the amount of plastic consumed by the black soldier fly (BSF) on the first day is very little and not too significant which is 0.992 grams from the original amount of 1 gram. On the second day, the weight of the plastic was 0.988 grams, a reduction of 0.012 grams. On the third day it was 0.979 grams, a reduction of 0.021 grams. The plastic weight for the fourth day was 0.969 grams reduced by 0.031 grams. The fifth day recorded 0.92 grams which decreased by 0.08 grams.

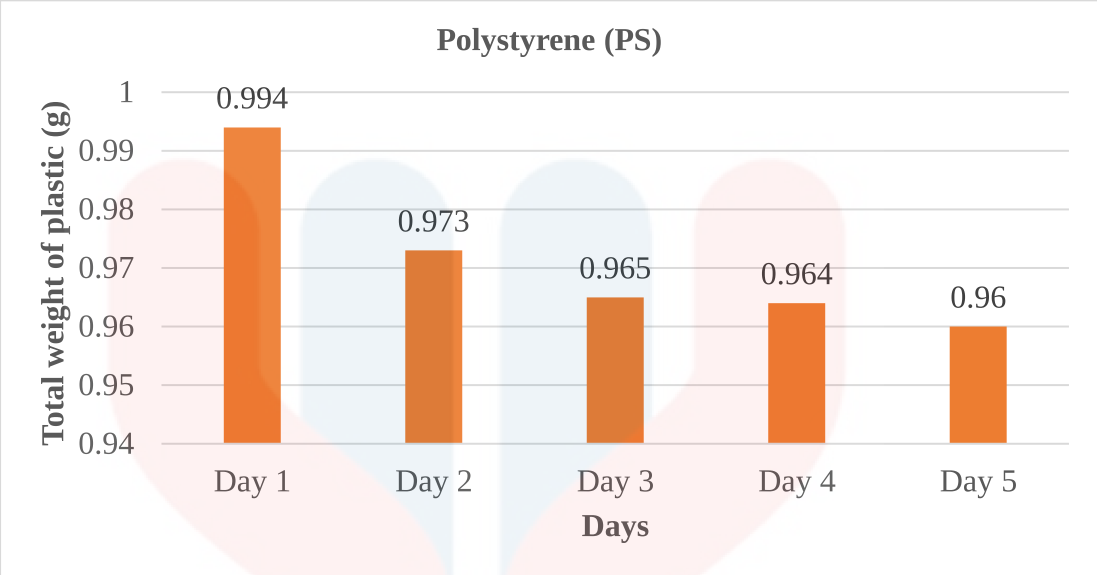


Figure 4.4: The total weight of Polystyrene (PS)

For Polystyrene (PS), the total weight of the remaining plastic is 0.96 grams, a decrease of 0.04 grams from 1 gram. On the first day it was recorded that the quantity of plastic available was 0.994 grams. On the second day, 0.973 grams decreased by 0.027 grams. On the third day, the amount of plastic was 0.965 grams, a decrease of 0.035 grams. The fourth day recorded that the quantity of plastic available was 0.964 grams, a decrease of 0.036 grams.

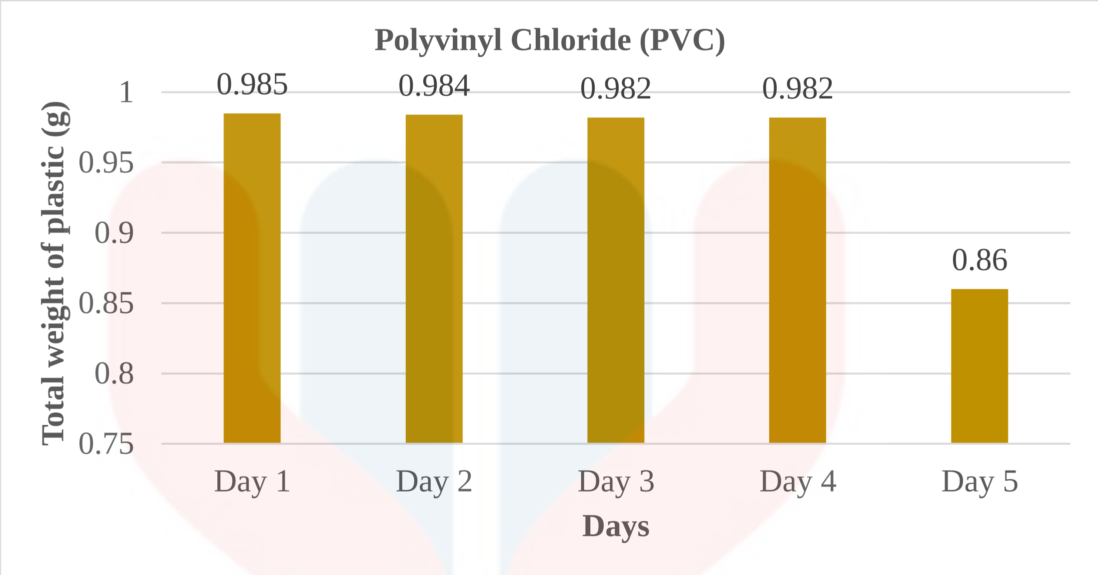


Figure 4.5: The total weight of Polyvinyl Chloride (PVC)

The figure 4.5 above displays the total weight of plastic for Polyvinyl Chloride (PVC). This table has shown that on the first day as much as 0.985 grams of plastic has been obtained from the previous amount of 1 gram, the reduction is 0.015 grams. On the second day the reduction was as much as 0.016 grams which had been recorded as much as 0.984 grams. The third day recorded 0.982 grams which is a reduction of 0.018 grams. The fourth day was 0.982 grams, a decrease of 0.018 grams. Where on the third and fourth day shows no change. The total weight of the remaining plastic on the third and fourth day recorded the same amount of 0.982 grams. On the fifth day the reduction was 0.14 grams.

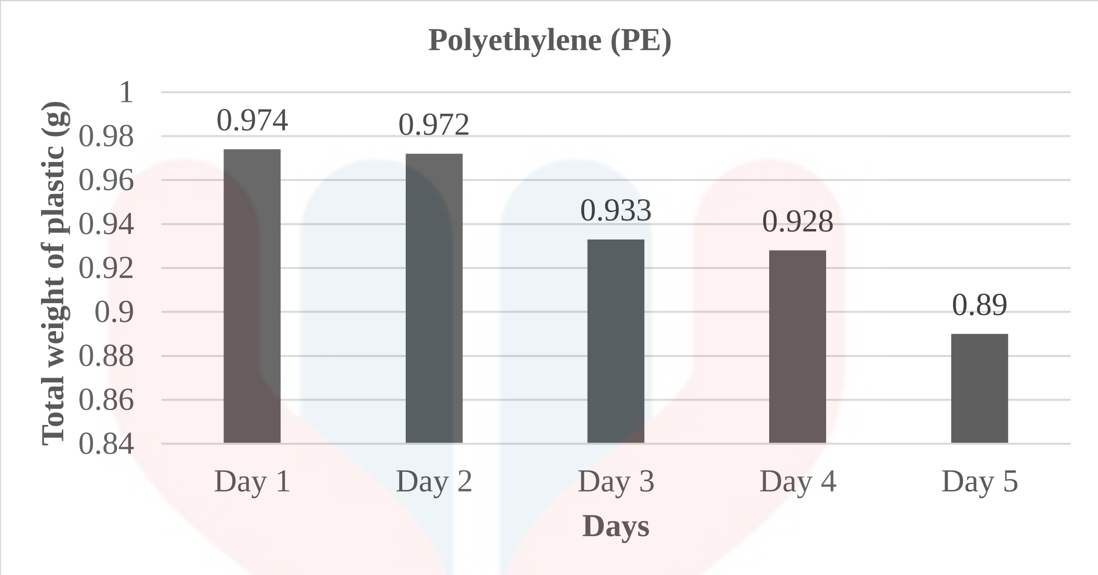


Figure 4.6: The total weight of Polyethylene (PE)

The figure 4.6 above is the result for Polyethylene (PE) plastic. The table above shows the decrease in quantity for the plastic from the first day to the fifth day. The amount of plastic chosen is 1 gram, which shows that there is a reduction of the remaining plastic which is 0.974 grams, a change of 0.026 grams on the first day. On the second day, it was 0.972 grams, a reduction of 0.028 grams. 0.933 grams is the weight of plastic recorded on the third day which is a reduction of 0.067 grams. Referring to the fourth day the reduction is as much as 0.072 grams which is the quantity obtained is 0.928 grams. According to the table above, the fifth day recorded 0.89 grams, which is a reduction of 0.11 grams.

Type of plastic	PP	PET	PS	PVC	PE
Weight (gram)	0.802	0.92	0.96	0.86	0.89

Table 4.8: Weight for the remaining five types of plastic

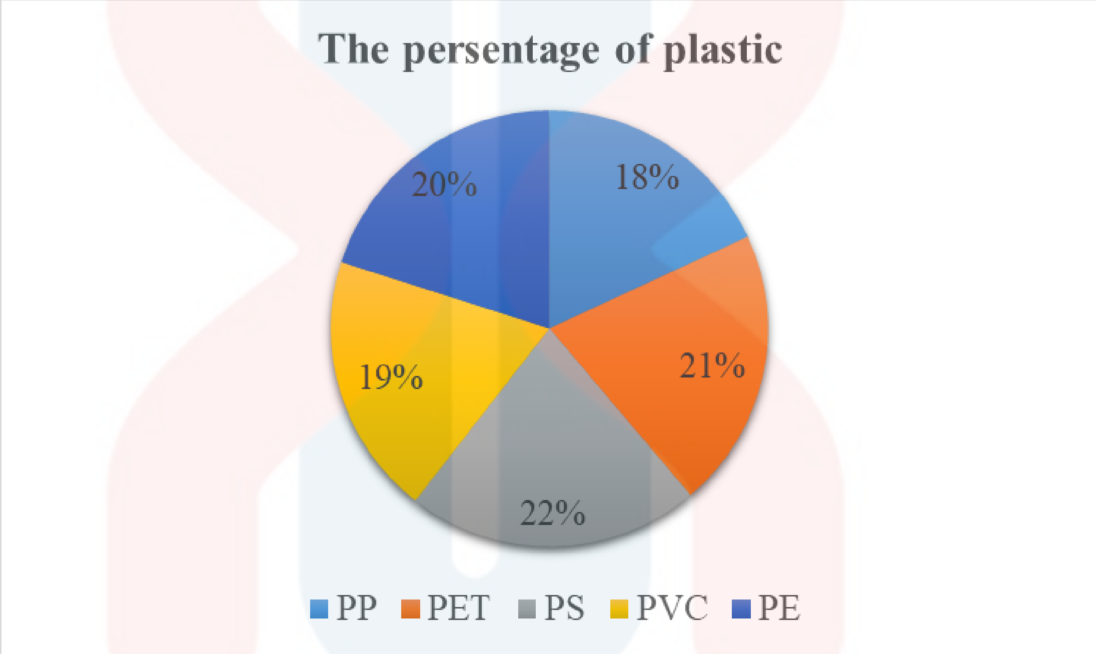


Figure 4.9: The percentage of plastic

The following is a formula to find out the percentage value of the remaining plastic weight (Weight of remaining plastic / Amount of plastic) x 100%. For the weight of the remaining plastic, the value must be taken on the last day, which is the fifth day as stated in table 4.8. The amount of plastic is the original amount chosen before the experiment started, which is 1 gram.

Table 4.8 had shown the remained plastic weight data that recorded on the lasted day. For polypropylene (PP) plastic had recorded as much as 0.802 grams which was the most plastic left compared to other typed of plastic. Polypropylene

(PP) has shown a decrease of 0.198 grams which was 19.8%. For Polyethylene Terephthalate (PET) plastic, the remained weight is 0.92 grams, which is a decrease of 0.08 grams, equivalent to an 8% reduction. The remaining Polystyrene (PS) weight is as much as 0.96 grams reduced by 0.04 grams which is 4%. Polystyrene (PS) is the least plastic left. The weight of Polyvinyl Chloride (PVC) plastic is 0.86 grams reduced by 0.14 grams representing a reduction percentage of 14%. While for Polyethylene (PE) recorded a valued of 0.89 grams which is reduced by 0.11 grams. The reduced percentage valued is 11%. To calculated the value of the percentage of plastic that is reduced it is necessary to used the formula (first weight of plastic – final weight of plastic / first weight of plastic) × 100%.

The figure on 4.9 shows that the percentage of plastic most consumed by the black soldier fly (BSF) is Polystyrene (PS) which is 22%. The least percentage of plastic consumed by the black soldier fly (BSF) is Polypropylene (PP) which is 18%. The second highest plastic is Polyethylene Terephthalate (PET) which is 21%. For the type of plastic Polyvinyl Chloride (PVC) is the second lowest plastic which is 19%. Polyethylene (PE) plastic has recorded as much as 20%.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

In conclusion, this experiment has shown that the black soldier fly (BSF) can survive for a long time through the amount of plastic weight that remains. Although the percentage of black soldier fly (BSF) larvae that consumed plastic was small, this experiment had been successfully conducted. The evidence is that there is a reduction in the quantity of plastic within five days. Sufficient environment and temperature were essential requirements for the secure and well-being of BSF larvae. Numerous studies had demonstrated that the optimal temperature range for Black Soldier Fly larvae was between 24 and 30 °C. The BSF larvae would stop feeding and crawl out of the meal in search of a cooler place to keep alive if it got too hot. The larvae would feed less and had a reversed metabolism if the temperature dropped too much, which caused them to grow and develop more slowly than usual.

Black soldier fly (BSF) one of the best indicator suitable to be used as a plastics component decomposer. The use of these larvae does not have to involve any high cost because of their easy care. This has shown that polystyrene (PS) is one of the plastics chosen by black soldier fly (BSF) larvae as a plastic decomposing. The proof was that the percentage of plastic polystyrene (PS) left was as much as 20% compared to other typed of plastic.

5.2 RECOMMENDATION

Studies or activities related to the laboratory need to have a lot of storage to facilitate the storage of goods to be done well. Storage of live samples is required in a suitable place according to the appropriate temperature.

The laboratory management needs to review the necessary or unnecessary equipment to facilitate the smooth running of the study. Unnecessary models should be discarded or stored in an appropriate place.

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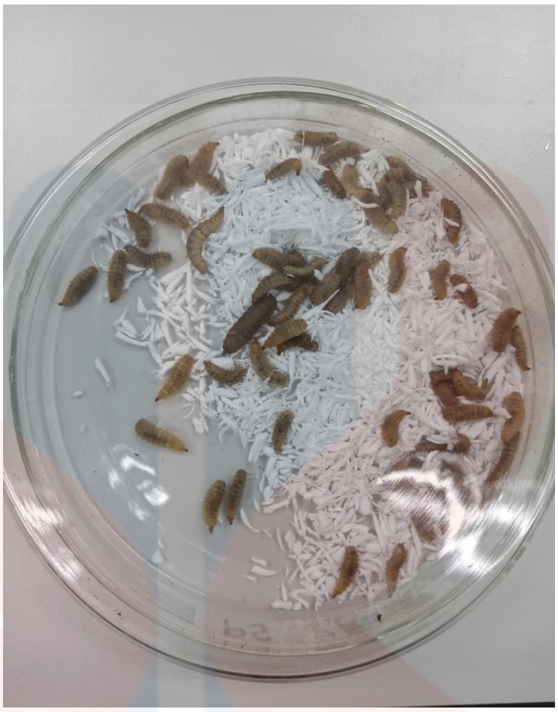
APPENDIX

Days	Total Weight of Black Soldier Fly (BSF) (g)				
	PP	PE	PET	PS	PVC
1	-	-	-	-	-
2	0.080	0.128	0.009	-	0.074
3	0.162	0.071	0.293	0.182	0.271
4	0.150	0.155	0.125	0.208	0.420
5	0.06	-	0.23	0.47	0.45

Shows the dead black soldier fly (BSF) weight on different plastics

Black soldier fly larvae with Polyethylene (PE)



Black soldier fly larvae with polystyrene (PS)

Black soldier fly larvae with polypropylene (PP)

Black soldier fly larvae with polypropylene (PP)

Black soldier fly larvae with polyvinyl chloride (PVC)