



Exploration of Sustainable Solid Waste Management through Composting Projects among School Students

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Solid waste or generated waste can increase as a result of population growth and human socioeconomic activities. Studies on waste management through composting involving school students are still lacking in Malaysia. School students are not exposed to the use of proper composting methods, causing difficulties in understanding the issue of sustainable waste management and how composting can be applied as a green practice. The design of this study is to use a qualitative study, with the research approach being a case study. The findings of this study were obtained using in-depth interviews. The selected informants consisted of three individuals including university professors and agricultural industry experts. Informants believe that solid waste management through composting methods can provide students' knowledge of environmental sustainability. In addition, the techniques of composting in schools can be diversified using various methods such as conventional methods like heaps, compost vermi or compost using Black Soldier Larval Fly (BSLF). Composting techniques can also include the use of effective microorganism (EM). In conclusion, school composting practices can not only provide knowledge of environmental sustainability, but sustainable solid waste management through composting can be a green practice that can be implemented in schools.

Key words: *Solid Waste Management, Sustainability, Compost, Black Soldier Larvae Fly compost, compost vermi.*

Introduction

Every year waste increases and as a result, the cost of solid waste management also increased especially in developing countries (Tchobanoglous & Kreith, 2002). S. T. Wee, (2004); Hamidi, (2009); and Latifah, (2011) stated that solid waste is defined as any substance, solid or liquid that is disposed of by its owner and deemed to be no longer necessary. Solid waste or waste also refers to any waste material that is no longer required by the owner due to damage, wear or loss of life (Haliza, 2017). Some definitions and meanings of solid waste as described in Table 1.1

Table 1.1: Definitions of Solid Waste Management

Source	Definition
Agenda 21 (United Nations Sustainable Development, 1992)	Non-hazardous domestic waste is commercial and institutional waste, road wastes and construction sites
Pitchel (2014)	Waste is any waste and waste that needs to be disposed of as a result of human activities and commercial and industrial operations
Shulman, (2011)	Waste is a material that is wanted and needs to be disposed of subject to national law whether derived from individuals, institutions and industries

Problem Statement

Organic waste is a major contributor to the production of solid waste in Malaysia, which has caused environmental pollution and odour. High moisture content if not properly managed will make it difficult to treat waste. Methane gas released during the decomposition of solid organic waste can cause greenhouse gas (GHG) problems and global warming (Sharifah Norkhadijah, 2014). This is a serious problem when United Nations Framework Convention on Climate Change (UNFCCC) in conjunction with the Ministry of Natural Resources and Environment reports that the waste management sector contributes 12% of GHG emissions in Malaysia as a result of organic waste disposal at waste disposal sites (JPSPN, 2016). In addition, the decomposition of organic waste at the landfill site is a major source of greenhouse gas (GHG) production from the waste management sector in Malaysia (Zainura et al., 2013). According to the JPSN report in 2016 the waste disposal site was the largest



source of methane gas emissions (47%), which is the main ozone layer pesticide, 21 times more than the damage caused by carbon dioxide gas.

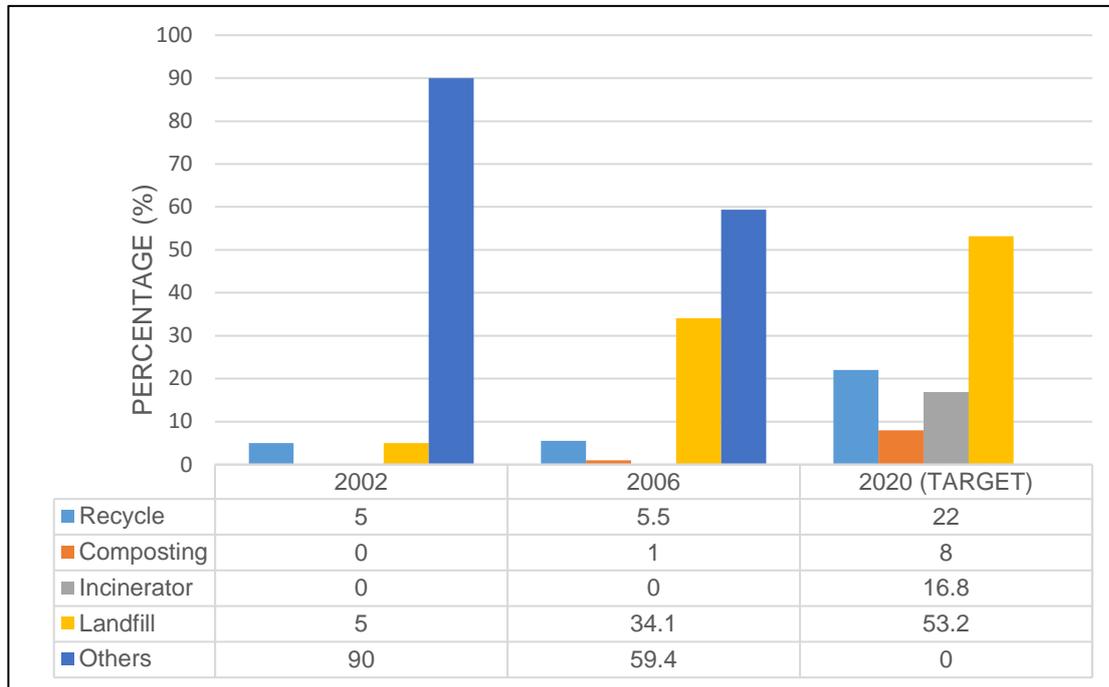
This shows that the Malaysian environment is facing a severe crisis in the management of solid waste especially organic solid waste. The various implications of unsustainable solid waste management have led to environmental pollution. Nonetheless, the practice of composting among Malaysians is still lagging behind countries such as the United States, Japan, China, India and Korea. Figure 1.1 shows the waste treatment technology in Malaysia as a percentage of waste disposal using composting method is being very low by 2020, as only 8% treatment methods is compost, compared to landfill and other methods (Periathamby & Shahul, 2010; MDM Samsudin & Don, 2013; Fazeli et al., 2016). Consequently, there is a conflict involving waste treatment in Malaysia because as much as 53% of the waste is disposed of at the landfill site (see Figure 1.1), while organic waste is the most abundant waste composition and handled using biological treatment and composting.

At school, students are not exposed to organic waste recycling activities like composting methods. As a result, students have difficulty understanding the issues of sustainable solid waste management and do not know how to implement composting methods as a viable green practice (Azura, 2018). This is evidenced by some recent studies about solid waste recycling practices and students' reported green practices (Noor Diyana, 2016); (Mahat et al., 2017); (Haliza Abdul Rahman, 2017). This problem is also linked to students who do not understand the application of sustainability to solid waste management (Hidayah Liew Abdullah, Hamid, Shafii, Ta Wee, & Ahmad, 2018). Previous studies have also found that levels of awareness, attitudes, behaviours, and environmental knowledge and compulsory practice among primary to secondary students are low (Maravić, Cvjetičanin, & Ivković, 2014). This is due to the lack of accurate knowledge of the environment and composting.

Through education on the concept of sustainable waste management and composting methods, school students can learn and understand about the practices. This will help raise awareness and improve the green practice of school students towards better food and organic waste management.

Hamidi, 2009 suggests that education is one of the important factors that influences the success of sustainable solid waste management. The Basis of Sustainability is a subject that has the potential to convey the concept of sustainable solid waste management. Project-based learning such as composting project activities can provide further awareness and can be a green practice in every student's life.

Figure 1.1. Methods of Solid Waste Treatment.



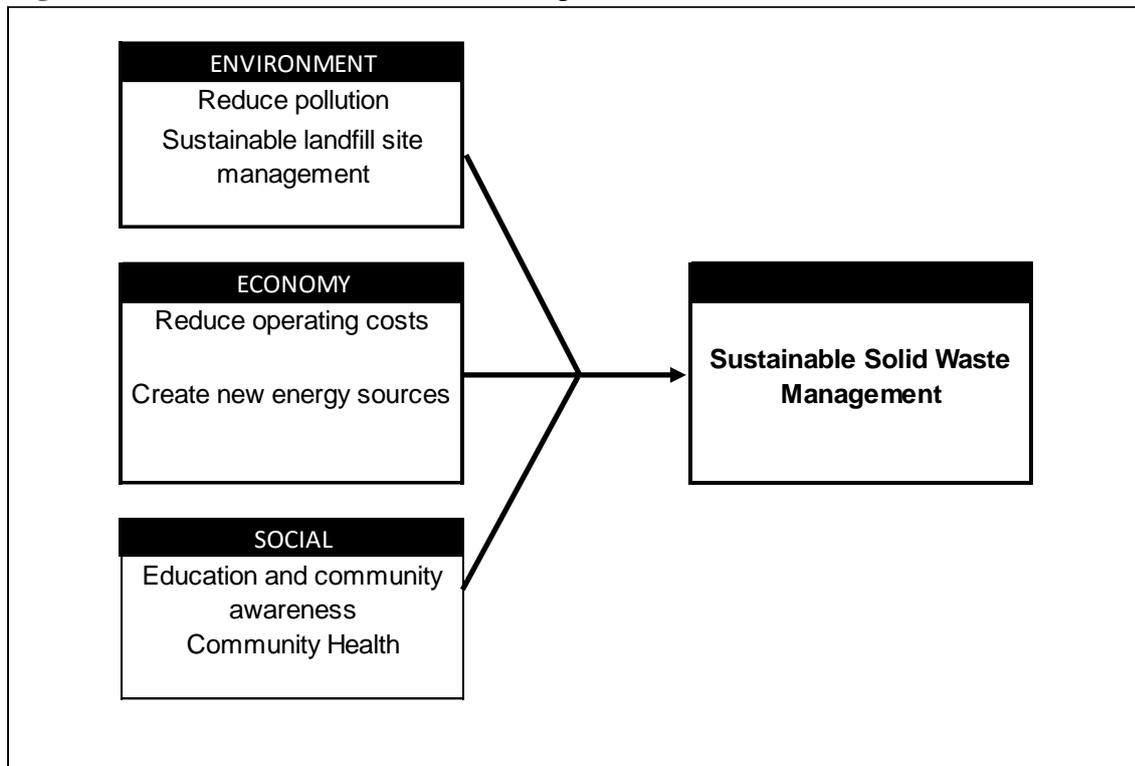
The SWM study through this composting project was conducted primarily aimed at exploring sustainable solid waste management through composting projects among students. The objective of this study is to propose sustainable solid waste management techniques for schoolchildren through composting projects

Literature Review

The concept of sustainable solid waste management

Figure 1.2 shows the sustainability relationship with the solid waste management sector based on three main elements namely environmental, social and economic. According to Taelman, Tonini, Wandl, and Dewulf; (2018) minimize waste generation is one of the issues affecting environmental sustainability other than land use issues; efficient use of energy and water; pollution control, biodiversity and ecology. In light of the environmental approach, pollution resulting from poorly maintained waste disposal sites is an environmental issue that contributes negatively to the quality of the physical environment and human health (Pai, Rodrigues, Mathew, & Hebbar, 2014). This condition also contributes to deterioration in environmental quality and urbanization (M. A. A. & S. T. Wee, 2014)

Figure 1.2. Sustainable Solid Waste Management.



Waste treatment method using composting method

Composting is the process of decomposition of organic waste such as agricultural, food, kitchen and garden waste that forms naturally composted fertilisers. Disposal of food waste accounts for up to 40% of the country's total solid waste and can be converted into valuable goods that do not pollute the environment (Ng & Yusoff, 2015). Compost is an organic material that is decomposed, recycled as fertiliser and forms humus-like material (Reyes-torres et al., 2018). Compost is a key ingredient in organic farming. Essentially, composting requires only a pile of organic waste outdoors and stored until the materials are evaporated for six weeks or more, along with the availability of appropriate environmental temperature and nutrient availability (Commission, 2000). The moisture and the presence of oxygen influences this process of compaction. Examples of this type of decomposition is aerobic decomposition that occur in the presence of oxygen and produce carbon dioxide gas and heat (Peninsular and Urban Planning Department of Peninsular Malaysia, 2012). These composting methods have the following advantages; (i) May reduce the amount of solid waste that needs to be disposed of at the landfill, (ii) Produce plantable fertiliser materials and (iii) Able to reduce the use of fertilisers containing chemicals.



Methodology

The design of this study uses qualitative research with the case study approach. Some researchers have described qualitative research as an appropriate method for deeper exploration in the social studies process (Silverman, 2014). Creswell, (2016) and Yin, (2016) emphasised that qualitative studies assist in interpreting informants' experiences and understandings of a subjective nature and are able to learn from informants in depth, in particular, their understanding of the issues studied. Othman (2018) has concluded that qualitative research has several features such as it is designed to find out what can be learned about a social phenomenon. In this study, researchers are trying to interpret the views and understandings of informants to create a framework for sustainable waste management through school composting methods.

The sample selected consisted of three individuals comprising of university lecturers and the Director of Corporate Affairs who handles the industry of composting. This sample selection criteria is based on experience in the field of sustainable waste management and industrial composting. The method of data collection is through semi-structured interviews. Researchers prefer to use semi-structured interview methods because they are more flexible than structured ones. Interview protocols are provided in advance and informants are more flexible in responding to the interview questions. The informant will be notified in advance of the purpose of the joint study contract agreement for the purpose of collecting the data. The researcher will obtain permission from the informant before recording the interview. Informants were asked about the proposal to build a sustainable solid waste management framework through computational methods.

Interviews are conducted in comfortable places for both the researchers and informants. The process is carried out after the informant has given consent based on the time, date and place discussed earlier. During the interview, the researcher also observed informants the body language and facial expressions each time they gave an answer. The context of the environment of the interview is recorded by the researcher in field notes . When working with informants, researchers always use the opportunity to build rapport with informants.

The researcher also used disclosure techniques during the interviews aimed at informing and explaining the questions that were asked. The researcher will minimise the question so that the informant can further explain the answer. Additionally, researchers will avoid asking questions by speculating answers to the informants in order to avoid researcher bias. In addition, researchers also avoided asking questions that can only be answered "Yes" or "No" as they cause hindrance on the conversation. According to Merriam & Elizabeth (2016) method of disclosure consists of follow-up questions and comments on a questionnaire through detailed descriptions, explanations and examples. According to Merriam & Elizabeth



(2016) further, semi-structured interviewing sessions should be provided with open-ended questions followed by disclosure questions. The researcher will ask again if there is a vague and elusive answer to obtain information from the informant. The researcher also record the responses along with the feedback of the informants during the interview process into the memos or field notes to obtain data triangulation methods. Upon completion of the interview, the researcher records the informant's appreciation. The researcher will begin writing transcriptions upon completion of the interview.

Data Analysis

Researchers use the data analysis method based on the following steps:

- I. Data file management
- II. Interview transcript writing
- III. Analyse interviews by forming codes and categories
- IV. Theme creation

The researcher labelled the transcript and interview record in each informant file. To facilitate the analysis of the data, the researchers used Nvivo 12. The software provided each informant with a name code and each interview was labelled with the date and time for each session. W.Creswell (2016) proposes five basic steps being collecting verbal data, reading data, splitting data into specific sections, organising and presenting data. The final process in data management is the synthesis of data. Since the researcher's position as a qualitative research instrument, the researcher should perform processes such as an audit trail, member checking, peer review and triangulation. These processes will enhance the validity and reliability of the study.

Audit trail

According to Merriam, (2009) the audit trail process is a method by which a researcher makes decisions and forms a category. The audit trail is a step in collecting and analysing data for the purpose of gaining trust. In the process of this audit trail, the researcher should explain each data collection process carefully in the interview process, transcription, coding and theme formation.

Member Check

The check-in process refers to the data validation process of the research informant. The research informant will be contacted again for approval of the researcher's interpretation. Silverman, (2014) stated that the check-in process is an endorsement by the informant to ensure that the information is as accurate as the informant intended.



Peer examination

This peer-review process is a joint endorsement process by the Supervisory Committee to assist researchers in examining the raw data obtained from informant.

Triangulation

Silverman, (2014) states that the triangulation process produces a supportive data source to increase the reliability of the qualitative study data. This triangulation process can play a role in comparisons involving different data from different informants. This is because triangulation is intended to provide a deeper understanding of the events and processes of different individuals.

Results and Discussion

The composting process involves the decomposition of organic matter. In order to ensure that the decomposition process is optimally carried out, the main factors of the compaction mechanism are the input of inputs such as organic materials rich in carbon and nitrogen, water and moisture and oxygen. This decomposition factor can be further accelerated by sufficient reversal, ventilation and moisture techniques.

Mechanism of composting process

Organic Materials

Informant 1 described the organic matter used in the composting process involving the materials made up of Carbon and Nitrogen elements such as dried grass, dried leaves and twigs, as well as wet grass.

- Informant 1 : Well, compost is whether from plant or animal waste..
So usually people will use mixture of things....like some residue...that
iiiiiiiis...ermmmm...rich with carbon for example.. the tree branches.. dried
leaves.. sawdust
- Researcher : What about the newspapers dr?... carbon isn't it?
- Informant 1 : Aaa..Haaa..ha... (nods his head)..it's dry... dry ones... carbon.. then it will be
mixed with some waste that is rich with nitrogen... waste that is rich with
nitrogen is usually wet...for example the grass that was recently cut ..

Informant 1 also added that organic materials that are easy to collect are better as they are easy to find and that do not smell bad. For example, the collection of organic materials such

as animal faeces or materials, such as fresh ingredients from kitchen waste such as fish or chicken belly. This was agreed by Informant 3.

Researcher : kitchen waste in school...with the students...can you explain further?
Using the skin...fruits..vegetables.. that is fine for students instead of using smelly substances such as fish..we can use that as well but It's smelly...it's not suitable for students to use, right?

Informant 3 : Aaaa..ahaaa...ha..(nods his head).. it is not suitable... if that's the case, perhaps the anaerobic method is advisable..

“There are other substances like leftovers of fish, meat and all but they're quite difficult tooooo.....with the smell..we need to control the smell..so that if we leave it in an open space..aaa..aa..you know..we need to handle it with extra care..”

-Informant 3-

Informant 3 stated that the Carbon Nitrogen ratio should be 25: 1. In addition to garden residue such as dried leaves or shrubs, organic materials such as newspaper papers is also ideal.

Researcher : Prof, about the compost substances, I still don't quite get the idea..like just now we take the plants waste but we also need nitrogen..carbon,right?

Informant 3 : C:N Ratio is compulsory..meaning to say C:N ratio is about 25 to 1. So we need to ensure the substances..usually carbon based substance is brown in colour..dried leaves...what do we call that...branches or barks of trees

Researcher : we can also use newspaper, right?

Informant 3 : aaa..yaa..Nitrogen is the one that is green

Informant 2 described organic ingredients that can be used in addition to garden, kitchen or plant waste such as rice straw, palm oil extracts and mushroom blocks. Informant 2 described garden residue as grass, leaves and twigs or kitchen waste as fruit and vegetable skins that can be supplemented with plant residues such as rice straw, mushroom moss and palm oil.

Researcher : Dato, if we were to apply this in school what kind of substances that you would suggest..

Informant 2 : Substance that we can suggest..food waste..

Researcher : So like leftover of fruit..food waste..sawdust..

Informant 2 : Yes..yes.. to me.. I will suggest those substances..meaning to say one..if in school...one substance is grass...

Researcher : aaaa...

Informant 2 :aaa.....grass...one..grass..second one..perhaps tree branches...the one that we use...the trees...we usually do...aaa...and you need to add a few..like I said..it's not solid enough..leave and this..it isn't solid..a container of mushrooms with the palm waste..

Moisture and ventilation

To produce aerobic compaction, which is the decomposition process using oxygen, the two important things are moisture and ventilation. Informant 3 stated that although composting uses a compost bin, it is always best to open it or make a hole, as oxygen is needed to dry the fertiliser.

Informant 3 : This one we use compost bin method..but it's very simple..we insert..but it is suitable for plant waste and then we insert em...

Researcher : Is it sealed, Prof?

Informant 3 : It is sealed..but aaa...we still have to unseal it regularly..to supply oxygen for them..

“We need to occasionally unseal it to supply oxygen..need to allow some space for oxygen to enter..which means..maybe once a day..then stir them to let the oxygen in..”

“Depends on the condition...the condition of the compost itself..if it's too damp..then maybe you need to add more oxygen or wind to let it dry a little..”

-Informant 3-

The third informant added that the layered organic residue can help with the ventilation process and facilitate oxygen breathing in the heap.

“Sometimes we need to ensure the oxygen..in layers...first the branches..then the dried leaves then the food waste..it needs to be done that way so that the oxygen can be absorbed...the air is absorbed..”

-Informant 3-

Regular mixing of the materials helps to mix the oxygen with the organic matter. This will also control temperature and humidity. The reversal process was described by informant 1 to obtain degrees of humidity as well as oxygen mixing.



“We can't let them be....one month ... cannot...it needs to be stirred...in 2-3 days they need to be stirred ...2-3 days it needs to be turned to the other way around..”

“It needs oxygen for decaying process...that's why it needs to be turned the other way around...because if we just leave it be...we don't change their position...the substance below another substance will not get the supply of oxygen...that's the reason being,”

-Informant 1-

Humidity

The humidity process should always be undertaken with care during composting process. This was stated by informant 1 and he suggested using the wooden spike method to ensure the moisture level of the compost pile.

“Ehmm..but wood is easy for you to indicate..the one in there (in the pile of compost) is dry..right..if we lift the wood we can see the side that is still wet...dry is..if the end of the wood is dry..it doesn't get enough water...so we put more water on it...water more...turn it and change the position..”

-Informant 1-

Appropriate composting techniques for schools

The technique of composting steel is known to be suitable for school students and it involves large-scale and small-scale projects. Large-scale projects involve a school community while small-scale projects are individual students.

Stacking techniques

The pile technique is a method of composting by mixing Nitrogen and Carbon materials in layers. These ingredients are stored for six (6) months to a year until they reach the compost maturity index. In order to reach the compost maturity index, the moisture needs to be maintained. The stacking technique was described by Informant 1:

“Madam, you need to make it into layers....carbon..dried substance...and then you water them..and then add another layer with nitrogen..for example grasses...ha....mix it with egg shell..For every layer...water it..”

Informant 1



The pile requires a covered location and close to a drainage area. Informant 2 proposed the size of an easy to make compost heap in a school is two (2) tonnes with a heap of seven (7) square feet.

“I would like to suggest if you can get a canopy tent with a measurement of 12x12 or 10x10 at least...you can make seven feet square of compost pile”

Informant 2

Covered locations, as suggested by informant 1, refers an environment which prevents heat and rain. Informant 1 also explained that the roof of the covered area looks like a hut or shed. Informant 1 added that a better location is one that is close to a well-drained area.

“Actually it is better.. sheltered place because we want to avoid the sun and the rain...if we make it in a wide open space for a big scale, people will provide like a hut or a booth”

“It's actually better .. a covered area because we want to avoid the heat with the rain”

“One more thing it needs to be near to drains, so if there is stagnant water at the compost we can easily get rid of it”

Informant 1

Informant 3 also stated that the location should be dim and cool enough to accommodate the bacteria.

“This location is the one that I mentioned need to be shady..not sunny..if it is exposed to the sun the bacteria will die shortly. Even if black soldier fly needs shady place because if it's too hot it'll die faster. If vermi compost is worm..it needs a shadier place.”

Informant 3

Methods of effective microorganisms

The mechanism of decomposition of organic waste materials requires effective aerobic bacteria. Microorganisms are the most important agent in producing compost steel because they break down organic matter into compost. Hundreds of species of microorganisms are involved in this decay process, mainly bacteria, fungi and more. The composting process will take a long time if the presence of these microorganisms is low. Therefore, the second informant suggested that effective microorganisms such as *Basillus Septilus* be added to speed up the decomposition process.

“We’re using aaaa..what do we call..microbe.. bacillus subtilis..the microbe is called bacillus subtilis..what size..what do we say..pile...aaa..what..sufficient raw substances.. I think maybe in 3 to 5 tan..it is more or less.....if we were to measure the size 7x7 feet square...the height is around 4 feet...we collect all raw substances...we use.. bacillus subtilis. It will raise the temperature to around 60 degree...its core temperature is around 60 degree...it will help to make the multiplication quicker... Basilus will multiply..and it will help in speeding up the decaying process..”

-Informant 2-

According to Informant 2, the addition of these effective microorganisms such as bacillus subtilis will assist in the decomposition process and possibly raise the temperature to 60 degrees. This was also explained by the third informant in that the garden waste was not sufficient to supply the amount of microorganisms, so it is better to have these microorganisms added, for example from the pollutant residues.

“If the microbe is leave... it won't ...Aaaa..it's like the microbe ... not much..not much....compared with..that's why people make research using sludge than waste water.. IWK for example..it enters..because it needs a lot of microbe..that's why if the plant waste need 3-4 months to decompost...it is due to the lack of microbe...that's why people need to add on sludge...”

-Informant 3-

Informant 3 : But we have this research they use leachate and it takes a short time as well..
Researcher :ohh..take the water of leachate and then add on again?
Informant 3 : What I was saying is take the leachate and recycle them together..

Method of Vermi Compost

An effective method for converting organic waste to humus compost is by using earthworms. The use of these earthworms can help to speed up and improve the efficiency of composting. The second informant explained how a simple worm digestive system can produce compost.

“Vermicompost is a process of excretion because worms...its...it's simple..its stomach is simple...the system is simple, you know... it eats...the food goes through the stomach and then it is released through excretion..”

“We say vermicompost..but it does excrete others...what cause it to be able to mince the food...”

-Informant 2-

Informant 3 also acknowledged compost vermi as one of the composting methods that can be practiced in schools as it will attract and develop students' knowledge of Veterinary Science subjects related to invertebrate animals.

Researcher : if school students, prof, what do you think...is it suitable?

Informant 3 : I think you can give an option..if there are people who like to play with worms...we can train them to be a veterinar...veterinar and then it will be..agriculture

Methods of Black Fly Larvae

Livestock breeding Black fly larvae (BSFL) can be used a methods to replace expensive animal feed. Organic waste materials will also be manufactured by BSFL. Therefore, methods using BSFL are considered as sustainable. Informant 3 explained that the method of compiling black flies (BSFL) is also very economical.

Informant 3 : Larva is available for sale...then it is put on food waste.. it is put in one layer only.. it will.at do we say.. this method is more to we learn the animal's life.. how do we make sure that the fly is alive.. alive and well.. what about the food that is suitable for the fly..we need to control it as well

Researcher : so that means the fly it will eat leftovers..it will eat the leftovers..so at the end the leftovers will be biodegraded..and then the fly itself we can sell.. meaning to say the larva we don't wait for it to become a fly..before it turns to a fly we take it and sell..

Informant 3 : The pupa is sold for animal's food..but at the same time we take a big fly so that it will lay eggs..so when the mother comes back, divide, meaning to say, for it to lay eggs for sale. It is economic because animal's food is expensive...bran is not cheap either.. and then the larva it is more nutritious.. the animal becomes fatter

To provide students with exposure to this composting activity, the mechanism for composting such as organic materials, ventilation, oxygen, temperature and humidity should be emphasised. This is in line with the opinion (Mohammed FM, Noor Ezlin, Shahrom, Nur Fatin, & Nurul Afida, 2015) that it is important to balance all the factors such as moisture, ventilation, temperature and oxygen into the compost mixture as it will affect microbial growth. The presence of Nitrogen and Carbon is essential for the development and life of microbes. Some compost techniques suggested by informants such as stacking techniques and the use effective microbes are an easy method to be practiced by school students as studied



by (Noor Ezlin, Shahrom, Zarina, Mohd Zainari, & Syarina, 2015). This technique can reduce the effects of environmental pollution and even the odour of waste. Easy-to-use Vermicompos are environmentally friendly, chemical-free and non-polluting. Studies from (Abdul Jalil, 2010) also indicate that vermikompos are a very effective in increasing soil fertility naturally. Similarly, the technique of using the Black fly larvae is seen to have no adverse effect on crops, soil and human health.

Conclusion

The importance of sustainable solid waste management methods should be addressed primarily through education sectors such as school institutions. The increasing amount of waste to a critical level shows that sustainable solid waste management is very important because it will reduce the impact of pollution on the environment, provide economical management costs and will not have harmful impacts society. The mechanisms of compost production such as moisture, water, air, oxygen, temperature and carbon and nitrogen ratios are important to keep in mind for optimal composting. Techniques that can be practiced in schools are pile techniques, techniques using microorganisms, worms such as vermikompos and black fly larvae. Composting projects are not only sustainable but economical as they can save on the cost of buying fertilisers as the final compost product is very useful for cultivation. In addition, school composting projects can also be seen to help school children develop green practices and indirectly help generate school income through the sale of compost products.



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