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Effectiveness of Organic Waste Degradation Level using the Black Soldier Fly Maggot

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Kata Kunci

Maggot BSF;
Degradasi;
Sampah Organik;
TPS 3R Sekar Manfaat;

Abstrak

Desa Sekaran merupakan desa dengan penduduk yang padat, sehingga kuantitas sampah, baik organik maupun anorganik dari masyarakat desa juga tinggi. Eksperimen ini fokus terhadap pengolahan sampah organik saja dengan media Maggot *Black Soldier Fly* (BSF) yang berpotensi dapat mengurai limbah organik. Tujuan penelitian ini untuk mengetahui tingkat degradasi sampah organik dengan media maggot BSF di Tempat Pembuangan Sementara (TPS) 3R Sekar Manfaat Kecamatan Sekaran, Kabupaten Lamongan. Hasil dari eksperimen ini antara lain massa Baby Maggot BSF sebelum dan sesudah mendegradasi sampah meningkat. Tingkat degradasi sampah organik dengan Baby Maggot BSF ialah sebesar Nasi (69.83%), tulang (50.5%), daging (46%), buah (45.83%), daun basah (31.5%) dan terakhir adalah daun kering (16.67%). Sedangkan, tingkat degradasi sampah organik dengan Maggot BSF Dewasa tidak sebesar tingkat degradasi sampah organik dengan media Baby Maggot BSF. Jenis sampah organik yang mudah terdegradasi oleh Maggot BSF Dewasa selama 24 jam yaitu daging, buah dan nasi yang terdagradasi sampai dengan 0.59, 0.44 dan 0.11 kg. Sedangkan jenis sampah organik yang paling lama terdegradasi selama 24 jam yaitu jenis daun kering, daun basah dan sayur yaitu terdegradasi sampai dengan 0.69, 0.59 dan 0.7 kg. Disimpulkan bahwa jenis sampah tidak mempengaruhi kuantitas Maggot BSF Dewasa sebelum dan sesudah mendegradasi sampah organik.

Keywords

BSF Larvae;
Degradation;
Organic waste;
Landfill

Abstract

Sekaran Village is a village with a dense population, so the quantity of waste, both organic and inorganic from the village community is also high. This experiment focuses on processing organic waste only with Maggot Black Soldier Fly (BSF) media which has the potential to decompose organic waste. The purpose of this study was to determine the level of degradation of organic waste with BSF maggot media at the Sekar Benefit 3R Temporary Disposal Site (TPS) Sekaran District, Lamongan Regency. The results of this experiment include the increase in the mass of Baby Maggot BSF before and after degrading waste. The level of degradation of organic waste with Baby Maggot BSF is rice (69.83%), bones (50.5%), meat (46%), fruit (45.83%), wet leaves (31.5%) and the last is dry leaves (16.67%). Meanwhile, the level of degradation of organic waste with Adult BSF Maggot is not as high as the level of degradation of organic waste with Baby Maggot BSF media. Organic waste type which easily degraded by Adults Maggot BSF for 24 hours are meat, fruit and rice up to 0.59, 0.44 and 0.11 kg. Meanwhile, dry leaves, wet leaves and vegetables, which were degraded up to 0.69, 0.59 and 0.7 kg. It was concluded that the type of organic waste did not affect the quantity of Adult BSF Maggot before and after degrading organic waste.

Introduction

Sekaran Village is a village with a population of 7058 people which is the village with the largest population in Sekaran Lamongan District(1). Automatically the quantity of waste throwed by the community is also high, both organic waste and inorganic waste(2). Seeing the amount of garbage that comes in every day, it is necessary to have other handlers in processing waste other than burning it. Burned waste can also cause many environmental problems and health problems for residents(3). If waste is burned, it will produce toxic fumes that are harmful to health, namely if the combustion process is not perfect(4). Garbage will decompose in the air as dioxin substances (5). This compound is very dangerous when inhaled by humans. The effects include triggering cancer, hepatitis, liver swelling, nervous system disorders, and triggering depression(6).

Garbage is one type of solid waste that is an environmental problem that has always been a serious problem in Sekaran Village and Sekaran Market, it can be said that the waste produced every day is countless, be it organic waste, inorganic waste, or toxic waste. The amount of waste produced by the people of Sekaran Village reaches an average of 955.76 kg on holidays and on normal days the average waste reaches 500 kg per day(7).

Maggot or larvae of the Black Soldier Fly (BSF) is one of the potential organisms used as an agent to decompose organic waste(8). Maggot growth is largely determined by the medium in which the maggot grows. The type of H. illucens fly likes a distinctive aroma of media but not all media can be used as a place to lay eggs for H. illucens flies(9). The use of larvae from these insects can be used to decompose organic waste that is usually produced by households. The opportunity to decompose using BSF larvae is very promising because harvested BSF larvae can be useful as a source of protein for an animal feed so that it can be used as an alternative feed to replace conventional feed(10). Mawaddah et al., 2018(11) stated that the fat content of BSF larvae flour was quite high at 27.36% compared to the fat content of flour in meat bone meal (MBM) which was only 5.59%.

Maggot BSF's ability to eat or degrade organic waste makes it widely used as a decomposer agent. According to Widyastuti & Sardin, 2021(12), Maggot BSF can digest organic waste by reducing organic waste by 65.5% to 78.9% per day from the amount of food it gets. Biological decomposition that occurs during composting is generally assisted by bacteria, actinomycetes, fungi, protozoa, worms, and several types of larvae (13). However, this microbial community is strongly influenced by the mesophilic phase and the thermophilic phase during the composting process and is also influenced by the physical properties of the waste-starting material (14). The ability of BSF flies in processing organic matter is caused by their digestive system which has a natural microbiome that helps the decomposition process of organic matter. According to (15), BSF flies have a variety of symbiotic bacteria including Bacillus sp.

Maggot BSF can also process organic matter into products that are used as fertilizer. The nutritional content is contained in commercial products on the market, so the solid product can be used as a substitute for compost (16). BSF maggots have a good ability to degrade organic waste indicated by the nutritional content of BSF larvae (17). The quality of nutrition given to Maggot BSF at the time of cultivation is important because it affects the body mass and size of the individual Maggot BSF produced.

Therefore, with this research, we were analyzed the percentage of domestic organic waste degradation by Baby Maggot BSF and Maggot BSF Adults and find out the potential for cultivating Maggot BSF collected at TPS 3R Sekaran Village, Sekaran District, Lamongan Regency.

Methods

This research uses an experimental method carried out at the Temporary Disposal Site (TPS) 3R Sekar Benefit Sekaran District, Lamongan Regency 19 to 26 September 2022.

Figure 1. Study Location
Source: Personal Documentation, 2022

There are seven types of organic waste used for this experiment, including bone waste, wet leaves, dry leaves, vegetables, fruit, rice, and meat. The types of maggots or fly larvae used were baby maggot black soldier fly (BSF) aged 3 days and adult BSF maggots aged 18-21 days.

Figure 2. Maggots BSF
Source: Personal Documentation, 2022

The tools and materials needed for this research include an observation tub measuring 33 x 28 x 13 cm, seven types of organic waste, baby maggot and adult BSF maggot, a storage rack, and plastic gloves. The organic waste studied came from household domestic waste in Sekaran Village, Sekaran District, Lamongan Regency, and also from Sekaran Market which had been sorted. The observed organic waste was 1 kg each with mixed media for baby maggot and adult maggot with quantities of 100 grams, 300 grams, 500 grams, 700 grams, 1000 grams, and 1300 grams, respectively. The treatment between observation samples can be described in the table below:

Table 1. The variants of sampling observation

Sample No.	Type / Maggot's Age	Type of Organic Waste	Maggot's Weight (gram)
1	Baby Maggot	Bone	100
2			300
3			500
4			700
5			1000
6			1300
7		Dry Leaves	100
8			300
9			500
10			700
11			1000
12			1300
13		Wet Leaves	100
14			300
15			500
16			700
17			1000
18			1300
19		Meat	100
20			300
21			500
22			700
23			1000
24			1300
25		Vegetables	100
26			300

Sample No.	Type / Maggot's Age	Type of Organic Waste	Maggot's Weight (gram)
27			500
28			700
29			1000
30			1300
31		Fruits	100
32			300
33			500
34			700
35			1000
36			1300
37		Rice	100
38			300
39			500
40			700
41			1000
42			1300
43	Adult Maggot BSF	Bone	100
44			300
45			500
46			700
47			1000
48			1300
49		Dry Leaves	100
50			300
51			500
52			700
53			1000
54			1300
55		Wet Leaves	100
56			300
57			500
58			700
59			1000
60			1300
61		Meat	100
62			300
63			500
64			700
65			1000
66			1300
67		Vegetables	100
68			300
69			500
70			700
71			1000
72			1300
73		Fruits	100
74			300
75			500
76			700
77			1000
78			1300
79		Rice	100
80			300
81			500
82			700
83			1000
85			1300

The independent variables in this study were: the mass or quantity of BSF maggot and BSF maggot age (baby maggot and adult maggot). While the dependent variables include: Types of organic waste (bone waste, wet leaves, dry leaves, fruit, rice, and meat) and the mass of organic waste weighing 1 kg.

The samples in Table 1 above were left for 24 hours for the organic waste degradation process. After being left for 24 hours, the organic waste data was recorded before and after being degraded by BSF maggots, after which the percentage of waste degradation was calculated. To calculate the effectiveness value or percentage of organic waste degradation using baby maggot and adult BSF maggot with the formula below:

$$\%Degradation = \frac{the\ mass\ of\ organic\ waste\ before\ mixing\ with\ Maggots - the\ mass\ of\ organic\ waste\ after\ mixing\ with\ Maggots}{the\ mass\ of\ organic\ waste\ before\ mixing\ with\ Maggots} \times 100\% \ldots\ldots\ldots\ldots 1)$$

The percentage of organic waste degradation data is then displayed using a bar graph using the Microsoft Excel 2013 application.

Results

1. Organic Waste Degradation Rate with Baby Maggot BSF

Based on the observations made, Table 2 below shows the results of the quantity of 1 kg of organic waste after being mixed with baby Maggot BSF media.

Table 2. Quantity of organic waste after mixing with Baby Maggot BSF

Baby Maggot's Weight in Reactor (gram)	The Weight of Organic Waste (kg)						
	Bones	Dry leaves	Wet leaves	Meat	Vegetable	Fruits	Rice
100	0.62	0.84	0.69	0.76	0.67	0.50	0.41
300	0.53	0.83	0.54	0.50	0.62	0.46	0.20
500	0.40	0.80	0.42	0.43	0.62	0.39	0.15
700	0.29	0.73	0.65	0.43	0.54	0.41	0.16
1000	0.28	0.65	0.54	0.37	0.41	0.41	0.15
1300	0.15	0.51	0.37	0.28	0.30	0.32	0.09

Based on the results of the above observations, it was found that the quantity of each degraded organic waste experienced a higher decrease when mixed with BSF baby maggot whose quantity was also higher. As a further analysis, Figure 3 below shows the percentage of domestic organic waste degradation with adult Maggot BSF media:

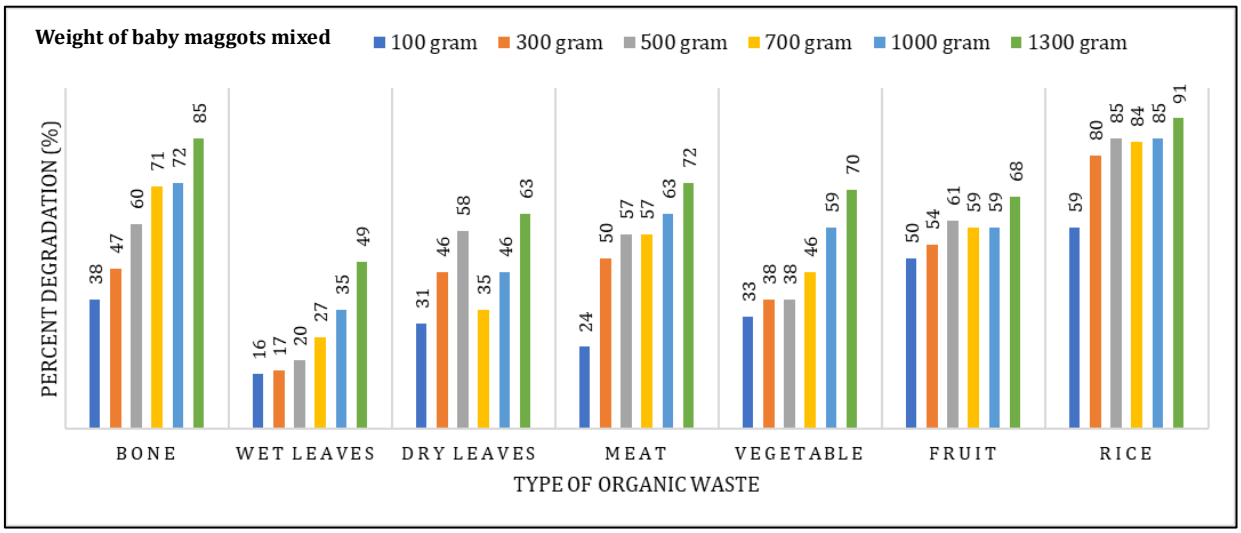

Figure 3. Percentage of Organic Waste Degradation with Baby Maggot BSF media

Based on Figure 3 above, it can be concluded that the order of organic waste from the easiest to the most difficult to degrade by Baby Maggot BSF are: Rice (80.67%), bones (62.17%), fruit (58.5%), meat (53.83%), wet leaves (46.5%) and the last is dry leaves (27.33%).

2. Baby Maggot BSF Quantity Before and After Degrading Organic Waste

In the previous sub-chapter, the level of degradation of organic waste has been analyzed. In this chapter, it is necessary to describe the analysis of changes in the mass of Baby Maggot BSF before and after degrading organic waste in Table 3 below:

Table 3. Baby Maggot BSF quantity before and after being mixed with organic waste

Baby Maggot BSF quantity before degrading with the organic waste (gram)	Baby Maggot BSF quantity after degrading with the organic waste (gram)						
	Bones	Dry leaves	Wet leaves	Meat	Vegetable	Fruits	Rice
100	120	170	200	290	273	190	540
300	310	380	470	462	490	460	760
500	521	590	599	523	540	660	788
700	707	860	893	750	747	742	720
1000	1080	1160	1620	1340	1310	1380	1483
1300	1324	1402	1582	1590	1430	1580	1450
	≥ Baby Maggot BSF quantity before degrading with the organic waste						
	≤ Baby Maggot BSF quantity before degrading with the organic waste						

Based on the observational data in Table 3 above, it shows that the quantity of BSF baby maggots after degrading all types of organic waste has increased, with an average of 254.71 - 1479. The order of the average quantity of BSF baby maggots after degrading organic waste from the lowest to the highest quantity is between others: bones (677 grams), dried leaves (760.33 grams), vegetables (798.33 grams), meat (825.83 grams), fruit (835.33 grams), wet leaves (894 grams) and rice (956.83 grams).

3. Organic Waste Degradation Rate with Adult BSF Maggot

Based on the observations made, Table 4 below shows the results of the quantity of 1 kg of organic waste after being mixed with Adult BSF Maggot media.

Table 4. Quantity of organic waste after mixing with Adult Maggot BSF

Baby Maggot's Weight in Reactor (gram)	The Weight of Organic Waste (kg)						
	Bones	Dry leaves	Wet leaves	Meat	Vegetable	Fruits	Rice
100	0.91	0.97	0.73	0.86	0.87	0.60	0.51
300	0.60	0.98	0.60	0.56	0.72	0.66	0.30
500	0.49	0.90	0.69	0.57	0.82	0.48	0.21
700	0.34	0.69	0.88	0.49	0.84	0.56	0.16
1000	0.32	0.77	0.62	0.37	0.71	0.51	0.52
1300	0.31	0.69	0.59	0.39	0.70	0.44	0.11

Based on the above observations, it was found that the more Adult BSF Maggot mixed with domestic organic waste, the more quantity of organic waste degraded. Types of organic waste that are easily degraded by the Adult BSF Maggot for 24 hours are meat, fruit and rice which are degraded up to 0.59, 0.44 and 0.11 kg respectively after being mixed with Adult BSF Maggot. Meanwhile, the types of organic waste that were degraded the longest for 24 hours were dry leaves, wet leaves and vegetables, which were degraded up to 0.69, 0.59 and 0.7 kg. As a further analysis, Figure 5 below shows the percentage of domestic organic waste degradation with adult Maggot BSF media:

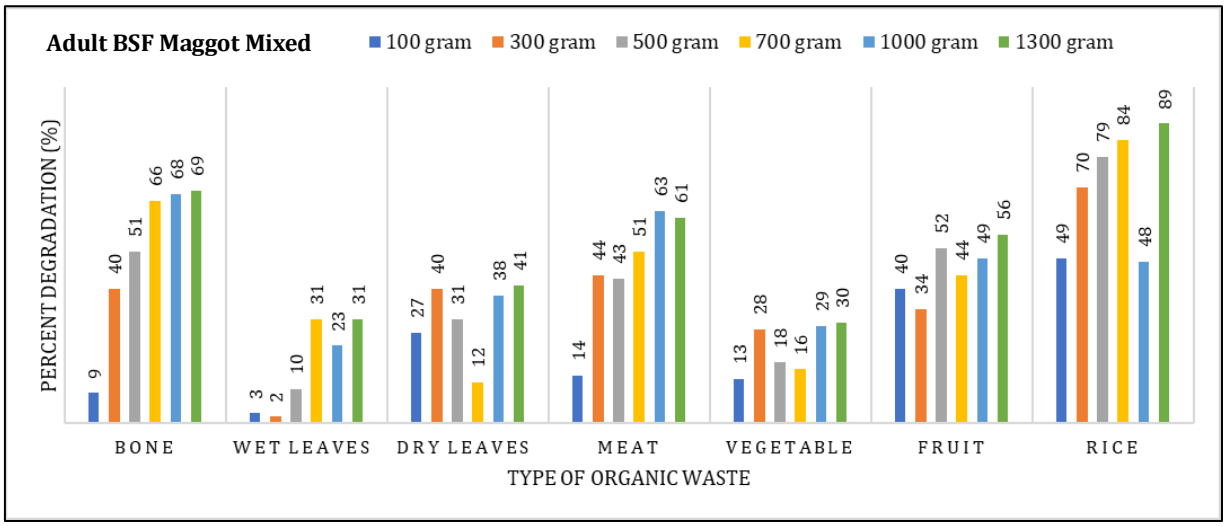

Figure 4. Percentage of Organic Waste Degradation with Adult BSF Maggot media

Based on Figure 4 above, it can be concluded that the order of organic waste from the easiest to the most difficult to degrade by Maggot BSF Adults are: Rice (69.83%), bones (50.5%), meat (46%), fruit (45.83%), wet leaves (31.5%) and the last is dry leaves (16.67%).

4. Adult BSF Maggot Mass Before and After Degrading the Organic Waste

In the previous sub-chapter the level of degradation of organic waste has been analyzed. In this chapter, it is necessary to describe the analysis of changes in the mass of Adult BSF Maggot before and after degrading organic waste in Table 5 below:

Table 5. Adult Maggot BSF quantity before and after being mixed with organic waste

Baby Maggot BSF quantity before degrading with the organic waste (gram)	Baby Maggot BSF quantity after degrading with the organic waste (gram)						
	Bones	Dry leaves	Wet leaves	Meat	Vegetable	Fruits	Rice
100	280	80	90	120	95	90	430
300	510	480	470	530	390	560	740
500	560	690	560	500	440	560	740
700	388	360	400	550	700	742	620
1000	1480	1460	1620	1240	1410	1680	1450
1300	960	1.000	1.190	2.190	1.230	1.080	940

≥ Baby Maggot BSF quantity before degrading with the organic waste

≤ Baby Maggot BSF quantity before degrading with the organic waste

Based on Table 5 regarding the Quantity of Adult BSF Maggot before and after being mixed with organic waste, it can be concluded that the type of waste does not affect the quantity of Adult BSF Maggot before and after degrading organic waste.

Discussion

According the observation result, it can conclude that when the mass of Baby Maggot BSF increase, then the degradation rate was also increasing. The order of organic waste from the easiest to the most difficult to degrade by Baby Maggot BSF are: Rice (80.67%), bones (62.17%), fruit (58.5%), meat (53.83%), wet leaves (46.5%) and the last is dry leaves (27.33%). There have been many ways of processing waste, one of which is by using the waste to become a protein source for feed ingredients through a bioconversion process (18). As said Nyakeri et al., 2017 (19) stated that in this process organic waste will be converted into simple compounds, both protein and fat, through a fermentation process that utilizes living organisms. This bioconversion process can be carried out by certain insects, one of which is the Black Soldier Fly *(Hermetia illucens)* have cellulotic activity in the presence of bacteria in their intestines (20). The presence of bacteria in the larvae's intestines helps the larvae convert organic waste in their intestines. Both

Baby Maggots and Adult BSF Maggots tend to be slow to degrade dry leaf litter. This is based on observations that show that the quantity of dry waste is not significantly degraded compared to other types of organic waste. This phenomenon occurs because BSF larvae do not like bait with high water content and will look for a drier place so that watery bait is not consumed optimally. Nursaid, 2019(21) stated that the most optimum bait condition for the growth of BSF larvae was a water content of 60%.

It was also stated by Saragi & Bagastyo, 2015 (22) that the condition of growing media/feed/feed for larvae with high water content will cause anaerobic conditions. The decomposition process of organic matter under anaerobic conditions will produce NH_3 (ammonia) and CH_4 (methane) which can inhibit the feed consumption process by larvae and affect their growth. Baby Maggot BSF tends to increase in quantity or weight after degrading waste. This is because Baby Maggot BSF is still old (7-14 days) and is still in its infancy. While the adult BSF maggots tend to decrease in quantity or weight because the adult BSF maggots have changed or metamorphosed into BSF flies (23). Naturally, BSF maggots can be found in fruit waste in the market and in biodecomposers in various places. Maggot is known not to be a pest, because its adult form has no interest in the human environment or food (24). The optimal environmental conditions for maggot are as follows: Maggots live in ideal environmental temperatures ranging from 24°C to 30°C. If it gets too hot, the maggot will walk out of its feed source to find a cooler location (25). If it is too cold, the metabolism of maggot will become slow. As a result, maggot consumes lesser and cause growth to slow down. Maggot BSF avoids light and always looks for a dim place and away from sunlight (26). When the food source is exposed to light, the maggot will move to a deeper layer of the food source to escape the light.

Three factors strongly influenced larval yield and waste reduction capacity: (1) lack of fertile eggs; (2) high larval mortality due to the hostile environment in the larva (anaerobic conditions) and (3) limited access to food due to stagnating liquid in the larveros. Though the elimination of these stumbling blocks is simple, future research will have to concentrate on two main aspects: the biological key factors as well as the design and operation of the treatment facility. Enhanced knowledge of the environmental and nutritional requirements of Maggot BSF will significantly improve the resilience of the treatment system. Thanks to the larvae's natural habit to colonise feed sources undergoing changes in time, Maggots have developed several peculiarities to warrant survival of the population. During food shortages or unfavorable conditions (oxygen deficiency or low temperatures), the larvae reduce or cease to feed. Under other conditions, when survival of the individual is endangered (e.g. high temperature, toxic conditions), the larvae try to abandon the feed source. For a successful soldier fly treatment system, it is therefore of utmost importance to determine what triggers cessation of food intake or mass migration of immature larvae.

The design and operation of the treatment facility are subject to the local context as well as existing habits and requirements. The nature of the waste products and the availability of labor and machinery strongly influence the construction of the facility. However, the following recommendations are generally applicable: (1) a regular, well-balanced food supply prevents bad odors and guarantees a consistent and efficient feeding activity; (2) a drainage system is required when working with wet material (household waste, pig manure) or in a humid climate and (3) use of a ramp for self-harvesting proved of great value and its further development should be pursued. Based on the aforementioned prerequisites, at least 15 kg of fresh municipal organic waste can be added daily yielding a prepupal harvest of 0.8–1.0 kg.

Conclusion

Based on the result, it can be concluded that the Baby Maggot BSF and adult BSF Maggot have the potential as a medium for degrading organic waste, especially the most effective rice, bone, and meat waste within one day. In degrading waste during the Baby Maggot BSF weight increases because it is experiencing a growth period, while the adult BSF Maggot weight after degrading waste decreases because some have changed or metamorphosed into BSF flies.

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References

1. Badan Pusat Statistik Kabupaten Lamongan. Banyaknya Penduduk dan Keluarga di Kecamatan Sekaran 2021. https://lamongankab.bps.go.id/statictable/2018/04/27/4674/banyaknya-penduduk-dan-keluarga-di-kecamatan-sekaran-2014.html. 2021.
2. Astuti RD, Budi AS. Upaya Pemberdayaan Masyarakat melalui Kardus (Kerajinan Daur Ulang Sampah) Plastik di Desa Manyar Kecamatan Sekaran Kabupaten Lamongan. J Abdimas Berdaya J Pembelajaran, Pemberdaya dan Pengabdi Masy. 2020;1(02):67–72.
3. Elamin MZ, Ilmi KN, Tahrirah T, Zarnuzi YA, Suci YC, Rahmawati DR, et al. Analysis of waste management in the Village of Disanah, District of Sreseh Sampang, Madura. J Kesehat Lingkung. 2018;10(4):368–75.

4. Sari PN. Analisis pengelolaan sampah padat di kecamatan Banuhampu kabupaten Agam. J Kesehat Masy Andalas. 2017;10(2):157–65.
5. Marliani N. Pemanfaatan limbah rumah tangga (sampah anorganik) sebagai bentuk implementasi dari pendidikan lingkungan hidup. Form J Ilm Pendidik MIPA. 2015;4(2).
6. Efrizal W. Dampak Cemaran Dioksin Bagi Keadaan Gizi Dan Kesehatan: Literature Review. J Kesehat Lingkung J dan Apl Tek Kesehat Lingkung. 2022;19(1):23–30.
7. Sekaran PD. Profil Desa Sekaran Kecamatan Sekaran Kabupaten Lamongan. 2022.
8. Utami I, Putra ILI, Khotimah K, Pangestu RG. Maggot Black Soldier Fly sebagai agen degradasi sampah organik dan pakan ternak warga mergangsan Yogyakarta. LOGISTA-Jurnal Ilm Pengabdi Kpd Masy. 2020;4(2):127–35.
9. Gold M, Tomberlin JK, Diener S, Zurbrügg C, Mathys A. Decomposition of biowaste macronutrients, microbes, and chemicals in black soldier fly larval treatment: A review. Waste Manag. 2018;82:302–18.
10. Dai M, McBride R, Dortmans JCFM, Peng W, Bakkers MJG, de Groot RJ, et al. Mutation of the second sialic acid-binding site, resulting in reduced neuraminidase activity, preceded the emergence of H7N9 influenza A virus. J Virol. 2017;91(9):e00049-17.
11. Mawaddah S, Hermana W, Nahrowi N. Pengaruh pemberian tepung deffated Larva BSF (Hermetia illucens) terhadap performa produksi puyuh petelur (Coturnix coturnix japonica). J Ilmu Nutr dan Teknol Pakan. 2018;16(3):47–51.
12. Widyastuti S, Sardin S. Pengolahan Sampah Organik Pasar Dengan Menggunakan Media Larva Black Soldier Flies (BSF). WAKTU J Tek UNIPA. 2021;19(01):1–13.
13. Pathiassana MT. Studi Laju Umpan Pada Proses Biokonversi Dengan Variasi Jenis Sampah Yang Dikelola PT. Biomagg Sinergi Internasional Menggunakan Larva Black Soldier Fly (Hermetia Illucens). 2020;
14. Wulansari R, Yuniarti A, Rezamela E. Efektifitas Pembuatan Kompos Limbah Pabrik Teh Hijau (Tea Fluff) Menggunakan EM4 dan Pupuk Kandang Sapi. soilrens. 2020;18(1).
15. Kusumawati PE, Dewi YS, Sunaryanto R. Pemanfaatan Larva Lalat Black Soldier Fly (Hermetia Illucens) Untuk Pembuatan Pupuk Kompos Padat Dan Pupuk Kompos Cair. J TechLINK Vol. 2020;4(1).
16. Nurrahmadhan BA, Gusta AR, Same M. Respons Pertumbuhan Tanaman Lada Perdu Terhadap Pemberian Pupuk Kompos Larva Black Soldier Fly. Agroplantae J Ilm Terap Budid dan Pengelolaan Tanam Pertan dan Perkeb. 2022;11(1):46–58.
17. Monita L, Sutjahjo SH, Amin AA, Fahmi MR. Pengolahan Sampah Organik Perkotaan Menggunakan Larva Black Soldier Fly (Hermetia illucens). J Pengelolaan Sumberd Alam Dan Lingkung (Journal Nat Resour Environ Manag. 2017;7(3):227–34.
18. Ichwan M, Siregar A, … TN-ICS, 2021 undefined. The use of BSF (Black Soldier Fly) maggot in mini biopond as a solution for organic waste management on a household scale. iopscience.iop.org [Internet]. [cited 2022 Oct 25]; Available from: https://iopscience.iop.org/article/10.1088/1755-1315/782/3/032032/meta
19. Nyakeri E, Ogola H, … MA-… of I as F and, 2017 undefined. Valorisation of organic waste material: growth performance of wild black soldier fly larvae (Hermetia illucens) reared on different organic wastes. ingentaconnect.com [Internet]. [cited 2022 Oct 25]; Available from: https://www.ingentaconnect.com/content/wagac/jiff/2017/00000003/00000003/art00005
20. Supriyatna A, Ukit U. Screening and isolation of cellulolytic bacteria from gut of black soldier flays larvae (Hermetia illucens) feeding with rice straw. Biosaintifika J Biol Biol Educ. 2016;8(3):314–20.
21. Nursaid AA. Analisis Laju Penguraian dan Hasil Kompos pada Pengolahan Sampah Buah dengan Larva Black Soldier Fly (Hermetia Illucens). 2019;
22. Saragi ES, Bagastyo AY. Reduction of organic solid waste by black soldier fly (Hermetia illucens) larvae. In: The 5th Environmental Technology and Management Conference "Green Technology towards Sustainable Environment" November. 2015. p. 2015.
23. Tschirner M, Simon A. Influence of different growing substrates and processing on the nutrient composition of black soldier fly larvae destined for animal feed. J insects as food Feed. 2015;1(4):249–59.
24. Kenis M, Bouwassi B, Boafo H, Devic E, Han R, Koko G, et al. Small-scale fly larvae production for animal feed. Edible insects Sustain food Syst. 2018;239–61.
25. da Silva GDP, Hesselberg T. A review of the use of black soldier fly larvae, Hermetia illucens (Diptera: Stratiomyidae), to compost organic waste in tropical regions. Neotrop Entomol. 2020;49(2):151–62.
26. Bosch G, Van Zanten HHE, Zamprogna A, Veenenbos M, Meijer NP, Van der Fels-Klerx HJ, et al. Conversion of organic resources by black soldier fly larvae: Legislation, efficiency and environmental impact. J Clean Prod. 2019;222:355–63.