Zero-Waste System Education in Ecotourism Area of Kebonagung Village, Imogiri District, Yogyakarta Province, Indonesia

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ABSTRACT

The amount of organic and inorganic waste which has not been appropriately managed has become a global problem. The zero-waste system can then be a solution to waste problems. The zero-waste system must be implemented to protect areas with valuable natural and cultural resources. For instance, it could be implemented in the ecotourism area of Kebonagung village, Imogiri District, Yogyakarta. This educational program aims to provide understanding and upgrading skills related to the zero-waste system by creating a waste-free ecotourism area. This program will be conducted from December 2021 to September 2022 through socialization, waste treatment training and application, and evaluation monitoring. This program resulted in the socialization implementation of inorganic waste processing, liquid organic fertilizer, home-grown vegetables, *Mina-padi* (rice-fish farming), biogas, and Black Soldier Fly (maggot) larvae cultivation—which is the main focus of this program. Waste system training and application are carried out by turning plastic bottles into crafts, building *Omah Maggot* (a maggot breeding ground), also maggot cultivation training, monitoring, and guidance. This maggot cultivation could accommodate up to four kilograms of organic waste per day, along with a half kilogram of harvested maggot that could be harvested as fish seed. The remaining organic waste, known as *kasgot*, can be used as plant fertilizer. From evaluation to in-depth interviews, it is known that the community understands the zero-waste system concept and application. Yet, they lacked the organic waste handling experience for maggot, and no group yet can handle inorganic waste processing. From the results obtained, it can be concluded that this program received positive support and responses from the community that has gained knowledge and skills related to a zero-waste system toward creating a waste-free area.

Keywords: Black Soldier Fly, Ecotourism, Inorganic Waste, Organic Waste, Zero-Waste System

1 Introduction

Almost all human activities produce waste from various sectors, e.g., the food industry, agriculture, factories, and households. A large amount of organic and inorganic waste has become a global problem. Waste that is not appropriately managed in the environment will cause many pollutions and diseases, which will undoubtedly affect the surrounding ecosystem, including humans, as it can even reduce the quality of human life. Hence, severe handling or management of waste is needed, while at the same time, it also must be financially sustainable, technically feasible, socially acceptable, legal, and environmentally friendly [1].

Zero-waste system (ZWS) is an alternative solution for waste management. It has a circular scheme to minimize or eliminate residual substances produced from the waste management process [2]. Zero-waste has a multi-positive impact on the economy, community, and environment sectors as it possibly creates job vacancy, generate additional income, increase community capacity and capabilities, prolong prosperity, reduce toxic materials, and make a healthy environment [3]. Many zero-waste-related activities include recycling plastic waste into crafts, using eco-friendly packaging, and processing organic waste by making fertilizer and cultivating Black Soldier Fly (maggot) larvae. Zero-Waste System is urgently needed in Indonesia, especially in areas with valuable natural and cultural resources, such as ecotourism.

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Kebonagung is one of the villages in Kapanewon Imogiri, Bantul, Yogyakarta—one of the ecotourism pilot villages with various potential resources, such as agriculture, animal husbandry, crafts, culinary, and community organizations [4]. As an ecotourism area, Kebonagung village has yet to have a good waste management system, so establishing a zero-waste system can be the proper solution to tackle this problem. In order to apply this concept, a program entitled zero-waste system education in the ecotourism area of Kebonagung was implemented. This program would conclude several activities, such as socialization and application, that focused on processing organic waste with maggot cultivation. Zero-waste system education also aligns with the Bantul Government's plan to become a waste-free area by 2025. This program aims to create a waste-free ecotourism area in Kebonagung Village by providing understanding and skills related to the zero-waste system to build a healthy and sustainable environment, attract visitors, and be considered a role model for other areas.

2 Methodology

This activity involved collaboration between the Faculty of Biology Community Service Team, which consists of 6 lecturers, along with the 2022 Student Community Service Community Empowerment Learning of Universitas Gadjah Mada (KKN-PPM UGM) YO-018 Team 2nd Period unit, which consisted of 14 students in Kebonagung Village, Imogiri, Bantul, Yogyakarta. This activity was carried out from December 2021 to September 2022, which was started by signing a joint memorandum of understanding regarding the collaboration between the Faculty of Biology UGM and the local government to carry out community service programs. The targets and outputs achieved in this program are human resources with adequate comprehension and skills related to processing waste (inorganic and organic) and other concepts related to zero-waste systems and creating activities that support zero-waste systems in the ecotourism area of Kebonagung. The methods are divided into socialization, training and applications, and monitoring and evaluation.

2.1 Socialization Related to Zero-Waste System in The Local Community

Socialization aims to provide the community with a comprehensive understanding. Socialization activities are performed periodically at different times with various topics of discussion related to the zero-waste system. Overall, the socialization was divided into three main steps at three different times: December 4, 2021, July 20, 2022, and August 4, 2022. The academic stakeholders and students of Universitas Gadjah Mada participated in this socialization as speakers and activity facilitators. The target participants for socialization and training vary, ranging from children to youth to elders.

2.2 Training and Applications of Organic and Inorganic Waste Management in an Integrated Manner

This activity aims to provide skills related to topics that have been previously socialized. Applications or hands-on are carried out so that participants get a higher level of comprehension from the knowledge they have acquired. This activity required processing waste that is divided into two different types, namely inorganic and organic waste. The implementation of organic waste processing activities is carried out continuously and integrated, which focuses on processing organic waste by cultivating Black Soldier Fly (maggot) larvae.

2.3 Monitoring and Evaluation

This activity aims to find out how far the knowledge and skills the community has gained and what obstacles they face. Monitoring and evaluation are conducted using online evaluation forms and direct interviews with several community representatives involved in the program. The information obtained would be taken into consideration and input for future steps.

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3 Theory

3.1 Huge Amount of Waste

Waste can be categorized into organic and inorganic waste. One of the wastes that contribute a lot to our planet is food waste. The data from UNEP [5] stated that in the household sector, countries, whether high-income, upper-middle, or even lower-middle, respectively, produce food waste with an average of 79, 76, and 91 kilograms per capita per year. Based on a study about household waste production in Jakarta, Indonesia, there were at least 1.32 kilograms per household each day or equivalent to 0.33 kilograms per capita per day of solid waste generated with a waste composition of 52% in the form of food scraps (kitchen waste) and 22% in the form of inorganic solid waste consisting of plastic, metal, and disposable diapers [6]. This waste management program is challenging for every developed and developing country. If not followed by proper waste management methods, waste production that increases daily will result in an unclean and unhealthy environment [7]. Waste that is not appropriately managed is usually only collected in a specific place, creating a pile of waste that is not separated based on their types (organic and inorganic) that will then cause disease. This waste pile may appear anywhere, for instance, land near settlements, reservoirs, or even floating (and flowing) in rivers. A pile of solid waste will be an excellent place for disease vectors to multiply and increase vector-borne diseases and urban zoonoses [8].

3.2 Zero-Waste System

The zero-waste system is a waste management strategy that involves an integrated process of preventing useless materials from maintaining environmental conditions [9]. The zero-waste concept is not an idea to banish waste entirely from the earth, which is impossible as no human activity does not produce waste. This concept is more about attempting to reduce the amount of waste that goes to landfills as much as possible [10]. This is considered a visionary concept for dealing with waste problems in society. This concept includes zero-waste sustainable production and consumption, optimizing recycling activities, and supporting resource recovery [11]. Zero-waste supporting activities include waste recycling, environmentally friendly packaging, innovative technologies, etc. [12]. A finding from the Resource, Environment, and Sustainability review study [13] shows that zero-waste programs are implemented in many countries without an overall zero-waste strategy. This study emphasizes that countries may achieve zero-waste goals by developing a national zero-waste strategy by integrating and promoting zero-waste initiatives (in society or industry) through policies regarding waste management. The zero-waste concept has begun to be implemented in specific areas worldwide. However, there are still many challenges, e.g., the zero-waste city of a coal resource-based area in China [14].

3.3 Black Soldier Fly Larvae (Maggot)

The Black Soldier Fly (BSF), scientifically named *Hermetia illucens*, is an insect that undergoes a metamorphosis from egg, larva, prepupae, pupa, to adult insects for approximately 45 or 46 days [15]. The step where larvae transform into pupae is commonly known as maggots. The Black Soldier Fly is well known and increasingly popular with its ability to bio-convert organic waste from several flows quickly and easily, for example, food industry waste, household kitchen waste, also cow and chicken manures. Processing organic waste with maggot is a step that may support a circular economy [16], as how the larvae and pupae of these flies can be used as animal feed, which is rich in nutrients, especially protein. These larvae are usually given as chicken and fish feed [17]. Meanwhile, Black Soldier Fly Frass, an organic waste's leftover material, can be used as a good fertilizer for plant growth as it is rich in soil nutrients and does not interfere with soil hygiene [18].

4 Results and Discussion

The results of this zero-waste system program were a series of implementations in the form of socialization, training, application, monitoring, and evaluations—which can be explained in detail as follows.

4.1 Socialization Related to the Zero-Waste System in the Local Community

The first phase of socialization, conducted on December 4, 2021, discussed topics related to introducing the zero-waste system concept, environmentally friendly concepts, waste management, and production efficiency (Figure 1). This socialization was entitled "Integrated Community Zero-waste System Training". This event was attended by Mrs. Marjiyem (the Head of the Kebonagung Village), Mr. Wagiyana (the Head of the Kanten Hamlet), ten representatives of the Taruna Tani (farming associations), and ten representatives of the Kelompok Wanita Tani or KWT (women farming associations). In this socialization, there were four topics of the discussion presented by different speakers, which are: (1) the manufacture of liquid organic fertilizer topic with Mr. Sukirno, M.Sc., Ph.D. as the speaker; (2) planting home-grown vegetable topic with Novita Yustinadiar, S.Sc., M.Sc. as the speaker; (3) increasing productivity with *mina-padi* topic with Nur Indah Septriani, M.Sc., Ph.D. as the speaker; as well as (4) production of biogas topic with Dr. Aprilia Sufi Subiastuti as the speaker. Liquid organic fertilizer was introduced to the community as it is easy to make and uses organic waste as the product's base material. It can be a solution to utilizing organic waste, especially household organic waste. The topic of growing home-grown vegetables can support children's and families' nutrition fulfillment. Growing our home-grown vegetables is more environmentally friendly than buying them from markets, especially vegetables in stores already packaged with plastic. The topic of increasing the productivity of mina-padi explains the particular technique of planting rice together with fish farming, which can increase the efficiency of rice and fish production. Fish manure can be a soil fertilizer to reduce fertilizer costs. *Mina-padi* also cut the need for fish farming land. In addition, we can already find an area that applied the *Mina-padi* concept in Kebonagung. Therefore, this socialization may improve the quality of the applied *Mina-padi.* The topic of making biogas explains the method of utilizing cow manure to be converted into valuable biogas. This topic can be considered a very suitable topic introduced to the community as several cattle farm groups are in Kebonagung.

Figure 1: *Socialization of Mina-Padi*

The second socialization stage was conducted on July 20, 2022, by discussing processing organic waste by cultivating Black Soldier Fly (BSF) larvae (Figure 2). This activity was carried out at the Kebonagung Village Government Office. There were 38 participants: farmer groups, youth associations, and the local community. This topic focuses on maggot cultivation, which is divided into three main parts: maggot cultivation in general, mass and integrated maggot cultivation, and small-scale maggot cultivation using the stacked bucket technique. Two speakers delivered this socialization from Universitas Gadjah Mada: Dr.

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Aprilia Sufi Subiastuti, S.Si, and Pipit Noviyani, S.Si. Cultivating maggots can also be a solution for utilizing organic waste from households and livestock manure, such as chickens and cows. The speakers at this socialization brought various props and maggot samples to provide an in-depth understanding of the community. The attendees were enthusiastic about this event, as seen by several participants asking numerous questions at the end. Three participants were given prizes for correctly answering the quiz the speakers gave. This enthusiasm leads to making maggot cultivation the main focus of the zero-waste system program series, especially direct practice activities. In addition, maggot cultivation was chosen as the main activity for several reasons. It can convert organic waste very quickly, does not carry pathogens that are harmful to humans, does not have a significant impact on greenhouse gases, and can be an alternative fish feed as maggot is a source of protein [17], [19].

Figure 2: *Socialization of organic waste processing with maggot cultivation*

The third socialization phase was conducted on August 4, 2022, with the topic of inorganic waste processing. This activity discussed the environment and environmentally friendly concepts involving elementary school children as these understandings must be embedded as a fundamental paradigm from a very young age. A collaboration has been established with SDN 1 Kebonagung within its implementation. The target participants are 5th graders, with approximately 25 children in total. In addition, Universitas Gadjah Mada students guided this activity.

4.2 Training and Application of Organic and Inorganic Waste Management in an Integrated Manner

Hands-on practice of inorganic waste processing was carried out directly during the socialization of waste sorting and waste processing on August 4, 2022. This activity involved children as the target participants. They were invited to sort organic and inorganic waste and utilize inorganic waste as the base material to make more valuable items. They also specifically made a toy as a water rocket from plastic bottle waste (Figure 3).

Figure 3: *Children's activity of making toys from plastic waste*

As the program's primary focus, maggot cultivation is an activity for the direct practice of organic waste processing. This hands-on practice is divided into three stages: the construction of *Omah Maggot* (a particular building for maggot cultivation), maggot cultivation training, and continuous monitoring and guidance. After understanding organic waste processing with maggot cultivation at the socialization, direct practical activities were carried out to build appropriate skills. Youth and elders were involved in building the *Omah Maggot,* which used to be an empty area 4x6m^2 wide and was approximately five meters away from the residential areas (Figure 4). This building's location is not too close to the residential areas, so the smell produced by the *Omah Maggot* would not easily bother the residents. *Omah Maggot* was made modestly with walls made of nets—so the air and sunlight could enter the building, yet the flies (BSP) could not come out, or other flies could not enter the building. Several facilities can support various needs for maggot cultivation inside this building, including a bio-pond shelf for larvae's growth, a bio-pond shelf for pre-pupae migration (a place for flies to lay eggs or commonly called "eggies"), a bio-pond shelf for hatching eggs, and flies breeding ground.

Figure 4: *Omah Maggot*

The training was carried out to provide examples of proper and correct maggot cultivation techniques. The training was held on August 13, 2022, at *Omah Maggot* (Figure 5). The target participants are representatives of youth who are members of the Rukun Santoso Tani (Youth Farmers Group), which will also be in charge of *Omah Maggot*'s future operations. The training explained the concept of the *Omah Maggot* building and facilities, as well as a series of maggot cultivation consisting of hatching eggs, maggot feeding techniques with different kinds of organic waste, separating pre-pupae techniques, producing flies (BSF) techniques, and harvesting flies' eggs techniques. This training is the first step, as youth can carry out maggot cultivation independently in the future. Afterward, the community carried out all maggot cultivation activities independently while still being given continuous monitoring and guidance.

Figure 5: *Maggot cultivation techniques training*

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From the maggot cultivation results that the community has carried out, *Omah Maggot* could accommodate around four kilograms of organic food waste per day from the surrounding households and traditional food stalls (the local community called them *angkringan*) near the *mina-padi* area. Apart from that, approximately ½ kg of maggot can be harvested from *Omah Maggot* per day, which can be used for alternative fish feed in the *mina-padi* area and other areas. This maggot cultivation activity does not produce useless waste or substances in line with the zero-waste system concept. The remaining organic waste used for maggot processing will form a dry and fine material commonly referred to as "*bekas maggot*" (lapsed maggot) and abbreviated as *kasgot*, which could be used as good organic fertilizer. The community uses it as fertilizer for the eggplant as there are eggplant gardens (in fact, Kebonagung has an area known as the Eggplant Village), which are also around the *mina-padi* area. This integrated activity will certainly save fertilizer and fish feed costs. In addition, this activity also reduces waste to create a cleaner and healthier environment, along with increasing tourism and residents' income. Afterward, the inorganic and organic waste processing will be operated and monitored by a village-owned enterprise or BUMDes to generate the whole activity effectively and integrate it. In summary, the implementation of the zero-waste system concept that has been carried out can be seen in Figure 6.

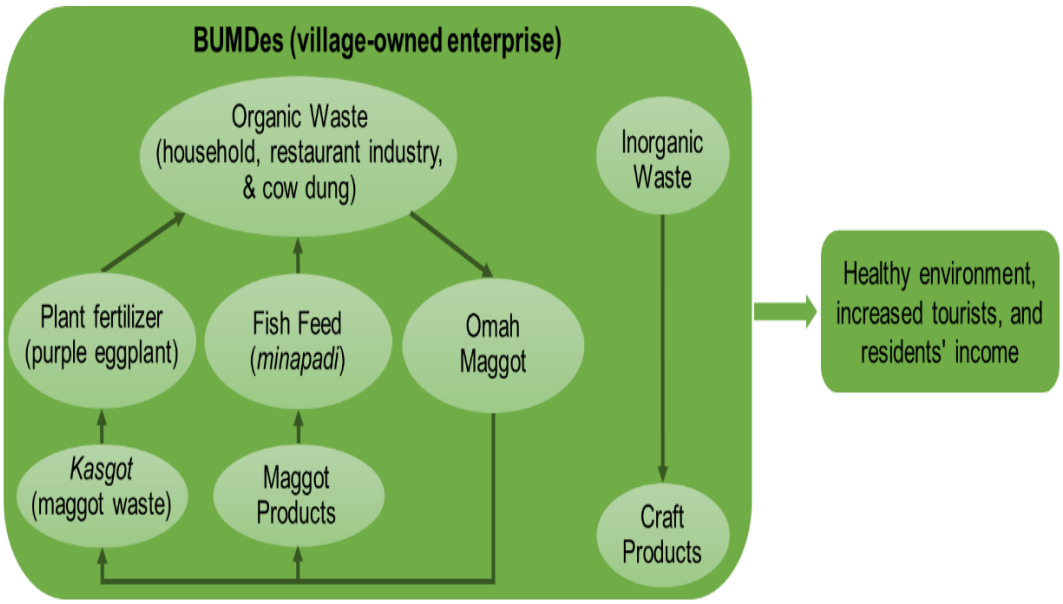

Figure 6: *Implementation of the Integrated Zero-Waste System*

4.3 Monitoring and Evaluation

Based on the monitoring and evaluation carried out by online evaluation forms and in-depth interviews, it has shown that the community had already understood the zero-waste system concept, especially regarding maggot cultivation seen by their comprehension of maggot cultivation techniques. Yet, the obstacles were the lack of water supply needed for the maggot feed and the absence of a group that could sustainably process inorganic waste. Nevertheless, this ecotourism area's visitors felt deeply interested in this concept – emerging an idea to apply this education as a tourist attraction and an interactive learning media as it is considered potential. One of the visits was from the SD Tumbuh (Figure 7). Based on these obstacles, the future program plans are to ensure *Omah Maggot*'s operations sustainability with an adequate supply of organic waste, pioneering the establishment of BUMDes for processing organic and inorganic waste, also creating more attractive ecotourism attractions and websites.

Figure 7: *A visit from SD Tumbuh to Omah Maggot*

5 Conclusion

The zero-waste system Education Program in Kebonagung, Yogyakarta, received positive support, response, enthusiasm, and attraction from the local community and visitors. Through this program, the community gained comprehensive knowledge and skills related to the zero-waste system, especially maggot cultivation, through socialization, training, application monitoring, and evaluation activities. This program can be the first step to creating a healthy and waste-free Kebonagung ecotourism area.

6 Declarations

6.1 Acknowledgments

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