

Hong Kong Student Science Project Competition 2023

Template of Extended Abstract (Invention)
(Word Limit: 1,600 words, Pages: 3 pages only)

Team Number: SAPE046

Project Title: Food Waste Up-cycler 2.0

Project Type: Invention

*To our best knowledge, there are / ~~are no~~ * similar works in the market; (if there are,) related product links are as below:*

Kim, Chul-Hwan, et. al. 2021. "Use of Black Soldier Fly Larvae for Food Waste Treatment and Energy Production in Asian Countries: A Review" Processes 9, no. 1: 161. (<https://www.mdpi.com/2227-9717/9/1/161>)

The enhancement our project made / the difference with related products are:

- For the similar works in this field, they usually focus on the large-scale food waste treatment but not those can work in a small community directly. Our system is suggested to make this goal possible.

**Please delete if not applicable. The competition values the originality of works. Students must do enough literature research to ensure that their works are unique and list relevant reference materials before starting research or invention.*

I. Background

The food waste problem has been deteriorating in Hong Kong. In 2022, 3,353 tonnes of food was sent to landfill everyday, which accounted for one-third of all solid waste. Food waste mainly comes from households, companies and industries. In the household, each Hong Kong resident is estimated to produce 71 kg of food waste every year. About 778 tonnes of food waste were generated from commercial and industrial sources such as restaurants, hotels, wet markets, food production and processing industries. However, only 4.6% was recycled and the others were thrown away to landfill. The only three landfills operated are nearly full [1] According to the United Nations Environment Programme, nearly 570 million tons of household food waste is produced which is 11% of global food production. As the food waste problem is getting more serious, it is crystal clear that an efficient way to handle food waste is needed. [2]

This project is about making use of larvae of black soldier flies, which have a very high food consumption and growing rate, to consume food waste. This can decompose food waste in a low cost and sustainably. [3] The experiments running in this project is also to reveal if any side effects in actual use of the system, especially on working efficiency and state of black soldier flies.

[1] E. Environmental Protection Department, "Food Waste Challenge", Environmental Protection Department, 2023. [Online].

[2] M. Niall, "The Enormous Scale Of Global Food Waste", Statista, 2021. [Online].

[3] Kim, Chul-Hwan, JunHee Ryu, Jongkeun Lee, Kwanyoung Ko, Ji-yeon Lee, Ki Young Park, and Haegeun Chung. 2021. "Use of Black Soldier Fly Larvae for Food Waste Treatment and Energy Production in Asian Countries: A Review" Processes 9, no. 1: 161.

II. Objectives

Our project aims to introduce our system at school to educate our students through an informative video and consume the lunch-time food waste. Then, the products, which are the digested food wastes, can be collected in our fertilizer collection chamber and be used in producing other products like fertilizer. Moreover, the increasing mass of black soldier fly larvae indicates that more biomass for further use like producing biofuel and extract chitosan can be carried out. We hope this small step can become a milestone to tackle the food waste problem in Hong Kong and even in the whole world.

III. Methodology

First, effect of humidity on the food waste consumption by BSF was found with help of our IoT system and humidifier. 50g of rice was prepared for BSF every day at room temperature and 3 different range of humidity, 60%-70%, 70%-80%, and 80%-90%, were tested. The weight of food waste left behind and mass of BSF were measured.

Second, effect of temperature on the food waste consumption by BSF was found with help of our IoT system similar to the humidity.

Third, food waste from school canteen during lunch time was collected to check the ability of BSF on the

digestion of food waste in daily life.

IV. Design of Invention

For the food waste digester, a valve structure was built on the top of our model to act as a food waste collector for users to put food waste inside, it also acts as a cover to prevent users from seeing the black soldier flies and prevent black soldier flies from escaping. Our system provides a digestion chamber for the black soldier flies to digest food waste. A fertilizer collection chamber was built under the digestion chamber to filter out the excretion from black soldier flies, which have a high utilization value and can produce various products. A weight sensor is installed to monitor the change in weight to monitor the food waste digestion activity of black soldier flies. IoT system with sensors, like hygrometer, thermometer, balance, fan, humidifier, etc., were installed to monitor their growth and control the growing environment. Ultrasonic sensor was added to notify whether the chamber is full or not.

UV lights are installed on the exhaust fan to kill germs and bacteria. Plastic plates were added outside our model to prevent users from seeing black soldier flies directly. The prototype was self-sufficient as a solar panel system was used to generate electricity to reduce carbon footprint. All the information can be monitored and controlled by our phone app.



V. Application / Market Need

The main goal of our invention is to provide the BSF larva with an optimal growth environment, suitable temperature, and relative humidity. Unlike the existing methods of dealing with food waste in society, we can dispose of food waste without emitting large amounts of greenhouse gases.

Our system is targeted to achieve the educational purpose of food waste management in our school and society. Besides, the excess larvae can be used as feed for livestock. BSF shells which is a flexible material that can produce various products like bioplastic, medicine capsules, food additive and even purify water. Their excretion can become fertilizer. Basically, our system is expected to attain 'low cost, high benefits'. According to the existing municipal solid waste collection and disposal system in Hong Kong, the per-liter charge for designed garbage bags is set at \$0.11. Using BSF to consume food waste can greatly reduce money from dumping waste and practice food waste reduction. In addition, the cost will be low since once the system starts to work, 1kg of BSF larvae can consume about 1kg of food waste everyday. At the same time, the transportation fee and rental cost can be significantly reduced. The carbon footprint will be reduced and the food waste problem can be solved. Therefore, the system can definitely attain 'low cost, high benefits'. With the help of the solar panel system, the whole system can be self-sustaining.

VI. If your team will compete the Sustainable Development Award, please indicate the specific sustainable development goal the project is related to, and provide justification for competing for this award. (Word limit: 300 words)

From the United Nation's 17 sustainable development goals, our project matches Goal 12, ensuring sustainable consumption and production patterns, which is critical to sustaining the livelihoods of current and future generations. Unsustainable patterns of consumption and production are the root causes of the triple planetary crises of climate change, biodiversity loss, and pollution. These crises, and related environmental degradation, threaten human well-being. Our project helps to achieve the sustainable management and efficient use of natural resources (Target 12.2), reduce food losses along production and

supply chains (Target 12.3), reduce waste generation through recycling (Target 12.5), and ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature (Target 12.8). Our project aimed to reduce food waste and turn it into biomass in BSF for further use. Data have proven that our product provided an optimum environment to consume more food waste, which matches Targets 12.2 and 12.3. BSF can consume over 70% of food waste in different scenarios, which reduces most food waste, matching Target 12.5. Through the educational video, our students and community can know more about how and the importance of food recycling, which matches Target 12.8. (*concerning <https://sdgs.un.org/goals/goal12>*)

VII. If your team will compete the Social Innovation Award, please list the target group or social issue the project focuses on, and provide justification for competing for this award.
(Word limit: 300 words)

In the beginning, the system targeted large-scale systems at farms in rural areas and small-scale rooftop devices for residential areas. Users can easily add food waste, wait for digestion and collect the product. As black soldier flies kill toxic bacteria with functional antimicrobial peptides, no odor will be produced by the increasing number of bacteria and microorganisms. To achieve the educational purpose of food waste management in our society, our system was introduced to our school. Food waste collection and treatment can be promoted and supported by our students and community through education. We are planning to collect the food waste during lunchtime. A promotional video about how to manage the food waste for our system is prepared to educate our schoolmates about how to separate the waste properly for recycling. It is hoped that by competing for the award, this method of food waste treatment can be more known by the public and the system can be set up in different places by companies in Hong Kong to maintain a better food waste treatment at lower costs and higher efficiency.







VIII. Conclusion

To conclude, using BSF as a food waste consuming method is effective. Moderate temperature and humidity are required for the process so as to achieve high efficiency with over 80% of food waste can be consumed in 2 days. With the 'Food Waste Up-cycler 2.0' prototype and an app with IoT system, we can obtain sustainable development goals by reducing various food waste and promoting universal understanding of sustainable lifestyles. By converting food waste into biomass for further use and the publication work through the educational video to promote food waste recycling, therefore, sustainable development goal would be achieved and promoted starting from our school and local communities.

*** Our project is developed based on previous project and the enhancement is below:**

- Compare to the Food Waste Up-cycler (*L. Tony, et. al. 2022. Food Waste Up-cycler, Hong Kong Student Science Project Competition 2022*), the new version has more sensors to make the system more user-friendly. And this project is aimed to educate the public about food waste recycle starting from school to community nearby.

	 Food waste up-cycler 2.0	 Food waste up-cycler	Phone app	 Phone app of our system	 Phone app of last year
Fertilizer collection chamber	✓		Show thermometer and hygrometer data	✓	✓
Weight sensor	✓		Control humidifier and fan	✓	✓
UV desentilizer	✓		Show mass of food waste and black soldier fly larvae	✓	
Ultrasonic sensor	✓		Show camera footage		✓
Camera		✓	Show data of total weight of our system	✓	
Fan	✓	✓	More information about Black soldier fly larvae	✓	✓
Humidifier	✓	✓	More about our aim	✓	✓
Solar panel	✓	✓			