Implementing Black Soldier Fly Larvae (Hermetia illucens) Based Sustainable Waste Management Method in Sri Lanka

Background and Local Waste Management Status

The world population is expected to rise nearly 9 billion by 2050 (Schiavone et al., 2017). The balance between food production systems, food sovereignty, and environmental sustainability has become the top argument among scientists and policymakers worldwide. Organic farming concepts have become popular in many parts of the world. Today organic fertilizer availability is a hot topic in Sri Lanka where all the farmers struggle to save their livelihood under mono fertilizer systems in Sri Lanka (Cordell et al., 2021). Shifting towards greener crop production through organic fertilizer is a positive economic, environmental, and health perspective. Producing quality organic fertilizer to meet the crops' nutritional requirements and acquiring sufficient amounts of nutritional factors through proposed models are challenging and competitive. Local soil has been extensively used for inorganic fertilizer in the last five decades (Upekshani et al., 2021). Therefore, the rapid transition of soil with rich organic amendments with readily available plants nutrients is challenging but not impossible. It is evident that nutritionally rich organic supplementations to soil are timely needed intervention.

On the other hand, managing generated waste is quite challenging for local governments in Sri Lanka where only 20-80% of the collected waste is managed (Eheliyagoda., 2016). Approximately 90% of the generated waste is open dumped (Menikpura et al., 2012). Furthermore, 53% of the waste is composed of food and green waste (Vidanarachchci et al., 2006). With the rapid urbanization, waste management is becoming challenging but controllable with necessary interventions; However, due to administrative weaknesses, inadequate financial and technical support, and people's poor willingness and attitudes towards waste management had created an unsatisfactory situation (Kuruppuge and Karunarathna, 2013). Local governments are unable to guarantee a promising solution due to improper organization and lack of financial resources (Sivanantharaja, A., 2018). Therefore, it must be urged to seek more reliable, effective, and hands-on waste management practices sustainably to ensure the nation's well-being.

Black Soldier Fly Larvae (Hermetia illucens) Mediated Waste Management

Sustainable waste management practices are often environmentally friendly and expected to reduce the impact on the environment by avoiding direct disposal and it is a source of income generation. Naturally, solid waste is degraded by worms and grubs. Usage of degradation ability to manage waste is a new tendency and Black Soldier Fly (BSF) (Figure 1) is a common fly of the Stratiomyidae family, and is one of the most commonly used insects in solid waste management worldwide (Sivanantharaja, A., 2018).

Figure 01: Adult Black soldier fly

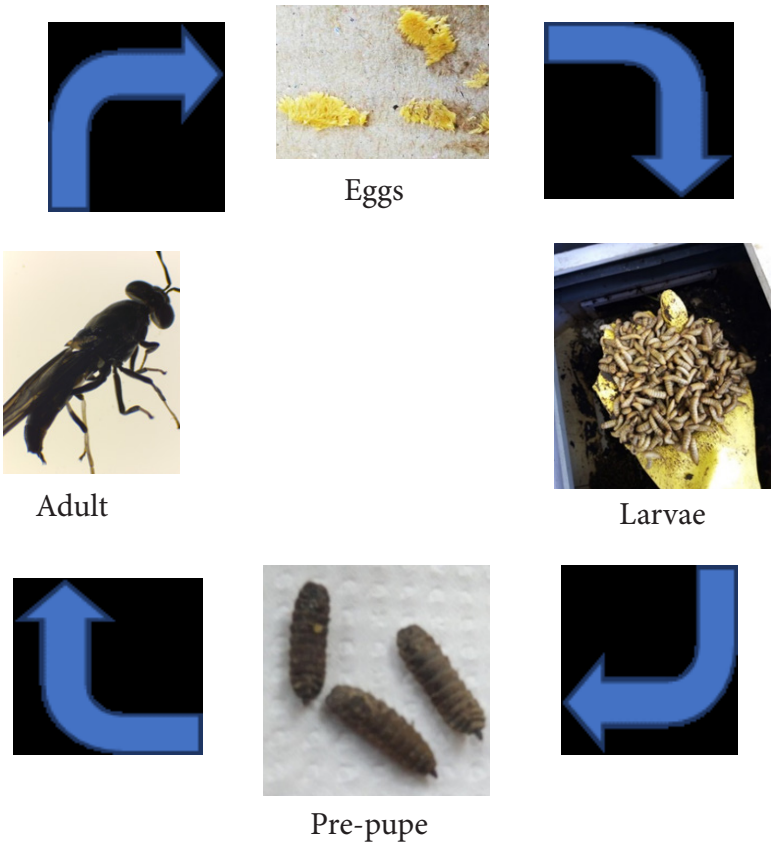

Figure 02: Life cycle of Black Soldier Fly

The eggs are laid near a food supply and hatch in about 4 days. The larval stage lasts 14 days and includes 5 instars, followed by the pupal and adult stages of the BSFL. The usual life cycle of a BSF is 41–43 days. The larval and prepupal stages can be extended significantly in the tropics to account for food supply and other circumstances (Liu et al., 2020). It is highly considered that insects have a low environmental footprint since BSF larvae mostly depend on biowastes, with considerable bioconversion ability. Since the BSF adult lacks functional mouthparts, a harmless insect is not a disease carrier vector. Also, the odour controlling power is very supportive of the cleanliness of the environment (Lalander, C., 2019). It comprises a short life cycle of about 45 days (Figure 02), and different instar stages occupy bio-degradation.

The larvae colonize in very dense populations and utilize organic wastes as diverse as, Manures (Yu et al., 2009, Sheppard et al. 1983), Rice straw (Li et al., 2011), Food waste (Alattaret al., 2012), Distillers grains (Webster et al., 2016), Faecal sludge (Banks et al., 2014, Lalanderet al., 2019), Animal offal and kitchen waste (Wang and Shelomi, 2017). Also, the larvae are highly accepted for their bio-conversion of organic wastes into crude proteins and fats; thus, it has proven as an excellent substitution for high-cost feed ingredients in the livestock sector (Lalanderet al., 2019, Priyadarshana et al., 2021).

Other than a bio-waste decomposer, BSFL are used in different ways. Due to its nutritional composition, it is more widely used as a protein and fat source in the animal feed industry for poultry, swine and aquaculture (Kierończyk et al., 2020). Bio-refining is another approach adopted by BSFL today for the bio-diesel production using crop leftovers (Wang et al., 2017).

Local Evidences Black Soldier Fly Larvae Applications

It is hardly reported in practical usage of BSFL in waste management where this is a fresh concept to our local community. Several local research outcomes are available in terms of life cycle characterization and livestock feed incorporation (Ellawidana et al., 2019).

Local Possibilities to Implement BSFL Based Waste Management

Growing Conditions and Substrate Specificity

Past literature indicates that BSF is native to temperate regions of the world (Park and Haeree, 2016). According work by , Perera et al., 2019, the rearing conditions required for egg-laying mating purposes were mainly observed under the IM2b Pambahinna area for four months (June to September 2019). Temperature, relative humidity(RH), light intensity, and wind speed parameters were measured and recorded. Favourable conditions for their mating and egg-laying were recorded at 27.4°C ± 1.00. The surrounding light intensity was 2.74 kLux ± 1.52. The most favourable RH range was observed as 59.4% ± 1.8. Their attraction and early egg-laying preferences were assessed by placing several substrates, 100% swill, fish offal, and rotten fruits and vegetables (Figure 1-3). Noteworthy findings included that the adults were attracted to the swill-treated bin, and at wind velocity ranged from 17km/h to 32 km/h; no evidence for BSF adult presence or egg-laying was recorded. It was noteworthy that BSF adults lay eggs from 10 a.m. to 2 p.m.. Magamage et al., 2019 and Ellawidana et al., 2020 have examined the substrate specificity of BSFL and rearing conditions under local climate, focusing on primary waste materials such as kitchen swill, fish offal, rotten fruits, and vegetables. The accelerated waste substrate consumption was recorded in kitchen swill with 33.06% of crude protein percentage of BSFL. Further, poultry starter feed could also be used for the nutritional sense in livestock feed production. Therefore, it has a huge potential of occupying majorly uncontrollable bio-degradable waste material into BSFL based bio-conversion.

Figure 03: Swill

Figure04: Fish offal

Figure 05: Rotten fruits and vegetables

Local community willingness to engage in BSFL based waste management

Ellawidana et al., 2019 evaluated the willingness of the rural community to utilize BSFL in Bleihuloya, Sri Lanka. From the 100 families in the test group, 85% of the collected waste was biodegradable, but 95% of them had practised throwing away or burying wastewithout any treatment. Even though 80% of the test group were not aware of BSFL based waste management , 65% of the participants were willing to produce BSFL.

The willingness of the catering sector in Ratnapura district to get involved in waste management practices were broadly examined. Accordingly, 58% of the catering sector participants generated 0-5Kg of biodegradable wastes daily. Out of that 88.6% collected their waste in a bin and only 46.6% practised separating waste, and the rest didn't separate due to insufficient space. More noteworthy, 1.1% of urban catering population were aware of BSFL utilization, and 3.4% were on BSFL based compost production. Even though people were less familiar with BSFL, 20.5% were willing to initiate BSFL composting (unpublished data).

Study similar to the catering sector was conducted among the household sector of Ratnapura district., 41.21% had collected bio-degradable waste within the range of 0-5kg. More positively, 89.19% of them have practised the separation of their generated waste. Even though 6.42% were aware of BSFL utilization and 13.85% were aware of BSFL based composting , only 45.27% were willing to produce BSFL based compost.

Challenges and Possibilities faced by local authorities in waste management

The waste management profile of the Ratnapura district's central urban councils were initially studied to identify the available possibilities and challenges in introducing BSFL based biodegradation technology. Balangoda, Ratnapura and Embilipitiya waste management plants were visited.

Commonly they are available on a day-night waste collection routine with permanent and contract-based employers. The produced compost has considerable demand, and for specific instances, they were unable to meet the demand. The maximum effort has been taken to encourage waste segregation and ease waste collection process by establishing colour coded seperate bins at public places and forming some policies and enforcing them. . The urban public and the school community werehighly encouraged to get involved in this process by forming 3R communities, introducing model compost bins. Further, universities were encouraged to get involved and carry out research at the composting plants. Futher, quality assuarance of the produced compost was done and remedial measures were taken when necessary.

Meanwhile, a considerable labour constraint was observed, and anaerobic waste digestion and leachate treatment failures were also observed.. The limited expertise of the resource personnels, lack of financial support from the state bodies and typical lapses in technology transfer were observed barriers.

There is a good potential for implementing a BSFL mediated biowaste degradation process and open interlinkage with organic fertilizer and livestock feed production. Noteworthy findings include, their request to reduce the waste collection by local councils and to implement a waste management system at their home.

Future Research Implementations with BSFL Mediated Technology

The research project, “From waste to animal protein; Black Soldier Fly Larvae (Hermetia illucens) production as a method of waste management and feed grade protein production, aims in multidisciplinary sustainable applications based on BSFL biowaste degradation technology as we are concerned to disseminate the research outcomes to the community without being confined to a paper material. Patented BSFL mediated compost bin (Patent no: LK/P/20919), and BSFL harvester (Patent is under processing) most ideally designed for the urban community for assisting overwhelming waste issue has been implemented. A new domestic type composting bin is under manufacturing. It is expected to commercialise the compost bin, and a joining hand is welcome. While addressing waste reduction, the by-product BSFL is directed for manufacturing livestock feed ingredients, especially for poultry and aquaculture, which could replace expensive imported feed ingredients like a Fish meal in terms of human nutrition and food safety. On the other hand, replacing

fishmeal as a major crude protein ingredient reduces massive marine overexploitation for feed production and ensures biodiversity (Figure vi-xi).

Once BSFL is well grown, the freshly topped up biodegradable waste is degraded within a day. The conversion rate was recorded as 25kg of fresh biodegradable waste generates 10-12 kg of compost fertilizer and 6-7 kg of BSFL. Well, ventilation in the bin facilitates a dry form of organic fertilizer where the nutritional composition and field-level crop performances are under research.

Figure 06: Freshly toped up bio-degradable waste

Figure 07: BSFL eggs

Figure 08: Abundant BSFL in the composting bin

Figure 09: Harvested BSFL as a livestock feed ingredient

Figure 10: Degraded waste material

Figure 11: Final compost production

Regarding public perception and research outcomes, there is a good potential for introducing and implementing BSFL based biodegradation for addressing uncontrollable waste management issues at the domestic level. Further, this is a good potential for self-employment opportunities related to compost production and mini livestock venture creations.

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