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Biological Treatment Method for Household Organic Waste: Black Soldier Fly

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Abstract: *Black soldier fly (*Hermetia illucens*) larvae (BSFL) are coming forward as an outstanding insects for bioconversion of organic waste, which can convert household organic waste, i.e. manure, kitchen waste, into biomass rich in protein and fat. The harvested BSF larvae contained 40% protein and 30% fat. BSF may be used in low middle income countries to biodegrade the organic waste into valuable animal feedstuff, in their last larval stage called as prepupa. Revenues from sales of this valuable animal feed can cover cost of waste collection. This newest technology is applied for municipal solid waste, faecal sludge in developed countries. This paper presents and opens the new research area for application of this technology for Indian household kitchen organic waste. The aim of this paper is to evaluate the feasibility of BSFL technology at small scale level, add value to the end product, and generate income.*

Keywords: *Black Soldier Fly, Hermetia Illucens, Household Organic Waste, Bioconversion, Value Addition.*

I. INTRODUCTION

Management of municipal organic waste (MSW) in low and middle income country becomes a neglected and challenging key issue [8]. The world is facing rise in population growth with urbanization and industrialization. Rapid urbanization and growth of urban population has caused increased environmental concerns [6]. The world population continues to grow along with high resource consumption and waste generation. There is need for constant need from all sectors, more so to ensure reduced resource use, consumption and waste generation [4, 5]. Food and other organic wastes are a valuable resource as it contains a lot of nutrients and energy, hence that we shouldn't waste.

Around the world 50% waste is organic waste. India second largest populated country, develops 100 tons of solid waste every day. Some of the waste is transferred to landfills where waste is not segregated properly, it mixes organic and inorganic waste, which results into loss of soil nutrients. The major problem is wrong waste treatment methods which results into bad odour, leachate formation and soil pollution. Some of the conventional methods like composting, biogas take months to complete. So there need to implement proper waste management method. Black soldier fly emerging as newest bioconversion organic waste management technology which converts the organic waste into valuable end products ie. Organic residue and animal feedstuff. It adds value to the end products and generates income sources for emerging small entrepreneurs. Also it could further reduce waste amounts and generate income source. They can also reduce a waste pile significantly, minimizing possible pollution.

Currently, there are large scale facilities using the BSF process to produce animal feed protein, oil and plant fertilizers. This BSF approach is previously used to treat municipal organic waste, animal manure etc. Now, there is a need of developing the domestic waste management plan on small scale to check the suitability of this technology.

Main aim is to design and develop the model suitable for treatment of kitchen waste.

II. WASTE TREATMENT BY BLACK SOLDIER FLY

Conversion of organic waste by larvae of black soldier fly into versatile prepupae is an interesting recycling technology, with a potential to give the aforementioned value. Black soldier fly, is a common fly of the startiomidae family, also known as *Hermetia Illucens* [Linnaeus]. The adult fly is 15-20 mm long. Primarily black, the female's abdomen is reddish at the apex and has two translucent spots on the second abdominal segment. The male's abdomen is somewhat bronze in color. Their legs are black with pale yellow forelegs. They are commonly found throughout the western hemisphere and the Australian region. But it is now widespread in tropical and warmer temperate regions all over world.

As adults, the black soldier fly does not possess a stinger, nor do they possess a mouthpart or digestive organs to allow them to consume waste; therefore, they do not bite either. They do not bite or sting, feed only as larvae, and are not associated with disease transmission. Black soldier flies make breeding areas of houseflies less desirable. The fly is often associated with the outdoors and livestock, usually being found around decaying organic matter such as animal waste or plant material.

The black soldier fly larvae (BSFL) are impeccable converters of feedstuff or manure into valuable biomass. The biomass looks like nutritionally is: +40% protein and +30% fat, all whilst reducing manure/compost (Newton, 2004). These half inch larvae can be immediately fed to fish or through a dried-supplemented diet.

A. Life cycle of Black soldier fly

- 1) **Eggs:** The first stage of black soldier fly life cycle is eggs. When Pupation stage occurs, the adult emerges after about 14 days. Females mate two days after emerging and oviposit into dry cracks and crevices adjacent to a feed source. Due to the relatively long period between oviposition and eclosion (3–4 days), eggs are never laid directly onto the moist rotting material. The duration of hatching eggs is approximately 4-5 days. One female fly can laid upto 500-900 eggs. Upto hatching of eggs, they must be feed on special diet mixture of corn meal, wheat bran and water.
- 2) **Larvae:** Once all the eggs hatched, larvae start to feed on organic decaying waste, thus achieving a dry mass volume waste reduction of approx.. 55%. Due to high larval densities and the voracious appetite of the larvae, fresh material is processed extremely fast and bacteria growth suppressed or restrained, thereby reducing production of bad odor to a minimum. The span of larval stage is from 4 to 14 days. The duration may exceeds upto 18 days to 4 months in case change in environmental conditions, food shortage.
- 3) **Pupae:** The pupation stage occurs within the larval skin. The duration of pupal stage is upto 7 days. In this duration, The prepupae, the last immature stage, show a pronounced migratory habit. They need to leave the food source to successfully pupate into adult flies. They migrate from food source by using ramps provided, in serach of darker location.
- 4) **Adult Fly:** Adult flies emerges after pupal stage and have lifespan of nearly 5- 8 days. The adult flies do not posses any mouth parts, so they do not bite and do not spread or transmit disease. They stay alive on fat stored in their body during the larval stage.

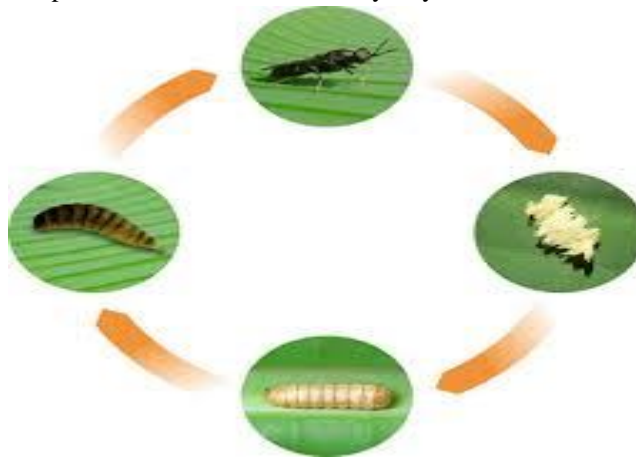


Fig. 1 Life cycle of black soldier fly

B. Breeding Requirements

BSFL, to get the desired possible outcomes, the care and attention should be given to proper rearing requirements. Following are the breeding requirement that should be given to rearing of BSFL.

- 1) **Temperature:** As the BSFL is the warm temperature species, the best suitable temperature condition is between 25°C to 35°C. Temperature condition should not exceed 40°C because chances of surviving are reduced and inactivity induced when temperature goes down below 10°C. A temperature range of 26-29°C to be good for the rearing process. The temperature range of 25-30°C as being optimum for pupation, while 35oC as optimum for BSFL consumption of food. For mating purposes, 27°C has been reported optimum.
- 2) **Humidity:** for the desired outcomes, it is important to maintain the humidic conditions throughout the breeding cycle of BSF. It reports that for BSF mating, optimal humidity is 30-90%. For eggs, around 80% hatching has been observed when the humidity is greater than 60%.
- 3) **Lighting:** Another aspect to be considered is a light source, considering black soldier flies do not mate in the winter months. Naturally, black soldier flies require direct sunlight to encourage mating. Thus, operations indoors require supplemented artificial lighting. the spectrum of a quartz-iodine lamp as being similar to that of sunlight, thus casting rays of hope on winter breeding prospects.

- 4) *Diet*: Feeding in the life cycle of BSL is only observed during the larval stage. It is important that, attention should be paid, good quality food should be provided to larvae. It cannot be overemphasized, because in case of elevated concentrations of Zinc led to high larval mortality as well as lack of egg fertility, which results into lower larval yield and slower waste reduction. Automatic or frequent water misting provides an adequate amount of water to the adults. The mists form droplets, which are then taken up by the adults. The adults' main energy source is the remaining fat stored from their larval stages.
- 5) *Space Requirement*: in the breeding of BSF, it is good to replicate the natural environmental conditions in which those species occur as much as possible.

III.SILENT FEATURES

Conversion of organic waste by larvae of black soldier fly, into versatile prepupae is an interesting recycling technology, potential to give waste the aforementioned value. BSFL can convert around 58% of dry matter within an organic source into high quality animal feedstuff. Waste biomass can be converted into larvae and residue. The larvae contains high quality crude protein which is 40% and above and crude fat content is 30%. This animal feedstuff is then provided to poultry farmers and fish farmers as high protein feed. As it help to achieve the risk reduction by reducing 80% material, because BSF do not transmit any disease. So we can decompose the waste without any hesitation.

Waste reduction upto 80% on wet weight basis can be possible to achieve by implementation of this technology. There is reduction in cost of transportation as waste is processed at its source. Also space requirements also reduced which is required for landfilling.

The end product of this technology ie. organic fertilizer can be used for rooftop gardening, for agriculture and small gardens. The residue is high in nutrients and organic matter, which help to reduce the soil depletion. As the larvae consume the waste fast due to their voracious appetite, the process is odour free and speedy. A high waste-to-biomass conversion rate of up to 25% on wet weight basis.

There is no need of specially skilled labour to operate, also there is no need for any high-end technology, so it is suitable for low-income groups without skill labours.

IV.CONCLUSION

The household waste often remains uncollected on streets and drains, thereby attracting disease vectors and causing water blockages. So, there is need for a systematic, reliable and efficient waste management plan for household waste disposal. The study has shown that the BSF process is feasible for residential societies and can add value to the organic waste management chain, generate income for the company and also help solve the paradox of the ever rising demand for animal protein. It can turn the waste into a sustainable resource as it reduces the pressure on the environment for both extraction of new raw materials and disposal of the resulting waste. The initial investment seems high but the quality of compost is excellent. It helps to reduce the resource consumption by minimizing cost of transportation, as we can process the waste at its source of generation, saving the time and related cost. It helps in material reduction, risk reduction and waste reduction by 80%. From the previous theories and researches it was confirmed that black soldier fly technique has a high potential as a waste manager on small scale.

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