A review on municipal organic waste management using black soldier fly larvae.

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Abstract

Black soldier fly constitutes a potential benefit by valorisation of municipal organic waste through its larval feeding activity. These maggots are not being employed for composting of municipal organic waste in India. Black soldier fly is not considered as a pest. Besides waste reduction and stabilisation, the product in form of the last larval stage, the so-called pre-pupae, offers a valuable additive in animal feed. The feasibility of black soldier fly larvae to digest and degrade municipal organic waste was studied in a medium-scale field experiment. This technology revealed its great potential for organic waste reduction, protein production and the fly as a waste manager.

Keywords

Black soldier fly larvae (BSFL) Hermetia illucens, municipal organic waste management, food waste.

1.0 Introduction

Recent trend of heavy migration of population to urban areas due to various factors like jobs, infrastructure facilities, modernization, etc. and their consumption habits, the problem of anthropogenic waste generation is increasing. Municipal Solid Waste (MSW) treatment is one of the most visible environmental issues in urban areas, out of which treatment for municipal organic waste by the use Black Soldier Fly Larvae is discussed in this paper. Every kitchen (commercial and residential) and food preparing industry generates food scraps during various preparation stages and processes which has to be disposed. Throwing these scraps in the garbage can create odour problems and add to the volume of waste going to the landfill.

However organic waste going to landfills will only produce harmful gases after its improper decomposition leading to fire hazards, it may produce leachate which will penetrate in the ground polluting soil and ground water and it may cause odour nuisance around the landfill site. Hence disposing organic waste in landfills is not a viable option. In addition to this, we will be wasting potentially valuable resource which can be successfully used for composting, production of biogas, bio-CNG, bio-diesel, vermicomposting, etc. Apart from the afore mentioned technologies, rearing and using black soldier fly's larvae (*Hermetia illucens*) for decomposing organic waste, is being assessed as a method for treatment of municipal organic waste.

2.0 Solid waste status in India [1]

Municipal Solid Waste (MSW) is described as household garbage, non-hazardous solid trash dumped by industrial, commercial entities, market waste, yard waste, and street sweepings collected by municipal authorities. Unscientific waste handling causes health hazards and environmental degradation. The quantity of waste and its composition changes with each passing day as it is understandable from Table 2.1.

Table 2.1: *Waste Generation Trends in India*

Year	Per capita waste generation (g/day)	Total urban municipal waste generation (MT/ year)
1971	375	14.9
1981	430	25.1
1991	460	43.5
1997	490	48.5
2025	700	Double the amt. of 1997

Source: India Energy portal

Various types of wastes are generated from rural areas like community wastes, wastes from agricultural activities, agro based industries, animal wastes, etc.

Table 2.2: *Estimated Annual Generation of Various Rural Wastes in India.*

Types of Waste	Estimated Generation(million tonnes)	Percentage of total waste (million tonnes)
Community	15	0.81
a) Night Soil	5	
b) Refuse	10	
Agricultural Residues	322	17.4
Animal dung	1365	73.74
Agro-Industrial By-products	49	2.65
Oil Seeds	100	5.4

Source: A. P. Jain

Table 2.3 presents average per capita solid waste generation and collection efficiencies data for various categories of towns in India. The large towns show distinctly higher per capita waste generation; there is no significant difference between medium and small towns.

Table 2.3: *Average per Capita Urban Solid Waste Generation and Collection Efficiencies in Indian towns.*

Category of town (Nos.)	Total Population	Waste generated (Tonnes)	Per capita waste gene. (gm/day)	Collection efficiency (%)
Large	22,312,961	11,761	527	82.8
Medium	9,567,133	3,025	316	59.0
Small	424,223	148	349	59.5

Source: A. P. Jain

2.1 Comparison of Urban solid wastes with rural wastes [1].

Approximately one-fourth of the entire population lived in urban areas. Large towns generate far more trash per inhabitant as compared to the smaller or medium towns. in India the cost of waste collection is much higher in overall solid waste budget. Next comes segregation followed by land filling of waste. In India most of the trash is landfilled. The procedures used are not in accordance with modern sanitary landfilling norms. The majority of the garbage is dumped. This dumping is typically done in low-lying locations that are prone to flooding. The diversion of a substantial portion of expenditures to waste collection and transportation leads in a lack of finances for disposal activities. This forces local governments to ignore even well-known protections and practices in favour of a more expedited approach. Bio-gas systems can successfully handle localised and specialised wastes and contribute to

waste disposal that is environmentally acceptable. Small-scale incineration will be required for hospital trash, among other things. All garbage-processing methods are challenging to master since they are historically designed to handle virgin and homogeneous materials.

2.1.1 Urbanization and solid waste management in India present practice and future challenge[9]

Urbanisation adds directly to waste generation, and improper waste management increases health risks and urban environment damage. The existing practises of unrestricted waste dumping on the edges of towns and cities have resulted in a significant environmental and public health issue. The study assesses the current techniques in India for dealing with solid waste and the difficulties that come with it. It also included steps for dealing with this garbage in a healthy and environmentally appropriate manner, so that it might be used as a resource rather than a waste. The conclusion was that public apathy and civic entities' low social standing attributed to SWM activities is a major impediment to tackling the problem. In order to properly dispose of and treat garbage, strict legislation should be enacted. No new plan for a residential or business area should be approved unless it includes a proper location for waste disposal and treatment. In India, there is a strong case for private sector involvement in this field, and the private sector can contribute experience, technology, finance, and better, more effectively managed services.

3.0 Treatment processes for organic waste

Conventional methods for treatment of organic waste include landfilling, composting and anaerobic digestion. These methods have certain difficulties and downsides which are discussed as follows.

3.1 Landfilling

In India, majority of the garbage is disposed in landfills. The procedures used are not in line with sanitary landfilling norms. The majority of the trash is discarded. This type of dumping is usually done in low-lying areas that are prone to floods. Flooding of these low-lying regions raises the risk of surface water pollution during the rainy season. Organic waste going to landfills creates problems like fly nuisance and foul odour which may affect nearby areas of landfill site, formation of hazardous gases in landfill sites posing threats of fire, formation of leachate which may penetrate in soil causing soil as well as ground water pollution. Also a very good portion of resource will be wasted and will be dumped on land fill site. Hence landfilling of organic waste is not the best solution of waste disposal.

3.2 Composting

Composting is an alternative for disposing of urban solid waste in India. It is particularly appealing because of its high organic content and wetness. The idea of composting is appealing as it helps to recycle the nutrients back to land. Mechanical organic waste composters are also being implemented on housing society level for treatment of organic waste fraction. This also helps in segregation of waste. The drawbacks with composting lies in the quality of the compost produced as it requires specials treatments and methods to prepare good quality compost. Also composting is a time taking process which depends on several parameters like temperature, moisture, aeration, etc.

3.3 Anaerobic digestion

Anaerobic digestion is another viable option for Indian wastes with high moisture and organic content. The feedstock to the process is the most essential initial consideration when considering the use of anaerobic digestion systems. Anaerobic digestion may handle almost any organic material; however, if biogas generation is the goal, the amount of putrescibility is a critical component in its

effectiveness. The greater the gas yields, the more putrescible (digestible) the substance. When employing wet digestion or plug-flow digestion, the amount of contamination of the feedstock material is an important issue. If the digester feedstock contains substantial amounts of physical pollutants, such as plastic, glass, or metals, the material will need to be processed to remove the contaminants before it can be utilised. It is possible that the digesters will be clogged if it is not removed.

4.0 Treatment of organic waste by employing Black soldier fly larvae

The most important benefit of BSF with respect to its proposed use for treating organic waste matter is that the adult flies are not attracted to human habitation or foods and therefore it is not considered as a pest. Black soldier flies lay their eggs in moist organic material during natural breeding. Various organic matter such as kitchen waste, food waste (animal and vegetable origin) and fresh manure have been found to be the habitat of larvae of black soldier flies. The harvested pupae and pre pupae have been found to be consumed by dogs, poultry, pigs, fish and even turtles.

Study of Bio-wastes of various kinds and compositions

Mill by-products, human faeces, poultry, slaughterhouse waste, cow dung, and canteen trash were the bio-wastes studied. Survival and bioconversion rates, waste reduction, waste conversion, and protein conversion efficiency were all evaluated as performance benchmarks. In comparison to chicken feed (the standard), veggie canteen waste fared the best and cow dung performed the poorest. Overall, this study provides a foundation of information and recommendations for how BSFL treatment facilities may effectively function with bio-wastes of various kinds and compositions.

Use of insects for management of organic waste

Organic waste recycling is ineffective over the world, resulting in water pollution and the loss of potential agricultural fertilisers. Black soldier fly can be used to convert organic waste into animal feed protein. Black soldier fly larvae have been observed to consume and degrade a variety of organic materials, with up to 70% material degradation. The pre-pupae contain roughly 40% protein and 30% fat, and have been shown to be a suitable alternative feed in fish and pig production, with the potential to replace fish meal and fish oil as a protein source in animal feed.

4.1 Analysis of Black solider fly reared on various types of feed

4.1.1 Black soldier fly Larvae (*Hermetia illucens* Linnaeus) as recyclers of organic waste and possible livestock feed [19]

In this research, the BSF could be used to recycle organic waste on small to medium scale and the waste reduction process comes with compost. It has the potential to considerably reduce waste volumes, hence reducing pollution and increasing environmental sanitation.

4.1.2 Study on occurrence of black soldier fly larvae in composting of kitchen waste [18]

The occurrence, problems and benefits of black soldier fly larvae during composting of kitchen waste was investigated. Experiment was conducted on kitchen waste and cow dung (3:1) for 60 days till the whole waste was converted into manure. Samples were taken at the interval of 10 days to analyse various parameters like moisture content, electricity conductivity, pH, TOC and TKN. Seed germination and root length test was carried out on water extracts. It was concluded that BSFL play role in converting the waste into compost, but the compost generated is low in nutrient content.

4.1.3 Modulation of nutrient composition of black soldier fly larvae by feeding seaweed-enriched media [17]

BSF has proven to be effective at obtaining protein and lipids from seaweed. However, as the percentage of seaweed in the feeding media increased, the total production of larvae per experimental unit decreased by up to 25%. Individual larvae's size decreased as seaweed inclusion increased. BSF larvae can be successfully grown on media containing up to 50% *A. nodosum*, according to the findings of this study. The nutritious composition of all larvae raised on seaweed was improved by supplementing them with EPA, iodine, and vitamin E.

4.1.4 Cultivation of black soldier fly larvae on almond by-products: impacts of aeration and moisture on larvae growth and composition [14]

Almond hulls are a suitable feedstock for larval development when moisture content and aeration are carefully regulated. More study is needed to define the bioconversion microbiome in order to understand the possible synergies that might be harnessed and the rivalry that must be handled between larvae and microorganisms in order to accomplish controlled larvae production and organic waste conversion.

4.1.5 Growth Performance of Black Soldier Fly Larvae Fed on Some Plant Based Organic Wastes [12]

Studies showed that larva of BSFL species has the ability to consume wide range of organic wastes such as agricultural wastes, animal and human remains, fish offal, food waste, as well human and livestock faeces. Due to this ability to be mass-produced this species has been studied as decomposer that recycling nutrients in organic wastes into their biomass which is high in protein and fat. Despite the small pupa size and possible negative effect of reproduction, giving BSFL with a significant volume of feed may overcome the negative effect of low quality feed on developmental time.

4.2 Use of Black solider fly larvae after rearing on waste feeds.

4.2.1 Evaluation of defatted black soldier fly's larvae as a protein source for broiler chicken [4]

The comparison of two different defatted BSFL treatments i.e. dry-rendered (DR) and extruded (EX), to that of a full-fat (FF) BSFL treatment and a control treatment. The protein source used was soybean meal. The use of dipteran species, common housefly larvae, and BSF pre-pupae in animal diets has shown to be effective in terms of productivity and digestion in a variety of animals. It would be important to test the BSFL as a possible alternative for soybean meal in broiler chicken diets, both full-fat and using various defatting processes.

4.2.2 Lipid and Protein from Black Soldier Fly Larvae Fed with Self- Fermented Coconut Waste Medium [20]

The growth rate of larvae was assessed by examining the changes in larval biomass weight throughout the period of the rearing period. The BSFL was fed for 4, 6 and 8 consecutive weeks. It was seen that the BSFL fed for four weeks had the highest growth rate and weight, followed by the BSFL fed for six and eight weeks. Week four had the greatest lipid value. Larvae fed for 8 weeks had the highest protein content. The sample of 4-week fermentation medium had the highest Efficiency of Converted Digested Food (ECD) value. The sample without fermentation had the lowest ECD value.

4.3 Black soldier fly larvae for organic waste treatment-prospects and constraints [21]

The ability of black soldier fly larvae to ingest and decompose mixed urban organic waste was tested in a medium-scale field experiment in Costa Rica. The benefits and limitations of this technology were explored. Waste reduction ranged from 65.5 to 78.9% depending on the daily amount of waste added to the experimental unit and presence/absence of a drainage system. The research concluded that the employment of black soldier fly larvae in organic waste management has a lot of promise, whether it's for treating market trash, municipal organic waste, or dewatered faecal sludge. It also concluded three factors significantly influenced larval yield and waste reduction capacity: (1) a lack of fertile eggs due to zinc poisoning; (2) high larval mortality due to the hostile environment in the larveros (zinc concentration, anaerobic conditions); and (3) limited access to food due to stagnating liquid in the larveros.

5.0 Conclusion

Black soldier fly larvae have a potential for utilization as a decomposer of organic waste and can be effectively used in waste management. Therefore, the application of black soldier fly larvae can be considered as one of the alternative biological decomposition process, which is macroscopic in nature. Using these macro organisms have shown a huge potential in reducing the size of waste in a noticeable amount of time as compared to other methods. Also the waste reduced is converted into a good source of protein and fat which further can be returned to the food chain by feeding these grown larvae (pre-pupa) to poultry and fishery. It can also be concluded that by some more amount of research work on this process, it can be successfully used as an efficient way of organic waste reduction.

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