MANAGEMENT OF FISH WASTE USING

BLACK SOLDIER FLY

Hermetia illucens L. (DIPTERA: STRATIOMYIDAE)

THEME: AQUATIC FAUNA AND FLORA IN KERALA - COLLECTION, MARKETING, TRADE AND ECONOMIC VALUATION STUDIES IN KERALA

SUB THEME: WASTE MANAGEMENT, WEALTH FROM WASTE

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ABSTRACT

Unscientific disposal of biodegradable waste materials pose a serious threat to the environment. Fish waste produced on the shore, at processing plants and through small local fisheries is a key form of pollution. This paper explores a viable environmental and economically sustainable model to address this issue. The insect, Black Soldier Fly (BSF) has the capability to break down various organic waste materials into usable products. The present study confirmed the efficacy of BSF to safely decompose fish waste and turn it into organic compost manure. The addition of inert materials like coir pith and waste from fruit and vegetables increased the quality of compost and prepupae formed. A total of four treatments involving fish waste was undertaken, with the study comprising 2.5kg of fish waste, 2.5kg of waste from fruit and vegetable, 1.75kg of coir pith, 500g of tea waste and 140g of chopped straw the most successful in producing a quality compost without liquid residue or a foul smelling odour. This trial also resulted in the highest quantity of prepupae. Hence, equal parts of fish and fruit/vegetable waste with an addition of 30% of the total combined weight of the fish and fruit/vegetable of coir pith, 10% of the total combined weight of tea waste and 2.8% of the total combined weight of chopped straw would result in the ideal compost.

Key words: fish waste, black soldier fly, prepupa, coir pith, compost.

INTRODUCTION

Solid waste management is a major challenge facing the health of global populations, as well as the natural environment. In 2016, the world's cities generated 2.01 billion tonnes of solid waste, amounting to a footprint of 0.74 kilograms per person per day (The World Bank, 2019). The challenges of poor waste management are nowhere more evident than across the Indian subcontinent with Kerala, a state in the south-west of India, reflecting the many challenges that poor waste management can bring. Fishing is the primary source of income for the majority of people who live along the Kerala coastline. The solid biodegradable waste generated from this sector is mainly fish waste i.e., flesh, entrails and skin, left over from fish processing industries. Unscientific disposal of these wastes contribute to major environmental and human health challenges with fish decomposition providing a breeding ground for disease and pollution of land and water.

Bioconversion of organic waste into useful products with low emission of greenhouse gases and positive effects on the environment is becoming increasingly sought after as a solution to the global waste problem. The Black Soldier Fly (BSF), *Hermetia illucens* (L.) (Diptera:

Stratiomyidae) is a wonder insect due to its ability to convert various kinds of organic waste into usable bio-products, which can be used as a feed, extracted as fuel or turned into residual compost for agricultural production; ensuring a low environmental footprint. A native of the American continent, they are now found globally between latitude 40° south and 45° north in Europe, Africa, Oceania and Asia, with human migrations and trade of goods contributing to their dispersion. BSF are not a pest or vector of pathogens and are naturally found to inhabit marshlands, (and) damp places with any rotting organic matter (Li *et al*., 2011). The insect has complete metamorphosis with various stages like egg, larva, pupa and adult being active feeding stages, with non-feeding during the last larval stage (prepupa). Sharanabasappa *et al.* (2019) observed the incubation, total larval and pupal period to be 5-7, 25-30 and 10-60 days, respectively. Prepupa is the last larval stage, which uses its hook-shaped mouthpart for moving away from feed to a shady place for pupation (Dortmans *et al.,* 2017), which makes it self-harvesting by nature. According to Park (2015), a temperature of 27^0C is favourable for development, with higher temperatures of 30-36^0C detrimental. Ideal conditions for development also requires humidity of ~70% (30% minimum and 90% maximum), with flies preferring natural direct sunlight. 85% of mating activity happens in the morning.

In this scenario, Positive Change for Marine Life undertook an experiment to evaluate the efficiency of BSF in managing fish waste between January to March, 2021 at their Marine Conservation Centre (MCC) in Kovalam, Kerala.

MATERIALS AND METHODS

Insect culture: BSF adults from the wild were lured to a compost bin containing fruit and vegetable waste for egg laying. Cardboard pieces were placed inside the lid towards the periphery and the flies laid eggs in groups into the grooves of cardboard. Egg masses were collected and the population was maintained at the MCC by rearing them in trays of 45x30x15cm filled with fruit and vegetable waste. This tray was placed in a larger tray to collect migrating prepupae. Prepupae were collected and transferred to a small plastic container filled with coir pith and kept in an egg laying cage (200x60x60cm) for the flies to emerge. Artificial plants were kept in the cage for the flies to congregate, with water provided in a small container with a polyurethane sponge immersed to avoid the flies from sinking. Water was sprayed with a hand sprayer twice daily in order to maintain humidity. A mixture of rotting fruits and vegetable waste and food waste was kept in a circular container (15x10cm) as an attractant for egg laying. Flies mated and laid eggs in bundled flat wooden sticks, which were placed above the attractant with string. The laid eggs were used for rearing larvae.

Treatments: Plastic trays of 45x30x15cm dimension were taken for conducting the experiment, which was laid out in a completely randomized design with 4 treatments and 5 replications.

Treatment 1 (T1): 5kg fish waste + 5g of 7-day-old BSF larvae.

Treatment 2 (T2): 5kg fish waste + 1.5kg coir pith + 5g of 7-day-old BSF larvae.

Treatment 3 (T3): 2.5kg fish waste + 2.5kg fruit & vegetable waste +1.75kg coir pith + 5g of 7-day-old BSF larvae.

Treatment 4 (T4): 2.5kg fish waste + 2.5kg fruit & vegetable waste + 1.75kg coir pith + 500g tea waste + 140g chopped paddy straw + 5g of 7-day-old larvae.

Observations on time taken for conversion of waste, quantity of residue and prepupae formed were taken at the end of prepupal migration. The data obtained was analyzed statistically using Web Agri Stat Package 2.0 of ICAR.

RESULTS AND DISCUSSION

Time required for composting varied from 12 to 14 days across all treatments. Table 1 shows that BSF larvae were highly effective at converting fish waste and that treatment T4 was significantly superior in producing compost (4.32kg). This was mainly due to the addition of inert materials, which were added for better absorption of moisture as well as controlling odour. T1 was less successful than T4, with 0.9kg residue (which was mainly bones and scales), as well as 500ml of leachate left over from the trial. A foul odour was also emitted during T1and subsided after three quarters of the material had been converted. Various smaller trials (outside of this study) as well as the study itself reflected that the odour reduced considerably with the addition of inert materials and there was no odour in the case of T3 and T4. The effectiveness of coir pith and moisture absorbing powder (Yadav *et al*., 2018) in the case of kitchen waste management using composting inoculum supports present findings.

In terms of the weight of prepupae formed, the treatments T4 and T3 were statistically similar and superior over others. This might be due to the enhanced nutrition received during the larval period since both T3 and T4 consisted of fruit and vegetable wastes, where T1 and T2 did not. This reflects the findings of Ewald *et al.* (2020) who reported that larval weight was affected by feed and a lower larval weight resulted when treatments contained fish waste only.

It is interesting to note that when BSF larvae were fed with a 22% fish offal diet within 24 hours of their pupation, they incorporated omega-3 fatty acids: α-linolenic acid (ALA), eicos apentaenoic acid (EPA), and docosa hexaenoic acid (DHA). Concentration of omega-3 fatty acids was achieved within 24 hours of the feeding of fish offal (St-Hilaire *et al*., 2007), further reflecting the resultant prepupae suitability as a fish meal and fish oil replacement for fish and other animals.

CONCLUSION

While this study was primarily undertaken to develop real-world solutions to marine pollution and human disease in coastal communities in Kerala, it also re-affirmed that the bioconversion of organic waste into BSF prepupae has significant potential in generating high value products with simultaneous waste valorization (Surendra *et al.,* 2016).

The study emphasised the capacity of BSF larvae in converting fish waste and it was found to be more effective to combine it with fruit and vegetable waste and inert absorbing materials like coir pith, tea waste and straw. Positive Change for Marine Life-led projects resulting from this study have led to the production of a certified organic (Kerala Agricultural University certified) compost for plant growth, as well as a nutritious insect biomass (harvesting BSF larvae before transition into adult fly) that can be used as feed for aquaculture and agriculture.

The study has the potential to create income-generating activities for people engaged in fisheries, agriculture, aquaculture and at the broader community level. It highlights a sustainable, decentralised waste to wealth model that has the ability to be scaled, whilst addressing one of the key human health and environmental challenges of our time.

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Table.1 Quantity of prepupae and residue formed after composting fish waste

Treatments	**Weight of prepupae(g)**	**Weight of residue (kg)**
T1	149.3 b	0.90 d
T2	149.5 b	2.36 c
T3	152.5 a	3.71 b

T4	152.7 a	4.32 a
CD (0.05)	2.386	0.145
CV	1.178	3.832