BIO-DEGRADATION OF PLASTIC USING GREATER WAX MOTH (GALLERIA MELLONELA)

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Keywords:

Galleria mellonella, Biodegradation, Polymers, Fourier Infrared spectroscopy -FTIR-ATR

Introduction:

Plastic degradation is a crucial concern for environmental deterioration. Plastic can be degraded by various means but a scientist and beekeeper, Federica Bertocchini while cleaning the beehive upon keeping the wax worms in the plastic shopping bag found that a pest on honey bee hives can chew the plastic. A larva named as "*Galleria mellonella*" commonly called as "wax worms" is found to be degrading the plastic. Bombelli et al., (2017) fed a polythene shopping bag to 100 G. *mellonella* for 12h and observed 0.1 grams of reduction. Upon testing the impact of diet on plastic degradation by feeding 150 wax worm larvae with plastic and co-diet for a period of 21 days, Yu Lou et al. (2020) reported a polyethylene consumption of 1.95 g with survival rate of 35.3%. Superworms, same family as wax worm, consumed approximately 1.42 g from initially supplied 2g of Polystyrene (PS) during a period of 21days, whereas fifty mealworms ingested 0.22 g from the same amount of PS supply and also extracted PS-degrading enzymes from Pseudomonas sp. found in the gut of the worms (Kim et al., 2020). Bacterial strains, Enterobacter asburiae YT1 and Bacillus sp. YP1 from the gut microbiome of the wax worm larvae consuming polyethylene have been identified by Yu Lou et al., (2020). Frass and plastic sample are subjected to tests like FTIR, GC-MS, GPC, TGA analysed to study the chemical change i.e the formation of C=O and C−O containing functional groups and long chain fatty acids as the metabolic intermediates of plastics indicating depolymerization (Chaudhary et al.,2018).

Objectives:

1. To explore and understand the concept of plastic degradation by greater wax moth
2. To study and understand the morphology, life-cycle and behavior of greater wax moth
3. To determine the plastic degradation rate and depolymerization by greater wax moth
4. To identify and critically analyze the changing chemical composition of plastics and frass sample (excretal matter of wax worm)

5. To identify the impact and challenges involved in plastic degradation by greater wax moth.

Methodology:

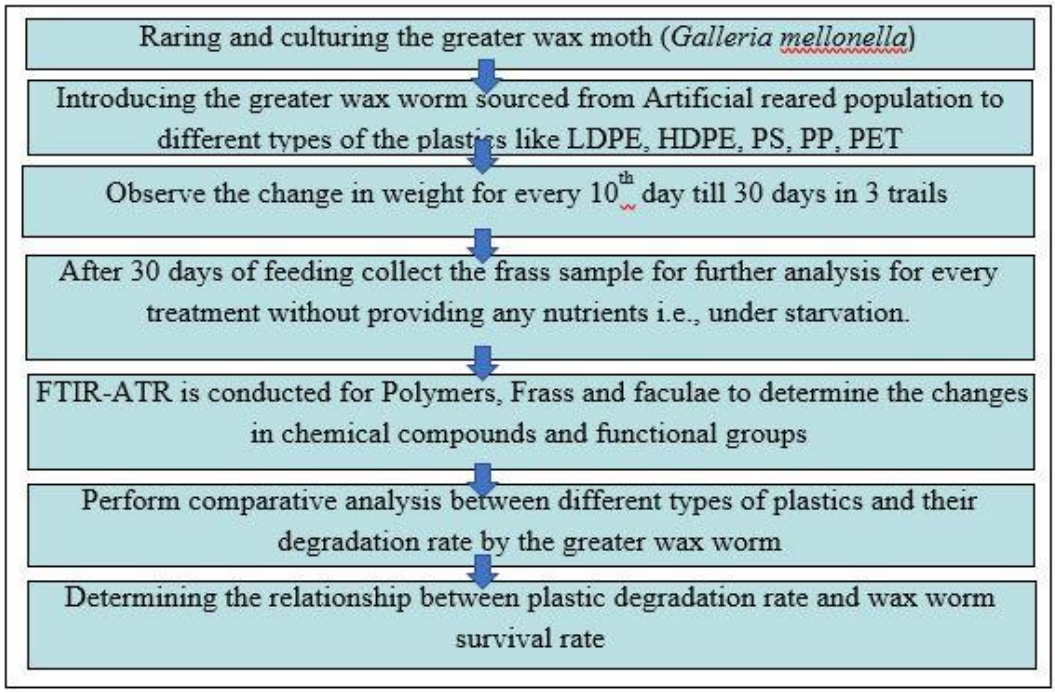


Figure 1. Flow chart of the methodology

The pre-treatment for the container and polymer sheet (5*5cm) was done with 90% ethanol after disinfecting. The larval culture and artificial diet was prepared for the treatments to be introduced. The treatment of polymers with co-diet and only polymer was experimented by introducing 50 larvae in 11 treatments with 3 replications for a period of 30 days. (Figure 2) represents the change in weight of the polymer sheets was recorded on every 10th day. At the end of 30th day the change in weight of polymer sheet, frass and faculae was collected in the petri dish and taken for the further FTIR analysis. A comparative study is done between different polymers, frass samples and faculae to know the chemical changes, degradation and survival rate of the larvae.

Figure 2. Representation of LDPE sheets before and after degradation (A) HDPE sheets before and after degradation (B) PS foam sheet before and after degradation (C)

Result:

a. Plastic consumption and survival rate of *Galleria mellonella*

The *G. mellonella* larvae were confirmed to masticate and ingest LDPE, HDPE and PS foam sheet (Figure 2). Considering an initial number of 50 larvae in each treatment, the weight loss of only LDPE fed larve was 1.78 g, only HDPE fed was 1.67 g and only PS fed was 1.56 g after 30days duration from 25g of initial feed. Adding polymers, LDPE, HDPE and PS as the only diet decreased SR to 36.11%, 33% and 28.34%, respectively whereas addition of artificial diet increased SR to 98%. (Figure 3) represents the weight loss w.r.t treatments.

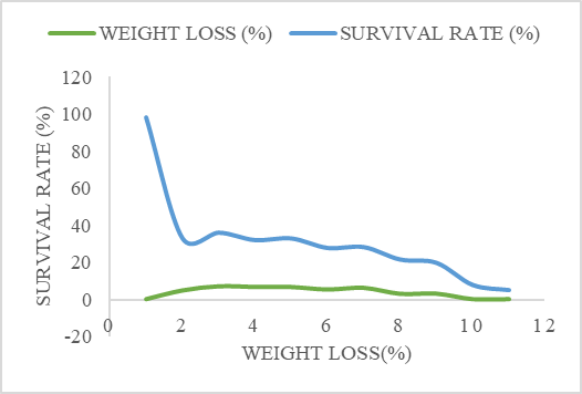
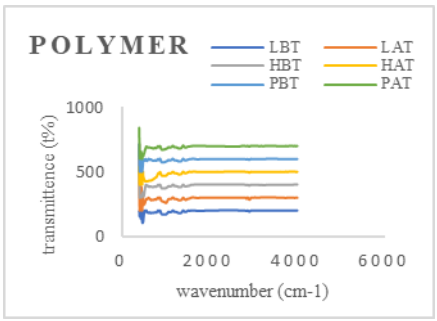
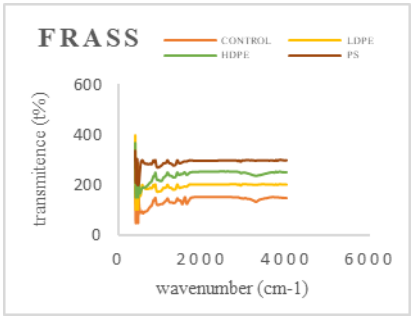


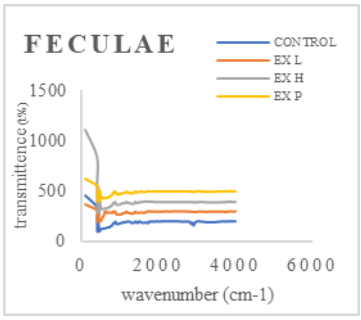
Figure 3 representation of weight loss in polymers w.r.t treatments

b. FTIR analysis:

The FTIR spectral analysis was carried out for polymer samples, degraded polymer samples, frass from polymer fed larvae and faculae of larvae. The graphical representations below explains the analysis. The treated samples of LDPE, HDPE, PS showed C-O stretching (ketone) whereas the untreated larval frass showed presence of C=O stretching (carbonyl group) and untreated faculae indicated C-H bonding.







Conclusion:

The chewing of polymer sheets by *G.mellonella* larvae is the prominent evidence of degradation. Among all the treatment Only LDPE fed treatment showed maximum degradation of 7.12% with 36.11% of SR. Since consumption of polymer reduced the SR and early moulting of larvae was observed.

Scope for future work:

The research can lead to the potential solution for the plastic waste management issues. The future scope can be isolating and identifying specific bacterial strain which will help in degradation of specific polymer. The derived bacterial culture can be made as bio culture used in efficient management of the landfill.