Styrofoam Degradation: One Mealworm at a Time

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The Issue: Plastic Waste

The Global Perspective

The accumulation of plastic has become a global issue, and contributes to global warming and ecosystem collapses. Some important numbers at a glance:

- 300 million tons of global plastic waste per year
- Plastic either sent to landfills, incinerated or recycled
- 30% of plastic waste is due to single-use plastic

Polystyrene is one of the most popular packaging materials as it is cheap, readily available and easy to manipulate. However, its high melting temperature and inertness make it difficult to degrade without incineration, which results in large emissions of greenhouse gases (CO_2).

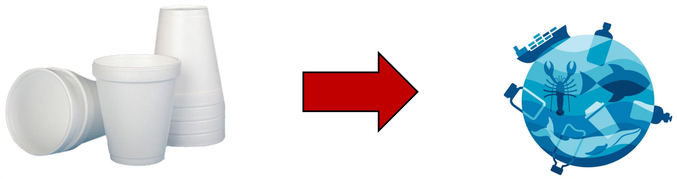
The Rutgers Perspective

Because of its large size, Rutgers is a significant contributor to plastic waste.

- ~50,000 students enrolled
- ~21,500 students living on campus
- 16 million lbs of plastic waste/semester
- 1.5 million lbs of polystyrene waste/semester

Total cost to incinerate Rutgers plastic waste = $45,760/semester

Cost to the environment = 193,765 kg CO_2/semester



Why Mealworms?

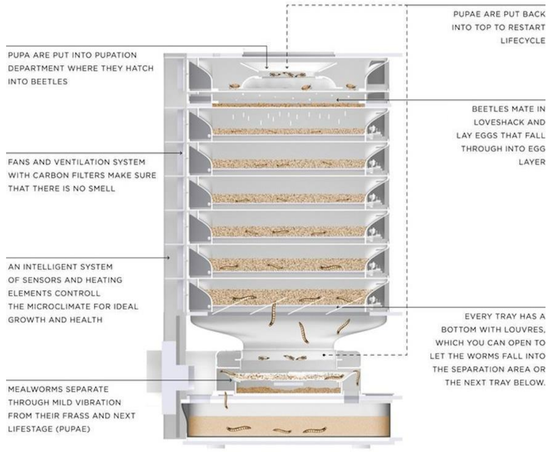
Mealworms, the larvae of *Tenebrio molitor*, have the ability to degrade polystyrene into 47.7% CO_2 and 49.2% nutrient filled feces. Benefits of mealworms include:

- Abundant
- Cheap
- Easily accessible

Mealworms have the ability to live off a diet of polystyrene and other types of plastic, offering the potential to create a mealworm farm which can process Rutgers plastic waste and degrade it to less CO_2 (which can be captured and stored) and biomass that can be recycled for other purposes (i.e fertilizers).

Our Plan

We are proposing that Rutgers establishes a polystyrene waste processing plant on the Cook-Douglass campus which would use mealworms to degrade polystyrene into CO_2 and nutrient-filled biomass. The proposed facility would include a layered mealworm farm to maximize the efficiency of the mealworm breeding and polystyrene degradation process.



Cost Analysis

The cost analysis assumes that 50% of polystyrene waste is converted to CO_2 by the mealworms. This equates to 1.54 kg of CO_2 for every kg of polystyrene consumed. Mealworms have four stages of life:

1. Egg (4-20 days)
2. Larva (10 weeks)
3. Pupa (6-18 days)
4. Beetle (8-12 weeks)

The mealworms can only degrade polystyrene from the larva to beetle stage, which gives ~154 fays of active life. The calculated costs in the table below assume that the cost of mealworms if $0.10/1000 mealworms and that 3,000,000 mealworms are needed to process a kg of polystyrene/day. This model also assumes that the mealworm population will double every 154 days as the mealworms mate and grow their population.

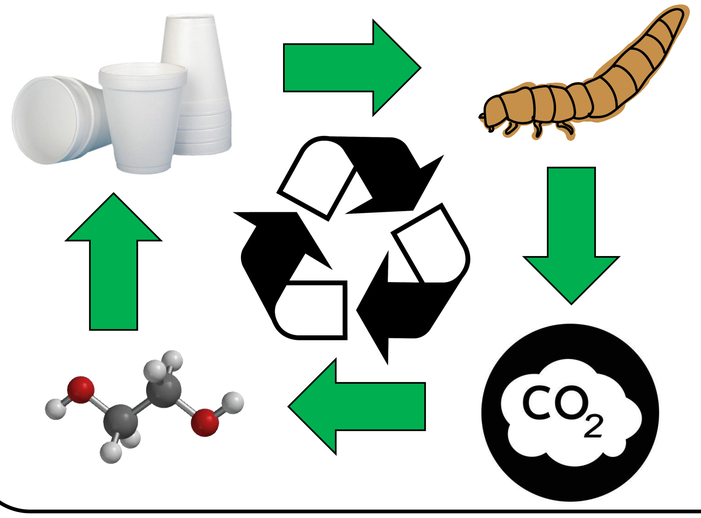
	Recycling	Waste Incineration	Mealworms
CO_2 emissions kg/kg polystyrene	0.271	2.6	1.54
Energy efficiency	-	21%	-
Process costs ($/kg)[1]	0.288	0.199	Cycle 1 = 1.950 Cycle 2 = 0.975 Cycle 3 = 0.488 Cycle 4 = 0.244 Cycle 5 = 0.122
Energy requirement (kwh/kg)[2]	1.347	7.95	0

The Future

The facility proposed is the first step to mitigating Rutgers' CO_2 emissions due to polystyrene waste. As time progresses, it is hoped that this facility will grow and expand to become a research facility in addition to the polystyrene waste facility. Some additions that we envision for the future of this facility include:

- Research labs to study the bacteria in the mealworms responsible for degrading polystyrene
- Testing facilities to test the ability of mealworms, and other insect types, to degrade other plastics
- Partner with the Rutgers EcoComplex to improve the plants process to increase the efficiency of polystyrene degradation
- Collaborations with lab groups within Rutgers University to develop efficient ways to capture and use the CO_2 created in the mealworm farm as well as the biomass excreted by the worms.

By continuous research and innovation of this process, our hope is that this facility could become a birthplace for plastic waste degradation by worms and other insect life.



Acknowledgements

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