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Hungry for Styrofoam: Mealworm's Solution to the Great Pacific's Garbage

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Abstract

Polystyrene, a recyclable material, used in packaging, drinking containers, and to-go boxes are linked to 30% of the materials in landfills. How do we cost effectively to solve this problem? Why is nothing being done about this? Will polystyrene ever become obsolete?

Subject Areas

Entomology, Environmental Sciences

Keywords

Styrofoam, Mealworms, Recycling, Polystyrene

Polystyrene[1], commonly known as Styrofoam (**Figure 1**), has made huge leaps since its discovery in 1947. Originally used as life rafts for the United States Coast Guard and building insulation it is now frequently used as grab and go containers and coolers. Polystyrene is not essential for life and is easily replaced with bamboo, mushrooms, and edible packing peanuts materials. Now that polystyrene is used for convenience and taking up above 30% of most landfills, measures must be taken.

Without a solution to the growing problem of unrecyclable Styrofoam the planet is slowly being cluttered by its easy access. 30% of landfills are polluted with polystyrene, which sometimes find their ways into waterways, that at 86 degrees Fahrenheit decompose. Additionally, unexpectedly cooler temperatures are also effecting plastic breakdown as early as within a year. Just one of the compounds broken down is **Bisphenol A**[2] which gets in the way of reproductive

[1]Widely used plastic made up of styrene monomers often found as a solid or foam.
[2]Organic near insoluble compound used in plastics.

Figure 1. Explains the different numbers on objects relating to their recyclability. Break down of the numbers found on all plastic objects that explains how they must be recycled and what objects fall under which numbers [6] (2015).

system of animals and **styrene monomers**[3] have suspected **carcinogenic**[4] properties (**Figure 2**). Styrofoam starts in a whole form however eventually it breaks into smaller pieces and gets swallowed by land and marine animals, which is toxic, and creates blockages in their stomachs. The blockages stop the nutritional gain and intestinal flow that is needed in any organism [1] (**Figure 2**).

With the sprinkled amounts of plastic in the water now marine and birds are becoming sponges to the carcinogens found in heated plastics (**Figure 2**). Styrofoam is one of the world's main marine debris that floats and when saturated, sinks to where fish eat it. Once fishermen pick up the fish they are shipped to our dinner plates but not before it had time to soaked in some carcinogenic pollutants such as **DDT**[5], an insecticide, from the polystyrene [2] (**Figure 3**).

Alone in the United State we consume more than 2.3 billions pounds of plastics annually. Of that 2.3 billion pounds of plastic some of that material is soaked in to the users' bodies [2] (2006). Bisphenol A, a compound found in plastics, is a chemical that accelerates human breast cancer cell growth along with decreasing sperm count in rats. Nearly all urine samples taken in 2004 from the US

[3]Easily evaporative colorless sweet smelling type of benzene which is used in polystyrene.
[4]Could cause cancer.
[5]Compound found commonly in insecticide.

Figure 2. Demonstrates effects of garbage on organisms near garbage dumps. To the left is a picture of a dead bird who has been decaying for about 3-5 weeks. Inside the bird are lighters, bottle caps, and an assortment of other plastic man made and used objects. To the right is a picture of a sea turtle. The sea turtle thinking the bag is a jellyfish their common source of food is about to eat the plastic bag [7] (2016).

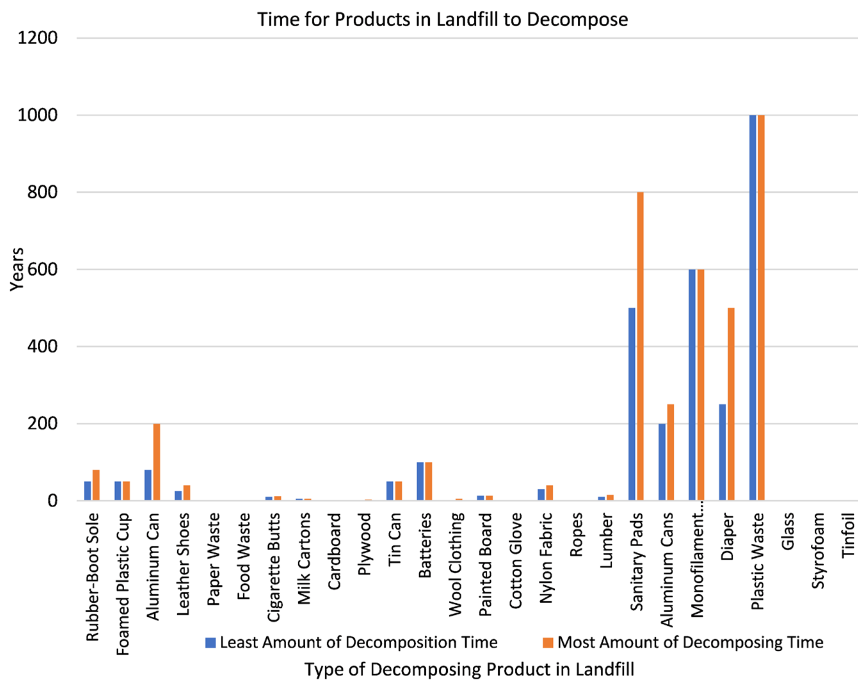


Figure 3. Demonstrates the number of years it takes to recycle different materials. Graph describing what happens to everyday products that are thrown out and sent to landfills to sit for years. In the graph, three products have values of 0 which indicates that they are unable to be biodegraded in a landfill or take more than a million years. Figure made and modified from [8].

Center for Disease Control found doses from 72 to 177 nanograms of Bisphenol A per pound of weight at any day in humans. By the US Environmental Protection Agency and the European Union's European Food Safety Authority, 1000 times higher than the safe amount found in humans [2] (2006).

Because our meals are accompanied by low constant easily dischargeable amount of Bisphenol A that is passed in a different form called glucuronide which can be broken down in only a few days. Found in a multitude of our everyday objects and even objects we deem safe for our children such as plastic cups and baby bottles have accelerated give off when heated or let sit with warm liquid [3] (2010). The human body fascinatingly can take most of the Bisphenol A consume by us and excrete it however even with this free passage at least ten times the recommended amount of Bisphenol A still rest constantly in our fatty tissue and blood.

Shocking inferential statistics have come back that over 90% of 2000 people, ages 6 to 85, had detectable levels of Bisphenol A showing that the ages and the level of Bisphenol A product are inversely correlated. Similarly in small mammals such as mice permeant effects have developed after only short exposure periods that are eventually excreted to the point that some ill effects found in animals may foreshadow permeant damage in adolescents and infants. The mice subjected to the study metastasized cancers and other health issues but were given 10 times less dosage than is fed to children each day. Leeway is warranted due to the recent studies on how tiny rodents are much more susceptible to estrogen however higher estrogen levels in **premenopausal**[6] women can cause a slew of cancers [2] (2006).

Even though plastic and polystyrene are both considered plastic materials they cannot be recycled the same way. Normal plastic is sorted into its different polymers then cut and heated into pieces that can be put together into any assortment of objects. On the other hand, polystyrene is problematic due to the energy output of storing, shipping, cleaning polystyrene. Because of these considerations polystyrene has been pushed aside as unrecyclable. If society renounced polystyrene we could switch to different more recyclable plastics, paper or cardboard and ceramic cups for hot liquids. One of the biggest issues is how light and big polystyrene, however can be easily solved by compressing them into cubes to be shipped to **EPS processors**[7] [4] (2017). Finally burning it and tossing it are two very unfortunate and different ways of hurting the planet, with the toxic gases and landfill space that polystyrene produces. Polystyrene is considered one of the hardest plastics to recycle.

While scientist today have looked into two solutions to the epidemic of polystyrene that is slowly covering our planet, they studied the effect that polystyrene had on **Tenebrio**[8], a mealworm, once consumed (**Figure 4**). Additionally, they also succeeded in super heating polystyrene until **Pseudomonas Putida**[9], a rod shaped bacteria, could consume and pass as a recyclable material

Scientist tested different invertebrates and found that mealworms were able to have a diet consisting exclusively of polystyrene [5] (**Figure 4**). The polystyrene

[6]Woman's life right before menopause, a period when ovaries purpose ends.
[7]Recyclable area for hard to recycle plastics such as Styrofoam.
[8]Species of darkling beetle.
[9]Bacterium with tube shaped characteristics found in moist soil areas with oxygen.

used in the test was 98% polystyrene and the mealworms were taken between approximately 3 - 4 **instars**[10], a phase between molting periods. When feeding on the polystyrene blocks any dead mealworms were immediately taken out. Time was measured periodically against the amount of polystyrene block that was consumed. Two sets of mealworms were compared one solely on a diet of polystyrene while the other solely on bran both with 500 worms [6] (2015) (**Figure 5**).

The diet lasted 30 days with **fecula**[11], insect fecal matter, being cleaned and stored every 12 hours in order to not contaminate polystyrene drop off that was not consumed. After three samples were analyzed, over a 30 day period, we discovered positive results. Depending on the test time different amounts of polystyrene was eaten due to number and growth stage however overall ate 31% ± 1.7% of the 5.8 g of initial polystyrene material. After the first month a second month was added and stopped once **pupae**[12] formed and within 2 weeks adult beetles formed explaining that no detriments were placed on the mealworms survival or molting [6] (**Figure 6**).

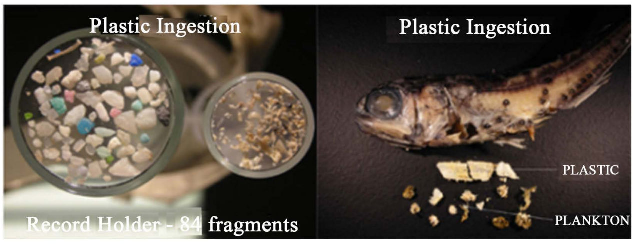


Figure 4. Demonstrates the particles found within fish in the surround areas of garbage. The left photo shows what fragments were found inside of a common fish pulled out of the ocean. The right photo shows the amount of plastic to plankton found in a common minnow and how the ratio is almost one to one [9] (2015).

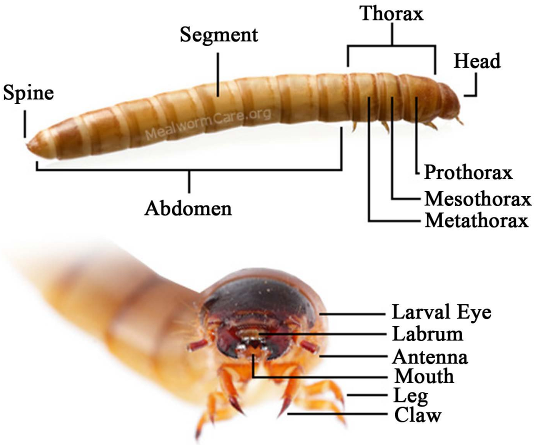
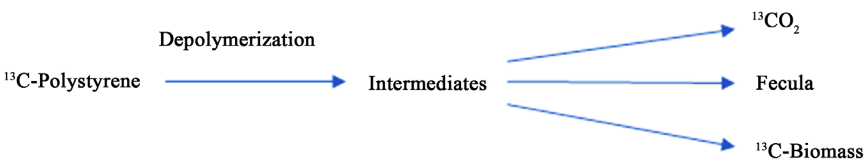


Figure 5. Explains the physiological parts of a Mealworm. Picture explaining what the different part of the exterior of a mealworm [10] (2015).

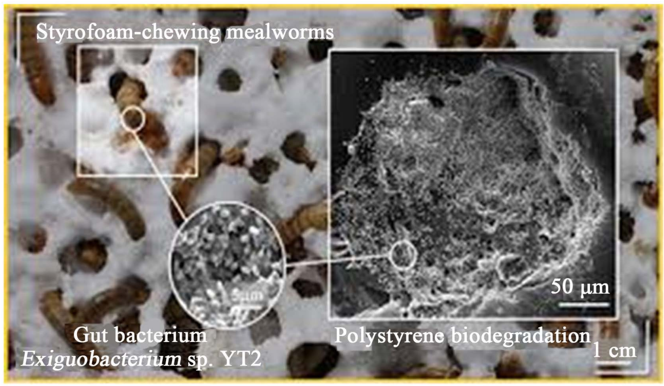
[10]The period between molting where larva develop.

[11]Insect feces.

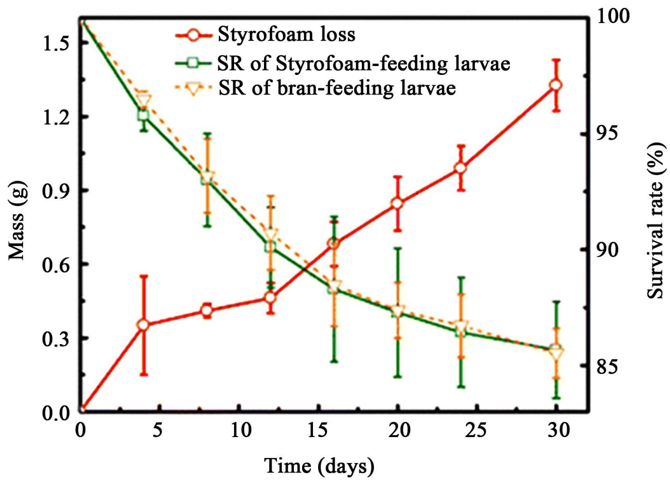
[12]Immature period between larva and adult.



(A)



(a)



(b)

(B)

Figure 6. Explains the digestive properties with Mealworms that breaks down the Styrofoam. (A) The process of how Mealworms take Polystyrene and degrades it into carbon dioxide, fecal matter, and mass for the mealworm. Figure modified from [6]; (B) Rate of consumption of Styrofoam. (a) a picture of mealworms eating polystyrene and the bacteria found inside their gastrointestinal tract that biodegraded the polystyrene, (b) a graph showing the mass of consumed Styrofoam over the time over the survival rate of bran fed larvae and Styrofoam fed larvae [7].

The planet needs a change but a change is expensive, progressive, and a choice. The biggest issue is because of the sudden drop in oil prices a drop all came with virgin plastics that helped to outcompete the cost of recycling the seasoned veteran plastics. Next is a movement towards more easily recyclable plastics that will help with the discrepancy of the quality of plastics with all of its additives and hazardous filth (**Figure 1**).

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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