A Systems Dynamics Model Exploring the Continuous Biodegradation of Plastic

Saha, Kreesha (School: West Lafayette Junior/Senior High School)

The global plastic production increases every year. In 2015, the worldwide plastic production was 322 million metric tons, an amount that will eventually be converted to waste. Due to lack of efficient recycling methods, much of this waste ends up in landfills and oceans, and depletes natural resources. Laccase, an oxidase enzyme, biodegrades polychlorinated biphenyl and polycyclic aromatic hydrocarbons, both compounds containing benzene rings. Polyethylene terephthalate (PET), a major form of plastic, also contains benzene rings. In this project, a systems dynamics model was created in the program Stella to determine the feasibility of using the enzyme laccase, produced by Trametes versicolor fungi, to biodegrade PET. Three variables were tested: amount of given media, dilution rate, and amount of starter fungi. Maximum plastic biodegradation was 8 mg/L and 11 mg/L for the given media and dilution rate, respectively, while maximum biodegradation was 2700 mg/L for starter fungi. Analysis showed that the amount of starter fungi was the most significant variable contributing to the biodegradation of PET. Fungal growth declined as dilution rate increased, implying that batch culture is a better option than continuous culture for PET biodegradation. Fungal growth increased as given media increased, showing that fed-batch culture is the most effective culturing method for increasing fungal growth and PET biodegradation. Usage of this biodegradation method can maximize the efficiency of the recycling process, improve sustainability for natural resources, and prevent the addition of new plastic waste to the environment.