The Mission of Plastic Decomposition: Fungi Edition

New Mexico Supercomputing Challenge

Final Report

April 29th, 2019

Team #59

UBMS through the New Mexico Institute of Mining and Technology

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Abstract

Tremendous increases in the manufacture and consumption of plastics over recent years have led to numerous ecological and economic concerns. The reproduction of synthetic plastics introduced into the environment by human industry and modern technology poses a major threat to natural environmental systems. The low cost and ease of manufacture have increased global plastic demand drastically, with the production of 1.5 million tons in 1950 and 239.6 million in 2017. Despite recognition of the pollution problems posed by plastic, global production is still increasing, with the largest increases expected in still-developing nations. The sheer mass and quantity of plastics produced each year presents a problem for waste disposal systems. The scale of this problem and the inefficiency of plastic recycling prompted the search for effective methods for the biodegradation of plastics. When looking at ways to get rid of plastic polymers for good, there has been experimentation with biodegradation of plastics, specifically polyester polyurethane. Polyester polyurethane (PUR) is a plastic widely used in industry and manufacturing that has been shown to be susceptible to biodegradation. In these experiments, scientists and mycologists were working in an effort to identify new organisms with the capability of plastic degradation. It was an effort that led to the exploration of the biological and chemical diversity of endophytes. Endophytes are hyperdiverse microorganisms, including bacteria and fungi, that live within the inner tissues of plants without causing overt disease symptoms, similar to a symbiotic relationship. The endophyte is able to extract energy from the plastic material in exchange for some of its biological material (it eats it). In this case, the endophyte best fitted to degregade PUR is a special genus called pestalotiopsis microspora.

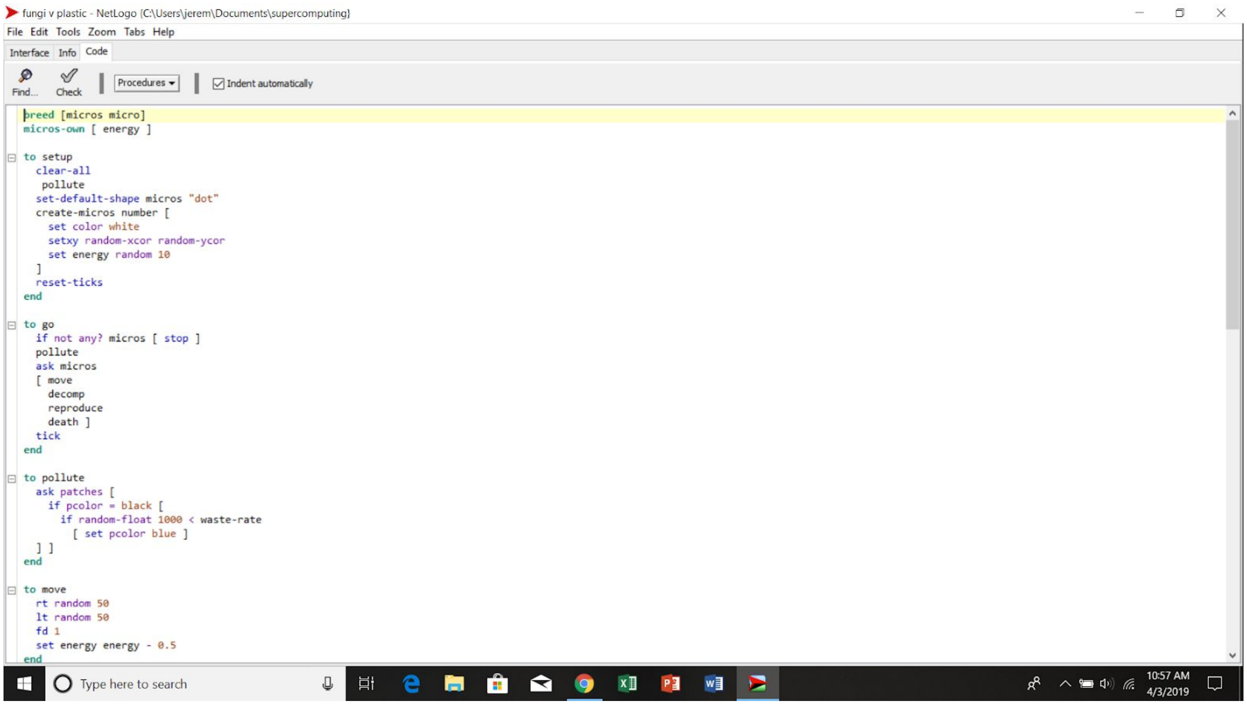
Executive Summary

The overall trajectory for our project is to test the potential *Pestalotiopsis Microspora* has at being an efficient method for plastic waste reduction. The plastic waste that the *pestalotiopsis microspora* consumes is polyurethane, which has a growth rate of 3.5 million tons per year. In this process of biodegradation, the plastic polyurethane would actually be erased into organic material, rather than just recycled into more plastic material, which is very beneficial since plastic is being produced rapidly and is not being recycled as efficiently. We have researched information on Pestalotiopsis Microspora through research that other people have conducted and our own sources. With this information we messed around with code in NetLogo to see how we could show the interactions between the *pestalotiopsis microspora* and the polyurethane. We coded a model suitable to explain (very basically) how effective and how fast the endophytes would eat and grow over a time span. The outcome that we got from all of our research is that the *pestalotiopsis microspora* would lower the polyurethane plastic levels in our waste production and is not a considerable investment for the level of efficiency a wide scale production of these mushrooms could have on the pollution crisis.

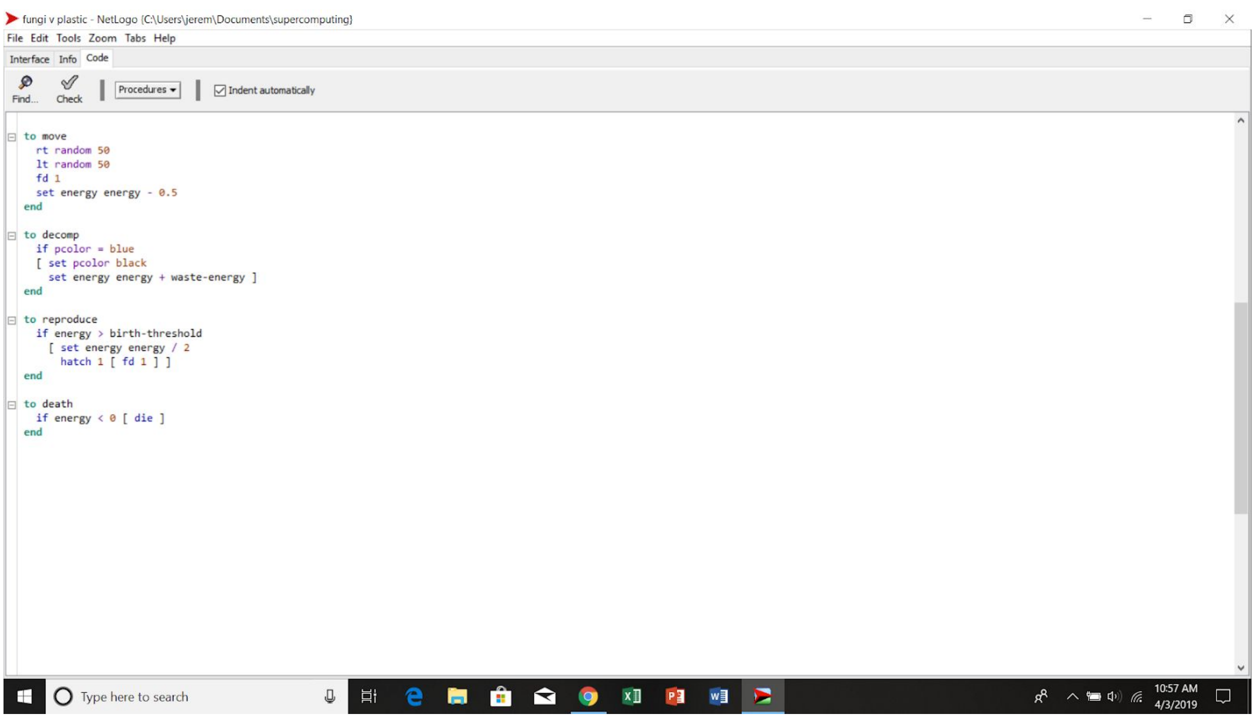
Problem Solution

We will implement the use of *pestalotiopsis microspora*, a fungi that would break down the waste material, polyester polyurethane, and absorb it into itself during the fertilization process, thus making it organic material which could be safely consumed. In this process, the plastic polyurethane would effectively be reduced down to a energy for the fungi and then used and erased from existence. This solution is one of very few that completely reduces the waste to nothing and therefore lowers the amount of waste rather than converting it into new waste. We do not know enough about the fungus as a food source, though we do know is safe for consumption, so our Netlogo presentation is simply presenting the process the fungus takes as a means of controlling plastic waste. Most of the results are seen in numbers, and must be examined over a long period of time. To compensate for the limitless number of conditions in which the process could take place, we add variables, in which basic, but different types of ecosystems can be added as well as temperature and location. Temperature is important because the fungi can exceed extremes of hot and cold temperatures and must grown in only some parts around the world. Location also affects how easy it is to get plastic waste; isolated, sparsely populated regions will have little plastic waste around while huge cities with booming infrastructure and growth will have an exceptional amount. All factors taken into account all affect the overall efficiency our fungi will have and are acceptable for our model as real world problems we'll have to overcome in any rendition of this experiment.

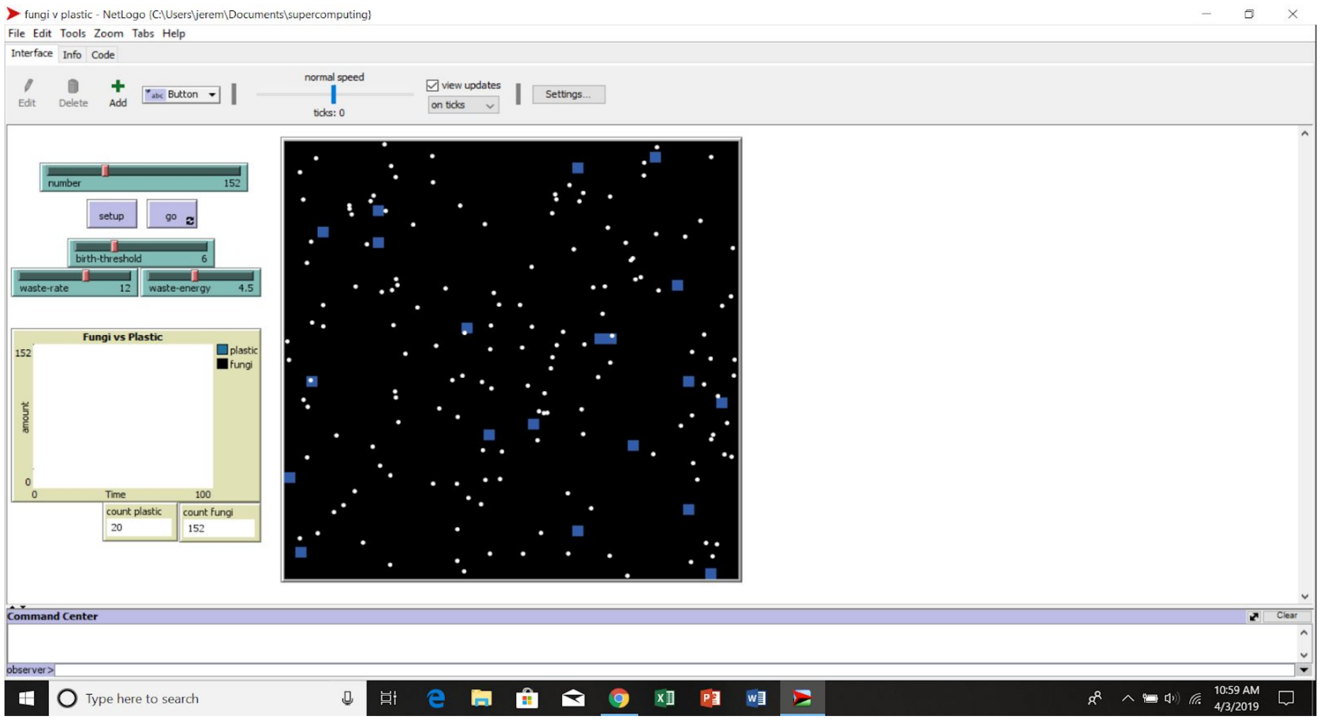
Code




```
breed [micros micro]
micros-own [ energy ]

to setup
  clear-all
   pollute
  set-default-shape micros "dot"
  create-micros number [
    set color white
    setxy random-xcor random-ycor
    set energy random 10
  ]
  reset-ticks
end

to go
  if not any? micros [ stop ]
  pollute
  ask micros
  [ move
    decomp
    reproduce
    death ]
  tick
end

to pollute
  ask patches [
    if pcolor = black [
      if random-float 1000 < waste-rate
        [ set pcolor blue ]
  ] ]
end

to move
  rt random 50
  lt random 50
  fd 1
  set energy energy - 0.5
end
```

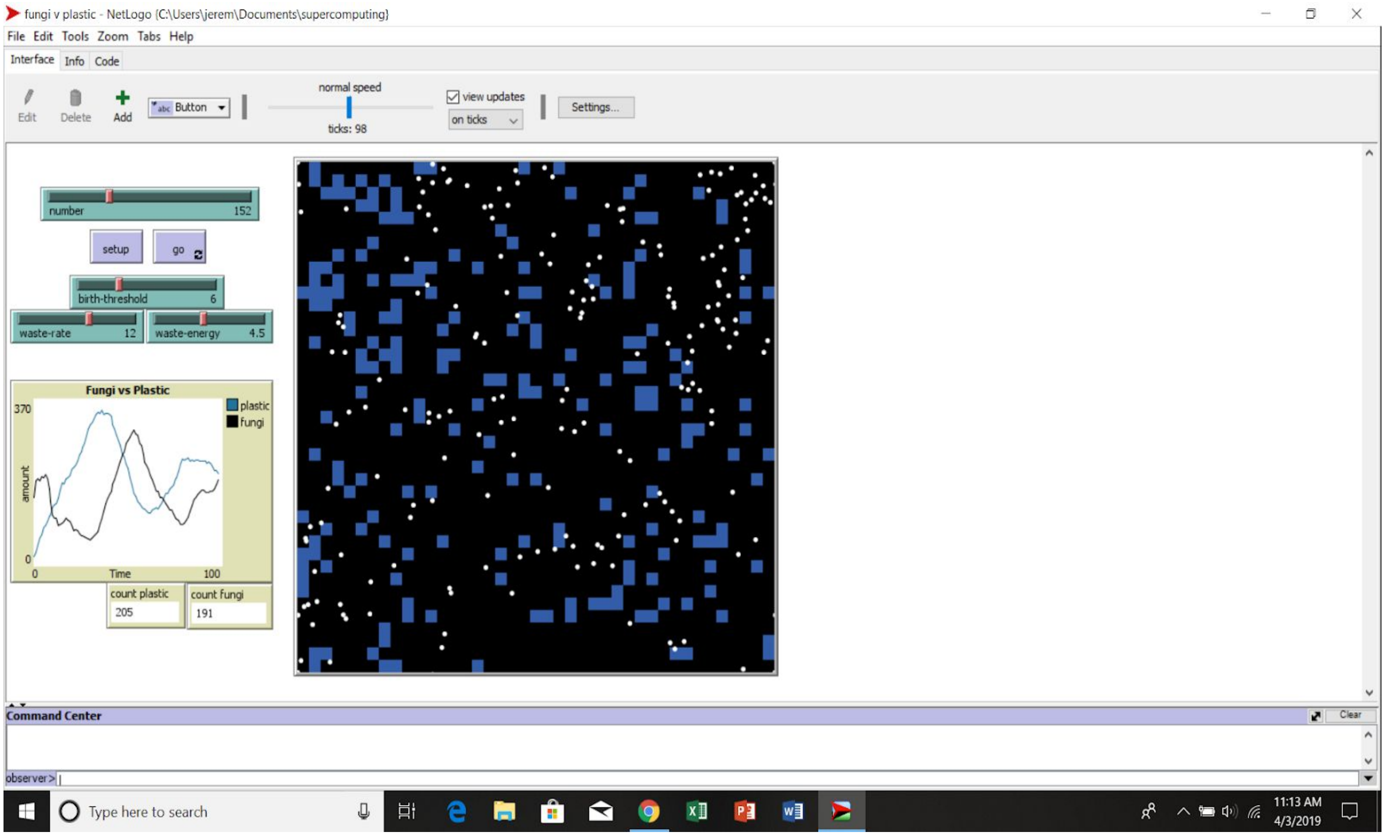



```
to move
  rt random 50
  lt random 50
  fd 1
  set energy energy - 0.5
end

to decomp
  if pcolor = blue
  [ set pcolor black
    set energy energy + waste-energy ]
end

to reproduce
  if energy > birth-threshold
    [ set energy energy / 2
      hatch 1 [ fd 1 ] ]
end

to death
  if energy < 0 [ die ]
end
```



The white specs represent the fungi while the blue patches represent plastic. There are multiple sliders that can be used to simulate different situations: the birth threshold is the energy level that will make the sprites reproduce, the waste rate is the rate at which the blue patches appear, and the waste energy is how much energy the fungi gains from eating the plastic. The number slider is simply the starting number of fungi. There is a plot to track the amount of both fungi and plastic over time, along with monitors that report the current amount of fungi and plastic.

The code the setup button has the initial fungi randomly dispersed, as well as the plastic, which is done by the pollute function. The pollute function exists because it is used in both the setup for initial plastic and with the go button to continuously disperse plastic based on the waste-rate. There is also a decomp function, which is saying that when the fungi come in contact with plastic(a blue patch), the patch turns black to represent removal of plastic and the sprite gains energy based on the waste energy slider.



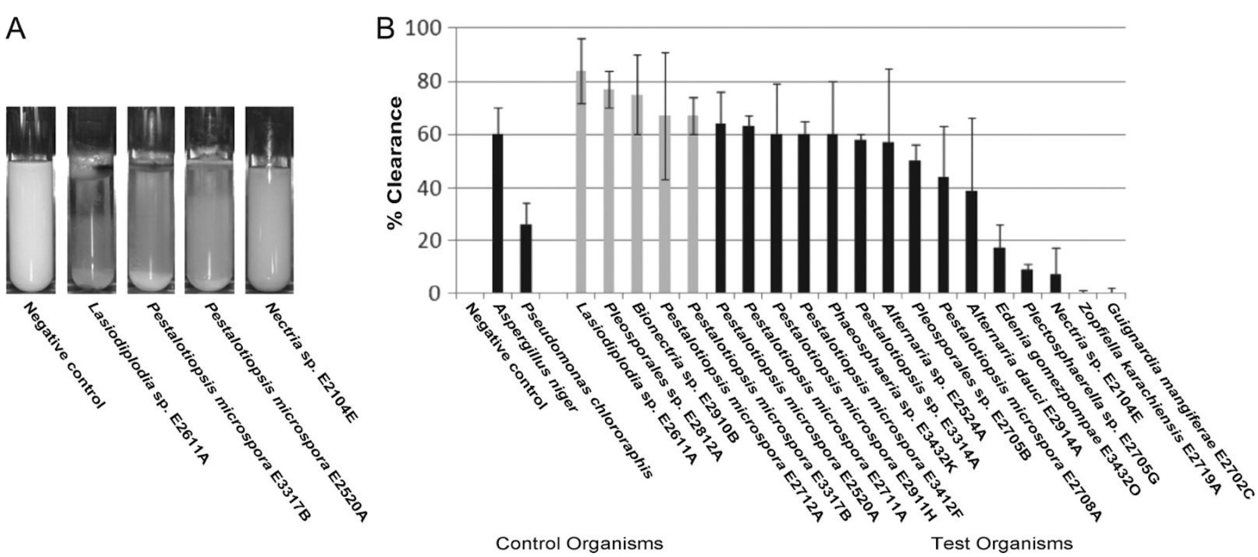
Methods

Fungal Farms- Sterilizing the plastic in a controlled environment using UV lights. Extracting the fungi from the nursery. Putting the fungi onto the agar (nutrient rich bodies where the fungi grows.)

Assuming the fungus can survive amongst thrown out trash with the polyurethane plastics as its food source, it could simply be driven to grow naturally amongst wild ecosystems or even modified landfills where plastic waste can be directly laid out as a food source for any naturally occuring *pestalotiopsis microspora* in the immediate area.

Results

We hope to determine the point (in time) at which the growth of fungal farms will start to effectively reduce the amount of plastic in landfills while still measuring current plastic waste intake. We want to determine how many fungal farms, water and plastic needed alongside it, will be needed to be grown to achieve such goal. And lastly we hope to incorporate cost, time, space, and availability to resources to see the true effectiveness of the project in a real world environment.



Conclusion

Unfortunately, due to how much is unknown about this fungus, much less the potential for it as a food source, we cannot accurately test its capabilities on such a large global scale. The risk of attempting to use it as a singular method against waste is too high, and thus can only be modeled on a rudimentary level. However it clearly shows promise as a disposer, and as such would be efficient on a smaller-scale level as of right now, maintaining waste that is freshly thrown away in order to keep the problem from getting worse than it already is. Or it could be managed and classified as yet another form of waste recycling. We also don't have the necessary funding or access to any of the right equipment to test out our research on a global scale. What we do know is that no matter what way you look at it, modern industry is going to kill. Synthetic waste and fossil fuel consumption is leaving the world with more than it can handle, and we're going to have to come up with ways to actually get rid of the waste. Luckily, its slowly already began, with the research and discovery process already done, experiments are being made and will hopefully continue until a breakthrough occurs: either a biological revelation, or a hopeless money surplus. Soon, waste management will be under control, but for now, we must look to all possible forms of degradation, until we find the key that clicks.

Acknowledgements

Huge thanks to Dr. Kalish for going over our interim and giving us valuable feedback that pushed our project in the right direction. Another large thanks to Donna, who gave us the info about endophytes and the starting background info for discovering what the fungus really was. We would also like to give a thanks to Ms. Glennon, Ms. Lunsford, and Ms. Meyer for being our mentors and keeping us up to date with the challenge, scholarships, and other related activities. We would also want to thank Geoff Danielson for giving us helpful ideas on what language we should use for our project and ideas on how to execute it.

Our Significant Achievements

Torrey- What I learned from this project is that communication is crucial in order to have everything completed in time. I think time management is important too so that everyone gets their work done. I helped on researching mostly and worked on the poster. I also helped with the final report by making sure everything looks nice.

Jeremy- I learned two different coding languages, and I would say doing this with this topic at all is an achievement of its own right because of what little there is known about it.

Danny- I learned that we can go green without always recycling in recycling bins but we can make edible recycles, and as time goes on we will be able to do more than just use mushrooms to reduce the amounts of plastic waste on this planet but turn it into energy that will be useful.

Seth- I learned about Python and NetLogo more than ever before. I learned how to deal with tough situations and problems. A big part of that was finding help with the many people who offered their advice and guidelines. They helped steer us into the right directions and fulfill the level of uncertainty we had during research.

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