Plastic Pollution Design Document

Model Description

When you toss a plastic bottle into the garbage because it is more convenient than recycling it at the time, where do you think that the bottle ends up? More likely than not, your bottle will ultimately make its way to the ocean where it will remain for eternity. Even if you live thousands of miles from a body of water, plastic is regularly blown away due to its weight and often ends up inside a storm drain or a river, from where it begins to make its way to the sea.

During this journey, while many plastics do remain in their full form, a good majority of plastics that take this long journey enter the ocean in the form of "microplastics" which are minuscule scraps of plastic that are 5mm or under in diameter. These microplastics may seem harmless due to their insignificant size, however, when ingested by marine animals, these plastics can be deadly. Microplastics may also bind with other harmful substances during their journey which further increases the damage that they cause to marine life but also affects our drinking water and seafood. Water treatment facilities are unable to remove all traces of microplastics. This journey from your hand to the sea can take multiple years depending on how far away you live from the sea but eventually, they will reach the ocean in one way or another.

With that in mind, this model attempts to present a basic simulation of how plastics can pile up over time and affect marine life in the sea. The model aims to envision the continuous accumulation of plastic in an imaginary body of water and the resulting effect on the marine life that calls this body home.

Possible states of a cell

A cell will have 5 possible states and depending on the state of the cell, may have additional subsets. The possible states of a cell are water, land, fish, plastic, and human.

- ➔ Water cells represent the area in which fish and plastic may freely move around. These cells are represented in #4B4BFF blue.

- ➔ Land cells represent the area where humans may walk and drop plastic. These cells are represented in #D2B48C tan.

- ➔ Fish cells represent marine life in the sea that is affected by the plastic and are restricted to only moving in the water cells. These cells are represented in various shades corresponding to their level of injury.
    - Healthy fish are represented in #FF7896 pink.
    - Acutely injured fish are represented in #A0508C magenta.
    - Severely injured fish are represented in #781E64 purple.

- ➔ Plastic cells represent plastic that has wound up in the ocean due to human activity and are restricted to only moving in the water cells.
    - Microplastic cells are represented in #781E64 blue; it takes three of these to kill a fish cell.
    - Large plastic cells are represented in #FFFFFF white; it takes only one of these to kill a fish cell.

- ➔ Human cells represent the cause of plastic pollution and are restricted to a fixed path in the land cells. These cells are represented in #000000 black.

A fish cell may “die” if it has taken enough damage, if this happens then the fish cell will become a water cell.
A plastic cell may be eaten by a fish if its position overlaps with one of a fish cell, in this case, the plastic cell will “merge” with the fish cell and cause the fish to either gain injury or die.

Evolution Rules

- ➔ Fish cells will be randomly placed throughout the area of water cells according to a percentage that the user may modify[1]
- ➔ The human cell will periodically appear at the bottom of the land strip and move up one cell each evolution until it has moved off the screen

[1] Default is 5%

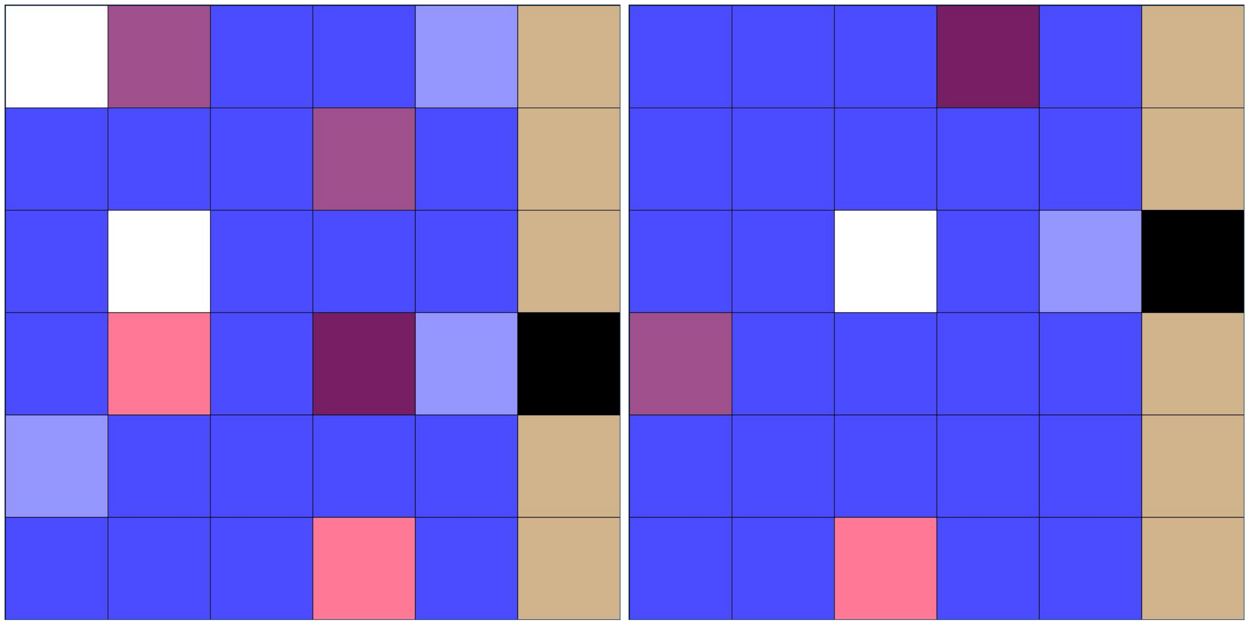
- Plastic cells will have a chance to spawn in the cell directly to the left of the human cell as if the human were dropping the plastic into the ocean.
    - Plastic cells will have a varying percentage of either being a large plastic or a microplastic which the user can modify[2]
    - The user may also modify the chance at which plastic cells spawn[3]
- Fish cells and plastic cells will move to a randomly chosen neighbouring water cell at each evolution
- If a fish cell and plastic cell happen to pick the same cell to occupy in the next evolution, then the fish cell will “eat” the plastic cell.
    - A fish will need three microplastics to be ingested before it will die.
    - A fish has three possible states
        - Healthy
        - Acutely injured
        - Severely injured
    - Ingesting a microplastic will cause a fish to advance to the next level of injury.
    - After three microplastics or one large plastic have been ingested by the fish, then the fish will “die” and become a water cell.
- If a fish cell is surrounded and has nowhere to move in the next generation, it will die due to overpopulation and become a water cell.

Sample evolution and explanation

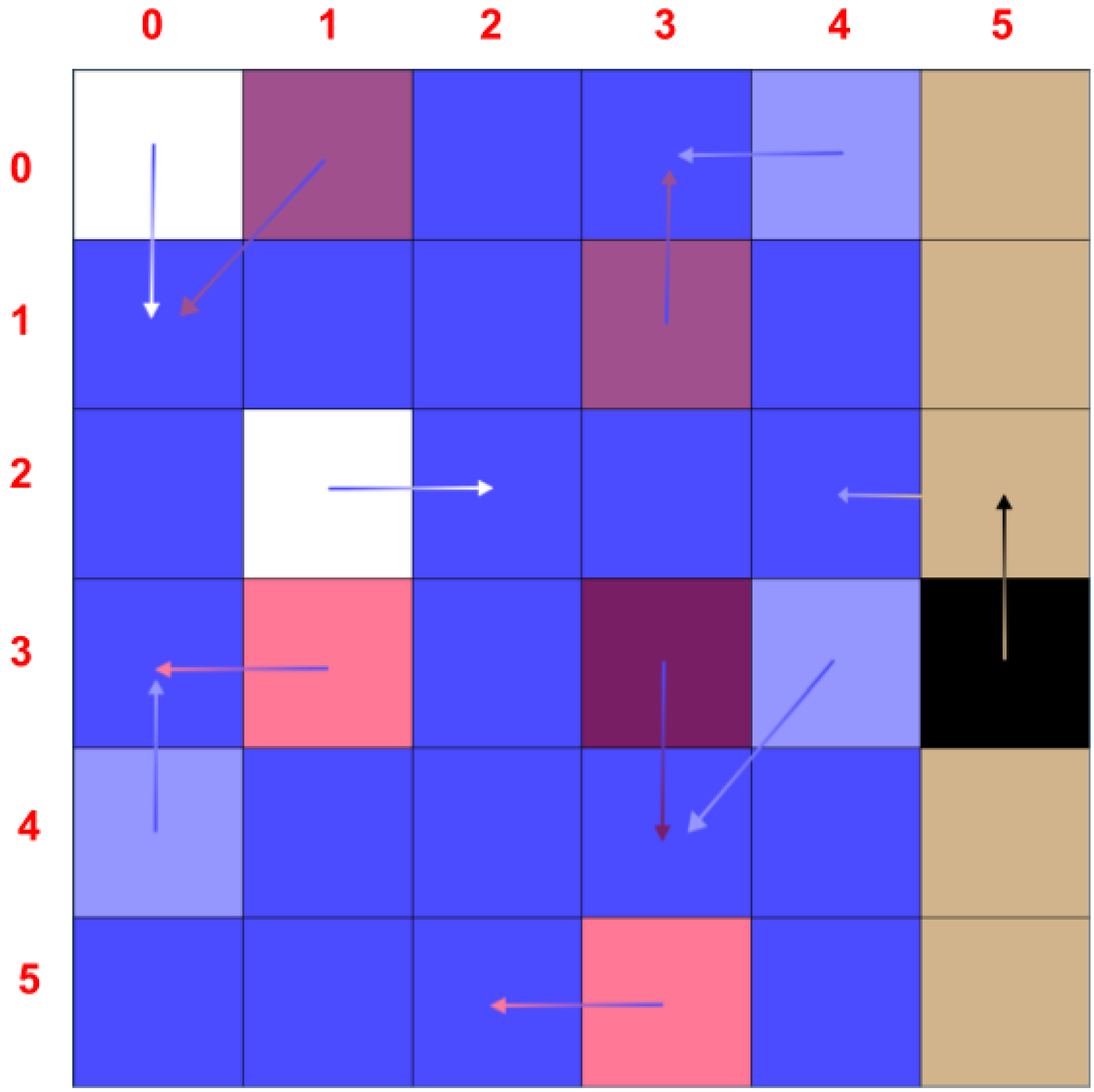
Generation 1:

Generation 2:

[2] Default is 90% microplastic and 10% plastic
[3] Default is 50%



Visualization of Transition From Generation 1 to Generation 2



Note that the direction in which cells move is randomized meaning that this result is only a prediction of a possible outcome that could occur. Cells are referred to with the notation *[row, column]* as labelled above.

- The large plastic at *[0,0]* and the acutely injured fish at *[0,1]* merge at *[1,0]*, the fish dies from ingesting the large plastic therefore *[1,0]* will be a water cell in the next generation

- The microplastic at *[0,4]* and the acutely injured fish at *[1,3]* merge at *[0,3]*, the acutely injured fish ingests the microplastic and therefore *[0,3]* will be a severely injured fish cell in the next generation.

- ➔ The large plastic at *[2,1]* moves to *[2,2]* and does not cross paths with any other cell and is therefore unaffected. *[2,2]* will be a large plastic cell in the next generation.

- ➔ The healthy fish at *[3,1]* and the microplastic at *[4,0]* merge at *[3,0]*, the healthy fish ingests the microplastic and therefore *[0,3]* will be an acutely injured fish cell in the next generation.

- ➔ The severely injured fish at *[3,3]* and the microplastic at *[3,4]* merge at *[4,3]*, the severely injured fish dies from ingesting the microplastic, therefore *[4,3]* will be a water cell in the next generation.

- ➔ The healthy fish at *[5,3]* moves to *[5,2]* and does not cross paths with any other cell and is therefore unaffected. *[5,2]* will be a healthy fish cell in the next generation.

- ➔ The human cell at *[3,5]* moves up one step to *[2,5]* and drops a microplastic into the water directly to its left at *[2,4]*. Therefore *[2,5]* will be a human cell and *[2,4]* will be a microplastic cell in the next generation.

<u>Strengths of the model</u>

This model accurately shows that:

1. Large amounts of plastics in a body of water will eventually result in mass injury and death of the marine life that occupies the said body of water. This model demonstrates a decay in the amount of healthy fish over time as more plastic is added.
2. Microplastics do not directly kill marine life however they do cause injury over a period of time and will eventually cause harm to the population as a whole. This model demonstrates the fact that microplastics are not directly harmful by giving the fish various stages of injury that they may take on before dying due to plastic.

3. Plastics tend to group together and form large clusters in the location that they are deposited, in this model the plastic tends to stick to the right edge of the screen since that is where they are being deposited from.

Simplifying assumptions of the model

1. In reality, fish and plastics do not move in a random direction, fish generally have a destination that they are swimming towards and plastics tend to follow the current of the water. This model takes these factors out of the simulation.
2. Humans do not dump plastic directly into the ocean. Alternatively, the plastic that ends up in the oceans is a result of humans choosing to not recycle or to litter for the sake of convenience. This plastic ends up in the oceans via storm drains or rivers. For the sake of simplicity and to emphasize that this is a direct result of human negligence this model has the human directly dropping plastic into the ocean.
3. This model assumes that all fish will die after ingesting exactly one large plastic or three microplastics. Of course, this is not what happens in reality. Some fish may be able to ingest multiple units of plastic and not see any negative effects. This model also assumes that the harm caused by microplastics is due to ingestion, in reality, microplastics are too small to cause any direct harm to aquatic life. Instead, microplastics tend to bond with other harmful chemicals in the water which then affect the ecosystem.
4. This model visualizes fish that have been injured by plastics. In reality, it is not so easy to tell if this has been the case from purely looking at the fish. Instead, the stomachs of dead fish must be inspected and have the quantity of plastic recorded manually.