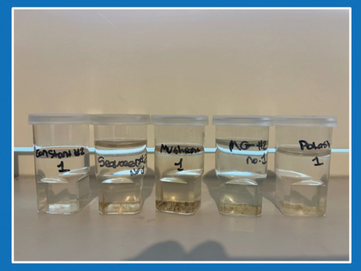
There's Trouble in the Water !

Introduction:

- We chose this research question for our project as we wanted to learn and explore more about the different types of fertilisers and their effects on plant growth and on eutrophication, linking closely to the agricultural sector in Ireland and climate change, a topic of utmost importance and relevance today.
- We divided our project into two respective experiments: one measuring plant growth and the other estimating eutrophication. In our first trials, we used miracle gro as our synthetic fertiliser and seaweed fertiliser as our organic fertiliser. We used bean seeds to test plant growth in the first trial. In the second trials, we added two new fertilisers: Mushroom (organic) and Sulphate of Potash (synthetic). We doubled the concentration of the fertilisers in the pond water samples. In the second trial, we used cress seeds as opposed to bean seeds to investigate plant growth.

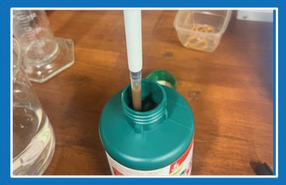


Background Information:

- **Fertilisers** refer to a natural or artificial substance with the necessary chemical elements to improve the growth and productiveness of plants.
- Most fertilisers are comprised of Nitrogen, Phosphorus and Potassium (**NPK**), three nutrients essential to plant growth. Fertilisers will contain different ratios of NPK, depending on their purpose. An equally balanced fertiliser has a ratio of 5:5:5 – 5% Nitrogen, 5% Phosphorus and 5% Potassium.
- **Nitrogen** is used by plants to produce leafy growth and for the formation of stems and branches. Nitrogen is required for grasses and leafy vegetables such as cabbage.
- **Phosphorus** is crucial for the development of roots and seed germination and is particularly important for young plants forming root systems and by seed and fruit crops. It is also very useful for root vegetables such as turnips and carrots to develop well.
- **Potassium** is used for flower and fruit production as well as maintaining growth and protection against disease. Vegetables and fruits are benefited in the process of building starches and sugars, while apples, potatoes and parsnips need potassium to crop well.
- **Organic fertilisers** are fertilisers derived from organic sources, such as farm manure and compost. They typically have a lower NPK content than synthetic fertilisers, meaning they work slower. Organic fertilisers make the plants less susceptible to disease and pests and are the most sufficient way for plants to get nutrients. In addition, organic fertilisers do not build up harmful residues, improve soil texture and fix imbalances in the soil. Organic fertilisers do not pose a threat to climate change as they do not cause pollution.
- **Synthetic fertilisers** are chemically manufactured materials containing the essential nutrients for plant growth, such as nitrogen, phosphorus, and potassium. They typically have higher NPK content than organic fertilisers and are absorbed more quickly by plants. Despite their strengths, these fertilisers can negatively impact soil quality, pollution, and soil fertility due to overuse and excessive microorganism growth.
- **Eutrophication** is the rise in plant nutrients in aging aquatic ecosystems, leading to algal blooms. These dense populations of microorganisms prevent oxygen absorption and light penetration, making eutrophic waters murky and preventing the survival of underwater life. Eutrophic waters may be harmful to humans and cause less support for larger animals such as birds and fish.
- To measure the algal growth in our pond water samples, we used a **spectrophotometer** at 664nm. A spectrophotometer is a device that counts the amount of light absorbed at a certain wavelength in to determine the presence of a chemical substance. Absorbance was used as an estimate of chlorophyll-a, a green pigment found in plants that will tell us how much algal growth has occurred.

Hypothesis:

We hypothesized that algal growth will be greater with the synthetic fertiliser than the organic fertiliser. We also expected that the growth rate of the bean plant will be greater in the synthetic fertiliser than the organic fertiliser. This is because synthetic fertiliser has higher NPK (Nitrogen Phosphorus Potassium) than organic fertilisers, thus meaning that it has more nutrients that plants require to grow and will in turn result in more algal growth.



Method:

To investigate eutrophication:

1. Collect water from St Andrew's Pond (21st November 2023)
2. Using a graduated cylinder, measure 20ml of pond water.
3. Pour pond water into a cuvette.

Repeat Steps 2-3 fifteen times

4. Prepare organic and synthetic fertilisers as directed in instructions
5. Add 5ml of diluted organic fertiliser to pond water samples 1-5 using a pipette. Add 5ml of synthetic fertiliser to samples 6-10.
6. Measure each samples with the spectrophotometer at wavelength 664nm and note the algal density on a table.
7. After measuring algal density, place all samples in an incubator at 25 degrees Celsius to maintain a constant temperature to encourage algal growth.

Repeat Step 6 on a regular basis.

** Note: Samples 11-15 are control samples and should not contain any fertiliser.*

** Note: Each apparatus was cleaned before and after use.*

** Note: For Trial Two, we had twenty-five samples in total as we added two new fertiliser groups.*

To investigate plant growth:

1. Poke five holes in the bottom of each disposable cup to allow for the drainage of water.
2. To find the average mass of one cup, weigh five cups using a mass balance and calculate the average.
3. Add the average cup mass to 90 g to determine how much soil should be added to the cup.
4. Pour 90±0.5g of soil into each cup.
5. Add one seed to each cup and push down by approximately 4 cm ensuring that each seed is completely covered by soil.

Repeat steps 3-4 fifteen times.

6. Prepare organic and synthetic fertilisers as directed in instructions by fertiliser manufacturer.
7. Add 50ml of diluted organic fertiliser to soil samples 1-5. Add 50ml of diluted synthetic fertiliser to samples 6-10. Add 50ml of water to samples 11-15.
8. Measure plant growth using a vernier callipers and note the change in height (mm) on a table.

Repeat Step 6 on day 8.

** Note: Samples 11-15 are control samples and should not contain any fertiliser*

** Note: Each apparatus was cleaned before and between uses.*

** Note: For Trial Two, we used three samples of each of the 5 fertiliser and control groups, meaning there were fifteen samples in total.*

Results:

To investigate eutrophication:

- We anticipated that there would be more algal growth in samples that contained synthetic fertiliser than those contained organic fertiliser. Though this was true, there was not as clear of a difference as we had expected.
- In Trial One, we found that Miracle Gro resulted in the most algal growth (i.e. light absorbance), then seaweed fertiliser and lastly, the control samples.
- In Trial two, Miracle Gro had the most algal growth, then Sulphate of Potash, Mushroom fertiliser, Seaweed fertiliser and finally, the control samples.
- Differences in light absorbance for control and treated pond water were significant as indicated by non-overlapping error bars on most dates.
- These results support our hypothesis that synthetic fertilisers result in more algal growth than organic fertilisers which we assume is due to their higher NPK content.

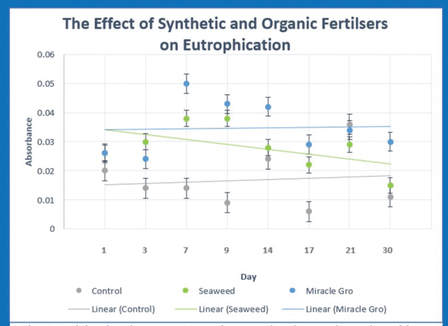


Fig 5.1: Light absorbance at 664nm in control and treated samples with Seaweed and Miracle Gro fertilisers (n=5 reps per group) from St Andrew's Pond water from 21/11/23 to 20/12/23.

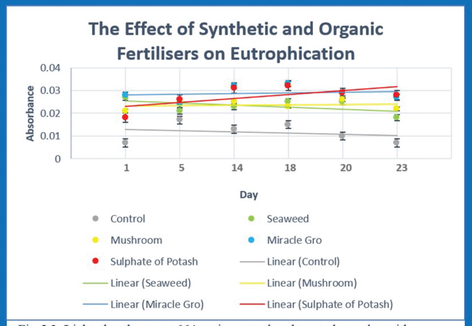


Fig 5.3. Light absorbance at 664nm in control and treated samples with Seaweed, Mushroom, Sulphate of Potash and Miracle Gro fertilisers (n=5 reps per group) from St Andrew's Pond water from 7/12/23 to 29/12/23.

To investigate plant growth:

- In our first trial investigating plant growth, we found that Miracle Gro samples had the most growth, then control and finally, seaweed samples.
- In our second trial, we found that the control samples had the most growth, then Miracle Gro, Seaweed, Sulphate of Potash, and finally, Mushroom.
- It is important to acknowledge that control samples in both trials resulted in significantly more plant growth than we anticipated, and in the case of trial two, control plant growth was even higher than for all fertilisers. Though average growth in the control plants may be due in part to a few outliers, it is possible that these runner been plants simply do not react well to fertiliser and grow better without fertiliser

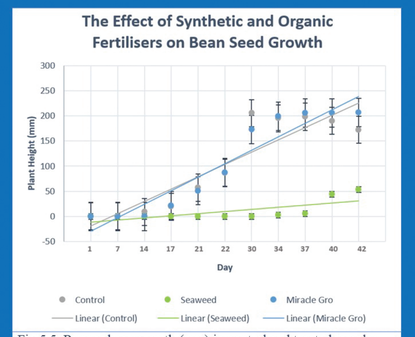


Fig 5.5. Runner bean growth (mm) in control and treated samples with Seaweed and Miracle Gro fertilisers (n=5 reps per group) from 21/11/23 to 1/1/24.

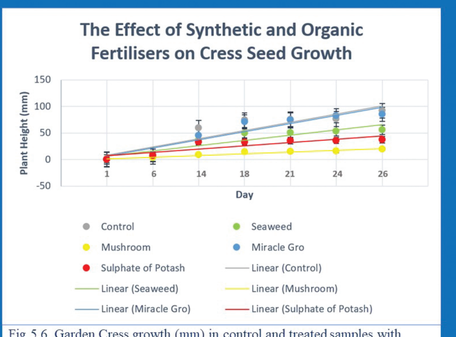


Fig 5.6. Garden Cress growth (mm) in control and treated samples with Seaweed, Mushroom, Sulphate of Potash and Miracle Gro fertilisers (n=3 reps per group) from 7/12/23 to 1/1/24.

Conclusion:

In conclusion, we have found that the majority of our results aligned with our hypothesis. In both trials investigating eutrophication, Miracle Gro resulted in the most algal growth, and the control samples had the least, supporting our hypothesis. Our results from our investigation on plant growth differed slightly from what we had initially thought. In our initial experiment examining plant growth, we found that the Miracle Gro samples grew the fastest, followed by the control and seaweed samples. In the second trial, we found that the control samples had grown the greatest, followed by the seaweed, Miracle Gro, sulphate of potash, and mushroom fertiliser. If we were to complete our experiment again, there are a number of aspects we would do differently, such as choosing plants with optimal conditions in winter, such as pansies and violas, or we would begin our experiment earlier, in summer months.