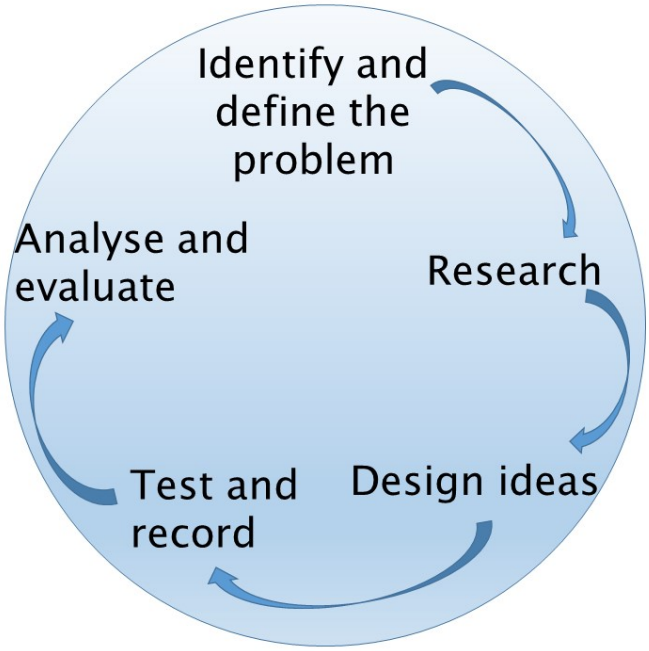
Farming for Food – Student Booklet

The Challenge

As the global population increases more food will be required but there will be less space to grow/produce it. To cope with the demand, farmers currently do things like add fertilisers to their soils, to produce a larger yield. However, fertilisers can leach into the groundwater and be carried long distances, effecting much more than just the intended area. To cope with the demands for space, methods such as vertical farming and the use of hydroponics systems are being utilised more and more.

Your task is to investigate the impacts of these methods of farming and to evaluate their suitability for use in your local area considering social, environmental and economic issues.



Background Information

You will be familiar with the equation for photosynthesis:

Carbon dioxide + water → Glucose + Oxygen

$$6CO_2 + 6H_2O \xrightarrow{\text{(Sunlight energy)}} C_6H_{12}O_6 + 6O_2$$

An initiative supported by Woodside and ESWA

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For plants to grow successfully they also need many nutrients, including nitrogen and phosphorus. Naturally plants get these nutrients through the phosphorus and nitrogen cycle. The nitrogen cycle is shown below.

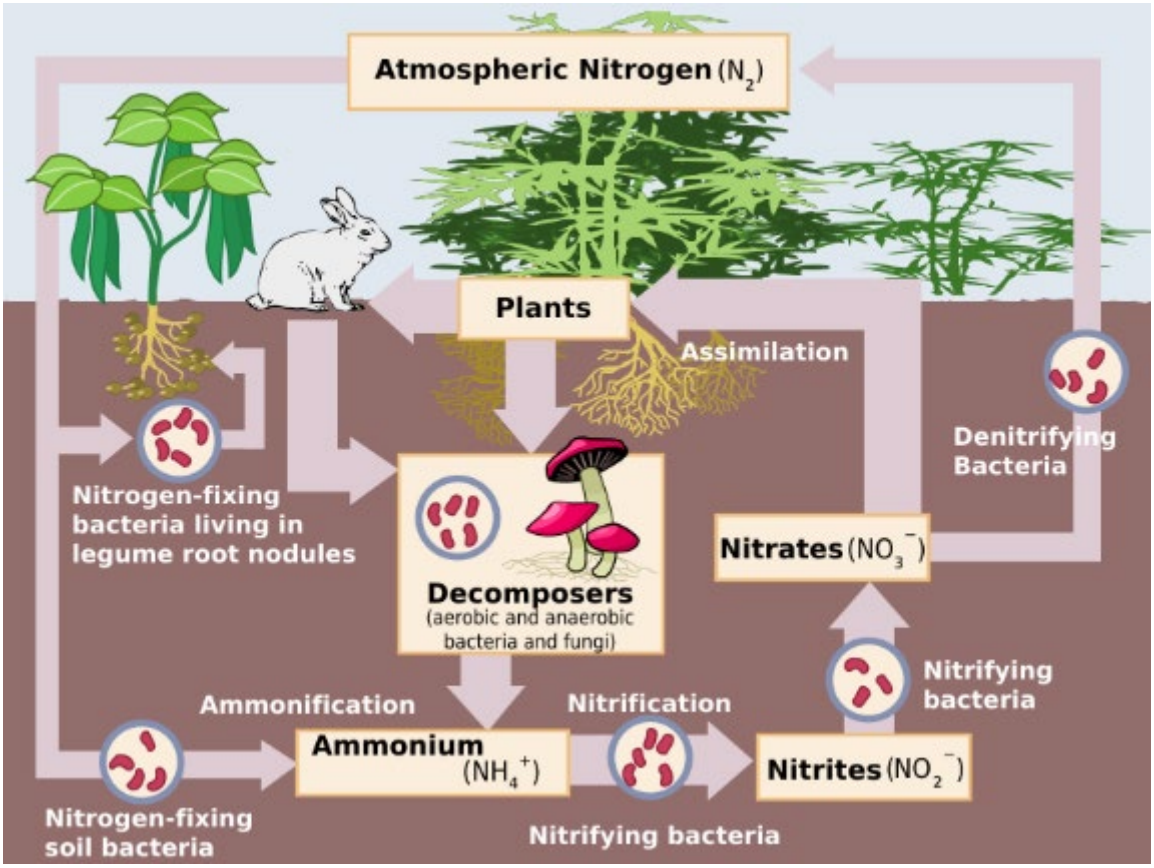

Figure 1: The nitrogen cycle.

Prior to the Industrial Revolution, the majority of farming was subsistence farming, where people grew enough only for their families. To ensure enough food for the year and maintain healthy soil as well as a varied diet, people would use crop rotation methods (changing the crop that was growing on the land over seasons or even from year to year). As different plants required different nutrients, this allowed time for the soil to replenish in the nutrients that had been used by a previous crop. However with industrialisation, farmers greatly increased the size of fields and scale of crops. As a result, it was more economical to grow the same crop as it required less machinery and specialisation than varied crops. However, this led to depleted soils and farmers began to add fertilisers to maintain the nutrients needed for crops to grow.

Most commonly, synthetic fertilisers are used as they provide predictable and efficient sources of nutrients and farmers can select how much they need of each type. In comparison, natural fertilisers, such as animal manure, have relative amounts of nutrients that are unknown. The addition of synthetic fertilisers to soils can lead to higher yield harvests and also speed up growth rates of some crops. They are also much easier to transport than organic fertilisers, which could possibly reduce fuel costs and CO_2 emissions.

A problem with using synthetic fertilisers is that many of them contain high amounts of acidic chemicals, which can be a health hazard. With a period of heavy rain the fertilisers run-off, entering water bodies. As they are high in nitrogen they can cause algal blooms (algae are plants after all!) and enter the groundwater, carrying toxins that can be poisonous to animals and humans.

Different methods of farming are being introduced around the world to minimise the amounts of fertiliser being used, as well as to cut down on water and land usage. These include small scale hydroponic farms, vertical farms and the farming of genetically modified (GM) crops (which can be seen as controversial). Technologies are also being used more frequently by farmers to measure nutrient and water levels in the soil, ensuring that any additions are actually necessary and making the process more efficient and cost effective.

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Background Research

1. Which crops are grown by farmers in your local area?
2. List some common fertilisers that are used for farming that fit the following criteria:
   a. Organic
   b. Synthetic
3. What are the dangers of synthetic fertilisers?
4. What are some of the disadvantages of using organic fertilisers?
5. Research the price (per 100g or 100mL) of a range of fertilisers (to allow for comparison). Be sure to note if they are organic or synthetic.
6. Which nutrient cycles are impacted by fertiliser use?
7. What are algal blooms and why are they a problem?
8. Outline some alternative solutions to using fertilisers.

Testing Fertilisers

Objective

To design and conduct an investigation to determine the effects of different fertilisers on plant growth and to complete cost analysis to decide which offers the best value for money.

Equipment

What equipment will you need for your investigation?

Method

Write a method for the investigation, ensuring you have made it clear how it will be conducted safely, what changes you would expect to observe, and how you will measure these changes. What could be an indication of healthy plant growth, or that the plant is not growing well?
Include a diagram to show how you will set up the investigation.
Show all of this to your teacher, for approval, before you conduct the investigation.

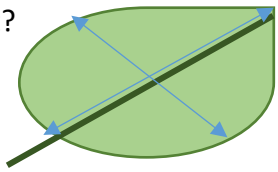
Results and Analysis

How can you present the results so that it is easy to make comparisons between other groups?
Remember if you are doing this as a class investigation it is important that the whole class measures and records their results the same way so that results can be fairly compared.

1. Create a table to record plant growth.

Consider the following points:

- Will you measure leaf length, leaf width, leaf area or height of plant?
- What do you think will be the fairest way to measure this – size every day, increase in size every day, or percentage increase in size every day?
- If the plant has more than one leaf will you measure and record them all and then take an average or just measure the largest/smallest leaf each time?



2. Create a scatter plot of your plant growth results.

Consider the following points:

- Will you plot a line for each plant, or each group's average growth, or just the plant which had the largest growth in each group?
- How will you ensure different fertilisers are clearly differentiated?

3. Using the class results determine the interquartile range and create box plots to represent the spread of data.

Consider the following points:

- What data will you use from the class results – leaf length, leaf width, or leaf area?
- Will you plot each groups average/maximum/ minimum?

4. Which fertiliser produced the largest growth?
5. Which fertiliser produced the smallest growth?
6. How did the plants that grew in just water compare to others? *We hope you remembered to have a control!*

Research

7. What is the cost (per 100mL or 100g) for each of the fertilisers used?
8. How much would each fertiliser cost to apply per hectare (following manufacturer's directions and assuming it only needed to be applied once)?
9. In 2012 18.2 million hectares of farm land was fertilised. How much would this cost using your fertiliser?
10. Calculate the cost per mm growth for each fertiliser used.
11. Was there a relationship between the cost of a fertiliser and average growth?
12. Which fertiliser was the best value in terms of cost per mm growth?
13. Which fertiliser would you recommend and why? Ensure you use data from your research to back up your answer.

Evaluation

1. Were there any potential sources of error in your investigation?
2. How could you improve this investigation?

Fertilised Algae

Objective

To design and conduct an investigation to determine the effect of different concentrations of fertilisers on the growth rate of algae. Then to relate your findings to algal blooms.

Equipment

What equipment will you need for your investigation?

Method

Write a method for the investigation, ensuring you have made it clear how it will be conducted safely, what changes you would expect to observe and how you will measure these changes.
Will you be able to get any quantitative data and carry out statistical analysis?
How will you set up a control?
Include a diagram to show how you will set up the investigation.
Show all of this to your teacher, for approval, before you conduct the investigation.

Results and Analysis

How can you present the results so that it is easy to make comparisons between other groups?
Remember if you are doing this as a class investigation it is important that the whole class measures and records their results the same way so that results can be fairly compared.
If possible present your results in a table and graph.

1. Which fertiliser concentration resulted in the most algal growth?
2. How did the algae that grew in just water compare to others?
3. Does your data support the idea that increased fertiliser use can lead to algal blooms? What could this mean for aquatic ecosystems that are close to farms? Use data to back up your conclusions

Evaluation

1. Were there any potential sources of error in your investigation?
2. How could you improve this investigation?

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Investigating the Health of Your Local Waterway

Objective

To plan and conduct an investigation which will use abiotic and biotic water quality parameters to investigate the health of your local waterway, as well as to explore if human influence is affecting its health.

Background Information

A healthy waterway will have a large number of different types of macroinvertebrates present with no one type dominating the system. A polluted waterway will have only a few different types of macroinvertebrates present, often in large numbers, and will generally include things like aquatic worms, water fleas and non-biting midge larvae (Government of Western Australia, Department of Water and Environmental Regulation, 2017)

Method

1. Research:
    - Which macroinvertebrates can be used as identifiers of healthy water. Ensure you have pictures of these so that you are able to identify them.
    - What is eutrophication, how does it occur and how could you identify if it is occurring?
    - What abiotic factors may give an indication of the health of a waterway, and how do you measure them?
    - What other biotic factors will give an indication of the health of a waterway, and how can you measure them?

2. Design a method for investigating the health of a local waterway ensuring you have made it clear how it will be conducted safely.
   Don't forget you will need to plan for activities before going to the waterway, at the waterway and back in the laboratory.
   You will also need to make it clear what data you will collect and why.
   Show all of this to your teacher, for approval, before you conduct the investigation.

Results and Analysis

1. Create a table adding in fauna and flora that you observed while at the lake. Add pictures you have taken or found on the internet.
2. Create a table to present any abiotic data you gathered.
3. Create frequency tables to show the macroinvertebrates you observed in the lab.

4. Using the data from the macroinvertebrate data tables create pie charts to show the percentage of macroinvertebrate identified – colour code your pie chart, so that pollution sensitive species are coloured green, somewhat pollution tolerant species are orange and very pollution tolerant species are red
5. Which macroinvertebrate was most frequently observed in your sample?
6. What percentage of your pie chart is green, orange and red?
7. How does the pH of the lake compare to the pH of a healthy waterway? (Healthy waterways should score between 6.5 – 8.5)
8. If you also measured other parameters, how do they compare to that of a healthy lake?
9. Overall how healthy is your local waterway? Use data from your investigation to support your conclusion.

Evaluation

Write an evaluation for your investigation. In your evaluation you should consider any sources of error and make suggestions on how to minimise these in future investigations of this type. You can highlight any precautions that you took to ensure the experiment was fair. You should evaluate your method of recording and analysing data – how reliable was it? You can also add suggestions for further experiments similar to this and explain why they would be useful to be carried out.

Modern Methods of Farming

Objective

To explain the principles behind modern farming methods and discuss the pros and cons of each farming type for use in your local area.

Method

Research the following methods of farming and produce a table/other appropriate representation :

Hydroponics, aeroponics, aquaponics, vertical farming and precision farming.

Discuss the advantages and disadvantages of each, considering social, political, environmental and economic issues.
In your discussion ensure that you have explained how each farming method works, providing case studies and annotated diagrams, where possible.

Evaluate which method of farming is most suitable for your area explaining why and which type of farming you predict will be used more in the future.

Are there any types of farming that you think should be used more, but might need legislation to enforce their emplacement? Likewise, are there any types of farming that you think could be very likely to disrupt natural cycles and should be discouraged?

If you were going to grow vegetables in your garden/the school garden which farming types would you suggest? Explain your choice(s).