SOIL FOOD
Measuring nutrient retention in soils

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Languages available
English

Summary
It takes a very long time for soil to form and some people have suggested it might become a non-renewable resource. So, it's important to use it well. Vermiculite is a clay mineral which can be added to soils to improve their quality and gain higher crop yields. But how do you know how good your soil is and how much vermiculite you should add? Being able to investigate soil and determine its properties is essential.

Students are members of a team of scientists working in a soil analysis laboratory. The team is asked to design test apparatus and a standard procedure to measure how well different vermiculite and peat mixtures retain the nutrients ammonium, copper and zinc. The team must write instructions to go with the apparatus and estimate its cost. The instructions are intended for farmers and other growers who wish to monitor the condition of their soil and improve it by the addition of vermiculite; they may not necessarily have a science background.

Activity type **G**
Use of scientific knowledge and understanding to solve problems
Working in teams to solve problems
Communication
Resource/budget management

Techniques
Colorimetric analysis

Field
Environmental
Agrochemical

Time

Practical lessons:	360 minutes
Theory lessons:	200 minutes
Out of class time:	60 minutes

StandardBase procedures
None

StandardBase techniques
None

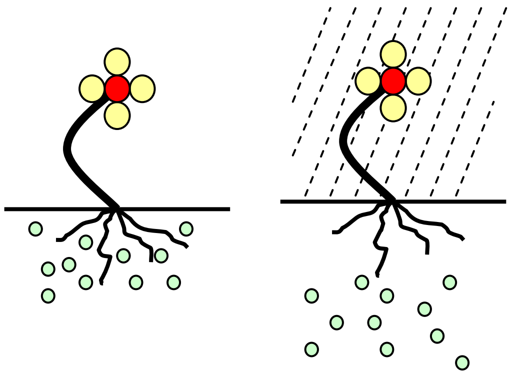
Other resources
David Bright Limited; www.davidbright.co.uk
Others are listed in the activity.

Student's document

SOIL FOOD: Measuring nutrient retention in soils

It takes a very long time for soil to form and some people have suggested it might become a non-renewable resource. So, it's important to use it well. Vermiculite is a clay mineral which can be added to soils to improve their quality and gain higher crop yields. But how do you know how good your soil is and how much vermiculite you should add? Being able to investigate soil and determine its properties is essential.

Plants need food. They need carbon dioxide and water to make carbohydrates. From these they can manufacture a variety of other compounds using minerals from the soil. Nutrients such as ammonium ions dissolve in water and are absorbed through the plant's roots. Some soils retain the soluble nutrients better than others.



In soils that show poor retention, nutrients are washed away from the roots. This means extra fertiliser is needed. If professional growers know about the nutrient retention of their soils and how to improve it, they may be more able to grow plants effectively and efficiently.

Your brief
You are one of a team of scientists that works in a soil analysis laboratory. The team has been asked to design a test kit for growers to measure how well different soils retain water and nutrients. You will need to make a range of:

- soils for testing (made by combining vermiculite and peat)
- nutrient solutions of ammonium ions, copper ions and zinc ions (all found in typical plant foods).

You will be given test kits for determining the concentration of ammonium ions, copper ions and zinc ions. Using the soils, nutrient solutions and cation test kits, try out the apparatus you design and make any necessary modifications.

When you have a successful kit (apparatus and chemicals) you need to estimate its cost. The kit should also contain instructions for its use, keeping in mind it may be used by people with little science background.

Your investigation
Work as pairs within a group of four. Planning is an essential part of this work. There are many variations to try, for example, different soils and nutrient solutions. As a group, you need to have a plan of action that is realistic for the time available. Your teacher will tell you, but the practical work will take at least five hours.

Read through the following sections carefully and decide who will do what in the group. Remember, your team needs to try sufficient experiments to be confident of the usefulness of the test kit.

Planning

- *Soils*

Your group will be provided with peat compost and vermiculite. These may be mixed in various proportions to give a range of test 'soils'. You will need to decide how many 'soils' to try.

Using **Study sheet***: Vermiculite*, find out about vermiculite. Write the answers to the questions in your notebook or file. Then decide what 'soils' you will make, to use with your test kit. **Information sheet***: Mixing vermiculite with peat* should help you.

- *Nutrients*

You will need a range of nutrient solutions to try out your kit. Use **Study sheet***: Plant foods* to help you. It gives you information about a typical plant food (Miracle-Gro Water Soluble All Purpose Plant Food). Try to find the composition of other fertilisers (note that they tend to vary, depending on the plants they are intended for).

You will work with solutions containing the nutrient ions: ammonium (NH_4^+), copper (Cu^{2+}), and zinc (Zn^{2+}).

Carry out the calculations and decide the concentrations of these ions in the nutrient solutions you will use. Think about different ratios of nutrient ions and different dilutions. Consider:
- solutions containing ammonium ions, copper ions or zinc ions
- solutions containing ammonium ions, copper ions and zinc ions.

Decide what concentrations and, for the mixture, the ratios of concentrations to use. If time permits, you may also want to investigate the effect of other cations and the influence of different anions (nitrate and phosphate ions are found commonly in fertilisers).

Make the solutions.

- *Cation analysis*

You will need procedures for estimating the concentrations of ammonium ions, copper ions and zinc ions in water. Your teacher will tell you which test kits are available to measure the concentration of these substances.

- *Apparatus design*

Think about the apparatus to use (see **Student sheet:** *Designing the apparatus to test for retention of nutrients*). There are a number of variables. Discuss within your team and make notes on the sheet. Design and assemble a suitable piece of apparatus. You may need to modify it in the light of your initial trials.

- *Instructions*

Write a set of instructions on how to use the test kit, keeping in mind they are intended for people who may have little science background. Also, estimate the cost of the kit in terms of the apparatus and chemicals required.

Practical work

Once you have decided what each member of the group will be doing, set up your work area and collect the equipment and materials you need. You may want to set up more than one piece of apparatus in order to carry out sufficient tests in the time available.

The test kits for determining the concentration of various substances in water come with instructions. Make sure you read these and understand how to carry out the tests and interpret the results.

You must be sure a risk assessment has been carried out before starting work.

Information

- You will need to find the prices of buying equipment and materials for the kit. You can look in catalogues from apparatus and chemical suppliers, for example:
  http://www.griffinandgeorge.co.uk/
  http://www.fisher.co.uk/
- Water test kits may be bought in pet shops and garden centres (especially those that also sell plants for ponds and aquaria). You will see that there are many different brands. It is possible to buy kits for individual substances and to buy multi-test kits.
  http://www.palintest.com/
  http://www.kittiwake.com/Default.aspx/ProductSection/90/ProductSubSection/106/ProductSubSubSection/293
  http://www.wagtech.co.uk/ShowCat.php?catid=1

Your findings

Compare and discuss the team's results. Agree the standard procedure(s) and the contents of the associated test kit. Give your reasons for your choice.

Write instructions for your test kit. They should be aimed at people who may not have a scientific background. You need to:

- explain the importance of measuring nutrients in the soil
- explain why nutrients are retained in some soils better than others
- write a standard procedure (or procedures) to go with your apparatus.

Record the details of the kit and its cost. You need to

- list the equipment and chemicals that are needed to make up the kit
- estimate the cost of the kit based on the equipment and chemicals you propose to include.

Student self assessment

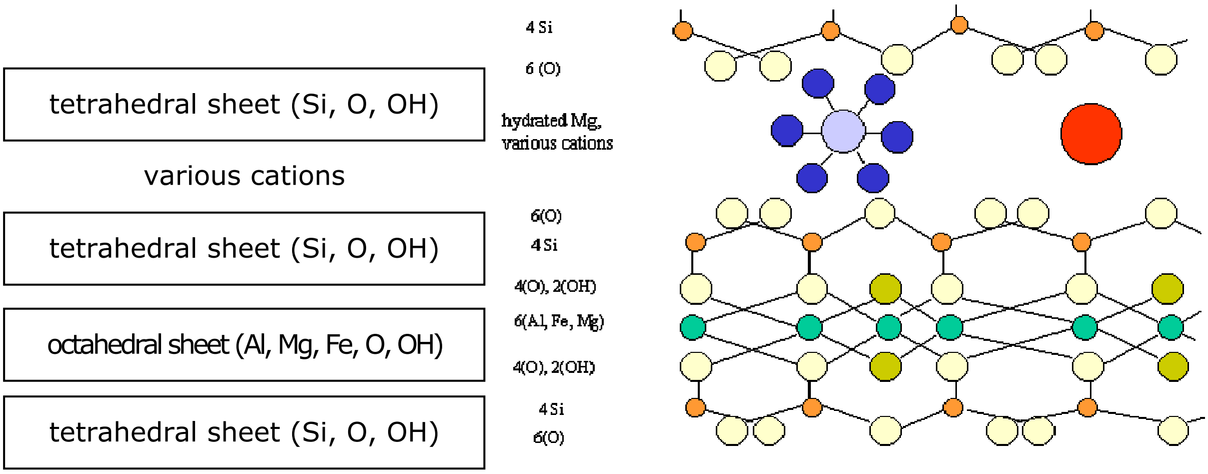
This activity was about using scientific knowledge and understanding to solve problems, working in teams to solve problems, communication and resource/budget management. For each case, write 50-100 words explaining:

- what scientific skills and knowledge you used and how effectively you used them
- how you worked as a team, giving examples of how you supported others in your group or were supported by them
- the ways of communicating that you used and how effectively you used them
- how you managed resources and budgets

Student study sheet: Vermiculite

Vermiculite is a soil additive that is said to *reduce nutrient leaching and produce an open structure for strong root development*. To understand why, we need to examine the chemical composition and structure of vermiculite.

Vermiculite is a clay mineral. It has the chemical formula $(Mg,Fe,Al)_3(Al,Si)_4O_{10}(OH)_2.4H_2O$.



Its structure can be summarised thus:

Hydrated cations weakly bond neighbouring tetrahedral sheets. This allows vermiculite to expand on wetting.

Cations are attracted to both internal and external surfaces of these clays. Many of these cations can be replaced by different ions from soil solution. This process is called ion exchange.

For example NH_4^+ ions can exchange with Mg^{2+} ions. The balance of charge must be maintained, so two singly charged ions replace one doubly charged ion.

$$\text{clay-}Mg^{2+}(s) + 2NH_4^+(aq) \rightleftharpoons \text{clay-}2NH_4^+(s) + Mg^{2+}(aq)$$

The ability of a clay mineral to exchange ions is measured by its cation exchange capacity. This is the amount in moles of exchangeable positive charge held by 1 kg of vermiculite. Typical values are 0.02 - 0.6 mol kg^{-1}.

Plant roots withdraw nutrients from the pool of exchangeable cations. Cations held by clay are in dynamic equilibrium with those free in the soil solution.

Questions

1. Write equations to show what happens when vermiculite is put in solutions of (a) copper ions, (b) zinc ions.

2. Explain why adding vermiculite to soil can improve the soil's nutrient retention properties.

3. Explain why vermiculite does not help retain anions such as nitrate (NO_3^-).

Student information sheet: Mixing vermiculite with peat

Many commercial composts or soils are made to meet specific growing needs. Many contain peat and vermiculite in different proportions. Here are some examples.

Dupré Micafil
Hoben International Ltd., based at Newcastle-under-Lyme in North Staffordshire, and *Dupré Vermiculite* joined forces in November 2006 as *Dupré Micafil*. It produces vermiculite, a mineral with many uses including horticulture. (http://www.dupre-vermiculite.co.uk/vermicapplications.htm)

The following mixtures of peat, vermiculite and fertilisers are recommended by the company:
Seed Sowing and *Premier Potting*, are both formulated to give optimum results. The *Economy Universal* is for those growers who require a reliable mixture but with the emphasis on economy.

Seed Sowing, Cutting and Module Compost
- 50% by volume vermiculite and 50% sphagnum peat
- to each m^3 add: 1000 g Simple Superphosphate Powder, 500 g Sulfate of Ammonia Crystal, 350 g Fritted Trace Element WM255, 1200 g Magnesium Limestone Powder.

Premier Potting Compost
- 25% by volume vermiculite and 75% sphagnum peat
- to each m^3 add: 2750 g Simple Superphosphate Powder, 800 g Nitrate of Potash Crystal, 1000 g Sulfate of Ammonia Crystal, 350 g Fritted Trace Element WM255, 4500 g Magnesium Limestone Powder.

Economy Universal
- 10% by volume vermiculite and 90% sphagnum peat
- then to each m^3 add: 1500 g Simple Superphosphate Powder, 750 g Nitrate of Potash Crystal, 500 g Sulfate of Ammonia Crystal, 350 g Fritted Trace Element WM255, 3800 g Magnesium Limestone Powder

What soil compositions will you use?
You will be able to use peat and vermiculite. Plan and prepare a range of ‘soils’ to use with your test kit.

Complete this table:

Soil number	Percentage by volume peat	Percentage by volume vermiculite

Student study sheet: Plant foods

Conversion data: 1 tablespoon = 14 g; 1 gallon = 4 dm^3

1. Calculate the recommended concentration in g dm^{-3}.

2. Calculate the concentration of ammoniacal nitrogen in a solution of recommended concentration.

3. Calculate the concentrations of water-soluble copper and zinc in a solution of recommended concentration.

4. Describe how you can make a solution of ammonium ions, copper ions and zinc ions with the same concentrations of these ions as the recommended concentration in the plant food.

Suggest some variations on this mixture. Compare, for example, liquid fertilisers for use with different plants, such as tomatoes, foliage houseplants, lawns and roses.

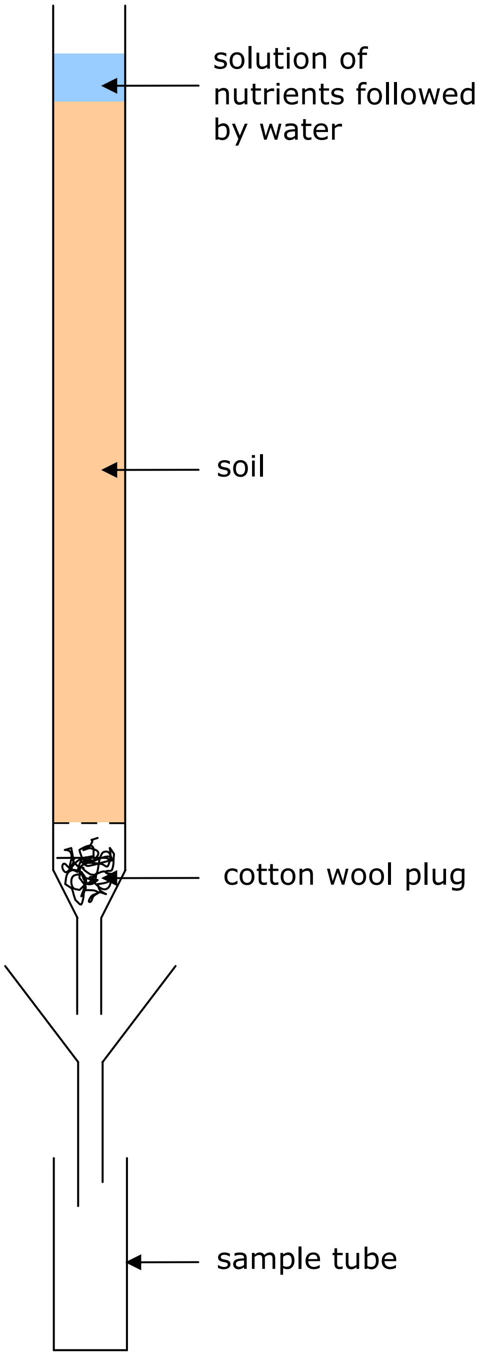
Draw up a list of nutrient feeds to prepare and investigate.

5. What concentrations of ammonium ions, copper ions and zinc ions do you think you will need to detect?
Note: Think about how the solution of nutrients will pass down the column.

Student sheet:
Designing the apparatus to test for retention of nutrients

Look at the diagram below. It will give you a starting point. Discuss with other members of your group.

Possible apparatus



Notes and ideas

Teacher's document

Overview
Students work in a small team, working in a soil analysis laboratory. The team has been asked to devise a procedure to measure how well different soils retain water and nutrients. It must design a test kit that may be used to check soil, estimate its cost and write a set of instructions for the kit which can be followed by a non-expert.

The *Student's document* details a series of tasks. As part of the planning process, you may wish to suggest to students that they construct a checklist to ensure that they complete all of the intermediate tasks. This may be compared with the checklist of tasks below. If time is short or students find this difficult, you may wish to provide them with a checklist of this kind.

Checklist of tasks		**tick**
(Use the Student's document to check that each aspect has been completed in full. If necessary, return to some tasks and modify the approach.)		
1	Select teams	[ ]
2	Read and complete **Student study sheet***: Vermiculite*	[ ]
3	Decide which soil types to test - read and complete **Student information sheet***: Mixing vermiculite with peat*	[ ]
4	Decide how many tests for each soil type to use	[ ]
5	Read and complete **Student study sheet***: Plant foods*	[ ]
6	Decide which nutrient concentrations you will test	[ ]
7	Decide which nutrient combinations you will test	[ ]
8	Make a provisional allocation of tasks. Alter as necessary as you progress. (Work in pairs to obtain data.)	[ ]
9	Make or obtain the nutrient solutions	[ ]
10	Obtain cation test kits and the instructions for their use	[ ]
11	Use **Student sheet***: Designing the apparatus* to test for retention of nutrients, and design and assemble a suitable piece of apparatus	[ ]
12	Write a preliminary set of instructions to use the cation test kit and the apparatus to test for the retention of nutrients by soil samples	[ ]
13	Estimate the cost of the kit, including the apparatus and chemicals	[ ]
14	Use your test kit (apparatus and reagents) to measure the retention of cations by vermiculite / peat samples (if necessary, modify 12)	[ ]
15	Compare and assess the team results	[ ]
16	Obtain any necessary additional data	[ ]
17	Agree the contents of your test kit and the associated standard procedures. Record the reasons for your choices.	[ ]
18	Write a set of instructions, to include	
	▪ Background - The importance of nutrients in the soil	[ ]
	- Why some soils retain nutrients better than others	[ ]
	▪ Standard procedure(s)	[ ]
19	Estimate and record the cost of the kit (apparatus + chemicals)	[ ]
20	Carry out and record your self-assessment	[ ]

Developing students' skills
Learning objectives
Students:

- manage relationships to work effectively with others to solve problems
- manage resources and budgets effectively
- use scientific knowledge and understanding to solve problems
- observe, measure, analyse and evaluate scientific data
- communicate precisely verbally, in writing and using ICT

Among the chemical concepts that students use are: ion exchange, hydrated ions, dynamic equilibrium. In addition, they may learn about the chemistry that underpins the quantitative chemical test for ammonium ions, copper ions and zinc ions.

Guidance and help
The amount of help depends on the nature of the students and their prior experience. If this is their first resource and budget exercise, they may need considerable help and guidance to find costs.

Groups with successful experience of working together can be left more to their own resources. Whether students are inexperienced or experienced, a sharp eye should be kept on the clock and it may be necessary to bring the whole class together at some point to facilitate progress.

It is the nature of this task that it cannot be successfully completed in the time available without the need for teamwork and setting targets with deadlines. Nonetheless, students should be encouraged to take care and pride in their work. Trouble shooting vigilance may be needed to help with:

- technical aspects, including manipulative skills and correct handling of chemicals and equipment
- health and safety issues
- working relationships with others.

www.presentingscience.com/aflchem/key/groupwork.htm has ideas for setting up student groups.

Students will progress through the exercise by achieving higher levels of teamwork. At the beginning, it may be necessary for the teacher to set clear targets and deadlines and elicit team working strategies through appropriate questioning. Short reviews at the end of sessions can be based on teacher observations of progress and help to set up the following sessions.

This exercise may allow a variety of assessment criteria to be met, according to the course being followed. Observations of practical work and the completed recording sheets and instruction sheet should provide evidence that can be judged against published grading criteria.

Organising and managing the class
Students work in pairs, in groups of four, coming together later to compare progress and, if necessary, revise their plans. They need to plan their work in terms of the soils to use, nutrients solutions to use and designing, assembling

and trying out their test kit. Clearly, the time required for this activity will determine the range of variables investigated.

- *Soils*

Give students **Study sheet***: Vermiculite*. This will help them understand why some soils retain nutrients better than others, something students need to explain in the instructions for their test kit.
Each team might investigate two soils (one studied by each pair in the team). These mixtures are given in **Information sheet***: Mixing vermiculite with peat*:
- 10% by volume vermiculite and 90% peat
- 25% by volume vermiculite and 75% peat
- 50% by volume vermiculite and 50% peat

For maximum contrast one pair might work with 10% by volume vermiculite and 90% peat and the other pair with 50% by volume vermiculite and 50% peat. Increasing the number of different soils used will decrease the range and number of nutrient solutions that can be used in the time available.

Note that proportions are given in terms of volume and not mass. If they do not think of it, students might be encouraged to consider running controls of
(a) vermiculite, (b) peat.

- *Nutrients*

Students use **Study sheet***: Plant foods* to estimate typical concentrations of ammonium ions, copper ions and zinc ions found in plant food. Answers:

  - Calculate the recommended concentration in g dm^{-3}
    Ans: 14 g per 4 dm^3 = 3.5 g dm^{-3}
  - Calculate the concentration of ammoniacal nitrogen in a solution of recommended concentration.
    Ans: 5.8% ammoniacal nitrogen. Therefore, recommended concentration contains 2.81 g dm^{-3} N or 2.58 g dm^{-3} NH_4^+.
  - Calculate the concentrations of water-soluble copper and zinc in a solution of recommended concentration.
    Ans: 0.07% Cu and 0.06% Zn (both soluble forms). Therefore, recommended concentration contains 0.00245 g dm^{-3} Cu^{2+} and 0.00210 g dm^{-3} Zn^{2+})

Based on these answers, students might prepare, or be given, these stock solutions:
10 g dm^{-3} NH_4^+ (from which, for example, 5 g dm^{-3}, 3 g dm^{-3} and 1 g dm^{-3} solutions may be made by dilution)
0.01 g dm^{-3} Cu^{2+} (from which, for example, 0.005 g dm^{-3}, 0.002 g dm^{-3} and 0.001 g dm^{-3} solutions may be made by dilution)
0.01 g dm^{-3} Zn^{2+} (from which, for example, 0.005 g dm^{-3}, 0.002 g dm^{-3} and 0.001 g dm^{-3} solutions may be made by dilution)
In addition to solutions containing just one type of nutrient cation, mixture can be made. For example:
Solution A 5 g dm^{-3} NH_4^+, 0.005 g dm^{-3} Cu^{2+}, 0.005 g dm^{-3} Zn^{2+}
Solution B 2 g dm^{-3} NH_4^+, 0.002 g dm^{-3} Cu^{2+}, 0.002 g dm^{-3} Zn^{2+}
Solution C 1 g dm^{-3} NH_4^+, 0.001 g dm^{-3} Cu^{2+}, 0.001 g dm^{-3} Zn^{2+}

The number of nutrient solutions to test is potentially very high. It is important that students have a realistic and achievable plan.

Note: Often concentrations are given in ppm (parts per million). To a good approximation:

$$1 \text{ ppm} \equiv 0.001 \text{ g cm}^{-3} = 1 \text{ mg dm}^{-3}$$

- *Cation analysis*

Water test kits may be bought in pet shops and garden centres (especially those that also sell plants for ponds and aquaria). You will see that there are many different brands. It is possible to buy kits for individual substances and to buy multi-test kits.

You will need to do some research to find what is readily available in your area. The important thing is to match the kits to the range of concentrations expected. In other words, for copper and zinc ions, students will be looking for concentrations in the range 0 to 0.002 g dm^{-3} and ammonium ion concentrations in the range 0 to 2 g dm^{-3}.

Here is an indication of some examples:

Ammonium test kits

http://www.swelluk.com/marine/marine-hydrometers-and-test-kits-380/test-kits-382/salifert-profi-test-kits-ammonia-6653.html#
Salifert Profi-Test Kits – Ammonia
50 tests £7.29

http://www.galgo.co.uk/index.html

Ammonia	0-7 ppm	INSTRUMENTAL	Vacu-vials
Ammonia	0-14 ppm	INSTRUMENTAL	Vacu-vials
Ammonia	0-1 & 1-10 ppm	visual	CHEMets
Ammonia	0-30 & 30-300 ppm	visual	VACUettes
Ammonia	0-60 & 60-600 ppm	visual	VACUettes
Ammonia	0-120 & 120-1200 ppm	visual	VACUettes
Ammonia	0-1000 & 1000-10,000 ppm	visual	VACUettes
Ammonia (salicylate)	0-3 ppm	INSTRUMENTAL	Vacu-vials
Ammonia (salicylate)	0-2 & 0-20 ppm	visual	CHEMets

http://www.kittiwake.com/ecommerce/e_zoom.asp?PN=FG-K21003-KW
Colour Card Ammonia Module
Range 0-2.0 ppm

http://www.hannainst.co.uk/acatalog/HI_3824_Ammonia_fresh_water_test_kit.html
HI-3824 Ammonia fresh water test kit
http://www.hannainst.co.uk/acatalog/hi3824236.pdf
A test kit designed to measure the ammonia content in fresh water using the Nessler chemical method. The kit contains everything required to carry out 25 individual tests.
This uses the colorimetric method of measurement which means that a colour develops in the sample to be measured when the chemical (reagent) is added. This colour is then compared with a colour scale, supplied in the kit, which

determines the amount present of the parameter being measured, and produces a result in mg/L.
Price: £19.90

Copper test kits
http://www.hannainst.co.uk/acatalog/HI_3856_Copper_low_range_test_kit.html
HI-3856 Copper low range test kit
(http://www.hannainst.co.uk/acatalog/HI3856080.pdf)
This measures very low levels of copper using the bicinchonic acid chemical method. The kit contains everything needed to carry out 100 individual tests.
It uses the colorimetric method of measurement which means that a colour develops in the sample to be measured when the chemical (reagent) is added. This colour is then compared with a colour scale, supplied in the kit, which determines the amount present of the parameter being measured, and produces a result in mg/L.
Price: £27.00

http://www.hannainst.co.uk/acatalog/HI_38075_Copper_low___high_range_test_kit.html
HI-38075 Copper low & high range test kit
(http://www.hannainst.co.uk/acatalog/HI3856080.pdf)
Featuring two ranges that allow measurement of low and high levels of copper, this uses the bicinchonic acid chemical method. The kit contains everything needed to carry out 100 individual tests.
It uses the colorimetric method of measurement which means that a colour develops in the sample to be measured when the chemical (reagent) is added. This colour is then compared with a colour scale, supplied in the kit, which determines the amount present of the parameter being measured, and produces a result in mg/L.
Price: £29.00

http://www.atlantisaquatics.co.uk/acatalog/seachemtestkits.html
Seachem MultiTest Copper measures copper (all types) down to 0.01 mg/L in marine or freshwater. It uses a highly sensitive catalysis-based procedure.
Seachem Multi Test Kit
75 tests £17.40

http://www.swelluk.com/marine/marine-hydrometers-and-test-kits-380/test-kits-382/salifert-profi-test-kits-copper-6652.html#
Salifert Profi-Test Kits - Copper
0.05 mg/L to 2 mg/L
50 tests £6.59

http://www.galgo.co.uk/index.html

Copper (total soluble)	0-12 ppm	INSTRUMENTAL	Vacu-vials
Copper (total soluble)	0-1 & 1-10 ppm	visual	CHEMets

http://www.seapets.co.uk/product-details/stkcode/443402.html
Interpet Easy Test Copper Tablet Test Kit
£10.99

http://www.seapets.co.uk/product-details/stkcode/442280.html
Red Sea Copper Mini Lab
This is specifically designed for use in marine aquariums, where accuracy is paramount. It measures the level of nonchelated copper as used in copper treatment for marine fish parasites. It is easy to use and includes comprehensive advice on water quality.

http://www.accepta.com/details.asp?cat=1500&scat=170&id=31658
Copper LR - comparator disc (price on request)
Range 1–1.0 ppm
Each comparator disc contains a continuous colour scale which makes it possible to achieve an exact colour match between the colour standard and the sample. These discs are specially manufactured in selected materials to remain colour-stable over a long period and guarantee reliable, reproducible measurement results.

Copper (colour card) - micro test kit (price on request)
Range 0.05 – 1.0 ppm
Accepta's self-contained Micro Test Kits allow you to perform a simple, single parameter test utilising a drop test or colour card procedure. Each kit will perform between 30 and 50 individual tests and is supplied its own plastic case with easy to follow pictorial instructions. Accepta's Micro Test Kits demonstrate increased accuracy over traditional test strips methods and are also cost effective.

http://www.kittiwake.com/ecommerce/e_zoom.asp?PN=FG-K21050-KW
Colour Card Copper HR Module
Range 1-4 ppm

http://www.kittiwake.com/ecommerce/e_zoom.asp?PN=FG-K21053-KW
Colour Card Copper Module
Range 1-10 ppm

http://www.kittiwake.com/ecommerce/e_zoom.asp?PN=FG-K21049-KW
DIGI Copper LR (Free) Photometer Module
Range 0-1 ppm

Zinc test kits
http://www.galgo.co.uk/index.html

Zinc	0-3 ppm	INSTRUMENTAL	Vacu-vials
Zinc	0-6 ppm	INSTRUMENTAL	Vacu-vials

http://www.accepta.com/details.asp?cat=1400&scat=70&id=30028
Zinc (colour card) - micro test kit (price on request)
Range 0-4 ppm
Accepta's self contained Micro Test Kits allow you to perform a simple, single parameter test utilising a drop test or colour card procedure. Each kit will perform between 30 and 50 individual tests and is supplied its own plastic case with easy to follow pictorial instructions. Accepta's Micro Test Kits demonstrate increased accuracy over traditional test strips methods and are also very cost effective.

Zinc - comparator test kit (price on request)
Range 0-1.0 ppm
Accepta's range of comparator-based test kits has been developed to offer a simple, cost effective solution to water analysis needs. Each system uses a high quality comparator unit and disc to test for a specific parameter, and will perform approximately 30 individual tests before replacement reagents are required. Accepta's Comparator Test Kits are presented in their own specially designed case which contains a high quality comparator unit, disc, all parameter specific reagents required to perform the test and comprehensive test instructions. Individual comparator discs and reagent packs can be purchased separately.

http://www.kittiwake.com/ecommerce/e_zoom.asp?PN=FG-K21147-KW
Colour Card Zinc Module
Range 0-4 ppm

http://www.kittiwake.com/ecommerce/e_zoom.asp?PN=FG-K26083-KW
DIGI Zinc (Free Soluble) Titrator Module
Range 0.1-10 ppm

http://www.kittiwake.com/ecommerce/e_zoom.asp?PN=FG-K21228-KW
ECON Zinc (Free Soluble) Drop Test Module
Range 1-10 ppm

http://www.hannainst.co.uk/acatalog/HI_3854_Zinc_test_kit.html
HI-3854 Zinc test kit
(http://www.hannainst.co.uk/acatalog/HI3854091.pdf)
Using the zincon chemical method, this kit contains everything you need to carry out 100 individual tests for Zinc.
This uses the colorimetric method of measurement which means that a colour develops in the sample to be measured when the chemical (reagent) is added. This colour is then compared with a colour scale, supplied in the kit, which determines the amount present of the parameter being measured, and produces a result in mg/L.
Price: £32.00

Apparatus design
Students will need to think about the apparatus to use (see **Student sheet**: *Designing the apparatus to test for retention of nutrients*). There are a number of variables. They should discuss within their team, make notes on the sheet and design and assemble a suitable piece of apparatus. They may need to modify it in the light of their initial trials.

Costing the kit
This gives students the opportunity to show they can manage resources and budgets.

Instructions
Students write a set of instructions on how to use the test kit, keeping in mind they are intended for people who may have little science background. Also, they estimate the cost of the kit in terms of apparatus and chemicals required.

Writing the instructions draws the activity together and provides evidence of students' communication skills.

Student self assessment
Students are asked to:
- identify, explain and assess the scientific skills and knowledge they used
- describe how they worked as a team
- give examples of how they supported others and were supported by others
- describe the methods of communication they used and assess their effectiveness
- explain how they managed resources and budgets

Most students are poor at self assessment and, unless they have effective prior experience, will need significant guidance. This might be provided in an open class discussion with groups being encouraged to compare their experiences.

Students are often poor at identifying scientific skills, tending to link the concept of skill to the use of more complex apparatus. They may not recognise as a skill the requirement to use even simple apparatus at appropriate levels of precision with sufficiently accurate results to make reliable measurements for valid comparisons to be made.

In this exercise, demonstration of the use of scientific skills may include:
- clear identification of aims
- construction of a workable action plan and updating of the plan
- contingency planning
- setting and meeting deadlines for intermediate and final goals
- effective team working
- identification of variables (independent, dependent and potential confounding)
- design of a 'fair test' to keep variables other than the independent variable (IV) or dependent variable (DV) constant or controlled
- correctly selecting and obtaining the necessary equipment and materials, and using them safely (including risk assessment to identify hazards and reduce risks) and efficiently (without undue waste of time and materials)
- demonstration of manipulative skills
- effective trialling to identify unseens and establish the experimental design
- use of a suitable method for changing the IV
- use of an appropriate method for measurement of the DV under test to the correct level of precision
- selection of an appropriate range and number of measurements, including repetition to check reliability and accuracy
- responding effectively to unforeseen events and overcome problems
- effective collation, display and analysis of results, including use of ICT and correct choice of charts or graphs
- use of estimation to check calculations
- correct explanation of relevant underpinning scientific principles
- communication of technical instructions with clarity, understandable to a lay audience
- referencing of sources using a conventional method

Session plan for teachers

Exact timing depends on many factors, but the following is suggested:

- Introduction and checking of prior knowledge (30 minutes)
- Students arranged in groups to discuss and plan the work (90 minutes)
- Carrying out the practical work and analysing the data (360 minutes)
- Completion of instructions for test kit and evaluation (140 minutes)

Technical notes

- **Preparation**

The necessary equipment and reagents are supplied in commercial water testing kits. Students should follow the instructions provided with the kit.

Reagents should be made up in advance by a technician.

- **Equipment and materials**

Materials

Students need access to water test kits and the instructions. It may be wise to take the instructions from the test kit packaging and mount them on a laminated board. They will last longer this way.

- peat
- vermiculite

(in quantities sufficient for students to make their own mixtures)

Equipment

- variety of glassware and standard laboratory equipment

(depending on the test apparatus that the students devise)

Testing prior knowledge

1. Write equations to represent what happens when the following are dissolved in water:

a. solid ammonium sulfate

$(NH_4)_2SO_4(s) + aq \rightarrow 2NH_4^+(aq) + SO_4^{2-}(aq)$ and

$NH_4^+(aq) + H_2O(l) \rightleftharpoons NH_3\,(aq) + H_3O^+(aq)$

b. solid copper(II) sulfate

$CuSO_4(s) + aq \rightarrow Cu^{2+}(aq) + SO_4^{2-}(aq)$

c. solid zinc sulfate

$ZnSO_4(s) + aq \rightarrow Zn^{2+}(aq) + SO_4^{2-}(aq)$

2. A fertiliser is said to contain '0.07% copper'.

a. What mass of copper is there in a 1 kg bag of the fertiliser?

0.7 g

b. What mass of blue copper sulfate crystals must be added to the other ingredient to make 1 kg of the fertiliser?

2.75 g

3. A fertiliser is said to contain '15% soluble potash (K_2O)'.

a. Explain why the fertiliser does not actually contain K_2O.

K_2O reacts with any moisture in the air to produce potassium hydroxide

b. The label says the only potassium compound used to make the fertiliser is potassium chloride. What mass is needed to make 1 kg of fertiliser?

238 g

4. Ion exchange is an exchange of ions between an electrolyte solution and a solid complex. Examples of solid ion exchangers are zeolites, clay and soil humus. Ion exchangers are either cation exchangers or anion exchangers. There are also amphoteric exchangers that are able to exchange both cations and anions simultaneously.

a. What is an 'electrolyte solution'?

A solution of an ionic compound

b. What charge is carried by ions that can exchange with cation exchanger?

Positive

c. What charge is carried by ions that can exchange with anion exchanger?

Negative

Note: Correct answers are given in red. These need to be removed before the test is used.

Testing prior knowledge

1. Write equations to represent what happens when the following are dissolved in water:

   a. solid ammonium sulfate

   b. solid copper(II) sulfate

   c. solid zinc sulfate.

2. A fertiliser is said to contain ‘0.07% copper’.

   a. What mass of copper is there in a 1 kg bag of the fertiliser?

   b. What mass of blue copper sulfate crystals must be added to the other ingredient to make 1 kg of the fertiliser?

3. A fertiliser is said to contain ‘15% soluble potash (K_2O)’.

   a. Explain why the fertiliser does not actually contain K_2O.

   b. The label says the only potassium compound used to make the fertiliser is potassium chloride. What mass is needed to make 1 kg of fertiliser?

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   a. What is an ‘electrolyte solution’?

   b. What charge is carried by ions that can exchange with cation exchanger?

   c. What charge is carried by ions that can exchange with anion exchanger?