SOIL SCIENCE AUSTRALIA

Water contamination from run-off

Teacher guide – Science Year 7

Overview

These teaching ideas enable students to explore the different sources of water contamination, and the link between soil quality and water quality. They investigate physical contamination caused by soil erosion, chemical contamination and the use of soil as a filter to clean water. These teaching ideas assume that students have an understanding about scientific concepts of the mixtures and separating techniques. They provide a real-world context for discussion about mixtures, suspensions, solutions, filtering and decanting. Additional Background information for these teaching ideas can be found in Appendix 1.

Activities

1. Soil erosion and water

Students learn how erosion happens and why it is a problem. They investigate how surface conditions and management practices can reduce erosion and repair the damage.

2. Contamination from run-off

Students explore the issue of waterway contamination from pollutants picked up during water movement in rural and urban environments.

3. Soil is a filter

Students build a simple filter and compare the results of using different soil media as a filter.

4. Soil chromatography

Students use another separation technique (chromatography) to separate different components in soil and water solutions using strips of filter paper. They compare the chromatographs to determine which soil type acts as a better filter.

5. Can plants stop soil erosion?

Students explore how plants can combat soil erosion by comparing water run-off over bare soil and over grass.

Australian Curriculum links[1]

Science Year 7

Science Understanding

Chemical sciences

Mixtures, including solutions, contain a combination of pure substances that can be separated using a range of techniques (ACSSU113)

Earth and space sciences

Some of Earth's resources are renewable, including water that cycles through the environment, but others are non-renewable (ACSSU116)

Science as a Human Endeavour

Solutions to contemporary issues that are found using science and technology, may impact on other areas of society and may involve ethical considerations (ACSHE120)

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Activities

1. Soil erosion and water

Water is the most common cause of erosion. Sediment is carried elsewhere and into waterways. This leads to the loss of fertile soils and the decline in biodiversity in waterways and coastal ecosystems. Refer to Soil erosion and water in Appendix 1 for background information.

a) Display one or two images that show the effects of soil erosion e.g. farm paddocks dissected by erosion gullies. Write the word 'erosion' on the board and ask students to write the word in their journals. They then write as many words as they can that connect to erosion. Discuss what erosion is and where students have seen examples of erosion.

   Watch Why water is mightier than mountains [9:12] (ABC Education). This video explains how sediments are formed from rock and eventually turned back into rock over very long periods of time. Display a starting list of terms from the video (e.g. rock, ice, water, gravity, mountains, flood, erosion, landslide, fast rivers, slow rivers, estuaries, uplift, dissolved minerals).

b) Ask students to create a concept map that represents the journeys of sediment. Place 'sediment' in the centre of the board as the key term. Then add other terms around it with arrows and linking terms that show the relationship between the terms. If students are unfamiliar with concept mapping, demonstrate how to start with just a few terms and show how to gradually build the concept map.

c) Discuss the positive and negative ways that soils interact with water (e.g. the role water plays in making soil, the damage that water does in eroding soils, the farmlands in river basins that depend on the sediment for replenishing nutrients, the impact of sediment on aquatic and estuarine ecosystems, how contaminants move from soil into waterways).

d) Visit a site in the school grounds that has been eroded because of lack of plant cover. Discuss why this area looks as it does. Compare it to another area that is not eroded. Ask students what are the key differences? (e.g. The area not eroded may have good plant cover).

   Conduct an erosion simulation activity. Galvanised cake tins and a watering can are used to test how different surface conditions (e.g. living grass, bare soil or mulch) and management practices such as sediment fencing, affect the amount of sediment and clarity of the run-off. Students hypothesise about amount of run-off, how soil cover affects water quality and the degree of sedimentation.

e) Discuss:

   Why is erosion a problem and how does it affect water quality?

   What mixtures are made when soil is eroded? Students record their ideas.

   How do humans contribute to erosion? Brainstorm ideas about how erosion can be prevented.

2. Contamination from run-off

Students explore the issue of waterway contamination from pollutants picked up during water movement and compare run-off from rural and urban areas.

a) Display the following questions and ask students for their initial ideas e.g. What is a solvent? What is a solute? What are some examples of water contamination from run-off?

b) Show Farmland run-off into estuaries [1:52] (The University of Waikato). This video explains the connection between activities on land and their impacts on the coastal ecosystems. Dr Candida Savage highlights the effects of farming practices (e.g. deforestation, fertiliser use and the impact of increased nutrients and contaminants). Ask:

- In this video, what is the solvent? (water) What are the solutes? (nutrients)
- What contaminants are not dissolved in the water but are carried with it as a suspension (sediment)?
- What are some of the impacts of these farming practices?

c) Show Turning stormwater into groundwater [2:44] (ABC Education). This video explains how stormwater is harvested to replenish diminishing groundwater supplies in Sydney.

Discuss:

- Consider the stormwater that flows through Sydney after heavy rainfall. What sorts of pollutants might be in the water (e.g. petrol, fertiliser, metals)?
- Where have these pollutants come from? Which of these pollutants might dissolve in water?
- In the video, how is the stormwater cleaned? How long does the stormwater take to move through the groundwater system?

d) Ask students to compare the run-off from rural and urban areas. In what ways is stormwater like run-off from farms (e.g. it will contain detritus – dead organic matter – and sediment)? What is the difference? Use a 'compare' graphic organiser such as Top Hat.

Alternatively – if you have access to enough digital devices – divide the class into small groups. Assign each video to half of the groups. The groups watch the video and then share the information in a class discussion.

3. Soil is a filter

Adapt the Soil is a filter activity to show what happens when dirty water is poured through a layer of sand and other types of soil (e.g. topsoil). The dirty water is a mixture of detritus and sediment particles and is mostly a suspension. There could be a small amount of different salts dissolved in the water, but the students would need a salinity meter to pick this up.

a) Students predict what the water in the bottom cup of the filtering apparatus will look like, conduct the experiment, compare the results with their predictions and devise an explanation for their results.

   How does the sand and soil separate the sediment and detritus from the water? It is important to explain that just because the filtered water might be clear it could still be contaminated with microscopic organisms such as bacteria.

b) Students repeat the experiment with coloured cordial and investigate what happens when a solution is filtered through different soils.

c) Discuss other ways that filtering is used in everyday applications.

4. Soil chromatography

Soil chromatography is a separation technique that can be used by land managers – with certain soil types in some areas – to monitor and track improvements in the health of the soil. In this activity, students create a chromatogram for distilled water, 'contaminated' water and water filtered through sand and other soils.

Students conduct the Soil Chromatography activity (Appendix 2). They create a chromatogram for:

- a sample of tap or distilled water (as a control)
- the 'contaminated' water from the 'Soil is a filter' activity or a fresh soil and water mixture
- the water that has been filtered through the sand and different soils (also from the 'Soil is filter' activity).

At the conclusion of the experiment, students compare the chromatographs and draw conclusions. Which soil type acts as a better filter?

Alternatively, demonstrate how to make the chromatographs as a whole class activity.

5. Can plants stop soil erosion?

Soil erosion can be caused by run-off (water that flows over the surface of the ground) after the soil is saturated and unable to absorb any more water. Plants can be used to help combat soil erosion. Plants have extensive root systems that can help grab on to soil and keep the soil clumped together. You can see this when you pull a plant out of the ground. Plants also absorb some of the energy in rain drops before they hit the soil and the presence of plants make it harder for water to erode the soil.

Students use trays of soil (with and without grass) to observe how plants can be used to combat soil erosion. Adapt one of the following activities:

- Erosion and soil [7:35] (Fun Science Demos)
- Can plants stop soil erosion? (Science Buddies)
- Soil erosion science experiment (Farm Wife Crafts)

Try changing the slope of the trays, changing the amount of plants, and the type of soil (e.g. sandy compared to clay).

Resource

Being a soil scientist (Queensland Curriculum and Assessment Authority)

While this resource is designed as an assessment task for Year 4 students, it provides teachers with a useful sequence of activities to elicit student prior understanding about soil erosion and what causes it. Students act as soil scientists to:

- build a simple model of soil erosion caused by water
- conduct a scientific investigation into the factors that affect soil erosion using a predict-observe-explain strategy
- devise a solution to an erosion problem.

Appendix 1 Background information

Soils are not only the resource for food production. They are the support for our structures, the medium for waste disposal, they maintain our playgrounds, distribute and store water and nutrients, and support our environment. They support more life beneath their surface than exists above. They facilitate the life cycle of growth, sustenance and decay. They influence the worldwide distribution of plants, animals, and people.

Soils perform services such as filtering water, capturing pollutants, housing fauna, and supporting the plants that capture carbon dioxide and provide our food and fibre. Soil is a highly important resource that is essential to complex life on earth. It is as important as water, light and oxygen.

There are many useful teaching resources about soil and water quality topics that can be used to introduce mixtures and separation techniques to students. For example, the What is the difference between mixtures activity introduces mixtures using the context of drinking water treatment. The How do we make water drinkable activity explores the contaminants found in rivers and how they can be removed in water treatment systems.

Topics

- Soil erosion and water
- Water mixtures in the landscape
- Chemical water contamination from run-off
- Soil and water quality

Soil erosion and water

What is soil erosion?	Soil erosion is the process where the Earth's surface gets worn down. Erosion can be caused by water or by wind (e.g. dust storms). Erosion can be natural or it can be caused by human actions.

Liquid water is the most common cause of erosion. Water can detach and wash away soil leaving shallow channels or large gullies. Water can also remove a thin uniform layer of soil from the soil surface. This type of erosion is called 'sheet erosion'. This occurs when the intensity of the rainfall is greater than the rate of infiltration into the soil. Sheet erosion can be difficult to detect but it accounts for large volumes of soil loss.

When water washes soil out of one place, it deposits it somewhere else. Soil loss is a critical issue for agriculture, but erosion is not just an agricultural problem. It can cause severe problems during construction, resulting in big fines for construction companies. In urban areas, the most severe erosion problems occur during construction of new buildings etc. The land is cleared of all vegetation, so it is unprotected from wind or water. It is the responsibility of construction contractors to minimise soil loss from a building site.

Why does erosion happen?	• The water is flowing too fast across the surface • The ground does not have vegetation cover • The ground is compacted and water cannot filter into the soil

Why is erosion a problem?	• Sediments clog waterways • It can cause structural problems in buildings • It wastes useful topsoil • It is expensive. Farmland is lost. Environmental problems are costly and difficult to fix. Construction companies can be fined. • It is dangerous. It can cause landslides like the Thredbro disaster.

How do you prevent or fix erosion?	• Keep the ground planted • Correct the drainage

Water mixtures in the landscape

As water moves across the landscape, it mixes with a variety of materials such as sediment, contaminants and organic matter to form a mixture. A mixture is a combination of two or more types of matter. When they are mixed, the different 'ingredients' retain their own properties.

These mixtures can be separated using a variety of techniques including sieving, panning, evaporation, freezing, chromatography. For instance, gold is found using panning techniques; river sediment is mixed with water and slowly swirled in a pan. The lighter particles float away and the heavier particles (gold) stay in the pan.

Chemical water contamination from run-off

Water can be contaminated by sediment, but it is also contaminated by chemicals.

In cities, much of the land surface is covered by buildings, roads and pavement, causing water to run into drains rather than soaking into the soil. Cities rely on stormwater drains to carry water to local waterways. Stormwater run-off often includes pollutants such as sediment, oil, chemicals and oil that are picked up during its travels through the city. These chemicals are then delivered to the waterways and impact on water quality and aquatic life.

In rural areas, run-off is not necessarily as pronounced or obvious as in urban areas. However, contaminated run-off can lead to problems such as sedimentation and algal blooms in the Great Barrier Reef. If more water falls – either from rain or irrigation – than a soil can accept, this excess water will run off the land and eventually into waterways. As the water travels across the land, it picks up sediments and chemical pollutants, and deposits them in different locations.

Surface water pollution occurs when hazardous substances come into contact either by dissolving or physically mixing with the water.

Chemical contaminants include:

- fertilisers
- metals
- solvents
- petrols and hydrocarbons
- pesticides, herbicides and fungicides.

One way to minimise chemical contamination of run-off is to improve the quality of the soil. A healthy soil can hold more water and capture more pollutants. Soil should be deep, not compacted, have good organic matter levels and a vegetative cover.

A healthy soil will:

- hold more water and minimise run-off
- capture and hold more nutrients
- capture more pollutants: healthy soil is rich in micro-organisms who immobilise and degrade pollutants
- regulate water flow: discharge water more slowly to waterways and aquifers.

Soil and water quality

Soil and water quality are strongly linked. Healthy soils directly contribute to healthier water resources.

Soil disturbance from human activity can cause dramatic changes to soils through compaction and erosion and can lead to the degradation of soil quality and fertility. When natural soils are removed or eroded, soil organic matter content is reduced, soil structure declines and the diversity of soil organisms is lost. Likewise, as heavy machinery moves across soil, the pores and channels within a soil profile collapse, resulting in a loss of habitat.

With the loss of these organisms, many of the soil's vital functions are lost, including its ability to hold water. Decreased biological activity in the soil reduces the availability of nutrients to plants and plant growth is suppressed. Some soil organisms break down toxins.

Soil compaction reduces water infiltration and increases water run-off. Soil erosion clogs and contaminates waterways.

What are the consequences of chemical contamination of soil? Catchment, estuarine and ocean ecosystems such as the Great Barrier Reef are degraded. Pollutants in waterways affect waterways directly (e.g. algal blooms can be caused by increased concentrations of phosphorus).

Appendix 2 Soil chromatography method

Materials

Chromatography, filter or coffee filter paper (about 20 cm x 20 cm)
Beaker or glass jar tall enough for filter paper
Cover for beaker (e.g. foil or a watch glass)
Water
Sodium chloride solution (NaCl) 0.1%
Filtered water (from the 'Soil is a filter' experiment, if available)
'Contaminated' water (from the 'Soil is a filter' experiment, if available)

Procedure

1. Cut the filter paper into long strips (about 3–4 cm wide and 10 cm long). You will need five strips.
2. Draw a horizontal line in pencil about 2 cm from the bottom of the paper. Mark each paper with a name or code, one for each type of water to be tested (clean, contaminated, filtered water 1, 2, and 3).
3. Using a clean toothpick for each sample, spot the paper by putting the toothpick in the sample and then touching the toothpick gently just above the pencil line. Let the dot dry, then add more solution to increase the concentration, but do not increase the size of the dot.
4. While the samples are drying, pour 50 mL of 0.1% NaCl solution into the beaker and cover the top. This is the chromatography chamber. The NaCl solution is the developing solvent.
5. Wrap the paper into a cylinder shape and carefully staple.
6. Put the paper into the chamber with the sample end (dots) near the bottom. Make sure the dots do not touch the solvent – if they do, they will dissolve. They must remain above the solvent.
7. Re-cover the beaker and wait about 20 minutes for the chromatogram to develop. You should wait until the solvent is about 2 cm from the top of the paper and it must not reach the top of the paper.
8. Remove the paper from the jar and, using a pencil, draw a line to mark how far the solvent has travelled. Remove the staples and lay the paper flat. Trace the different coloured bands from each of the samples.
9. Compare the chromatographs. Which soil type acts as a better filter?

Extension activity

You can also make a chromatogram of different soil types. Grind a soil sample with a mortar and pestle into a fine powder. Mix with a little water to make a solution. Dot this solution onto the filter paper and follow the method above.

Interpreting the soil chromatogram

- The lighter and more plain the chromatogram, the poorer the soil quality.
- Dark brown indicates higher levels of organic matter.
- Purple coloured bands indicate increasing mineralisation.
- The more colours and bands, the more minerals or organic substances in the soil.