




EXPLORE OUR WORLD

SSERC BIOLOGY



Fieldwork is a valuable part of the biology and environmental science curriculum. Its inherent interest for many young people can make it a powerful motivating influence. It can encourage an appreciation of living things and help develop an understanding of the relationships between living things and their environment. It can illustrate the practical need for conservation and thus contribute to their development as responsible citizens and effective contributors to environmental concerns.

(SSERC, Materials of Living Origin)





Contents

Get ready to *Explore Our World*

In this resource, you will be presented with three environmental challenges that will test your knowledge and wider STEM skills. To succeed, you will need to think like a global citizen, work as a team to solve problems and present your solutions. There are opportunities suggested for how you could use your work to become a Young STEM leader and also how you could include a STEM ambassador in your classroom to learn more about the world of work in this area.



Challenge 1

Protect Scotland's Water Challenge

Challenge 2

Plants for Life Biodiversity Challenge

Challenge 3

Nature's Paint Palette Challenge



Curricular Links

Education Scotland: Biodiversity & interdependence

- **SCN 3-01a:** I can sample and identify living things from different habitats to compare their biodiversity and can suggest reasons for their distribution.
- **SCN 4-01a:** I understand how animal and plant species depend on each other and how living things are adapted for survival. I can predict the impact of population growth and natural hazards on biodiversity.
- **SCN 4-20b:** Having selected scientific themes of topical interest, I can critical analyse the issues, and use relevant information to develop an informed argument.

NQ Biology

- **National 3: Life on Earth, Key Area 1:** Sampling and identifying living things from different habitats to compare their biodiversity and suggest reasons for their distribution.
- **National 4: Life on Earth, Key Area 1:** Animal and plant species depend on each other. Suggested learning activities: *Use sampling techniques.*
- **National 5: Life on Earth, Key Area 1 and 2:** Ecosystems (*Research a variety of ecosystems and the organisms found in them*) and Distribution of Organisms (*Use of techniques for abiotic factors; sampling of plants and animals using quadrats; Investigate the abundance of plants/ invertebrates in an area*).

NQ Environmental Science

- **National 4: Living Environment, Key Area 1:** Interdependence (*Include methods of sampling / measuring organisms and their environment*). Sampling and identifying living things from different habitats to compare their biodiversity and suggest reasons for their distribution.
- **National 5: Living Environment, Key Area 1:** Investigating ecosystems and biodiversity (*Investigate biodiversity in aquatic and terrestrial ecosystems, Quantitative techniques for sampling plants and animals, techniques to measure abiotic factors, importance of random sampling*).

HEALTH & SAFETY

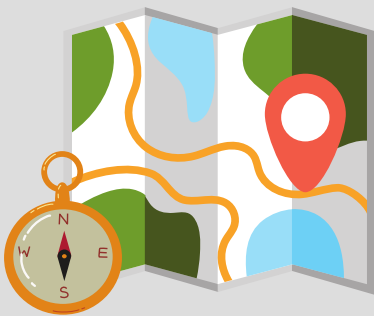
During the planning stages for an ecology/fieldwork investigation, health and safety must be carefully evaluated for staff and learners. The age and maturity of the learners must be taken into account when assessing the risk of potential hazards. Locations must be chosen with an awareness of the potential hazards in the particular area.

Identify hazards 

Assess level of risk 

Identify suitable control measures 

Any site used for fieldwork should be subjected to minimum disruption. Any stones or rocks overturned, or otherwise disrupted, should be replaced. Heavy trampling should be avoided. See the [Scottish Outdoor Access Code](#) for your rights and responsibilities in relation to the [Land Reform \(Scotland\) Act 2016](#).



Click on the button opposite to access our health and safety document for fieldwork that supports the three challenges in this resource.

**Health and Safety
Fieldwork studies**



PROTECT SCOTLAND'S WATER CHALLENGE



Sampling aquatic invertebrates and the water they need to thrive.

sserc

Challenge 1

www.



Scotland's water is a unique resource that we must protect to ensure it is healthy, safe and sustainable, capable of supporting rich biodiversity. Unfortunately, pollution and chemical contaminants, such as fertilisers and detergents, are contributing to growing environmental concerns about water quality and the inevitable consequence this will have on aquatic organisms.

You are an ecologist working for the Scottish Environmental Protection Agency (SEPA). You must sample a suitable site for water quality, measuring a range of abiotic factors, and diversity and abundance of aquatic invertebrates. Can you work out the "biotic index" of your ecosystem?



This task involves:

- Use of Google Maps to choose sampling coordinates without bias.
- Use of digital technology to measure a range of environmental factors.
- Development of coding skills using the Micro:bit.
- Water analysis tests.
- Kick sampling.
- Identification of sampled organisms.
- Analysis of results to form conclusions.



MATERIALS



For this Challenge, you will carry out a range of procedures. The materials you will need for each section are outlined below.

1 MAPPING YOUR LOCATION

- Google Maps installed on a smartphone, with location enabled.
- Results table to note down coordinates.



3 KICK SAMPLING

- Sampling tray (pale colour is best)
- Net
- Identification guides
- Hand lens, plastic spoon and/or pipette
- Hand sanitiser to use after sampling
- Appropriate clothing, e.g. waterproof trousers and wellington boots.

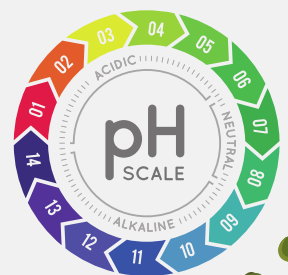
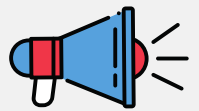


2 MEASURING ENVIRONMENTAL FACTORS

Backpack Science Kit:



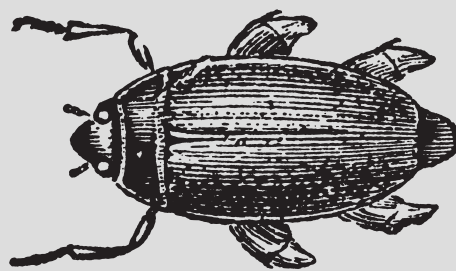
- Arduino Science Journal app installed on a smartphone. Check sensor availability:
 - Ambient light (LUX)
 - Sound intensity (dB)
- Micro:bit (version 2) with Light Sensor code uploaded.
- Thermometer
- Results table to note down values.
- 5 universal containers, labelled with the sample site number.
- Marker pen
- Nitrate sample strips
- 5 microcentrifuge tubes containing 1 drop of Universal indicator
- 5x plastic pipettes
- Universal indicator pH colour chart



METHOD



before you leave the
classroom



BEFORE YOU LEAVE THE CLASSROOM, YOU NEED TO:

1. Choose a sample site
2. Identify sampling coordinates using Google Maps
3. Input the code on your micro:bit to allow it to function as a light meter

METHOD

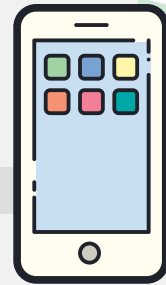


Section 1: Mapping your location

To perform systematic kick sampling, you must choose sample sites at regular intervals. You can use Google Maps for this before you arrive at your location. This removes any bias you may have shown towards particular areas upon arrival.

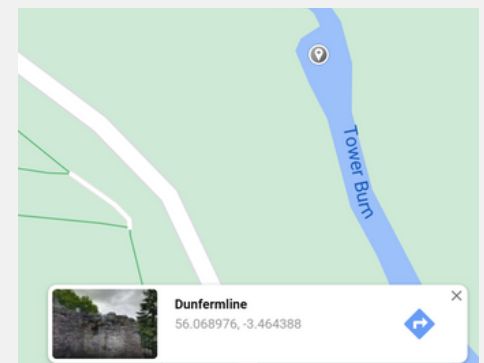
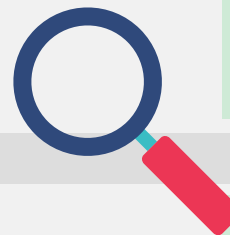
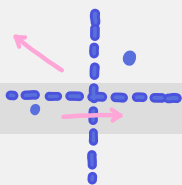
STEP 1

Choose a suitable location using Google Maps. In this image, the site chosen is Tower Burn in Dunfermline. Remember to consider health and safety - the water should be easily accessible and shallow.



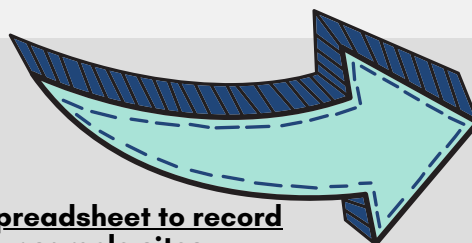
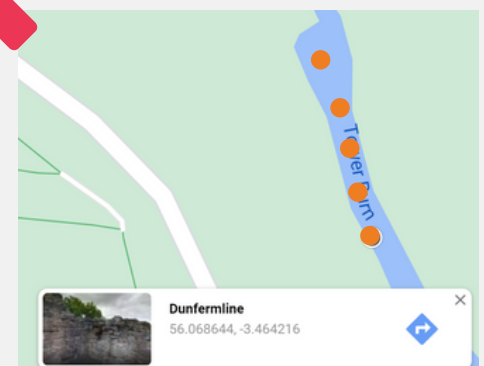
STEP 2

Zoom into your sample site and click on a location along the stream/burn. The coordinates of this location will appear. Note these down.



STEP 3

Systematic sampling involves sampling at regular intervals along a sample site. Choose 4 more sample locations, at approximately regular intervals along the burn/stream and note down the coordinates. This remote approach to location selection reduces bias.



Use a spreadsheet to record your sample sites.

Systematic Kick Sampling			
File Edit View Insert Format Data Tools Add-ons Help			
100% \$ % .00 123 Default (Ari...)			
E6			
	A	B	C
1	Kick sample location	X Coordinate	Y Coordinate
2	1	56.068976	-3.464388
3	2	56.068902	-3.464363
4	3	56.068806	-3.464313
5	4	56.068742	-3.46428
6	5	56.068644	-3.464216
7			

METHOD



To allow the Micro:bit to function as a light meter, the Light Meter code must be written and transferred onto the device. For this activity, you need your Micro:bit (version 2), access to a device with a USB port and the "[MakeCode](#)" website.

STEP 1

Go to the MakeCode website and scroll down to "Tools". Click on "Light Meter".



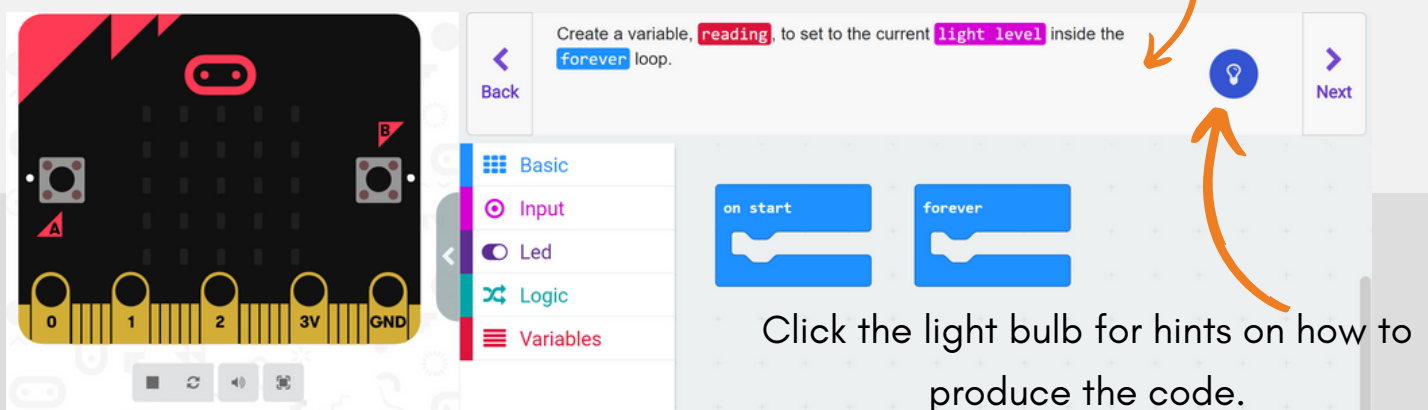
STEP 2

Click "Start Tutorial".



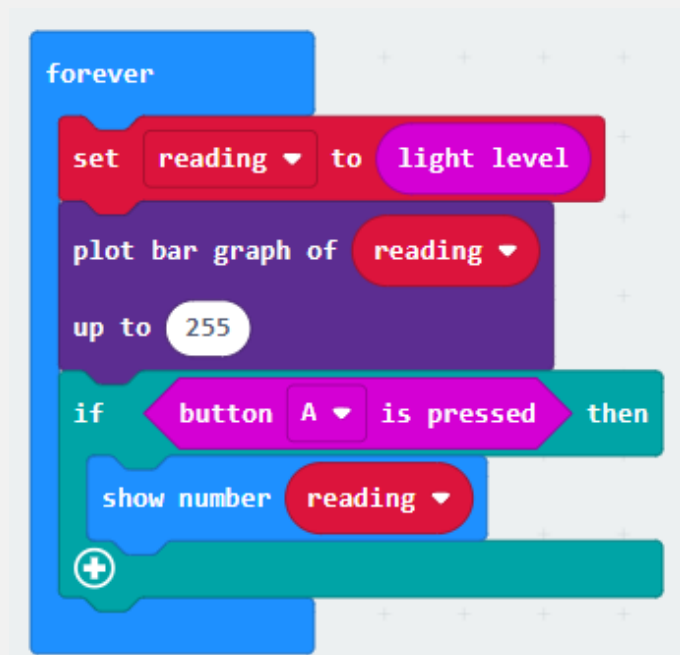
STEP 3

You will be presented with a screen like this. Follow the tutorial instructions, visible at the top, to complete the code.



STEP 4

The final code should look like this.



WHAT DOES THIS CODE MEAN?

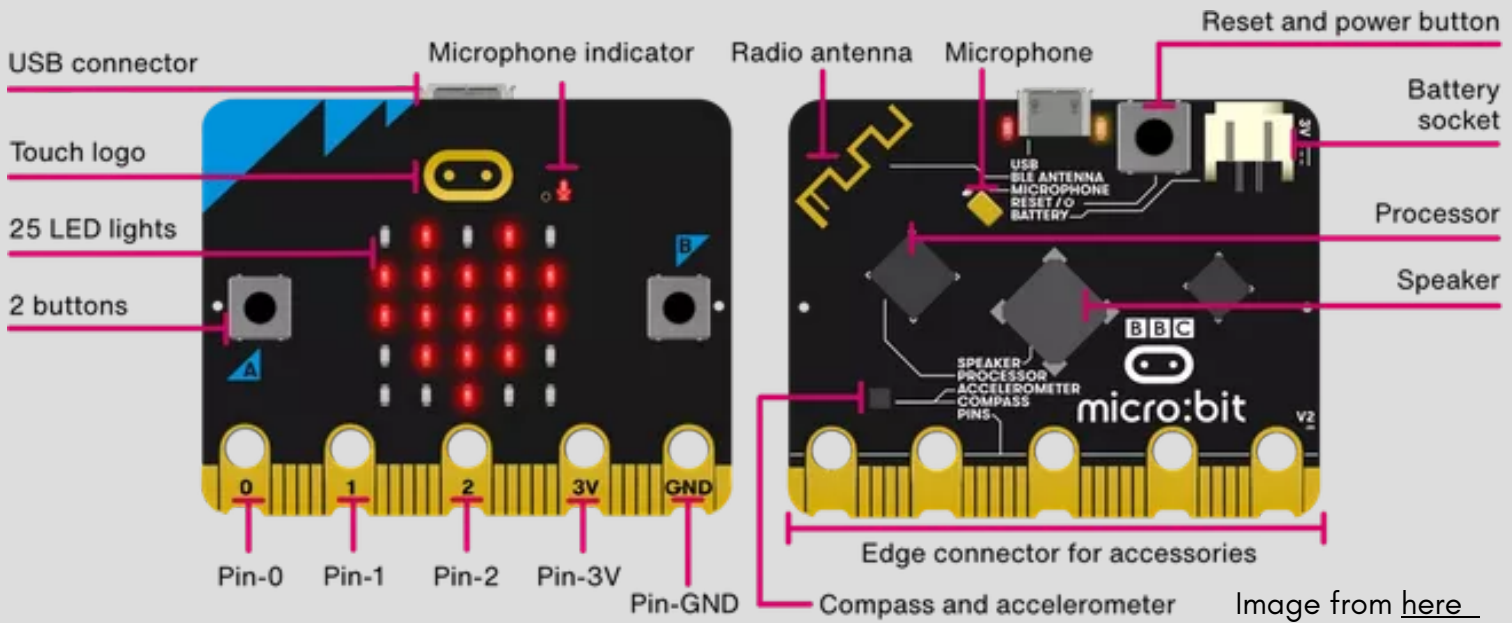
The code instructs the Micro:bit to read the light level. It will automatically present this as a "bar graph" with the number of LEDs lit increasing as light levels increase. However, when button A on the Micro:bit is pressed, a numerical value for the light levels will be displayed between 0 and 255.

STEP 5

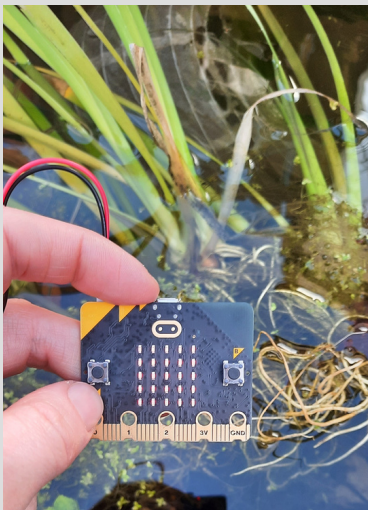
Click on the download button at the bottom left of the screen. On the device, open:

- the Download folder
- the Micro:bit folder

Drag the downloaded code file (a Hex file) into the Micro:bit folder. Disconnect the Micro:bit and try it out! Alternatively, if time is tight, download the hex file [here](#).



The Micro:bit has 25 LED lights that also acts as light sensors. Click on the video icon to see how it works. When you are measuring light levels, ensuring the LED lights are directed towards the light source.

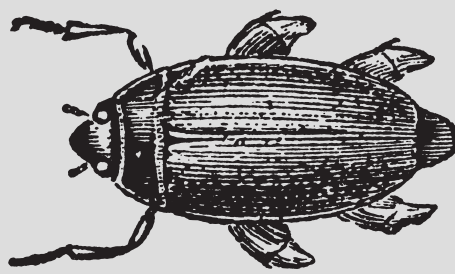


In the video above, you will see the Micro:bit used as a light sensor. Notice the "graphical" display changing as light levels alter; the numerical displays read 191, 63 and 105 (note down the values scroll across the screen).

METHOD



time to leave the classroom



The next part of this protocol involves heading to your sample site.
Here, you will:

1. Use Google Maps to find your pre-chosen coordinates
2. Carry out a range of abiotic sampling techniques
3. Perform kick sampling and species identification
4. Record your data in a suitable format.

METHOD

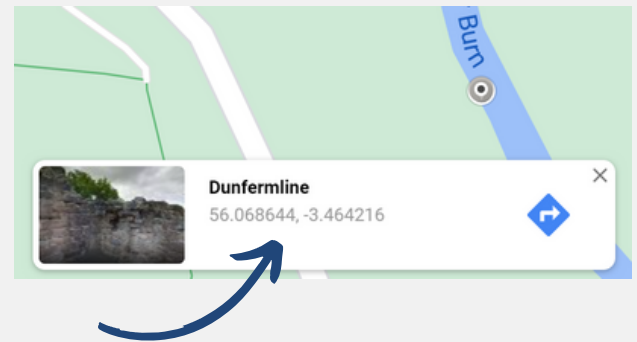


Section 2: Measuring Environmental Factors

Use Google Maps to find your sample sites and start measuring your abiotic factors. You will need the materials outlined in "Measuring Environmental Factors". Repeat the steps for your 5 sample sites.

STEP 1

Open the Google Maps app on your device and type in the coordinates of your first sample site. Click on the blue arrow to find your directions. Enter **Live View** when you are close to your location to help find your exact spot.



Here is a digital record sheet
for your abiotic factors.

Sample Site	Light intensity (LUX)	Sound (dB)	Micro:bit Light Reading	Water temperature (°C)	[Nitrate] mg/L	Water pH
1						
2						
3						
4						
5						

STEP 2

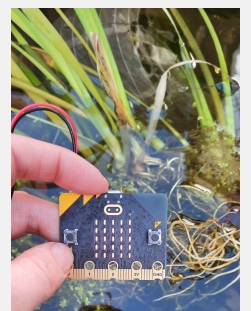
Using the Arduino Science Journal App, record the following measurements at your first sample site:

- Ambient light (at water level) - be careful not to drop your phone in!
- Sound intensity at the sample site



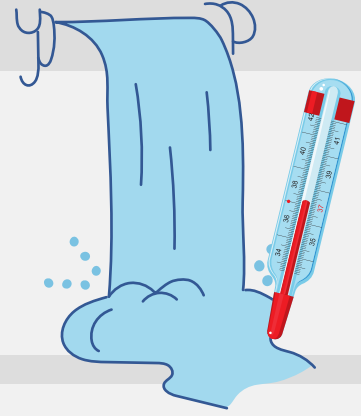
STEP 3

Use your Micro:bit to measure the light levels at your sample site. You can later compare this to the result you got with the Arduino Science Journal App or to a Scientific Light Meter device you had in school.



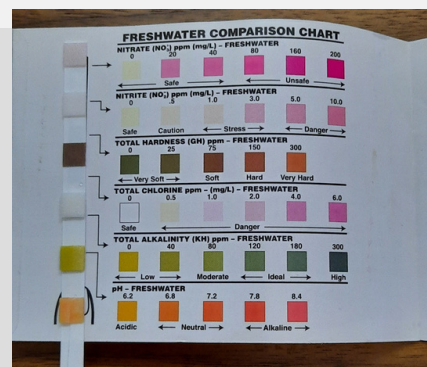
STEP 4

Using the thermometer, place the end into the water at the sample site and measure the water temperature.



STEP 5

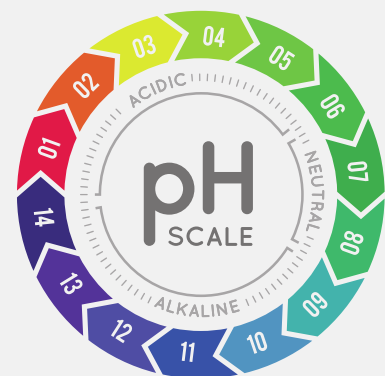
Collect a sample of water from the site location in a small Universal bottle - label the universal with the sample site number, e.g. "Site 1". Use a nitrate test strip to quantify the nitrate levels in the water. Read the instructions on the packet carefully - often this involves dipping the test strip in the water for 1s and then taking the reading after 60s. This can be influenced by fertiliser run-off from nearby farming land.



Some test strips will quantify additional variables, like the one used above. If your test strips provide information about pH, you can miss out Step 6 below.

STEP 6

Using a plastic pipette, transfer 0.5ml of water collected from sample site 1 to a microcentrifuge tube, containing 1 drop of universal indicator. Replace the microcentrifuge tube cap, give it a shake and record the pH of the water using a pH colour chart.

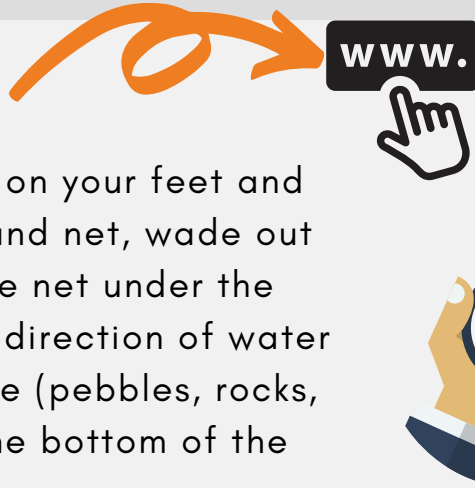


Section 3: Kick sampling

In this section, you will perform kick sampling at each of your five locations. You will need the materials outlined in "Kick Sampling".

STEP 7 - KICK SAMPLING

With your wellies securely on your feet and armed with a stopwatch and net, wade out into the water. Holding the net under the water surface (and in the direction of water flow), kick up the substrate (pebbles, rocks, sand and silt) that form the bottom of the river. Do this for 3 minutes.



STEP 8

After 3 minutes, carry the net back to dry land and transfer all trapped material to the sampling tray.



STEP 9

Use a key to identify any organisms you see in the sampling tray. Record the organism type and the number present - the next page will outline digital resources to support you here. Return all organisms to the river.

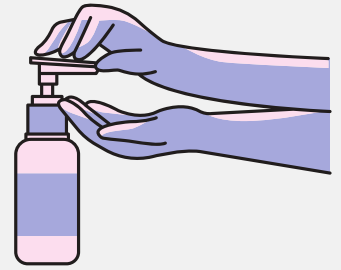


Identification keys can be purchased from the [Field Studies Council](#). A free downloadable guide is available [here](#). Free apps may become available over time and links will be provided here.

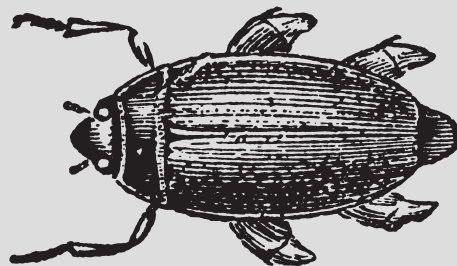
You might find this [image guide](#) we have developed useful - this provides a photo ID for each of the organisms in the Google Sheet.

STEP 10

Repeat Steps 1-9 for each of your sample site locations. Return all water samples to the environment. Use the hand sanitiser to clean your hands before leaving the site.



return to the classroom



PRESENT YOUR RESULTS

You should now have:

- A range of abiotic factors recorded at your 5 sample sites.
- Identified aquatic invertebrates present at each of your 5 sites.

Time to analyse your results and compile your report to present at your next SEPA Management Meeting. How healthy is the water ecosystem?

RECORDING YOUR BIOTIC DATA

Click on the Google Sheet icon opposite and go to the tab "Biotic Data". This will list a range of species that you are likely to meet during your sampling. Tally the number of each species you find at each location. Total up the number of each species found across your 5 sites (right column) and the total number of organisms found at each site (bottom row).



Species identified	Feeding type	Biotic Index Score	Sample Site (frequency tally)					Total number of each species
			1	2	3	4	5	
Alderfly larvae	C2	0						
Beetle larvae	C1	5						
Biting midge larvae	D	0						
Blackfly larvae	D	0						
ased caddis fly larvae	H	8						
seless caddis fly larvae	H/C1	5						
Damselfly nymph	C2	0						
Diving beetle	C2	5						
Dragonfly nymph	C2	0						
Flatworm	C1	0						
Freshwater clam	D	0						
Freshwater hoglouse	D	3						
Freshwater shrimp	D	4						
reater water boatman	C2	0						
Leech	C1	3						
esserwater boatman	H	0						
Mayfly nymph	H	3						
Mosquito larvae	D	0						
on biting midge larvae	D	2						
hantom midge larvae	C1	0						
Pond skater	C1	0						
Pond snail	H	3						
Ramshorn snail	H	0						
Rat-tailed maggot	C1	0						
Stonefly nymph	C1	0						
True worm	H/D	1						
Water beetles	C1	0						
Water flea	H	0						
Water mite	H	5						
Water spider	C2	0						
Total number of species								

This image reference guide will help support your species identification.



Aquatic invertebrate identification guide

EXPLORE OUR WORLD

SSERC BIOLOGY

ASSESSING POLLUTION

Pollution harms the environment. You are going to calculate a **biotic index** based on the organisms you have found at each of your sites. Organisms sensitive to pollution are assigned a higher score, while those more tolerant of pollution are given a lower score. Organisms that tell us something about the health of an ecosystem are called **Indicator Species**.

Use the "Biotic index" tab to work out the biotic index of your site. The key will allow you to determine the overall health of the aquatic ecosystem you sampled.



Species identified	Feeding type	Biotic Index Score	Sample Site (frequency tally)					Total number of each species	Total Biotic Index Score
			1	2	3	4	5		
Alderfly larvae	C2	0						0	
Beetle larvae	C1	5						0	
Biting midge larvae	D	0						0	
Blackfly larvae	D	0						0	
Cased caddis fly larvae	H	8						0	
Caseless caddis fly larvae	H/C1	5						0	
Damselfly nymph	C2	0						0	
Diving beetle	C2	5						0	
Dragonfly nymph	C2	0						0	
Flatworm	C1	0						0	
Freshwater clam	D	0						0	
Freshwater hoglouse	D	3						0	
Freshwater shrimp	D	4						0	
Greater water boatman	C2	0						0	
Leech	C1	3						0	
Lesserwater boatman	H	0						0	
Mayfly nymph	H	3						0	
Mosquito larvae	D	0						0	
Non biting midge larvae	D	2						0	
Phantom midge larvae	C1	0						0	
Pond skater	C1	0						0	
Pond snail	H	3						0	
Ramshorn snail	H	0						0	
Rat-tailed maggot	C1	0						0	
Stonefly nymph	C1	0						0	
True worm	H/D	1						0	
Water beetles	C1	0						0	
Water flea	H	0						0	
Water mite	H	5						0	
Water spider	C2	0						0	
Total number of species									
								Total	0
								Water quality	refer to key

Key to biotic index	
0-4	Very poor water quality
5-10	Poor water quality
11-18	Moderate-poor water quality
19-24	Moderate water quality
25-29	Moderate-good water quality
30-35	Good water quality
36+	Very good water quality

Feeding type key	
H	Herbivore (primary consumer)
C1	Primary Carnivore / Secondary consumer
CS	Secondary carnivore / Tertiary consumer
D	Decomposer / Detritivore

ANALYSE YOUR RESULTS

You have now determined the biotic index and the water quality of your aquatic ecosystem. Can you link the abundance and diversity of organisms found to the abiotic factors you measured?

Do you think the biotic index was **correlated** with the level of light intensity or the nitrate levels in the water? Did pH have a part to play in the biotic index?

Based on your findings, could you present any recommendations to SEPA on improving the biotic index of the area?



STEM AMBASSADOR HUB

STEM AMBASSADORS IN SCOTLAND



Invite a STEM ambassador into your classroom to share their experience of their working world. Daniel is from Madrid and now works in Scotland, focusing on sustainable aquaculture. Could he support a classroom activity and raise awareness of this growing STEM sector? Use the STEM learning website to post a request for a STEM ambassador.

SPOTLIGHT

Daniel Carcajona
Aquaculture Innovation Officer at Sustainable Aquaculture Innovation Centre

Spotlight: Daniel Carcajona, Aquaculture Innovation...

STEP 1
Sign in at www.stem.org.uk/dashboard

STEP 2
Select 'Advertise an activity' in the menu on your online dashboard, fill in the details and publish your activity

STEP 3
STEM Ambassadors will express an interest in your activity and you can offer them a place

STEP 4
Once the STEM Ambassador has accepted, click confirm and communicate through the integrated messaging tool to arrange the details for your activity

STEP 5
Complete your activity

STEP 6
Give us feedback on your activity





YOUNG STEM leader

led by 



Could you embed the Young STEM Leader Programme into your curriculum? The non-formal YSL4 Award focuses on the positive impact of STEM including collaborative and teamworking skills, as well as how STEM can change the world for the better. Let's explore how the YSLP could work in this resource.

DISCOVER

Explore the meaning of STEM and the use of different technologies to carry out the environmental survey. What impact might this kind of environmental monitoring have at a local, national and international level?

CREATE

What have you learned about your local environment? Design your own activity relating to environmental monitoring to involve the school community. Who might your audience be? Could you present your findings at a parents evening event or assembly?

INSPIRE

What does it mean to be inspired? Consider inspirational individuals or groups of people who work in the environment? What makes them inspirational? Can you inspire your audience with your activity?

LEAD

The YSL4 Award allows you to lead an activity or event you have designed, either yourself or as part of a team. Think about the skills, qualities and behaviours to build and develop to deliver your inspirational STEM activity.

If the YSLP is for your class, sign up for [Tutor Assessor Training](#) on the Young STEM leader programme website. You will gain access to a full range of resources to support your learners through the award.

REFERENCES

The list of aquatic organisms and biotic index processing was supported by [The Field Studies Council "Water Pollution" activity](#).

The [Microsoft MakeCode website](#) was used to produce the Light Sensor code for the Micro:bit.

One of identification guides shared in this resource was from [OPAL](#).

[Young STEM Leader Programme](#) at SSERC

[STEM Ambassadors in Scotland](#) at SSERC

Background information was obtained from [SEPA](#).

Data processing file presented throughout this resource is available for you to make your own copy [here](#).

