Assessing water quality of rivers using invertebrates as indicators: desk- and field-based activity

Teacher/technical guide

Curriculum links

National 5, Unit 3 Life on Earth

Mandatory Course key areas	Suggested learning activities	Exemplification of key areas
5 Human impact on the environment	Investigate the impact of pollution on water quality in rivers using macroinvertebrates.	

Learning Intentions

- I will learn about paired-statement keys
- I will investigate how organic pollution of river ecosystems affects the biodiversity and distribution of macroinvertebrate communities

Success criteria

By the end of this exercise, you will:

- construct and use paired-statement keys to identify macroinvertebrates.
- understand how freshwater organisms (macroinvertebrates) indicate the environmental quality of rivers, specifically, the levels of organic pollution.

Background to study

This practical activity is based on macroinvertebrate indicator systems developed to allow rapid assessment of water quality in rivers. These systems include a number of indices, for example, Biological Monitoring Working Party (BMWP) and the *Guide to British Freshwater Macroinvertebrates for Biotic Assessment, Freshwater Biological Association, Scientific Publication No.67, 2011*), as well as simplified versions of these scoring systems.

Macroinvertebrates are used by the Scottish Environment Protection Agency (SEPA) to assess water quality in rivers. They are also used for monitoring river health by citizen science programmes, such as SmartRivers (https://www.salmon-trout.org/smart-rivers/) and the Riverfly Partnership (https://www.riverflies.org/).

The macroinvertebrate species indicator scores that are part of these assessment systems are not included in the field and desk-based activities outlined for pupils. The assessment has been simplified for the purpose of these activities and is based on presence/absence and abundance of a few macroinvertebrate groups that are easy to identify.

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The **purpose** of this practical activity is to:

- Demonstrate the effect of organic pollution on macroinvertebrates in rivers
- Demonstrate how aquatic organisms can be used as indicators of water quality

Macroinvertebrates are animals without a backbone that can be seen with the naked eye. Freshwater macroinvertebrates spend either entire or part of their life cycle in flowing or standing waters and include insects (fly nymphs and larvae, beetles and bugs), snails, mussels, leeches, worms, flatworms, slaters and shrimps. Fly nymphs and larvae leave water when they metamorphose and reach maturity, spending their adult life on land. In many cases, the insects' adult life stage is short and lasts only from several hours to a few days in contrast to their immature stage spent in water, which can last a year or two.

Macroinvertebrates play an important part in the aquatic food web - they can be **herbivores**, feeding on algae and plant material, for example leaves, helping to break down organic matter, or **carnivores** feeding on other invertebrates. They are a food source for other animals higher up the **food chain**, such as fish, birds and mammals. They are also good indicators of water quality due to species having different tolerances to pollution and showing responses that integrate pollution over time, rather than just the time of sampling (like spot water samples analysed for the pollutant chemicals), and, as such, are useful to assess the health of freshwater ecosystems.

Organic pollution is a problem affecting the quality of fresh waters. Bacteria decompose the organic matter and the respiration of the large populations of bacteria that grow can lead to decreased levels of dissolved oxygen in the water impacting animal life in our rivers. The main sources of organic pollution are discharged from wastewater treatment systems (sewage works) and run-off from urban and agricultural land. Some freshwater macroinvertebrate species are more sensitive to this form of pollution than others, and therefore, investigating which groups are present and comparing abundance of these groups allows us to indicate the level of organic pollution. For example, stoneflies and most species of mayflies and caddisflies are sensitive to organic pollution whereas shrimps, worms, blackflies and midge (chironomid) larvae are much more tolerant of the organic matter and low oxygen levels.

Notes on field study methods

The macroinvertebrate sampling method follows the standard kick-sampling method used by SEPA for macroinvertebrates living on the bed of a stream or river. It is designed to sample a **representative** range of river **habitats** (riffles, runs, pools) in a 10 – 15 m long river reach. This allows collection of a **representative sample** from various habitats. For example, many macroinvertebrates, such as stoneflies mayflies and some caddisflies, prefer to live in riffles (stream areas with faster and more turbulent water), because the water temperature there is colder and the faster current increases the dissolved oxygen content in water. Some macroinvertebrate groups, such as aquatic worms, chironomid midge larvae and leeches, are very tolerant of organic pollution and do not require high levels of dissolved oxygen.

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Grazers, such as snails, can be found on stones or plants in slower flowing or standing water, because they feed on algae that grow on surfaces.

Kick sampling nets can be purchased from: http://www.duncanandassociates.co.uk/equip.htm#invert.

When wellies or waders are unavailable, areas can be sampled from the shore by sweeping through the surface of the sediment and vegetation.

Shoulder length gloves should be worn during macroinvertebrate sample collection. If shoulder length gloves are not available, the hand search method of sampling should be restricted to shallow/marginal waters.

Hands must be washed prior to and on completion of the field study activities involved in this practical work. Similarly, benches should be swabbed with 1% bleach on completion of the work.

The Field Studies Council (FSC) "Freshwater name trail" fold out guide (available at https://www.field-studies-council.org/shop/publications/freshwater-name-trail/) can be used by teachers to help with macroinvertebrate identification, and is a useful source of information about macroinvertebrate groups and their sensitivity to pollution.

Although we can generalise, in some macroinvertebrate groups such as mayflies and caddisflies, most species are sensitive to pollution. Only some species within these groups are fairly tolerant of pollution. Therefore, the abundance of such a group, treated as a whole, can sometimes be higher at a 'polluted' site than a 'good water quality' site. Hence, it is important to assess water quality based on all macroinvertebrate groups recorded and not worry too much if one sensitive group appears to be abundant in a sample where most groups indicate polluted water.

We recommend that desk-based activity is carried out first, as it will allow pupils to learn about the sensitivity of macroinvertebrate groups to organic pollution. This knowledge will be necessary for water quality assessment conducted during the field-based activity.

Activities

1. Creating a macroinvertebrate identification key
2. Water quality assessment using invertebrates – desk based study
3. Water quality assessment using invertebrates – field study with Macroinvertebrate recording sheet

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