

Fresh Water Habitats and Biodiversity (Edexcel AS)



Discover Ltd.
"Timbers",
Oxted Road,
Godstone,
Surrey. RH9 8AD

www.discover.ltd.uk

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Fresh Water Habitats and Biodiversity

Teachers Notes

In this unit, students compare two freshwater habitats, a stream and a pond and develop an understanding of biodiversity and the adaptations which organisms have to abiotic factors which influence their environment (behavioural, physiological and anatomical). The sites are within easy walking distance of the centre, and the day could be combined with elements of the terrestrial biodiversity study.

This unit introduces students to a range of concepts and sampling techniques essential to the understanding of biodiversity and how it is measured.

KEY SYLLABUS AREAS:

Unit 2, Topic 4: Biodiversity and Natural Resources.

13) Explain the terms biodiversity and endemism and describe how biodiversity can be measured within a habitat using species richness and within a species using genetic diversity, eg. Variety of alleles in a gene pool.

14) Describe the concept of niche and discuss examples of adaptations of organisms to their environment (behavioural, physiological and anatomical).

Bibliography and Useful Web Sites

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Introduction

Still freshwater ecosystems – ponds and lakes – are referred to as lentic ecosystems. Moving freshwater ecosystems – streams and rivers – are referred to as lotic ecosystems. Both present the invertebrates occupying these ecosystems with a range of limiting factors which must be overcome through adaptation, in order to occupy the habitat successfully. Some members of the biotic community may be able to successfully occupy both freshwater habitats, others will be exclusive to one or the other with an aspect of their physiology or behaviour which limits them to one habitat.

Importantly, the abiotic environment in a stream is more constant than that in a pond. The pond habitat is subject to seasonal change through the year, whilst the ceaseless renewal of water in the stream from upriver provides a more equitable set of abiotic conditions. The physiological and behavioural constraints presented by the two habitats are very different.

In the stream, invertebrates must primarily be adapted to withstand the ever-present flow of water. Their adaptations may be behavioural, burying into the sediment in the river bed, or physical, possessing claws or

suckers with which to grip onto rocks on the bottom of the stream. In the pond, the limiting factors are more varied. As well as the diurnal changes in carbon dioxide and dissolved oxygen concentrations, and seasonal changes in temperature, organisms which live in a pond need to be able to disperse should the pond dry out – organisms which cannot move to a new pond by some means will die if the pond ever dries out.

Specific Information

There are few natural ponds in the Souteyran Valley. Although the underlying geology is granite, which is impermeable and fractured in places, the number of ponds is limited. This is thought to be due to land improvement for grass production on the flatter valley bottom, any natural ponds presenting a hazard to machinery having therefore been filled in. Above the valley bottom, the land is too steep to have natural ponds, although there are several areas which are seasonally very boggy and small semi-permanent pools have formed there.

The pond which will be studied is a small pond, constructed by Andree Moline's grandfather at the beginning of the 20th century, to provide a small water reservoir for watering raspberry canes. It is a well established, clean pond and ideal for our purposes. The River Souteyran rises on a peat bog below the summit of Mont Lozere. It's route follows a fault in the granite, winding down the valley to the south where it meets the River Tarn in Pont de Montvert. Above the Eagles Nest, the river passes through Office National des Forets (ONF) conifer plantations, below the centre, it emerges into open countryside which is initially used for rough grazing before being replaced by fields used for grass production.

Aims

- To compare two different freshwater habitats: a pond – a lentic ecosystem (still water) and a stream – a lotic ecosystem (running water).
- To measure and understand differences in the abiotic environment and how it affects the biotic community at the two sites;
- To investigate how different species are adapted to their environment;
- To use different techniques for sampling the habitats, and understand the importance of taking random samples when measuring biodiversity

Objectives

- To assess the abiotic environment at the two sites, measuring:
 - ✓ Oxygen saturation (%);
 - ✓ pH;
 - ✓ Dissolved load (mg/l);
 - ✓ Suspended load;
 - ✓ Bedload;
 - ✓ Light penetration (cm);
 - ✓ Temperature (oC);
 - ✓ Current (m/s);
 - ✓ Nitrate concentration;
 - ✓ Ammonium concentration;

- ✓ Phosphates concentration.
- To compare the biotic community at each site, assessing species richness, total abundance, dominant species, species diversity and biotic index;
- To consider the different approaches of invertebrates to adaptation to the contrasting environments.

Hypotheses

- Oxygen concentration will be higher in the lotic ecosystem (stream) due to the oxygenation caused by a rapid current;
- pH will be lower in the lotic ecosystem (stream) due to the acidic nature of the underlying granite bedrock and the surrounding landuse (forestry);
- Dissolved load will be greater in the lotic ecosystem (stream) due to acidic minerals dissolving out of the parent rock in the stream bed;
- Suspended load will be greater in the lentic ecosystem (pond) due to the accumulation of silt from the surrounding farmland;
- Bedload will be more diverse and offer more micro-habitats in the lotic ecosystem (stream) due to the exposure of rocks on the stream bed, and the accumulation of sediments and detritus between them;
- Light will be a limiting factor in the lentic ecosystem (pond) – it will not be able to penetrate the full depth of the pond due to an accumulation of sediments in the bottom of the pond;
- Temperature will be lower in the lentic ecosystem (pond) due to the gradual warming up of a static water body during the year – will depend on the time of year – will freeze in the winter!;
- Current will be greater in the lotic ecosystem (stream);
- NO_3^- concentration will be greater in the pond as it accumulates from farmland;
- Ammonium concentration will be greater in the pond as it gradually accumulates from the surrounding farmland;
- Phosphates concentration will be greater in the pond as it gradually accumulates from the surrounding farmland;
- The stream will have a high species richness and total abundance than the pond due to the more constant abiotic conditions;
- The stream will have a higher species diversity index and biotic index than the pond due to the more constant abiotic conditions.

Data Collection Sites

The River Souteyran, at the bottom of the Centre driveway;

A small, artificial pond in the valley, on land belonging to Andree Molines.

Equipment

IN THE FIELD

Per group: D-ring sampling net
 Small white collection tray
 Spoons

Identification key
Collection pot for counting animals
Magnifying glass or hand lens
Plastic bags, pens and labels

For whole class: Oxygen meter with integral thermometer
Nitrate indicator strips
Narrow range pH indicator papers
Secchi disk for measuring light penetration
Meter ruler
Flow meter and conversion chart
Conductivity meter
3 plastic beakers
4 water sample pots

IN THE CLASSROOM

For demonstration: Ammonium test kit
Phosphates test kit
Safety glasses
Gloves

Method and Organisation of study

Abiotic data collection:

NB. This should be done before the biotic data collection. Sampling should be carried out from the river bank or pond edge, to avoid disturbance, which affects suspended load and disturbs the invertebrates.

Advise students about the potential hazard of Weil's disease (speak to your group leader). Students must cover cuts with micropore tape and not splash each other. Students with eczema should wear latex gloves, or avoid contact with the water.

Divide students into work-groups and distribute abiotic equipment. Your group leader will demonstrate the use of the equipment to the students;

Collect a sample of water and a sample of water from each site – using the clear sample bottles provided;

Each group of students takes one reading with the piece of equipment they have been given, records the results on recording sheet 1, then passes it to the next work team. Pass equipment between the sites as necessary. Alternatively, your group leader will demonstrate the use of the equipment and circulate around the sites collecting the data with the student's assistance.

Biotic data collection:

Distribute biotic equipment between work groups. Your group leader will demonstrate the kick sampling technique and the use of the key;

Students should kick sample (in the stream) or sweep sample (at the pond) for one minute. Point out the boundaries for the sampling and any microhabitats to be included;

Students kick sample carefully for the allocated time. Empty invertebrates into a white sampling tray, two-thirds full of stream water. Identify the invertebrates using the key, count into the pot, and enter onto tally list (recording sheet 2);

Carefully replace animals and total up invertebrate tallies.

Repeat the sampling procedures above at each site.

Classroom follow-up

Ammonium and phosphate concentration.

Students must wear safety goggles and latex gloves for this work, and read the hazard information on the instructions. Simple 'Aquamerck' chemical titrations are used to establish lead and zinc concentration in mg/l. Instructions are included in the kits – speak to your group leader. Allow up to one hour, depending on the number of samples. Tets the sediment – not just the water!! Lead and zinc are insoluble in neutral to alkaline water and will not be present in the river water samples – they are 'locked up' in the river sediments – this will be acidified during the chemical test which will reveal the actual extent of lead and zinc contamination in the river.

If you are not confident with the ability of yourself or the students to use these kits safely, ask your group leader to carry out this classroom work as a demonstration.

The Eagles Nest

Recording Sheet 1. Freshwater Ecosystems. Abiotic Factors.

Factor	Pond	Stream
O ₂ (% saturation)		
pH		
Total dissolved load (mg/l)		
Suspended load (mg/l)		
Bedload		
Light penetration (cm)		
Temperature (°C)		
Current (m/s)		
Nitrate concentration (mg/l)		
Ammonium concentration (mg/l)		
Phosphates concentration (mg/l)		

The Eagles Nest

Recording Sheet 2. Freshwater Ecosystems. Invertebrate Tally Sheet.

Factor	Pond	Stream
Olive mayfly nymphs		
Flattened mayfly nymphs		
Striped mayfly nymphs		
Small stonefly nymphs (<10mm)		
Large stonefly nymphs (>10mm)		
Cased caddis fly larvae (small stones)		
Cased caddis fly larvae (fine sand)		
Cased caddis fly larvae (stone & debris)		
Cased caddis fly larvae (vegetation only)		
Caseless caddis fly larvae (brown)		
Caseless caddis fly larvae (green)		
Dragon fly larvae		
Crane fly larvae (Tipula spp.)		
Crane fly larvae (Dicranota spp.)		
Freshwater mites		
Flatworms		
Black fly larvae		
Elmid beetle and larvae		
Small diving beetle and larvae		
Tubifex worms		
Midge larvae		
Red midge larvae ('bloodworms')		
Leaches		

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Data Presentation and Analysis

Each group enters their abiotic and biotic data onto the spreadsheet on the computer in the classroom. This could be done during a break – allocating each group a time to report to the class room – or while students are writing up their methods. Calculate the means for each abiotic variable. Total up each invertebrate species.

Print a copy of the master results and photocopy enough for each student. For the combined data for each site, allocate groups of students to calculate:

- Species richness [the total number of species present at the site];
- Total abundance [the total number of organisms present at each site];
- Dominant species [which species is most common];
- Calculate the Simpson's index of Diversity for each site using the following formula:

$$D=1-(\Sigma(n/N)^2)$$

- Biological Monitoring Working Party Score (BMWP) biotic index (appendix 1).

Abiotic factors could be presented as histograms of the two sites.

CRITICAL APPRAISAL

- How could the reliability of the results have been compromised by the data collection techniques? Students should be encouraged to critically appraise the sampling procedure and make suggestions for its improvement.
- Biotic sampling: Were any invertebrates under sampled, such as those clinging to weed or rocks? Were invertebrates swept down stream due to high water levels or poor kick sampling technique? Was account taken of the variety of microhabitats in the stream channel?
- Abiotic sampling: Was there any possibility of contamination? Were samples taken from the out fall when the propeller was spinning?
- If students plan to use this work as secondary data, or as part of a project comparing the Lot with a river at home, it is important to discuss the limitations of this idea. For example, time of year, species present, effect of local geology, etc.

Data Interpretation and Discussion

- Explain the differences in the abiotic environment seen at the two sites. How would individual factors change diurnally and seasonally?
- Do any of the individual factors have an influence on any other? For example, how is pH affected by CO₂ and O₂ concentration during a 24 hour period? What factors affect the total dissolved load?

- How does the abiotic environment at the two sites affect the biotic community – total abundance, species richness (diversity), dominant species, diversity index, biotic index?
- Were any of the species you found exclusive to one site or the other? Were any species found at both sites?
- Were any invertebrates absent? Eg. molluscs. Why is this?
- Discuss individual adaptations of invertebrates found at each site – you may find it useful to group adaptations under the following headings:
 - Surviving the current;
 - Shape and streamlining;
 - Breathing / respiration;
 - Predation avoidance;
 - Feeding;
 - Protection;
 - Movement;
 - Dispersal – moving between sites;
- Do the invertebrates present reflect the water quality at each site – why are freshwater invertebrates useful as indicator species – could you identify any indicator species for this experiment?
- What is the significance of the diversity index score? Does it indicate that one ecosystem is more settled than the other – how does the score work?
- What is the significance of the biotic index score – what does the final score mean in terms of water quality?
- What is a niche?
- Give examples of ways in which different organisms are adapted to their environments – give two examples of behavioural, physiological and anatomical adaptations for each species.
- How is biodiversity measured *within* a species?

Suggested Follow-Up Activities (evening)

Design-a-bug.

Using poster paper, students work in pairs and design the ultimate survival machine for either the pond or stream ecosystem. The creature can be based on what students have seen during the day, or be entirely fantastical, with adaptations to survive the abiotic environment in the pond or stream. Allow one hour for the creative juices to flow and for the posters to come together. Each pair should then give a short presentation to the rest, introducing their creation and explaining the adaptations they have given it.

We have some posters which have been produced by past students at the centre, to give your students some ideas and inspiration.

APPENDIX 1 Calculating the BMWP Score

This biotic index is based on the tolerance of freshwater invertebrates to oxygen depletion caused by organic pollution. Species that need lots of dissolved oxygen have a high score. Species requiring low concentrations of dissolved oxygen have a low score.

Species / Family	Score
Mayfly nymphs (flattened and striped only)	10
Stonefly nymphs (large and small)	
Cased caddis fly larvae (cases made from stones/sand only)	
Cased caddis fly larvae (cases made from vegetation only)	
Caseless caddis fly larvae (green)	8
Dragon fly nymphs	
Damsel fly nymphs	
Cased caddis fly larvae (cases made from vegetation and stones)	
Freshwater shrimp	6
Freshwater limpets and mussels	
Caseless caddis fly larvae (brown)	
Water boatman	5
All water beetles	
Water measurers and pond skaters	
Black fly larvae and pupae	
Crane fly larvae	
Flatworms	
Mayfly nymph (olive)	4
Alder fly larvae	
Water mite	
Fish leech	
Fresh water snails and cockles	
Leeches (except fish leech)	
Water hoglouse	
Midge larvae (including 'bloodworms')	2
Freshwater worms (including tubifex)	1

BMWP score	Environment Agency Water Quality grade	Environment Agency River Ecosystems Classification
151 +	Very clean	RE1
100 – 150	Clean	RE2
51 – 99	Intermediate	RE3

16 – 50	Pollution	RE4
0 - 15	Very polluted	RE5