# Save the Salmon!

*A problem of pH*

**Science content**

**Acids, alkalis, carbonates, water purity and pH, (breeding and natural selection).**

**Science curriculum links**
AT 1 Exploration of science
(AT 4 Genetics and evolution)
AT 5 Human influences on the Earth
AT 7 Making new materials

**Syllabus links**
- GCSE Science, Biology, Chemistry
- Technology

**Cross-curricular themes**
- Environment
- Economic Awareness

**Lesson time**
¾ to 2 hours

**Links with other SATIS materials**
801 The Water Pollution Mystery
902 Acid Rain
1210 Bottled water

**NERIS**
Search on WATER POLLUTION and SALMON
or on WATER POLLUTION and FISHES

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## SUMMARY

This unit is about acidity and includes practical work. It begins with information about the salmon, its economic value and its life cycle. The practical activities involve measuring pH and making polluted 'river' water less acid.

## STUDENT ACTIVITIES

- ☐ Reading and questions about the salmon.
- ☐ Activity A Questions and practical work for individuals or small groups: pH and neutralisation.
- ☐ Activity B Collaborative problem-solving: suggesting how to make a river less acid.
- ☐ Activity C Teacher demonstration or practical work: modelling and testing solution(s).
- ☐ Questions for group discussion about Activity C.

## AIMS

- ☐ To complement work on acids
- ☐ To apply the measurement of pH to a 'real' problem
- ☐ To show some of the practical constraints accompanying the solution of real-life problems
- ☐ To provide opportunities for collaborative problem-solving

## USING AND ADAPTING THE UNIT

- ☐ This is a short unit unless part C is done.
- ☐ Parts may be selected to adapt it for students of a range of abilities. Activity A is revision of work on acids and designed to cue students into Activity B.
- ☐ To save time, teachers may wish to demonstrate a solution to part C.

## APPARATUS REQUIREMENTS

Part B Usual laboratory apparatus for work on acids and pH.

Part C Lengths of plastic guttering (with end stops) to model a river, crushed limestone or marble chips.

*A list is given in the teaching notes.*

## Teaching notes

Page 1 provides background information. Questions Q1 to Q6 are to aid students' comprehension of the text and could be omitted. **It is suggested that students are not given page 3 until they have completed pages 1 and 2.**

## Activity A

Activity A is designed to revise ideas needed to solve the problem posed in B. Students may need to try out the ideas for themselves or see them demonstrated. Able students could be set this part as a written exercise for homework.

Requirements if practical work is undertaken:

- test tubes,
- universal indicator or narrow range pH paper,
- dilute sulphuric acid,
- dilute sodium hydroxide,
- calcium carbonate / limestone,
- eye protection.

If students are familiar with their use:

- pH meter,
- burettes, conical flasks.

## Activity B

It is envisaged that students will work in groups of 2 to 5 with a strict time limit (say 15 minutes). Reporting back to the class is probably best kept very brief.

Some possibilities for 'saving the salmon' could be:

- diluting the acid by adding water. However, this would be difficult because a large amount of water would be needed very quickly and there was a drought when the incident in the newspaper article happened.
- adding alkali to neutralise the acid.
- adding limestone (calcium carbonate) to neutralise the acid is perhaps the best suggestion. Limestone is cheap, readily available and effective. The limestone could be dumped in 20 tonne loads into the river every 0.5 kilometres. It has proved very effective in other rivers, being insoluble it cannot add excess alkalinity.

## Activity C

Students will need to devise an accurate method of measuring pH, preferably an electrical method.

Apparatus requirements will depend on the solutions proposed. If the limestone method is used suggestions include:

- sulphuric acid and means of measuring pH,
- crushed limestone (garden centres may give away pieces which are too small for rockeries). Marble chips are fine and every laboratory has them.
- lengths of plastic guttering with end stops,
- plastic funnels,
- jubilee clips,
- rubber/plastic tubing to connect to funnels / taps,
- constant head devices (these are sometimes used for A-level physics but can be made by a technician from tin cans).

## General information

Fishing and fish farming of the Atlantic salmon (*Salmo salar*) make major inputs to the economy of rural areas. The licensing of anglers is more profitable than commercial netting of fish. Poaching is so profitable that the Inland Revenue has decided to tax illicit earnings. Fish farming is largely located in Scotland and has grown exponentially over the last decade.

The salmon's life cycle is remarkable, though only outlined in the unit. The young freshwater salmon parr looks very different from the mature salmon and was believed to be a separate species, similar to the trout. It was not until 1840 that the parr were confirmed to be the young of salmon. The length of time that salmon spend in their home river and at sea may be considerably longer than given in the unit, but seems to depend on water temperature.

Atlantic salmon migrate to the waters around Greenland to feed on sand eels, capelin and large zooplankton. Their method of navigation is still not fully understood but salmon are able to sense electric fields and it is thought that they detect the electric potential set up by the ocean currents and the earth's magnetic field. It is believed they identify their home river by 'smelling' its chemical constituents.

## Answers to the questions

***Q1*** *Income from fishing licences, employment as wardens, tourist industry, commercial fishing, fish farming, etc.*

***Q2*** *Poaching, pollution and disease given in the text. Other reasons include the extraction of water from rivers, hydro-schemes and afforestation.*

***Q3*** *No – exceptional drought could not have been foreseen; lack of money to take preventative measures; the cause of acid pollution may not be understood (hence the confused explanation in the newspaper article).*

***Q4*** *No – but the reading might have been beyond the range of the instruments.*

***Q5*** *No – the account is confused. It talks about sulphuric acid and then mentions nitrates from adjoining farmland. In fact the chemistry of acidification is not simple. It was unlikely that the acid was mostly 'sulphuric', although some sulphate ions may have been present from ammonium sulphate, a common fertiliser. Nitrate ions, giving rise to a 'nitric acid', will also be present. An excess concentration of hydrogen ions with a variety of anions were the 'acid' in the river.*

***Q6*** *Salmon returning to the same river to spawn have adapted to its conditions over many generations and developed a unique gene pool (genetic bank in the article). Salmon rivers have been restocked with hatchery fish but important genetically-based behaviours like the timing of migration and spawning have been lost and hence the concern expressed in the newspaper extract.*

## Activity A

***A1*** *pH 7.*

***A2*** *Use universal indicator, a pH meter, by titration with an alkali.*

***A3*** *(a), (b) and (c) its pH increases, [in (c) carbon dioxide is given off].*

***A4*** *Unpolluted water has a pH somewhat less than 7 due to dissolved gases, such as carbon dioxide, coniferous woodland and peaty soils. Carbonate rocks may make some waters slightly alkaline.*

## Questions C

***C1*** *(Students should include ideas they subsequently rejected.)*

***C2*** *(Individual answers.)*

***C3*** *(Individual answers.)*

***C4*** *(See Science AT1 level 6e, 10a and Technology AT4.)*

***C5*** *(Science AT1 level 10b, Technology AT4.)*

***C6*** *Rate of flow of river, cost of materials, labour, transport, maintenance.*

***C7*** *Provide running costs, calculate economic value of having fish in the river, draw attention to environmental benefits etc.*

***C8*** *Legislation or effective enforcement of existing anti-pollution laws; changes in farming practices (if this was found to be the cause); extraction of water from the river and nearby aquifers could be stopped.*

**Acknowledgements**

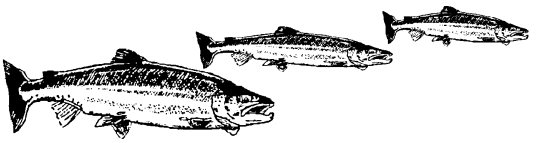
The extract on page 1 is reproduced by permission of the *Daily Express*.

# Save the Salmon!

## *A problem of pH*

Salmon rivers are big business. Anglers will pay more than £50 a day for a *rod*, that is, for permission to fish for salmon. Salmon are also harvested by netting wild fish but most of the fresh salmon you see in supermarkets is reared by fish farming.

A 5 kg freshly caught fish costs around £60 and salmon fishing brings employment to many rural areas. The fishing of wild salmon in Scotland, for example, is worth £100 million per year.



The wild salmon lays its eggs in fast-flowing streams where there is very pure water. Scientists have found that salmon will not spawn when the pH of the river is less than 4.5.

On hatching, young salmon stay in the river for about a year before migrating across the Atlantic Ocean towards Greenland. After about three years they return to lay their eggs and die in the river where they hatched. Since salmon return to the same river to breed, each river is stocked with fish well adapted to its conditions.

Sadly, salmon have disappeared from many rivers, due to poaching, pollution and disease.

The activities in this unit include:

- reading
- questions
- practical work on acidity
- deciding how to reduce acid pollution in a river
- modelling and testing the solution.

***Questions about the text and newspaper extract***

***Q1*** *How may salmon fishing bring employment to an area?*

***Q2*** *Why have salmon disappeared from many rivers?*

***Q3*** *Was it fair to suggest that the death of the salmon was 'wholly avoidable' in the newspaper article?*

***Q4*** *Would river water really 'blow the tops off instruments'?*

***Q5*** *Does the newspaper explain how acid got into the river?*

***Q6*** *(a) What is meant by the term 'genetic bank'?*
*(b) Explain why the River Torridge cannot be restocked with salmon from the same genetic bank.*

*From the Daily Express, October 1989*

**Acid kills off trout in fishing paradise**

By James Davies
environment correspondent.

Pollution has killed more than 100,000 salmon and trout in a West Country river.

Last night river authority chiefs were under fire for failing to prevent "this wholly avoidable tragedy".

One conservation campaigner said after checks: "It was effectively sulphuric acid in the water, and I was told it nearly blew the tops off the instruments."

It is thought that acids from nitrates on adjoining farmland were washed into the river by rainfall. Because water levels were low following the long, hot summer, they were not sufficiently diluted.

"We have lost virtually the whole genetic bank of salmon and brown trout for the Torridge because this was the only successful spawning tributary."

## Activity A

The strength of an acid is measured on the pH scale.

Use textbooks or carry out experiments to help you answer the following questions. (Remember that practical work must be supervised by a teacher. Wear eye protection.)

*A1* *What is the pH of very pure water?*

*A2* *How could you find the pH of the solution of an acid? (Hint: there is more than one way to do this.)*

*A3* *What happens to the pH of an acid solution when these substances are added to it?*
*(a) water*
*(b) an alkali*
*(c) a carbonate (e.g. calcium carbonate)*

*A4* *Suggest why unpolluted water in rivers and ponds may have a pH ranging from 4.5 to 8.*

## Activity B – How would you save the salmon?

You are scientists working for the National Rivers Authority. What should be done to save the salmon in the River Torridge?

**1** ☐ Work in small groups.

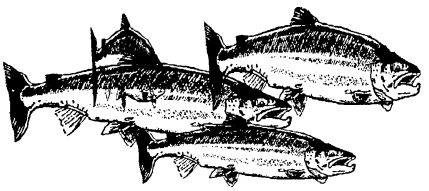
☐ Spend about 15 minutes on this part.

☐ You are to think of a method to save the salmon from acid pollution. Assume the pH of the river water is around 3. Aim to increase the pH to between 4.5 and 7.0.

☐ Although the members of the group may have different ideas try to come to some agreement quite quickly on a good method.

**2** Work out some details. For example, draw sketches, work out quantities or chemical equations.

You will need to think of a method which
- is cheap and works on a large scale,
- does not depend on piping more water into the river in times of drought,
- you could test out in your school laboratory.



**3** How could such a scheme be paid for? (E.g. would you charge the taxpayers, the local council, the fishermen, the farmers, etc?)

**4** Elect a spokesperson to tell the class about your plan.

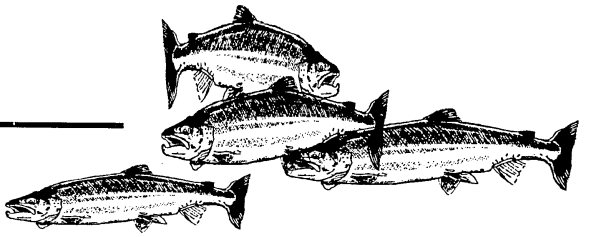
## Activity C Will it work?

Build a working model of your idea and test it.

Measure the pH of the water before and after treatment and record any results that you take.

There are a few points to remember.

- ☐ Safety – always consult a teacher first.
- ☐ The water must be 'running water', so you cannot just use a beaker.
- ☐ You need an accurate means of measuring if the water is suitable for fish.
- ☐ You cannot use live fish. This might be cruel.



***When you have finished activity C, try answering these questions to explain how you did it.***

***C1*** *What ideas did your team have for solving the problem?*

***C2*** *Which design did you use? Draw a diagram of your model and explain how it worked.*

***C3*** *How did you measure the pH of the water?*

***C4*** *Evaluate your model – did it work as you predicted? Could you improve the design in any way?*

***C5*** *What changes might be necessary to scale up your model to full size?*

***C6*** *What information would you need to work out the running cost of the full scale scheme?*

***C7*** *What could you do to persuade people that your scheme should be adopted?*

***C8*** *Suggest other ways of saving the salmon.*

Answers to questions are given in the *Teachers' Notes.*