The watery world of underground chemistry

Using pH to link the atmosphere, hydrosphere, biosphere and lithosphere together

Running the 'watery world' activity

This activity works best out of doors, but can be run in the classroom. It also works best if pupils are asked to contribute to the discussion through the questions and answers suggested below.

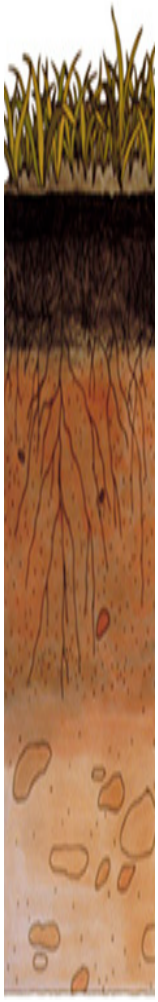
First introduce pupils to the pH scale and how pH can be measured using Universal indicator. The colour chart shows that strong acids give red indicator colours, weaker acids range from orange to yellow, neutral solutions are green, while weakly alkaline solutions are greenish blue to dark blue and strong alkalis give a purple colour.

Tap water (rainwater)

1. Have tap water in a bottle (or even better, some rain water you have collected), a drinking glass and some Universal indicator. Also have hidden a drinking straw and a bottle of unopened spring water.
2. Pour some tap water into the drinking glass. Ask what colour they expect Universal indicator to turn when it is added – most will predict that the water is not acid or alkali, but will show a neutral green colour.
3. Add indicator, it will normally turn green or slightly bluish green, showing it is neutral or slightly alkaline.
4. Ask what will happen when the water is poured onto the ground – most pupils will say it will soak into the soil.

Soil water

5. Pour the water onto the ground and watch it soak into the soil. Ask what will happen to the water in the soil; you may have to remind pupils that the soil contains decaying vegetation that is likely to produce acid, and that it contains animals that are respiring, producing carbon dioxide – pupils may then predict that the water will turn acid.
6. Ask how we could mimic the effect that carbon dioxide from respiring animals has on the water – pupils may suggest that someone blows air into the water using a straw, and that indicator will go yellow.



7. Put some more water into the glass, add indicator, get out the straw and ask someone to blow into the water for some time (eg. 30 seconds) – the indicator will normally turn yellow (sometimes orange), showing that a weak acid has formed.
8. Ask what then will happen to the acid water in the soil – pupils may suggest that some will stay in the soil, some will be lost through transpiration by plants or evaporation from the soil surface, but some will trickle into the rocks below to become groundwater.

Groundwater

9. Ask how the acid water is likely to affect the rocks – most will suggest that a chemical reaction will occur and the water will become neutral again.
10. Ask what will happen to this water over time; you may have to give the clue that water will flow through pore spaces in the rocks and will also flow downhill – some pupils will say that the water will flow sideways.
11. Ask whether this water will come out of the ground – some will say the groundwater will leak out in a spring.

Spring water

- Following all this discussion, ask what colour they would expect Universal indicator to turn in spring water – most will predict it will turn a neutral green colour.
- Get out the bottle of spring water, open it, pour some into the glass and test it with indicator. It will normally go a neutral green or a slightly alkaline bluish green.

Linking the Earth's spheres

- Ask which of the Earth's spheres have been mentioned in the discussion; the ere, biosphere or pils will realise that r, origin of e (trickling into the water, springs); ck); and biosphere the soil)) have all

The back up

Title: The watery world of underground chemistry.

Subtitle: Using pH to link the atmosphere, hydrosphere, biosphere and lithosphere together.

Topic: A discussion, with demonstrations, of the likely change in pH of water as it goes through the underground part of the water cycle.

Age range of pupils: 10 – 18 years

Time needed to complete activity: 15 mins

Pupil learning outcomes: Pupils can:
- describe how the colour of Universal indicator shows the pH of a solution;
- describe and explain the likely changes in pH of water as it goes through the underground part of the water cycle.

Context: The pH of water is used as the basis of a discussion of how water flows through, and interacts with, the rocks and soil during the underground part of the water cycle – integrating aspects of the atmosphere, hydrosphere, biosphere and lithosphere.

Following up the activity:
1. In the discussion of the groundwater section, where pupils are asked, **'**how the acid water is likely to affect the rocks', try adding some powdered chalk (eg. enough to cover your small fingernail) to the yellow-coloured weakly-acid water. The water, when shaken, will soon turn a cloudy green colour; it is cloudy because of the chalk, and green showing that the acid has reacted with the chalk to form a neutral solution.
2. For those in coastal areas, who have access to some sea water:
- Ask what would happen to acid soil water that flows into the sea? – pupils will probably answer that it will go neutral.
- Ask, could this be replicated by adding salt (NaCl) to the acid 'soil water' – they will probably answer 'yes'.
- Add salt to the yellow-coloured water, it often turns the water green for a brief moment, then it reverts back to yellow again. This is because salt has no effect on the pH, since it produces a neutral solution.
- Ask – so, what will happen if we test sea water for pH using Universal indicator? – pupils will probably answer, from what they have seen that, it will go yellow.
- Add Universal indicator to sea water. It will usually go green to bluish green showing it is slightly alkaline. Explain that when acid soil water flows into the sea, a range of reversible reactions takes place involving much of the dissolved material, in addition to sodium chloride (NaCl). These reactions adjust and so absorb the acidity of the soil water without the seawater becoming acid itself. This is just as well, since it allows the oceans to absorb a lot of the carbon dioxide put into the atmosphere by human activities, and so reduces the global warming effect of CO_2.
- Ask, how could the effect of acid soil water flowing into sea water be reproduced? Pupils will probably suggest that someone blows through a straw into the sea water containing Universal indicator to see how quickly the pH of the seawater changes.
- Use a straw to blow into the seawater with the Universal indicator. You will find it takes much longer to change the pH of sea water than it does with fresh water, because of all the reversible reactions that can accommodate the CO_2 until it 'can't take any more'! This 'buffering' effect of the reversible reactions in sea water is vital to the well-being of our planet. If the oceans ever 'can't take any more' and they become acid, the Earth system will be in very difficult circumstances!
- Ask, which parts of the Earth system have been brought into this extended discussion? The answer is that all of them have (atmosphere (CO_2 in the atmosphere), hydrosphere (soil water, seawater), lithosphere (water from the soil) and biosphere (human activities producing CO_2)).

3. Ask the pupils to look at the label on a bottle of shop-bought spring water, and discuss how the chemicals in the water got there.
4. Try the 'From rain to spring- water from the ground' activity on the Earthlearningidea website http://www.earthlearningidea.com/English/Resources_and_Environment.

Underlying principles:
- The pH of liquids can be found using Universal indicator.
- As it flows through soil and bedrock, the pH of groundwater changes in response to biological processes (eg. respiration and decay) and chemical processes (reaction with the rock and soil).
- The pH of seawater is buffered by a wide range of reversible reactions, which allow it to absorb a lot of CO_2 without becoming acid.

Thinking skill development:
Pupils **construct** a picture of how the pH of water is likely to change at different stages of the underground rock cycle; **cognitive conflict** comes each time they are asked to make a prediction, and particularly when their predictions are wrong, as is often the case with sea water; if handled carefully the discussion can involve pupils in **metacognition**; the **bridging** element is the link between the discussion and the 'real world', such as in when spring water is tested.

Resource list:

- tap water (from a tap or in a bottle) or rainwater
- Universal indicator solution (*health and safety information: wear eye protection; flammable; do not swallow)*
- eye protection
- drinking glass or wine glass
- a drinking straw
- a bottle of spring water
- Optional, for follow up activity 1: some powdered chalk (enough to cover a small fingernail)
- Optional, for follow up activity 2: a bottle of sea water and a teaspoonful of salt (NaCl)

Useful links:

See the interactive water game at: http://www.scottishwater.co.uk/education/html/aboutWater/aboutWater7.html

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