1. Pick a piece of pipes

1 hour *and*
10 mins a day
for a week

Testing aluminium, steel and a plastic for rusting when exposed to water. Children test materials for their resistance to corrosion. Using this knowledge, they choose a material for constructing a pipeline for the water.

OBJECTIVES

- Give reasons, based on evidence from comparative and fair tests, for the particular uses of everyday materials, including metals, wood and plastic.
- Planning different types of scientific enquiries to answer questions, including recognising and controlling variables where necessary.

RESOURCES

(Per group of 4 children unless otherwise stated)

- Washing-up liquid bottle (cut into a 'plastic pipe')
- Food can[1] (cut into a 'tin-plated steel pipe – see safety note)
- Fizzy drinks can[1] (aluminium 'pipe')
- 3 x 2-litre plastic bottles, with tops cut away
- Rubber gloves
- Coarse sandpaper
- 1.2 litres tap water
- Activity sheets 5 and 6
- Activity sheet 7, copied onto an acetate sheet

Safety note

An adult uses a safety tin-opener (which leaves a smooth edge) to cut cans into 'pipes'. Sand, file or tape any slightly rough edges that remain. If this is not possible use the cans whole. The children should wear rubber gloves whenever they are handling the 'pipe', to prevent loosened rust being transferred to children's mouths via their fingers.

1 Prior to the lesson, rub the fizzy drinks and food cans along their length with sandpaper, to remove the paint and tin respectively. Section of the cans are left intact, so a comparison between the protected and unprotected surfaces can be made.

BACKGROUND INFORMATION

Metals corrode in the presence of air and water, therefore the corrosion occurs most on the metal surface at the air/water boundary. The metal reacts with the oxygen in the air to form a metal oxide. The steel pipe corrodes quickly. Aluminium corrodes relatively slowly in water to form a white powder (i.e. it looks tarnished). The time taken for the aluminium to corrode is far greater than the children's testing time, therefore they are unlikely to see any corrosion.

'Rusting' is the term given to the corrosion of metals which contain iron, e.g. steel.

It is impossible to stop corrosion, but it can be controlled. In the case of steel, a layer of zinc can be added to the steel. This process is call **galvanising**. The zinc corrodes to form an oxide layer, which provides a protective coating against further corrosion. To control corrosion of food cans the thin steel plate is coated with tin, and if the contents are acidic a layer of lacquer may provide added protection against corrosion. Mild steel corrodes relatively quickly and therefore requires a protective coating.

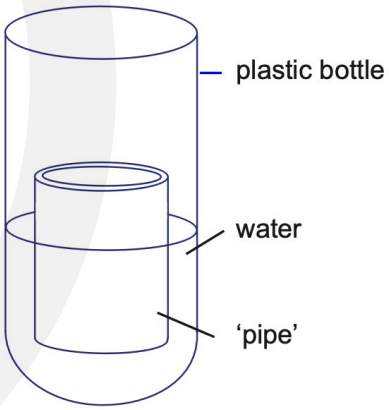
Pipelines exposed to the atmosphere are usually painted to provide protection, and are inspected regularly. Pipelines are designed with a safety factor (increased thickness), so that in the worst possible cases of corrosion leakage should not occur.

Pipelines running underground may have zinc blocks attached to their interior, so that the zinc will corrode before the pipeline does. Zinc-based chemicals are also added to the water to prevent oxygen attack to the pipeline. Bactericides are added to the water to prevent the growth of bacteria, as chemicals produced by the bacteria can cause corrosion.

Cooling water is typically carried around an industrial site in pipes made from galvanised steel or mild steel. These can be lined with glass or certain types of plastic to prevent corrosion. Stainless steel may also be used to carry cooling water, as this does not corrode, but is much more expensive than mild or galvanised steel. Aluminium is not used because it is a mechanically weak metal. Plastics are a relatively new group of materials and therefore have been considered for use in recent years.

With the advances in polymer (plastics) technology, new pipelines can be made from uPVC (Unplasticised polyvinyl chloride) and other plastics, as their mechanical strength has gradually been improved. Plasticised PVC has added flexibility which is an undesirable property for a pipeline. Plastics do no corrode and they also provide a lightweight pipeline which requires less support from the ground than metal pipelines (which therefore reduces costs).

CARRYING OUT THE ACTIVITY



A class discussion of everyday items made from plastic, aluminium and steel puts the materials into a context for the children, for example; aluminium tent poles and pans; steel exhaust pipes and nails; plastic yogurt pots and rulers. The children also discuss the meaning of 'rusting# and where they may have seen rusting occur, e.g. car bodies and exhaust systems, nails, screws, metal gates, etc. They could carry out a 'rust hunt' around the school, listing the rusting objects and (possibly) what they are made from. This will aid the process of making predictions about which materials may rust, based on their knowledge of everyday objects. Children may not be aware that some metals do not rust. This does not require detailed explanation at this stage, as the children can discover this through the following activity.

The activity is then presented with Activity sheet 5, which poses the question; How will you choose the best material for the pipelilne?

The resources that the children are asked to use are the plastic bottle, aluminium can and steel can. These should have been opened into pipes by the teacher before the lesson. Spaces are provided on Activity sheet 13 for children to write the material that each 'pipe' is made from. The first letter of each material has also been given. The children plan their test and choose additional resources needed to carry it out. They may require prompting by the teacher to limit the variables to one (the pipe material), to maintain fair test conditions. This may need further discussion, if the children's previous experience of carrying out fair tests is limited. Variables to consider include the quantity of water used each time; the position of the pipe in the water; and the method of measuring the amount of rusting.

One method of carrying out the test is outlined below. This method can be used by those children who have difficulty in planning their own test.

The children set up the test by pouring 400 ml of water into each plastic bottle. This quantity of water allows the top half of the pipes to be exposed to

the air and the bottom half to be submerged. The pipes are cleaned using warm water containing a little detergent, and rinsed. The children place a pipe in each bottle (is using whole fizzy drinks cans, the children must make sure that some of the water is poured into the can, to hold it in position on the bottom of the bottle).

The children are now given the opportunity to make predictions about what they think will happen to the different pipes in the water. These predictions can be recorded on Activity sheet 6.

Each day the children remove the pipes to assess any rusting that has taken place. This can be measured or described. The results of their observations can be recorded on Activity sheet 6. The children either record an area of rusting, or use short phrases to describe the state of the pipes.

One method of measuring the rusting is to hold a square grid (on an acetate sheet or tracing paper) next to the pipe, and count the number of squares through which rusting is visible. A square grid is cut from Activity sheet 7 for this purpose.

N.B. Care should be taken not to remove the rust formed when the pipe is lifted out of the water.

The children can mark the material for the pipeline on a copy of Activity sheet 2, using arrows to show the flow of water through the pipeline from the reservoir to the site.

DISCUSSION QUESTIONS

- Which pieces of pipe rusted?
- Which parts of the pipe rusted? Why?
- Which material would you choose from your pipeline? Why?

EXTENSION ACTIVITY

The children explore the effectiveness of a variety of coatings on the pipe that has rusted. They could use Vaseline, cling-film, water-based paints, oil-based paints, etc.