

Resistant Materials in our Environment

Teacher Introduction

Definition of resistant materials

A resistant material is a durable substance that stays in the same condition, in the product in which it is used, for a substantial period of time. Metal, glass, plastic and cement that are used to build homes and other buildings are obvious resistant materials. Straw bales, used in buildings, and reeds, used as thatched roofs, are also resistant materials in those situations. When added to a compost heap, these same materials, straw and reed, would decompose fairly quickly and so would not be resistant materials in those situations.

Design and technology

This unit is based on the QCA Design and Technology Unit 7A(ii) Understanding Material (Focus: Resistant Materials). The unit could be adapted and used in Year 9 as part of the 'Designing for Clients', units 96i and 96ii. This strand of work also supports Year 9's Units 9aii 'Selecting Materials - Focus Resistant Materials'.

Sustainable development

Along with 171 other countries, the UK signed up to a Sustainable Development charter at the conclusion of the first Earth Summit in Rio de Janeiro in 1992. Part of the commitment is to:

Protect and safeguard the environment while still allowing for future development.

Live within the physical limits of the Earth's resources so we can pass the planet to our children's children with its ability to support life undamaged.

This unit promotes both of these commitments.

It proceeds through the process of evaluating products. It examines items designed to improve the human environment and those constructed to facilitate our contract with wildlife. Then, as part of a design and make assignment, pupils are given the opportunity to create a product that would improve either the access, the range of habitats or the interpretation at a local nature reserve.

This unit particularly develops the strand in the QCA Unit 7A(ii) "*Pupils become aware how the extraction, use and disposal of some materials affect the natural environment.*" It also develops the pupil's understanding of *finite* and *renewable* materials plus the concept of *embodied energy*. Finally, in order to develop a greater insight into considering environmental impacts the unit looks in greater detail at the implications of using wood.

As well as being used in the school curriculum it could be used as a project that is part of a school community or environment week.

Basic background information - See the Internet Links page.

The source of some common materials and their impact on the natural environment.

Finite materials:

Many of the materials that we use in everyday life are derived from substances that accumulated over millions of years in geological time. They cannot be replaced in terms of human life spans. So, even though vast reserves of some of these substances exist they will be effectively exhausted in some relatively short period of geological time. In pupil's terms "They come from out of the ground and they'll run out!"

Common materials derived from finite resources include metals, aggregates and glass, most plastics (including a few 'manmade fabrics') and, arguably most important of all, fossil fuels!

Metals

All metals are derived from mined or quarried mineral ores. Historically many metals have been mined within the UK. These ores are now for the most part exhausted or in such low concentrations as not to be economically worth extracting. Arguably, the legacy of some of this mining in some areas has been the creation of a more diverse landscape. The copper mines in the Lake District at Coniston and the lead mines in Lathkill Dale, Derbyshire are two well known examples. The negative legacy of this mineral extraction is some persistent toxic pollution and waste problems. In Derbyshire, for example, arsenic from lead mining waste persists in the soil. This prevents some agricultural land from being used for growing arable or market gardening crops.

Most metals, derived from virgin raw materials, that we use in the UK today, are sourced from abroad. Apart from the environmental cost of the energy consumed in their transport to the UK (see 'embodied energy' below) many of these materials are obtained at great environmental cost. Some are mined in what were once wilderness areas. The mine and the infrastructure (roads, rails etc) to support extraction has damaged large areas of environmentally sensitive areas. An example is Brazilian iron ore mined at the expense of Amazon rainforest.

Stone, aggregates and glass (sand, gravel, clay, limestone and some igneous rocks)

Large amounts of rock and aggregate are quarried in the UK each year. Apart from being used as stone for buildings and other constructions, much clay and aggregate is used for bricks, tiles, glass, plaster and concrete that create many of our buildings. They are used in things as diverse as toothpaste, bread and roads. Aggregates are used to clean our water supply and reduce air pollution from coal fired power stations. They are a vital part of our lifestyle.

English Nature's policy on the sensitive extraction of these materials is explained in its position statement 'Aggregate extraction and nature conservation' and outlined in the primary unit 'Rocks and Soils'. However, wherever aggregates are quarried, landscapes are permanently changed. The legacy can sometimes be a more diverse landscape, such as a water park, but often the exhausted workings are exploited as a landfill site. Restoration of the surface of the site may create or restore wildlife habitats but this is a difficult process. Sometimes, where flooding is not a risk, it will be more beneficial for nature conservation to leave the quarry or pit unfilled. This is particularly important where it reveals geological interest.

Most plastics and fossil fuels

Plastic is mainly derived from crude oil which is pumped from beneath the ground. Apart from pictures of a sticky black treacherous substance polluting beaches, most pupils (and adults) will have no real experience of *crude oil*.

Most scientists accept that crude oil is a finite fossil fuel that was formed in warm seas millions of years ago. Plants and small creatures, called plankton, thrived in the sea. When they died their remains sank to the ocean floor where they were covered by silt and sand. Over millions of years the pressure from accumulations of further silt and sand, plus heat from the Earth's core, has changed the remains of these organisms into crude oil.

Crude oil is obtained by drilling oil wells and pumping the substance to the surface. Then, by heating, different useful substances are separated from it. Pupils will recognise several of these other products ie petrol, diesel, and 'natural gas'. They may be surprised that most plastics, some fabrics, chemicals, paints and polishes are derived from crude oil too.

Equivalents to many of these products could be produced from alternative renewable resources. For example, in the USA some plastics are made from maize. However the crude oil based products are 'cheaper' to produce! The reason is simple. The constituents of crude oil that are in greatest demand are petrol and diesel. When these products are produced, byproducts, such ethylene and propane are 'left over'. Converting them into plastics such as polyethylene (using ethylene) and polypropylene (using propane) makes economic sense.

Basic details of the other fossil fuel, coal, are in the introduction to the primary unit 'Rocks and Soils'.
Scarcity and how long will finite materials last?

Predicting either global or local reserves of finite materials is a notoriously inaccurate business.

Predictions in the 1950s included the demise of world oil supplies by 2000.

Currently, some people predict that the world's reserves of crude oil will be exhausted within 70 to 100 years. However, as with other finite materials, if new reserves of crude oil are found and exploited they will almost certainly be located in more inaccessible wilderness areas such as the ice caps or beneath the seas.

The scarcity of some useful materials indirectly causes environmental neglect or destruction. For example, Coltan, a mineral which is mined to make heat resisting semi conductors in mobile phones is found in relatively few locations around the world. One location is central Africa where the mineral's extraction is fuelling violent competition between warlords to control the valuable resource. Similar conflicts have been fuelled by diamonds. Environmental protection has become a low priority in 'resource conflicts'.

Exploitation comes with an environmental cost. It makes sense to use finite materials wisely.

Renewable Materials

These are materials such as wood, wool, straw and reeds (see above) that can be replaced in human timescales. In pupils' terms: "They are grown as plants and animals".

In theory, if grown using methods that are sensitive to the environment all these materials will contribute to sustainable development and have a positive environmental benefit. Use of some of these materials, especially those traditionally harvested such as reeds and coppice, contributes to nature conservation through habitat maintenance.

Wood (as an example.)

Some products, made from wood, may be marketed as having environmental advantages over similar products made from alternative finite materials. An environmental assessment of the origin and production techniques involved in producing the item will determine whether this assertion is true. One lesson in this unit guides pupils through a simplified form of this environmental assessment.

Wood will often need chemical treatment to prevent decay. The treatment used to be with a poisonous pesticide, using a combination of copper, chrome and arsenic, which persists in an environment and may cause damage. Although more environmentally friendly wood preservatives are being developed it may be preferable to use naturally resistant timber such as Douglas fir (a non-native conifer) than repeatedly having to apply wood preservative in a sensitive environment.

If new wood is required for a product it is important that the timber possesses certification from an organisation such as the *Forestry Stewardship Council* or the *United Kingdom Woodland Assurance*

Scheme. Both would indicate that the timber comes from *sustainable forests*. Use of timber from the UK supports our forestry industry and reduces pollution from transport.

Forestry is described as *sustainable* when:

- new trees are planted to replace those cut down;
- the soil is protected from erosion and nutrient depletion;
- jobs, food and materials are provided for the local population.

Many of the forests in the developed world comply with these definitions. Look carefully at the certification scheme when buying wood products for school. Sometimes a single species of tree is planted over huge areas of forest and this has a negative impact on local wildlife. Only a limited range of plant and animal species will be supported by this *monoculture*. Some wildlife species that previously existed in 'more natural' mixed forests will be threatened with localised extinction.

Probably the greatest negative environmental impact from using wood products occurs when products are designed and made from hardwood grown unsustainably in tropical areas. Apart from the embodied energy in transporting the material to the UK, timbers such as teak, mahogany, iroko, edinam, afromosia, sapele and lauan are often harvested from unsustainable forestry. In order to obtain these few valuable species, large areas of mixed tropical forest are felled with huge consequences for both the local environment and population. For example, it has been estimated that only 12 of the 680 indigenous species of tree in Indonesia are harvested. If replanting does occur then only the few valuable species are replaced. This has a terrible impact on local wildlife and often leads to wider environmental damage eg the nutrients in a rainforest system are quickly absorbed by the fast growing plants but cannot be retained in the soils (because of high rainfall etc). Therefore, when the forest is cleared to grow crops nutrients are quickly lost - after a couple of seasons no more crops can be grown and the forest may not regrow. These huge forests also act as carbon sinks absorbing carbon dioxide from the atmosphere. When large areas of forest are cleared they can no longer mitigate climate change effects by storing carbon dioxide.

In addition, mahogany trees take more than 90 years to mature and iroko 150 years. Other species have an even longer life cycle so there is no real incentive for logging companies to replant them. It is estimated that at least 140,000 sq km. of tropical forest are felled and not replaced every year. The environmental consequences are literally devastating.

When making something from wood it may be better to use recycled wood rather than new wood since this choice reduces the need to harvest trees. However, use of new wood encourages people to plant trees and maintain existing woodlands since there will be a market for the produce. When using timber, hardwoods such as oak may be preferable to conifer softwoods because they are more durable and encourage growth of broadleaved trees which support more wildlife in this country.

Having ascertained that the wood comes from a sustainable source it is better for the environment to use:

- local timber with low embodied transport energy;
- wood obtained from native trees, since these species will support more wildlife than species from a different environment. The trees have been growing here for a long time and a variety of plants and animals have become adapted to them forming complex ecological relationships.

Finally, if possible, it makes sense to use traditional craft skills when making an object. These can promote a more diverse economy than industrial scale manufacturing processes. Traditional skills are usually less dependent on fossil fuels and provide more rewarding jobs than the factory production line. However, the time involved in traditional production often means such items are more expensive to buy.

Embodied Energy

One of the key environmental impacts of acquiring and using materials is the global air pollution caused by the use of fossil fuels. A basic explanation of the damage to the environment by humanity's consumption of fossil fuels is in the primary unit 'Traffic, Environment and Me'. See also the secondary unit on 'Shopping and Sustainable Development'.

Most of the products and materials we use have been brought to our doorstep through the consumption of large amounts energy. This energy is principally derived from fossil fuels which damage the environment by air pollution. The energy consuming processes include:

- acquiring , transporting and processing raw materials;
- combining materials and manufacturing products;
- transporting, advertising and retailing products;
- purchasing ,operating, and maintaining a product throughout its lifetime;
- the eventual safe disposal of the product.

Environmentalists describe the energy consumption required by a material or product to bring it to its present useful state as *embodied energy*.

Often the totality of this energy is impossible to accurately calculate if only because it is often very difficult to identify the original source of a material or component in a product.

What is certain is:

- some renewable materials obtained locally will have very little embodied energy;
- complex products, such as the computer you're using, containing a large variety of finite materials, will contain huge amounts of embodied energy;
- the consumption of fossil fuel energy is having a huge effect on the global natural environment;
- the acquisition and use of products, particularly complex technologies, has major implications for the environment.

Disposing of materials

It is important for the natural environment to consider how materials and products are disposed of when they have reached the end of their usefulness. There are four basic disposal options:

1. *Reusing a product* has the smallest environmental impact because often very little embodied energy is added to the product.

2. *Recycling the material*, particularly those which are finite, makes good sense. This is particularly true if the energy consumed in the recycling process does not significantly outweigh the energy consumption in producing the material from raw ingredients. This is true for several materials such as aluminium and glass.

In rural areas recycling renewable materials such as cardboard and paper may make less sense. It is probably best to avoid the energy consumption in the recycling process and compost the waste locally. New renewable materials and food can be grown with the help of the decomposed matter.

3. *Incinerating the waste* is the preferred option in some areas where land fill opportunities are exhausted. Some of the embodied energy in the waste is recovered and converted into heat which can be used to warm homes and generate electricity. Unfortunately, the incineration process has air pollution effects which needs to be considered.

4. *Landfill the waste* - the polite term for dumping valuable materials, some of which are toxic, in a hole in the ground from which other materials have been extracted. Not only are finite materials wasted but so too is a vast amount of embodied energy. Some holes in the ground are valuable wildlife refuges or geological sites - their existing nature conservation value will be lost with landfill.

Summary

The acquisition, use and disposal of materials all have implications for the environment.

Pupils in England have grown up in a culture where:

- the acquisition of materials and products has been encouraged;
- most waste in recent history has been dumped in landfill sites;
- the implications of this culture have been poorly understood.

This unit introduces pupils to some of the issues and could help promote more sustainable attitudes.