

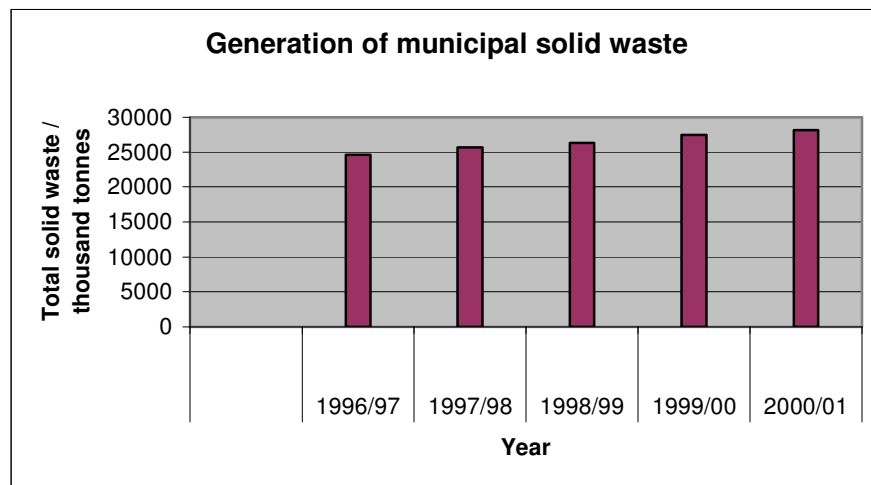
# How does waste affect our environment?: teacher's notes

## Activity 1

Students can plot the graph either by hand or on a computer using a program such as Microsoft Excel<sup>®</sup>. Graph-drawing software can generate a wide variety of graphs and can help show the usefulness of various styles of graphs. Although a bar chart is probably most useful for this data teachers may want to let the students choose the kind of graph they produce. This could lead to a discussion on the merits of the different styles of graph.

## Answers to questions

Q 1.



It can be seen from the graph that the amount of municipal solid waste generated has increased linearly from 1996 to 2001.

- Q 2. (a) Total recycled in 1996 was 1750 tonnes out of 24 588 tonnes of total municipal waste = 7.1%. Total recycled in 2001 was 3454 tonnes out of 28 150 tonnes of total municipal waste = 12.3%
- (b) The main reason for the increase in recycling is the increased public awareness of the need to recycle and the provision of more facilities to make it possible. This includes more bottle banks and the kerb-side collection schemes operated by some local councils.
- Q 3. (a) Composting is the accelerated decomposition of waste from the garden or kitchen, for example, vegetable peelings and grass cuttings. As much as 30% of household waste is suitable for composting. This can be done in individual gardens, or at a larger facility serving a whole town.
- (b) Composting at home eliminates the need to transport the waste and reduces the amount of material in landfills. If this type of waste is just dumped in a landfill site it will take longer to decompose as these sites are sealed to moisture. The waste needs moisture and air in order to be broken down by micro-organisms into compost. Landfilling also means that all the nutrients in the waste are lost and cannot be reused, rather than creating good quality soil for your garden.

- Q 4. (a) Increasing waste not only uses up valuable resources but also creates problems in finding adequate means of disposal in terms of landfill sites or incinerators.
- (b) The following ways to reduce waste are taken from the Waste Watch website <http://www.wastewatch.org.uk> (accessed September 2002).
- Take your own shopping bag to the shops.
  - Purchase refillable containers for cleaners, washing solutions and detergents whenever possible.
  - Purchase rechargeable batteries rather than disposable batteries.
  - Avoid disposable products eg nappies, tissues, face wipes, razors, paper and plastic cups, plates and cutlery, kitchen towels, serviettes, computer cartridges, cameras.
  - Avoid over-packaged products and try to buy unpackaged goods.
  - Use a milk delivery service.
  - Buy products in returnable containers wherever possible.
  - Pass on unwanted clothes and furniture to friends or charities and second-hand shops.
  - Buy products made from recycled materials.
  - Avoid using cling film and aluminium foil. Use a box with a lid instead.
  - Use washable nappies and handkerchiefs.
  - Buy products such as washing up liquid in large containers to help minimise packaging waste.
  - Use a refillable ink pen rather than a disposable biro.
  - Ask your council to provide you with a home composter for garden and kitchen waste.
  - Reuse envelopes - purchase re-use labels.
  - Use and refill your own durable drinks bottle.
  - Contact the Mailing Preference Service, <http://www.mpsonline.org.uk/mpsr/> (accessed August 2005) to discourage unsolicited mail shots.
  - Place a note on the door stating no unsolicited mail.
  - Tick boxes in surveys stating no requirement for further unsolicited mail shot material.
  - For domestic appliances check whether spare parts are available locally, and when items break, try to repair them rather than replacing them.
  - Use resealable containers for school packed lunches.

## Activity 2

Why are products packaged in various types of materials? Some products require boxes, others need only bags or no packaging at all. The type of product usually dictates the type and extent of packaging required. Fragile items require more packaging, while durable or sturdy items require little or no packaging. Not all materials are practical for protecting products and some packaging materials are better than others.

Why are some consumer products so heavily packaged? A bottle of aspirin is typically sealed with foil, the cap shrink-wrapped onto the bottle and placed inside a

cardboard box that is glued closed. The multiple layers of packaging, particularly for products that people will eat or drink, is partly a result of a number of poisoning incidents. Tampering with pharmaceuticals or food is now much more difficult thanks to packaging that can indicate whether a product has been tampered with.

Allow the students a few minutes to list their ideas of ideal properties of packing materials and then discuss them as a group. Some suggested characteristics are compressibility, shear strength (resistance to tearing), density, durability, flexibility and cost.

Natural substances readily decompose but synthetic materials can be more difficult. Micro-organisms have not had time to adapt and evolve the metabolic processes required to digest and decompose these new materials. Perhaps over millions of years they could develop this ability but for the foreseeable future synthetic substances tend to be a problem especially in landfill sites. In this respect the hazards associated with packaging materials are not toxic but they are a problem in the environment as they use materials that are not recycled naturally.

Some critics of modern landfill design say that many natural substances also persist in land fill sites. As landfills are sealed and dry the natural processes of decomposition do not occur.

## Practical activity

### Each group of students will need

- Eye protection
- Samples of typical packaging materials used for cushioning such as shredded paper, bubble wrap, polystyrene packing, including pellets and moulded block, and starch-based packaging granules
- Six 100 cm<sup>3</sup> beakers
- Dropping pipettes
- Access to a top pan balance
- A 24-well plate
- Glucose test strips
- A little amylase
- Distilled or deionised water
- Iodine solution (0.01 mol dm<sup>-3</sup> in potassium iodide)

### Safety

- Wear eye protection

Starch-based pellets are often used as packaging for the delivery of chemicals from suppliers. They can be distinguished from polystyrene pellets by their yellowish colour, their smell and the fact that they tend to dissolve in water.

In this activity the enzyme amylase is used to break down starch into glucose. Amylase is a very common enzyme found in both plants and animals, including humans. Amylase in saliva is involved in one of the first steps of digestion, beginning the breakdown of complex carbohydrates as soon as chewing starts.

The expected result is that the starch pellets will test positive for starch and negative for glucose in the control sample. After the enzyme has been allowed to work completely, the sample will test negative for starch and positive for glucose.

Fungal amylase is available from scientific suppliers as are glucose test strips which can also be obtained from local pharmacies.

### Answers to questions

- Q 1. (a) The paper may have flattened and lost its shape in to the water. The polystyrene is probably unchanged and the starch pellets should have at least partially dissolved.
- (b) Only the starch pellets. Some paper samples may show a slight colour change due to starch sizing that may have been added during the paper manufacturing process.
- Q 2. The expected result is the enzyme should break down the starch into glucose. The evidence for this is in the chemical tests. It is hard to tell by just looking, as the starch is fairly soluble in water and just dissolves.
- Q 3. (a) Glucose is a simple sugar. Starch and cellulose are natural polymers made from glucose subunits. Polystyrene is a man-made polymer made from phenylethene (styrene) subunits.
- (b) They are all polymers.
- (c) Starch is a polymer of which the monomer is glucose.
- Q 4. Micro-organisms have developed an enzyme to decompose the natural polymer, starch, but not the synthetic polymer, polystyrene.
- Q 5. As starch breaks down naturally, it is easily disposed of, whereas polystyrene doesn't readily decompose and remains as litter or in landfill sites.

### Activity 3

#### Answers to questions

The answers given by the students will vary according to the chemical or region that they investigate.

#### Discussion and questions: the pollution inventory

##### Answers to questions

- Q 1. The answers given by the students will vary according to the region that they investigate.

#### Discussion and questions: pollution inventory data by region

##### Answers to questions

- Q 1. (a) The region with the highest total pollution is the North East of England.
- (b) This region is the highest polluter by air though not by water or sewer. The highest polluter by water is the Anglian region and the highest polluter by sewer is the North West.
- Q 2. (a) If products are 'benign by design', any accidental escapes or careless disposal will have a minimal effect on the environment.
- (b) Again, if processes do not involve hazardous substances, the dangers of accidental escapes or careless disposal will be minimal
- (c) It is much more efficient if all, or most, of the raw materials end up in the final product of a process. It is not helpful if the amount of by-product

produced is far in excess of the benefits of the product. Clever chemical engineering can make processes more efficient by design.

(d) The concept of building for the entire life cycle of a product is a relatively new idea for industry. If careful consideration is given during the design process as to how the product will be recycled or reused, this can significantly reduce the amount of pollution.

## Background information on how waste affects our environment

The information below may be found useful by teachers to improve their own knowledge and understanding and to enrich their lessons.

### Municipal waste

Approximately 28.2 million tonnes of municipal waste was generated in England in 2000/2001. This has risen steadily from 24.6 million tonnes in 1996/97. In fact the volume of waste produced in England in one hour would fill the Albert Hall.

Approximately 89% of the municipal waste came from household sources, meaning that we generated around 500 kg (half a tonne) of municipal waste per person in 2000/2001, that is nearly 1.4 kg per day each. This is an increase of nearly 10% per person since 1996/97. However recycling rates of household waste have also increased from 7% in 1996/97 to 11% in 2000/01. All of this compares to about 75 million tonnes of commercial and industrial waste generated per year but, of this, nearly 39% is recycled and 51% sent to landfill.

The state of the economy has a direct impact on the amount of waste generated. Generally the stronger an economy is the more waste it generates. Most governments, including that in the UK, now realise that the link between economic growth and increased waste must be broken.

According to a DEFRA report household waste is growing by around 3% each year. If this growth rate continues we will need nearly twice as many new waste management facilities by 2020 as we would if the amount of waste stayed constant. This would increase pressures on the land available for development and would not be acceptable to the general public. In 2000/2001 around 21% of municipal waste was recycled, composted or had energy generated from it. The government has committed itself to recycle or compost at least 25% of household waste by 2005 rising to at least 30% by 2010 and 33% by 2015.

We already have mechanisms in place to encourage the reduction and re-use of packaging, and the recycling and recovery of packaging waste. The Government has reached agreement with the Newsprint Publishers Association on target levels of recycled content of newsprint, rising to 70% by 2006.

The typical composition of rubbish in a UK dustbin is shown in Table 1.

Type of rubbish	Amount / %
Paper and Card	30
Food and Garden Waste	26
Others	14
Plastics	10
Glass	10
Metals	7
Textiles and Shoes	3

**Table 1 The typical composition of rubbish in a UK dustbin (from <http://www.northamptonshire.gov.uk/council/wasteconsultation/docs/Consultation%20Paper.doc>. (accessed September 2002))**

As the public becomes more aware of the finite amounts of natural resources available it is becoming more amenable to recycling, and many local councils now offer some recycling facilities with the normal refuse collections. Data on current UK recycling rates can be found on the Environment Agency website at

[http://www.environment-agency.gov.uk/yourenv/eff/resources\\_waste/213982/203620/?version=1&lang=en](http://www.environment-agency.gov.uk/yourenv/eff/resources_waste/213982/203620/?version=1&lang=en)

(accessed September 2002)

The Government is now committed to a strategy of sustainable development. One of the key priorities for this is to tackle waste and improve our energy efficiency. For more details go to <http://www.sustainable-development.gov.uk> (accessed September 2002)

The Environment Agency web site is full of information on waste, recycling and facts and figures. Much of the information in this section has come from their website.

## **Plastic waste**

About three million tonnes of plastic waste are produced in the UK each year, much of which is packaging (60%). Packaging is important as it protects our food (and other goods) meaning more of it gets to the consumer in a palatable state so reducing waste. In fact less than 3% of food is spoilt before it reaches the consumer thanks to packaging. However, once we have finished with plastic products, most of them are buried in the ground at landfill sites.

Plastic is very durable and does not readily degrade because it is not digestible by micro-organisms and so remains in its original form in landfill sites. So the more plastics we use and throw away, the more ends up in the ground. Plastic is also a large component of litter and most litter found on our beaches is plastic. Plastic that is left lying around in the environment can also pose a threat to wildlife. Animals can get their heads trapped in the plastic rings that hold cans of drink together and the ingestion of plastics mistaken for food can be fatal. Some biodegradable plastics are now in use. These help to ensure that any that do get into the environment do not become an eyesore or a hazard to animals.

Currently about 7% of plastics are recycled in the UK. Many local authorities do now offer collection of plastics for recycling and details can be found here

<http://www.environment-agency.gov.uk/commondata/103196/135902?referrer=/yourenv/issues/plastics/141616/> (accessed September 2002)

Another option is to use the plastic as fuel as many plastics have a similar energy content to coal and oil. In the UK at present around 2.5 million tonnes of waste a year is being used to fuel 180 MW of power generation, enough for a quarter of a million homes.

Of the 7000 incinerators in England and Wales, 11 burn municipal waste. There are environmental concerns regarding the emissions from these incinerators despite the strict guidelines governing their operation. Compounds of heavy metals like cadmium and lead can be given off into the atmosphere. Waste incineration is also a source of sulfur dioxide, particulates and dioxins. Hard PVC especially is known to give off hydrochloric acid and dioxins when incinerated. Dioxins are accumulative (they build up in our bodies) and can cause cancer.

Ash from incineration needs to be disposed of, usually in landfill sites. The use of incineration also means that a certain amount of waste will be incinerated that could be recycled. According to Friends of the Earth, in order for waste management

contractors to make a healthy return on their investment councils must agree to continue to provide a certain level of waste for 25 years.

However, incineration still appears to be part of the government's long term plans for waste management despite many local councils' objections. The Royal Commission on Environmental Pollution has confirmed that waste incinerators which meet present-day standards for emissions are an environmentally acceptable method of dealing with wastes which cannot be eliminated at source or recycled. In the case of municipal waste the Commission believes that incineration with energy recovery, followed by landfilling of the solid residues, will in fact prove to be the best practicable environmental option.

It is well known that plastics do not readily degrade in landfill sites due to the largely anaerobic conditions of landfill sites. However some degradation of plastics can occur and give rise to the leaching of phthalates from landfill sites. Phthalates are hazardous substances that are used in plastics like PVC to soften them. They can mimic hormones in wildlife and humans. Some sources suggest that incineration is best for softened plastics to avoid the risk of phthalates leaching from landfill sites into the environment.

Plastics, metal and glass make up the bulk of the non-organic matter in municipal solid waste. However, some plastics are now being manufactured from plant-based rather than oil-based materials that can decompose in compost environments or by sunlight. Landfill sites are not ideal environments for even easily-degradable waste to decompose due to their largely dry, and anaerobic, conditions. (They are kept dry to prevent material leaching into the groundwater.) Organic waste is much more likely to decay in the environment than it would in a landfill site. In fact organic matter can effectively be mummified due to the lack of oxygen. It has been reported that 20 year-old hot dogs and 30 year-old newspapers have been found intact at landfill sites.

The solution to this problem may be bioreactors that can speed up degradation by flushing or circulating liquids through the waste. There are problems with this idea in terms of the space they would need and the form the waste would need to be in for them to operate efficiently. The size of the waste particles and the density of waste would both need to be reduced to allow the high rates of liquid flushing that are required. To achieve this, the waste would need to be shredded and crushed before being fed into the reactor. This would mean extra cost to the landfill site operator and that less waste per unit volume could be dumped at any time. Pre-treatment costs and accepting less waste for a given volume would lead to a reduction in the overall income received for the site. Many existing landfill sites already operate a similar principle and are not generally seen as a possible answer to our waste problems.

## **Toxic waste**

The amount of toxic waste entering the environment is now carefully monitored and recorded in the Pollution Inventory (PI). The information is available online through the 'What's in my backyard?' section of the Environment Agency's website (<http://216.31.193.171/asp/introduction.asp>, accessed September 2002), where inputting a postcode displays data on the sources of pollution in that area. The PI records pollution that is released into the air, discharged into rivers or the sewerage network, or disposed of as waste on land. The PI currently includes three years of data from major industrial sites and is being gradually extended to cover sewage treatment works and sites licensed to work with radioactive substances.

Details on who is required to report to the PI and some background information can be found at <http://www.environment-agency.gov.uk/pi> (accessed September 2002).