

Q1: Identify three types of waste and at least two waste examples of each of these types. (1.1) At its simplest waste can be classified as materials not required or left over from any organisation or manufacturing process, or produced at the end of the product life cycle. The linear economy of take-make-dispose is unsustainable as it leads to resource depletion and excess waste production which can cause pollution in all its forms seriously damaging the environment. A circular economy is needed to reduce resource depletion and produce less waste. This is often defined by the 6 R's; rethink-reduce-refuse-reuse-repair and recycle, and tackling waste is a sustainable approach as it helps address many of the UN's Sustainable Development Goals (SDGS).

Waste types can be classified in several ways. The UK government (www.gov.uk/how-to-classify-different-types-of-waste) classifies 5 types of waste; construction and demolition waste, packaging waste and recyclables, electronic and electrical equipment, vehicles and oily wastes and healthcare and related wastes. Another simple classification splits the waste in 2 categories, hazardous and non-hazardous, although it is possible to view all waste as being hazardous to the environment in some way. Hazardous waste is put into 4 categories, ignitable, corrosive, radioactive and toxic, although another type has been recognised, Persistent Organic Pollutants (POP's), materials that are harmful to humans and the environment, breakdown very slowly and spread easily.

The simplest and most straightforward starting point is to consider just 3 types of waste:-

1. Solid.

Waste in solid or semi-solid form. It includes industrial waste such as slag or metals, commercial waste from offices, construction waste, electrical and electronic waste. Municipal Solid Waste (MSW) including bottles, tins, plastic etc. is that which is collected by councils or taken to council owned tips.

2. Liquid.

Although organic materials and solids are found in domestic waste water it can be classified as liquid waste, as is sewage from hospitals, offices, industry and businesses. Industrial waste water can contain toxic or corrosive chemicals, although the chemicals it contains and their toxicity depends on the type of industry. Agricultural waste water may contain toxic chemicals such as pesticides, herbicides and fertilisers that may negatively impact the environment.

3. Organic.

Waste that comes from plants or animals and is biodegradable. This includes food waste that comes from supermarkets, restaurants or homes and can be composted to speed up decomposition and form carbon based material, minerals such as nitrogen, phosphorus and potassium, carbon dioxide and methane. Plants remains such as grass cuttings, twigs and leaves are also organic waste, as is animal manure and the organic material found in domestic sewage.

Q2: Explain the three main characteristics of waste and why we divide waste into these categories. Give two examples for each of these to support your answer. (1.2) Waste can be divided into 3 main categories, Hazardous waste, Biodegradable waste and Recyclable waste.

Hazardous waste

I will discuss hazardous waste first, as an even simpler classification of waste might be hazardous and non hazardous.

Hazardous waste has the potential to be the most harmful to both humans and the environment in general, so it is the most important to investigate and understand.

Possible impacts on human health (epa.gov) include behavioural abnormalities, cancer, genetic mutations, birth defects, physical defects and physiological malfunctions, and since we are merely mammals the same applies to the animal kingdom. The environment, ecosystems, habitats, flora and fauna can all be adversely affected, rivers, lakes, land and sea can have organisms destroyed or endangered and biodiversity degraded. It is therefore vitally important to identify, classify and deal with hazardous waste effectively.

The UK government has put hazardous waste into 6 categories based on the source (uk.gov.uk), although each of them may produce some non hazardous waste.

Construction

This includes insulating materials containing asbestos and tars and other bituminous mixtures.

Metallic

This is mainly from waste electric cabling as well as paints and varnishes.

Packaging

Most packaging is recyclable and/or biodegradable but empty packaging that has been contaminated with hazardous substances is not.

Electronic

Most electrical and electronic waste material is hazardous. This includes circuit boards, flame retardants, capacitors, batteries and older household and office appliances such as TV's, fridges, freezers when they reach the end of their useful life.

Vehicle

Vehicles produce oily fluids, engine oils, brake fluid and petrol which are all hazardous. End of life vehicles themselves also present a hazard.

Healthcare related

Waste medicines and laboratory chemicals are obviously hazardous, but we must also consider sharps and infected materials. I think it is possible to add a 7th, Agricultural. Pesticides, herbicides and fertilisers are chemically based and can easily spread beyond the area of their intended use by run off or by leaching down to the water table. Excess nitrogen and ammonia from animal feeding operations can also impact on local ecosystems and biodiversity.

Another hazard from agriculture, although not exclusively, are Persistent Organic Pollutants (POP's). These can come from pesticides but can also be derived from waste produced by homes and industry. These organic pollutants are slow to break down and spread easily by air, water or migratory species causing disorders of the immune system, cancers and the increased risk of birth defects.

A final area to look at as a hazardous waste is micro-plastics, particles of plastic smaller than 5mm and the even smaller microscopic and nano-plastics. These materials are derived from wear on tyres and microfibres from synthetic clothes and easily contaminate the soil, freshwater rivers and lakes and the oceans. Found in fish and animals it is easily transmitted through the food chain to humans and has recently even been found in the coral polyps of the worlds coral reefs (pme.ncbi.nlm.gov). Coral reefs are already badly affected by bleaching exacerbated by climate change and the increased stress caused by micro-plastics could cause more to die endangering coastal communities and their economies as well as negatively impacting on the extraordinary biodiversity of reefs.

There are, then, many sources for hazardous waste including, businesses, industry, offices, homes and farms, and it is not only the producers of the hazardous waste that are responsible for its impact, but also the carriers of it and the holders. In developed areas of the world such as the UK there are strict regulations that apply to those responsible for hazardous waste and it must be registered and tracked to avoid heavy fines.

Biodegradable waste

Biodegradable waste will break down naturally under the action of microorganisms such as bacteria. This form of decomposition occurs in nature; in a forest leaves fall to the forest floor, decomposition occurs releasing minerals and nutrients that are taken up by the roots of the trees, the so called nutrient cycle. This process is controlled by a number of abiotic factors such as temperature, the availability of moisture, oxygen and acidity (intechopen.com/chapter/84112) and the speed of decomposition depends on these factors as well as the composition of the biodegradable material.

There are 4 main types of biodegradable waste, biological waste (green waste), food waste, paper waste and some plastic waste and generally the process offers little risk to the environment, although if handled improperly smells, rats and disease, and methane emissions can result. Paper will degrade in 2-6 weeks, unless treated with plastics when it will take much longer, sewage, grass cutting and food waste degrade reasonably quickly, but plastics and electronic waste take a very long time.

Recyclable waste

Recycling is taking materials that could otherwise end up being incinerated or put in landfill and either breaking them into the constituent parts in order to reuse the most valuable or processing and returning back as new items and products made of the same material.

Related to this are up-cycling and down-cycling (metabolic.nl.news). Up-cycling is where low value items are recycled into high value items, as with old cycles being made into lamps or furniture and down-cycling (much the same as recycling really) is where the items produced are less valuable than the original product.

There are established benefits to recycling (epa.gov/recycling) which involve the move from a linear economy to more of a circular economy with the added bonus of the economic benefit of job creation. Less energy is used in recycling than the exploitation of resources and making of the original product and carbon emissions can be considerably reduced, resource depletion is lessened and smaller amounts go to incinerators or landfill.

6 key areas of recycling are:-

1. Batteries

Batteries are in common use in modern society and are found in phones, laptops and power tools and usually contain valuable metals such as lead, mercury, cadmium and lithium which have a finite world supply. Car batteries and increasingly electric car batteries are another valuable source of these metals, but it has been calculated that at present only 5% of new battery metals are from recycled materials.

2. Electronics and electrics

There are many sources of electronic and electrical materials including TV's, cameras, hairdryers, kitchen appliances, computers and phones, and of course many contain batteries as well. In Europe these items are classified as e-waste or Waste from Electrical and Electronic Equipment (WEEE) (environment.ec.europa.eu) and it is estimated that in 2022 5 million tonnes was collected from e-waste at 11.2 tonnes per person.

When e-waste is collected it is shredded, magnets extract the steel, plastics are separated and valuable metals such as copper and platinum remain and this is a rapidly growing waste stream.

3. Glass

Glass is said to be infinitely recyclable (recyclenow.com). When glass is collected at a recycling centre it is sorted, crushed, melted and remoulded and since it is mostly made of silica this can be done many times and there is no need to ever throw it away. In the UK 71% of glass is now recycled and the goal is to reach 90% by 2030.

4. Paper

Recycling of paper and card is a success story. In the USA (archive.epa.gov/waste) the recovery rate was 56% in 2007 and reached 68% in 2023, the picture in the UK is even better with about 80% of paper and card currently being recycled. There are distinct benefits to this, less paper goes to landfill, forests are saved and carbon dioxide emissions are reduce, estimated to be 20% less than when paper is incinerated.

Recycling paper and card involves sorting it, cleaning, shredding, liquifying and pulping to create new products such as packaging and toilet paper and it takes 70% less energy to do this than making new paper from trees.

5. Aluminium and steel

Cans and other metal containers are usually made of aluminium or steel. When cans are sorted the aluminium cans are separated, shredded and melted to make new products time and again, and this uses only 5% of the energy needed to exploit bauxite and make cans from new. It has been estimated that 75% of all the aluminium that has been produced in the world is still in circulation.

Steel can be recycled again and again. Scrap steel can be charged into a steel furnace and melted to form molten steel that can be made into any steel item required. Basic oxygen steel furnaces generally use about 30% scrap steel to 70% pig iron, but modern electric arc furnaces are fully charged with scrap steel.

6. Plastics

This is the most difficult and most contentious area of recycling. Plastic can be recycled, especially low density polyethylene, it is shredded, washed, melted, pelletised and remoulded, but plastics degrade with each recycle which limits the number of times it can take place to 2 or 3. It has been estimated that 300-400 million tonnes of plastic is produced every year (recyclenow.com), but only about 9% is recycled, 19% is incinerated, 50% sent to landfill and as much as 22% illegally dumped. Rivers and oceans are now awash with plastic that can take hundreds if not thousands of years to degrade, much of this is micro-plastic which is very difficult to collect.

Bioplastics have been hailed by some as the answer to the waste plastic problem. Unlike the traditional plastics which are oil based, bioplastics are made from plant material and should biodegrade faster, a few years rather than possibly thousands. and this could help the move towards a more circular 'plastic' economy. There are problems, however, companies have been accused of greenwashing by claiming their packaging is made from bioplastic when some of it is made from oil based plastic and is less recyclable.

'Infinite plastic' may be the answer (bbc.com/future/article). If plastic could be chemically recycled back to the original oil based materials new plastic could be made from this, a true circular 'plastic' economy. New developments are taking place in the UK and around the world, and if successful it would make plastic infinitely recyclable.

Q3: Describe the factors that influence the amount of waste an organisation produces and give examples to support your explanation. (1.3) There are a number of factors that influence the amount of waste an organisation produces.

1. Size of the organisation

The total number of staff employed by an organisation is a good measure of the size of an organisation. It would be expected that larger organisations would produce more waste, especially food waste if it has kitchens and canteens that cater for staff, and paper, card and packaging waste, particularly if no efforts have been made to make administration paperless. The number/footfall of clients and customers will also be important, especially if they are catered for in cafes or take goods in paper, card or plastic packaging.

The size of a company will be important since they may vary in size from one man businesses, to small businesses, large and even corporations that may be transnational and have staff in a number of countries. The larger a business is the more difficult it will be to manage and control waste, particularly if it is transnational and has administrative, research and development, manufacturing, packaging and carrying elements that may be spread over several countries.

The size of a region or local authority will also determine the amount of waste generated (www.gov.uk/statistics/). The size will determine the total population and the number of households and while this may affect total waste the percentage recycled should be similar unless some regions/councils manage waste better than others. Figures for 2022-23 show that a total of 24.5 million tonnes of waste was collected by councils in the UK and on average only 7.2% went to landfill, 49.1% was incinerated and 40.7% recycled or composted (the rest is 'other' unspecified). Comparing the South East (SE) and the East Midlands (EM) illustrates this well. The SE has a population of around 9.5 million, whereas the EM is much smaller at around 5 million and this difference shows up in the total waste collected by councils, the SE collects just over 2 million tonnes in total and the EM only around 1.3 million tonnes. Simple maths shows that the SE collects 0.21 tonnes per capita per annum and the EM 0.27 tonnes per capita. The SE recycles or composts 47% and the EM only 42% which shows that size is not the only factor, but governance and management strategies can make a significant impact.

2. Types of organisation/industry

The type of organisation or industry producing the waste will determine the amount and type of waste produced. It will affect the total waste, how much is liquid or solid, how much is hazardous and whether parts of it are recyclable or biodegradable. An examination of contrasting industries will help to illustrate this point.

Steelworks are an example of a heavy industry where large quantities of raw materials are assembled and processed. Many of these plants are integrated works which involve ore preparation, coke making, blast furnaces for iron making, steel furnaces and finishing mills, and each of these processes produce waste. Ore preparation is the crushing of iron ore and limestone, and as such generates a great deal of dust. Coke ovens produce coke from coal to charge the blast furnaces and produce toxic effluent containing arsenic and ammonia as well as coal tar and coke dust. Blast furnaces produce pig iron, and depending on the grade of the iron ore, a great deal of slag which is tipped onto slag banks, but may be recycled later by road-stone companies. Steel furnaces are, of course, an opportunity to recycle scrap steel, as modern furnaces take from 20%-100% in each charge. The finishing mills rolling plate or wire produce solid waste mill scale some of which can be recycled. In general large quantities of sludge and slurries are also generated during the steelmaking process.

The healthcare sector generates a very different waste stream which can be difficult to deal with as at least 15% is hazardous waste (who.int). Much of the waste is not hazardous such as food waste from the kitchens and cafes for clients and staff, and paper, card and plastic from the administrative areas, some of it, however, can be classified as hazardous, including clinical waste, pharmaceutical waste, biological waste and the toxins they may contain. Sharps are another hazardous waste produced

in large quantities, especially when we consider that it is estimated that 16 billion injections take place worldwide each year. Finally, agriculture produces its own waste stream with its own problems and opportunities. Crop residues and livestock waste can produce manures and slurries, but in 2003 it was estimated that 93% of all agricultural waste was biodegradable (ciwn.co.uk). Apart from these 'natural' waste products, however, farms produce hazardous waste in the form of plastic and containers which have been contaminated with pesticides and herbicides, and are difficult to recycle. Excess pesticides, herbicides and fertilisers may run off fields into local water courses damaging the local environment, and vehicle and clinical waste are produced on most farms.

3. Customers and clients

Customers and clients can affect the volume of waste produced by an organisation in two ways. Demands may be made by customers and clients for particular products or types of packaging, they may want new items and change them regularly leading to the disposal of the older items. Conversely, customers may be environmentally aware and businesses may be worried that they will stop using them if the organisation is not seen to take environmental issues such as recycled or biodegradable packaging seriously. Increased environmental awareness could reduce waste in two ways, it may be the organisation that educates its clients and customers to be concerned about waste, or customers may force companies to change their approaches to ensure sales and profits don't decline. Waste management firms may also be instrumental in educating organisations about waste reduction and management policies which may make them think more carefully about their waste streams.

If a company is accused of greenwashing the bad publicity could hit sales and profits. MacDonald's, the fast food chain, has been accused of greenwashing and is now making efforts to appear more sustainable. Affordability and convenience are always likely to outweigh sustainability efforts with the MacDonald's corporation (rsm.nl/fileadmin/) but it is making efforts to appear more responsible. Packaging is the main waste problem and in 2018 the company announced that by 2025 all packaging would come from recyclable or certified sustainable sources, and waste is now separated within each restaurant by staff or customers. The company is striving to bring in new initiatives, but it is, perhaps, only driven by the need for a competitive advantage.

4. Waste management policies

Organisations that develop effective waste management policies and strategies are much more likely to see their volumes of waste reduce. By doing so companies will develop responsible decision making and it will allow them to think in a circular rather than a linear way. A responsible waste management strategy should begin with a waste audit where waste streams are evaluated and waste volumes calculated (ciwm.co.uk), allowing the organisation to identify ways to reduce waste and resource consumption. Organisations should develop a waste policy (groundworkksbs.co.uk) with a designated waste management leader and team, set targets, and review and monitor progress. All employees should be engaged through an education/training programme and organisations should also liaise and collaborate with suppliers.

The resource material presents a case study of two very similar hotels with vastly different attitudes towards and strategies for waste, with markedly different outcomes. One is committed to waste reduction and has a successful zero landfill policy, as well as attempting to reduce food waste and composting any that is left. This company makes a big deal of its sustainability credentials on its advertising website, whereas the second company that produces much more waste makes no mention of sustainability issues on its website.

5. Geographical location

a. Geographical location across the UK has been shown to impact the amount of waste produced by councils and local authorities (theguardian.com/environment/), the amount of food waste in particular appears to relate strongly to food poverty. Local authorities across the UK with the poorest wards produce the most food and packaging waste and this may link to the fast food ethos dominant in many of the poorest areas.

'Waste not want not' a report on recycling rates across London (london.gov.uk) showed clearly that the socio-economic status of boroughs was strongly linked to the volume of recycled waste. Housing density, levels of deprivation and income levels all seemed to influence the rates of recycling with less affluent areas clearly sending a greater proportion of waste to landfill and for incineration. There was an extremely strong correlation between average deprivation scores and the percentage of waste that was recycled, although it was accepted that political leadership, education and communication, and waste service changes could have some impact.

b. Global location will also have a major impact on amount of waste that organisations produce since different countries have different rules and regulations governing waste and waste disposal. In many developed countries such as the UK there are strict regulations, often enforceable by fines, set by government that control the disposal of waste and local authorities and firms will seek to follow the guidelines and rules to prevent financial penalties and the bad press that is associated. Surprisingly, some of the most developed countries still produce the most waste per capita with Canada and the USA being among the highest since they are high mass consumption economies. In less developed countries, however, where regulations are weak and poorly enforced a much larger proportion of the waste is illegally dumped and contaminates urban areas and waterways, although some developed nations still use the less developed world as a dump for their waste.

Q4: List the main legislation relevant to waste management and briefly describe what each one covers. (2.1) UK waste management legislation

1. Environmental protection Act (EPA) 1990

This set the scene for waste management in the modern British economy and applies to all households, industries and commercial organisations. It covers all aspects of waste management; production, storage, transport, treatment and disposal, and specifies that licenses are needed by any organisation that keeps, treats or disposes of waste. It developed the idea of a 'duty of care' in that any organisation or individual must handle and dispose of waste in an environmentally sustainable way,

ensuring that it will not harm the health of humans or the environment. The act backs up these regulations with strict penalties including fines and even imprisonment.

2. The Waste Regulations 2011

These regulations force a business to separate recyclable and biodegradable waste such as food, paper, plastic, glass and metal from other waste and specifies dry recyclables must be collected separately. The aim is to limit the negative impacts of waste on environmental and human health. A business has to confirm that it has applied the waste management hierarchy of prevent, prepare for re-use, recycle, recover, before disposal. The regulations also set up the idea of regulated 'waste dealers' to deal with waste and set up special regulations for hazardous waste.

3. Environmental Permitting Regulations (EPR) 2016

These regulations, that are periodically revised and improved, specify that different organisations that may have different impacts on humans and/or the environment must apply for different permits, and it confirmed the Pollution Prevention and Control and Waste Management Licensing of earlier legislation. The criteria for negative impacts on the environment and humans are quite broad and even include impact on human senses, so nasty smells and eyesores would be included. The permits are issued by local authorities allowing operations to take place and regulating specific waste disposal firms who may liaise with waste producing organisations, and fines are strict and unlimited, up to 100% of an organisation's pre-tax profit.

4. Waste Legislation, comes into force 31st March 2025

The new and incoming regulations state that any organisation, business, school, hospital, care home, in fact all non-domestic/household establishments with 10 people or more must separate food waste and other biodegradable materials and collect them separately. This waste must then be collected and transported by a licensed waste carrier, and it is hoped that the cost of this to firms will encourage them to reduce food waste in the first place. All other recyclables, glass, paper etc. must also be collected and transported off-site separately.

Q5: Describe types of public and private sector organisations that have a role in waste management. (2.2)

a) Public sector a. Public sector

1. United Nations (UN)

The UN sustainability targets include some that relate to waste management, but the body can only set targets and encourage countries to try to achieve them and assess how quickly particular countries are moving towards those targets, but it does not have the power to make it happen although it does have a certain moral authority. The UN is clear that it is not just the responsibility of countries, but also companies and businesses both small scale and transnational to help the world deal with problems such as waste. Sections of goal 12 sustainable cities and goal 13 climate action contain important targets for waste management including management of chemicals and waste, reducing waste generation and managing municipal waste. This push towards sustainable consumption and production is steered by the UNEP (UN Environment Programme) which shares innovative ideas and good practice between countries in an attempt to reach a zero waste world.

2. The Government and the Environment Agency set the overall scene for the country in terms of waste management. It does this by enacting laws and setting regulations, enforceable by fines and imprisonment, overseeing, regulating and registering carriers, brokers and dealers, and setting targets for waste reduction and recycling rates.

The main themes of its policies are to prevent pollution, protect the environment, and, as part of its net zero target, to eliminate biodegradable waste from landfill by 2028. The Waste Management Plan published in 2021 (assets.publishing.service.gov.uk) was part of the 25 year Environmental Action Plan and it set targets on waste prevention and waste management such as recyclable and biodegradable waste to reach 65% of total waste by 2025, with a future target for landfill at 10% or less. The National Planning Policy Framework for Waste (NPPW) encourages the reduction of packaging through public awareness campaigns, a push for reusable packaging systems and overseeing permits that set up a polluter pays principle.

Despite this important leadership and oversight, however, it is local councils, backed by government legislation, that have the responsibility to reach the targets and fulfil the aspirations.

3. Local councils are probably the most important bodies in the waste management field, and can do so down to the ward and neighbourhood level. I will use the North East Lincolnshire Council (NELC) (nelincs.gov.uk) to illustrate the role of local government. A recent document set out the council strategy for the period 2020-2035, pushing the need to develop a circular economic model. Landfill has fallen in NELC area from 11% to 6% of total waste in the period 2009-19 and the council has hopes that it will hit 2% in the future, and that recycling will be 65% or more of total waste by 2035.

The council now provides 3 wheelie bins to all households, one for general waste, one for paper and card, and one for glass, plastic and cans. Residents can also pay a small charge for regular collections of garden waste and for a nominal fee purchase a composter, there are also community collection centres around the main urban areas. NELC also offer home collections of large household items, free collections of clinical waste and work closely with schools and colleges, retail outlets and businesses to facilitate collections. The local council assume the responsibility for the local environment and see responsible waste management as a vital part of this.

b) Private sector b. Private sector

1. Non-governmental organisations (NGO's)

NGO's are considered to be private not for profit organisations that operate without government funding. However, some of them are run as charities and all get funding from public donations, although a few such as Greenpeace are also funded by private foundations, so we could also classify them as quasi-public. Greenpeace is an excellent example of an environmentally aware international group that brings sustainability issues like waste management into the public eye and attempts to persuade governments and companies to consider the environment first.

Greenpeace are perhaps most famous for the stand they made against the indiscriminate dumping in deep oceans of nuclear power station waste, taking action to highlight the danger of the waste and its longevity. They brought both public and government attention to the fact that optimistic costings of nuclear generated electricity did not take into account the ongoing expense of dealing with the radioactive waste, and it may be that the slow down in the construction of new nuclear power stations in some parts of the world stems from their actions.

More recently Greenpeace has turned its attention to plastic which it sees as the major threat to the future health of the planet, its environments and its people. It is mobilising its membership, conducting research, lobbying government agencies and private companies, educating the public and encouraging people to back its campaign to phase out plastic waste. A recent campaign in the UK saw 250,000 people audit 4 million pieces of plastic (thebigplasticcount.com) and the research showed that UK households produce 90 billion pieces of plastic waste annually, over half of which is incinerated and 11% still goes to landfill. They conclude that recycling is not the answer and put their very persuasive efforts into pushing for a UN led Global Plastic Treaty.

2. Companies and corporations

When the UN set up the SDGS it recognised that every part of society would need to be committed to achieving change (undp.org/sdgs-accelerator). The private sector would have a critical role to play in developing partnerships with governments, councils and communities and this is especially true in the case of waste and waste management. It is clear that private companies and businesses across the complete range from small to transnational will need to be involved since so much of the economic success and waste production of a country stems from these firms.

INEOS is a global company (ineos.com) with 36 businesses on 194 sites in 29 countries, a very large transnational corporation. It concentrates on chemicals, polymers, oil and gas and is therefore a significant waste generator, much of it hazardous, and any efforts it can make to reduce its waste streams and deal with its waste in a more efficient and environmentally friendly way will have a positive impact on any country it is based in and the world in general. INEOS make a very public show of its efforts to be more sustainable (ineos.com/sustainability/), but some would suggest there may be an element of greenwashing in its strenuous efforts to appear clean.

Being such a large organisation, however, it does have the resources, financial, manpower and expertise to make a real change to waste control of plastics. INEOS is now designing plastics to be more recyclable, investing in intelligent sorting technology, researching sustainable feedstocks and building a state of the art plant to make raw materials from plastic waste.

3. Private waste companies

Private waste companies have become very important in waste management. All companies that store, carry or dispose of waste must be licensed by the government and have a continuing duty of care for the waste they deal with. Private waste companies are hired by other private firms to collect and deal with their rubbish and also enter into partnerships with local councils. These public-private partnerships (PPP) are very important to councils who hire the firms to collect, treat, recycle and dispose of their waste, in many cases the recycling plants, recovery plants and landfill sites used by councils are actually privately owned. The NELC has many contracts with private firms to deal with its different waste streams (nelincs.co.uk), garden waste is sent to nearby Kirton Lindsey for composting by the NEWLINCS firm, card and paper is sent to Palm Paper in Kings Lynn where it is recycled into newsprint and cardboard, and the glass, cans and plastic is sent to Bespoke Recycling Solutions, where it is sorted and sent to other recycling and reuse centres across the UK.

Q6: Explain the four reasons to manage and minimise waste and give examples for each. (3.1) Reasons to manage and minimise waste.

1. Threat to public health

Mismanagement of waste and excess waste production can cause serious threats to the health of people. If too much waste is sent to landfill this can cause the obvious problems of vile smells and vermin infestation that can transmit diseases to the population. Older landfills in particular are not well sealed and toxic leachates may develop as water seeps through waste containing chemicals, solvents, toxic materials and metals. This leachate can then leak into water courses and the water table and move into the water supply system giving severe negative impacts on health. Incorrect management of this toxic waste can lead to respiratory problems, heart disease and cancers.

Incineration of excess waste has its own set of problems. The burning itself may release toxic gases into the atmosphere and the ash that results could contain toxins, which if spread on land could enter the food chain. Persistent Organic Pollutants (POP's) are a product of organic waste, but can also be present in the gases and ash resulting from incineration. Dioxins are an example of a POP, a long lasting pollutant, it is easily spread and can enter the food chain to cause immune and nervous system disorders, and an increase in cancers near incineration sites.

In 2006 a toxic waste disaster occurred in the Ivory coast when 500,000 litres of toxic waste was illegally imported and dumped near the port of Abidjan in many cases adjacent to schools, homes and workplaces (justices.gov/eoir/). The resulting health problems included nausea, headaches, burning skin and eye irritation, 15 deaths occurred and in one day 8000 people were seen by medical services. Compensation has been paid to some of those who suffered but the possible longer term health issues are unknown.

2. Environmental damage

There is no doubt that excess waste and/or mismanagement of waste can cause serious problems including ecosystem loss, biodiversity loss and rendering ecosystems less resilient to changes and stresses such as climate change. It has been estimated that 38% of all waste produced is dumped (earthday.org) and even if it is legally placed in landfill sites toxic leachates can impact on nearby habitats and methane emissions can enhance climate change and global warming putting more stress on

ecosystems and biodiversity.

Mismanagement of organic waste, sewage, manures and excessive fertiliser application can cause eutrophication of nearby rivers, lakes and coastal waters (nature.com). This produces an over enrichment of nutrients, particularly phosphorous and nitrogen which produces algal blooms. This in turn causes oxygen depletion, anoxia, which impacts fauna and can prevent photosynthesis, the driver of the food chain, as plants are unable to use sunlight to make glucose, the base of the food chain/web. This can lead to devastation of aquatic ecosystems and major fish kills, and of all the estuaries and coastal waters around the USA that have been studied 65% have been found to be moderately or severely damaged by eutrophication (oceanservice.noaa.gov).

Eutrophication can also add to ocean acidification as the decomposition of blooms of algal matter leads to increased carbon dioxide emission into the ocean. This has been shown to slow fish and shellfish growth damaging oceanic ecosystems.

The production of plastic products, the extremely long time it takes for them to degrade and the mismanagement of plastic waste disposal are all problems of modern society. It is estimated that the world produces over 400 million tonnes of plastic annually, much of it single use plastic, and much of it ends up in the oceans. Although it does not decompose, it does break into smaller and smaller pieces eventually producing micro-plastics and even nano-plastics. 1500 different aquatic species including whales, turtles and seabirds, have been found to have consumed plastic, much of it toxic and carrying chemical pollutants (ore.exeter.ac.uk). Filter feeders ingest the micro/nano-plastics which then moves up the food chain, for instance krill will pick up the micro-plastics which are then consumed by blue whales in their millions.

These toxic plastics reduce the ability of fauna to function properly, reducing growth and fecundity, and with fewer offspring a species is endangered or unable to face ecosystem change effectively, affecting other species in the food chain.

3. Excessive waste is expensive.

The standard linear economy of take-make-dispose creates a great deal of waste that can be costly to an organisation, better to move towards a circular economic model where far less waste ends up being sent to landfill or incineration. There are many scales at which managing and minimising waste can be cost effective, individuals and households to councils, local authorities and governments, and on the business side from small one man businesses to larger enterprises and even transnational corporations. Time, money and labour can be saved that would be otherwise spent on collecting, handling, transporting and disposing of waste.

Cost savings and financial benefits of waste reduction can come in several ways (wastemanagement.co.uk). Increased operational efficiency will result, freeing up staff and storage space and streamlining operations, there may also be energy savings involved in using less packaging. Companies will pay less to dispose of waste and reputational gain may enhance profitability, and finally working with suppliers to implement just-in-time policies may benefit everyone.

Costs for disposal of waste can be significant, it has been estimated that up to 5% of company turnover can be spent on collecting, transporting and disposing of the waste (greenbankwastesolutions.com). The cost will depend on the type of waste, general waste costs around £200 a tonne, uncontaminated plastic up to £50 a tonne and paper up to £25 a tonne. Companies must also pay a landfill tax designed to encourage sustainable options such as re-use and recycling of waste and this is currently around £100 a tonne. Firms must also consider the fines and penalties imposed for incorrect handling and disposal of waste materials, particularly hazardous waste.

Tesco, a major retailer responsible for a large chain of retail outlets is an example of a company that has been making significant inroads into waste reduction, especially food, and has sent no food waste to landfill since 2009. Tesco have been reporting food waste figures since 2013 (tescopic.com/sustainability/planet) and identify the 4 ways in which this has been possible:-

a. Involving the supply chain and reducing prices to clear stock approaching its sell by date, reducing the amount of waste in the first place.

b. Redistributing still good to eat food to charities and to Tesco staff.

c. Food that cannot be eaten by humans is sent to be made into pet or animal food.

d. And finally as a last resort, any left at this stage is sent to anaerobic digester plants to be made into biogas.

Tesco also work closely with suppliers to allow less than perfect vegetables such as 'wonky' carrots and potatoes to still be sold, and through 'Tesco Exchange' offer an online market place to allow farmers to find buyers for any surplus or glut (tescopic.com/media). It has not all been plain sailing for Tesco, however, it was recently disclosed that some of the food waste that was reported as being sent to be made into animal feed had in fact been sent to anaerobic digestion plants which still counts as waste. Despite that Tesco continue to report increased revenues of up to 13% some of which they claim is due to their innovative waste management policies.

4. Reducing emissions from production.

Managing and minimising waste through better waste management, recycling and biodegrading more material will cut down on the need to manufacture new glass, plastic, metals etc. The move from a linear economy to a more circular one where reducing, re-using and recycling are the norm will cut down on the harmful emissions produced during the initial manufacturing processes. 99% of plastic is still made from fossil fuels, notably the hydro-carbons, particularly polyethylene, from which most plastic bottles are made (stanfordmag.org). It is estimated that each ounce of plastic manufactured causes the release of 1 ounce of carbon dioxide, and this is the greenhouse gas most responsible for climate change and global warming. Recycling of plastic, where it is possible, is said to release approximately 30% less carbon dioxide than the initial manufacturing process. Moving to more 'sustainable' organic plastics and the so called infinite plastic may help to ameliorate the problem (bbc.com/future/article).

Recycling metals such as aluminium, copper and steel produce far fewer emissions than the initial smelting process. Aluminium and copper are smelted by electrolysis, using a great deal of electricity which is often produced by burning fossil fuels, both can be recycled infinitely and by doing so up to 90% less energy will be used producing much less carbon dioxide and sulphur dioxide. In 2018 the manufacture of steel caused 8% of the total world carbon dioxide emissions, and the remelting of scrap steel in modern furnaces uses for less energy and produces far fewer emissions than traditional steel making from iron ore. With

all metals, using biomass as the fuel for electricity generation will generate far fewer emissions than using coal, oil or even gas. Recycling of glass presents a similar picture (recyclenow.com). In the glass making process energy is used to heat the raw materials and 1kg of glass causes the release of approximately 1kg of carbon dioxide (depending to some extent on the fuel source used), but recycling glass is estimated to give a 20% reduction in polluting emissions.

Q7: Explain the ways in which waste can be used as a resource and give examples to support your explanation. (3.2)

Items that may no longer be of use to one person can, of course, be passed on to another, waste for one person may be treasure for another. Despite this there are 3 ways in which waste can be used as a resource.

1. Energy

Biological waste can be used to produce energy. One way is to use waste flammable materials, paper, card, wood etc. to burn in a biomass power station to create electricity. Municipal Solid Waste (MSW) is an important resource used in power stations, cleaner than fossil fuels, it does still produce some carbon dioxide an important greenhouse gas. Incinerators are often used near major urban centres to deal with urban waste such as MSW and the heat generated can be used for local homes, schools and businesses or can be used to generate electricity.

The state of California (USA) uses biomass to create electricity in a significant way, using MSW and waste materials from crop production, but it still only contributes just over 2% of the total electricity generated in the state. Biomass power stations exist in the UK, one example Glandford power station near Scunthorpe burns poultry litter to generate the heat, and a proposed site near Immingham will use a wider range of waste material. Biomass waste can also be used to fuel district heating systems like the one at St Andrews in Scotland which heats the university and student homes.

Biofuels, liquid or gaseous fuels, can be produced, but crops are often grown specifically for this. Waste food and plant material can be used, however, in an anaerobic digester plant where bacteria decomposes the waste to produce biogas, methane. This is increasing in popularity, but still only takes place on a relatively small scale, the largest plant in the UK being one in Staffordshire that produces enough gas to make the electricity needed for 6000 homes.

2. Food

Composting of food waste is an excellent way of making a natural fertiliser. Decomposition is a natural process where decomposing microbes such as bacteria releases nutrients back into soil. This can be speeded up by using composting bins that produce a nutrient rich compost that can be added to soil (nrdc.org/stories/composting). The chemical free material produced by layering food waste and adding water allows rapid aerobic decomposition that produces a compost that enriches, retains moisture and gives better soil texture and structure, increasing soil fertility and crop yields. Local councils in the UK often offer cheap compost bins to the public, N E Lincolnshire council offer 220 litre bins for a nominal £10, and for those without a vegetable plot communal composting is on offer.

Waste food is also increasingly seen as a resource for animal feed. Companies, retail, restaurants and cafes are encouraged to direct food waste away from anaerobic digestion to animal feed production. Coca Cola and Tesco are examples of companies that do this on a large scale, and Tesco has recently opened its own animal feed facility in the UK, processing 1000 tons a week in its 'surplus food to feed' programme.

3. New products

Repurposing of items no longer required is an excellent way to deal with what would normally become waste. This can be done on a small scale in the home, used glass bottles and jars can be used to store new things, cans can be used as containers, old clothing can be used as cloths and dusters, and even an old toothbrush can become a new fine cleaning tool. Upcycling is where old items are repurposed into something more valuable and with a new application, and this is part of the circular sustainable economy that attempts to cut waste. It is becoming more popular and has opened up some successful business opportunities in making jewellery, fashion accessories, textiles and furniture. Larger firms have also very successfully embraced using waste materials to make new products such as Patagonia who make coats and jackets from recycled polyester and it now has an estimated value of \$3 billion.

Q8: Explain the ways in which responsible waste management can be promoted. (4.1) There are 3 main ways in which responsible waste management can be promoted.

1. Identify and measure waste

The initial stage in developing a responsible approach to waste management is to conduct a waste audit. This is usually conducted by a business or organisation wanting to look at its current waste situation and waste streams, but it can also be conducted by individual households. The business waste audit will usually involve developing a waste 'leader' and a team of staff responsible for the audit and any ensuing policies, although it may also involve outside agencies or consultants.

The present waste situation is assessed by looking at existing waste streams, types of waste, whether any is hazardous, sources of waste and quantities. Current levels of sorting and where the waste goes is also assessed to allow plans to be made to improve the waste management. Waste leaders must be aware of current waste legislation and any plans must be communicated to staff, who must be educated on new procedures and the reasons for them.

The new policies, processes and procedures need to be evaluated on a regular basis to monitor their success. The waste hierarchy should be the focus for the policies and for all staff, in order waste must be reduced, reused, recycled and then recovered, and finally in exceptional circumstances only disposed of.

2. Raise awareness

Raising awareness of waste management issues and the need to minimise waste and reduce its impact on the planet and people is a foundation stone of the implementation of responsible waste management systems. This is true in any organisation

attempting to introduce its own waste policies as staff must be educated about the need to reduce waste and the procedures that are being put in place to accomplish the aims of the policy. Raising awareness, however, needs to embrace all of society. Education may be the key, increasing environmental awareness in schools and colleges, putting on community events and company sessions so that the whole of society is reached (unsaccopolito.com).

Education may be essential for progress, as information brings informed and responsible choices. Awareness by itself, however, is not enough, from this must follow action. Effective campaigns such as 'Reduce, Reuse, Recycle' must reach people, educate them, enthuse them and change their mindset to motivate them to take action. Research by the Stockholm Environment Institute (sei.org) titled Reducing Plastic Pollution, Campaigns That Work, looked at many campaigns directed at reducing the use and misuse of plastic, and found that effective awareness raising campaigns need to be; accessible and relevant, motivational and signal opportunities for specific actions by individuals.

3. Understanding our responsibilities

It is important to understand that everyone is responsible for waste, waste management and waste disposal. It is not just the responsibility of the large companies producing the plastic, the companies using the plastic, the retail outlets selling plastic goods or goods packaged in plastic materials but also the consumers and what they do with the plastic, in fact the whole of society is responsible. The government (www.gov.uk) sets out these responsibilities in what it calls a duty of care which outlines guidance and regulations relating to waste. The duty of care applies to all who produce, carry, keep, dispose of, treat, import or control waste, and there are separate sets of instructions for producers, carriers, dealers, brokers or managers. Anyone who deals with waste must do so with regard for and respect of the environment, keep accurate records and only pass the waste on to authorised individuals or firms, and offences carry fines with no upper limit.

Individual householders also have a duty of care and household waste must only be disposed of through the local authority or authorised contractors. They do not have to keep records and will not be fined unless they engage in waste crime such as fly tipping.

Q9: Identify methods for disposal of reusable or recyclable waste. (4.2) If the waste hierarchy protocol is applied, reduce, reuse, recycle, recover, dispose, then only reducing the amount of material used and waste produced is better than reusing and recycling. Reusing is best, either to fulfil the same role or repurposed, but after this as much waste as possible should be recycled. Recycling is, however, a problem area since it is initially important to identify what can and what cannot be recycled, no the easiest task, the materials must then be sorted before it is decided how and by whom it will be recycled.

Most organisations, including local councils, now attempt to collect separated glass, paper, metal cans and garden waste and transfer it to a company that can recycle it (recyclenow.com). Glass is infinitely recyclable, in the UK at present 71% of glass is recycled with the target of 90% by 2030, and at recycling plants it is cleaned, crushed, heated and remoulded or blown into new bottles or containers. Aluminium and steel cans are another form of waste that is infinitely and relatively easily recycled.

Aluminium is shredded and remelted into ingots ready to make new products, and waste steel can be put into modern steel furnaces as a scrap steel charge.

Plastic waste is a more complex issue. It can be recycled by shredding, melting and reforming into new products such as bottles, polyester or plastic bags, but there is a great deal of confusion about which plastics are recyclable and which are not. There are several types of plastic, some like Polyethylene Terephthalate (PET) from everyday bottles and High Density Polyethylene (HDPE) from toys and milk jugs are recyclable, but even these can absorb odours or be contaminated by their contents. The British Science Association (britishscienceassociation.org) have conducted research into people's understanding of waste and waste recycling, and while 80% of the British public believe that recycling makes a difference, most are still confused by what can be recycled, what cannot, and what must be done to some items before recycling. Labelling of plastic products is far too complex, a much simpler and easier to understand system is required and many UK residents think that sorting and preparing recyclables is too time consuming. It is clear that an extensive programme of 'waste' education and campaigning is needed, and some new way of motivating the general public to be more involved.

Q10: Identify methods for disposal of waste that is not reusable or recyclable. (4.3) Any organisation producing waste should apply the waste management hierarchy (www.gov.uk) of prevent-reduce-reuse-recycle-recovery-disposal. If waste is not reusable or recyclable as a last resort the last two in the hierarchy may be applied, recovery and disposal. Organisations must take into account relevant legislation and always opt for the most sustainable method first.

The organisation should go through a 4 stage process when faced with waste that is not reusable or recyclable. First, it is essential to determine if any of it is hazardous or toxic, as if it is special regulations will apply and special care will need to be taken. Secondly, it should be placed in biodegradable bags not the usual plastic bags and thirdly stored securely. Finally, disposal must be done properly and legally through officially registered organisations.

Recovery

This will usually involve some form of incineration to recover heat energy or gases that may be used to generate electricity, since incineration without this recovery is really just another form of disposal (assets.publishing.services.gov.uk). Incineration of unprepared MSW is a long standing method of burning waste to create heat to generate electricity, but recently more effective and efficient methods such as Mechanical and Biological Treatment (MBT), Mechanical Heat Treatment (MHT) and Advance Thermal Treatment (ATT) have been introduced. While these new processes do need some processing and preparation of the initial MSW, they can be used to efficiently and relatively cleanly generate power (electricity), recover the heat only, or be a combined heat and power plant.

Problems with incineration are twofold, emission of greenhouse and other more toxic gases, and the residual ash that can

contain toxic materials. The modern methods of incineration are regulated to use a minimum temperature and release less gas, carbon dioxide is still released but far less than when burning fossil fuels themselves. The residual ash is about 10% of the volume of the original waste, but can contain toxic materials, although valuable materials such as metals can be recovered.

Landfill

Historically landfill has been the default destination for waste in the UK. Figures for landfill have been declining in recent years, but still stood at a depressing 23% of all household waste in 2018. There are a number of waste materials that should not be sent to landfill, liquids, infectious materials and explosive or flammable materials, but landfill continues to blight the countryside. Landfill is basically burial, hoping for the long term decay of the waste, however, a look at some typical decay rates (businesswaste.co.uk), plastic bags up to 100 years, disposable nappies over 400 years, plastic bottles about 450 years and glass up to 1 million years shows the futility and unsustainable nature of this process. The UK has over 500 landfill sites and still disposes of 35 million tonnes to them each year, and in 2021 8 million tonnes of this was biodegradable municipal waste. Unsealed or poorly sealed landfill sites can allow toxic leachates to escape to nearby water courses and the water table to impact on human and environmental health, and methane, a powerful greenhouse gas, is released by the decay process. In some cases the methane can be recovered to provide heat and/or power, and used sites can eventually be covered and reclaimed, but the blight and cost of landfill make it unsustainable in the long term. Hazardous waste (www.gov.uk) must be sent to special sites. There are strict regulations and penalties governing this form of waste, and producers, carriers and consignees all have a 'duty of care'.

Q11: Describe ways of disposing of waste safely. (4.4) When disposing of waste health and safety must be the priority.

Some waste may be hazardous or offensive and it is this waste that must be effectively and efficiently dealt with to minimise problems. All organisations should have an Environment Management Strategy (EMS) which oversees the possible impact on the environment and people, and within the EMS must be a Waste Management Strategy (WMS) overseen by responsible staff. The WMS will set out what hazardous or offensive waste is produced by the organisation and how it can be disposed of safely, and the waste management team will be aware of all the relevant legislation relating to waste, waste management and hazardous waste management in particular.

The UK regulations on hazardous waste (www.gov.uk) outline what hazardous waste an organisation may have or hold, such as asbestos, chemicals, batteries, oils and the containers that held these materials. The WMS of any organisation must identify these types of waste, classify it, separate it, store it safely and consign it only to firms that have an environmental permit and keep a detailed site inventory. The final disposal be it landfill, surface impoundment, deep injection or release into a water body must also be authorised and regulated.

All waste materials, including hazardous, must be stored in secure containers that do not allow leaks or access by vermin, and all bags should be made of biodegradable material. When the waste is disposed of it should only be through authorised and regulated agencies who have the same duty of care as the producing organisation.

Despite the fact that safe storage is a priority accidents do occur causing pollution events. All relevant organisations must have a Pollution Incident Response Plan in place to enable them to deal effectively with any pollution incident. The plan should outline the possibilities for a pollution incident and set out how staff will respond to it, what strategies and equipment are in place and what outside agencies would be contacted.
