urban science

Zero Waste

Students investigate how cities might look if they achieve zero waste. They explore different ways cities are working towards zero waste and create their own plans to present.

A curriculum linked learning module for students aged 13-15 to develop competences in working scientifically.

Learning challenge: Making Waste Zero

Zero waste lifestyles are becoming popular amongst lots of people, and a zero waste city is something many cities across the world are trying to achieve. The zero waste city concept means that cities are planned to leave no negative impact on the environment and that this aspect is integrated in to all decision-making.

This learning module can be used flexibly within the curriculum to support key knowledge about chemistry, biology and develop working scientifically competences. The learning links with the Sustainable Development Goals and provides a broader context for student learning. It is suitable for adapting as a STEM activity or Eco Club.

The topic of zero waste links with the life cycle assessment of products and their environmental impacts, and with how human waste impacts upon ecosystems.

www.urbanscience.eu

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To deliver this module we recommend:

- Start with one or both of the Stage 1 activities to generate interest and context about how humans deal with waste compared to nature.
- Elicit current student understanding in Stage 2 and discuss students views and opinions.
- Stage 3 is the practical challenge where students gather data and make conclusions.
- In Stage 4 students will provide suggestions for sharing and presenting results.

Subject

Biology	Chemistry	Physics	Raising Attainment
✓	✓		✓

Programme of Study reference

1. Chemistry	**Chemical and allied industries** • life cycle assessment and recycling to assess environmental impacts associated with all the stages of a product's life. • the viability of recycling certain materials.	3. Working scientifically	Students successfully completing this module will have had the opportunity to access these statements: 1c,1d,3ai,3aii,3aiii,3av,3avi,3avii. See Annex 1 for full statements.
2. Biology	• the importance of biodiversity. • positive and negative human interactions with ecosystems.		

Sustainable Development Goals

All Urban Science modules try to 'ensure inclusive and equitable quality education and promote lifelong learning opportunities for all' and in addition focus on education for sustainable development and global education - SDG 4.7. Support and resources here:

http://www.teachsdgs.org/

This module has strong links to SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation, SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable, and SDG 12: responsible consumption and production.

Activities Overview

Stage 1	Time (mins)	Resources needed
An Invitation	30 mins	Student Sheet 1
Natural Waste	20 mins	Student Sheet 2

Stage 2	Time (mins)	Resources needed
Forming Scientific Arguments	30 mins	Student Sheet 3
Traffic Lights for Change	20 mins	Student Sheet 4
Five Whys	20 mins	None required
Plenary	10 mins	Student Sheet 5; Teacher Sheet 1

Stage 3	Time (mins)	Resources needed
How Does Our City Work Now?	30 mins + research time	Student Sheet 6
What Can We Do Differently?	35 mins	Student Sheet 7 and 8
Zero Waste in 2030	30 mins + homework	None required

Stage 4	Time (mins)	Resources needed
Presenting Results and Peer Assessment	50 mins	Student Sheet 9

Health and Safety: please refer to the guidance provided on the Urban Science website before commencing the module.

www.urbanscience.eu/uk/learning-modules/health-and-safety/

STAGE 1 - Zero Waste City

Inquiry based learning stage

Stage 1 - Initiating and eliciting	✓	Stage 2 - Defining and responding	
Stage 3 - Doing and making		Stage 4 - Communicating, presenting and evaluating	

Learning objectives

1. Students are able to distinguish between human and natural waste.
2. Students understand how nature deals with waste through decomposition.
3. Students can ask questions and make predictions about the future.

Learning outcomes

1. Students make predictions about the future.
2. Students debate different futures for their city.
3. Students discuss the differences between how nature and humans deal with waste.

Overview of lesson

This lesson introduces the topic of waste to students and elicits their views and current knowledge of the issues involved. It asks students to compare and contrast how humans and nature deal with waste differently.

The teacher's role is to help students draw on their own lives and experiences to discover things that interest them, make them excited, curious and want to ask questions.

Lesson structure

Introduction

This module allows for lots of opportunities for students to follow their curiosity. However, there are some key science misconceptions that are good to address at the beginning. These links from the STEM learning site are good if a bit old. It is a sobering thought that little has changed in the last 10 years in terms of what to recycle and which packaging has the biggest impact. Referencing a small exhibition with key data on the 'messy wall' (see the plenary below) is an excellent way to start this module. Using these links necessitates registering on the STEM learning site but this a great idea, all resources are peer reviewed, quality checked and are free to use.

https://www.stem.org.uk/resources/elibrary/resource/31943/one-planet-packaging

https://www.stem.org.uk/resources/elibrary/resource/26879/recycling-and-sustainability

https://www.stem.org.uk/resources/elibrary/resource/26659/domestic-waste

https://www.stem.org.uk/elibrary/resource/25306

Main 1: An Invitation

Students receive a letter from the City Council telling that there will not be any waste bins in the City starting from year 2030 (see Student Worksheet 1).

What will your city look like in 2030? Litter all over the streets or clean and green?

The following video offers a helpful starting point:

https://www.youtube.com/watch?v=G4IDZ5hCNCM&feature=youtu.be

In groups, ask students to discuss the future of their city without waste bins:

- How might that look?
- What problems could this create?
- Is this harmful?
- From where the litter come? Where does it go?

Note key words from each group on the board.

Main 2: Natural Waste

Initiate a discussion with students: If we walked into a woodland, would we see litter? How does nature deal with waste?

The video below shows leaf litter decomposition:

https://www.youtube.com/watch?v=ECh52Nt8WXc

In groups, ask students to discuss how nature deals with waste:

- What happens to 'waste'?
- What is this process called?
- Is this harmful?
- From where the waste come? Where does it go?

Note key words from each group on the board.

Compare words from the city waste activity above; how are cities and nature different in the way they deal with litter/waste? Use the compare and contrast proforma (see Student Sheet 2).

Continued on page 6...

Lesson structure (Continued)

Plenary: The messy wall

As this module allows students to choose from a range of activities this is a great opportunity for an extended 'messy wall'. Adding the proformas from this session and literature from the main 'UK waste charities' is a good starting point for this module.

UK waste charities:

- Friends of the Earth -
  https://friendsoftheearth.uk/natural-resources/all-you-need-know-about-waste-and-recycling
- Recycle Now -
  https://www.recyclenow.com/
- The Pod -
  https://www.jointhepod.org/

Student Sheet 1

Dear Students

Over the last 20 years we have worked hard to reduce the amount of waste created in our city. However, we must do more to ensure we stop wasting valuable natural resources and polluting our environment. The City Council has decided, therefore, that by 2030 our city will become zero waste.

What might this mean? It means there will no longer be waste bins on the streets. No shop or business will be permitted to generate waste. All citizens will be required to reuse and recycle everything. We know this is a big challenge but it is one we need to tackle together for all our futures.

Detailed planning and consultations will take place over the coming months, and we invite you to share your ideas for our zero waste city.

Kind regards

Chief Executive.

Student Sheet 2 - Compare and Contrast

Make comparisons between two topics. Establish what is unique and what is similar about each one.

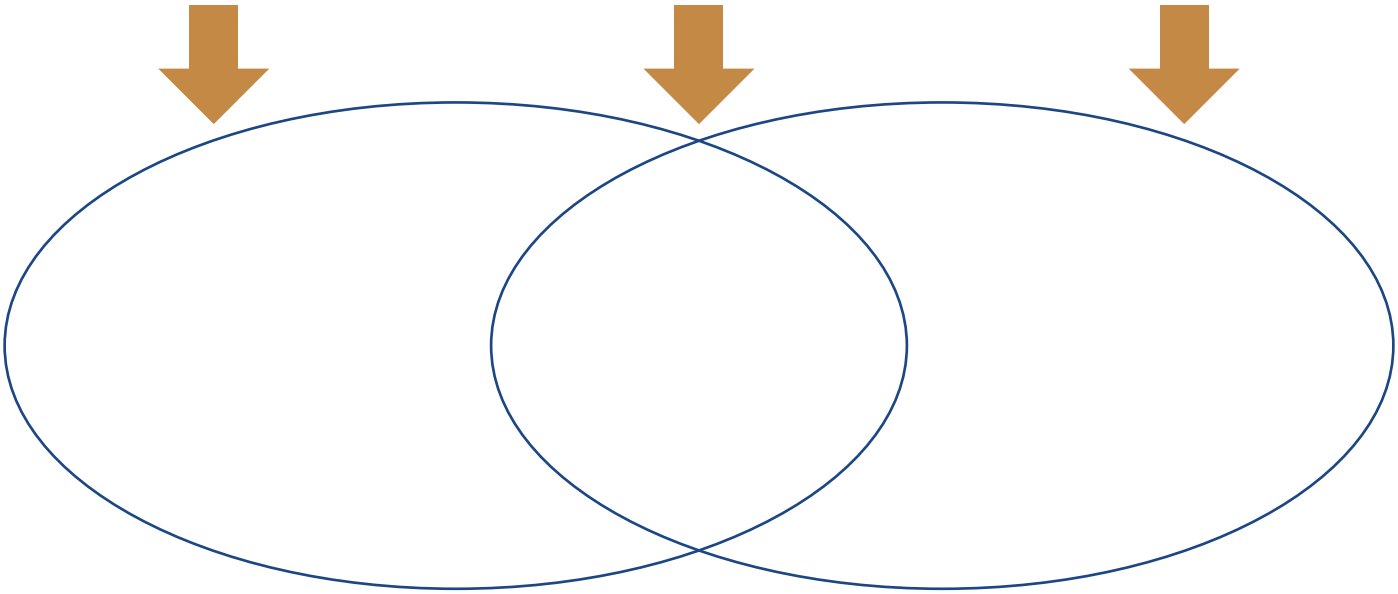
TOPIC: Add topic name here

TOPIC: Add topic name here

What is different about this?

What is similar about them?

What is different about this?



I think that ...

STAGE 2 - Zero Waste City

Inquiry based learning stage

Stage 1 - Initiating and eliciting		**Stage 2 - Defining and responding**	✓
Stage 3 - Doing and making		**Stage 4 - Communicating, presenting and evaluating**	

Learning objectives

1. Students are able to distinguish between facts and opinions.
2. Students are able to express their own views and justify them.
3. Students can interrogate a range of opinions.

Learning outcomes

1. Students research and analyse a range of viewpoints.
2. Students test evidence for themselves.
3. Students question evidence to reach conclusions.

Overview of lesson

This lesson asks students to dig deeper into the topic, ask questions and form their own scientific opinions based on evidence. It concludes with students testing ideas for making improvements to their city which will be explored in Stage 3.

The teacher's role is ensuring students can advance their enquiries meaningfully; providing frameworks and learning so that students can organise their research.

Lesson structure

Main 1: Forming Scientific Arguments

Provide students with the web links below. Ask them to use the Facts or Opinions worksheet (Student Sheet 3) to review the information provided and distinguish between fact and opinion.

https://metro.co.uk/2019/07/03/uks-top-towns-cities-plastic-recycling-revealed-10108620/

https://www.theguardian.com/news/datablog/2011/nov/04/recycling-rates-england-data

http://theconversation.com/is-there-any-point-in-recycling-109550

https://friendsoftheearth.uk/natural-resources/all-you-need-know-about-waste-and-recycling

How can we distinguish fact from opinion? What criteria can we apply? How can we test the evidence for ourselves?

Main 2: Traffic Lights for Change

Using the information students have researched above, use 'traffic lights' (see Student Sheet 4) to analyse what students feel needs to be changed in their city.

Main 3: Five Whys

Students work in pairs to test the ideas developed in the traffic lights activity.

The aim is to ask 'why' questions in response to five consecutive answers.

For example:

Q: Why do we need to change the food supply in a city? A: Because it generates a lot of waste.

Q: Why does it generate waste? A: Because it has a lot of packaging.

Q: Why does it have so much packaging? A: Because it comes from a long way away?

Q: Why does it come from far away? A: Because there is no space to grow food in the city?

Q: Why is there no space in the city for growing food? A: Because we choose to provide space for car parking rather than food growing.

The technique promotes an enquiring stance and challenges students to examine their thinking and reasoning.

Plenary: Data race

This is a 'quick fire' active exercise that ensures students have a good grasp of the key science behind recycling and its impacts.

The teacher sets students off on a race to find out key bits of information on the topic of waste.

- At the word 'Go', one person from each group takes a card from the desk (cut up from Student Sheet 5), takes the first question only and takes it back to the group.
- Students research information from:

https://friendsoftheearth.uk/natural-resources/all-you-need-know-about-waste-and-recycling

- Then they write down the answer on a separate piece of paper.
- A second person takes this to the front.
- The answer is checked. If it is accurate and complete, the second question is collected... and so on (see Teacher Sheet 1 for answers).
- If any answer is inaccurate or incomplete, the runner will be sent back to the group to try again.
- The first group to complete all the answers 'wins'.

Student Sheet 3 - Facts or Opinions

Sort out the facts from the opinions about a particular topic. Document what you agree/disagree with.

Student name: ..... **Topic:** .....

Topic / Theme / Question

Fact...

Fact...

Fact...

Opinion...

Opinion...

Opinion...

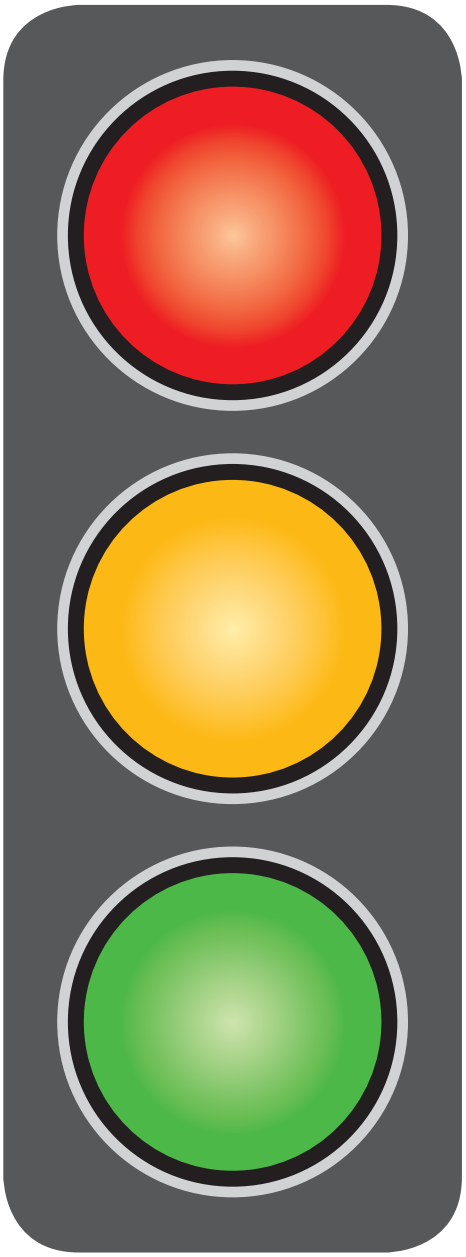
Opinions I agree with...

Opinions I disagree with...

Other opinions I have...

To explore further...

Student Sheet 4



What would you like to **stop** in the city?

Why?

What do you want to make **ready** to start?

Why?

What do you want to make **go** in the city?

Why?

Student Sheet 5 - Data race zero waste cards

Q1. What do we waste?

Give three examples.

Q2. Why is waste a problem?

Hint 1 - natural resources.

Hint 2 - climate change.

Hint 3 - pollution.

Q3. Are there waste problems with plastics?

Give 5 examples of the main ones.

Q4. Detail five waste facts.

Hint 1 - coffee cups.

Hint 2 - plastic bottles.

Hint 3 - food waste.

Hint 4 - sea dumping.

Hint 5 - packaging.

Q5. What can we do to waste less?

Hint 1- alternatives.

Hint 2 - food waste.

Hint 3 - water.

Hint 4 - campaign about recyclable packaging.

Teacher Sheet 1 - Data race zero waste answer

Q1. What do we waste?

Give three examples.

- We **waste natural resources** - digging up, using and burning more than we need.
- We waste the products we make - supermarkets leave unwanted food to rot in fields.
- We even waste our waste - sending stuff to landfill that could be reused, recycled or composted.

Q2. Why is waste a problem?

Hint 1 - natural resources.

Hint 2 - climate change.

Hint 3 - pollution.

Waste

- Is an **inefficient use of our resources.**
- When waste decays it gives off climate-changing emissions.
- Can pollute soils and waters.

Q3. Are there waste problems with plastics?

Give 5 examples of the main ones.

1. It's **in many common products** e.g. computer, TV, food packaging, so hard to avoid.
2. It's made from **non-renewable fossil fuels**.
3. Most plastic isn't recycled. A lot of it ends up in landfill where it can take **up to 1,000 years** to break down.
4. The rest is dropped as **litter**, and often ends up in our waterways.
5. It **damages sea life** - for example fish and other sea life can get tangled in plastic products or **mistake them for food**.

Q4. Detail five waste facts.

Hint 1 - coffee cups.

Hint 2 - plastic bottles.

Hint 3 - food waste.

Hint 4 - sea dumping.

Hint 5 - packaging.

1. 2.5 Billion coffee cups are binned each year in the UK.
2. Only 7% of plastic bottles are recycled globally.
3. One third of all food waste across the globe is lost or wasted.
4. One truck load of plastic is dumped in the sea every minute.
5. We don't organise our recycling systems well, for example 'black' plastic can't be picked up by recycling machinery so 1 billion black plastic 'take away' trays go to land fill each year in the UK.

Q5. What can we do to waste less?

Hint 1- alternatives.

Hint 2 - food waste.

Hint 3 - water.

Hint 4 - campaign about recyclable packaging.

1. There is lots on this FoE site – any of these that relate to their lifestyle? https://friendsoftheearth.uk/plastics/9-really-good-alternatives-plastic
2. Many ideas regarding food waste here https://friendsoftheearth.uk/food-waste
3. Water use ideas https://friendsoftheearth.uk/natural-resources/13-best-ways-save-water-stop-climate-breakdown
4. This FoE site lists how and who to complain to /campaign against. https://friendsoftheearth.uk/food/demand-recyclable-packaging?origin=d-7

STAGE 3 - Zero Waste City

Inquiry based learning stage

Stage 1 - Initiating and eliciting		**Stage 2 - Defining and responding**	
Stage 3 - Doing and making	✓	**Stage 4 - Communicating, presenting and evaluating**	

Learning objectives

1. Students are able to plan and carry out an investigation.
2. Students can use primary and secondary data to understand an issue.
3. Students recognise, understand and consider limitations in their method.
4. Students can apply their scientific knowledge to a local context.

Learning outcomes

1. Students plan and carry out surveys to collect primary data.
2. Students interrogate secondary data to find trends and patterns of change.
3. Students make recommendations based on their research.

Overview of lesson

Students collect primary data and interrogate secondary data to understand how waste is dealt with in their city. They use this to make recommendations to improve waste management and move towards zero waste.

The teacher's encourage students to manage their time, identify clear goals and monitor their progress.

Lesson structure

Main 1: How does our city work now?

Students work in groups to collect data and information about their city: go on field trips to the local council, food stores, water and energy companies to find out how their city deals with waste. Carry out research online into who provides what services and how. Where does food, energy and water come from, how is it transported, what waste is generated?

There are many websites which can assist students; waste statistics for local authorities is a good place to start exploring changes in how effectively we deal with waste:

https://www.gov.uk/government/statistical-data-sets/env18-local-authority-collected-waste-annual-results-tables

Students may need to prepare interview questions prior to visits/research. Student Sheet 6 can be used to help organise research.

Main 2: What can we do differently?

Cities trying to become zero waste have a common philosophy driven by four key strategies:

1. Moving away from waste disposal.
2. Supporting comprehensive reuse, recycling and composting programmes.
3. Engaging communities to work together.
4. Designing new systems without waste.

Provide students with the case studies in Student Sheet 7 and ask them to identify the key characteristics of a zero-waste city:

- What steps are involved?
- What are the key issues to address?
- What can we learn from the case studies for our own city?

Use Student Sheet 8 for students to record their suggestions.

Main 3: Zero Waste in 2030

In groups, students prepare plans for their city to become zero waste by 2030:

- How can you organise food, energy, transport and water to be waste free?

Groups could work on a single topic each and then use a carousel activity to share ideas. Each group appoints one person to stay with the group and present whilst other members visit different groups to find out information which they then add to their own.

Groups use all the information gained to produce a diagram/poster illustrating their zero-waste city.

Plenary: Messy wall

Students add their results to the messy wall.

Student Sheet 6

Investigate supporting evidence and conflicting views, then make your own new ideas.

Student name: ..... **Topic:** .....

Inquiry question / statement	My hypothesis

What I want to know	What I found out	Why is it important?

New ideas:

Student Sheet 7 - Kamikatsu, Japan

Kamikatsu is a small town in Japan with just over 1500 inhabitants. It has become a near-waste-free city with no significant financial investments or dedicated infrastructure. It started in 2003, until that time the waste management method of the town was simple - the waste was incinerated. However, over time, the townspeople have realized that incineration is not a good solution, as it creates pollution that eventually enters the food chain. Therefore, in 2003, the city set itself the goal that by 2020 Kamikatsu should become a waste-free city and waste generated by residents should not be incinerated or landfilled.

Due to the small size of the city, the available resources for efficient waste management and recycling were not available, so an innovative, low-cost solution was found. The residents of the city live in 55 neighborhoods far from each other, which would make it expensive and inefficient to collect and transport waste by vehicle. This was understood by the city management back in the 90s, so further research and ideas followed. Studies have shown that up to 30% of all waste is raw, wet, mainly food waste. Therefore, already in 1995, financial assistance was offered to the population for the purchase of biodegradable waste containers. In this way, each household was able to purchase this type of container at an extremely low price and up to 97% of the biodegradable waste produced by households is recycled on site. This was followed by the introduction of sorting of packaging materials; the city management contacted various manufacturers who further use recycled materials and introduced sorting grades based on what can be further used in production. Every time a new manufacturer was found using another material, a new category was introduced. It started with 9 groups but has now grown to 45 groups in 13 categories. For example, metals are sorted into 5 groups, plastics 6 and paper 9. At present, a small part of the waste is incinerated: PVC, rubber, diapers and other hygiene products.

As there is no waste collection transport in the city, residents have to bring their own waste to a waste sorting station. The waste sorting station is open from 7.30am to 2pm daily and staff are there to help people sort their waste properly. Waste is carefully sorted so it can be resold at relatively high prices. With the money raised, the city is able to maintain and improve this management system. As a new initiative, the city has introduced the provision of washable, reusable diapers for households with babies.

There is also a shop in the city where residents can bring clothes or furniture and other things they no longer need and exchange them for things brought by other people. There is also a workshop nearby where local women make new things from the residents' junk, like sewing toys from old kimonos.

With all this, by 2016, 81% of the waste generated in the city was recycled.

The key to success story:

- Citizen involvement, very nuanced waste sorting.
- City benefits.
- Proceeds from the sale of recyclable materials.
- Well-organized waste management system.
- Excellent waste recycling rate.
- Awareness of the zero waste principle.

More information

https://www.nippon.com/en/guide-to-japan/gu900038/

https://www.youtube.com/watch?v=sCz5OZyPzG8

http://zwa.jp/en/

Student Sheet 7 - New York City

The city of New York has set itself a very ambitious goal of becoming a waste-free city by 2030. The aim is to reduce the ecological footprint, reduce greenhouse gas emissions and produce the cleanest air and water possible. For a city with no landfill and incinerator but more than 8 million inhabitants, waste management is a major challenge. To achieve this goal, New York has set up a major program that identifies key areas of activity: buildings and energy, transportation, waste.

1. Energy efficiency is one of the main areas of focus for the city; the 1 million buildings in the city as a whole are responsible for the majority of greenhouse gas emissions. About $500 million has already been invested in improving the energy efficiency of residential and public buildings. Replacement and renovation of power plants and energy supply systems as well as the implementation of renewable energy projects are also underway. It is planned to significantly increase the use of solar and wind energy, as well as decentralized energy supply, thus significantly reducing energy losses during delivery. Greenhouse gas reduction measures are estimated to save nearly 1.5 million tonnes of CO_2 during the implementation of the program, which will save about $700 million.
2. The transport sector is planning major improvements to the public transport system (with particular emphasis on waterborne and rail transport, as they are more environmentally friendly), improvement of cycling infrastructure, and will encourage the move away from diesel and gasoline powered vehicles.
3. New York undertakes to reduce landfill by 90% by 2030 compared to 2005. Every day, the city generates more than 18,000 tonnes of waste of which only a fraction is recycled, composted or used for energy production, most of which is landfilled, generating more than 2 million tonnes of CO_2.

New York is the largest producer of waste in the world, generating approximately 6 million tonnes of waste per year, costing the city about $1 billion a year. Due to New York's limited area, waste is shipped far beyond New York State to other states such as New Jersey, Pennsylvania, and Virginia. Traveling long distances creates an additional traffic load, generates a lot of harmful gases, and is also very economically disadvantageous; in 2007 $290 million of taxpayers' money was spent on moving waste away from New York. So far, New York has succeeded in reducing emissions from the sector by 22% since 2005, due to a reduction in waste generated in the city and the use of barges and trains to take the remaining waste to landfill.

In order to move towards the set goal, in the coming years it is planned to focus on reducing the amount of waste, significantly increasing the amount of organic waste treatment, and promoting waste recycling. The organic waste collection program is particularly important as this type of waste represents more than 30% of all household waste. Prior to the implementation of the program, all of this waste was collected, transported over long distances, to be disposed of in a landfill site where it decomposes to produce harmful gases. Old-fashioned organic waste management alone cost New York $85 million a year. The new program manages leftovers, food-grade paper packaging and garden waste to compost it, which can then be used in agriculture as fertilizer, and some is recycled into renewable energy. Participation in this program is voluntary. Citizens participating in the program receive a biowaste collection container of appropriate size with information booklet, coupon and sticker. Organic waste is collected along with other waste, but convenient disposal points are also created. Significant steps are also being taken to promote separate collection and recycling of other types of waste, and since 2015 the city has committed itself to significantly reducing non-recyclable and non-biodegradable packaging, which is very costly for the city itself. For example, it is estimated that disposable plastic bags account for 2.3% of all waste and cost the city budget $10 million a year.

The key to success story:

- Education, legislation, construction of new infrastructure and active engagement with society and business are key ways of achieving the goal.
- City benefits.
- Financial benefits, reduction of emissions, improvement of citizens' quality of life.

More information

https://onenyc.cityofnewyork.us/

https://onenyc.cityofnewyork.us/wp-content/uploads/2018/04/OneNYC-1.pdf

https://www.grownyc.org/recycling/facts

https://thekidshouldseethis.com/post/where-does-new-york-citys-trash-go

Student Sheet 7 - San Francisco, USA

Will we be the first city without waste in the US?

In 2000, the City of San Francisco set itself the ambitious goal of becoming a waste-free city by 2020. As early as 2020, the city wanted all waste produced in the city to be neither disposed of nor incinerated. To achieve this, the city based its waste management strategy on the basic principles of waste reduction: non-waste generation and waste reduction, waste recycling and waste composting. Becoming a waste-free city aims to achieve 3 key goals: preserving valuable resources, reducing greenhouse gas emissions and their negative impact on the environment, and helping to create new green jobs.

In 2009, the city introduced mandatory waste sorting into three groups: recyclable materials, compostable and unsorted waste to landfill. This applies to all citizens and businesses in the city. To ensure that everyone has an interest in sorting waste, penalties have been introduced and waste collectors will not accept waste unless it is properly sorted.

Several projects have been implemented in the city that significantly reduce landfill, such as strict control and sorting of debris and construction waste prior to disposal, mandatory compostable or recyclable packaging for take-away food, and more.

Thanks to the implementation of the program, the amount of urban waste landfilled is the lowest in recent decades. Thanks to this program, San Francisco has also become a leader in North America in terms of recycling and composting. By 2016, the city had achieved 78% recycling rates and collected about 300 tonnes of food waste daily, the largest initiative of its kind in US cities. The city has also succeeded in significantly reducing the use of plastic bags by about 100 million less each year.

The key to success story:

- Aligned legislation on waste management and food packaging.
- Public involvement and education on waste sorting.
- City benefits.
- One of the leading cities in terms of waste recycling.
- The city has created over 1000 new green jobs.
- Reduction of greenhouse gas emissions; 80% reduction by 2050.

More information

https://www.c40.org/case_studies/c40-good-practice-guides-san-francisco-zero-waste-by-2020

https://sfenvironment.org/striving-for-zero-waste

Student Sheet 8

City	What steps were taken?	What issues arose?	What can we learn from this case study?
1			
2			
3			

STAGE 4 - Zero Waste City

Inquiry based learning stage

Stage 1 - Initiating and eliciting		**Stage 2 - Defining and responding**	
Stage 3 - Doing and making		**Stage 4 - Communicating, presenting and evaluating**	✓

Learning objectives

1. Students are able to communicate their results.
2. Students can apply a range of communication techniques.

Learning outcomes

3. Students select an appropriate communication technique.
4. Students present their results using their chosen technique.
5. Students critique the work of others.

Overview of lesson

In this lesson students think about how to communicate their results. They consider a range of options and then select the most appropriate. After communicating their own results, they listen to and provide constructive feedback to other groups.

Lesson structure

Main

Students consider how to present their results. This is a generic list of ways students can consider.

- **Poster** - create a poster communicating your results and making recommendations for the café; the poster could include a picture of the café based on your recommendations.
- **Film** - create a 5-minute film communicating to the café owners how you carried out your research and the results; you could include interviews with potential customers.
- **Presentation** - deliver a 5-minute presentation for the café owners.
- **Report** - write a report laying out your recommendations and evidence.
- **Other** - add your own suggestion.

Student Sheet 9 offers feedback sheets to use during presentations.

Plenary

Ask students to share their reviews of each presentation. Groups can review their work and consider ways to improve it in the future.

Student Sheet 9 - Review form

Review plans

This activity can be used to analyse or appraise anything in a structured way.

Student name: .....

Topic: .....

Strengths

Weaknesses

Enablers

Barriers

Opportunities

Threats

Annex 1 - Key Stage 4 Working Scientifically Statements

Through the content across all three disciplines, students should be taught so that they develop understanding and first-hand experience of:

1. **The development of scientific thinking**
    a. the ways in which scientific methods and theories develop over time.
    b. using a variety of concepts and models to develop scientific explanations and understanding.
    c. appreciating the power and limitations of science and considering ethical issues which may arise.
    d. explaining everyday and technological applications of science; evaluating associated personal, social, economic and environmental implications; and making decisions based on the evaluation of evidence and arguments.
    e. evaluating risks both in practical science and the wider societal context, including perception of risk.
    f. recognising the importance of peer review of results and of communication of results to a range of audiences.

2. **Experimental skills and strategies**
    a. using scientific theories and explanations to develop hypotheses.
    b. planning experiments to make observations, test hypotheses or explore phenomena.
    c. applying a knowledge of a range of techniques, apparatus, and materials to select those appropriate both for fieldwork and for experiments.
    d. carrying out experiments appropriately, having due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations.
    e. recognising when to apply a knowledge of sampling techniques to ensure any samples collected are representative.
    f. making and recording observations and measurements using a range of apparatus and methods.
    g. evaluating methods and suggesting possible improvements and further investigations.

3. **Analysis and evaluation**
    a. applying the cycle of collecting, presenting and analysing data, including:
        i. presenting observations and other data using appropriate methods.
        ii. translating data from one form to another.
        iii. carrying out and representing mathematical and statistical analysis.
        iv. representing distributions of results and making estimations of uncertainty.
        v. interpreting observations and other data, including identifying patterns and trends, making inferences and drawing conclusions.
        vi. presenting reasoned explanations, including relating data to hypotheses.
        vii. being objective, evaluating data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error.
    b. communicating the scientific rationale for investigations, including the methods used, the findings and reasoned conclusions, using paper-based and electronic reports and presentations.

4. **Vocabulary, units, symbols and nomenclature**
    a. developing their use of scientific vocabulary and nomenclature.
    b. recognising the importance of scientific quantities and understanding how they are determined.
    c. using SI units and IUPAC chemical nomenclature unless inappropriate.
    d. using prefixes and powers of ten for orders of magnitude (e.g. tera, giga, mega, kilo, centi, milli, micro and nano).
    e. interconverting units.
    f. using an appropriate number of significant figures in calculations.