Life cycle assessment: shopping bags

This resource accompanies the article Life cycle assessment of takeaway containers in *Education in Chemistry* which can be viewed at: rsc.li/48PcLEY. The article looks at a study of the environmental impact of different types of takeaway containers and provides another example to bring into your teaching.

Learning objectives

1 Understand how the overall environmental impact of a product is assessed using a life cycle assessment.

2 Evaluate the use of three different types of shopping bag using a life cycle assessment of each one.

Introduction

In 2008, supermarkets in the UK gave away approximately 10 billion lightweight single-use carrier bags. This equates to around 10 bags a week per household. In 2011, the Environment Agency conducted a life cycle assessment (LCA) of carrier bags used in supermarkets in England. This provided the evidence for the government to act on single-use plastic waste.

Differentiation

There are two versions of the blank LCA table in the student sheet. One (marked with one star) has a set of key questions to prompt learners to include information that will help them to draw valid comparisons.

You can use the slides to support learners to fill in the LCA. They will also need to draw on their own subject knowledge. Alternatively, point learners to online resources that will help them fill in the table independently. The Environment Agency Evidence report *Life cycle assessment of supermarket carrier bags: a review of the bags available in 2006* (available at bit.ly/3HwGSF5) is a good place to start.

Answers

1. An example of a completed table from the student sheet follows.

Stage of life cycle	Key questions	Single-use plastic bag	Reusable plastic bag	Cotton bag
Raw materials	What is the bag made from? What is the source of the raw material? How much is needed to make one bag?	**Poly(ethene), an addition polymer made from ethene. This is sourced from crude oil. 8.12 g.**	**Poly(ethene) an addition polymer made from ethene. This is sourced from crude oil. 34.94 g**	**Cotton from the cotton plant. 183.11g**
	What pollution and energy use are linked with the raw materials?	**Oil extraction, fractional distillation and polymerisation all require a lot of energy and result in pollution.**	**Oil extraction, fractional distillation and polymerisation all require a lot of energy and result in pollution.**	**Soil cultivation, fertilisation, application of pesticides, irrigation, harvesting and ginning - using energy and causing pollution.**
	Are the raw materials renewable?	**No, crude oil is a finite resource.**	**No, crude oil is a finite resource.**	**Cotton is a plant and is therefore renewable but the process of growing cotton has a high environmental impact.**
Manufacturing and processing	What is the process of turning the raw material into a bag?	**Plastic melt is blown and sealed to form a bag.**	**Plastic melt is blown and sealed to form a bag.**	**Yarn production, textile refinement and weaving.**
	How much pollution and energy use are linked with the bag's manufacture and processing?	**0.758 kWh kg^{-1} of electricity 418.4 g of waste Global warming potential of 1.578 kg CO_2 equivalent**	**0.932 kWh kg^{-1} of electricity 171.2 g of waste Global warming potential of 1.385 kg CO_2 equivalent (if used 5 times)**	**0.06 kWh kg^{-1} of electricity 1,800 g of waste Global warming potential of 1.570 kg CO_2 equivalent (if used 173 times)**
Transport	Where is the geographic location of the raw materials?	**China/ Indonesia/Malaysia**	**Turkey**	**China**
	What are the methods of transport?	**Lorry, sea freight and rail**	**Lorry, sea freight and rail**	**Lorry and sea freight**
Consumer use	How many bags are needed for a month's shopping?	**82.14**	**60.68**	**45.59**
	How many times is the consumer likely to reuse the bag?	**About half of all respondents reused single-use bags but not for their primary use. The most common secondary use is as a bin liner.**	**5 times**	**Multiple times. Although, needs to be 173 times needed to reduce the global warming potential below that of the single-use bag.**
Disposal	How is the bag disposed of at the end of its useful life? Can it be recycled?	**Landfill, incineration or recycling**	**Landfill, incineration or recycling**	**Landfill or incineration. Learners may offer other options from their own experience eg fabric recycling.**

2. This is an open-ended question and learners' answers will differ. Learners should justify their answers with supporting evidence from the LCA.

Examples of learner answers could include:

- Reusable plastic bags have the least environmental impact because they produce the least amount of waste during manufacture, they have the lowest global warming potential and can be recycled at the end of their useful life. A suggested action that the government could take is to introduce a discount on shopping if you remember to bring reusable carrier bags. This would help to encourage reuse of bags which is the best way to reduce the environmental impact.
- Single-use plastic bags have the least environmental impact because they require the least amount raw material and electricity to produce. Plus, they have a secondary use as bin liners, which reduces the need for producing single-use bin liners which would have a high environmental impact. A suggested action that the government could take is to ban the sale of bin liners to encourage the reuse of items that have a different primary use.
- Cotton bags have the least environmental impact because they are made from a renewable resource. They can carry the largest number of items of shopping so you need fewer bags and they can be reused a greater number of times before breaking. A suggested action that the government could take is to introduce a 'plastic tax' to make the manufacture and use of plastic carrier bags expensive and force retailers to switch to renewable alternatives. *See note below.*

Note:

Although this is a valid learner response, the answer that cotton bags have the least environmental impact is incorrect based on the information used in the Environment Agency LCA. The Environment Agency concluded that: 'The cotton bag has a greater impact than the [single-use plastic] bag in seven of the nine impact categories even when used 173 times (ie the number of uses required to reduce the global warming potential of the cotton bag to that of the [single-use plastic] bag with average secondary reuse). The impact was considerably larger in categories such as acidification and aquatic and terrestrial ecotoxicity due to the energy used to produce cotton yarn and the fertilisers used during the growth of the cotton.' An important factor is that far more material is needed to make one cotton bag.