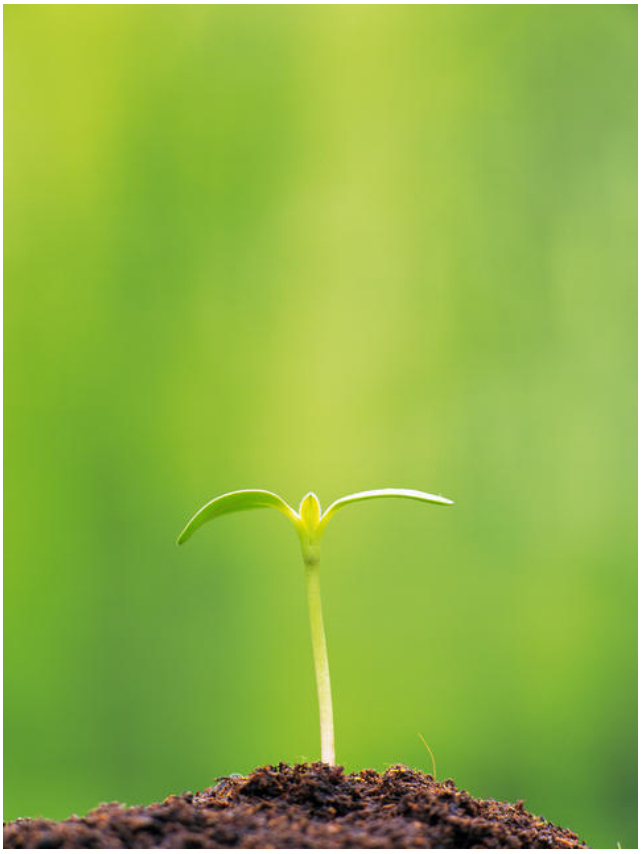
Material change for a better environment

Summary

Environmental benefits of recycling – 2010 update



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WRAP's vision is a world without waste, where resources are used sustainably.

We work with businesses and individuals to help them reap the benefits of reducing waste, develop sustainable products and use resources in an efficient way.

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Front cover photography:

Executive summary

Context

In 2006, WRAP (Waste & Resources Action Programme) published a major research report, Environmental Benefits of Recycling, based on an international review of life cycle analyses (LCA) that evaluated the impact on the environment of recycling, landfilling or incineration of key materials in UK waste streams. The review assessed 55 'state of the art' LCAs on paper and cardboard, glass, plastics, aluminium, steel, wood and aggregates. The conclusion was clear – most studies show that recycling offers more environmental benefits and lower environmental impacts than the other waste management options.

With the emergence of new waste management options and new waste streams in the last three years, WRAP has decided to update this report and ensure that policy makers and stakeholders are aware of the latest conclusions from LCA data on waste management options. The methodology behind the new report remains the same[1] – careful screening of over 200 LCAs published worldwide since 2006 against strict criteria to focus on only the highest quality analyses. However, the scope of the review was changed in several ways:

- New waste management technologies were added: composting and energy from waste (EfW) technologies such as anaerobic digestion, pyrolysis and gasification.
- New waste streams/materials were added: food waste, garden waste, textiles and biopolymers
- Some materials were excluded from further analyses - aluminium, steel, glass and aggregates – as the results of the first study (that recycling is the preferred waste management option for these materials) are not impacted by the new technologies.

In summary, the material / technology combinations of this study is shown in the following table (those included in the first report are highlighted in grey)

	Recycling	Composting	Incineration	Landfill	Anaerobic digestion	Pyrolysis	Gasification
Paper and card	x		x	x			
Plastics	x		x	x		x	
Biopolymers	x	x	x	x	x		
Food and garden waste		x	x	x	x		
Wood	x		x	x			
Textiles	x		x	x			

The key impact categories used for the assessment of the different waste management options were:

- depletion of natural resources
- climate change potential
- cumulative energy demand
- water consumption

[1] The criteria used for the selection were: (i) the study had to be an LCA or LCA-like; (ii) includes a comparison of two or more end-of-life scenarios for the material fraction under study; (iii) representation of recycling or composting among the waste management options assessed; (iv) robustness of the publication, either peer reviewed or published in a scientific journal: (v) transparency in the assumptions made; (vi) primary research and not a review of previous work; (vii) no ambiguity in the way impacts are ascribed to materials; (viii) plausibility of the waste management options.

Key conclusions from the LCA studies

Because of the international nature of the study, the review has attempted to interpret the results in terms of UK impact. The key parameter in this respect in the energy mix used in the scope of a specific LCA, which might be quite different from that in the UK. The key conclusions are outlined below by material/waste type.

Paper and cardboard

- The results of the first study are confirmed in that landfilling of paper and cardboard is the least preferable option, particularly from a climate change potential and energy demand perspective.
- The comparison between recycling and incineration appears more complex, as better energy recovery efficiencies have been built into the more recent LCAs. In general, the data shows that recycling is preferable for energy demand and water consumption, but they are comparable for climate change.
- The key parameter affecting the comparison between these two alternatives is the energy mix used in recycling and virgin paper manufacture. Where the energy recovered through incineration replaces the use of fossil fuels (as in the UK), the environmental benefits are augmented, especially with regard to climate change potential and depletion of natural resources.
- The type of paper and card also has a significant influence. For example, it is more beneficial from an environmental point of view to recycle high quality products such as office paper.
- Looking to the future, as the UK moves to a lower carbon energy mix, collection quality improves and recycling technology develops, then recycling will become increasingly favoured over energy recovery for all impact categories

Plastics

- The results confirm that mechanical recycling is the best waste management option in respect of the change potential, depletion of natural resources and energy demand impacts. The analysis highlights again that these benefits of recycling are mainly achieved by avoiding production of virgin plastics.
- The environmental benefits are maximised by collection of good quality material (to limit the rejected fraction) and by replacement of virgin plastics on a high ratio (1 to 1).
- Incineration with energy recovery performs poorly with respect to climate change impact, but pyrolysis appears to be an emerging option regarding all indicators assessed, though this was only analysed in two LCA studies.
- Landfill is confirmed as having the worst environmental impacts in the majority of cases.
- As the UK moves to a lower carbon energy mix, recycling will become increasingly favoured.

Biopolymers

- Although biopolymers are only just emerging in the various waste streams, the limited data shows the good environmental performances of mechanical and chemical recycling regarding energy demand, depletion of natural resources and climate change potential.
- However, for LCA studies that did not consider recycling as an option in the analysis, the data shows that incineration is a preferred option.
- A main advantage of biopolymers that is often highlighted is the fact that some of them are degradable or compostable. Nevertheless, the analysis pointed out that composting does not appear to be advantageous for energy demand and depletion of natural resources compared to the other alternatives.
- Two studies also assessed anaerobic digestion. The results for these scenarios showed that anaerobic digestion performs better than composting regarding both indicators analysed, climate change potential and energy demand. The advantage of anaerobic digestion over composting comes from the recovery of the biogas produced via electricity and heat production.

Food & garden waste

- Anaerobic digestion probably qualifies as the most preferable option, especially for climate change potential and depletion of natural resources. However, this conclusion should be caveated by the fact that this option was included in less than half of the selected studies.
- Composting brings benefits as a result of the compost that can be used as a substitute for products such as peat or fertilisers. However, as composting is not associated with energy recovery, it generally does not perform well compared to the other options for depletion of natural resources and energy demand.

- Following anaerobic digestion, composting and energy recovery are generally comparable in their contribution to climate change potential.
- The analysis also highlighted that home compost bins should be properly managed (aerated and with a mix of input materials) to avoid anaerobic conditions forming, leading to methane emissions.
- Incineration with energy recovery presents another good environmental performances for the four indicators, despite the relatively low heating value. The key parameter, especially regarding climate change potential, is the energy mix. The benefits brought by incineration are greater if the energy produced substitutes fossil energies.

Wood

- Based on the lack of published LCAs, recycling of wood waste has been given little attention by LCAs practitioners. As a result, a comparative analysis between the waste management options for wood waste could not be conducted.
- However, from the data available, the key conclusion is that incineration with energy recovery is preferable for energy demand while recycling is preferable for climate change potential. On the other hand, landfill is to be avoided due to the associated methane emissions. Analysis of a larger set of indicators would be required in order to be able to come up with reliable evidence of the benefits of wood recycling.

Textiles

- There is a large gap in terms of LCAs conducted over the waste management options for textiles. Of interest is that no study assessing “closed loop” recycling whereby recycled fibres are used in the manufacture of new clothing has been found.
- Despite this lack of data, four studies were reviewed to provide a qualitative comparison of the environmental impacts of different options. The overall conclusion is that textile recycling brings substantial environmental benefits. The scale of the benefits mainly depends on the recovery routes and the material production that is avoided.

General conclusion and recommendations

This report reinforces the key conclusion of the first report that recycling of paper / cardboard, plastics and biopolymers for most indicators assessed gives more environmental benefits than other waste management options. For wood and textiles, more studies are needed to be able to make firmer conclusions regarding the environmental benefits of recycling for these materials.

There were a disappointing number of LCAs which included an assessment of more innovative technologies such as gasification, pyrolysis and anaerobic digestion. This probably reflects the requirement for a lot of process data to model a particular option, which can be sparse with the newer technologies. However, the results of the few selected studies that included anaerobic digestion and pyrolysis are very encouraging.

There needs to be a stronger evidence base on certain materials (textiles, biopolymers and wood) and the more innovative EfW technologies. LCA studies need to focus on a larger set of indicators rather than only on climate change potential or energy demand. There are also LCA methodological issues needing clarification, such as the treatment of biogenic carbon and the time period considered for landfill impacts, that can help the comparison of waste management options.

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