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Municipal solid waste as a resource: part 1 – specifying composition

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Waste is a complex societal problem and its management brings together various stakeholders. However, lack of sufficient information on the quantities and types of materials in the waste stream can make sustainable waste management difficult. Since waste in one sector can be valuable as a resource in another, there is a need to understand the distribution of materials within the resource stream, especially those that go to landfill. Current work is seeking to address this: whereas much material is already recycled, this is not the only management option and there remain several problematic materials and components that need to be removed from residual waste. This paper, the first of two case studies, presents a more comprehensive waste composition specification to improve the management of municipal waste. In developing the approach, waste composition specifications currently in use were reviewed and compared with the solid municipal waste collected at community recycling centres and from kerbsides. Key primary and secondary descriptors for the better management of resources arising from municipal waste were determined and the impact of these changes on the information arising from composition analysis is discussed.

1. Introduction

Waste is a complex societal problem, and one that requires urgent attention. At the same time, there is growing appreciation that the supply of feedstocks is finite and while there may be natural reserves of various materials, they may not be easily accessible or cost appropriate to reprocess. For example, new and more efficient processes are required to extract iron from low-grade ore and hence there is an interest in securing a supply of 'pure' recycled material (Müller *et al.*, 2006). On the other hand, the municipal sector needs to reduce waste sent for residual treatment (e.g. landfill), both to meet recycling targets and to avoid the high cost of gate fees for such treatments. The latter is a significant budgetary problem as gate fees are increasing rapidly (Wrap, 2013) and significant resources are being squandered that could be returned to the supply chain.

In many ways, the industrial sector is further ahead than local governments in closing the material loop (Desrochers, 2000), and there is significant scope for them to act (Greenfield, 2013). Current work at Surrey County Council (SCC) is seeking to take advantage of potential resources within the residual waste stream to provide sustainable management practices. In a classical view of sustainability, three elements need to come together – economic, social and environmental. It must be remembered that sustainability is a property of the system, not a property of the material (Mitchell *et al.*, 2004), and so all three elements must be considered when comparing management options.

In this, the first of a two-part paper, a case study is presented that reviews the composition of waste managed by SCC (collected at community recycling centres (CRCs) and from from the kerbside) in order to better understand what materials are still present after a range of recycling and waste reduction initiatives have been in place for several years. Having undertaken this study, the results were used to inform a programme designed to remove a problematic component of the resource stream; this work is presented in a separate paper.

The structure of the current paper is as follows. Section 2.1 reviews the available literature on composition analyses in order to understand the current problems faced by the waste management industry. Further, it explores the importance of a standardised specification for this industry. Section 2.2 considers the role of international and national legislation in influencing the UK waste industry and Section 2.3 presents

Surrey as the case study area. Subsequently, a comparison of current composition specification data, including that from local authorities, government and industry, is presented in Section 3. This leads to the development of a standardised specification. The potential of this specification to be used more widely is also discussed. Section 4 concludes the paper and makes recommendations for the waste industry.

2. Background

2.1 Closing the loop

Archaeological dating often relies on the analysis of waste associated with communities. Historically, in relatively small communities, waste was predominantly biodegradable and easily managed. Increasing population densities and access to more durable materials such as ceramics and metals have led to more complex relationships with such goods, with reuse or recycling (usually) being more favourable than disposal (Seadon, 2006). However, the industrialisation of society inevitably meant that goods became intrinsically less valuable (Bulkeley *et al.*, 2005) and a willingness to 'make do and mend' was replaced by a 'throwaway culture'. An alternative paradigm is that waste has value as a resource (Cooper, 2013; Mathews and Tan, 2011).

Industrial ecology, and in particular industrial symbiosis, is central to developing such a paradigm shift. Industrial ecology can be defined as 'a field of study concerned with the inter-relationships of human industrial systems and their environments' (Seager and Theis, 2002). This suggests that an industrial system requires inputs and generates outputs, much like a biological ecosystem. Developing this further, industrial symbiosis suggests that if one organism can make use of another organism's waste, then this can also occur within an industrial system (Korhonen *et al.*, 2004). This approach seeks 'to optimize the total materials cycle from virgin material to finished material, to component, to product, to waste product, and to ultimate disposal' (Jelinski *et al.*, 1992) with the intention of producing a 'more elegant, less wasteful network of industrial processes' (Erkman, 1997). More formally then, industrial symbiosis can be defined as 'the part of industrial ecology [that] engages traditionally separate industries in a collective approach to competitive advantage, involving physical exchange of materials, energy, waste and by-products' (Chertow, 2000). It is important to note that closed-loop systems are not new and it would be a mistake to assume that the manufacture and industrial use of products is fundamentally mismanaged (Desrochers, 2000).

This paper approaches industrial symbiosis from the perspective of local authorities, who are responsible for the collection and disposal of municipal solid waste (MSW) from households. MSW is considered as all types of waste generated by households managed by the waste collection authority. This also includes any commercial premises where the composition of the waste is similar to that of households (Defra, 2011a). The challenge for local authorities is to engage more effectively in the supply chain to secure and improve value from the resources within it. This can be achieved either by working together with designers and manufacturers to influence upstream activities or by actively operating within downstream activities (see Figure 1).

For local authorities, developing new ways of working is made more difficult by a lack of knowledge about the materials that are being discarded. MSW composition has changed significantly since the initial records of the 1930s and 1940s (Bridgewater, 1986: Coggins *et al.*, 1994) and thus there is a need to change the way this waste is recorded. A number of significant (governmental) composition studies have taken place since the 1990s, particularly in response to the implementation of the Environmental Protection Act 1990, from which the first recycling targets were devised. The national household waste analysis project was the most comprehensive of its type (DoE, 1994a, 1994b, 1994c), classifying household waste at the

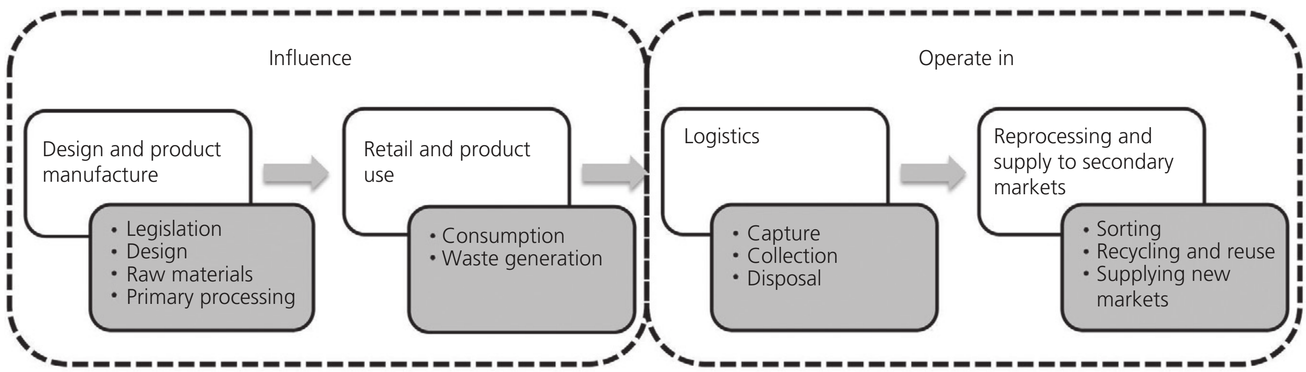

Figure 1. Aspirational roles of local authorities to work more effectively within the supply chain

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national level. It was also used to inform the first waste strategy for England some 6 years later in 2000. However, this study has been criticised by Burnley (2007) for excluding electrical and hazardous waste streams (which can be costly to the local authority) and also for the exclusion of CRC site data (which is a significant proportion of UK household waste). In addition to this, Burnley *et al.* (1997) also suggest that many of the early composition studies, including those by Jones *et al.* (1996) and the Environment Agency (EA, 1996) were limited in their scope, and did not address the entire MSW stream in a 'systematic manner'.

Often, composition specifications have to balance the number of material categories with the cost of conducting an analysis of the waste stream (DoE, 1994c). Inevitably, as the number of material categories increases, so too does the cost. This is reflected by the significant variability in composition analyses conducted by different local authorities and between the same local authority at different times. With no standards provided by international or national bodies, each local authority devises their own waste specification. Consequently, there is often poor comparability between studies (and organisations), both temporally and spatially (DoE, 1994c). However, this variability also mirrors changes in lifestyle, culture and consumption habits, as well as reflecting modifications to manufacturing processes and advances in the design of goods (Beigl *et al.*, 2008; Coggins *et al.*, 1994).

Using the term 'waste' to classify material streams arising from households is understandable, but it represents a mind-set that is potentially closed to the opportunities they present as a potential resource. This suggests that such an approach is neither appropriate nor helpful (Pongracz and Pohjola, 2004). By placing a value on what is traditionally viewed as waste, it is possible to generate revenue or save money directly, reduce the environmental burden and ensure a sufficient standard of living for the community. Thus, there is a need to provide recommendations to local and national governments regarding a standardised specification for MSW categorisation in order to support the transition to a more resource-conscious and sustainable approach. This, however, is simpler to say than to do.

One of the key barriers to effective management of any resource stream is a lack of good-quality data in relation to its type and quantity. In addition, it is not always easy to understand how such a potentially complex mix of materials fits within national and international legislation and guidance.

2.2 Geo-political considerations

European law is the main driving force behind changes in UK waste management. Policies from European Union (EU) directives are devolved to UK local authorities with the purpose of defining waste and setting guidelines for its management. The 'waste hierarchy' is one of the most significant tools outlined by these directives (EC, 2008), encouraging sustainable development by placing emphasis on the preservation of resources over inefficient reprocessing or management (e.g. energy from waste (EfW)) or 'permanent' disposal (e.g. landfill). In support of this is a useful matrix of management options for MSW proposed by Greenfield (2013), which could be used to prioritise interventions. This is not a new ideology, given that industrial ecology has been occurring in industry for centuries (Desrochers, 2000). However, it demonstrates the importance of understanding what the constituents of the resource stream are, particularly when the integrity of the resource and the price commanded are significantly impacted by the quality of that material. For example, the current UK price obtained for mixed plastic is between £60/t and £125/t, but separating the plastic into grades (e.g. high-density polyethylene (HDPE) natural and HDPE coloured) can command significantly higher prices of £160/t to £420/t (Lets Recycle, 2014a).

Traditional composition analyses are carried out on a bi- or tri-annual basis to determine what materials are disposed of as part of the household waste stream (MEL, 2010). They are based on a specification of waste types, generally comprising primary waste descriptors representative of the broad category of waste and secondary descriptors that represent specific types of material or specific goods. For example, a primary descriptor might be paper and the corresponding secondary categories could be low-quality recyclable, high-quality recyclable, non-recyclable and so on. More often than not, the secondary descriptors are of most value to local authorities because they provide a detailed evidence base in order to

- understand what materials have been collected for treatment each year
- evaluate the success of recycling and reduction campaigns
- understand the amount and composition of materials that were recycled
- inform decision-makers of priority waste streams
- inform future waste management strategies, particularly with respect to the extraction of value.

In order for local authorities and other members of the waste industry to work together effectively, there needs to be agreement on the categorisation and terminology surrounding waste management (Coggins *et al.*, 1994) as well as a focus on resources (EC, 2008). In that sense, current specifications are not fit for purpose due to a lack of standardisation (Fehr *et al.*, 2006; Lisa and Anders, 2008; Parfitt and Flowerdew, 1997). The creation of a composition specification that presents waste streams as a resource in material-based categories allows for a better understanding of the opportunities available to local authorities. In turn, this enables them to make sustainable management decisions based on a strong evidence base

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(Pongracz and Pohjola, 2004; Qu *et al.*, 2009). Khan and Burney (1989) suggest that this will allow for a better understanding of available opportunities to meet reduction and recycling targets. This is particularly important when considering the principles of industrial symbiosis coupled with the shifting roles that local authorities may need to occupy in the supply chain, as indicated in Figure 1.

Beigl *et al.* (2008) suggest that information concerning the type and quantity of waste is the minimum required for local authority decision-makers (Ogwueleka, 2013). This is because it can

- provide an indication of the opportunities available for service improvements and operational optimisation, and
- aid with the design and planning of collection systems and other infrastructure (Qu *et al.*, 2009).

Khan and Burney (1989) state that 'the success of any (…) recycling effort is directly related to the accurate determination of solid waste composition'. This is supported by Coggins (2009) who suggests that 'if you do not, or cannot measure it, you cannot manage it'. Additionally, comprehensive specification data can help estimate material recovery, identify waste sources and allow for improved compliance with legal requirements (Fehr *et al.*, 2006; Gidarakos *et al.*, 2005; Joos *et al.*, 1999; Lisa and Anders, 2008; Sfeir *et al.*, 1999). Indeed, according to Lebersorger and Schneider (2011), current waste specifications are 'insufficiently described and not reproducible by a third party'. This makes cross-organisational comparisons problematic and detailed analyses of changes in year-on-year compositions impossible. It is thus essential that there are sufficient secondary descriptors, supported by data on quantities, to make a meaningful assessment of the composition of resource streams. Hence, a standardised composition specification will allow for

- targeted prevention and recycling schemes and their monitoring
- informed decision-making on facilities and infrastructure
- improved financial outcomes for local authorities
- collaborative efforts between authorities and industry.

In summary, the use of a standardised specification will have positive environmental, financial and social impacts.

2.3 Surrey County Council

Surrey is a county in southeast England, covering 167 000 ha with a population of around 1·2 million (2014 estimate). It comprises 11 districts and borough councils and a county council, which have a variety of management procedures. To some extent, this is due to the variation in population density: some boroughs, such as Guildford, have a comparatively high urban population, whereas Mole Valley has comparatively few conurbations and the population is dispersed in rural settlements.

Surrey County Council (SCC) is Surrey's waste disposal authority and it arranges the disposal of MSW collected by the 11 district and borough councils who are the waste collection authorities. SCC also provides 15 CRC facilities. SCC has an ambition to be a world leader in waste management by working sustainably and taking action to prevent climate change.

2.4 Summary

This section has discussed the potential benefits of having a standardised composition specification, to identify the material composition of waste generated by households. It has shown that such a specification could facilitate the effective and sustainable management of this resource. The remaining sections of the paper address how a standardised specification could be developed and considers its application to the case study area of Surrey.

3. Standardised specification

As stated in Section 2.2, there is currently no material or other standardised specification available for the analysis or presentation of the composition of MSW. This presents a significant barrier to the effective management of the available resource because opportunities can be missed, particularly when efficient management is dependent on there being a critical mass of material. Ultimately, an international standard may be useful when attempting to track the flow of particular waste streams around the world. However, as there may be local differences in composition, arising from different consumption habits and the capacity to collect data (Beigl *et al.*, 2008; Coggins *et al.*, 1994), the focus here is on the UK and MSW. Within the current context, this limits the effect of cultural differences on the composition data collected.

Local authority composition specifications from locations across the UK were collected and additional data were gathered on material grades and acceptance criteria (related to material quality) from operators of reprocessing facilities. Furthermore, current UK waste policies from organisations including Waste Resources Action Plan (Wrap) and the Department for Environment, Food and Rural Affairs (Defra) were reviewed. The different sources of information are summarised in Table 1. It can be seen that, in the case of Surrey, two different specifications are used to identify the composition of materials at CRCs and materials collected from the kerbside. As with the other compositions, this makes aggregation of materials and comparison between the two problematic (Burnley *et al.*, 1997). Thus, determining the critical mass of materials is difficult, which in turn can cause inefficiencies in the management system as a whole.

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Organisation	Data type	Year	Measure/process of interest	Comment/source
Local authorities				
Bristol City Council	Specification	2009	Kerbside collected waste breakdown	BCC (2009)
North Somerset Council	Specification	2009	Kerbside collected waste breakdown	NSC (2009)
SCC Household Waste Recycling Centres	Specification	2007	Waste composition analysis for household waste recycling centres	MEL (2007)
Surrey Waste Partnership Kerbside	Specification	2010	Waste composition analysis for kerbside collected waste	MEL (2010)
West of England Partnership	Specification	2009	Jacobs; kerbside collected waste breakdown	WoE (2009)
On behalf of local authorities				
Axion Consulting	Report	2012	Kerbside collected waste breakdown	SCC (2012a)
Oakdene Hollins Consulting	Report	2012	Household waste recycling centre waste breakdown	SCC (2012b)
Policy				
Defra	Report	2012	Wood grade classifications	Defra (2012a)
Scottish Environmental Protection Agency	Specification	2008	Waste composition analysis for residual material analysis	Sepa (2008)
Waste Data Flow	Materials analysis and reporting	2011	Waste composition analysis for recycled materials	WDF (2011a, 2011b)
Waste Resource Action Plan	Report	2012	Rigid plastic classification	Defra (2012a)
Reprocessor and industry specifications				
Confederation of paper industries (EN643)	Specification	2002	Paper breakdown and reprocessor standards	Lets Recycle (2013)
Defra	Report	2009	Suggested categorisations for key kerbside material streams.	Defra (2009)
Recoup plastic categorisation	Report	2009	Product specific polymer breakdown	Recoup (2013)
Sita UK	Specification		Materials recovery facility acceptance criteria	
Resource Association	Specification	2014	Recycling quality specifications	Resource Association (2014)

Table 1. Review of waste composition data

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Source	Specification													
	Paper and card	Plastics	Glass	Textiles	Metals	Wood	Offensive waste	WEEE	Putrescible	Hazardous	Miscellaneous combustible	Miscellaneous non-combustible	Miscellaneous reusable	Total
SCC (2012a)	✓	✓	✓	✓	✓									4
BCC (2009) and NSC (2009)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	13
Lets Recycle (2013)	✓													1
Defra (2009)	✓								✓					2
SCC (2012b)					✓	✓		✓		✓	✓	✓		6
Recoup (2013)		✓												1
Resource Association (2014)	✓	✓	✓	✓	✓	✓		✓			✓			8
Sepa (2008)	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓		10
Sita UK (2013)	✓													1
MEL (2007)	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓		10
SCC (2008–2012) HWRC reporting lists for waste arisings. Available on request for SCC. SCC, Kingston upon thames, UK	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓			10
MEL (2010)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			11
WDF (2011a, 2011b)	✓	✓	✓	✓	✓	✓		✓	✓		✓		✓	10
Defra (2012a)						✓								1
WoE (2009)	✓	✓	✓	✓	✓				✓	✓	✓	✓		9

Table 2. Variations in primary descriptors used

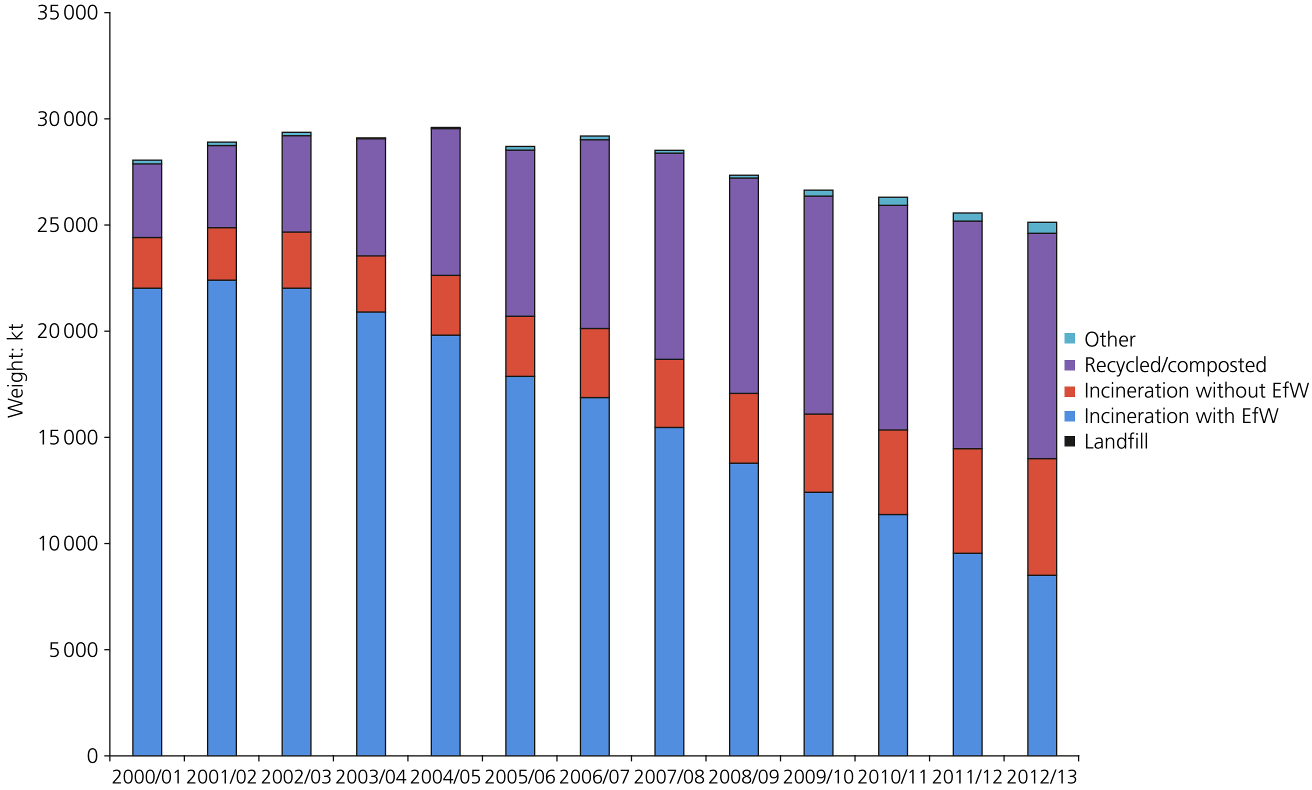

Figure 2. Local authority collected waste by management method, England, April 2000 to March 2013

It is clear that separate organisations are using a range of descriptors to cover what are essentially the same wastes and are also applying identical descriptors to what are different materials; variations in the primary descriptors used are presented in Table 2. It can be seen that not all specifications are based on the same number of primary descriptors. The reason for this is that some materials, for example, offensive wastes could be hidden within another primary descriptor, for example, miscellaneous combustibles. Additionally, categories such as 'offensive' and 'miscellaneous reusable' may not have been considered as a primary descriptor when these local specifications were first devised. However, as EU legislation suggests recycling rate targets of up to 70% (EC, 2014), problematic categories of materials are becoming of interest for local authorities. Legislation, including the EU waste framework directive (EC, 2008), and associated initiatives such as the waste strategy for England (Defra, 2007, 2011b), have been relatively successful in encouraging the capture of easily reprocessed material such as paper, metals, glass and some plastics. Hence, it becomes increasingly important to categorise the composition of residual MSW more consistently and precisely.

By contrast to local authority derived specifications, policy-led specifications and those from the reprocessing industry often describe categories in detail at the secondary level and therefore consider fewer primary descriptors (typically between one and four). For example, the Recoup (2013) specification has the primary descriptor 'plastics', along with nine secondary descriptors. Such secondary descriptors are essential because not all materials can be reprocessed in the same manner. In order to make best use of the resource, it is important to know when aggregation hidden within a primary descriptor compromises the ability to identify potential feedstocks from waste. For example, the 'plastics' category can have many different polymers concealed within the primary descriptor, ranging from low-density polyethylene (LDPE) to polyethylene terephthalate (PET). Each polymer has a different set of properties that affect the ability to recover it from the resource stream for reprocessing and subsequent reintegration into the supply chain. Secondary descriptors can capture such information and hence inform the decision-making process. In some cases, such as WEEE (waste electrical and electronic equipment), where the primary descriptor relates to a composite set of materials, the secondary descriptors are

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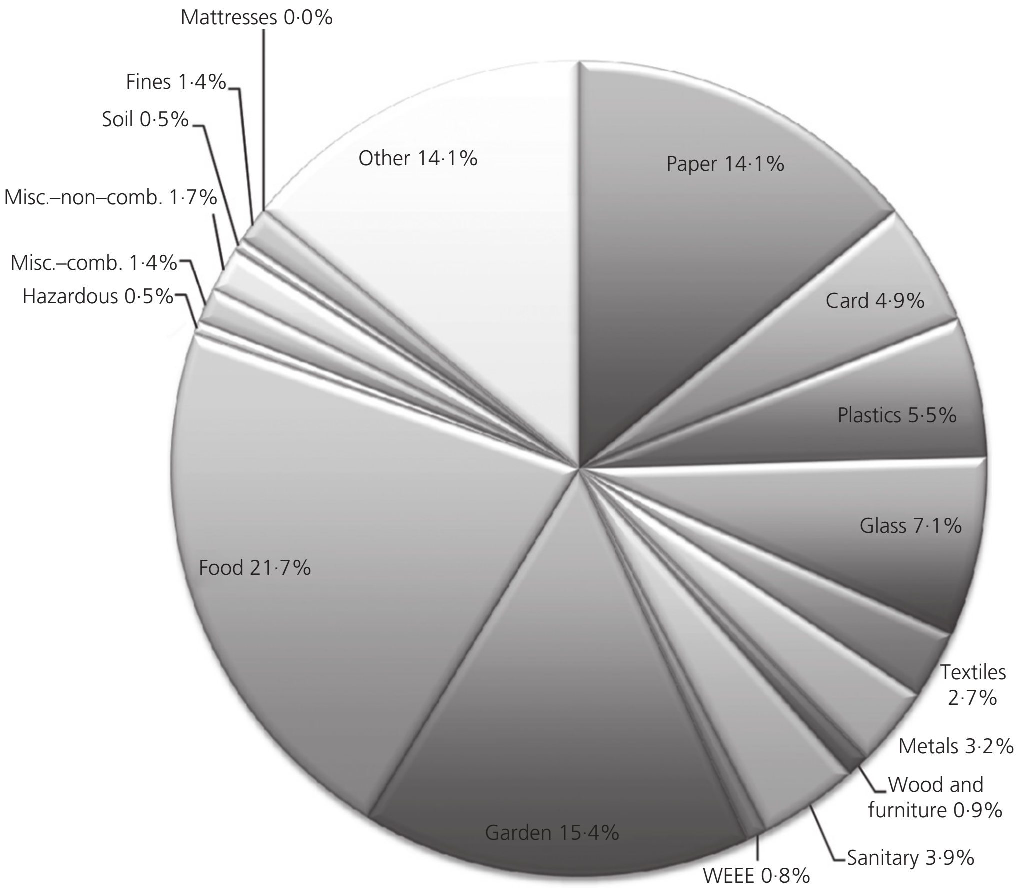

Figure 3. Local authority collected waste composition, England, April 2010 to March 2011 (Defra, 2012b)

described as goods as opposed to materials. For example, the management of cathode ray tubes is different to that of fluorescent tube lighting: both sets of goods are composed of several materials that would not be 'available' at initial collection from households. In the case of 'miscellaneous reusable', two sets of goods were found to be identified by name, these were 'videotapes, CDs and DVDs' and 'bicycles'. A third was 'list all others', which is where the majority of reusable goods that do not reside in other categorisations are placed. 'List all others' was found to be a common category in the specifications when it came to one-off reusable items and, as previously discussed, the financial implications of having numerous secondary categories for all goods (that may not appear in the composition) would not be economical.

Figure 2 shows the changing proportion of treatment methods for all local authority collected waste in England over the period 2000 to 2013. The figure shows that the overall total weight of MSW is decreasing, but a significant quantity of this material is still being treated through either incineration (with energy recovery) or landfill. Figure 3 shows a more detailed composition of MSW produced in England in 2010 to 2011: 14·1 wt% of the total waste was classified as 'other', a term used to cover all the waste that could not be otherwise accounted for in other categories. This is significant because it represents almost 2·5 Mt of material. While it might be anticipated that there may be fluctuations in this quantity from year to year (Coggins, 1997), this is a significant mass of material that is currently difficult (if not impossible) to target and manage in the most effective way. Figure 4 shows the equivalent composition for Surrey in 2010 to 2011. In this case, some 28 wt% of the total material was recorded as 'other' waste; again highlighting the need for a composition specification that ensures all materials are captured as part of primary and secondary categories.

Table 3 shows the standardised specification produced in this study. It includes information regarding the changes made

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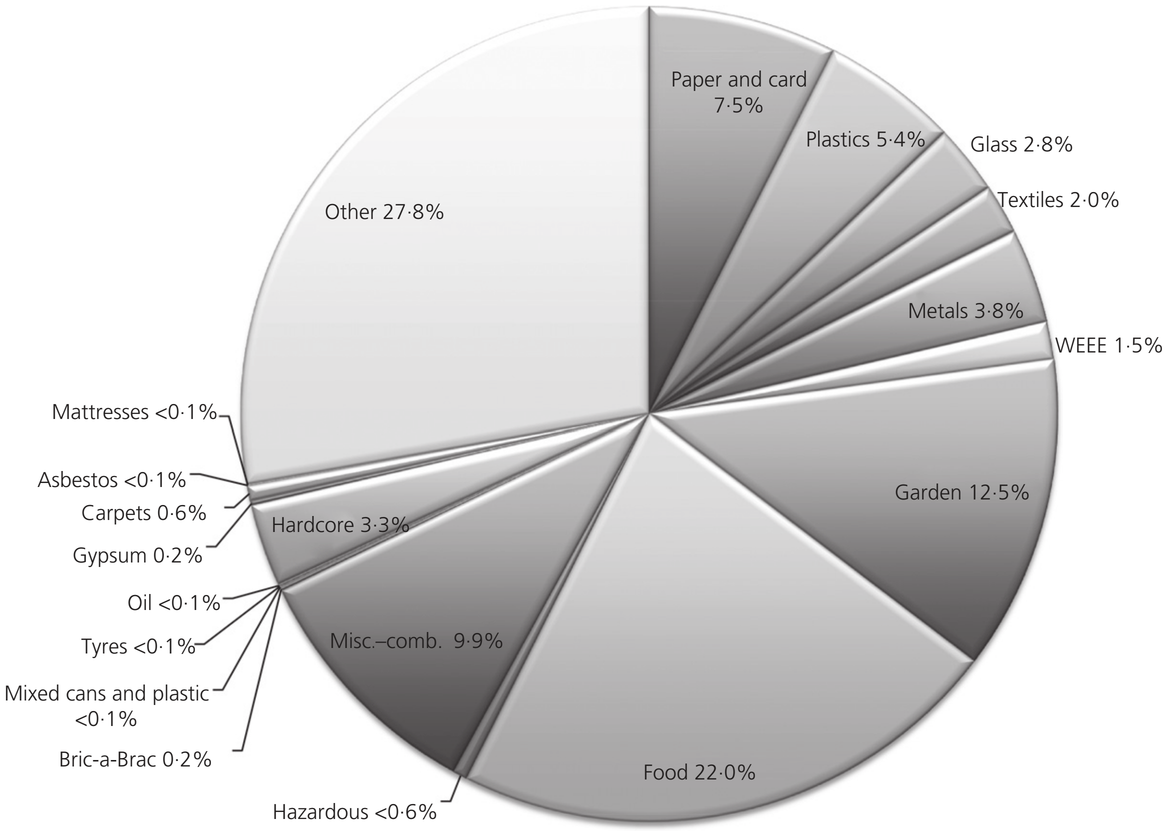

Figure 4. Aggregated kerbside and CRC collected waste composition, Surrey, April 2010 to March 2011

from the initial 2007 (CRC) and 2010 (kerbside) specifications used for Surrey to the standardised specification that is being used (2013 to 2014). In Table 3 there are some categories that do not appear in either of the previous specifications. For example, 'wood' waste was originally grouped with 'miscellaneous combustibles' as a secondary descriptor. However, with over 20 000 t/year of wood available in Surrey, it was necessary to have a separate primary descriptor, coupled with five secondary categories, to allow for effective management.

Furthermore, Table 3 lists other categories that have been expanded from the previous specifications. An example of this is the expansion of the 'paper and card category' to include 'low-quality recyclable' paper (10·7 wt% total waste in Surrey) and 'medium-quality recyclable' paper (4·7 wt% of total waste in Surrey). The benefit of this is that the value that can be obtained from knowing the different categorisations can be substantial: UK prices (as of August 2014) were £34/t to £52/t for mixed paper, but £82/t to £90/t for 'low-quality recyclable' and £122/t to 127/t for 'medium-quality recyclable' paper (Lets Recycle, 2014b). A significant benefit of the new specification for SCC is that it covers materials disposed of by households at both the kerbside and CRCs, and thus eliminates any data aggregation issues (DoE, 1994a, 1994b, 1994c).

Figure 5 shows the results of the November 2013 phase of SCC's composition analysis using the specification outlined in Table 3. It should be noted that some seasonal variation in the proportion of waste collected is usually observed and so direct comparison with Figure 4 is difficult. However, the results in Figure 5, although only a part of a full year's collection, are useful in understanding the importance of removing the 'other' descriptor because specific changes within material streams can be identified. Additionally, it allows local authorities to better understand the composition of residual waste, enabling material-specific and targeted approaches to improve waste management (Joos *et al.*, 1999).

Once primary and secondary descriptors are in place, there remains a need to establish the absolute quantity of any resource that resides within the waste stream (Boer *et al.*, 2010). This is because knowledge of percentage compositions on their own

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Primary	Secondary
Paper and card	Low-quality recyclable [b]
	Medium-quality recyclable [b]
	Non-recyclable
	Liquid cartons
	Corrugated cardboard
	Other card packaging
	Wallpaper
	Books
Plastics	PET (polyethylene terephthalate) [a]
	HDPE (high-density polyethylene) [a]
	PP (polypropylene) [a]
	PS (polystyrene)
	Black pots, tubs, trays [a]
	LDPE (low-density polyethylene) [a]
	Dense plastic and PVC (polyvinyl chloride)
Glass	Clear
	Amber
	Green
	Non-packaging
Textiles	Reusable clothing [a]
	Other household textiles [a]
	Duvets, pillows and soft toys [a]
	Bags [a]
	Shoes
Metals	Non-ferrous packaging
	Non- ferrous aerosols [b]
	Other non-ferrous metals
	Ferrous packaging
	Ferrous aerosols [b]
	Other ferrous metals
Wood [a]	Grade A a – reusable furniture [a]
	Grade A – clean [a]
	Grade B – industrial feedstock [a]
	Grade C – fuel [a]
	Grade D – hazardous [a]
Offensive waste [a]	Nappies
	Incontinence [a]
	Sanitary [a]
	Non-infectious healthcare [a]
WEEE	Cathode ray tubes
	Fluorescent tubes/CFL
	Other light bulbs
	Fridges and freezers
	Other large domestic appliances
	Other small domestic appliances
Putrescible	Woody garden organics [a]
	Soft garden organics [a]
	Cooking oils and other liquid foodstuff
	Avoidable food
	Non-avoidable food
Hazardous	Engineering oils
	Paints and varnishes
	Batteries: household
	Batteries: post-consumer automotive
	Gas bottles [a]
	Asbestos
	Other hazardous chemicals
	Ink toner and cartridges
	Clinical waste
Miscellaneous: combustible	Tyres
	Carpet and underlay
	Vinyl flooring
	Mattresses
	Pet bedding and animal waste
	Fines
Miscellaneous: non-combustible	Rubble
	Soil
	Ceramics
	Plasterboard [a]
Miscellaneous: reusable [a]	Videotapes, DVDs and CDs [a]
	Bicycles [a]
	Other reusable (list all reusable items that appear) [b]

[a]Categories that do not appear in either of the previous specifications (i.e. 2007 CRC and 2010 kerbside)
[b]Categories expanded from previous specifications

Table 3. Standardised composition specification

Table 3. Continued

cannot allow rational and informed business decisions to be made. Figures 3 and 4 show that there are several material categories that make up less than 1 wt% of the total waste composition. In the case of Figure 3, 1 wt% of the waste accounts for 20 000 t, while in Figure 4, 1 wt% accounts for around 5000 t of material (in both cases 1 t is less than 0·0001 wt% of the total waste). The importance of understanding this is that, although a material category may represent only a very small percentage of the waste stream, it can be of substantial value (e.g. WEEE) or cost (e.g. hazardous) to local authorities, or a material could be responsible for significant environmental harm if not managed effectively (e.g. asbestos). The availability of a detailed composition such as that proposed in this work can thus have an impact on environmental issues in a number of ways. Firstly, a better understanding of what is in

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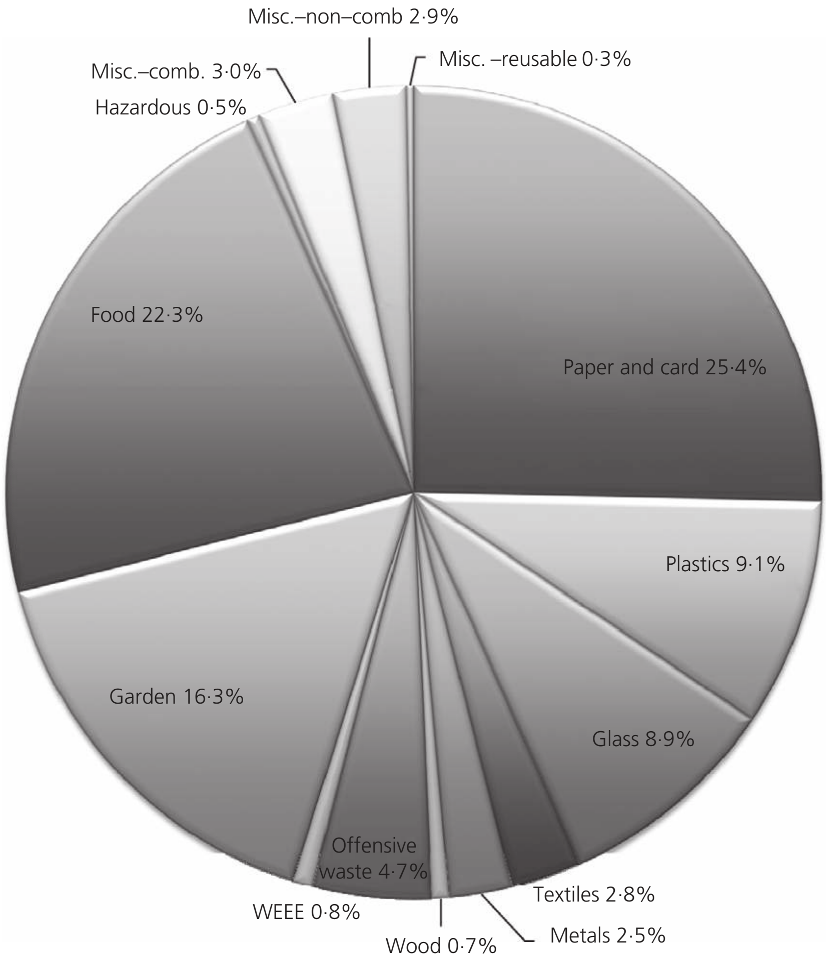

Figure 5. Initial kerbside collected waste results for Surrey, November 2013, using new specification

the waste stream can help improve recycling rates by identifying the resources that have value. Secondly, local authorities can begin to work with suppliers up the supply chain to reduce the amount of material produced (e.g. LDPE plastic film waste) and in turn work together to reduce what is thrown away.

There is thus a clear need to understand what materials are being disposed of in order to manage the resource stream represented by MSW. Effective management can help create a 'virtuous cycle' that reduces the environmental burden of waste at the same time as reducing its economic burden. As stated by Jackson (2008)

> The age of irresponsibility demonstrates a long-term blindness to the limitations of the material world. This blindness is as evident in our inability to regulate financial markets as it is in our inability to protect natural resources and curtail ecological damage.

Local authorities – and their partners in the supply chain – have the ability to influence global material resources and ecological impacts, while generating income at the same time.

4. Concluding remarks

Recycling is easy. Efficient waste management is less so and, as a consequence, opportunities to make best use of the MSW resource stream collected by local authorities are being missed. The creation of an agreed standardised specification would contribute to evidence-based decision-making with respect to sustainable waste management. With the paradigm changing to view waste as a resource, such a standardised specification becomes even more important and needs to incorporate knowledge of what constitutes a 'resource'. In turn, this allows traditionally problematic resource streams to be viewed as value-adding opportunities.

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Local authorities periodically undertake analyses of waste composition, but it is not straightforward to compare studies as they often use different descriptors when presenting their analyses. This is perhaps the greatest barrier to the effective (and sustainable) management of waste, as it becomes almost impossible to share best practice and identify strategies for separating resources within a waste stream.

Having reviewed various local authority specifications, government policy, legislation and guidance from sector bodies such as Wrap, Recoup and Sepa, it has been possible to define a new specification that balances usability with a useful depth of data. The production of a standardised specification for resource composition must follow three basic principles.

- Primary descriptor categories must provide continuity with existing composition specifications, compatibility with secondary descriptors used, and be relatively future-proof.
- Secondary descriptors must adequately reflect the full extent of the materials available in order for them to be treated as a resource; for example, within the high-level plastics category, secondary groupings that sensibly reflect management options must be identified.
- In addition to the primary and secondary descriptors, it is important to include meaningful quantitative data (in terms of both volume and mass) since these will affect the decision-making process when comparing management options.

Such a specification can usefully inform evidence-based decision-making frameworks for waste management, enabling assessment of issues such as economic value, significance of a material, and environmental and social impacts. In so doing, partners who are involved in the supply chain can not only identify new opportunities, but can also take a view as to the 'resource security' implicit in the future collection and management of the material, leading to a more sustainable use of resources.

In particular, this work has shown that there is a significant quantity of complex resource streams (e.g. absorbent hygiene products) that are overlooked because they were not fully accounted for in previous composition specifications. In identifying this opportunity to remove a component of the residual stream going to landfill or energy from waste, the next question is: What is the most appropriate method of managing this resource? This question is addressed in further work by the authors.

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