Waste Sorting Social Technology in Brazilian Informal Materials Recovery Facilities

PURSHOUSE H.[1], RUTKOWSKI J.[2], VELIS C.[1*], RUTKOWSKI E.[3], DA SILVA ESTEVAM V.[4], SOARES, A.[5],

[1] School of Civil Engineering, University of Leeds, Leeds, West Yorkshire, LS2 9JT, UK

[2] SUSTENTAR Institute for Sustainability Studies and Research, Belo Horizonte, Minas Gerais, Brazil

[3] FLUXUS Laboratory, School of Civil Engineering, Architecture, and Urban Design, UNICAMP, Campinas, São Paulo, Brazil

[4] Coopesol Leste / MNCR, Rua São Vicente, Belo Horizonte, Minas Gerais, Brazil

[5] INSEA, Rua Padre Rossini Cândido, Belo Horizonte, Minas Gerais, Brazil

*Corresponding author: e-mail: c.velis@leeds.ac.uk

Abstract - It is commonly accepted that the recycling and reuse of solid waste materials in developing countries has the potential to create many social, environmental and financial benefits. Given that the majority of recycling in these locations is carried out informally by waste pickers, it is also recognised that their inclusion into formal service provision could be the most efficient way of maintaining and increasing the recycling rates of a city. In the absence of sophisticated equipment, the informal recycling sector (IRS) has developed a wealth of self-taught knowledge and skills for manually identifying and processing waste materials. Using primary and secondary data gathered from a materials recovery facility (MRF) in Belo Horizonte, Brazil, this study describes the so called 'social technology' techniques used to sort municipal waste materials by a cooperative of informal sector recycling workers. This involves identifying and separating 17 types of plastic polymers by visual and tactile sorting skills. The methods presented are compared and contrasted with manual sorting techniques used mainly in the near past in the UK. To conclude, the study discusses whether these techniques provide a viable method for increasing recycling rates at scale in the Global South.

Keywords: Waste pickers, Informal recycling, Brazil, Materials recovery facility, Solid waste

1. Introduction

In the 21st century, the management of solid waste is still a global challenge. It is widely accepted that sound solid waste management is crucial for public and environmental health, whilst also having the potential to provide sustainable livelihoods and support economic development (UNEP & ISWA, 2015). In particular, whilst the Sustainable Development Goals (SDGs) focus on poverty reduction, and waste strategies focus on recycling, there is an interest in solutions that can address both these issues simultaneously (Wilson & Velis, 2015).

In this context, it is interesting to note that recycling rates in developing countries are sometimes comparable with those in modern Western systems, due to millions of people in the informal sector making a living from recovering and processing discarded materials (Wilson et al., 2012). These people are known as 'waste pickers' and frequently come from marginalised and impoverished backgrounds, with their work providing an important survival strategy (Medina, 2000). In addition to providing a livelihood, their work also saves money to municipal authorities, who no longer have to transport and dispose of these materials at landfill sites - a study by GIZ (Scheinberg et al., 2010) suggested that waste pickers saved municipalities across 3 cities a yearly total of €29.4 million for avoided collection costs alone. Waste pickers are also able to provide collection services to areas of the city where the municipality cannot reach, such as informal settlements (Gutberlet et al., 2016).

It is therefore commonly recognised that the inclusion and support of the informal recycling sector could be beneficial to the municipality and the environment (Velis et al., 2012). Formalisation of waste pickers into cooperative groups, and setting up contractual arrangements with the local authority for provision of collection and recycling services are good strategies towards this aim (Velis et al., 2012). These strategies can also help to mitigate the severe occupational health and safety risks that waste pickers are frequently exposed to (Gutberlet & Baeder, 2008; Lenis Ballesteros et al., 2012; Parizeau, 2015), and generally improve their working conditions and remuneration (Rutkowski & Rutkowski, 2015).

Brazil is a world-leading example of waste picker formalisation and inclusion, featuring an active civil society component, the emergence of organised networks, and formalization of waste picker groups into cooperatives and associations (Dias, 2009; Rutkowski & Rutkowski, 2015). It is alleged that the waste picker cooperative initiative not only provides environmental and economic benefits, but also nurtures a sense of community, personal development, and social inclusion (Gutberlet, 2008, 2012).

Waste pickers exhibit wide variation in their activities and abilities, but many are highly skilled individuals who add value to the materials that they process (Jaligot et al., 2016). Working with plastic materials in particular is not a straightforward task as there are many different types of polymers in use, which must be carefully separated to a certain degree of quality according to the requirements of the purchasing industry in order to be recycled (Ellen MacArthur Foundation, 2016).

As the world approaches a '4th industrial revolution' whereby automation is poised to replace millions of jobs worldwide, it is also important to note that for a country such as Brazil, where unemployment and poverty remain significant, the jobs provided by skilled, labour-intensive work such as separating recyclable materials remain important for society and the economy (Velis, 2017).

This study describes and analyses the skills of a cooperative group of waste pickers, who operate a materials recovery facility (MRF) in Belo Horizonte, Brazil. This cooperative group sorts and sells more than 29 sub-categories of material from source separated waste, including 17 different sub-categories of plastic material. This is predominantly accomplished by using self-taught visual and tactile skills. The study also describes quality control procedures, cooperative finances, and support from the wider cooperative network. The MRF is compared and contrasted with typical manual MRFs in the UK.

2. Background to Coopesol Leste

Coopesol Leste (CL) is a waste picker cooperative in the city of Belo Horizonte, Minas Gerais state, Brazil. In 2016, CL had an average of 39 members, of which 30 were female and 9 male. Members are generally from marginalised and disadvantaged backgrounds, with limited educational qualifications and restricted employment opportunities. Since 2015, CL has been contracted by the Belo Horizonte municipality (BHM) to sort and process source separated recyclables from the municipality selective collection service, in addition to providing source separated collection services to 2,491 households once per week.

The MRF was constructed for CL by BHM in 2010. The facility consists of: a main warehouse building and attached office / work room (covered area 1,404m^2); an external sorting shed (covered area 30m^2); a weighbridge; and a weighbridge office. The total site area covers approximately 4,700m^2. CL has access to the following equipment: cargo lift (not in use); 2 electronic scales; a paper shredder; 4 hydraulic presses; an electronic road scale; a fork lift; a truck; a van; a crane; storage drums and carts. The majority of the equipment (apart from the vehicles) are owned by BHM, but are loaned to CL indefinitely.

3. Method

This study explores the sorting techniques of a cooperative-run MRF in Belo Horizonte, Brazil, through primary and secondary data collection.

Sources of primary data relating to the cooperative-run MRF include site visits and observations, and unstructured interviews with workers, the cooperative management team, and BHM. Secondary data relating to equipment, plant structure, and material stocks and flows were obtained through BHM and SUSTENTAR. This includes volumes of incoming and outgoing material for 2016. Data for April - December 2016 has been used for this analysis, as data for January - March is incomplete. Basic descriptive statistics was conducted, with the median taken as average.

Data on typical UK manual MRFs was obtained from WRAP, and dates from 2006. It should be noted that data for UK facilities was collected by WRAP in 2006 and therefore does not represent the current state of the industry (which is progressing towards predominantly automated facilities, in line with Europe), but still provides a useful comparative benchmark.

4. Results

4.1 Material flows (inputs and outputs)

CL receives material from three main sources: the BHM co-mingled selective collection service, using a compactor truck; CL selective collection service (from large generators and 2,491 households); and autonomous waste pickers (AWPs), who sell material collected from the street to CL. Reject material from the sorting process is collected by BHM and transported to a sanitary landfill for disposal. **Figure 1** shows the amount of material received by CL from these sources, and the amount of material rejected. The average reject rate is 14.1%. Material is generally rejected either because it is non-recyclable (e.g. used nappies), or because the material is technically recyclable but there is no market available, or it is not economically feasible to reach that market (e.g. items made from recycled plastic are typically not accepted by local buyers for further recycling).

The material stream of highest quality (i.e. clean, and containing the lowest % of non-recyclable material) allegedly comes from the CL selective collection service and AWPs. In order to ensure the quality of source separated material received by their collection service, CL carry out periodic educational campaigns to households in their collection area. This involves visiting residents door-to-door, carrying leaflets (produced by the cooperative), and explaining directly what materials can and cannot be recycled. CL can also refuse to collect poorly-sorted material. However, CL are able to exert less control over the quality of material collected by BHM.

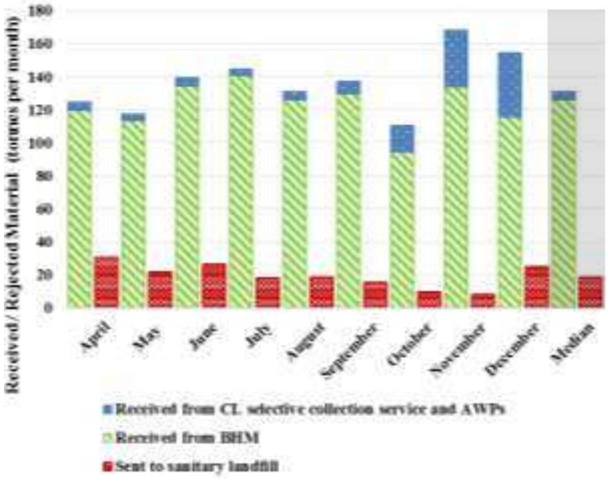


Figure 1. Municipal solid waste material received and rejected by CL per month in 2016 from different sources. The amount of material received in November/ December was above average due to two companies discarding an unusually large amount of paper. Please note this graph does not show a reconciled and fully balanced material flow analysis (i.e. no stocks considered).

4.2 Sorting procedure

The main warehouse has a truck unloading area, where the municipality deposits material from the compactor trucks and CL workers separate large objects. The material is then pushed down a slope (approximately 20 degrees), and stacks up at the bottom against a grate. CL workers pull material through the grate and sort it into sacks. CL workers then find a space on the warehouse floor to carry out the plastics sorting stage – separating plastic materials into 17 categories. Material is compacted, baled, and stacked within the warehouse or outside until sale. A picture of the slope and grate are shown in **Figure 2**. Material collected by CL or AWPs is sorted in the external sorting shed, in order to avoid mixing it with the lower quality municipality-collected material.

4.3 Sorting techniques and knowledge

An overview of the materials sorted and sold by CL is given in **Table 1**. Identification techniques for separating the 17 categories of plastic are described and visualised in **Figure 3**, and the sub-categories are described in **Table 2**. Experienced workers tend to learn and memorise the polymer types of various products, rather than performing identification tests on each piece of waste that they handle.

Figure 2. CL MRF – view from truck unloading area down slope, to grate and warehouse floor.

Table 1. Material sub-categories sorted and sold by CL

Material	Sub-Categories
Paper and cardboard	7
Plastic	17
Glass	1
Metal	4
WEEE	Varies

4.4 Quality of products

The final quality of materials is directly negotiated with CL by the buyers, who typically inspect the warehouse and sorting procedure to determine the likely quality of the end product, and can make specific requests (such as removing labels and caps from bottles) to adjust the sorting process to their requirements. Buyers also visually inspect bales before purchasing, and may refuse payment if bales are not to their required quality. Contracts and quality requests are generally specified verbally, and not written down.

4.5 Sales and finances

In 2016, CL received an average of $12,000 USD per month for material sales, and $1,000 USD from collection services. Each CL member works 8 hours per day, 5 days per week, and receives an average monthly salary of $290 USD, that is in excess of the Brazilian minimum wage. CL receives substantial in-kind support from Belo Horizonte municipality, including payment of electricity and water bills, transporting of materials, disposal costs, and free access to equipment and premises. In kind support is also received from NGOs, who provide training and support to cooperative members. Significant expenditures for CL include transport of materials (both from donors and to buyers), and worker wages.

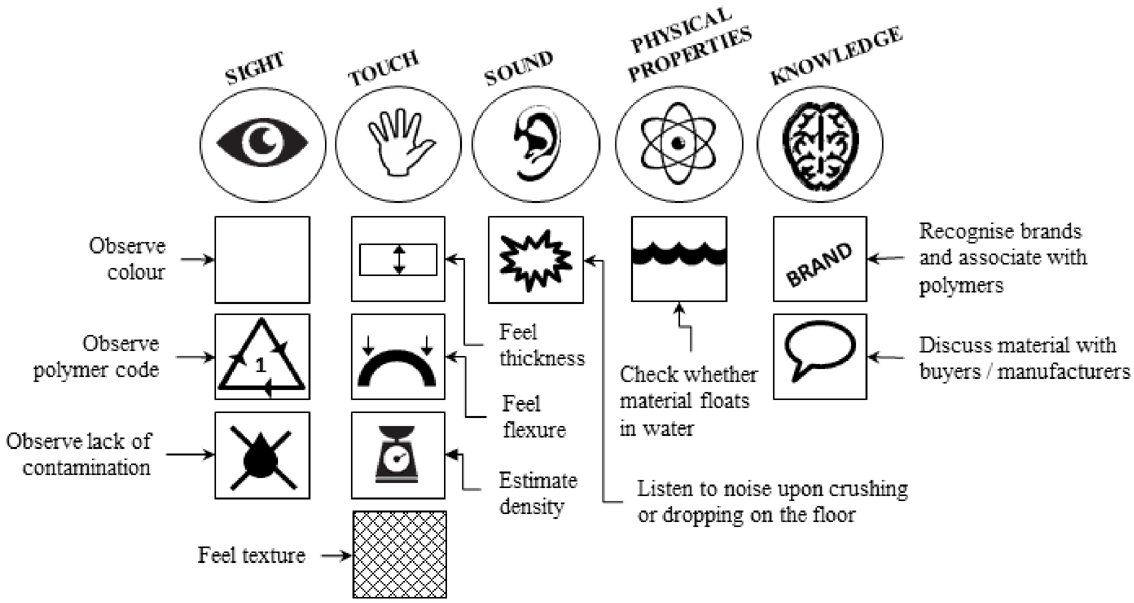
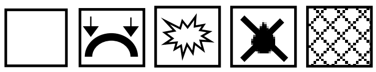
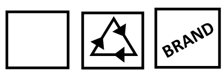
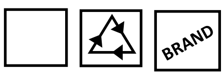
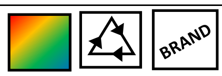
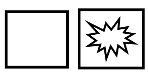
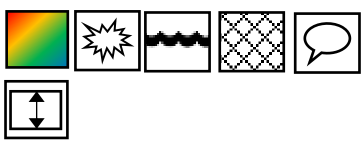
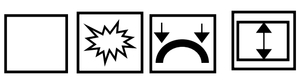
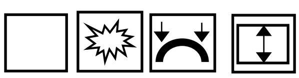
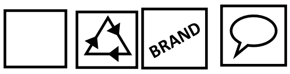
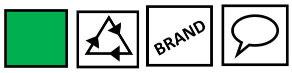
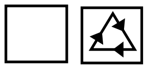
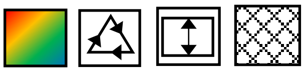
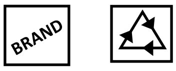
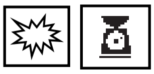


Figure 3. Techniques used by CL to distinguish plastic sub-categories.

Table 2. Plastic sub-categories manually sorted and sold by CL and material identification techniques.

Plastic Kind	**Description**	**Identification Techniques**
White or transparent film	White and transparent plastic film - e.g. fresh food packaging, pillows packaging, appliances packaging.	
Coloured or black film	Coloured or black plastic film.	
White HDPE	Hard, white HDPE - e.g. yoghurt puts, shampoo bottles, cleaning product bottles.	
Transparent HDPE	Hard, transparent HDPE - e.g. yoghurt puts, shampoo bottles, cleaning product bottles.	
Coloured HDPE	Hard coloured HDPE.	
White PP	Hard, white PP - e.g. paint pots, cleaning buckets, food pots, chairs, tables, folders and boxes.	
Butter PP	Butter and ice cream packaging. Coloured ice cream packaging lids are generally sold separately, with the PET bottle caps or tetra pack boxes.	
Coloured PP	Hard, coloured PP - e.g. paint pots, cleaning buckets, food pots, chairs, tables, folders and boxes. Also some ice cream packaging and mineral water bottles.	
Transparent PP type 1	Jam and sweet pots with label embedded directly in plastic.	
Transparent PP type 2	Jam and sweet pots with no label embedded in plastic.	

White transparent PET	Transparent PET drinks bottles. Caps (generally made of PP) are removed, to facilitate air release and increase density of bales.	
Green PET	Transparent PET green drinks bottles. Caps are removed.	
Mixed PET	Transparent PET bottles - e.g. liquid soap, juice, mouth wash, 'Gatorade' bottles, and others.	
Coloured PET	Coloured PET bottles and packaging - e.g. liquid soap bottles, mineral water bottles.	
Oil PET	Packaging of oil and mayonnaise. These must be sold separately to other PET packaging due to oil contamination.	
Water PP	Small, PET plastic cup for drinking water.	
Caps	Bottle caps and straws.	

5. Discussion

5.1 Comparison with UK MRF

Table 3 compares data from the CL MRF with data from indicative UK MRF facilities which used to employ predominantly manual sorting techniques.

Table 3. Indicative comparison between CL MRF and typical manual UK MRF (WRAP, 2006) – general aspects and number of material sub-categories.

Aspect / sub-categories	CL MRF	Typical Manual UK MRF
Tonnes per hr per worker	0.031	0.775
Rejects (solid)	14.1%	13.5%
Paper and cardboard	7	2
Plastic	17	1
Glass	1	0
Metal	4	2

Table 3 shows that the CL MRF achieves sorting into significantly more material sub-categories for each material category in comparison to a typical manual UK MRF in 2006. The rejects rate is similar. The tonnes sorted per hour per worker is significantly lower for the CL MRF case, and could be partially attributed to the extra number of sorting categories, and to the differences in automation in the plants: even predominantly manual UK MRFs utilise as a bare minimum conveyor belts to transport material faster through the sorting process.

With regards to plastics, it is convention in the UK for MRFs to sort ‘mixed plastics’ and then send the material to a specialized plastic recycling facility for more extensive sorting, and therefore the true number of plastic sub-categories which are ultimately valorized in the UK is likely to be higher, although not necessarily as high as those achieved by CL. For example, a ‘state-of-the-art’ plastics recycling facility in Rochdale, operated by Viridor, separates incoming mixed plastics into just 8 material streams (Viridor, 2016).

It should be noted that the tactile skills used by CL to distinguish plastic polymers (e.g. examining texture, flexure and thickness of material) are potentially inhibited by wearing PPE, such as thick gloves. During site visits, it was observed that sorting workers tended to wear gloves during the first sorting stage (distinguishing the main categories of material) but not at the second sorting stage (distinguishing 17 sub-categories of plastic). There is therefore a need to consider the appropriateness of PPE equipment to enable workers to demonstrate their tactile skills safely and effectively.

Advantages of Coopesol Leste MRF

The ability of CL to achieve numbers of recycling sorting categories on a par with and in exceedance of UK facilities in 2006 demonstrates the capability of the informal recycling sector to make a substantial and sophisticated contribution to waste management, despite having limited formal training and educational qualifications.

CL has a distinct advantage of being able to respond directly and flexibly to the particular needs of buyers in the recycling industry, and can modify their sorting procedures for any material to achieve specific requirements. They can also valorize a greater number of material sub-categories by regularly contacting an extensive register of potential buyers to advertise their current stock, and utilizing the wider cooperative network.

CL also provides jobs and income for individuals who might otherwise be unemployed, as cooperative members are described as being from marginalized and low-educational backgrounds. Working in a cooperative environment engenders a sense of pride and recognition with the workers. It also circumvents certain negative aspects of working in informal recycling industry (e.g. low and irregular pay, and poor working conditions). The salary received by CL members is above the typical rate for an unskilled worker in the Brazilian job market. CL members reportedly show a low absence and turn-over rate.

Finances of Coopesol Leste

Substantial in-kind support is provided to CL from the municipality and other organisations, making it challenging to determine the true financial cost of running the facility. However, CL claims that it is difficult to maintain their business from the sale of recyclables alone. Allegedly, this is firstly due to the bulk of profits from recyclables being captured elsewhere in the value chain (predominantly by middlemen, who aggregate material volumes before selling to industry), and secondly by price fluctuations in the global recycling market. Cooperatives would therefore be more financially stable and resilient if they receive a complementary income for their services to waste collection and the environment (e.g. monetizing the benefits of diverting materials from landfill). This revenue would most likely come from the municipality. In comparison to UK manual MRFs, it should be noted that their financial sustainability does not depend on the sale of recyclables alone, and receive payment from authorities for the services that they provide (gate fees and subsidies). The research team is producing a tool – the Solidary Selective Collection Tool (SoCo) to capture and analyse these costs, and give a full view of the financial picture of cooperative groups (publications forthcoming).

6. Conclusion

Participation of waste pickers in the recycling industry through cooperative waste-sorting organisations has the potential to provide an effective service, whilst also contributing towards important environmental goals. Comparison of a Brazilian cooperative-run MRF with an average UK MRF in 2006 shows that the former can achieve separation of more material sub-categories. Specific advantages of the cooperative-run MRF include: the ability to rapidly customize the sorting process to the specific requirements of industry (buyers); and the provision of jobs and skills to marginalized and vulnerable members of society. However, revenue from the sale of recyclables alone is not always sufficient to maintain the MRF in Brazil, and a complementary revenue stream for recycling service provision could increase resilience of the operation.

Acknowledgements

Project Partners include: University of Leeds, University of Campinas Fluxus Laboratory, Instituto SUSTENTAR, INSEA, Centro Mineiro de Referencia em Residuos, and Movimento Nacional Dos Catadores de Materiais Recyclaveis. The kind support of Coopesol Leste members has been instrumental to this publication.

Funding

This work was carried out with funding from the British Council - Newton Fund, through their Institutional Links Programme. Call: Institutional Skills Development – Brazil – 2016: Grant CNPJ (Cadastro Nacional da Pessoa Jurídica) of the Leading Institution in Brazil: 07972773000189 and match funding from Project Partners.

References

Dias, S.M. (2009) 'Overview of Legal Framework for Social Inclusion in Solid Waste Management in Brazil', Wiego, p. 10.

Ellen MacArthur Foundation (2016) 'The New Plastics Economy: Rethinking the future of plastics', Ellen MacArthur Foundation, (January), p. 120.

Gutberlet, J. (2012) 'Informal and Cooperative Recycling as a Poverty Eradication Strategy', Geography Compass, 6(1), pp. 19–34.

Gutberlet, J. (2008) 'Organized and informal recycling: Social movements contributing to sustainability', WIT Transactions on Ecology and the Environment, 109, pp. 223–232.

Gutberlet, J. & Baeder, A.M. (2008) 'Informal recycling and occupational health in Santo André, Brazil.', International journal of environmental health research, 18(1), pp. 1–15.

Gutberlet, J., Kain, J.-H., Nyakinya, B., Oloko, M., Zapata, P. & Zapata Campos, M.J. (2016) 'Bridging Weak Links of Solid Waste Management in Informal Settlements', The Journal of Environment & Development,

Jaligot, R., Wilson, D.C., Cheeseman, C.R., Shaker, B. & Stretz, J. (2016) 'Applying value chain analysis to informal sector recycling: A case study of the Zabaleen', Resources, Conservation and Recycling, 114, pp. 80–91.

Lenis Ballesteros, V., López Arango, Y.L. & Cuadros Urrego, Y.M. (2012) 'Health and informal work conditions among recyclers in the rural area of Medellin, Colombia, 2008', Revista de saúde pública, 46, pp. 866–74.

Medina, M. (2000) 'Scavenger Cooperatives in Asia and Latin America', Resources, Conservation and Recycling, 31(31), pp. 51–69.

Parizeau, K. (2015) 'Urban political ecologies of informal recyclers′ health in Buenos Aires, Argentina.', Health & place, 33, pp. 67–74.

Rutkowski, J.E. & Rutkowski, E.W. (2015) 'Expanding worldwide urban solid waste recycling : The Brazilian social technology in waste pickers inclusion', Waste Management & Research, 33.

Scheinberg, A., Simpson, M., Gupt, Y., Anschütz, J., Haenen, I., Tasheva, E., Hecke, J., Soos, R., Bharati, C., Garcia-Cortes, S. & Gunsilius, E. (2010) Economic Aspects of the Informal Sector in Solid Waste Management.

UNEP & ISWA (2015) Global Waste Management Outlook. Wilson, D. C. (ed.). UNEP International Environment Technology Centre, Osaka.

Velis, C. (2017) 'Waste pickers in Global South: Informal recycling sector in a circular economy era', Waste Management & Research, 35(4).

Velis, C.A., Wilson, D.C., Rocca, O., Smith, S.R., Mavropoulos, A. & Cheeseman, C.R. (2012) 'An analytical framework and tool (’InteRa’) for integrating the informal recycling sector in waste and resource management systems in developing countries', Waste Management & Research, 30(9 Suppl), pp. 43–66.

Viridor (2016) Plastic Recycling. Available from: https://www.viridor.co.uk/our-operations/recycling-and-resources/plastic-recycling/ (Accessed: 6 April 2017).

Wilson, D.C., Rodic, L., Scheinberg, A., Velis, C.A. & Alabaster, G. (2012) 'Comparative analysis of solid waste management in 20 cities.', Waste Management & Research, 30(3), pp. 237–54.

Wilson, D.C. & Velis, C.A. (2015) 'Waste management--still a global challenge in the 21st century: An evidence-based call for action.', Waste Management & Research, 33(12), pp. 1049–51.

WRAP (2006) Materials Recovery Facilities. Available from: http://www.wrap.org.uk/sites/files/wrap/MRF_v6_19Dec06_LC.pdf.