WM&R

Waste Management & Research
1–3

DOI: 10.1177/0734242X16671100
wmr.sagepub.com
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Sound and advanced municipal waste management: Moving from slogans and politics to practice and technique

There is no doubt that solid waste management is a very complex issue, particularly when recycling is part of the programme where one needs to retrieve the maximum from a very poor quality input. Like most complex issues, it has to be tackled from many different points of view, with all the actors playing their roles towards attaining a common objective. No magic wands exist, nor universal solutions applicable to every geographical and social context. We have to deal with situations where the most important challenge is to reliably collect the waste and store it somewhere, up to more advanced waste management processes, where not one single kilogram of waste is 'wasted', neither in terms of material, nor of energy. Here I focus on the latter situation, touching some points that have fuelled debate and that deserve continued attention. Finally, I will also give some insights on what is going on in Italy, a nation where waste management has become 'a matter of State', which periodically floods the media because of various emergency situations stemming from lapses in planning and execution.

Finding the right balance

To which extent should material recycling be encouraged vs. energy recovery? This is a very important question that has long confronted waste managers, public authorities, legislators, researchers, and environmentalist citizens. Clearly there cannot be a universal answer applicable to specific conditions in every locality. At the current state of knowledge we can say that good quality waste materials (e.g. those with minimal contamination), both because of their intrinsic characteristics and because of the way they have been separated by the households, are better destined to material recycling. This includes at least high grade plastic items, such as Polyethylene terephthalate (PET) and High-density polyethylene (HDPE) bottles, glass, metals, clean paper, and cardboard. But recycling should not come at any cost, because one needs an efficient, and possibly local, recycling infrastructure in order to avoid long range shipping, which is expensive and in itself can negatively impact the environment. In any case, for such materials we might at least aim at a real 'recycling', that is, the production of secondary materials with the same level of quality as the virgin ones. This obviously comes at a cost, which is the material loss occurring at the different sorting, shipping, and recycling stages. But such losses can be kept to a minimum, again thanks to the combined effort by producers, who are asked to put in the market easily recyclable items, citizens, who are requested to properly sort them at home, and waste managers, who must establish and maintain an efficient collection and recovery chain. The more we move towards recovering lower quality waste materials, the more we should expect losses during sorting and recycling to significantly increase, and moreover, we enter a scenario of 'downcycling', where recycled items will replace lower quality materials. This is for example the case of mixed plastic polymers that, owing to their poor mechanical properties, can only be used in a narrow range of applications rather than as substitutes for virgin materials for the production of new plastics. But also environmental concerns start to increase, because of the contaminants that can be found entrained in or mixed with otherwise recyclable wastes. The paradox is that the more we tend to increase source separation to encourage material recycling vs. energy recovery, the more difficult it becomes to achieve our goals owing to the cited limitations. At such a point, energy recovery from residual, poorly recyclable waste materials enters the stage as a competitive option. Among other advantages, such practice does not suffer the 'downcycling effect', simply because thermal and electric energy produced from the combustion of wastes as a fuel are not affected in the quality of the 'dirty' energy source. Both forms of energy still play a basic role in societies, the former because of the renaissance of district heating systems in some locations, including in mild climate regions' the second because of its role as a baseload, at least partially renewable, fuel source, helping the transition towards the phasing out of fossil fuels. An example of cutting edge energy recovery technology is the new waste-to-energy (WTE) plant in Copenhagen, where, let alone the ski slope on the roof, the declared energy and environmental performances are setting new performance benchmarks.

Exploiting synergies

Regarding the materials vs. energy recovery debate, interesting developments are coming from the role of thermal treatment with respect to the possibility of recovering some metal fractions embedded within plastics or other combustible materials. This falls under the concept of 'thermo-recycling' and, when coupled with an advanced metal recovery from incineration bottom ash, allows extraction of high quality metals from even the finest fraction, down to below 1 mm. Among the best experiences, it is worth mentioning the strategy adopted by the Canton Zurich in Switzerland (ZAR, 2015), where all WTE plants are being converted to bottom ash dry extraction, to be delivered to a new centralised treatment plant where ferrous, non-ferrous (including precious) metals, and glass are sorted with high efficiency and pureness, thanks to advanced systems based on eddy current, stainless steel, and optical sorters. We can say without fear of

contradiction that such metals would hardly be recoverable with the more traditional mechanical or chemical techniques.

A matter of trade-offs

Responsible managers must regularly identify and evaluate options and select both manufacturing and waste-handling systems based on trade-offs, considering, among other factors, economics and environmental impacts. For instance, food industry managers have long used plastics as a packaging material for their products. Over time, the weight of plastics used for food packaging has decreased as more sophisticated designs have been developed. Now emerging are advanced packaging systems aimed at either avoiding or at least decreasing the amount of food lost to spoilage. The so-called active food packaging, including for example the use of oxygen absorption systems, may create relatively higher environmental impacts at the production stage, as well as at the disposal end; the material perhaps being more difficult to recycle. But on the other hand, they allow for a longer shelf-life of the product, meaning less wastage at the retail and household level. Quantitative literature in the field is still poor (Manfredi et al., 2015; Williams & Wikström, 2011), and more research is need to clearly define such trade-off effect.

An even more complex trade-off involves the plastic packaging material vs. marine litter. Marine litter is among the most critical issues on the world's environmental protection and waste management agendas (UNEP and GRID-Arendal, 2016). For the size of the problem and the extreme difficulties in tackling it, it can be defined as 'the global warming of the oceans'. It mainly entails small plastics items that, being very light and floatable, can be easily transferred to the sea by wind and rivers, where they undergo a number of chemical and physical changes, finally leading to their micronisation and consequent build-up in the food chain. On the one hand, the packaging industry has pursued significant efforts in recent years to decrease the weight of materials and consequently improve their environmental performances; but only provided that they end up in proper collection and recovery schemes. On the other hand, such very light materials are also more easily dispersed in the environment because of their very nature (think for example of the disposable plastic gloves used at grocery stores for selecting fruits, or at gas stations when fuelling your car). The boundary between such opposite consequences is very thin, and depends on the degree to which customers deposit the gloves in a handy bin or carelessly drop them to the ground.

Slogans on waste

'Zero-waste' is an increasingly common slogan used in the debate on waste management. Being often promoted by non-expert environmentalists who seek an idealistic but unattainable perfect solution (recycle everything indefinitely), the term is generally surrounded by an aura of uncertainty. If we exclude, for obvious reasons, its literal meaning as the total absence of any type of waste, different interpretations can be made. Among those modified definitions we might cite 'zero-waste to landfill', which is something that has already been put in place in some countries (such as Germany, The Netherlands, and Belgium), at least for the municipal waste stream first destination, thanks to the enforcement of a government-imposed landfill ban. This is in line with the definition given by the US-EPA, for which 'achieving Net Zero Waste means reducing, reusing, and recovering waste streams to convert them to valuable resources with zero solid waste sent to landfills over the course of the year'. But purists advocate other approaches that include any form of energy recovery among the type of waste treatment that must be phased out in order to achieve their idea of Zero-Waste. Very recently in Italy, a new definition has been put forth – 'waste-free'. Waste-free municipalities are those that generate less than 75 kg per inhabitant of residual waste yearly. Well, by this definition there is still waste, and it certainly will not be 'free' to anyone to achieve even this goal.

Stories from Italy

At this stage, let me throw some lights on the peculiarities of the 'Italian way' of dealing with waste management. Italy is a country where the waste management sector faces extreme differences in conditions in its Regions. But while the outstanding performances achieved by some Northern regions, such as Lombardia and Veneto, are relatively unknown outside the country, the worldwide famous crisis in Naples and the whole Campania Region, and more recently in Rome, were well covered by the international media. The emergency in Campania was managed, and possibly solved, by finding the right balance between material and energy recovery from waste. Separate collection of recyclable and compostable waste has been put in place with some very promising results. The whole region has reached nearly 50% of source separation as of year 2014, while the new WTE plant in Acerra is processing more than 50% of the residual waste. The rest of the waste is being treated by a number of Mechanical-Biological Treatment (MBT) facilities scattered around the territory. Waste is not stored anymore in the form of so-called 'eco-balle' (more than 4 million, to a total of about 6 million tonnes of waste were accumulated during the emergency), which are actually in the process of being gradually removed and processed elsewhere. Still lacking are the plants for processing source-separated materials, particularly the organic fraction. Only 10% of the huge amount of food waste that is collected (nearly 700,000 t per year as of 2014) is in fact processed within the region. Significant amounts of source-separated waste materials are still shipped to other regions (and countries) for biological treatment and material recovery, which raises a number of political issues.

The city of Rome has more recently begun to experience a waste management emergency, with broad media coverage in the summer months. Again, the lack of proper infrastructure, following the closure in 2013 of the monster landfill in Malagrotta (one of the largest in Europe, with a surface of 240 hectares and

about 5000 t of waste delivered each day), renders the system very fragile, being based on outdated and environmentally unfriendly pre-treatment plants, and on waste exports to other regions and countries. It is well known that in summer WTE plants undergo shut down for maintenance, which has led to a lack of disposal options in a period when the 'eternal city' is filling up with tourists. Then came the politics, with vocal advocates chanting their 'Zero Waste' slogan, the hard struggles between the administration and the opposition parties, and the search for scapegoats. This unfortunately has evolved into a daily routine, in a country where everyone claims to be a waste management expert and where candidates can raise easy consensus to win local elections by promising to shut down an unwelcome waste treatment facility.

Waste Management & Research serves as a forum for exchanging research expertise and scientific ideas supporting the development and application of novel waste management options. Thus, *Waste Management & Research* invites researchers and practitioners to submit manuscripts focusing on the optimisation of integrated management schemes, the synergic role of material and energy recovery, and the quantitative study of trade-offs affecting waste management. Articles about how rational and economic engineering solutions were implemented in the face of pressures from a small (but loud) group of well-meaning but misinformed environmentalists are also welcome.

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