Food Waste As A Global Issue

- From the perspective of municipal solid waste management

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Prepared for ISWA by the ISWA Working Group on Biological Treatment of Waste

With substantial contributions from:

Enzo Favoino
Marco Ricci
Jane Gilbert
Morten Brogger
Josef Barth
Wolfgang Müller
Davide Mainero
Erwin Binner
Felicitas Schneider
Frederico Valentini
Rachael Williams
Jiao Tang
Alberto Confalonieri

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1. SCOPE OF THE DOCUMENT

The World today is facing the serious issue of widespread human undernourishment and at the same time huge amounts of food are being wasted in all phases of food production and consumption. With this document ISWA wishes to underline, once more, the important issues that arise from the huge flow of food waste both in high income as well as in low income countries.

This paper focuses on food waste from the perspective of municipal solid waste (MSW) management, and its implication for policy makers as well as on the various treatment schemes. We are pointing out the principal issues in order to emphasise the neglected problems worldwide and contribute to an open public discussion on this topic.

Since inappropriate management of MSW in landfills contributes from 4% to 11% of the world’s Greenhouse Gas (GHG) emissions\(^1\), properly managed food waste by means of separate collection and recycling has a positive impact on climate change; by transforming food waste into compost by means of a low-cost and immediately available technique\(^2\), the organic matter is stored in soils and not lost into the atmosphere as CO\(_2\) or methane.

2. DEFINITIONS

In general, most literature refers to “food waste” as the sum of the avoidable (edible) and the unavoidable (non-edible parts), hence it includes both:

- Wasted food originally produced for consumption, and
- residues from food preparation (e.g. peelings)

From a life cycle perspective, the term “food waste” can be used to include large sources of biogenous waste (biowaste) along the food production chain. A tentative list is shown below:

- losses after harvesting
- losses during transportation to industry
- losses and surplus from food industry
- residues from markets
- residues from restaurants and catering
- leftover food of different origin
- household food waste

In the field of municipal solid waste (MSW) management, many authors and experts use the term “biowaste”, which can have a wide range of origins, from households and restaurants to canteens, cafes and public parks and gardens. Biowaste produced and collected in municipalities is commonly divided into two main categories:

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\(^1\) Documentation of the ISWA Master class on Biowaste Management, 2012, Portugal

\(^2\) CLIMSOIL Report, EC 2009
1. Garden waste, generated in gardens and streets from plants and grass

2. Food waste, generated in Kitchens

For the purpose of this document, we define food waste to be wasted food originally produced for consumption and residues from food preparation, originated from households and commercial activities (such as restaurants, canteens, bars, cafes, etc.). The term “biowaste” in this document refers to the common definition used in the field of MSW management, as defined in the previous paragraph; it contains food waste and garden waste. It is important to note that this document considers food waste and biowaste as “clean fractions”, suitable to be recycled into compost and biogas, only if source separated and separately collected.

The unit measures used in the text are kilogram (kg) and metric tonnes (1t=1000kg). Decimal digits are separated by commas (,). The word billion refers to 1.000.000.000 or (scientific notation) $1 \times 10^9$.

3. THE MAGNITUDE OF THE PROBLEM

Wasting food costs – it costs money; it costs the environment; and it also costs society. With an estimated 925 million people deemed to have been undernourished in 2010\(^3\) (equivalent to about 13% of the world’s population\(^4\)), it also has a profound moral dimension. As the global population continues to increase, the security of our food supply is an issue that challenges governments all over the world. Competition for land, water, energy and fertilisers are all factors in a complex web that affects the amount of food available.

Estimates of how much food is wasted\(^5\), however, vary. The most recent report commissioned by the Food and Agriculture Organization (FAO) of the United Nations indicated that approximately 1,32 billion tonnes of food is lost or wasted annually, equivalent to about one-third of food produced for human consumption\(^6\). A recent study conducted on behalf of the European Commission’s DG Environment estimated that approximately 89 million tonnes of food waste was generated in 2006 within the EU27, equivalent to 179kg per person.\(^7\) This amount is expected to rise to approximately 126 million tonnes (a 40% increase) by 2020 unless additional preventive measures are taken.

Food is wasted at all stages along the supply chain, from primary production, through processing to end use by the consumer. In a comprehensive review of food waste supply chains, Parfitt et al.

\(^3\) [http://www.worldhunger.org/articles/Learn/world%20hunger%20facts%202002.htm](http://www.worldhunger.org/articles/Learn/world%20hunger%20facts%202002.htm) [accessed 5 April 2012]


(2010)\textsuperscript{8} identified eleven distinct stages where food waste could arise. This is shown schematically in Figure 1.

\textit{Figure 1 - Schematic representation of the food supply chain}

The proportion of food waste arising at different stages of the food supply chain (FSC) varies depending upon the level of industrialisation. In general, lower income countries tend to produce proportionally more food waste during production and processing, as these tend to rely on lower-tech production methods, and the supply chains are often fragmented. By contrast, despite the more advanced production and processing technologies in higher income industrialised countries, food is wasted because of the high expectations placed on the supply chain by retailers, consumers and society on the quality and visual appearance of food products. Subsequently, even more food is wasted at the consumption stage than within the food supply chain, particularly by consumers in higher income countries. The FAO estimated that 95 – 115 kg per person is wasted every year by consumers in Europe and North America, compared to 6 – 11 kg per person per year in sub-Saharan Africa and South / South East Asia. The comparison is shown in Figure 2.

\textit{Figure 2 - Comparison between the quantity of food wasted by consumers in high and low income countries}

According to recent studies\(^9\), for every kilogram of food produced, 4.5 kg of CO\(_2\) is released into the atmosphere. In Europe, the approximate 89 million tonnes of food wasted produces 170 million tonnes CO\(_2\) eq. per year, broken down this amounts to:

- food industry, 59 million tonnes CO\(_2\) eq./yr,
- domestic consumption, 78 million tonnes CO\(_2\) eq./yr,
- other, 33 million tonnes CO\(_2\) eq./yr;

Figure 3 provides specific information about the breakdown of total food wastage across the food supply chain in the European Union.

**Figure 3 - Breakdown\(^{10}\) of food waste across the EU27(t/year)**

<table>
<thead>
<tr>
<th>Category</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing</td>
<td>34,755,711</td>
</tr>
<tr>
<td>Households</td>
<td>37,701,761</td>
</tr>
<tr>
<td>Retail / wholesale</td>
<td>4,433,331</td>
</tr>
<tr>
<td>Food service / catering</td>
<td>12,263,210</td>
</tr>
<tr>
<td><strong>EU27 total</strong></td>
<td><strong>89,154,013</strong></td>
</tr>
</tbody>
</table>

---

### 4. IMPACT ON MUNICIPAL SOLID WASTE

Food wastage by consumers has a direct impact on the quantity and composition of municipal solid waste (MSW). As food waste is readily biodegradable, it has a direct impact on the biodegradability of MSW if mixed with food waste, which in turn affects how MSW is collected, treated and disposed of. The higher the percentage of food waste in MSW, the more crucial the need for source separation of waste. This is because separately collected food waste (together with other biowaste) can be recycled into quality compost and can also be used to produce biogas as a renewable source of energy. When food waste is not source-separated, it can only be partly sorted by mechanical methods, however the quality of recycled materials (particularly the end compost) largely decreases.

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\(^9\) Report on how to avoid food wastage: strategies for a more efficient food chain in the EU (2011/2175(INI)) Committee on Agriculture and Rural Development Rapporteur: Salvatore Caronna

due to source contamination with other substances which might be hazardous. Alternatively, mixed waste could be incinerated, however the high water content from food waste reduces the combustion efficiency and energy recovery efficiency.

In addition, several studies have shown (in Sweden and Italy) that if municipalities introduce source separation of food waste, households are more likely to also sort other recyclable fractions, hence increasing overall recycling amounts. As such, food waste is a considerably important factor in managing MSW.

It is observed that the percentage of food waste in MSW is negatively correlated to both GDP per capita and the amount of MSW generation per capita. Table 1 demonstrates the correlation, grouping countries by the level of per capita income and showing the percentage of food waste in MSW. The amount and percentage of food waste in MSW could be even higher in reality, because reported figures might be methodologically biased due to different definitions of MSW and compositional analyses methods. The negative correlation is mainly due to the lower amount of paper and plastic consumption in lower income societies, particularly those from product packaging. Consumers in affluent economies have far more excess economic capability to purchase goods made of sophisticated materials that satisfy other needs besides basic needs.

Such trends mean that the treatment of food waste posts a greater challenge to lower income countries, where separate collection at source is usually not in place. The current waste management practise of these countries comprises of basic collection of mixed waste and landfilling (or dumping) of collected mixed waste. The high percentage of biodegradable waste in landfills results in large amounts of leachate and GHG emissions (CO₂ and methane), causing ground water pollution and climate change, if not managed properly.
Table 1 - Percentage of biowaste in different countries

<table>
<thead>
<tr>
<th>Countries</th>
<th>Compostable or organic</th>
<th>Components (%)</th>
<th>Metal</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-income</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nepal (1994)</td>
<td>80</td>
<td>7</td>
<td>2.5</td>
<td>3</td>
</tr>
<tr>
<td>Bangladesh (1992)</td>
<td>84.37</td>
<td>5.68</td>
<td>1.74</td>
<td>3.19</td>
</tr>
<tr>
<td>Lao PDR (1998)</td>
<td>54.3</td>
<td>3.3</td>
<td>7.8</td>
<td>8.5</td>
</tr>
<tr>
<td>Sri Lanka (1993-94)</td>
<td>76.4</td>
<td>10.6</td>
<td>5.7</td>
<td>1.3</td>
</tr>
<tr>
<td>China (1991-95)</td>
<td>35.8</td>
<td>3.7</td>
<td>3.8</td>
<td>2</td>
</tr>
<tr>
<td>Myanmar (1993)</td>
<td>80</td>
<td>4</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>India (1995)</td>
<td>41.8</td>
<td>5.7</td>
<td>3.9</td>
<td>2.1</td>
</tr>
<tr>
<td>Middle-income</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thailand (1995-96)</td>
<td>48.6</td>
<td>14.6</td>
<td>13.9</td>
<td>5.1</td>
</tr>
<tr>
<td>Malaysia (1990)</td>
<td>43.2</td>
<td>23.7</td>
<td>11.2</td>
<td>3.2</td>
</tr>
<tr>
<td>Mexico (1993)a</td>
<td>52</td>
<td>14</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Turkey (1993)a</td>
<td>64</td>
<td>6</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Indonesia (1993)</td>
<td>70.2</td>
<td>10.9</td>
<td>8.7</td>
<td>1.7</td>
</tr>
<tr>
<td>Philippines (1995)</td>
<td>41.6</td>
<td>19.5</td>
<td>13.8</td>
<td>2.5</td>
</tr>
<tr>
<td>High-income</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada (1993)a</td>
<td>34</td>
<td>28</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>USA (1993)a</td>
<td>23</td>
<td>38</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Australia (1993)a</td>
<td>50</td>
<td>22</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Denmark (1993)a</td>
<td>37</td>
<td>30</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Finland (1993)b</td>
<td>32</td>
<td>26</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>France (1993)b</td>
<td>25</td>
<td>30</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Greece (1993)b</td>
<td>49</td>
<td>20</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>Netherlands (1993)b</td>
<td>43</td>
<td>27</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>Norway (1993)b</td>
<td>18</td>
<td>31</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Spain (1993)b</td>
<td>44</td>
<td>21</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>Switzerland (1993)b</td>
<td>27</td>
<td>28</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>Japan (1993)</td>
<td>26</td>
<td>46</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Hong Kong (1995)</td>
<td>37.2</td>
<td>21.6</td>
<td>15.7</td>
<td>3.9</td>
</tr>
</tbody>
</table>

Note: in this table decimal digits are separated by points (.)

5. PREVENTING FOOD WASTE- SOME EXAMPLE SCHEMES AND INITIATIVES

Over the last few decades, several food waste prevention initiatives have been implemented worldwide, targeting different stakeholders along the food supply chain. These initiatives include those that have been implemented in cooperation with industries or retail businesses with an impact on consumers as well (e.g. Courtauld Commitment\(^ {11}\) in the UK), and those focused on gastronomy (e.g. Green Hospitality Awards programme\(^ {12}\) in Ireland). On the demand side, a lot of effort has been put into direct consumer awareness building campaigns (e.g. “Lebensmittel sind kostbar” in Austria\(^ {13}\),

\(^{11}\) [http://www.wrap.org.uk/category/initiatives/courtauld-commitment](http://www.wrap.org.uk/category/initiatives/courtauld-commitment)


\(^{13}\) [http://www.lebensministerium.at/lebensmittel/kostbare_lebensmittel.html](http://www.lebensministerium.at/lebensmittel/kostbare_lebensmittel.html)
Zu gut für die Tonne” in Germany14, “Love Food Hate Waste”15 in Australia). These experiences have shown that it is relatively easy to use economic incentives to attract industries and retailers to take food waste prevention measures, while it is more challenging to convince households to prevent food wastage by only highlighting the economic advantages. There are in fact many non-economic barriers which are in conflict with preventing food wastage on the household level, such as time constrains, lack of food handling knowledge, convenience, and the wish to have a broad assortment of food at home.

Food rescue programmes have been widely implemented in some EU countries like Germany (Tafel Initiatives) and Italy (Last Minute Markets), involving usually charities or local social services to carry out the redistribution of edible food from restaurants, supermarkets and markets to avoid it becoming waste. Food aid is typically provided to a wide range of people in need. In doing so, the environmental impact is decreased, and there is a positive social impact on combating hunger. Nevertheless, food donation is only one of several options to prevent the wastage of edible food. Other measures such as optimisation of processes and technologies should also be considered at the same time.

Recently the initiative http://www.thinkeatsave.org was launched by the Save Food Initiative, a partnership between UNEP, FAO and Messe Düsseldorf, and in support of the UN Secretary-General’s Zero Hunger Challenge.

Case Study – The UK

In 2008, the United Kingdom’s Waste and Resources Action Programme (WRAP) engaged in an extensive promotional campaign aimed at reducing food waste generated by households. Called “Love Food, Hate Waste”, it set out to inform and educate individuals about the benefits (both economic and environmental) of reducing food wastage.

The website http://www.lovefoodhatewaste.com/ provides an impressive overview of the causes (and mistakes) causing food wastage, the related environmental impact, the economic burden, and possible solutions to capture unused food at various levels, including e.g.:

- more careful storage at home
- better portioning at home and in restaurants; a portioning tool is also provided (http://england.lovefoodhatewaste.com/content/portions-and-planning)
- better labelling of food in shops and markets, and improved comprehension by customers of the meaning of “use by”, “best before”, “sell by”
- use of leftovers in innovative and tasty recipes
- donations to food recovery programmes

According to the website, one of most comprehensive sources concerning food wastage, almost 50% of the total amount of food thrown away in the UK is done at home, totalling 7.2 million tonnes of food and drink, and more than half of this could have been used. Wasting this amount of food costs the average household £480 a year, or £680 for a family with children.

14 https://www.zugutfuerdietonne.de/
Case Study – Food Share Schemes in Italy

About 6 million tonnes per year of edible food is wasted in Italy by households\(^{16}\) and losses include about 10% of the average supermarket-shopping which is thrown away as waste.

The Italian non-for-profit organisation ACLI started in 2009 the Rebus project\(^ {17}\), a programme for collecting perishable goods (among these food-products) and unsold goods from supermarkets, local markets, pharmacists, canteens and other retailers. The programme has been established in 5 provinces involving mainly the northern regions of Veneto and Lombardy. Similar projects have also been started in other regions like in Emilia-Romagna and Lazio.

In 2010 the Rebus initiative collected about 680 tonnes of goods, about 77% of which consisted of both fresh and packaged food products. The goods are delivered for free to charities or local social services with the aim of supporting people in need\(^ {18}\). Logistics are managed by local voluntary groups or social cooperatives.

Case Study – Food Share Schemes in the USA

With the ever-increasing concern for more appropriate use of resources, food wastage has gained attention in North America, too. According to the website http://www.wastedfood.com/, Americans waste more than 40% of food produced for consumption, which corresponds to an annual cost of more than $100 billion, while at the same time, food prices and the number of people without enough to eat continues to rise.

Subsequently, the website and other qualified sources\(^ {19}\) provide insights into the reasons for food wastage, from crops to leftovers after meals, and list the possible approaches to recover food at various stages in the supply chain, starting from capturing food which is not harvested to turning leftovers into new meals.

Food rescue programmes are highlighted in order to retrieve edible food that would otherwise go to waste and distribute it to those in need. In most cases, the recovered food is perfectly edible, but not sellable such as day old bread and bagged lettuce past its “sell by” date. The food that food-banks pick up is donated by supermarkets, restaurants and farms. In the case of restaurants and supermarkets, the rescued food is being saved from disposal or processing into compost, whereas food recovered on farms is typically kept from being ploughed under. On farms, the donations often must be harvested, or gleaned, by volunteers.


\(^{17}\) See http://www.acliverona.it/rebus/homepage

\(^{18}\) Eurostat uses to measure income poverty is the “at risk of poverty rate”. This represents the share of people with an income below 60% of the national “equivalised median income”

Businesses that participate in those food rescue programmes receive tax benefits for their donations and limited liability\textsuperscript{20} protection thanks to the Bill Emerson Good Samaritan Food Donation Act\textsuperscript{21}.

\textit{Case Study – Food Share Schemes In India}

Food wastage is of serious concern in a country like India where 37 per cent of the population lives below poverty line.

The Centre for Development Communication (CDC) located in Japour started in cooperation with Annakshetra Foundation probably the first Indian project\textsuperscript{22} for effective utilisation of excess leftovers from weddings, parties, restaurants and temples. CDC, which also works in the field of solid waste management, together with Annakshetra aim to deliver the spare food collected from donors to those who need it in the local community. The foundation also runs awareness campaigns to prevent food wastage. Almost a million persons have benefited so far with a network of 1.500 donors, comprising caterers, marriage hall and restaurant owners as well as individuals.

On receiving the calls, the Annakshetra van goes to the site to collect food. After collection, the food is kept in refrigerators and served to labourers, slum dwellers, orphanages and shelter homes in the morning. If the collected food is found unsuitable for human consumption, it is sent for composting.

\textit{The Initiative Of The European Parliament}

Remarkably, the significant quantities of food waste generated across the EU27 led the European Parliament to address ways in which food waste can be prevented in the EU. In its resolution of January 2012, it urged the European Council and Commission to designate 2014 the European Year against Food Waste. The Parliament also called on the Commission to undertake a series of actions aimed at reducing food losses throughout the food supply chain\textsuperscript{23}.

6. POLICY DRIVERS AND REGULATORY APPROACHES TO IMPROVE FOOD WASTE MANAGEMENT

Given the pivotal role of managing food waste in ensuring safety and sustainability in municipal solid waste management as a whole, food waste has long been at the core of various regulatory provisions. The key attempt of many such provisions has been to promote diversion of biodegradable waste (or narrowly organics, i.e. food + garden waste) from sanitary landfills and dumpsites. In this respect, 2 types of approaches have been commonly taken:

\textsuperscript{20} liability is limited to intentional misconduct or gross negligence which is defined as “voluntary and conscious conduct (including a failure to act) by a person who, at the time of the conduct, knew that the conduct was likely to be harmful to the health or well-being of another person”.


\textsuperscript{22} The Hindu, May 24, 2013, \url{http://www.thehindu.com/news/national/other-states/waste-not-want-not/article4743159.ece}

\textsuperscript{23} See: \url{http://www.europarl.europa.eu/RegistreWeb/search/simple.htm?fulltext=2011/2175(INI)}
• Bans on landfilling, such as those adopted in various US federal states on yard trimmings (garden waste) and more recently those in the new Waste Bill\textsuperscript{24} in Brazil.

• Targets (usually phased) for diversion, such as those stipulated by the EU Landfill Directive 99/31\textsuperscript{25}.

Although bans tend to exert a stringent pressure on the system, the lack of flexibility of total bans has been sometimes highlighted. Besides, one must be aware that no measure for diversion can have a 100\% efficacy. Separate collection may achieve up to 85-90\% capture; biological stabilisation may similarly lead to an 80-95\% loss of biodegradability/fermentability; while incineration may leave some volatile solids in the ashes. Hence the limits of the three above-mentioned different options call for the need of flexibility of “interpreting” compliance requirements in practice (e.g. definition of thresholds for acceptance at landfills)\textsuperscript{26}.


\textsuperscript{25} The European development is based on several political decisions starting from the waste hierarchy definition that fixes, since a long time (75/442/EEC - 1975 Waste Framework Directive), a clear strategy to face properly the management of the waste stream. The waste hierarchy renewed by the Directive 2008/98/EC on waste (Waste Framework Directive) establishes the legislative framework for the handling of waste in the Community:

“[...]Article 4 Waste hierarchy

1. The following waste hierarchy shall apply as a priority order in waste prevention and management legislation and policy:

(a) prevention;
(b) preparing for re-use;
(c) recycling;
(d) other recovery, e.g. energy recovery; and
(e) disposal.”

Where we can read that: “[...]‘recycling’ means any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations [...]”

In Europe, the issue of biodegradable waste is partially addressed, among others, by Directive 1999/31/EC on the landfilling of waste, which sets the reduction targets for landfilling of biodegradable municipal waste, and by Directive 2008/98/EC on waste, which invites the Member States, among others, to introduce measures supporting separate collection and appropriate treatment of bio-waste (Council meeting Luxembourg 2009).

At the same time, other European political decisions support the issue of biodegradable waste suggesting the use of compost to combat the soil organic matter decline:

“[...]concerning measures for combating the decline in soil organic matter, not all types of organic matter have the potential to address this threat. Stable organic matter is present in compost and manure and, to a much lesser extent, in sewage sludge and animal slurry, and it is this stable fraction which contributes to the humus pool in the soil, thereby improving soil properties.” (Commission of the European Communities 2006).

\textsuperscript{26} e.g. the German TASi (Technical Guidelines on Household Waste) stipulated the need to get below a certain % of Volatile Solids in waste to be landfilled, which could be met only by ashes from thermal treatment. After a long debate, stressing the lack of flexibility of such a system (which might cause problems of scaling in small waste management districts, or cross-problems in areas with separate collection still in slow but steady progress) in 2001 the new Ablagerungsverordnung
An interesting approach has been considered by the LATS (Landfill Allowances Trading Scheme) in the UK, which establishes some biodegradable waste “allowances” to landfills in each district/authority and then measures the actual amount of landfilled biodegradable MSW. The amount can be reduced through composting/digestion of separated collected biowaste, recycling in the case of paper, incineration or mechanical biological treatment. Waste disposal authorities achieving high levels of biowaste diversion may “bank” or “sell” their allowances to those lagging behind, thereby obtaining further economic benefits from measures aimed at drastically reducing the volume of biowaste to landfills.

Both bans and targets for diversion are in essence intended to “push organics away” from landfills, although they do not provide any direction as to which treatment option should be prioritised in that respect.

In practice, many countries have already taken specific measures to promote the treatment of food waste through composting and/or anaerobic digestion as a primary option, in order to seize the benefits of returning organic matter to the soil, and the possibility of producing a fully renewable biogenic fuel (biogas) to replace fossil fuels. Common among most measures in this respect are provisions to promote separate collection and biological treatment of biowaste, either in the form of obligations (e.g. Austria, Netherlands) or targets (e.g. Sweden). The national general recycling targets (e.g. in the UK and Italy) and the EU material recovery targets mandated by the EU Waste Framework Directive (Directive 2008/98, WFD) also act as a driver to stimulate separate collection of biowaste, which, given the high percentage of biowaste in MSW, plays a fundamental role to meet the target of 50% material recovery or separate collection of the WFD.

Concurrent/ancillary drivers can be found in different, though complementary, policies and regulations, such as:

- soil policies (e.g. UN Convention against Desertification and EU Soil Strategy which highlights soil organic matter depletion as one of the “threats” to soil)
- agriculture policies (in some areas, subsidy programmes have been established for farmers to use soil improvers, including compost, instead of mineral fertilisers in order to fight erosion and eutrophication)
- climate change policies (e.g. policies on renewable energy providing subsidies that cover also biogas from anaerobic digestion and Clean Development Mechanisms covering compost programmes diverting biowaste from landfills)

Although legislations are being implemented to help prevent, collect and recover food waste, other legislations and regulations such as those for food safety and animal health may conflict with the prevention of food waste. The most remarkable conflicts are those concerning contamination of food, import control, hygiene packaging requirements, provision of food information, such as “use by” and “best before” dates, norms and quotas in fisheries, animal by-products and specific marketing standards. It is therefore important to consider the effect on the prevention and recovery of food waste when new legislations on other related topics are being developed. Equally important is to ensure that legislations are properly interpreted by stakeholders along the food supply chain, with an overarching goal to minimise food waste.

established an “equivalency principle” according to which also biological stabilisation is considered as a suitable method, if meeting a certain reduction in fermentability
Based on observations from different experiences where a Biowaste Strategy (or parts of it) has already been established, the following advantages and disadvantages of different approaches can be outlined (Table 2) for recovering biowaste as a material.

**Table 2 - Key approaches for promoting/mandating a biowaste management strategy**

<table>
<thead>
<tr>
<th><strong>[A] BANS ON BIODEGRADABLES TO LANDFILLS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>This is the approach taken in many states in the US, in the form of bans on landfills garden waste.</td>
</tr>
<tr>
<td><strong>Advantage</strong></td>
</tr>
<tr>
<td>• This is the most stringent provision, hence it potentially represents the most powerful driver</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>[B] OBLIGATION ON SEPARATE COLLECTION</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>An obligation on separate collection is applied to municipalities (e.g. Netherlands, Denmark by 2015) or to households (e.g. Austria, with exemptions for those households participating in home composting programmes; recently, a similar approach has been adopted in Ireland)</td>
</tr>
<tr>
<td><strong>Advantage</strong></td>
</tr>
<tr>
<td>• An obligation on households may be very effective, if acceptance of people and stringent control is possible.</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

\(^{27}\) According to EU WFD recycling is ranked higher than recovery.
consider less suited areas and housing / societal conditions.

[C] TARGETS FOR SEPARATE COLLECTION / COMPOSTING / RECYCLING

Targets may be expressed in terms of:

- separate collection rates to be achieved (e.g. Italy, UK)
- specific biowaste processing targets (e.g. Sweden)
- general recycling + composting targets

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Targets represent a result-oriented approach; local planners and the processing industry have a consistent reference for calculating capacities and related investments in time.</td>
<td></td>
</tr>
<tr>
<td>• Flexible, since phase targets drive implementation in most suited areas and conditions first (low-hanging fruits), then at a later stage move towards more challenging areas.</td>
<td></td>
</tr>
<tr>
<td>• Targets require the establishment of calculation methods to ascertain fulfilment (although this is in line with many provisions stipulated by various EU Directives, e.g. the reuse and recycling targets of the Waste Framework Directive and the packaging recovery targets of the Packaging Directive).</td>
<td></td>
</tr>
</tbody>
</table>

7. PRINCIPLES AND MODELS FOR SEPARATE COLLECTION, LESSONS LEARNT AND RESULTS

There are three main approaches for the separate collection of food waste:

- collected separately using a kerbside or bring system (“tailor made” food waste collection)
- collected together with garden waste (e.g. “VGF” or “GFT” collection in Netherlands or “Bioabfall” in Germany)
- collected separately but at the same time as the collection of other wastes or recyclables using a compartmentalized vehicle

Some schemes exclude the collection of meat, such as the “GFT” (“VGF” = vegetable, garden, fruit) schemes in Netherlands and Flanders.

It is important to ensure that the design of a scheme attracts the public’s support and active participation. The requirements for a successful scheme are:

- provide easy-to-use containers suitable for food waste
- flexible enough to meet the needs of all residents
- reliable and consistent
- with clear instructions on how to use the collection service.

Traditionally, schemes have implemented commingled collection of food and garden waste, because of their common destination. This still represents the most widely applied approach, e.g. in Central Europe, with the use of “Biotonne” (bio bin) where both food and garden waste is delivered for commingled collection at the kerb.

More recently, however, “dedicated” or “tailor made” collection of food waste is being implemented, which shows many beneficial implications:

- remarkably smaller volume of receptacles, which allows hand-picking at detached or terraced houses thereby saving time and cost
- the higher bulk density of food waste, which makes it possible to use small, financially affordable open lorries instead of expensive compactors
- the subsequent lower cost for a single collection round, which allows an increased frequency for collection
- increased frequencies of collection, alongside the use of biobags, makes the system user-friendly, enhancing captures and minimising the percentage of food waste in residual mixed waste
- leads to a sharp decrease in the frequency of collecting residual mixed waste, which releases human and financial resources for the collection rounds for compostable and recyclables

The amount of food waste collected depends on a number of factors specific to the community served, including among others, commitment to recycling, cultural influences on cooking habits, home composting rates, amount of food left in packaging. Therefore participation rates can be highly variable. The amount of collected food waste per household (hhd) can also vary from one region to another.

A study conducted in the UK calculated\(^\text{28}\) the amounts of collected food waste (commingled collection), which range between 0.5 – 3kg/hhd.week, equivalent to roughly 35 - 150 kg/hhd.year. However, schemes based on tailor-made food waste collection such as that implemented in Italy and Spain (Catalunya + Basque Country) show a consolidated capture of 80 - 140 kg/person.year, equivalent to 200 - 350 kg/hhd.year based on a 2,5 persons/hhd average. The higher collection amount of food waste of such schemes is attributable partly to:

- the different lifestyles (higher tendency to cook and have meals at home, producing a higher presence of food waste in household which is targeted by separate collection)
- higher captures for the more user-friendly nature of tailor made food waste collection schemes: the relatively low cost of the single collection round makes it possible to increase

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\(^{28}\) WRAP (2009) Food waste collection guidance
frequencies, and the general use of biobags increases comfort for households, thereby enhancing participation and capture rates\textsuperscript{29}.

The costs involved in separate collection depend on various factors including:

- frequency of collection – which tends to increase moving from North to South due to climatic differences

- the type of scheme: although a bring system implies lower direct costs than kerbside collection because of fewer pick-up points, its remarkably lower capture leads to a higher frequency of collection of residual mixed waste, due to the consequent higher amount of biowaste in residual mixed waste. Hence, the total costs of collecting biowaste and residual mixed waste may end up being higher for bring schemes. Commingled collection of food and garden waste implies a higher cost due to the use of mechanical loading devices, longer pick-up time and the use of compactors needed to pack bulky garden waste\textsuperscript{30}; a lower frequency of collection is needed but may lead to a lower capture of food waste, consequently increasing the need for a comparatively high frequency of collection of residual mixed waste (as mentioned above).

- local cost of equipment and above all manpower, which naturally makes labour-intensive schemes (e.g. kerbside collection) even more preferable in low-income countries, besides creating jobs

- density of population (with decreasing costs at increased densities, due to less time spent for moving from one pick-up point to the next)

An integrated approach, for example by changing overall collection rounds, may yield considerable savings, as when a separate collection system for biowaste is in place, the frequency of residual mixed waste collection can be reduced, offsetting partially the additional separate collection costs.

Hence, an accurate assessment must be performed on the total cost of collection per person (or per household), which often shows that the additional cost of “collection of food waste (or biowaste)” is offset by the savings from the reduced cost of “collection of residual mixed waste”\textsuperscript{31}.

In this respect, Figure 4, excerpted from an official survey carried out in some Italian municipalities, demonstrates that with increasing separate collection rates (mostly driven by increasing adoption of kerbside collection, including separate collection of food waste for maximising collection rates) the TOTAL cost of collection (green bars) per person remains unchanged in most of the municipalities (i.e. the additional costs of introducing separate collection of biowaste in an operationally optimised way are offset by the savings on collection of residual mixed waste); the costs for processing / treatment / disposal (blue bars) steadily decrease, due to lower amounts of waste being

\textsuperscript{29} Ricci, M. Favoino, E.: An overview of different approaches of biowaste collection, Proc. Congress on biowaste and compost, 2005 - Seville

\textsuperscript{30} Also, garden waste generation varies enormously during the year, so collection may be largely affected. For example, trucks may drive half empty in winter time if the collection is designed on summer generation rates, or additional trucks may be needed if collection is designed on winter generation rates.

\textsuperscript{31} This is then complemented and made even more cost-competitive by the subsequent cost reduction for biological treatment vs. management off mixed garbage in landfills with pretreatment (through incineration or MBT)
sent for disposal, lower fees for composting than for disposal and higher revenues from separately collected packaging waste.³²

Figure 4 - Total collection and treatment costs for MSW at increasing recycling rates – annual cost per inhabitant

8. BIOLOGICAL TREATMENT OPTIONS TO RECYCLE FOOD WASTE

Food waste, containing at least 70 % water and 90 % volatile solids, is an ideal material for biological treatment. The flexibility in treatment capacity makes biological treatment the preferred option for recycling in most situations, with plant sizes varying from 5,000 t/y to more than 200,000 t/y.

By integrating anaerobic digestion and composting, both energy yields of 0.6 MWh/t and material recycling rates of 40 % can be achieved³³. Thus biological treatment contributes positively to CO₂ savings both by saving the use of fossil fuels through the production of biogas and by sequestration of carbon into soils through composting.

In the scenario where separate collection of food waste is absent or at a starting phase, it is worthwhile to underline that biological treatment options are applicable to both mixed MSW and

³² We underline that the cost-analysis is done per capita and not per ton, so to get an economic parameter independent from specific waste production; the cost per capita (or per person) can be easily linked to the revenues of waste taxes and fees.

³³ Modern heat-pump technology and more advanced heat exchange systems might in the future improve the energy yields even further.
source-separated biowaste. Source separation improves the quality of compost and facilitates recycling of plastic and other materials. An integrated approach involving source separation, anaerobic digestion and composting is the preferred approach, although due to the flexibility of biological treatment systems the solution can be developed stepwise and upgraded gradually.

**Pretreatment**

Pretreatment has several functions: it opens bags, removes impurities, mashes or crushes large-sized biowaste and homogenises the biowaste. The quality of the end product as well as the efficiency of the later biological process depends on the quality of pretreatment. There is not one single way to pretreat biowaste, but several options due to the variety of biological treatment methods.

The ideal method involves completely separating the biodegradable fraction without any spillage, however in reality either some impurities must be accepted or some biodegradable waste will remain in the residual fraction. Each technical solution entails its own efficiency depending on the quality of the incoming materials. Nevertheless, it is crucial that pretreatment does not make recycling impossible by shredding down impurities in the biodegradable fraction. Today good technologies exist for both small and large scale facilities comprising of either mobile or stationary equipment.

**Composting**

Composting is the decomposition process of biowaste (collected separately from other MSW streams) under controlled aerobic conditions. Compost is the valuable end product which contains recycled nutrients and carbon.

Composting systems are fully scalable. The choice of design depends on the expected annual incoming waste tonnage, variety of feedstocks (biowaste for composting), location of the plant, etc. More advanced systems make operation easier due to the automatic control of turning and ventilation, however well operated, low-tech, open windrow systems usually applied for smaller composting plants can also be operated effectively with an excellent output quality. Composting is suitable for structure-rich, woody and hard degradable organic matter. Wood is not degradable under anaerobic conditions.

A simplified material flow chart of a typical composting plant is shown in Figure 5, where an enclosed installation for treating separately collected food waste (mixed with structuring material: wood, leaves, etc.) is assumed. Besides producing quality compost, composting releases a considerable amount of heat which could also be utilised but currently is not.
For proper aeration of food waste during composting, structure-rich materials such as wood always have to be added. At the end of the composting process, the un-degraded parts have to be screened out. Most of the oversized particles may be reprocessed by adding them to the next composting cycle.
Anaerobic Digestion

When anaerobic digestion (AD) is applied to food waste, it can be operated under different technological conditions. Currently available technologies can be divided into three categories based on the amount of total solid (TS) content (CIC 2010):

- **Dry**: more than 20 % TS
- **Semi-dry**: between 10 and 20 % TS
- **Wet**: less than 10 % TS

However, in order to classify an AD scheme, TS content is not sufficient to describe the technology. Temperature plays an important role in differentiating technologies between mesophillic (35-40 °C) and thermophillic (50-55 °C) operating conditions. The pattern flow (mixed, plug flow) and the number of steps (one or two) are also important factors that differentiate AD technologies.

In any case, the solution depends largely on the input material (MSW or OFMSW), especially pre-treatment complexity. Table 3 provides a summary of the distribution of different AD set-ups in Europe.

**Table 3 - European AD distribution by technology aspects (CIC 2010)**

<table>
<thead>
<tr>
<th>Wet</th>
<th>Semi-Dry</th>
<th>Dry</th>
<th>n.d.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Mesophillic</td>
<td>39</td>
<td>15</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Termophillic</td>
<td>16</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Meso+Thermo</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Not classified</td>
<td>26</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>88</td>
<td>23</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>% distribution</td>
<td>55%</td>
<td>1,5%</td>
<td>41%</td>
<td>2,5%</td>
</tr>
</tbody>
</table>

Where A = OFMSW (+other biomasses); B = MSW (+ other biomasses as well as OFMSW); n.d. = not defined; Wet (<10%TS), Semi-Dry (10 – 20%TS); Dry (>20%TS); Mesophillic (35°C-40°C) Thermophillic (50°C-55°C)

In wet systems the liquid is used as a transport media. Consequently food waste has to be made easy for pumping. Pumpability requires two conditions: 1) the waste has to be very well separated from impurities to avoid damage to the installation; 2) the waste has to be mashed so that a high degree of degradation can be achieved. Because of intensive separation of impurities, significant quantities of organic matter may be lost through pre-treatment. In the following stage, energy gain in the form of biogas from the mashed fraction can be very high. The end products of anaerobic digestion are: digestate which can be composted and nitrogen-rich process water which is to be treated and discharged or may be used as fertiliser after sanitation.

34 “Biogas e Compost dai rifiuti organici selezionati” Technical committee CIC report 2010

35 Organic Fraction of MSW, used as a synonymous of biowaste separately collected
In dry systems the transport of waste is done mechanically by conveyor belts, screw conveyers, front loaders, etc. The feedstock (i.e. input food waste) is not actually dry; it still contains 70-80% of water. One of the advantages of dry systems is that some impurities can be accepted and that the end-product digestate is better suited for composting because of its higher share of solids. Another advantage is that less waste water is produced compared to wet systems. The disadvantages are a lower amount of recoverable energy and a higher requirement of plant-surface area for the same amount of waste treated compared to a wet solution.

Both dry and wet systems can be split into steps to improve the degradation process or to stabilise the process. In terms of temperature, the mesophillic digestion is slower but in general less sensitive to overfeeding than thermophilic digestion. The energy consumption is reasonably larger for thermophilic digestion, but the lower retention time helps to compensate the higher cost.

A simplified material flow chart of a typical wet AD plant is shown in Figure 6. As indicated in the chart, input material must include added water. The assumption is made based on common practices that 2.440 kg of water is added for every ton of biowaste, part of which (732 kg) is recirculated. In practice, liquid will be added in the form of waste fluid rather than clean water. Thus it is difficult to distinguish energy yields from different feedstock.

In comparison to a wet AD plant, the material flow is different in a semi-dry AD plant (see Figure 7). As indicated in the material flow chart Figure 7, there is no need for added water. The assumption is made based on common practices that the process water is treated in a water-treatment plant.
Integrating AD and Composting

Integrating Anaerobic Digestion and (Aerobic) Composting (AD-A) offers the potential to adapt the process layout in order to enhance each peculiar aspect of both technologies (Piccinini 2006), producing energy through bio methane from the anaerobic process and compost, nitrogen and nitrogen derivatives from the aerobic technology. It enables both material and energy recovery from biowaste, corresponding in an effective way to the waste management hierarchy.

The technical evolution of a composting plant into an AD-A system leads to a classic win-win solution. It is argued (Piccinini 200636) that the AD-A solution offers:

- a better energy balance with a net production of energy, providing alternative renewable energy source replacing fossil fuels;
- a better solution and lower cost for odour control;
- a lower use of land surface compared to an only A solution for the same amount of waste treated;
- a reduction in CO₂ emission (zero emission balance or positive) because of the reduction in using fossil fuels and substitution of chemical fertilisers;
- a higher homogeneity of flows entering the A section, with a better agronomic use of the fertilising elements (Nitrogen is fixed);
- a better sanitation effect due to double thermal treatment;
- a lower use of structuring material (i.e. green and park waste) compared to an only A solution;
- a high efficiency in recovering material (compost) and energy (biogas), in order to reduce the climate impact and to close the nutriment cycle using digestion residues as fertiliser.

It is necessary to underline that compost compared to digestate shows:

- A higher nitrogen content comparable to a stable manure with a slow release;
- A higher sanitation effect37;
- An easier way of storage compared to the digestate.

An extensive assessment of AD-A integration has led to the conclusion that it represents an overall approach to manage the OFMSW in order to close the water balance of a single AD treatment and to remove the phytotoxicity of the digested effluent (Vallini et al. 199338). Recent publications conclude

37 EC regulation n° 1069/2009
that AD-A systems enhance the benefits of final compost as a soil amendment (Abdullahi et al. 2008; Smidt et al. 2011)\(^3\)

Hence, to recycle digestate, turning it into compost, aerobic treatment needs to take place. The disadvantage of aerobic treatment is the need to remove water and to add structure-rich materials to enable oxygen supply. During the change from anaerobic to aerobic conditions, methane might be emitted. New investigations of AD-A systems have found that the process starts aerobic for a few days, then anaerobic digestion takes place in the same reactor. When gas production drops, the reactor again is operated aerobically. The observed advantages are:

- excess heat from the first composting step contributes to the heating of the reactor
- excess water from the waste is evaporated during the composting process
- hydrolysis takes place under aerobic conditions. With sufficient oxygen supply carboxylic acids are degraded which may help to raise the pH-value
- the change from anaerobic to aerobic conditions happens within the same reactor. Thus methane emissions can be controlled

The combination offers a versatile waste treatment option because biowaste containing hardy organic matters (wood, lignins) can also be degraded by the following composting step. The integrated system offers a good waste management option in a transition period when diverting organic waste away from landfills.

Even during the phase when source separation is not yet in place, energy can be produced and the remaining solid fraction can be dried and stabilised by the aerobic process. Aerobic treatment leads to stabilised landfill fraction (MBT), refuse derived fuel (RDF) or material for landfill cover. A shift to composting of source separated waste is easily possible in the AD-A system. Thus the integrated concept may produce quality compost, RDF or landfill fraction and biogas at the same time (in different reactors). A material flow chart of a typical integrated AD-A plant is presented in Figure 8 below.


The specifications of two existing AD-A plants are provided in Annex 1.

**Overview of Options**

There are quite a number of composting and anaerobic digestion concepts for separately collected food waste and other forms of biowaste. A general comparison is shown in Table 4, which gives an overview without going into technical detail and operational specification of each concept. It is important that “optimal capacity” should always be properly defined based on the conditions of the target area, its peculiar challenges and the number of inhabitants served. Hence optimal capacities do not depend on the annual amount nor on the technology, but rather on the location and the logistics that are available for delivering separately collected biowaste.

**Table 4 - Comparison of options for biological treatment and optimal capacity ranges**

<table>
<thead>
<tr>
<th>Food waste options</th>
<th>Annual amount [t] (optimal range)</th>
<th>End-product</th>
<th>Typical energy win kWh per ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>General concept</td>
<td>Minimum</td>
<td>Maximum</td>
<td>Type</td>
</tr>
<tr>
<td>Open windrow composting</td>
<td>n.a.</td>
<td>15.000</td>
<td>compost</td>
</tr>
<tr>
<td>In vessel composting</td>
<td>20.000</td>
<td>&gt;200.000</td>
<td>compost</td>
</tr>
<tr>
<td>Wet AD systems</td>
<td>30.000</td>
<td>&gt;200.000</td>
<td>digestate liquid</td>
</tr>
<tr>
<td>Dry AD systems</td>
<td>20.000</td>
<td>&gt;200.000</td>
<td>digestate</td>
</tr>
<tr>
<td>Integrated AD-A</td>
<td>20.000</td>
<td>&gt;200.000</td>
<td>compost</td>
</tr>
</tbody>
</table>
9. CONCLUSION

Food waste occurs globally and has been growing at a tremendous pace over the last few decades: in high income countries as well as in lower income countries. Large amounts of food are wasted along the production-transportation-retail-consumption chain. Food waste is a severe global problem that has negative moral, environmental and financial implications. Besides international and local initiatives that are raising awareness and taking actions to prevent food waste, the waste management sector has an important role to play in addressing this global issue.

Some initiatives around the world have shown concretely how to prevent food waste through many different ways, such as better planning and storage, being informed about the real meaning of food product labels, and food rescue programmes that have been widely implemented worldwide. From the perspective of municipal solid waste management, food waste management has a profound impact on the whole municipal solid waste management system. It affects the rate of recycling of other recyclable materials, the treatment methods and efficiency of other fractions of municipal solid waste, and the cost of logistics of the overall waste management system.

Currently, the main regulatory approaches, namely bans on landfill, diversion targets and obligation, all show advantages and disadvantages. It is important to ensure a common understanding among stakeholders along the value chain with the overarching aim of reducing food waste, as well as to harmonise with other legislations that may impact on food waste, in particular legislation for soil, agriculture, climate change, and food safety.

Methodologically, biological treatment options to recycle food waste include composting and anaerobic digestion. An integrated concept, combining composting and anaerobic digestion is ideal in order to maximise the recovery of both energy and materials from food waste. In fact, there are a wide range of design varieties for biological treatment of food waste based on different local situations and treatment capacities. Thus, the available technologies can support local authorities and decision-makers who wish to reduce and recycle food waste by effectively managing the process of food waste recycling.

ISWA and the Working Group members on Biological Treatment of Waste who contributed to this document intend to encourage an open public discussion on this topic.
FURTHER READINGS – ISWA KNOWLEDGE BASE

Further readings and ISWA publications addressing the topic of food waste and biowaste management can be found at ISWA’s Knowledge Base at: http://www.iswa.org/en/76/publications.html

<table>
<thead>
<tr>
<th>Title</th>
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<td>2006</td>
<td>ISWA Guidelines &amp; Reports</td>
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<tr>
<td></td>
<td></td>
<td>Author: ISWA WG-Biological Treatment of Waste</td>
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<tr>
<td>ISWA TECHNICAL POLICY NO. 7 BIOLOGICAL TREATMENT AS PART OF INTEGRATED WASTE MANAGEMENT</td>
<td>2007</td>
<td>ISWA Papers</td>
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<td></td>
<td>Author: ISWA</td>
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<td>Challenges for the Implementation of Municipal Biodegradable Waste Management in the Baltic States. ISWA PROJECT GRANT &quot;Regional Biowaste Workshops&quot;</td>
<td>2012</td>
<td>ISWA Projects</td>
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<td>3rd Baltic Biowaste Conference, Vilnius, 23/24 Nov: ISWA GRANT PROJECT</td>
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<td>Author: Josef Barth</td>
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<td>Biowaste management and the role of landfills</td>
<td>2012</td>
<td>Author(s): APESB, WG-Landfill, WG-Biological Treatment of Waste</td>
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</table>
ANEX 1: SPECIFICATIONS OF TWO EXISTING AD-A PLANTS

1. **AD-A Plant At ACEA Pienerolese Waste Treatment District (Italy)**

   The plant of ACEA Pienerolese manages food waste collected from a third of the Turin province in Piedmont for about 800,000 inhabitants. The plant treats annually up to 50,000t of separately collected food waste. The AD process is semi-dry, thermophilic. Per ton of food waste produces about 128Nm$^3$ of biogas and 0.15t of digestate. The digestate is mixed with garden waste and composted together.

   **Key data:**
   - Annual total capacity: 50,000t
   - Biogas: 128Nm$^3$ per t of food waste
   - Digestate: 0.15t per t of food waste


2. **AD-A Plant For The Guetersloh District (Germany)**

   The KOMPOTEC plant manages the food and garden waste of the 350,000 inhabitants the district of Guetersloh. Started as a 35,000 t/a tunnel composting plant in 1996 the plant was enlarged in 2011 with a 30,000 t/a AD plant. The KOMPOFERM AD system operates dry, thermophilic, batch-wise with 9 fermenter tunnels and an underground percolation storage. Per ton of biowaste treated produces about 85 Nm$^3$ of biogas and 0.9 tons of unseparated digestate. The digestate is mixed with garden waste and composted in 8 additional tunnels. The whole plant markets annually 25,000 t of quality compost successfully.

   **Key data:**
   - Annual total capacity: 30,000 t
   - Biogas: 85 Nm$^3$/ t of biowaste
   - Digestate: 0.9 t per t of biowaste

   Source: KOMPOTEC, Guetersloh, Germany