FORESTRY IDEAS, 2014, vol. 20, No 2 (48): 181–187

QUANTIFICATION, MAIN CHARACTERISTICS AND POSSIBILITIES FOR RECOVERY AND DISPOSAL OF FOOD WASTE

Dilyana Yordanova* and Vanya Kyoseva

Department of Environmental Engineering, University of Chemical Technology and Metallurgy, 8 St. K. Ohridski Blvd., 1797 Sofia, Bulgaria.
E-mail: dilyana.yordanova@outlook.com*, vanya_kyoseva@uctm.edu

Received: 07 July 2014 Accepted: 30 October 2014

Abstract

Food waste is a serious global problem that leads to negative environmental, social and financial impacts. Worldwide losses of food in the stages of production, transportation, retail and consumption of food are significant – a third of the annual production output falls in the waste stream. A quantification of food waste in the country is presented in the paper. An analysis of the possibilities for sustainable management of food waste in Bulgaria by introducing measures to prevent its generation, separate collection implementation and application of proven technologies such as composting and anaerobic digestion, to ensure protection of the environment and human health is done.

Key words: anaerobic digestion, bio-waste, composting treatment, Introduction, utilisation.

Introduction

Food waste has important economic, environmental and social implications. As the global population continues to increase, the security of food supply is an issue that challenges governments all over the world.

Inappropriate management of municipal solid waste (MSW) in landfills contributes from 4 % to 11 % of the world's Greenhouse Gas (GHG) emissions (Ingram 2011). 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, the organic matter is stored in soils and not lost into the atmosphere as CO_2 or methane (Bond et al. 2013).

Food waste also classified as 'bio-waste' is a major group of biodegradable waste. The concept of food waste includes food from households, restaurants, caterers and retail premises, obsolete and expired food, inedible stocks from food processing plants (Henningsson et al. 2004). Table 1 presents the main groups of food waste according to Bulgarian legislation.

Main Characteristics of Food Waste

From a life cycle perspective, the term 'food waste' includes large sources of biogenous waste (bio-waste) along the food production chain:

Table 1. Major food waste types (Regulation No2 2014).

Description	Code	Waste
Food waste from households and catering	20 01 08	biodegradable kitchen and canteen waste
Expired food products of animal origin	02 02 03	materials unsuitable for consumption or processing
Expired food products of plant origin	02 03 04	materials unsuitable for consumption or processing
Only biodegradable waste equivalent to codes 20 01 08 and 20 02 01	20 03 02	waste from markets

- losses after harvesting;
- losses during transportation to industry;
- losses and surplus from food industry;
- residues from markets;
- residues from restaurants and catering;
- household food waste.

Estimates of how much food is wasted vary. The most recent report commissioned by the Food and Agriculture Organization (FAO) of the United Nations indicates that approximately 1,32 billion tonnes of food is lost or wasted annually, equivalent to about one-third of food produced for human consumption (Flammini et al. 2013). A recent study conducted on behalf of the European Commission's DG Environment estimated that approximately 89 million tonnes of food waste (674,000 tonnes in Bulgaria) was generated in 2006 within the EU-27, equivalent to 179 kg per person (Buchner et al. 2012). This amount is expected to rise to approximately 126 million tonnes (40 % increases) by 2020 unless additional preventive measures are taken (Kalley 2013).

The proportion of food waste arising at different stages of food supply chain varies depending upon the level of industrialisation (Gustavsson et al. 2011). Lower income countries tend to produce proportionally more food waste during production and processing, as these tend to rely on low-tech production methods. 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 (Parfitt et al. 2010).

Figure 1 provides specific information about the breakdown of total food wastage across food supply chain in European Union.

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 its biodegradability if mixed with food waste, which in turn affects how MSW is collected, treated and disposed of. The higher percentage of food wastes in MSW, the more crucial the need for source separation of waste. This is because separately collected food waste (together with other bio-waste) could be recycled into quality compost and could 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 due to source contamination with other substances which might be hazardous. Alternatively, mixed waste could be incinerated, however the high water content of food waste reduces the combustion efficiency and energy recovery efficiency.

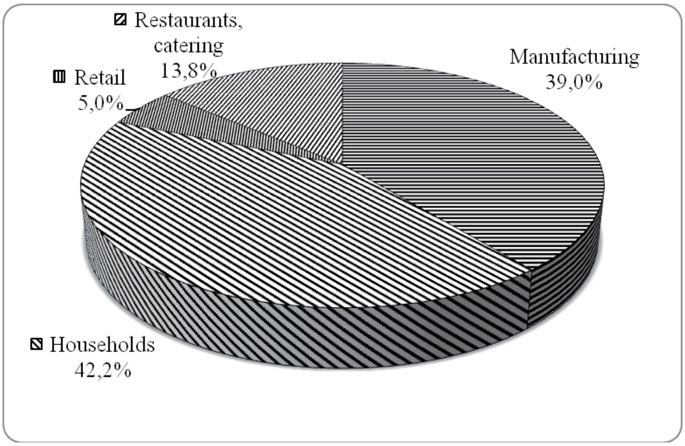

Fig. 1. Breakdown of Food Waste across EU-27 (Monier et al. 2010).

Analysis of Possible Methods for Recovery and Disposal of Food Waste

The Waste Management Act sets out a 'waste hierarchy', from prevention through to disposal via preparation for reuse, recycling and recovery. As applied to food, the waste hierarchy translates into a 'food use hierarchy' from prevention to landfill via redistribution to humans, feeding to animals and energy or nutrient recovery by methods such as anaerobic digestion and in-vessel composting (Figure 2).

The necessity for solution for the recovery and disposal of food waste is defined by some of its key features:

- easily contaminated by hazardous substances;
- unstable, source of nuisance and of pollution in landfills (emission of greenhouse gases, groundwater contamination and contamination of surface waters by leachate);
- moisture of food waste is variable, which has an influence on the logistical and technical requirements for its collection and further processing and also on the net calorific value.

There are several alternatives for managing food waste, including anaerobic digestion, composting (aerobic digestion), incineration and landfill.

Disposal of mixed municipal solid waste collected without pre-treatment or separation of food waste is common in almost all Bulgarian municipalities. This is an unacceptable practice as disposal of bio-waste involves a number of risks to the environment such as generation of landfill gas with a high global warming potential, leachate formation and occupation of space. It is a general requirement

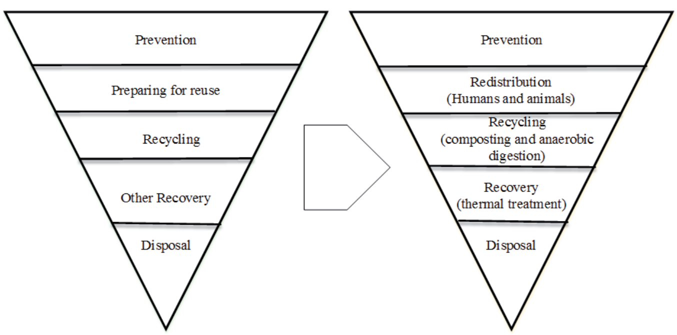

Fig. 2. Application of waste management hierarchy to food waste.

of EU Landfill Directive that all Member States have to reduce the amount of biodegradable municipal waste landfilled by 35 % by 2016. The target is related to the generated amount of bio-waste in 1995 (2,248,000 t). However, Bulgaria has benefited from a four- year derogation period.

Combustion of food waste is economically inefficient. The reason for this is high water content of food waste and its relatively low calorific value, which varies in the range of 1.8–4 GJ/t. However, these properties of food waste make it very suitable for disposal through biological treatment. By integrating anaerobic digestion and composting, both energy yields of 0.6 MWh/t and material recycling rates of 40 % could be achieved (Lipinski et al. 2013). Thus biological treatment contributes positively to CO_2 savings both by saving the use of fossil fuels through the production of biogas and by sequestration of carbon into soils through composting.

Composting is the decomposition process of food waste under controlled aerobic conditions. Compost is a valuable end product which contains recycled nutrients and carbon. Composting associated emissions include CO_2 (of biogenic origin), CH_4, NH_3 and N_2O, which should be minimized by using bio-filters. Measures to ensure the necessary qualities for the use of compost as a soil improver include the introduction of separate collection of food waste to avoid contamination with toxic elements such as heavy metals and organic pollutants, and carry out the process under optimum conditions (O_2 content, humidity, temperature, C/N ratio and maturing time).

Anaerobic digestion is a process of degradation of organic matter into simpler compounds in the absence of oxygen. When anaerobic digestion is applied to food waste, it can be operated under different technological conditions (Gray et al. 2008). Currently available technologies can be divided into three categories based on the amount of total solid (TS) content:

- dry: more than 20 % TS;
- semi-dry: between 10 and 20 % TS;
- wet: less than 10 % TS.

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 – the waste has to be very well separated from impurities to avoid damage to the installation and the waste has to be mashed so that a high degree of degradation can be achieved. In the following stage, energy gain in the form of biogas from the mashed fraction could be very high. The end products of anaerobic digestion are digested semi-product which can be composted and nitrogen-rich process water which is to be treated and discharged or may be used as liquid fertiliser after sanitation.

In dry systems the transport of waste is done mechanically by conveyer belts, screw conveyers, front loaders, etc. One of the advantages of dry systems is that the digested semi-product 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.

Integrating anaerobic digestion and composting offers the potential to adapt the process layout in order to enhance each specific aspect of both technologies, producing energy through biogas from anaerobic process and compost, nitrogen and nitrogen derivatives from aerobic technology (Figure 3). It enables both material and energy recovery from food waste, corresponding in an effective way to the waste management hierarchy.

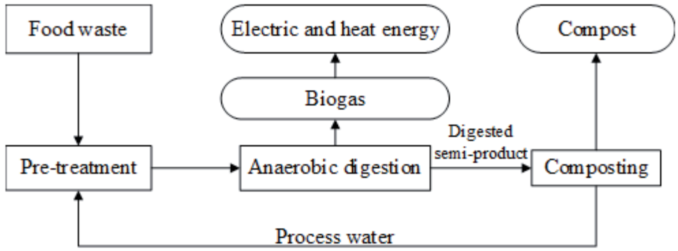

Fig. 3. Integrated system for food waste treatment.

The analysis of the advantages of integrated systems for anaerobic digestion and composting of food waste shows that they offer:

- a better energy balance with a net production of energy, providing alternative renewable energy source replacing fossil fuels;
- a lower use of land surface compared to an only composting solution for the same amount of waste treated;
- a reduction in CO_2 emission because of the reduction in using fossil fuels and substitution of chemical fertilisers;
- a higher homogeneity of flows entering the aerobic section, with a better agronomic use of the fertilising elements (Nitrogen and other micronutrients are fixed);
- lower use of structuring material (i.e. green and park waste) compared to an only composting 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.

Results and Discussion

Prerequisites for the choice of food waste treatment method are its quantity and quality, and the availability of markets for related products. Table 2 shows a comparative analysis of different technologies for biological treatment of food waste.

In order to choose the most environmentally sound technology for the treatment of food waste, ensuring maximum use of their raw material and energy resources it is necessary to carry out a life cycle assessment of the processes. In some cases, the energy resulting from incineration of food waste (dry matter content <25 %) can be in a smaller quantity than from anaerobic digestion. The advantages of incineration of wet food waste are limited to emissions saved.

When comparing anaerobic digestion and subsequent composting of the digested semi-product and direct composting the key question is whether they produce a similar amount of compost and whether the composition of the compost-output from both processes is similar. If the composition is similar and the amount generated is similar, then the integrated system is likely to be environmentally preferable to direct composting. When anaerobic digestion is not technically feasible but composting is technically feasible, the choice is mainly between composting and incineration. In this case, a life cycle assessment is necessary to balance both types of benefits – key parameters include process efficiency, waste composition, transportation distances, etc.

Table 2. Comparison of options for biological treatment of food waste.

Treatment method	Capacity		End product		Energy yield, kWh/t
	Minimum, t/y	Maximum, t/y	Type	Application	
Open windrow composting	–	15,000	Compost	Growing media, soil improver	0
In-vessel composting	20,000	>200,000	Compost	Growing media, soil improver	0
Wet anaerobic digestion systems	30,000	>200,000	Digested semi-product	Soil improver	645
Dry anaerobic digestion systems	20,000	>200,000	Digested semi-product	Soil improver	600
Integrated systems anaerobic digestion + composting	20,000	>200,000	Compost	Growing media, soil improver	510

Conclusion

The review and analysis of alternatives for the treatment of food waste allows to formulate the following conclusions:

- food waste is generated at all stages of food production and supply chain – from agriculture, transport and storage, production, retail and consumption but priority should be given to biodegradable components of MSW and food storages, because of the quantities released and negative health and environmental effects;
- the percentage of food waste in the mixed municipal solid waste stream varies between 30 and 40, which means that in Bulgaria about 1.3 million t/y of food waste is generated;
- currently there is an effective system for recovery of food waste as raw material and energy resource;
- the analysis of applicable treatment technologies for food waste shows that the most preferable method for Bulgaria is an integrated system of anaerobic digestion and composting.

References

ANONYMOUS 2009. Green Paper on the management of bio-waste in the European Union. Committee on the Environment, Public Health and Food Safety.

ARSOVA L. 2010. Anaerobic digestion of food waste: Current status, problems and an alternative product. Columbia University, 77 p.

BOND M., MEACHAM T., BHUNNOO R., BENTON T.G. 2013. Food waste within global food systems. A Global Food Security report, 43 p.

BUCHNER B., FISCHLER C., GUSTAFSON E., REILLY J. 2012. Food waste: causes, impacts and proposals. Barilla Center for Food and Nutrition, 71 p.

FLAMMINI A., HOOGEVEEN J., IWEINS M., TUBIELLO F. 2013. FAO, Food Wastage Footprint. Impacts on Natural Resources, 63 p.

GRAY D., SUTO P., PECK C. 2008. Anaerobic Digestion of Food Waste, Final Report. U.S. Environmental Protection Agency, 62 p.

GUSTAVSSON J., CEDERBERG C., SONESSON U., VAN OTTERDIJK R., MEYBECK A. 2011. Global Food Losses and Food Waste: Extent, Causes and Prevention. FAO, 23 p.

HENNINGSSON S., HYDE K., SMITH A., CAMPBELL M. 2004. The value of resource efficiency in the food industry: a waste minimisation project, East Anglia UK Journal of Cleaner Production 12(5): 505–512.

INGRAM J. 2011. A food systems approach to researching food security and its interactions with global environmental change. Food Security 3(4): 417–431.

KALLEY T. 2013. Municipal waste management in Bulgaria. European Environment Agency, 16 p.

Lipinski B., Hanson C., Lomax J., Kitinoja L., Waite R., Searchinger T. 2013. Reducing Food Loss and Waste. Working Paper, Instalment 2 of Creating a Sustainable Food Future, Washington, DC: World Resources Institute, 40 p.

Monier V., Mudgal S., Escalon V., O'Connor C., Gibon T., Anderson G. 2010. European Commission, Preparatory Study on Food Waste across EU 27 (2010) Technical Report 2010 – 054, 213 p.

Parfitt J., Barthel M., Macnaughton S. 2010. Food waste within food supply chains: quantification and potential for change to 2050. Philosophical Transactions of the Royal Society 365(1554): 3065–3081.

Regulation No2 2014. Regulation No2 from 23.07.2014 on waste classification. Ministry of Environment and Water. (In Bulgarian).