D9.2 EU Policy on biowaste management: a review

VALUEWASTE

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Contents

Executive summary

The present document is a Deliverable of the VALUWASTE project (Grant Agreement No.: 818312). This Deliverable provides an overview on the current European biowaste policy framework and related management practices: separated collection efficiency, disposal and valorisation methods, and recycled amounts. At present, all waste streams produced by EU citizens are regulated by the European Circular Economy Package, which includes the waste directive 2008/98/EC. The EU circular Economy action plan has been launched on 2 December 2015 and, after three years, on 4 March 2019, the Commission reported on the complete execution of the action plan. However, many actions have still to be carried out to ensure that biowaste streams will be efficiently valorised in the future. In fact, at present, there is a strong barriers in most of EU countries, against the authorization of using "biowaste-derived products", as alternative to other conventional ones. The report analyses the current most common biowaste treatment solution adopted in Europe, and gives an overview on the present regulation influencing (and affecting) the take-off of innovative solutions for processing biowaste as a resource, extracting and commercializing high value products. This report aims to be a a guideline for ValueWaste project to start approaching the regulatory framework and develop strategies towards a fast market penetration.

Abbreviation

AD: Anaerobic digestion
BAT: Best available techniques
CEP: Circular Economy Package
COM: Communication
EU: European Union
EC: European Commission
ECN: European Compost Network
GHG: greenhouse gas
IED: Industrial Emission Directive
IPPC: Integrated Pollution, Prevention and Control
MS: Member State
REACH: Registration, Evaluation, Authorisation and Restriction of Chemicals
RES: Renewable energy source
RDF: Residue Derived Fuel
SGD: Sustainable Development Goals
WFD: Waste Framework Directive
WID: Waste Incineration Directive

Introduction

Each European citizen produces approximately 230 kg of municipal biowaste per year, what makes between 118 and 138 million tonnes of biowaste annually[1] across Europe (EU). Despite the ambitious targets set by the European Commission concerning the recycling percentages for different materials, 14 Member States have been identified as at risk of missing the 2020 target of 50% recycling: Bulgaria, Croatia, Cyprus, Estonia, Finland, Greece, Hungary, Latvia, Malta, Poland, Portugal, Romania, Slovakia and Spain. For these countries the Commission presents blueprints for action to ensure compliance with EU waste legislation. Also in most excellent countries, the actual amount of waste recycled is usually lower than the amount separately collected, due to the lack of really efficient valorisation technologies. The latest update of EU Waste directive states the following targets: 55 % of municipal waste to be recycled and prepared for reuse by 2025, 60 % by 2030 and 65 % by 2035. The most critical waste fraction is exactly the biowaste, representing, on average, more than 45% in mass of produced municipal waste. However, the biowaste can be transformed into green energy, organic fertilizer, feed, biopesticides, bioplastics and many others biobased products.

At present, most common technologies adopted for biowaste treatment are anaerobic digestion and composting. Moreover, anaerobic digestion can't be considered alone a waste treatment solution, as it produces an amount of biowaste Compost production is relatively easy and cost-effective to implement at local, regional or national level. Compost production can go hand in hand with production of biogas. Compost made from biowaste can improve the quality of soils with sustainable and renewable fertilizers. This could improve the economic value generated per tonne of biowaste. Moreover, biowaste holds considerable promise as a renewable source of energy in EU. According to estimates, about one-third of the EU's 2020 target for renewable energy in transport could be met by using biogas produced from biowaste, while around 2% of the EU's overall renewable energy target could be met if all biowaste was turned into energy. Optimal biowaste management can reduce greenhouse gases, so it can help in the fight against climate change.

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52010DC0235

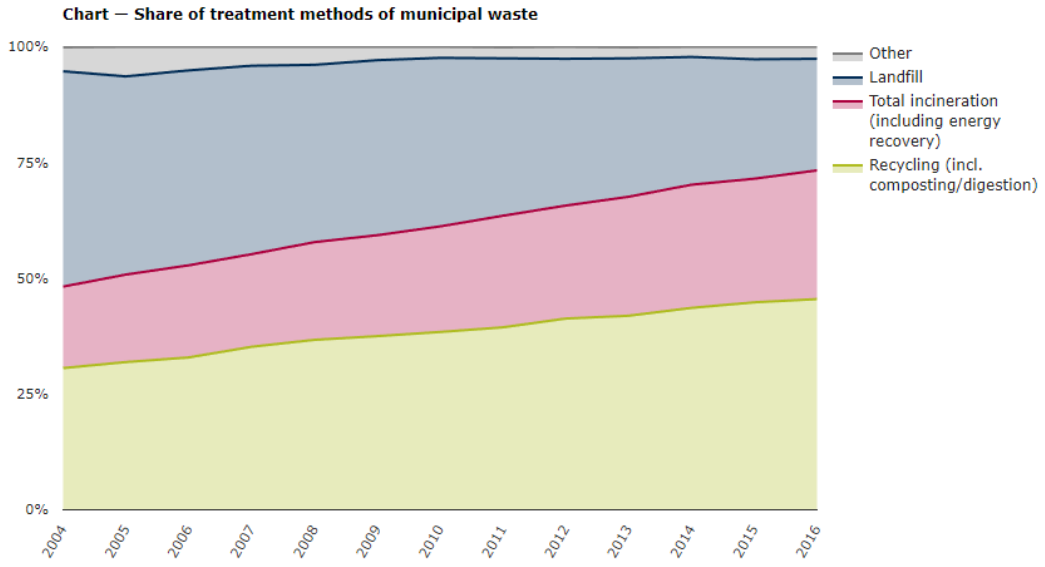

Figure 1. EU Waste management and disposal. (Source: Eurostat, 2017).

As visible from the chart above, In EU, recycling average is still lower than 50%. Regarding municipal biowaste management, the average recycling rate in Europe is 80 kg per capita, with an average production of about 230 kg per capita, it comes out that, on average, less than 35% of the biowaste is recycled (composting, digestion), in Europe. The other systems adopted, that currently exist are landfilling (40% up to 100% in some Member States (MS)), and incineration,

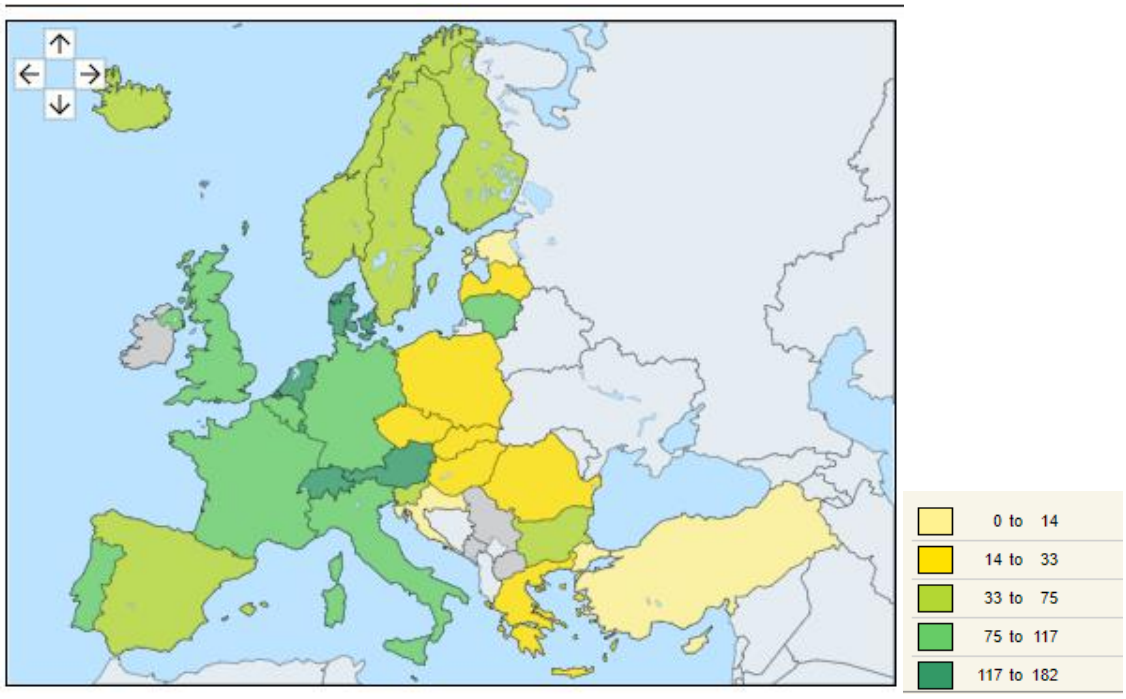

Figure 2. EU biowaste recycling per capita (source: Eurostat, 2017). The indicator is indirectly measured as the ratio of composted/methanised municipal waste (in mass unit) over the total population (in number). The ratio is expressed in kg per capita. The underlying assumption is

that, by and large, the only reasonable treatment of biowaste is composting or anaerobic digestion.

In December 2015, the EC published the European Circular Economy Package that introduced a resource-efficient society and sustainable recycling industries across Europe. Biowaste recycling and recovery stimulates Europe's transition towards a circular economy. In addition to this action plan, the proposal suggested revisions to European Union waste legislation that aiming to avoid, reuse and recycle more waste in the future. The circular economy strategy goes beyond the waste hierarchy by designing circular resource flows at regional and global level and between industries. A transition to a circular economy will require changes in the whole value chain: in product design identifying new methods turning waste into products, new business and market models and changes in consumer behaviour. Many legislations have been adopted at the EU level to address the issue of waste prevention and recycling and introduce the circular economy approach in Europe.

This paper provides a review of EU policy and legislative framework including all stages of biowaste management such as collection, storage, processing, material and energy recovery, and disposal. This paper analyses the current regulatory aspects in relation to waste management in Europe and related environmental and health risks.

The EU policy on biowaste: circular economy and bioeconomy

The circular economy strategy

The European Union policy on biowaste relies mainly on the circular economy package, aiming at ensuring a sustainable use of natural resources, improve resource efficiency and reduce environmental pressures. The circular economy strategy brings the waste hierarchy and the bioeconomy together, where the bioeconomy concentrates on the conversion of renewable carbon reserves from agricultural or forestry biomass and organic wastes into different products and materials. The bioeconomy is the underlying parameter for the development, production, and use of biological products and processes through bio-valorisation.

The European biowaste management policy, covered by several pieces of EU legislation, aims to promote the circular economy throughout MSs contributing to achieving the overall goals of decreasing waste generation, improving recycling, extending responsibility to waste producers and implementing stricter measures regarding waste separation, including biowaste.

The core point of a circular economy approach consists on avoiding landfilling and valorise biowaste as a resource for biorefineries. The carbon and nutrient contents of biowaste are mainly concentrated in organic fertilisers, soil improvers and growing media, or can be extracted, modified or transformed into several bio-based products. All these secondary products can replace fossil-based products. After use, the residues of these products can flow back safely into the biosphere, thereby closing carbon and nutrient cycles.

The CEP consists of an EU Action Plan for the Circular Economy and annex to the action plan outlining the timetable for proposed actions, and related legislative proposals on waste. The CEP was published in the Official Journal of the European Union on June 14, 2018. The Package includes:

- Directive 2018/849 of May 30, 2018, amending Directives 2000/53/EC on end-of-life vehicles; 2006/66/EC on batteries and accumulators and waste batteries and accumulators; and 2012/19/EU on waste electrical and electronic equipment
- Directive 2018/850 of May 30, 2018, amending Directive 1999/31/EC on the landfill of waste
- Directive 2018/851 of May 30, 2018, amending Directive 2008/98/EC on waste
- Directive 2018/852 of May 30, 2018, amending Directive 94/62/EC on packaging and packaging waste.

To shift towards a European circular economy and reach a high level of resource efficiency, the CEP imposes several targets:

- ➔ 55 % of municipal waste must prepared for re-use and recycling by 2025, 60% by 2030, and 65% by 2035.
- ➔ The amount of municipal waste landfilled must be reduced to 10% or less of the total amount of municipal waste generated by 2035.
- ➔ As of 2030, all waste suitable for recycling or other recovery, in particular in municipal waste, must not be accepted in a landfill, excepted for waste for which landfilling delivers the best environmental outcome.
- ➔ The total amount of recycled packaging waste must be at 65% by 2025 and 70% by 2030. MSs can ask for derogations to the EC under certain circumstances.
- ➔ Specific minimum targets for recycling some materials contained in packaging waste (plastic, wood, ferrous metals, aluminum, glass, paper, and cardboard) are imposed.
- ➔ By December 31, 2023, Member States must ensure that biowaste is either separated and recycled at source or is collected separately and not mixed with other types of waste.

The EC Staff Working Document - Measuring progress towards circular economy in the European Union – Key indicators for a monitoring framework[2] presented in January 2019, measures progress and assesses the effectiveness of action towards the circular economy in the EU and Member States. The paragraph 6F describes the recycling rate of biowaste per capita in MS (more information in section *Material recovery and recycling of biowaste).*

The proposed actions of the Closing the loop - An EU action plan for the Circular Economy COM (2015) contribute to “closing the loop” of product life cycles through greater recycling and reuse and bring benefits for both the environment and the economy. This Communication recognised the importance of biowaste in the circular economy. Realising this potential depends on investment in integrated biorefineries, capable of processing biomass and biowaste for different end-uses. The EU is supporting such investments and other innovative bioeconomy-based projects through research funding.

[2] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=SWD:2018:17:FIN

The bioeconomy strategy

The Bioeconomy strategy was updated in October 2018 and one of the main objectives of the strategy is reducing dependence on non-renewable resources. Moreover, a scaled-up and strengthened bio-based sector can do more than non-renewable substitution: support the renewal of the EU industrial base; contribute to the greening of industrial products; and help to systematically turn biowaste and discards into value, thus achieving circularity. The Bioeconomy strategy recognised biodegradable waste (or biowaste) as an important source of biomass, whose potential economic value is starting to be recognised by several sectors (e.g. the agricultural, forest-based, chemical and energy sectors). With the development of the Bioeconomy, the demand for these secondary products is likely to increase, changing the economic conditions of production. A sustainable Bioeconomy is the renewable segment of the circular economy. It can turn biowaste, residues and discards into valuable resources and can create the innovations and incentives to help retailers and consumers cut food waste by 50% by 2030. The Review of the Bioeconomy Strategy highlighted that there are only a few cities that have Bioeconomy-related priorities in their policies, despite the potential of municipal biowaste for nutrient recovery, bio-based products and energetic use. This shortcoming is significant, considering that cities and urban areas now house more than 70% of all Europeans.

Further EU policies on general waste management

Other EU policies and programmes such as 7th Environmental Action Programme, Resource Efficiency Roadmap and the Raw Materials Initiative provide the ground for the development and implementation of EU waste policy and legislation.

The 7th Environment Action Programme

The 7th Environment Action Programme sets the following objectives for waste policy in the EU:

- To reduce the amount of waste generated;
- To maximise recycling and re-use;
- To limit incineration to non-recyclable materials;
- To phase out landfilling to non-recyclable and non-recoverable waste;
- To ensure full implementation of the waste policy targets in all Member States.

Waste prevention and management are among top priorities of EU 7th Environmental Action Programme.

The Roadmap to a Resource Efficient Europe

The Roadmap to a Resource Efficient Europe (COM (2011) 0571) is part of the resource efficiency flagship initiative of the Europe 2020 strategy. It supports the shift towards sustainable growth via a resource-efficient and low-carbon economy. The roadmap takes into account the progress made on the 2005 Thematic Strategy on the Sustainable Use of Natural Resources (COM (2005) 0670) and the EU's Sustainable Development Strategy and sets out a framework for the design and implementation of future action.

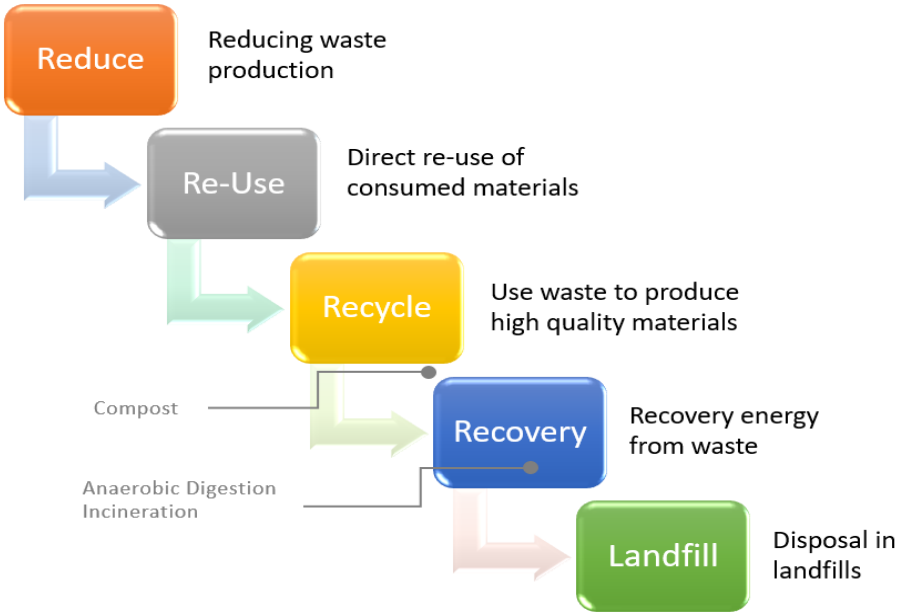

Figure 3. European Commission Waste hierarchy (Source: EUBIA)

It also outlines the structural and technological changes needed by 2050, including milestones to be reached by 2020. It proposes ways to increase resource productivity and decouple economic growth from resource use and its environmental impact.

"*Milestone: By 2020, waste is managed as a resource. Waste generated per capita is in absolute decline. Recycling and re-use of waste are economically attractive options for public and private actors due to widespread separate collection and the development of functional markets for secondary raw materials. More materials, including materials having a significant impact on the environment and critical raw materials, are recycled. Waste legislation is fully implemented. Illegal shipments of waste have been eradicated. Energy recovery is limited to non-recyclable materials, landfilling is virtually eliminated and high quality recycling is ensured.*" (Roadmap to a Resource Efficient Europe, 2011)

Raw Materials Initiative

In 2008, the European Commission adopted the Raw Materials Initiative, which sets out a strategy for tackling the issue of access to raw materials in the EU. This strategy has three pillars, one of which consists on ensuring resource efficiency and supply of secondary raw materials through recycling. Producing goods using recycled materials is often less energy intensive, reduces production costs and carbon emissions, and increases resource efficiency in Europe. In the Raw material Initiative Communication published on February 2nd, 2011, the Commission proposed measures to improve the recycling market through:

- development of best practices in collection and treatment of waste;
- improving the availability of statistics on waste and materials flows - see the Knowledge base;
- reviewing EU waste and Eco-design legislation;
- supporting research and innovation;
- promoting economic incentives for reuse and recycling. (Raw Materials Initiative, 2011).

Furthermore, the Raw Materials Initiative sets out actions to improve the enforcement of EU rules on how waste may be traded.

Biowaste management and related legislation

Biowaste definition

Biowaste is defined by the Waste Framework Directive as biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises, and comparable waste from food processing plants. It does not include forestry or agricultural residues, manure, sewage sludge, or other biodegradable waste such as natural textiles, paper or processed wood. It also excludes those by-products of food production that never become waste. Biodegradable waste, as defined by the Landfill Directive, includes "any waste that is capable of undergoing anaerobic or aerobic decomposition, such as food and garden waste, and paper and paperboard. Biodegradable waste is a broader concept defined in the Landfill Directive as any waste that is capable of undergoing anaerobic or aerobic decomposition, such as food and garden waste, and paper and paperboard.

Sometimes refers to kitchen waste only and excludes green waste. Kitchen waste consists largely of food waste. On average, the amounts of kitchen and green wastes are about the same but there are important local variations, for instance, between rural and urban areas.

The risks and opportunities of biowaste management were recognised by EU in the past few years.

EU legislation on biowaste management

The EC took actions in preparing potential legislative proposal on biowaste, such as **Green Paper on the Management of Biowaste in the EU COM(2008)811**. The paper was published as integration to the Waste directive in order to put a focus on biowaste, not sufficiently treated in the directive. Citing the paper: "biodegradable waste should preferably be recycled through material recovery in composting plants or […] through energy recovery at biogas stations with subsequent material recovery of the digestate. The paper also underlined that compost and digestates of lower quality should be avoided as far as possible.

The paper drove the further initiatives of the European commission in terms of biowaste recycling, creating the first, great barriers towards sustainable biowaste valorisation: limiting the recycling practice to two single technologies: Composting, AD. This aspect was repeated in the further important study published by the JRC: End-of-waste criteria for biodegradable waste subjected to biological treatment (compost & digestate). Again, the sole technologies intended by the commission for biowaste recovery were Composting, and Anaerobic digestion. With an additional issue: the residue of anaerobic digestion, "digestate", must be composted before any agriculture application.

The Paper was also followed by a **Communication on future steps in biowaste management in the EU COM (2010)235122**). This Communication explains the steps considered necessary by the EC at this stage for optimizing the management of biowaste. In particular, the EC lays out recommendations on the way forward to reap the full benefits of proper biowaste management; describes the main potential courses of action at EU and national level and how to implement them best. The Communication presents a variety of approaches that are applied by EU MSs:

- Countries relying heavily on incineration of waste diverted from landfills, accompanied by a high level of material recovery and often advanced strategies promoting biological treatment of waste;
- Countries with high material recovery rates but relatively little incineration, with some of the highest composting rates in the EU;
- Countries relying on landfills, where diversion of waste from landfills remains a major challenge due to lack of alternatives.

Despite the limits of initial policy communication, Biowaste is going to be recognized as a biomass streams playing a key role in sustainable bioeconomy development. However, biowaste management covers aspects from collection, to treatment, and recovery through dedicated channels, which influence its quality and the related reliable end uses. The Figure 2 below represents the main steps in biowaste management. However, currently, there is no single management model for Europe and biowaste management systems highly differ within member states.

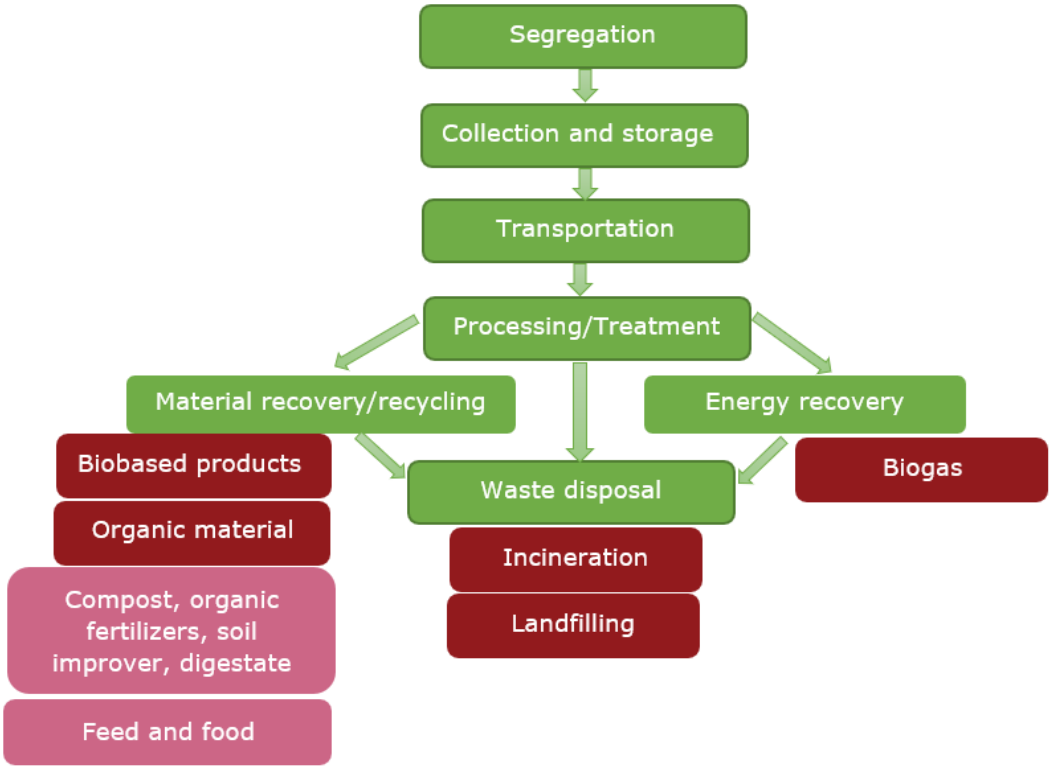

Figure 4: Steps in Biowaste management

According to the **Working document Biological treatment of biowaste of DG ENVI**, an improved management of biowaste should be encouraged in the community:

1) the prevention or reduction of biowaste production (e.g. sewage sludge) and its contamination by pollutants,
2) the reuse of biowaste (e.g. cardboard), across the EU.

3) the recycling of separately collected biowaste into the original material (e.g. paper and cardboard) whenever environmentally justified,
4) the composting or anaerobic digestion of separately collected biowaste, which is not recycled into the original material, with the utilisation of compost or digestate for agricultural benefit or ecological improvement,
5) the mechanical/biological treatment of biowaste,
6) the use of biowaste as a source for generating energy.

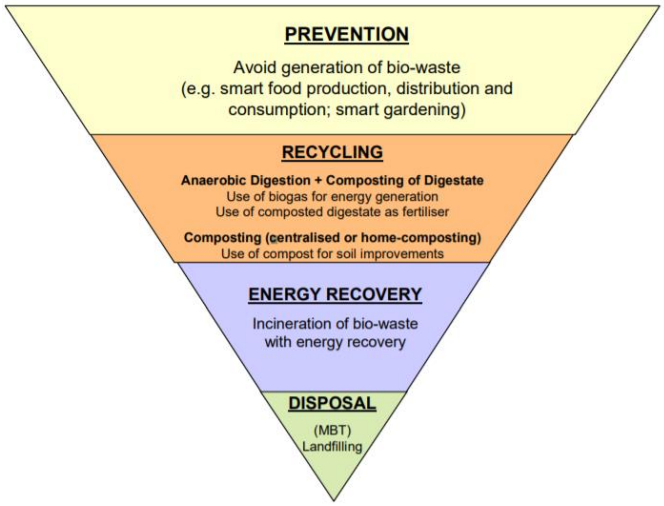

Figure 5: Waste hierarchy applied to biowaste

The WFD requires MSs to develop general waste management policies that protect environmental and human health during waste treatment and priority for waste recycling. It is important, in accordance with the waste hierarchy, and for the purpose of reduction of GHG emissions originating from waste disposal on landfills, to facilitate the separate collection and proper treatment of biowaste in order to produce environmentally safe compost and other biowaste based materials. The EC, after an assessment on the management of biowaste, will submit proposals for legislative measures, if appropriate. It also contains specific biowaste related elements (new recycling targets for household waste, which includes biowaste) and a mechanism allowing setting quality criteria for compost (end-of-waste criteria, Article 6). The WFD ensures a sustainable use of natural resources. MSs are thus legally bound to optimize the treatment of biowaste according to their specific conditions. Article 4 on the “waste hierarchy” states that the prevention of waste is the best option, followed by re-use, recycling and energy recovery (see Figure 4). Disposal (landfilling, incineration with low energy recovery) is defined as the worst environmental option. MSs may depart from this hierarchy where for specific waste streams this is justified by life cycle thinking on the overall impacts of such waste. Furthermore, the WFD enables the setting of EU minimum requirements for biowaste management and criteria for the quality of compost from biowaste, including requirements on the origin of the waste and treatment processes. Such criteria have been called for to enhance user confidence and strengthen the market in support of a material efficient economy.

Biowaste collection and storage

European regulations require restaurants and the agri-food industry to set up separate collection systems for the biowaste they produce and to optimize landfill, incineration, and biological treatment, i.e. by composting or anaerobic digestion. Article 22 'Biowaste' of Waste Framework Directive proposed revisions oblige MSs to introduce the separate collection of biowaste as far as is technically, ecologically and economically feasible. It states that "Member States shall take measures, as appropriate, and in accordance with Articles 4 and 13, to encourage the separate collection of bio-waste with a view to the composting and digestion of bio-waste". Notably, the separate collection of biowaste is a prerequisite to ensure compliance with quality standards for compost and digestate, as well as contributing towards attaining the 65% municipal waste recycling target. MSs should make strong efforts for introducing separate collection in order to meet high quality recycling and anaerobic digestion. Systems of separate collection can differ significantly depending on, for instance, the types of waste collected (food waste, garden waste etc.) and the availability of treatment options. The key for success lies in adaptation to local conditions and user-friendly design.

The 2010 Communication from the Commission on Future steps in bio-waste management in the European Union (COM(2010)235 Final) states the following: "Composting and anaerobic digestion offer the most promising environmental and 63 economic results for bio-waste that cannot be prevented. An important precondition is a good quality of the input to these processes. This would in the majority of cases be best achieved by separate collection."

The 2012 Guidance on the interpretation of key provisions of Directive 2008/98/EC on waste states that "co-mingled collection of more than one single waste stream may be accepted as meeting the requirement for separate collection, but the benchmark of ‘high-quality recycling’ of separately collected single waste streams has to be examined; if subsequent separation can achieve high-quality recycling similar to that achieved with separate collection, then co-mingling would be in line with Article 11 WFD and the principles of the waste hierarchy". And although the Guidance document subsequently states that "practically, this usually excludes co-mingled collection of biowaste and other ‘wet‘ waste fractions with dry fractions such as e.g. paper", it also states that "the wording of Article 22 WFD leaves the introduction of separate bio-waste collection to Member States’ discretion but obliges Member States to concretely encourage separate collection".

Separate Collection of biowaste in Europe

Separate collection schemes are important in order to prevent the contamination of biowaste with other polluting wastes, materials and substances. Different strategies can be applicated by Member States to increase the biowaste quality and make it sustainable for many applications.

a) food waste from private households;
b) food waste from restaurants, canteens, schools and public buildings;
c) biowaste from markets;
d) biowaste from shops, small businesses and service undertakings;
e) biowaste from commercial, industrial and institutional sources unless used on site;
f) green and wood wastes from private as well as public parks, gardens and cemeteries.

Member States may waive the obligation of separate collection of biowaste: in inner cities where the logistic of separate collection may make it difficult to achieve a low level of contamination of biowaste with other polluting wastes, materials and substances; and in rural or less populated areas with a density of less than 10 inhabitants per square kilometre in which the setting up of separate collection schemes would not be environmentally justified. In these areas special campaigns to particularly promote home, on-site and community composting shall take place. In order to avoid an unjustified increase in the quantity of sewage sludge, it should be prohibited to dispose of shredded biowaste to the sewer.

Large differences exist in the provision of separate collection and treatment capacity for biowaste across Europe. Countries such as Austria, Switzerland, Germany, the Netherlands, Flanders (Belgium), Sweden and Norway, have relied upon separate bio-waste collection and treatment systems for over 15 years, whilst countries, such as the UK, Italy, Finland, Ireland, Slovenia, Estonia and France have made significant advances during this period. On the other hand, considerable potential for expansion remains in a number of countries such as Bulgaria, Greece, Croatia, Latvia, Lithuania, Malta, Poland, Portugal, Romania, Slovakia, Spain, Czech Republic, Hungary and Cyprus.

In some instances, countries with established biowaste collections rely predominantly upon composting green waste, leaving further potential for separate household food waste collections. Similarly, studies in regions where established separate biowaste collections have been in place for many years, indicate that a high proportion of biowaste (60-70 kg per inhabitant per year) remains within the residual waste stream (ECN,2019).

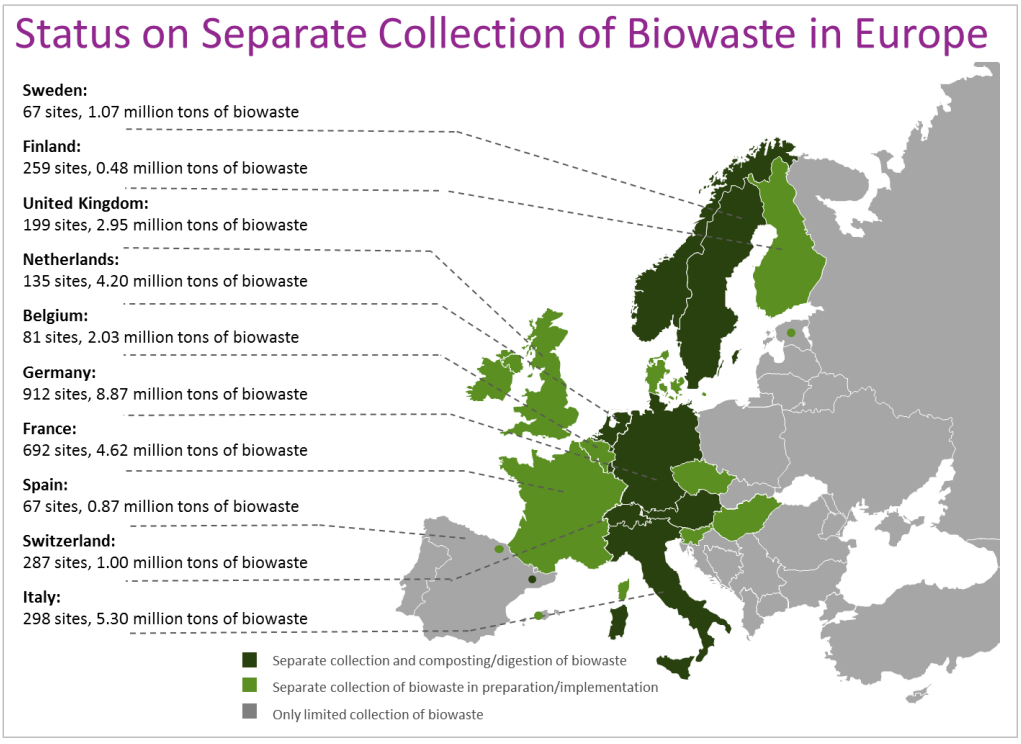

Figure 6: Status on Separate Collection of Biowaste in Europe adopted from ECN

Processing and treatment of biowaste

Conventional options of biowaste or biodegradable waste recycling are composting, and anaerobic digestion. Unsafe biowaste, unable to be used for agriculture, is currently disposed by incineration or landfilling. Unfortunately, the strict quality established for compost reutilization in agriculture are generating a large amount of "not usable" compost. . . Additionally, compost market value is usually very low, on average: 10 €/t. This makes composting plants not economically sustainable without a high treatment fee, which has an average price of around 80 €/in all European Member States. In practice, composting is not changing the economy of biowaste sector. MSs are often inclined to the seemingly easiest and cheapest option such as incineration or landfilling, disregarding the actual environmental benefits and costs. Until new real high value products won't be recovered, waste sector will be always a cost for citizens

Choices between composting, energy production by digestion and various ways of using the energy produced (transport, electricity, heat production) will depend on local conditions (energy mix, possible synergies with other policies) and should be left to MSs. The proposed Directive on Industrial Emissions, aimed to replace the current IPPC Directive, is laying down the main principles for the permitting and control of larger biowaste treatment installations (above a capacity of 50 tonnes per day). Regulation on biowaste could complement but should not affect health rules for the collection and treatment of Animal By-Products. (COM)

Biological treatment

Biological Treatment of biowaste is an EU-initiative that should improve the present situation for biodegradable waste (biowaste) management and helps meeting the targets of the Landfill Directive 1999/31/EC which could be based on Articles 95 and 175 EC Treaty and should include the following elements:

• To promote the biological treatment of biowaste by harmonising the national measures concerning its management in order to prevent or reduce any negative impact thereof on the environment, thus providing a high level of environmental protection.

• To protect the soil and ensure that the use of treated and untreated biowaste results in benefit to agriculture or ecological improvement.

• To ensure that human as well as animal and plant health is not affected by the use of treated or untreated biowaste.

Several MSs have already reduced or are expected to dramatically reduce landfilling of biowaste and increase its biological treatment. It is however improbable that without further incentives the less advanced MSs will in the foreseeable future take significant steps towards composting and biogas production. More likely, they will continue choosing the seemingly easiest options, disregarding overall environmental benefits and costs. This explains why some MSs and stakeholders continued to call for EU action in this area. (COM)

The most conventional methods adopted for separated biowaste in EU are anaerobic digestion and composting. Based on surveys carried out by the European Compost Network,

approximately 30 M tonnes of separately collected biowaste is composted or digested annually in about 3,500 treatment plants across EU. Green waste accounts for more than 50% of this biowaste, which is processed in more than 2,000 composting plants. Composting predominates over anaerobic digestion for the biowaste stream, resulting in over 90% of food and green waste being processed into compost.

Home composting

MSs shall encourage home composting whenever there are viable outlets for the resulting compost such as private gardens. MSs shall ensure that an appropriate information campaign is carried out in order to inform the general public on how to make compost and to illustrate the benefits for the environment from recycling biowaste.

On-site composting or anaerobic digestion

MSs shall encourage on-site composting or anaerobic digestion whenever there are viable outlets for the resulting compost or digestate such as farmland. Local authorities shall be encouraged to compost on site their own green and wood waste, for example from cemeteries and public parks. The competent authority shall be satisfied that an on-site composting or anaerobic digestion plant fulfils the requirements of Article 4 of Directive 75/442/EEC as amended.

Community composting

MSs shall take appropriate measures to encourage the setting up of community composting schemes as a way of involving the general public in the management of their own waste, reducing transport of waste and increasing awareness of waste recycling practices. The competent authority shall be satisfied that a community composting plant fulfils the requirements of Article 4 of Directive 75/442/EEC as amended.

Biowaste suitable for biological treatment

The 6-digit code refers to the correspondent entry in the European Waste Catalogue (EWC). The biowastes listed below are in principle suitable for biological treatment and/or spreading on the soil. In case of production of compost, the producer shall put in place the necessary controls on the incoming biowastes to ensure that there is no intentional dilution of polluting substances.

Shipments of mixed municipal waste (waste entry 20 03 01) collected from private households, including where such collection also covers such waste from other producers, to recovery or disposal facilities shall, in accordance with the Regulation on shipments of waste, be subject to the same provisions as shipments of waste destined for disposal.

Waste code	Waste description	Additional comments and use restrictions
20 00 00	Municipal wastes (household waste and similar commercial, industrial and institutional wastes) including separately collected fractions	
20 01	Separately collected fractions (except 15 01)	
20 01 01	Paper and cardboard	The addition of high-gloss paper and waste wallpaper is not permitted.
20 01 08	Biodegradable kitchen and canteen waste	
20 01 25	Edible oil and fat	Only for anaerobic digestion.
20 01 38	Wood other than that mentioned in 20 01 37	
20 02	Garden and park wastes (including cemetery waste)	
20 02 01	Biodegradable waste	Except grass and bush cuttings from roadside.
20 03	Other municipal wastes	
20 03 01	Mixed municipal waste	Only for mechanical/ biological treatment.
20 03 02	Waste from markets	Only if the biowaste is separately collected, otherwise only for mechanical/ biological treatment.
20 03 04	Septic tank sludge	Only if it fulfils the requirements of Directive 86/278/EEC for the use of sludge in agriculture.

Figure 7. Biowaste suitable for biological treatment (adopted from DG ENV.A.2/LM/biowaste/2nd draft[3])

The Regulations 2007/1432/EC120 and 2002/1774/EC Animal By-products Regulations established detailed rules for the protection of public and animal health that apply to the use of animal by-products in biogas and composting plants. This regulation concerns “biogas and composting plants”, but in some EC MSs this regulation is extended to home composting ‘plants’ (e.g., Belgium/Flanders) in order to reduce health and contamination risks.

Information relevant for the safety of persons conducting waste management activities shall complement the information given in Section 8 of the regulation Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) which involves waste treatment methods, such as:
(a) Waste treatment containers and methods shall be specified including the appropriate methods of waste treatment of both the substance or mixture and any contaminated packaging (for example, incineration, recycling, landfilling);
(b) Physical/chemical properties that may affect waste treatment options shall be specified;
(c) Sewage disposal shall be discouraged;
(d) Where appropriate, any special precautions for any recommended waste treatment option shall be identified.
Any relevant Community provisions relating to waste shall be referred to. In their absence any relevant national or regional provisions in force shall be referred to.

Material recovery and recycling of biowaste

MSs are required to introduce appropriate incentives to achieve recycling targets. The introduction and increase of landfill and incineration taxes are intended to contribute to the

[3] https://www.compost.it/www/pubblicazioni_on_line/biod.pdf

recycling of waste in accordance with the waste hierarchy. In conjunction with the promotion of recycling, markets for secondary raw materials need to be created. The amendment to Article 6 of WFD, 'End-of-Waste Status', will empower the Commission to adopt delegated acts defining detailed criteria for end-of-waste status for certain waste streams. Where necessary, these criteria must include limit values for contaminants in secondary raw materials in order to avoid possible adverse environmental effects. About biowaste, the Commission envisages establishing harmonised quality standards for compost and anaerobic digestate in the revised EU Fertilisers Regulation.

The material recovery and recycling of biowaste is not explicitly mentioned or denied in the WFD, but the concept of transforming waste into valuable materials and is within the spirit of the WFD policy objectives. Technologies that apply biowaste as a feedstock for producing biobased products are referred to as biorefineries. The biowaste refinery concept has received significant attention in recent years as a sustainable alternative the petroleum refinery. Due to the mixed nature of biowaste, the composition is complex and is chemically composed of starch, cellulose, protein, fats, lipids, and other organic matter. A biorefinery process can be adapted to handle specific feedstock-related problems, but variations in the feedstock properties may be challenging. This can explain why the use of biowaste in biorefineries like as feedstock to produce high value products is less studied.

Separate collection of biowaste and its subsequent recycling is essential to achieving high recycling rates of municipal waste (currently contributing to the recycling of about 17% of total municipal wastes in mass terms). At the same time, it deserves special attention as currently a number of countries do not collect municipal biowaste separately and recycling levels of this important waste stream remain low. [4] Every EU citizen recycled on average 79 kg of municipal biowaste in 2016, an increase of more than 23% compared to 2007. Recycling biowaste per capita varies among Member States, ranging from less than 10 kg per capita in some Member States to more than 100 kg per capita in others. The recycling of bio-waste per capita has increased in all Member States during 2005-2016, with just few exceptions.

The Regulation (EC) No 2003/2003 on fertilisers lays down the rules related to the placing on the market of fertilisers, as well as the provisions regarding their labelling and packaging. It also introduces measures to reduce existing trade barriers and potential risks for public safety from the use of certain categories of fertilisers. If a product is in compliance with this Regulation, it can be produced and sold anywhere in Europe as so-called EC fertiliser. However, only mineral fertilisers are regulated at EU-28 level. The regulation did not set rules relating to organic fertilisers and soil improver products. The Fertiliser Regulation does not affect national fertilisers. Member States have in place national provisions regarding the placing on the market of fertilising materials. The producers can choose between EC fertilisers or National fertilisers. The Mutual Recognition Regulation (Reg. EC No. 764/2008) for intra community movement of national registered fertilisers defines the rights and obligations for public authorities and enterprises that wish to market their products in another EU country. The Regulation also defines how a country can deny mutual recognition of a product. The barriers are that the MS

[4] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=SWD:2018:17:FIN

legislations are not identical. Therefore, the EC intends to revise Regulation (EC) No 2003/2003 to extend its scope to other fertilisers and fertilising materials including organic fertilisers, growing media, soil improvers and possibly biostimulants. The objectives of the harmonisation efforts are to harmonise legislation for all fertilising materials including inorganic and organic fertilisers, growing media, soil improvers and biostimulants. The harmonization also aims to guarantee the safety of fertilising materials, to ensure agronomic efficacy of fertilising materials and to reduce administrative burden.

The labelling of all organic fertiliser components and processes are necessary to ensure full transparency and the integrity of the product used. Organic farmers can use only organic fertiliser components and products which are 100% in line with the Regulation (EC) No 834/2007 on the labelling of organic products. Failure to fully label quantities under 5% may have a significant effect on the total characteristics of the mixture. Under this regulation, the labelling of organic fertilisers should indicate the following:

- Raw materials used for production, e.g. cow manure, chicken manure, guano, feathers, household waste/compost and approximate % of ingredients.
- Key nutrients and other elements should be declared including values for nitrogen, phosphorus, and potassium as well as pH, dry matter and % of organic matter. To avoid negative impact on human health, the contents such as heavy metals should be obligatory given on the fertiliser label (in mg/kg).
- Treatments e.g. an indication if the substance went through thermal treatment and/or mechanical treatment. This is because farmers want to be aware of potential phytosanitary risks. Form e.g. pellets or powder. In the case of pellets, it should be indicated which gluing agents were used. Recommendations for use including storage, duration of use, use on different crop species.
- Sensitivity reaction evaluations should not be reserved only for microbial plant stimulants but also for all non-organic fertiliser which can have potential allergic effects in the direct contact with skin, eyes or mucosa.

In 2016, the European Commission released a proposal for the revision of the EU Fertilisers Regulation. The objective of the proposal is to place secondary raw materials on the EU fertiliser market while preserving primary raw materials from over consumption. It also aims at enabling access for recycled organic fertilisers and soil improvers into the EU market and create a competition with mineral fertilisers. The proposal with the title Fertilising Product Regulation, introduces criteria about safety, quality and labelling. All fertiliser products can be traded freely across EU when they meet these criteria. Moreover, the proposal sets quality requirements for specific raw materials for the production of fertilisers, soil improvers and growing media, which are specified in the annexes, as well as criteria for compost and digestate from biowaste, and other input materials. The annexes include:

1. Product Function Categories, PFC‘ of CE marked fertilising products
2. Component Material Categories
3. Labelling requirements
4. Conformity assessment procedures
5. EU Declaration of conformity.

The proposal also defines a list of component material categories (CMC), where compost is CMC 3 and non-energy crop digestate is CMC 5. Specific labelling requirements are set out for product function categories (PFC), which are subdivided into fertilizers, soil improvers, growing media, liming materials and biostimulants. Manufacturers of these product groups will need to prove that their products comply with environmental and health requirements to display the CE mark on their products. In addition, compost and digestate products manufactured from waste must be subject to external quality control, which is recognized by each MS through a conformity assessment.

Energy recovery

Biowaste represents a great resource for renewable energy production. In terms of biowaste, incineration with energy recovery is still a usual practice in EU. If incinerated with energy recovery, the opportunity to extract valuable bioproducts is lost.

The EU Policy for Renewable Energy and Directive on Renewable Energy Sources (RES) (2009/28/EC) establishes targets for total Renewable Energy Sources. Since biomass accounts for a relatively large share in total RES, this may lead to competing demands for biomass. The RES Directive also relates to biowaste and encourages its use to replace fossil fuels. National targets are established for the total share of energy from renewable sources. It lays down rules relating to statistical transfers between MSs, joint projects between MSs and with third countries, guarantees of origin, administrative procedures, information and training, and access to the electricity grid for energy from renewable sources. It establishes sustainability criteria for biofuels and bioliquids, while encouraging the use of biowastes, e.g. cooking oil or biomethane, for developing so-called second-generation biofuels. The RES directive is adopted and in force; MSs transposed it on December 2010. The RES Directive considers the use of biomass, i.e. the biodegradable fraction of products, wastes and residues from agriculture (including vegetal and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste, to count towards the renewable energy targets, but leaves it up to MSs to decide how certain renewable energy resources should be supported.

Biowaste disposal

The last step of biowaste management is the waste disposal by landfilling or incineration. The Landfill Directive (1999/31/EC) aims to prevent or reduce as far as possible negative effects on the environment from landfilling the waste by improving the overall operating conditions of landfill sites and by introducing stringent technical requirements for waste. Currently the main environmental threat from biowaste is the production of methane from such waste decomposing in landfills. The Directive demands that MSs introduce national strategies aiming to progressively reduce the quantities of biodegradable waste landfilled. It obliges MSs to reduce the amount of biodegradable municipal waste that they landfill to 35% of 1995 levels by 2016, MSs which relied heavily on landfilling in 1995 have a four-year extension period.

Incineration of biowaste may be used to recover energy from a carbon-neutral source, providing an alternative to fossil fuels and contributing to climate change. However, the energy efficiency of current MSW incinerators varies considerably, depending mainly on whether an incineration plant delivers heat, electricity, or both in combined heat and power plants as well as technology used. The revised Waste Framework Directive encourages a shift to highly efficient new plants.

On 21 December 2007 the Commission adopted a Proposal for a Directive on industrial emissions (2010/75/EC), so-called Industrial Emission Directive (IED). The Directive on industrial emission has been adopted in November 2010. It lays down rules on integrated prevention and control of pollution arising from industrial activities as well as rules designed to prevent or reduce emissions into air, water and land, and to prevent waste generation. It is destined to prevent, reduce and eliminate pollution at the source through the sustainable use of natural resources. It protects water, soil and air from emissions stating that any "installation" covered by this Directive requires a permit to operate and any emissions from that facility would be reportable. The type of waste management facilities that fall under this Directive are primarily landfill and energy from waste plants. The Proposal recasts seven existing Directives related to industrial emissions into a single legislative instrument including the Waste Incineration Directive (WID) and Integrated Pollution Prevention and Control (IPPC) Directive.

The incineration of waste is regulated in the Waste Incineration Directive 2007/1432/EC120 and 2002/1774/EC. The organic waste is under that legal provision but not all the organic waste. The directive regulates the technical requirements for the operation of incineration plants, including emission limit values for selected potential contaminants (e.g., NOx, SOx, HCl, particulates, heavy metals and dioxins) in order to prevent, as far as practicable, negative impacts on human health and the environment. It is relevant for biowaste treatment as it covers incineration of most of biowaste (including mixed waste containing biodegradable fractions).

The IPPC Directive established a set of common rules for permitting and controlling industrial installations - it has recently been codified (Directive 2008/1/EC). This directive lays down the main principles for the permitting and control of installations based on best available techniques (BAT). It currently covers biological treatment of organic waste only if it constitutes pre-treatment before disposal. In the revision the EC has proposed covering all biological treatment of organic waste above a capacity of 50 tonnes per day.

The IPPC Directive also covers many of the plants that are covered by the WI Directive. In these cases, the WID only sets minimum obligations, which are not necessarily enough to comply with the IPPC Directive. That Directive excludes from its scope the plants that treat only vegetable waste from forestry, agriculture and the food processing industry, wood waste and cork waste. Its main provisions are limit values of emissions, the need of permit, the operation conditions. The Directive does not impel the energy recovery of waste incineration and that is not in accordance with the waste hierarchy of waste management

Environmental and health risk of biowaste management

Negative impacts of landfilling

By landfills de-composting of biodegradable waste, the landfill gas and leachate are produced. The non-captured landfill gas contributes to the greenhouse effect, as it consists mainly of methane. According to the Intergovernmental Panel on Climate Change, methane is 23x more powerful than CO_2 in terms of climate change effects in the 100-years time horizon. Before the Landfill Directive, methane emissions from landfills accounted for 30% of the global anthropogenic emissions of methane into the atmosphere. The uncollected leachate can contaminate groundwater and soil. Landfills could be a source of nuisance for neighbouring areas by generating bio-aerosols, odours, and visual disturbance. Another negative impact of

landfilling is the area of land used, which is bigger than for other waste management methods. There are hardly any positive aspects of landfilling biodegradable with the possible exception of "storage" capacity for carbon sequestrated in pre-treated waste and very limited energy production from collected landfill gas if landfill is carefully managed. The main negative impacts of landfilling are reduced by adhering to the EU Landfill Directive, but not eliminated. Also, landfilling means irrecoverable loss of resources and land, what is considered as an unsustainable waste management solution and is not favoured.

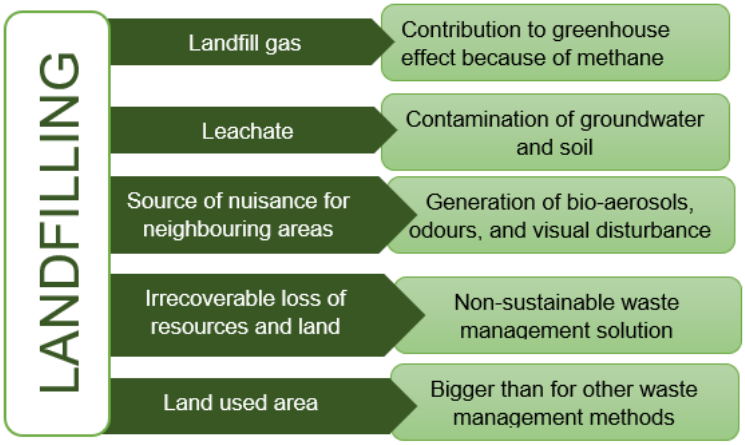

Figure 8: Negative impacts of landfilling on environment

Negative environmental impacts of incineration[5]

The environmental impacts of incinerating MSW containing biodegradable waste are related to airborne emissions from incinerators, greenhouse gas emissions, loss of organic matter and other resources contained in biowaste. Compliance with the WID limits emissions of selected heavy metals and a range of other emissions including dioxins as far as practicable and requires reduction of any health risks. Nevertheless, some emissions will occur. There are some environmental burden from the disposal of ashes and slags, for example the flue gas cleaning residues, which often have to be disposed of as hazardous waste. The environmental performance of incineration of bio-waste depends on many factors, such as especially fuel quality, energy efficiency of installations and source of replaced energy.

[5] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52008DC0811

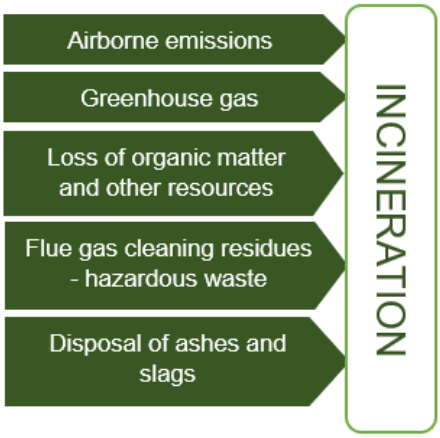

Figure 9: Negative impacts of incineration on environment

Environmental impacts of biological treatment[6]

Composting, anaerobic digestion and mechanical-biological treatment produce emissions. After stabilisation through biological treatment, the resulting material binds short cycle carbon for a limited time. The use of compost and digestate as soil improvers and fertilizers offers agronomic benefits such as improvement of soil structure, moisture infiltration, water-holding capacity, soil microorganisms and supply with nutrients. In particular, the recycling of P can reduce the need to import mineral fertilizer while replacement of peat shall reduce damage to wetland ecosystems. Increased water retention capacity improves workability of soils, thereby reducing energy consumption when ploughing them. Better water retention can help to counteract the desertification of European soils and prevent flooding. Finally, the use of compost contributes to counteracting the steady loss of soil organic matter across temperate regions.

Direct environmental impact of composting process is mainly limited to GHG emissions and volatile organic compounds. Further impact on CO2 balance must be assessed considering the amount of energy consumed for composting plants The impact on climate change due carbon sequestration is limited and mostly temporary. The agricultural benefits of compost use are evident but there is debate about their proper quantification (e.g. by comparison to other sources of soil improvers), while the main risk is soil pollution from bad quality compost. As biowaste easily gets contaminated during mixed waste collection, its use on soil can lead to accumulation of hazardous substances in soil and plants. Proper control of input material coupled with the monitoring of compost quality is crucial. Only a few MSs allow compost production from mixed waste. Most require separate collection of biowaste, often in the form of a positive list of waste which may be composted. This approach limits the risk and reduces the cost of compliance testing by allowing less extensive monitoring of production and use of compost. Home composting is sometimes regarded as the environmentally most beneficial way of handling domestic biodegradable waste, as it saves on transport emissions and costs, assures careful input control and increases the environmental awareness of the users. As AD is conducted in closed reactors the emissions to the air are significantly lower and easier to control than from composting. Every tonne of biowaste sent to biological treatment can deliver between 100-200 m3 of biogas. Due to the energy recovery potential from biogas coupled with

[6] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52008DC0811

the soil improvement potential of residues, it may often represent the environmentally and economically most beneficial treatment technique.

As most emissions from Mechanical-Biological Treatment operations result from biological treatment of biodegradable waste, the emissions into air are similar to composting or AD. However, the end product is usually contaminated to a level which hinders its further use. Nevertheless, these techniques have the advantage of purifying the combustible fraction for incineration with energy recovery.

Health impacts of waste management

There is a general lack of quality data on the health impacts of various waste management options based on epidemiologic studies. A study by DEFRA did not reveal any apparent health effects for people living near MSW management facilities. However, it identified small risks of birth defects in families living near landfill sites and of bronchitis and minor ailments for residents living nearby (especially open) composting plants though

Health issues of composting

When compost production is controlled appropriately, no health risk are associated. Biological wastes used to produce compost may contain different types of pathogens. The presence of pathogens in the input material depends on the origin, storage and pretreatment. If the composting process does not provide the required conditions to reduce or even eliminate the pathogens during the composting process, these pathogens may still be present in the compost. After application to land, the pathogens may then infect animals, plants or humans and pose serious health and plant disease control problems. Particular care needs to be taken in the case of grazing animals and in the production of salads, vegetables and fruits that grow close to the ground and may be consumed raw. The main measures for controlling the contamination of compost with pathogens are to sort out especially risky material from the compost feedstock and to ensure that all of the material in the compost process is subject to temperature-time profiles that kill off the pathogens (sanitation) or reduce the population to an extent where it is considered to be below a specific hazard threshold. When compost is used as a component in growing media, direct health and safety aspects are of special importance because of the often quite intense contact workers have with the material.

Health issues related to anaerobic digestion

In general, anaerobic digestion provides a hygienisation of the input material. Lukehurst et al. (2010) mentions following advantages of anaerobic digestion: very effective lowering of the pathogen load, such as gastrointestinal worm eggs, bacteria and viruses; plant pathogen reduction and spore destruction; weed seed reduction. However, according to the German Environment Ministry, plant pathogens like the Tobacco Mosaic Virus may not be reliably reduced by an anaerobic digestion process. From a precautionary point of view the use of digestate in certain crops such as tobacco or tomato and similar susceptible plants that are used to be grown in greenhouses is not appropriate.

7th EAP — The new general Union Environment Action Programme to 2020[7]

[7] http://ec.europa.eu/environment/pubs/pdf/factsheets/7eap/en.pdf

Conclusions

The European policy framework on biowaste was limited to few inefficient valorisation techniques for many years. Until 2015, only composting and anaerobic digestion were considered as sustainable solution for recovering the material into a bioproducts. Unfortunately, the issue experienced by many countries concerning the products quality, and the economic sustainability of composting plants, contributed to open the door for the introduction of innovative technologies able to really change the sector.

Thanks to the recent communication published by the European Commission, biowaste is going to be considered more and more a sustainable, biological, renewable resource for many applications. First, the commission underlined the need of avoiding landfilling, and, more important, the low sustainability of mixing biowaste in RDF for incineration practice. Furthermore, biowaste has been included in the list of biofuels and bioproducts source in the reviewed Renewable Energy Directive of 2018, and it has been recognized to be an important source of Phosphorus in the study on critical raw materials published in the context of Circular Economy Package.

New emerging technologies for biowaste valorisation into high value products, like food and feed, and advanced fertilizers, are now under the attention of many expert groups. The matter of cultivation of insects for turning biowaste into valuable animal feed is recognized by many European institutions as a crucial practice for the future.

In summary, it can be state that there's a positive trend of the European policy framework concerning the introduction of new technologies and new products into the EU market. However, limits are represented by the inertness of waste sector itself, and by the scepticism of both industrial actors and citizens concerning novelties. For too many years waste was waste, the importance was to avoid it smelling bad and remaining on the streets, but growing attention to environmental issues could drive the change towards acceptance of new, advanced, sustainable solutions

Table 1: Summary of policies on biowaste and biowaste management

EU legislation related to biowaste and biowaste management
Updated Bioeconomy strategy
Roadmap to a Resource Efficient Europe COM/2011/0571 final
Closing the loop - An EU action plan for the Circular Economy COM/2015/0614 final
Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste
Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (Text with EEA relevance)
Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control)
Regulation (EC) No 1069/2009 of the European Parliament and of the Council of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption and repealing Regulation (EC) No 1774/2002 (Animal by-products Regulation)
Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC
Green Paper on the management of bio-waste in the European Union {SEC(2008) 2936} /COM/2008/0811 final /
Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions - Thematic Strategy for Soil Protection [SEC(2006)620] [SEC(2006)1165] /COM/2006/0231 final /
Regulation (EC) No 2003/2003 of the European Parliament and of the Council of 13 October 2003 relating to fertilisers
Proposal for a regulation of the European Parliament and of the Council laying down rules on the making available on the market of CE marked fertilising products and amending Regulations (EC) No 1069/2009 and (EC) No 1107/2009 {SWD(2016) 64 final} {SWD(2016) 65 final}
Communication from the Commission to the Council and the European Parliament on future steps in bio-waste management in the European Union {SEC(2010) 577} /* COM/2010/0235 final */
Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC

Regulation (EC) No 1013/2006 of the European Parliament and of the Council of 14 June 2006 on shipments of waste

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