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End of Waste – Compost Case Study

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Contents

1 Introduction

In the Communication of the Commission regarding the thematic strategy on waste[1] the issue of when a waste ceases to be waste is highlighted as being ambiguous. It is proposed that in order to improve this situation, the revised Waste Framework Directive shall contain a provision that is designed to clarify the waste status for those waste streams where the use of 'end of waste' would be appropriate, on a stream-by-stream basis. The aim of the IPTS project is to support the development of such end of waste criteria under the revised Directive, through a scientific, thorough and transparent analysis.

On the request of the DG ENV, the IPTS project is to achieve the following three objectives:

- to propose candidate waste streams for the definition of end of waste criteria based on operational selection criteria according to the principles of the thematic strategy on the prevention and recycling of waste as well as the proposed revision of the Waste Framework Directive (WFD)

- to develop a methodology (including the frameworks for the technical analysis and impact assessment) for proposing end of waste criteria under the WFD

- to test the methodology in a number of pilot cases

To achieve these objectives, a number of research activities have been initiated. A literature review and assessment has been carried out in identifying current practices within the EU and also the general views of the various stakeholders regarding the end of waste concept. As a result, some candidate waste streams / secondary material categories have been identified together with early indications of possible end of waste criteria.

An analysis of waste streams in the EU both in quantitative terms and in respect of the associated environmental issues (i.e. the upstream examination) is being launched. This work will basically result in a list of waste streams, categories for the recovered material, and the general steps involved from which specific ones can be selected for more detailed examination.

To develop a framework methodology as a guidance to define end of waste criteria, three pilot cases, i.e. aggregates, compost and metal scrap, are being carried out to provide feedback and to refine the general framework methodology so that it can be applied consistently for detailed assessment for other waste stream categories. These parts of the project are closely linked and interactive. When applying the framework methodology, the pilot cases are expected to assess the feasibility of end of waste criteria on each of the studied waste streams and to propose the suitability of a general framework methodology for the development of the end of waste criteria. The case studies may also conclude that end of waste criteria are not appropriate for the studied waste stream.

This working paper is part of the case study on compost. The case study started in September 2006 and will be finalised in 2008. The working paper contains information and initial elements of the analysis intended as a starting point for the expert workshop on compost

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[1] Communication COM(2005) 666 final

which will be held on 22 March 2007. The paper represents work in progress and may not be used directly for any conclusions about end of waste criteria.

2 Scope of 'compost'

This study defines compost as the solid particulate material that is the result of composting, which has been sanitised and stabilised. Composting is a process of controlled decomposition of biodegradable materials under managed conditions, which are predominantly aerobic and which allow the development of temperatures suitable for thermophilic bacteria as a result of biologically produced heat.[2]

Composts in the sense of this study do not include the sludges from biogas production through anaerobic digestion unless they are stabilised in a subsequent aerobic process and result in a solid particulate material.

Also sewage sludge and sludges from other waste water treatment are included only if they have undergone a composting process (aerobic thermophilic conditions), possibly together with other materials, and result in sanitised and stabilised solid particulate material.

Since this study is about 'end of waste' criteria, it only considers composts resulting from composting of wastes. It does not cover any compost produced from virgin raw materials.

Nota bene: The inclusion of a material in the scope only means that the material will be included in the analysis of this study; by no means does this prejudge whether end of waste criteria should be defined for that material or not.

The current version of this working paper concentrates on composts from municipal solid waste. Composts from other types of waste (industrial and agricultural wastes) may be included in the paper at a later stage.

<u>Open question:</u> Which other types of biological wastes should be considered when studying end of waste criteria for compost?

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[2] This definition corresponds to the most common use of the term 'compost', although the word is not always used in this sense. Compost may sometimes also refer to products of the anaerobic digestion of organic materials or to biological materials that have not undergone any substantial decomposition at all.

3 Compost and the treatment of municipal solid waste (MSW)

3.1 The biological fractions in MSW

MSW comprises wastes from private households and similar wastes from other establishments that municipalities collect together with household waste. While the exact composition of MSW varies considerably from municipality to municipality and across Member States, it always contains an important part of biological material. Depending on the country, kitchen waste and 'green' waste from gardens and parks make up about 30% to 50% of the total mass of MSW. Together they are sometimes called putrescible wastes or 'biowastes'. The term 'biowaste' however is not always used in the same way and 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. Also the paper fraction in MSW consists, to a large degree, of processed biological material, and so does a part of the textile waste (from non-synthetic fibres).

Practically all biological wastes are biodegradable in the presence of oxygen (aerobic conditions), and most biological materials are biodegradable also without oxygen (anaerobic conditions). The main exception is lignin (in woody materials), which does not degrade anaerobically. The speed of the degradation depends on the environment in which it takes place. Moisture, temperature, pH and the physical structure of the materials are some of the key parameters. Burning or incineration is the other main option for decomposing biological material.

3.2 Alternative options to treat the biological fractions of MSW

3.2.1 Landfill

In the past, landfill of mixed MSW without pre-treatment or separating out the biological fraction was common practice in most Member States. This option is today considered bad practice because it is associated with serious environmental and safety risks related to landfill gas, leachate and landfill settlement.

Through the Landfill Directive[3], the European Union has laid down strict requirements for landfills to prevent and reduce the negative effects on the environment as far as possible. Amongst other things, the Landfill Directive requires that waste must be treated before being landfilled and that the biodegradable waste going to landfills must be reduced gradually to 35% of the levels of the total amount of biodegradable municipal waste produced in 1995.

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[3] Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste

3.2.2 Incineration and other thermal treatments

The combustion of waste in incinerators allows reduction of the waste for disposal in landfills to an inert inorganic ash residue. The organic carbon is oxidised to CO_2 and H_2O, which are discharged to the atmosphere in the stack gas.

Large scale mass burn incineration is the most common form of incineration today. It means that waste is combusted with little or no sorting or other pre-treatment. In modern incinerators, the energy is recovered to produce electricity and/or heat. The calorific values of individual types of waste vary considerably, from about zero for wet putrescible wastes to over 30 GJ/tonne for some plastics (Smith et al., 2001). If too much wet putrescible waste comes through the waste streams, a pilot fuel may be required to ensure sufficiently high combustion temperatures.

An alternative option to mass burn incineration is to pre-process the waste to produce refuse derived fuels (RDF). Processing the waste allows materials that can be recycled to be removed from the combustible residue, along with wet organic materials such as food and garden wastes for separate treatment. The combustible fraction may be burned directly or co-combusted, for example in coal-fired power plants or cement kilns.

Newly emerging technologies involve pyrolysis and gasification to first break down the organic matter in the waste into a mixture of gaseous and/or liquid products that are then used as secondary fuels.

The Waste Incineration Directive[4] aims to prevent or to reduce negative effects on the environment caused by the incineration and co-incineration of waste as far as possible. In particular, the Directive should reduce pollution caused by emissions into the air, soil, surface water and groundwater, and thus lessen the risks which these pose to human health. This is to be achieved through the application of operational conditions, technical requirements, and emission limit values for waste incineration and co-incineration plants within the Community.

3.2.3 Mechanical biological treatment

In mechanical biological treatment, the mixed MSW undergoes a mechanical sorting of the whole waste into a biodegradable fraction and a reject fraction, which may be further split, especially to sort out and recycle metals. The remainder of the reject fraction is landfilled, used as landfill cover material or incinerated.

The biodegradable fraction is then composted or aerobically digested. The volume of the composted residue is reduced. When landfilled it has a much reduced capacity to produce landfill gas and leachate, and it can provide a very compact material. Usually the material is not of sufficient quality to be useable in agriculture or horticulture, but it can be used to cover or restore land on landfills.

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[4] Directive 2000/76/EC

3.2.4 Composting

Composting is the aerobic degradation of waste to produce compost. It has a long history in many parts of Europe. Originally it was used in the form of simple processes on a small scale for farm and back yard composting. In the last two decades, composting has received renewed and widened interested as a means of addressing current waste management challenges, in particular to reduce the amount of wastes going to landfills and the associated CH_4 emissions from the degradation of organic materials in landfills. The production of compost is also seen as an opportunity to provide a material that can be used as a component in growing media or as an organic fertiliser or soil improver. This and other uses of compost are discussed in more detail in Section 4 below.

Most installations which produce composts for use as growing media or soil improvers rely on source separated biological fractions of MSW. The reason for this is to keep the levels of contamination of compost with undesired materials, such as glass or plastic, and substances, such as heavy metals and organic pollutants, low. Recently, technologies have been under development with the aim of achieving higher compost purities from mixed MSW by means of enhanced material separation before and throughout the composting process.

The size of composting plants ranges from treatment capacities of less than 1000 tonnes to more than 100,000 tonnes. The process technologies of composting are very diverse. Distinctive features of different composting technologies are:

- open or closed composting
- with or without forced aeration
- different process techniques like windrow-, container-, box- or tunnel-composting.

Open air windrow composting is the simplest technique. Generally, these plants work without forced aeration and waste gas collecting. Techniques with forced air systems are mostly associated with the collecting and treatment of waste gas. Combined scrubber and biofilter systems are a typical form of waste gas treatment. Different types of mechanical separation techniques are usually applied before, during or after the composting processes to sort out undesired components from the material.

Depending on the composting technique applied and the 'maturity' of the compost product, the duration of the composting process ranges from little more than a week to several months.

An important part of the composting takes place by the action of thermophilic micro-organisms at a temperature of up to 70 degrees Celsius and sometimes even more. If high temperatures are maintained for a sufficiently long time, pathogenic micro-organisms are killed off along with the weed seed, and the material can be considered hygienically safe.

3.2.5 Anaerobic digestion

Alternative to, or in combination with, aerobic composting, biological wastes can also be decomposed in controlled processes in the absence of oxygen. Increasingly, anaerobic digestion is applied to the putrescible fractions of MSW. The process runs in airtight vessels, usually for two to three weeks, and produces methane-rich biogas. The biogas is burnt to generate electricity and/or heat. A part of the energy may be used to heat the process and keep it at the required temperatures (30 - 65 degrees C). The process also produces a sludge-like residue, termed digestate. The digestate is often dewatered and 'cured' by composting to stabilise the material and can then be used as an organic fertiliser or soil improver if of sufficient quality. The liquid from the process is recycled back into the process to a large extent, and in excess can be used as a liquid fertiliser if the quality allows this. Otherwise, it is disposed of to sewer. Typically, anaerobic digestion applied to MSW uses source separated putrescible waste as the input, possibly in co-digestion with agricultural residues, if the digestate is to be spread on land.

3.3 Trends in the treatment of MSW

The Landfill Directive[5] requires the reduction of biodegradable waste going to landfills to

- 75% by 16 July 2006
- 50% by 16 July 2009 and
- 35% by 16 July 2016

calculated on the basis of the total amount of biodegradable municipal waste produced in 1995 or the latest year before 1995 for which standardised Eurostat data are available.

Member States that landfilled more than 80% of their municipal waste in 1995 were allowed to postpone each of the targets by a maximum of four years.

The Landfill Directive requires Member States to set up a national strategy for the implementation of the reduction of biodegradable waste going to landfills. On 30 March 2005 the European Commission reported on the national strategies it had received from Austria, Denmark, France, Germany, Italy, Greece, Luxembourg, the Netherlands, Portugal and Sweden as well as on the regional plans for England, Wales, Scotland, Northern Ireland, Gibraltar, the Flemish Region and the Walloon Region. The report shows that there are large differences in the roles given to composting in the different national and regional strategies. The following three examples illustrate the diversity of the national strategies.

Austria has introduced a legal obligation to collect biodegradable waste separately, which may then be used to produce compost. As a consequence, the amount of separately collected biodegradable waste has risen from a few thousand tonnes in 1989 to approximately 500,000 tonnes in 2001. (In 1995 the amount of biodegradable municipal waste produced in Austria was 2,675,300 tonnes.) This was complemented by the entry into force of an Ordinance on Composting in 2001, which regulates the quality requirements for composts from waste, the type and origin of the input materials and the conditions for their placing in the markets. Austria has already now achieved the last reduction target of the Landfill Directive.

Also Denmark has already achieved that target, but with a completely different strategy. An Order concerning waste issued in 2000 requires all Danish municipalities to send waste that is suitable for incineration to incineration. In recent years, only very small amounts of biodegradable municipal waste have therefore been landfilled, corresponding to far less than 10% of the total amount of biodegradable municipal waste produced in 1995.

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[5] Article 5(2) of Directive 1999/31/EC on the landfill of waste.

Italy is an example of a country that has opted for a mixed strategy. The country currently fulfils the target for 2006. In 2002 8,300,000 tonnes of biodegradable waste were deviated from landfills through:

- separate collection (3,800,000 tonnes),
- mechanical biological treatment (5,600,000 tonnes of unsorted waste with an estimated biodegradable fraction of 3,100,000 tonnes) and
- incineration (2,700,000 tonnes of waste, of which about 1,500,000 tonnes was biodegradable).

3.4 The environmental and health impacts of composting

Quite independently of the composting technique applied and the nature of the input materials, composting has a series of typical environmental interventions associated to it (although in quantitative terms there are wide variations between the techniques and input materials). The overview of this section has been written using Eunomia (200?) as a main source.

3.4.1 Emissions to air

Gaseous emissions from the composting process include carbon dioxide (CO_2), water vapour, and in smaller quantities ammonia (NH_3), volatile organic compounds (VOC), bioaerosols (fungi, bacteria, actinomycetes, endotoxins, mycotoxins) and particulates. Usually there will also be methane (CH_4) emissions, as it is often not possible to guarantee that all material will be kept under aerobic conditions at all times. Furthermore, composting may generate strong odour.

In closed composting systems, biofilters are often used to treat the waste gas to reduce the emissions of ammonia, aerosols, particulates, certain VOC and odour. On the other hand, new emissions may emerge from biofilters, in particular N_2O and new VOC.

The CH_4 and N_2O emissions are relevant for the climate change impacts of composting while the CO_2 emissions are considered climate-neutral because they originate from biomass. The other emissions are relevant for potential occupational and local population health impacts and perceived nuisance. Workers at a composting facility may be exposed to, and inhale, large quantities of bioaerosols. Certain individuals, for example asthmatics and the immuno-compromised, may suffer adverse health effects after exposure to bioaearosols. It is, therefore, important to take measures to protect plant workers and residents in the surrounding areas.

Generally there is a lack of representative quantitative air emission data and a complete lack of data on emissions during the storage of the biological material (ADEME, 2005 and DEFRA, 2004).

3.4.2 Leachate

Some composting systems recirculate leachate, whilst others treat the liquid residue if required or discharge it direct to sewer. Often composting requires a net input of water because of evaporation during the composting process. In well managed composting processes impacts on the environment can be assumed to be negligible. However, there is no consolidated information on the amounts and composition of leachate released that considers the variety of composting plants in operation.

3.4.3 Soil-related

The application of compost to soil changes the soil's chemical, physical and biological properties. The parameters affected include: contents and availability of plant nutrients, soil organic matter, pH, ion exchange capacity, chelating ability, buffering capacity, density, structure, water management, biological activity. Composts become part of the soil humus and have long term effects on soil properties. The ways in which compost can affect soil are very complex and far from being fully understood; however, it is widely accepted that compost can have a positive long-term effect on soil fertility.

At the same time, the use of compost on soil as an organic fertiliser or soil improver has diverse environmental implications. If composts are applied to land, the chemical content of the composts is transferred to the soil. For potential negative effects, heavy metals and organic pollutants especially need to be considered.

The contents of heavy metals in composts are generally well-studied and controlled in compost applications. They are determined by the input materials to the composting process. Heavy metals may be directly toxic to plants or passed through the food chain to humans. The fate of the heavy metals in soil is very site specific and depends on a number of factors such as the nature of the crop and the pH of the soil. Repeated applications of compost to soil generally lead to an accumulation of heavy metals but there is no consensus among researchers about how this should be assessed in terms of environmental impacts. There are important local variations concerning the accumulation of heavy metals (background concentrations are generally increasing), their leachability into ground water, the uptake of heavy metals by plants and consequences of them once in the food chain. Some metals such as zinc, copper and nickel are vital trace elements for plant growth as long as their quantity is not too high.

[Paragraph on organic pollutants to be written later.]

From a hygienic point of view, if not controlled appropriately, the application of compost is associated with risk because biological wastes may contain different types of pathogens, which may be bacteria, viruses, fungi, parasites and prions. Their presence depends on the origin, storage and pre-treatment of the material. If the conditions during the composting process do not prevent it, these pathogens may still be present in the compost, and in the worst case some of them may even have multiplied during composting. After application to land the pathogens may 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 and of produccing salads, vegetables and fruits that may be consumed raw. The main measures for controlling contamination of compost with pathogens are to sort out especially risky material, such as nappies, from the compost feedstock and to ensure that all the material in the compost process is subject to temperature-time profiles that kill off the pathogens (sanitation).

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. Macroscopic glass fragments, for example, must not be present. Pollutant concentrations are more important in this case than loads because there are usually no repeated applications of compost.

3.4.4 Positive environmental effects

The use of compost as an organic fertiliser can, to some extent, replace the use of mineral fertilisers. This is more relevant for potassium and phosphate than for nitrogen because the nitrogen contained in the organic matter of compost only slowly becomes availably to plants. Not more than about 2% of the nitrogen content of compost is usually released per year. If compost is used to reduce the need for mineral fertiliser, some of the environmental stresses of fertiliser production can be avoided. These include greenhouse gas emissions (N_2O and energy related emissions), and impacts of phosphate extraction. Use of compost over longer periods of time and a lower use of mineral fertilisers also reduces nitrate leaching. The nutrient run-off from compost into ground and surface water is usually very low.

The humus produced from compost increases soil organic matter and stores some of the biomass carbon contained in compost in soil for longer periods of time. This carbon can be considered sequestered from the atmosphere, which acts against global warming.

Other potential positive environmental effects that have been attributed to compost include:

- Reduced soil erosion
- Compost of good quality may help to control plant diseases and thus reduce the need for applying pesticides
- Water retention is improved, reducing the need for irrigation and reducing the risk of flooding
- The improved soil structure reduces the need to work the soil with agricultural machinery and the related use of fuel.

When compost can be used instead of peat in growing media, there is also a lower global warming potential, mainly because peat degrades relatively fast under release of 'long cycle' CO_2 when exposed to oxygen. Replacing peat also contributes to the protection of the biodiversity and landscape value of peatlands and bogs.

3.5 Quantitative assessments

This section reviews the quantitative assessments that have been made of composting and alternative waste treatment options. It first addresses the question of climate change impacts because they dominate the environmental concerns and can be quantified relatively well. Then it looks at the possibilities of quantifying and comparing other environmental and health impacts, and finally deals with analyses that aim to cover the wider costs and benefits (including financial).

3.5.1 Climate change

The relevance of organic waste management for climate change is dominated by the fate of the organic carbon contained in the waste: the extent to which it is immobilised (e.g. in landfills) or dissimilated and emitted as gas, and the proportions of CO_2 and CH_4 in the gas emissions. Other emissions are of much smaller relevance (from process energy requirements or transport, and the other greenhouse gases).

According to the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, CO_2 from organic waste handling and decay should not be included in greenhouse gas inventories. The reason is that organic material derived from biomass sources which are re-grown on an annual basis is the primary source of CO_2 released from such waste. These CO_2 emissions are not treated as net emissions from waste in the IPCC methodology. (If biomass raw materials are not being produced sustainably, the net CO_2 release should be calculated and reported under agriculture, land use change or forestry).

However, consideration should be given to the fact that if organic waste or materials obtained from biomass remain at least partly un-degraded for longer times, this effectively removes carbon from the atmosphere. This is the case, for example, when compost that has been spread on agricultural land is only slowly mineralised and increases the soil organic matter, or when organic material in landfills decays only over many years.

In the following subsections the main factors that determine the potential climate change impacts are discussed for the different treatment options for biological solid municipal waste, and finally an overall comparison of the treatment options concerning climate change is made.

Composting

Composting, as an aerobic biological degradation process, dissimilates the carbon of the input materials mainly into CO_2. The percentage of the carbon content that is converted depends on the nature of the input material. In the case of kitchen waste, composting converts about two thirds of the carbon content of the input material into CO_2. This means that about 0.9 kg CO_2 is generated per kg dry matter of the biowaste input. In the case of green waste, this value is much lower (about 0.17 kg CO_2 per kg dry matter). (ADEME, 2005)

After the composting process is finished and when compost is used, for example, as a soil improver, the remaining organic matter in the compost is then relatively stable and further degradation is rather slow. This depends on the physical, chemical and biological environment in which the compost is used. The further release of carbon to the atmosphere is therefore only gradual. Relatively little is known about the rates of transformation, which vary depending on climate and soil type. It has been estimated that, on average, some 13% of the organic carbon supplied by the application of compost remains in the soil after 50 years (Eunomia, 200?; Annex p. 95). Assuming that the composting process had reduced the original organic carbon content by 50% (for example of a mixture of green waste and kitchen waste), this means that about 6.5% is still not dissimilated after 50 years.

If compost displaces other fertilisers, this may lead to CO_2 emission savings through the avoidance of fertiliser production. If it displaces peat as a soil improver or in growing media, then this avoids the long cycle carbon emissions emanating from the degradation of peat under aerobic conditions.

In theory, composting as an aerobic process should not generate CH_4. In practice, however, and depending on the type of composting process and its management, the oxygen supply and the aerobic conditions during the biological degradation are not perfect. The lack of oxygen may then lead to anaerobic processes and to emissions of CH_4. The proportion of the carbon content of the input material that is transformed into CH_4 emissions varies widely, depending on the type of input materials and the processes, from 0.01% to 2.4% of the original carbon according to (ADEME, 2005). A typical value found for CH_4 emissions from household waste composting would be 0.04 kg CO_2 equivalent per kg of dry matter of the input material.

Sometimes organic waste composting is preceded intentionally by a phase of initial anaerobic degradation to reduce odours for example. If the generated gas is not captured adequately, this will lead to CH_4 emissions to the atmosphere. The CH_4 emissions of such intentional anaerobic pre-treatment seem potentially important but have not yet been investigated.

It is quite likely that the application of compost on agricultural land is neutral in terms of CH_4 emissions; however, this has not yet been scientifically confirmed. There is a lack of literature and measured data on how the use of compost on agricultural land influences the flows of CH_4 between the soil and the atmosphere (ADEME, 2005).

For the composting of biowaste, the N_2O emissions have been found in the range of 0.002 to 0.05 kg CO_2 equivalents per kg of input dry matter (typical value: 0.02 kg CO_2-eq.). For household waste, the range is 0.005 to 0.125 kg CO_2 equivalents per kg of input dry matter (typical value 0.1 kg CO_2-eq.). (ADEME, 2005)

The use of compost as an organic fertiliser may, to some extent, reduce the N_2O emissions associated with the use of mineral nitrogen fertilisers. However, this effect has not been quantified reliably so far.

Generally the figures on greenhouse gas emissions other than CO_2 (i.e. CH_4 and N_2O) are based on a limited number of measurements, which are not very representative.

Landfill

Disposal of organic waste to land is a major source of CH_4 emissions. The IPCC has estimated that approximately 5 - 20% of annual global anthropogenic CH_4 produced and released to the environment is a by-product of the anaerobic decomposition of waste.

In landfills the degradation of organic carbon starts slower than in composting and a constant rate of degradation is often used as an approximation to describe the kinetics. Much of the carbon, typically about half, is released as CH_4 rather than CO_2 (see below). For landfills (solid waste disposal sites in IPCC terminology) the default value that has been proposed is that the half life of degradable organic carbon is about 14 years[6]. This would imply that about 8% of the original degradable organic carbon has not been dissimilated after 50 years. Some types of organic wastes such as woody materials are, however, hardly degraded at all under anaerobic conditions such as in landfills. The permanency of this type of carbon sink is difficult to assess and depends on the time scale used to define permanent. The IPCC handbook assumes as a default that only 77% of the generally degradable organic carbon is actually degraded in landfills, and new recommendations suggest even lower percentages.

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[6] In the 2000 Good Practice Guidance to the IPCC Guidelines.

In modern landfills, the landfill gas is at least partly captured and then flared or combusted to generate energy (heat and/or electricity). This increases the CO_2 emissions and decreases the CH_4 emissions.

If landfill gas displaces non-biomass fuels for energy generation, this avoids CO_2 emissions in emission inventories according to the IPCC.

Mechanical biological treatment

It has been shown that MBT prior to landfill can reduce the landfill gas emission potential by 90% compared with untreated MSW and the remaining organic carbon is degraded so slowly in the landfill that methane oxidising organisms in the cover soil will, in all probability, oxidise all of the residual CH_4 released. By combining MBT and landfill, about 40% of the organic waste contained in the MSW will be demobilised in the landfill and effectively sequestered from the atmosphere.

As in composting, there is, however, a risk of some methane emissions during the MBT processes if anaerobic conditions are not fully avoided.

Incineration

If organic waste is incinerated, the amount of carbon released as CO_2 is very close to 100%. If there is a net energy generation from combusting biomass, this may displace non-biomass fuels for electricity or heat generation and thus avoid climate-relevant CO_2 emissions. However, the moisture content of putrescible waste is often too high to allow a net energy generation from that fraction.

Anaerobic digestion

Anaerobic digestion usually balances better than composting in terms of greenhouse gas emissions because the biogas it generates is typically used for energy production and the avoided emissions of the displaced energy generation processes can be credited to the process. This, of course, only applies if the methane in the biogas is effectively burnt and there are no methane leakages of importance.

Overall comparison of the treatment options for biological wastes

Methane emissions and the sequestration of carbon of biological origin (in landfills or increased organic matter in soil) are the two main factors that determine the potential climate change impacts of the different options to treat biological wastes. The energy balance of incineration is another factor to take into account. Carbon sequestration through wastes is, however, often not considered in greenhouse gas inventories and so CH_4 emissions become the sole decisive factor that determines the climate change impacts.

In the latter case, landfill is practically always the worst option. Assuming that all carbon is dissimilated, then in a landfill with a gas capture rate of 50% over the whole lifetime and an oxidation of 10 % of the methane in the non captured gas, 22.5% of the carbon would be emitted as methane. In well managed composting that avoids anaerobic conditions throughout the process, the percentage of carbon emitted as CH_4 should be at least a factor 10 lower. If the waste is incinerated, there are practically no CH4 emissions so that the process is practically carbon neutral.

But what if carbon sequestration by landfill and compost is taken into account, i.e. assuming that part of the organic matter is not dissimilated in landfills and in compost spread on land?

A simple model calculation assuming a landfill where 50% of the landfill gas is captured (without assuming any oxidation of the non captured gas), and the gas is half CH_4 and CO_2 in terms of volume shows that when more than about 66% (or 62% if a corrected methane CO_2 equivalent is used[7]) of the organic carbon are not dissimilated in a landfill, the carbon sequestration outweighs the remaining methane emissions. Only woody materials would probably have such a high stability under anaerobic conditions.

Similarly, if for composting it is assumed that in the composting processes 50% of the organic carbon is dissimilated, of which 99% is converted into CO_2 and 1% into CH_4, then it would be required for composting to become a net carbon sequestrating process that about 7 or 8% of the compost applied on land remains undegraded.

- Overall comparison of the treatment options for MSW as a whole (all waste fractions)

Looking at the management of MSW as a whole, including all the different fractions, and taking carbon sequestration into account, the following becomes apparent from the data and results of Smith et al. (2001):

- From a purely climate change point of view, the optimal treatment of MSW is to collect paper, glass, ferrous metals, aluminium, plastics and textiles separately and recycle them, and to subject the rest, which consists to a large extent of putrescible material (from food and garden waste), to MBT and subsequent landfill.

- The second best option from a purely climate change point of view would be to also collect the biological waste separately and treat it through combination of composting or anaerobic digestion with energy recovery so that the compost can be used on land or in growing media. (It is notable that the main positive climate effects of this option are obtained from the recycling of the non-biological waste fractions, and to a lower extent from the anaerobic treatment but not from composting.)

- The third best option would be MBT of mixed MSW (bulk) followed by landfill. Then comes incineration with and without energy recovery, and finally the direct landfill (current average technology) of MSW, although even landfill without pre-treatment but with very good gas capture rates can be a net carbon sequester.

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[7] Usually it is assumed that 1 tonne of CH4 is equivalent to 21 tonnes of CO2, i.e. one mol of CH4 has the same global warming potential as 7.64 mol of CO2. Since the global warming potential of 'short cycle' CO2 from biomass is assumed to be 0 instead of the standard CO2 global warming potential of 1 for fossil CO2, it is more logical to assume that 1 mol of CH4 from biomass is equivalent to 6.64 mol of CO2.

- If carbon sequestration is not considered, then incineration with energy recovery has a better climate change performance than any of the landfill options including those with MBT.

3.5.2 Life cycle assessments (LCA)

The data situation

A study for the UK Department for Environment, Food and Rural Affairs (DEFRA, 2004) carried out a "review of environmental and health effects of waste management: municipal solid waste". It is based on a substantial sample of the available literature and data. The study has systematically assessed the reliability of all the data, taking into account, for instance, the number of waste management facilities from which data are available, if an extrapolation to the full sector at a national level is possible, and whether the information came from peer reviewed literature, was endorsed by governmental bodies, or came from 'grey' literature. The study report as such underwent an external review by the Royal Society.

The study concluded that the available data were not sufficient to quantify air emissions from composting, MBT or anaerobic treatment. A quantitative assessment of the related environmental and health impacts was therefore not deemed possible.

A report for ADEME (2005), which systematically establishes emission data for biological treatments based on a reliability assessment of data found in literature, comes to similar conclusions, and confirms that there is a general lack of representative air emission data (in the case of compost especially VOC). It also notes a general lack of data on emissions during the storage of the biological material.

Despite the lack of representative quantitative data, the DEFRA report stresses that emissions of methane from composting of MSW on a commercial scale may be significant.

The DEFRA report also says that the information on emissions to surface water, ground water and the sewer is not enough to enable different waste management options to be compared. It notes that, while not all compost facilities give rise to liquid effluent, so far as comparative data exist, composting facilities appear to give rise to greater emissions of metals to sewer than landfills.

Concerning composting, the report notes that increases in some respiratory diseases have been observed in people living very close to composting facilities. Furthermore it says that emissions from open windrow composting of MSW can be increased if the waste is not properly turned to allow full aeration of wastes. The report considers this a "significant concern in the light of indications of adverse health effects for people living very close to commercial scale composting facilities. It would be less of a concern for in-vessel composting of MSW because of the improved control on aeration, and opportunities to treat air extracted from in-vessel systems."

Both of the studies supply little information on the environmental and health effects of applying compost to land.

Tendencies in LCA results

In the light of the lack of reliable data on air emissions from biological treatments and the huge complexities, site-dependence and uncertainties of assessing the environmental impacts of compost on soil, it is clear that the results of LCAs that have still endeavoured to make comprehensive assessments of composting and comparison with other treatment options for biological wastes must be treated with great caution.

Earlier LCA studies that compared composting, anaerobic digestion and incineration typically found that composting was the worst option for the environment. Either anaerobic treatment or incineration turned out best for the environment, depending on the assumptions made about the energy recovery and the moisture content of the input materials (Schleiss, 2006).

Discussions on such results then showed that there may have been a few intrinsic biases built in to the LCA methodology and databases used that required consideration. The possible biases included: excessively negative weighting of impacts from heavy metals, the fact that the manifold positive aspects of compost in soil are not reflected in LCAs (including the value of humus or soil organic matter increase, potential improvement of water retention capacity, potential reduction of erosion, potential suppression of plant diseases), and general difficulties to consider local effects adequately in global LCAs (Schleiss, 2006). In fact, the LCA methodology was developed to assess negative environmental and health impacts. LCAs were not made to cover any positive environmental effects, let alone other, not strictly environmental benefits. (They can consider, though, the avoidance of negative impacts.)

Following this, efforts were made in newer LCAs to compensate or correct the assumed biases, and results were produced in which the comparative performance of composting is evaluated more positively. According to recent Dutch LCAs reviewed by Essent Milieu (Van Haeff, 2006) for example, separate collection of biological wastes and composting, tends to give better results than mass burn incineration, although the differences are not always regarded as significant. Despite all efforts, however, it appears that LCA methodology is still too dependent on relatively arbitrary assumptions and far from being robust enough to allow any meaningful conclusions on the general preference of waste management options.

3.5.3 Cost-benefit analyses (CBA)

A cost-benefit analysis has to deal with the same high uncertainties concerning the emissions of composting and the comparative assessments of different environmental and health impacts (called externalities in the terminology of CBA) as an LCA, but at least this methodology allows, in principle, the potential benefits of compost uses to be taken into acount. Furthermore, it considers the financial costs of the different waste treatment options. In practice, however, it turns out that CBA applied to composting and alternative treatments hardly leads to more reliable results than an LCA.

A study for the European Commission endeavoured to carry out a cost-benefit analysis of the different options for managing biodegradable municipal waste, including financial costs and positive and negative externalities (Eunomia, 200?). In the end, the report concludes that neither the private costs, nor the external costs and benefits, can be specified with much certainty, the analysis is incomplete (in practice some costs and benefits could not be quantified at all) and the results have to be treated with considerable caution. The report also concludes that the analysis is influenced by certain key assumptions which have material effects on results and regards it as unlikely that agreement could easily be reached on the correct nature of the assumptions. In summary, the report says: "It seems reasonable to state that cost-benefit analysis alone cannot be used as a basis upon which to make decisions regarding waste management policy. The incomplete nature of such an analysis calls for other tools and criteria to support proposed changes in policy".

3.6 Conclusions with regard to managing the environmental and health effects

There are three main groups of environmental and health issues related to composting that need to be managed.

1. Climate change

Choices about how to manage and treat the putrescible fraction of MSW have a substantial influence on the net greenhouse emissions caused in the EU. The Landfill Directive addresses this by requiring that biological wastes be diverted from landfills. The performance of the alterative options to manage the biological MSW depends basically on three factors: how much of the carbon content is emitted to the atmosphere as methane; the energy balance and whether there is the generation of energy that can displace any other energy production; and whether the treatment effectively leads to the sequestration of biomass carbon ('short cycle' carbon) from the atmosphere. The most critical factor for a high performance of composting with respect to greenhouse gas emissions is the avoidance of methane emissions during the composting process, pre-treatment and storage.

2. Local health and environmental risks at, and close to, the composting facility

Odour, gas emissions, leachate, and pathogens in bioaerosols are released from composting processes and may affect the local environment and the health and well-being of workers and residents. Plant permits for composting facilities address these issues more and more appropriately and some Member States have issued guidelines on state-of-the-art composting techniques that help address these aspects.

3. Soil, environment and health protection when using compost, especially when applying compost to land

This aspect is highly complex because it requires managing the trade off of the benefits of compost application on land with the environmental and health risks associated with releasing a material derived from waste that contains a cocktail of chemical compounds (including heavy metals and potentially organic pollutants) and biological agents on soils. Whether the benefits outweigh the risks depends on the quality of the compost and the local conditions under which it is applied. The complexity is aggravated by the fact that there are huge knowledge gaps regarding soil properties and functions and the interactions with compost and its components. Furthermore, there are many uncertainties in the toxicological and eco-toxicological assessments.

Member States where the use of compost plays a substantial role have usually put regulations in place to deal with this aspect, considering the specific situations of the countries. Depending on the countries or regions, the use of compost is regulated by soil protection, fertiliser or waste legislation or combinations thereof. If the introduction of European end of waste criteria changes the waste status of compost in a Member State, then this may affect the system of rules applying to the use of compost on land. This will then impact on the corresponding levels of soil, health and environmental protection.

4 Compost from a product perspective

4.1 Introduction

The JRC-IPTS is about to issue a contract for a quantitative study of compost production and use in the EU. That study aims to establish a comprehensive information base on what classes of composts are produced in the Member States of the EU and in what quantities; the amounts of these composts going to different uses, the imports and the exports. The study will also identify and quantify the use of alternative materials and analyse the degree of substitutability between the materials. Finally, the study will estimate and assess the future production, market, import and export potentials of compost.

Since the results of that study are not yet available, this first paper only makes a brief appraisal of the main aspects relevant for compost produced from MSW (both with or without source separation) based on available literature and information from the experts. This appraisal will be reassessed and completed once the results of the contracted study become available.

4.2 Compost production

The European Compost Network estimates that the production of compost in EU-15 in 2003 was 9 million tonnes (Barth, 2006). Only a few countries make up most of the EU compost production from MSW. In absolute amounts, Germany is by far the biggest compost producer with more than 3 million tonnes, followed by Italy and the Netherlands. On a per capita basis, compost production is highest in the Netherlands, followed by Austria, Germany, Luxembourg and Belgium. These countries rely almost exclusively on source separated putrescible fractions of MSW for compost production (compost that is not landfilled). In France and Spain, compost is also produced in considerable amounts from mixed MSW. In the UK, the interest in compost production has increased considerably in recent years. In Denmark, compost is only produced from green wastes. In the new Member States (EU-12) compost production from MSW plays a very small role.

In France, the production of compost from mixed MSW plays a relatively important role. A recent study by ADEME (2006) gives the following numbers for yearly production totals and representative for the time after 2000: 500,000 tonnes of compost were produced per year from non-source-separated household waste, 170,000 tonnes from separately collected household 'biowastes' mixed with green wastes, and 920,000 tonnes from pure green wastes. Most of the compost produced from MSW appears to be used in agriculture.

Around 2000, about 43% of composts produced in the main compost producing countries were used in agriculture, 14% in earth works, 14% in landfills and for their restoration, 12% in private gardens, 8% in landscaping, and 4% in horticulture. Only 1% was exported (SV&A, 2005).

4.3 Use of compost as organic fertiliser or a soil improver

4.3.1 The functions of composts in agriculture

Compost is considered a multifunctional soil improver. The application of compost usually improves the physical, biological and chemical properties of soil. Repeated applications of compost lead to an increase of soil organic matter, often help to reduce erosion, to increase the water retention capacity and pH puffer capacity, and to improve the physical structure of soil (aggregate stability, density, pore size). Composts may also improve the biological activity of the soil.

The fertiliser function of compost (supply of nutrients) is less pronounced than the general soil improvement function. Especially the supply of plant available nitrogen by compost in the short term is very low. Only repeated applications over long periods may have a relevant effect. However, the phosphate and potassium demand of agricultural soils can, in many cases, largely be covered by adequate compost application. Compost also supplies Ca, Mg, S and micronutrients.

The effects of compost substantially depend on the local soil conditions and agricultural practices, and many aspects are still not well understood.

The quality parameters that positively characterise the usefulness of compost in agricultural applications include:

- Organic matter content
- Nutrient content (N, P, K, Mg, CaO)
- Dry matter
- Particle size
- Bulk density
- pH

See also Section 3.4.4 on positive environmental effects.

4.3.2 Risks

As summarised above in Section 3.4.3, there are a number of potential environmental and health risks when compost is spread on soil. Generally, there is considerable uncertainty about the exact nature and size of the risks and benefits. The reasons include the variability of the input materials used to produce compost and the fact that composting is a biological process which is more complex than, for example, many chemical processes. This leads to a relatively high variability in the qualities of the different compost batches produced at the same site and even more so between different compost plants. Rather little is still known about what actually happens to compost and its constituents once spread on soil.

If composts are not sufficiently hygienised, pathogens may be spread on land together with the compost, which may cause plant diseases, affect the animals grazing on the land and, mainly through the food chain, also human health. Compost may also encourage weed growth on the land.

Macroscopic impurities of compost not only reduce the aesthetic value of land, they also bring the risk of accidents, such as worker injuries when handling compost containing glass fragments.

There is also the risk of chemical pollution transferred from composts to land. This includes organic pollutants as well as heavy metals. Pollutant concentrations of individual applications are less important than the accumulated loads of repeated applications. It appears that the regular application of compost from the putrescible fractions of MSW as organic fertiliser or as a soil improver in amounts that follow the soil requirements for nutrients and organic matter (in the range of 5 to 10 tonnes of compost per hectare per year) leads to an accumulation and concentration increase of the heavy metals is the soil (Amlinger et al., 2004). This even applies to composts with relatively low heavy metal contents made from source separated green or kitchen wastes. An accumulation of heavy metals in soil is likely to be associated with environmental and health risks as least in the long term. Also other pollutants, including organic pollutants, may pose a risk.

That the risks are not well understood is reflected in the opinion of the Scientific Committee on Toxicity, Ecotoxicity and the Environment (CSTEE; adopted on 8 January 2004) on the report "Heavy Metals and Organic Compounds from Wastes Used as Organic Fertilizers" (Amlinger et al., 2004). This study had been commissioned by DG Environment in the framework of its background work related to possible legislative proposals concerning the biological treatment of biodegradable waste. The CSTEE concluded that the study did not provide sufficient scientific bases for the Commission to be able to propose the appropriate threshold levels for pollutants in compost produced from biowaste. Up until today there appears to be no other studies or research results that could easily provide such a scientific basis at a European level. The CSTEE made a number of suggestions about an appropriate methodology for deriving threshold limit values for the relevant metals and organic pollutants (pesticides, feed and food additives, pharmaceuticals, etc.) and the information this should include:

Regarding the selection of pollutants:

- The list of relevant pollutants should not be restricted to heavy metals and a few organic pollutants. An exhaustive pre-selection of candidate substances should be conducted on the grounds of both their use patterns and the raw material employed for each type of compost. The list of the entire candidate chemicals based on their likelihood of presence should be prepared for each different type of compost.

- The persistence/transformation of the substance during the composting process and after spreading the compost onto the soil, as well as the bioaccumulation and bioavailability of the parent substances and the by-products (metabolites, reaction and degradation products) in the different parts (roots, leaves, grain) should be taken into account.

Regarding the data needed on pollutants:

- The secondary contamination of the water compartment from pollutants released from the compost should be evaluated through knowledge on the leaching and drainage potential leading to both surface and groundwater contamination.

- Collection of toxicological and ecotoxicological data on parent compounds and relevant metabolites and by-products possibly produced during the composting process and following spreading on soil. For chemicals under positive regulation, such as pesticides, additives or pharmaceuticals, a significant part or even all of the required information could be obtained from the information presented for registration. Other EU databases such as those related to HPVC or IUCLID can provide information on other chemical compounds.

4.3.3 Production costs, compost prices and the market situation

The costs of composting depend on local conditions and the quality of the material to be composted. Eunomia (200?) reviewed the information from various sources about the cost of composting source-separated biological waste and made a cost estimate of 35 – 60 EUR per tonne of waste for larger 'best practice' plants in closed systems, although higher costs had also been reported in some cases. The cost of low tech windrow composting may be less than 20 EUR per tonne of waste. Gate fees charged for green waste tend to be smaller than for kitchen waste or for mixed kitchen and green waste.

The price of bulk compost for use as organic fertiliser or a soil improver is much lower than the 'production costs', i.e. the costs of treating biological wastes in a composting plant. The prices achieved for composts for agricultural use in central Europe are hardly higher than 5 EUR per tonnes of compost and, in most cases, lower. Often, the compost is actually given away to farmers free of charge. A typical scenario in Germany is that the compost producer offers the transport, the compost and the spreading of the compost on the field as a service to the farmers (usually through subcontractors) and charges about 1 EUR per tonne for everything.

A recent French compost market study for ADEME (2006) reports the following price ranges for compost use in agriculture ("grandes cultures"):

- Compost from green waste: 0 EUR (in most cases) to 10 – 12 EUR/tonne (including the cost for transport and spreading)
- Compost from mixed MSW: 0 EUR (most frequent) to 2 – 3 EUR/tonne (including spreading)

The combined separation-composting plant for MSW at Launay Lantic sells most of the compost produced to artichoke or cauliflower growers at a price of 2.34 EUR per tonne (personal communication).

In Austria, decentralised composting plays an important role and often farmers run small and simple windrow composting facilities in which they treat source-separated biological waste from nearby municipalities. The farmers use the compost on their own farmland, and if their farmland is of a suitable size, there is no need for these compost producers to sell or give away the compost. For the highest quality compost, suitable for organic farming, prices of a little more than 10 EUR per m^3 have been found. An example of the gate fee charged by a 'farmer-composter' in Austria is 48 EUR per tonne of biowaste from separate collection.

In 2001, the average sales prices for compost made from pure garden and park waste in Denmark were reported to be about 8 to 9 EUR/tonne (Hogg et al., 2002).

Unless sizeable proportions of the compost produced can be sold to outlets other than agriculture for higher prices, the financial feasibility of the composting plants essentially depends on the gate fees charged for the treatment of the wastes used as input or on subsidies. Some Italian regions subsidise the use of compost soil improvers on depleted soil following the Rural Development Plan 2000-06.

The low value per weight of compost soil improvers and fertilisers is a strong limitation to the distances over which the transport of compost for agricultural use makes economic sense. Transportation over more than 100 km for agricultural use will only be feasible if there are specific areas where agriculture has an exceptionally strong demand for organic fertilisers that cannot be satisfied from local sources or if the waste management sector 'cross-subsidises' the transport cost (negative prices of the compost before transport). The latter is likely to occur if the alternative treatments for biological waste diverted from landfill, such as landfill or incineration, are more expensive than composting.

Often the main factor influencing the use of compost is the quantity of manure on the basis of livestock units in a region.

4.4 Use of compost in growing media

Growing media are materials, other than soil in its original location, in which plants are grown. About 60% of growing media are used in hobby applications (potting soil), the rest in professional applications (greenhouses, container cultures). The total volume of growing media consumed in the EU is estimated to be about 20 – 30 million cubic metres annually. Worldwide, peat-based growing media cover some 85 – 90% of the market. The compost market share as a growing medium constituent is below 5%. Growing media are usually blends with materials mixed according to the required end-product characteristics. (SV&A, 2005).

The Waste and Resources Action Programme (WRAP) together with the Growing Media Association have issued "guidelines for the specification of composted green materials used as a growing medium component" based on the BSI PAS 100 specifications for composted materials (WRAP, 2004). (The guidelines introduce additional requirements to those of BSI PAS 100, e.g. concerning heavy metal limits.)

According to these guidelines, any growing media shall have the following basic attributes:

- Have a structure which physically supports plants and provides air to their roots and reserves of water and nutrients
- Be easy to use with no unpleasant smell
- Be stable and not degrade significantly in storage
- Contain no materials, contaminants, weeds or pathogens that adversely affect the user, equipment or plant growth
- Be fit for the purpose and grow plants to the standard expected by the consumer in accordance with the vendor's description and claims.

Specifically for compost, the guidelines identify the following fundamental requirements of a composted green material supplied as a component of a growing medium:

- Be produced only from green waste inputs
- Be sanitised, mature and stable
- Be free of all 'sharps' (macroscopic inorganic contaminants, such as glass fragments, nails and needles)
- Contain no materials, contaminants, weeds, pathogens or potentially toxic elements that adversely affect the user, equipment or plant growth (beyond certain specified limits)
- Be dark in colour and have an earthy smell
- Be free-flowing and friable and be neither wet and sticky nor dry and dusty
- Be low in density and electrical conductivity.

According to the WRAP guidelines, such composts "would normally be suitable for use as a growing medium constituent at a maximum rate of 33% by volume in combination with peat and/or other suitable low nutrient substrate(s) such as bark, processed wood, forestry co-products or coir." Higher rates usually affect plant growth negatively because of the compost's naturally high conductivity.

It is important to note that compost from kitchen waste is often not suitable for use in growing media because it has an even higher salinity and electrical conductivity.

[…]

5 Utilising the potential of compost and managing the risks

5.1 Introduction

The use of compost as a soil improver or organic fertiliser can improve the chemical, physical and biological properties of soil and lead to better agronomic performance as well as positive environmental effects. The use of compost as a component of growing media can reduce the dependence on peat to some extent. Diverting putresible waste from landfills to produce compost reduces the climate change impacts of waste management. At the same time there are, however, substantial environmental and health risks associated with the production and use of compost.

Regulators are thus faced by the challenge to optimise the benefits of recycling organic matter through compost and to avoid unnecessary barriers. At the same time the health and environmental risks need to be managed ensuring adequate levels of safety and environmental protection.

The analysis here focuses on those risks whose management is directly linked to the question if composts are a waste or not. These are mainly the risks related to the use of compost. Risks that are more directly related to the processes in composting installations are typically managed by plant permitting. This paper addresses them only as far as they are relevant to the question of end of waste criteria (e.g. temperature-time profiles during the composting process).

The specific risks related to the use of compost that have been produced including animal by-products are addressed by the Animal By-Products Regulation[8], which is directly applicable throughout the EU. Where the only animal by-products used to produce compost are kitchen and food waste as well as manure, there are no restrictions from this Regulation to spreading the compost as organic fertiliser or a soil improver to pasture land.

If any other animal by-products of category 2 or 3 were used as inputs, then records have to be kept of the quantities of compost used, when it was spread and when livestock is again allowed to graze on the land, or when the land is cropped for animal feed. For 21 days after the spreading of such compost, grazing or harvesting for feed production is forbidden.

Concerning other risks, the risk management solutions that Members States have adopted for compost are quite diverse. The Hogg et al. (2002) report and its annexes gives a very detailed comparison of the different types of compost standards and other provisions in place in the main composting countries. This paper highlights some especially relevant aspects for European end of waste criteria.

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[8] Regulation (EC) No 1774/2002 of the European Parliament and of the Council of 3 October 2002 and Commission Regulation (EC) No 181/2006

5.2 Frameworks in place in Member States

Austria

In Austria there are a number of legal instruments that work together to manage the recycling of organic waste as compost and to manage the associated risks. Some instruments apply at the federal level, others at the levels below (Länder).

As a central instrument Austria has issued a Compost Ordinance[9] that regulates manifold aspects of compost. It explicitly specifies the conditions under which compost is considered a product and not a waste. These include:

- a positive list of wastes from which the compost may be produced
- specifications of the product quality (heavy metal threshold values)
- temperature-time profile during composting to achieve hygienic safety
- labelling provisions
- quality control provisions on the input materials and the product
- external quality control provisions
- mandatory record keeping (for 5 years) of batch wise information on input materials and products, including details of who receives the compost
- obligations for registering and notification of the authorities
- analytical methods
- etc.

Already before issuing the Compost Ordinance, Austria had introduced far-reaching legal obligations to collect putrescible wastes separately (source separation), with the aim of avoiding the contamination of the input materials to biological treatments as far as possible.

A compost ceases to be waste for use in accordance with the Austrian regulations when it is documented in the producer's records that a certain batch belongs to one of the compost quality classes as specified by the Ordinance and that it is suitable for at least one of the use areas specified in the Ordinance, based on the results of the latest external quality control and the input material used.

The three compost classes are defined by different heavy metal threshold values and by the input materials that may be used for them.

The highest quality class (A+) is defined so that it complies with the requirements for composts from household waste that may be used in organic agriculture[10]. The medium quality class (A) may be used in agriculture and private gardens. Usually only composts from source separated biological wastes achieve the requirements of the compost classes A+ and A.

Compost of quality B can usually be achieved by composting mixed MSW. The use of this class of compost is limited to the recultivation of landfills and use in limited amounts on areas not used for food or feed production.

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[9] Verordnung des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft über Qualitätsanforderungen an Komposte aus Abfällen (Kompostverordung). BGBl. II – Ausgegeben am 14. August 2001 – Nr. 292

[10] According to Council Regulation (EEC) No 2092/91 of 24 June 1991

Additional limit values regarding organic pollutants are set for compost from mixed MSW. (For compost from source-separated materials, such limit values are deemed not necessary because they are unlikely to be exceeded if 'pure' input materials are used.) The producer or importer of quality B compost must declare the potential users/receivers to the authorities as well as the amounts of compost actually delivered. Compost from mixed MSW cannot be marketed freely but must be transferred from the producer directly to the user.

Composts of categories A+ and A may be designated 'quality composts' if produced from source separated biological MSW fractions. Composts of category B and any composts from mixed MSW get the designation 'compost'. (Composts from sewage sludge and bark have their own legal designations.)

Apart from the general requirements that define the compost classes, there are specific requirements for certain use areas regarding maximum uses of compost from the different compost classes.

For example, compost not complying with the Austrian end of waste criteria, may still be used in agriculture; however this requires a specific permit according to waste law. Both the use of 'product compost' and 'waste compost' needs to comply with the relevant soil protection regulations and may require water protection law permits.

In Austria, soil protection is regulated at Länder level. The Länder may directly use the provisions of the Austrian federal Compost Ordinance, they may further specify them or even introduce deviating provisions, for example concerning the amounts of a certain classe of compost that may be used on land. They can also introduce their own obligations for compost producers and users to provide information or access to the authorities, etc. There are even cases of Länder specifying their own compost classes. All this allows the management of compost benefits and risks to be adapted to the specific local requirements and soil conditions.

In addition to soil protection law, the use of compost on land must also comply with the water protection legislation. If the amount of nitrogen applied exceeds certain limits, a specific permit is required for spreading the compost, whether it is considered a product or a waste.

According to fertiliser law, only compost from green wastes may be used for organic fertiliser or growing media ("Kultursubstrat").

There are also two private quality assurance systems in Austria, which are managed by non-profit compost associations.

Belgium/Flanders

The marketing of fertilisers, soil improvers and growing media is regulated for the whole of Belgium by a Royal Decree of the Federal Ministry of Agriculture. It does not consider compost. Compost marketing therefore requires derogations (temporary permits) to be issued by the Ministry. In practice, these derogations are given for one year if a compost fulfils the standards established by the Ministry.

In addition, the use of compost in Flanders requires approval by the Public Waste Agency of Flanders (OVAM). OVAM has specified maximum heavy metal loadings (g/ha/year) and also requires quality control of the compost by VLACO. VLACO is a cooperation between OVAM, communities, private compost producers, some cities and compost distributors and producers of growing media/soil conditioning products. The main tasks of VLACO are compost marketing, quality control and research.

Compost in Belgium is either produced from separately collected green waste (organic waste generated by gardening and maintenance in public and private gardens, in parks and along roadsides) or from biowaste or 'vegetable, fruit and garden waste' (VFG waste; comprising kitchen waste and the garden waste collected together with the kitchen waste). There is only one statutory compost class in Belgium, which is defined by product quality criteria and applies to both 'biocomposts' (composts from biowaste) and green waste compost. The heavy metals concentration limit values are all stricter than the Austrian B class but do not show a comparable pattern to any of the other Austrian compost classes. (There are values less strict than the corresponding value of Austrian A but the value for Ni is stricter even than that for Austrian A+.)

Generally, only green compost can be used in growing media.

The VLACO quality assurance system is based upon regular inspections of composting plants, checking input materials, processes and product control. Particular attention is given to the separate quality of the separately collected waste. The introduction of the scheme in a company takes two years and, if successful, the company obtains the VLACO label. There are also external inspections by OVAM and the Federal Ministry of Agriculture.

Denmark

For green waste from gardens and parks, there are no regulations at all. It can be freely produced and used.

For household biowaste (kitchen and food waste), there are concentration limit values on heavy metals and some organic pollutants. The limit values for cadmium and some of the organic pollutants are extremely low and very hard to achieve. The limit value for copper appears extremely high compared to standards in countries relying on source separated wastes.

France

This summary for France follows Coppin (2006). The product quality requirements for compost produced from MSW are defined by the French standard NF U44-051. This standard has been made statutory by the French Government. It applies to both compost from separately collected biological wastes and mixed MSW. The standard includes thresholds for concentrations of heavy metals and some organic compounds as well as microbiological and agronomic parameters. The standard addresses the compost composition but not the compost production process. Except for sewage sludge, for which a separate standard exists, no input materials are excluded (neither a positive nor a negative list). Composts that comply with the requirements of the standard are considered products (and not wastes). There are also quality assurance agreements between individual compost producers and the agricultural associations of the users.

The heavy metals threshold values of NF U44-051 are, in most cases, less strict than the standards applied to compost for general use in countries that rely substantially on separate collection of putrescible wastes. They are, however, stricter than the Austrian compost quality class B for example.

A new generation of MSW compost treatment plants are being introduced in France with the aim of achieving compliance with NF U44-051 for compost from MSW without source separation of putrescible wastes. The technology relies on using a relatively clean residual waste fraction as input, obtained by separating off well the hazardous components of domestic wastes and also the glass fraction at source. These plants then include a number of sorting and screening steps throughout the compost production process. So far there is one plant of this type that appears to achieve the requirements of the standard.

Germany

There are two main legal instruments that together regulate the production and use of compost: the Biowaste Ordinance, which deals with the 'precautionary' aspects such as heavy metal concentrations and hygienic standards, and the Fertiliser Ordinance, which addresses issues such as nutrient supply. There is a 'positive list' of wastes that may be used for composts to be spread on land, which includes organic municipal waste (kitchen and garden waste, paper, hair, feathers, pet excreta). Mixed MSW is not allowed. There are no limit values for organic pollutants, based on the rationale that the limitations on input materials warrant sufficient control. Farmers who produce compost for use on their own land are not bound by the Biowaste Ordinance, based on the rationale that self-interest ensures sufficient control in this case.

There are two classes of compost regarding limits of heavy metal concentrations. The differences between the classes are relatively small (maximum 50%). The volumes of compost that may be applied on land are different for these two compost classes (20 or 30 tonnes per hectare in three years). Furthermore, the use of compost is prohibited on soils that exceed certain heavy metal concentration thresholds.

The Biowaste Ordinance includes provisions to guarantee the traceability of the compost and the organic wastes used. The compost producer has to give a 'bill of delivery' to the user of the compost on soil and to send copies to the regulator and to the agricultural authority.

In addition to the legal standards, the voluntary compost standards of the German Compost Quality Assurance Organisation (BGK) play an important role in Germany. The BGK has established general quality standards and a nationwide system for external monitoring of composting and compost. BGK members participate in a quality assurance system with the following elements:

- External monitoring (continuous and independent control of product quality)
- Internal monitoring
- Product quality criteria
- A quality label
- Compulsory product information/declaration standards (regarding product properties and constituents)
- Provision of application guidelines to the user

- Documentation of legal compliance
- Reduced traceability obligations.

The German legislator has acknowledged this voluntary quality assurance system as a 'self regulation of the industry' and introduced a number of exemptions for members of the quality assurance scheme in the Biowaste Ordinance (such as reduced requirements for laboratory tests and external controls).

In Germany, compost from waste is always considered a waste strictly speaking, but the waste-related requirements are reduced considerably if a quality assurance system is applied.

Italy

The fertiliser legislation includes clear criteria that compost must fulfil in order to be considered a product and not a waste. Only compost from source-separated waste can achieve product status. There are limits to heavy metal concentrations and loads spread on land per year and standards for physical impurities and the biological properties. There are quite demanding requirements concerning the organic matter contents. The heavy metal concentration thresholds are somewhat less strict than in the corresponding standards for source separated wastes in Belgium, Germany, the Netherlands and Austria. They are, however, stricter than the French standards defining product quality.

The legislation specifies two categories of compost soil improvers: composted green soil improver and composted mixed soil improver. The first allows only green/vegetable waste. The second one also food waste and, remarkably, up to 35% of sewage sludge in the composting starting mixture. The heavy metal limits are the same for both categories.

If a compost qualifies as a compost product according to one of the two categories, then it can be marketed and used freely as long as compliance with best agricultural practices is made.

Compost from mixed MSW is always considered a waste and requires a permit by the authorities whenever it is spread on land. Much less strict limit values apply to heavy metal concentrations in this case, but there are limits to the loads that can be brought to land per year.

The Netherlands

As part of the fertiliser legislation, a decree originating in 1993 regulates the quality and use of sewage sludge, compost and topsoil as organic fertiliser. The decree distinguishes two classes of compost according to the limit values for the concentrations of heavy metals and their minimum content of organic matter: standard compost and high quality compost. The limit values are very strict and even the limits for standard compost are amongst the strictest in Europe. (The high quality compost requirements are hardly ever reached in practice. The strict limit value for zinc is especially problematic in this sense.)

The decree is also linked to the soil protection legislation, which follows the strategy that the heavy metal supply to soil should not exceed the losses (draining away).

Compost can be produced from 'green waste' or 'vegetable, fruit and green waste'. Limitations on loads for use on land are specified in tonnes as dry matter as well as kg of P_2O_5 per ha and year. For green waste and high quality composts, only the phosphate limitation applies.

In addition to the legal requirements, there is a voluntary quality assurance and certification scheme. Compost producers can have their compost production process and quality control system examined by KIWA, the official certification institute, in order to obtain certification. Participation is less common than in the German QAS.

Spain

The marketing and use of compost as organic fertiliser or an organic soil improver is regulated by the Royal Decree on fertilisers[11]. It incluyes provisions ensuring the traceability of the product (including batch number, producer, input materials used and their suppliers). The use of wastes to produce any of the products covered by the Decree requires a permit by the competent environmental authority. The organic input materials from MSW may or may not be separately collected. There are limit values for the presence of salmonella and escherichia coli. Regarding the heavy metal concentrations in the product, there are three product classes. The thresholds for class A correspond to the requirements for composts from household waste that may be used in organic agriculture. Class B and C are clearly less strict than in the corresponding standards for source separated wastes in Belgium, Germany, the Netherlands and Austria. There are no limit values for organic pollutants. The amount that may be applied on land is limited for class C products (5 tonnes of dry mass per hectare and year). Generally, the codes of good agricultural practice have to be followed.

UK

In the UK there is no specific regulation for compost and compost from waste is considered a waste until its final use. There is a publicly available specification for composted materials (BSI PAS 100) and a certification scheme by the Composting Association. The BSI PAS 100 includes provisions on process control, input materials, sanitation, stabilisation, compost quality requirements, labelling and marking, monitoring and traceability, etc. Composts produced must be classified as one of the following products: soil improver, mulch, growing medium, turf dressing, topsoil (manufactured), other (as specified by the producer). Guidelines with additional specifications for the different uses have been developed. The general heavy metal limits of BSI PAS 100 are stricter than the French NF U44-051 limits but less strict than the standards for source separated wastes in Belgium, Germany, the Netherlands and Austria. A formalised quality control procedure ('quality protocol') for the production and use of quality compost from source-segregated biodegradable waste, based on BSI PAS 100, is under development.

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[11] Real Decreto 824/2005, de 8 de Julio, sobre productos fertilizantes

6 Approaches to European end of waste criteria for compost from MSW

6.1 Potential benefits of European end of waste criteria for compost

Currently there is no coherent way in the EU to determine whether a compost material is a waste or a 'normal' product. Member States deal with the question rather differently. In at least eight Member States, there are types of composts that are explicitly recognised or treated as products although they are produced from input materials that are waste. However, the standards that the composts must meet in order to qualify as normal products differ considerably between these Member States. Then there are other Member States where composts made from waste are always considered waste regardless of the quality of the material, at least until the compost has been used, for example on soil. The establishment of EU-wide end of waste criteria would reduce such differences, increase the legal certainty and improve the harmonised application of Community legislation. A product status may also be associated with fewer administrative procedures that cost less.

Another deficiency of today's framework conditions for the use of compost that end of waste criteria would help to overcome is the lack of widely recognised quality standards for compost. End of waste criteria would automatically introduce such quality standards on an EU-wide basis. With end of waste criteria that are demanding in terms of product quality, they would allow the potential users of the material to have more trust in the compost's quality, safety, suitability for purpose and environmental performance. In this way, end of waste criteria may be instrumental for improving the recycling of organic waste. This is because legal certainty and confidence are both important for stimulating the use of composts in applications where the potential benefits of compost use are still underexploited.

However, end of waste criteria may not only lead to more recycling, they can also help to strengthen environmental and health protection. In cases where the new European end of waste criteria would be stricter than the existing national end of waste criteria of a Member State, such criteria might introduce a waste status for materials that formerly did not fall under waste legislation. This may increase the power of authorities to control the movement and recovery of compost and thus lead to higher levels of environmental and health protection.

Open question: Which other benefits may European end of waste criteria for compost have?

6.2 Risks of European end of waste criteria for compost

In other cases, there may be exactly the opposite effect. In Member States where compost is currently considered a waste, the introduction of European end of waste criteria for compost may 'push' certain types of compost outside the waste regime. This may reduce the possibilities for the authorities to control the movement and recovery/use of these types of compost and, as a consequence, lower the levels of protection from health and environmental risks associated with compost.

Also regarding recycling, there is a risk that EU-wide end of waste criteria do not meet the particular needs of all Member States. If the new European end of waste criteria are stricter than the existing national end of waste criteria of a Member State, this may introduce a waste status for materials that formerly did not fall under waste legislation. Potentially, this could lead to new barriers to the use of compost in applications where the use delivers a net benefit under the specific local conditions.

Open question: Are there any other risks of European end of waste criteria for compost?

6.3 Requirements for the end of waste criteria

As a starting point, the general principles for end of waste criteria are that they should not lead to increased environmental or health impacts and that there should be a market for the product. This means for a material like compost to be considered a product it must be useful and safe regarding occupational health, public health and the environment. Practically, the material must correspond to a standardised compost type. More specifically, the standards must ensure

- that the product is useful for at least one clearly defined purpose, fulfilling the relevant use specifications within acceptable tolerances
- that the product does not pose unacceptable direct health risk to those that will be exposed to it (workers handling the product and other people that might be in contact with it)
- that the product does not pose unacceptable indirect health risk, for example through the food chain, when the product is used according to the different practices and regulations in place wherever it may be used
- that the protection of the environment is safeguarded when the product is used according to the different practices and regulations in place wherever it may be used
- that also the risk of damage to health and the environment from misuse of the compost product is reduced to tolerable levels
- that it can be expected that there will be sufficient absorption capacity in the market for the product so that no need will emerge for disposing of material for which there is not sufficient use.

Furthermore, controls must be in place that allow users and regulators to have confidence that the product effectively complies with the corresponding standards, independently of where it has been produced.

EU-wide end of waste means that there must be adequate provisions outside waste law that ensure the protection of health and the environment everywhere in the EU if compost is traded and used as a normal product. Depending on the country, such provisions may, for example, be part of soil protection law or fertiliser law. European end of waste criteria should be designed in a way that allows consistency with other complementary legislation.

Furthermore, it should be clear that the material will be considered waste whenever it turns out in reality that there is not sufficient use for it or there is the need or intention of the holder of the material to dispose of it, regardless as to whether it complies with the other end of waste criteria.

Ideally the introduction of end of waste criteria should lead to a situation where the production and use of compost is controlled at least as strictly as today, and where high quality compost can be traded freely as a product in the internal market. This would allow the balancing of local gaps between the production and demand of compost and it gives a signal that there are standardised and quality assured products in the European market. This again may increase the confidence of users in areas where there is a lack today and also give clearer perspectives of a demand for high quality compost to those that make decisions on organic waste management.

Open question: Are the requirements identified here really relevant? Are there further requirements to be considered?

6.4 Compost types

A review of compost standards across the EU shows that it is possible to identify a limited number of compost types that cover most of the compost produced from MSW and that there are two main parameters used to define compost types (or classes):

- the input materials (waste fractions) used to produce the compost and
- threshold values for heavy metal concentrations.

There appears to be a close correlation between the two. Certain input materials are usually associated with quite typical strictness of heavy metal concentration limits.

In addition, there are many other parameters used in compost quality standards (such as stability/maturity, macroscopic impurities, organic pollutant concentration, organic matter content, nutrient content, presence of pathogens, etc.) but they are additional requirements rather than defining parameters for compost types.

There are basically three types of compost produced from MSW and used in considerable amounts in several Member States. They are briefly characterised in the following three points:

1. Compost from separately collected green waste with or without strict heavy metal limits[12]

Status:

- Considered a product if complying with the corresponding national standards and quality assurance at least in: Austria, Italy, the Netherlands, Belgium, France (with softer heavy metal limits)
- Not regulated: Denmark
- Considered a waste: Germany (with reduced waste-related obligations and restrictions if quality certified), and the UK

Main uses:

- As a soil improver in agriculture
- As a component of growing media

This type of compost can be used in organic agriculture without specifications on maximum heavy metal concentrations.

2. Compost from separately collected biological waste (including green waste and kitchen waste) with strict heavy metal limits

Status:

- Considered a product if complying with the corresponding national standards and quality assurance at least in: Austria, Italy (the biological MSW fraction may be mixed with up to 35% sewage sludge), the Netherlands, Belgium
- Considered a waste: Germany (with reduced waste-related obligations and restrictions if quality certified)

Main uses:

- As a soil improver or organic fertiliser in agriculture (typically has higher salinity and nutrient contents than compost from green waste)

For using compost that was made from kitchen waste in organic agriculture, it must comply with very strict (usually stricter than for general agricultural use) heavy metal limits that apply EU wide.

Sets of heavy metal limits applying to the first two types of compost are summarised in the following table:

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[12] It is sometimes considered that heavy metal concentration limits are not needed for compost from green waste because of a very low risk of concentrations that may be too high .

Group of 'strict' heavy metal concentration limits (mg/kg dry matter)

	Cd	**Cr (total)**	**Cr(VI)**	**Cu**	**Hg**	**Ni**	**Pb**	**Zn**	**As**
Austria*	1	70	-	150	0.7	60	120	500	-
Belgium	1.5	70	-	90	1	20	120	300	-
Denmark^{+}	0.4	-	-	1000	0.8	30	120	4000	25
France (NF U44-051)	3	120	-	300	2	60	180	600	18
Germany**	1.5	70	-	100	1	50	150	400	-
Italy	1.5	-	0.5	150	1.5	50	140	500	
The Netherlands	1	50	-	60	0.3	20	100	200	15
UK	1.5	100	-	200	1.0	50	200	400	
Organic farming^{+}	0.7	70	-	70	0.4	60	120	500	-

* Quality class A

** Quality class II

$^{+}$ Heavy metal limits not regulated for green waste

3. Compost from mixed MSW (no source separation) with soft heavy metal limits

Status and use:

- Considered a product if complying with the corresponding national standards in Spain and in Austria. However, in Austria there are very tight restrictions on use (cannot be used on soil for feed or feed production)
- In a number of countries (including Italy and France) this type of compost may be used on soil as waste requiring special permits.

Sets of heavy metal limits applying to the third type of compost are summarised in the following table:

Examples of 'soft' heavy metal concentration limits (mg/kg dry matter)

	Cd	**Cr (total)**	**Cr(VI)**	**Cu**	**Hg**	**Ni**	**Pb**	**Zn**	**As**
Austria	3	250	-	500	3	100	200	1800	-
Italy	10	500	10	600	10	200	500	2500	10
Spain	3	300	0	400	2.5	100	200	1000	-

The three compost types above are currently produced and used as common practice in several countries. The following compost type corresponds to a new development emerging in France and is not yet produced in significant quantities:

- *Compost from mixed MSW which complies with the French standard NF U44-051*

  The standard includes heavy metal concentration limits of a high to intermediate strictness. There is a hope to produce composts which comply with this standard from the residual fraction of MSW. This would involve separating off at source problematic waste components and intensified mechanical separation before, during and after composting. So far there are reports only from one composting plant in which this is achieved.

<u>Open question</u>*: Have the three compost types with a European dimension been identified appropriately? Are there other compost types of European relevance?*

6.5 Towards a protocol for end of waste criteria for compost

The general principles are that end of waste criteria should not lead to an increase of environmental and health impacts and that there should be a clear market for the product. They can be converted, together with additional important considerations, into the following operational principles in order to set up end of waste criteria for compost:

- The product must fulfil <u>minimum quality requirements</u> ensuring usefulness in its application and the protection of health and the environment when placed in the internal market. Only composts that can be transported, applied and otherwise handled safely should cease to be waste. Only composts whose misuse is relatively unlikely and associated with limited risks should cease to be waste.

- <u>Integration in the regulation environment</u>: To ensure the protection of health and the environment when using compost products in different applications, the quality requirements must be designed so that they work together with the corresponding soil protection, fertiliser and other relevant regulations for the use of compost. The full set of regulations should provide the full desired protection at all locations, allowing for the adaptation of quantities and other application parameters to the local requirements.

- The user of the product, as well as the authorities, must have sufficient quality guarantees. The quality of the product must be <u>assured independently of where</u> (in which country or region) it is <u>produced</u>.

- The user of the product must have <u>sufficient information on product properties</u> in order to adapt the use of the compost product to the concrete application requirements and local use conditions, in particular to ensure compliance with the corresponding regulations and legal obligations for the different uses (such as local soil protection law, etc.)

- End of waste should not apply to composts with a high risk of 'sham recovery' as a consequence of placing a compost outside the waste regime.

- Existence of a market: The quality requirements and quality assurance provisions should be such that there will be sufficient capacities in the corresponding use outlets to absorb all product produced.

- End of waste criteria should respect the existing national approaches to composting and compost use as far as possible, and build on the composting infrastructure (installations, trusted quality assurance systems, etc.) in place in the Member States.

Supplementary obligations might be required for compost as a product. They would, in principle, be less strict that the requirements linked to the waste status. These might include:

- If there is uncertainty persisting as to whether there will always be sufficient demand for the product, the product status should be linked to mechanisms that ensure use according to purpose (e.g. ensuring contractual responsibility of each successive compost holder from production to use).

- Measures to ensure the traceability of the product (allowing to monitor the related material flows throughout their cycle).

Open question: Are these operational principles useful, necessary and sufficient? What other principles should be considered?

6.6 Impact assessment approach and parameters

The impacts of the end of waste criteria for a certain compost type should be analysed for the different Member States or groups of Member States. The following points need to be addressed:

- How will the amount and quality of the composts used for the different applications change?

- How will the possibilities of Member States controlling the use of compost on soil and in other applications be affected?

- Will the end of waste provisions allow to fulfil the different pertinent obligations from other legislation to be fulfilled (environmental, product safety, etc.)?

- How will the environmental impacts concerning soil, water and air change?

- What will be the agronomic (and of the other use sectors) costs or benefits? Of what kind and size?

- Will there be increased or decreased costs due to changes in licensing and other administrative requirements?

- Will there be an increased trade of compost between MS? Will this lead to any benefits (internal market benefits) or risks?

Open question: What other types of impacts may be important?

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