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Responding to climate change

Sector Script for Solid Waste Management

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This document was developed by EuropeAid in cooperation with DG RELEX, DG DEV and DG ENV with the support of the "environmental integration advisory services" project. It was designed to provide practical guidance on the links between climate change and a specific sector, together with possible responses to climate-related challenges. The purpose of this "script" is to support political dialogue on climate change implications between the European Commission, partner governments and other national partners involved in EC development and external cooperation activities, as well as to facilitate strengthened climate change integration in ongoing and future cooperation programmes and projects, with a focus on developmental benefits for the partner countries.

This sector script is one of a series prepared in a standard format. Scripts are available for the following topics:

- Introduction and Key Concepts
- Agriculture & Rural Development *(incl. forestry, fisheries and food security)*
- Ecosystems & Biodiversity Management
- Education
- Energy Supply
- Governance
- Health
- Infrastructure *(incl. transport)*
- Solid Waste Management
- Trade & Investment *(incl. technological development, employment and private sector development)*
- Water Supply & Sanitation

Note that the script is not country or region-specific, and has been prepared to cover a wide range of possible effects and responses. Users are invited to appreciate which elements, among those proposed, are relevant to their specific needs and circumstances.

Note: This sector script was written with a focus on the management of solid waste. Sanitation and wastewater treatment are addressed in the sector script dedicated to Water Supply & Sanitation. The text makes references to other related and complementary scripts.

Users of this script are advised to read it in conjunction with the Introduction and Key Concepts information note, which introduces the series and puts things in context.

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RESPONDING TO CLIMATE CHANGE: SECTOR SCRIPT

SECTOR: SOLID WASTE MANAGEMENT

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0. EXECUTIVE SUMMARY

Climate change impacts on the waste management sector

Extreme climatic events may affect the waste management sector through damage to sector and associated infrastructure, including transport infrastructure. This may disrupt both waste collection and waste management operations. Increased average temperatures may affect landfills, waste dumps and centralised waste collection sites in various ways, e.g. increased risk of fire and subsidence, increased microbial activity, increased activity of pathogens and release of bio-aerosols, increased vermin, pest and odour nuisance. Landfills and waste collection sites may also be affected by both an increase or a decrease in rainfall, with effects such as increased leachate production, reduced stability of the slopes of landfill pits, increased risk of groundwater contamination and offsite pollution, altered waste decomposition rates, etc. The collection and transport of solid waste materials may be affected by disruption in transport infrastructure as a result of extreme weather events.

Generally speaking, increased temperatures and rainfall, and the increased incidence of floods expected in some areas, are likely to make the consequences of inadequate waste management (or complete lack thereof) more acute, in particular as far as health consequences and vermin proliferation are concerned. Also, climate-induced migrations to areas with high population densities and ineffective waste management systems will directly lead to increases in waste production, which will cause an increased stress on existing waste management systems (or make their absence even more problematic).

Compared with municipal waste, agricultural and agro-industrial wastes are characterised by a higher proportion of organic materials of biomass origin. The techniques traditionally used to manage this waste (e.g. composting, landfilling, incineration) do not differ fundamentally from those used for processing the organic fraction of municipal waste. Potential climate change impacts are therefore similar. As far as industrial waste and the non-biomass fraction of agricultural and agro-industrial waste (e.g. used oils, chemicals) are concerned, the projected increase in extreme weather events and, in some regions, wildfires, is likely to increase the risk of environmental contamination (of soil, water and air) by toxic waste, unless specific precautions are taken to make industrial waste storage sites more resilient to such events.

Adapting to climate change in the waste management sector

For municipal waste and the non-toxic fraction of agricultural, agro-industrial and industrial waste, a range of adaptation options exist and may be considered with regard to specific local circumstances. They include making municipal waste management infrastructure gradually as “climate-resilient” as possible (including in the choice of locations for new infrastructure); adapting waste management techniques and processes to take account of the potential adverse effects identified above; improving conditions at domestic and community waste collection points; strengthening formal waste collection and management processes; implementing policies that reduce the volume of waste at the source; promoting other options than landfilling; and where increases in migration, especially rural-urban migration, are expected, upgrading waste management systems to prepare for absorbing the expected increase in waste production.

Special attention should be dedicated to avoiding that toxic wastes stored on industrial premises and in specialised waste treatment facilities contaminate the environment as a result of floods or storms, or because of conditions that increase the risk of leaching of contaminants into soils. With regard to international movements of toxic waste, laws that ban export to and import by developing countries should be strengthened or more strictly enforced to reduce the risks associated with transport, handling and disposal.

Contributing to climate change mitigation in the waste management sector

The treatment and disposal of solid waste can be an important source of greenhouse gas emissions, mainly methane (CH_4) and carbon dioxide (CO_2) but also (to a minor extent) nitrous oxide (N_2O). The release of fluorinated gases (which are ozone-depleting substances as well as powerful greenhouse gases) may also result from the failure to recover these gases from refrigeration equipment, solvents and foam materials at the time they are disposed of. Improved waste management practices can contribute to a reduction in greenhouse gas (GHG) emissions while providing significant co-benefits in terms of public health, environmental, quality of life and availability of renewable energy.

The best way to reduce GHG emissions from the waste management sector is to promote waste reduction, the re-use of products and materials and, for the waste that cannot be avoided, the adoption of modern waste management techniques. From the point of view of climate change mitigation, but also from a wider environmental and sustainable development perspective, the next best options after waste reduction and re-use are:

- *recycling*: it helps reduce the use of fossil fuels whenever the processes involved for producing recycled materials (including the collection and transport of recyclable materials) are less energy-intensive than those for producing new materials; net effects on energy consumption and GHG emissions should be established using lifecycle analysis tools since they can vary significantly across materials, recycling techniques and recycling circuits, and may also depend on the fossil fuel content inherent in electricity consumption;
- *composting*: controlled aerobic composting (i.e. the decomposition of organic matter by bacteria in the presence of oxygen) fixes much more carbon than it emits and is thus an option for reducing GHG emissions from organic waste;
- *energy recovery with heat and power generation*: "waste-to-energy" thermal processes substitute waste for conventional (fossil) fuels for the generation of heat and/or power; controlled incineration of organic waste, especially if associated with energy recovery, results in minor net CO_2 emissions – but incineration must absolutely be "controlled" because waste burning at inadequate (too low) temperatures is a source of dioxin and heavy metal emissions; waste-to-energy solutions require considerable upfront investment and are more expensive to implement than landfilling, so they are not always suitable for developing countries; another way of reducing GHG production from waste is to recover its carbon (and thus its energy) content by producing biogas by means of anaerobic digestion (i.e. decomposition by bacteria, in the absence of oxygen); the recovered gas can also be used to generate heat and/or power;
- *mechanical biological treatment (MBT)*: this approach combines mechanical waste treatment such as sorting, shredding and crushing, with biological treatment in the form of aerobic composting or anaerobic digestion; this option is also comparatively more expensive than landfilling, so its financial sustainability should be assessed on a case-by-case basis;
- *landfilling with landfill gas recovery*: methane, generated by the anaerobic degradation of organic matter, is the main source of GHGs from the waste management sector; reducing methane emissions from landfills (as well as other sources) is thus a way of moderating global warming over the next few decades; this can be achieved at the source by reducing the quantity of organic waste that is sent to landfills; another option is to recover landfill gas and use it as a renewable source of energy, for electricity and/or heat generation.

Landfilling without gas recovery should remain a solution of last resort, and increasingly be replaced by improved waste management systems. Unmanaged open-air dumping and low-temperature burning (common in developing countries) are the worst options of all: they are major sources of two GHGs, CH_4 and CO_2, and also generate atmospheric pollution and health hazards.

1. HOW CLIMATE CHANGE MIGHT AFFECT THE WASTE MANAGEMENT SECTOR

Climate change may affect the waste management sector through a range of biophysical and socio-economic impacts. The table below shows the main links between such impacts and the sector.

	Waste management
Biophysical effects	
Changes in temperature and rainfall patterns	√
Increase in extreme weather events / natural disasters	√
Raised sea level and increased coastal erosion	√
Changes in hydrological flows, in permafrost	√
Increase in disease and pest outbreaks	√
Socio-economic impacts	
Damage to infrastructure	√
Reduced availability of energy (hydropower)	√
Population displacement and human migrations	√

Some of the possible impacts of climate change on waste management are reviewed below. Most are expected to be negative (increased risk), but some specific positive impacts may also be observed.

1.1. MUNICIPAL WASTE MANAGEMENT

Extreme climatic events may affect the waste management sector through damage to sector and associated infrastructure, including transport infrastructure (e.g. flooding of waste segregation sites and landfills, damage to buildings, damage to road infrastructure). This may disrupt both waste collection and waste management operations.

Increased average temperatures may affect landfills, waste dumps and centralised waste collection sites in different ways:

- The drying of soils increases the risk of subsidence in landfill sites, leading to increased occupational risks for (formal and informal) workers.
- The risk of fires in landfill sites may increase, leading to increased occupational and environmental risks (in particular air pollution from uncontrolled burning).
- Microbial activity (and thus decomposition rates) may increase, leading to increased leachate production[1] and therefore increased risk of soil and groundwater contamination. However waste decomposition also depends on moisture (directly related to changes in precipitation); thus reduced rainfall may lead to lower degradation and lower production of leachates in spite of higher temperatures.
- Increase in the activity of pathogens[2] and the release of bioaerosols[3] may be expected, leading to increased health risk for (formal and informal) workers and the neighbouring populations, especially in open air dumps and uncontrolled landfills.

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[1] Leachates are liquids carrying soluble elements found in soils, waste, etc., that form as a result of percolation processes. They seep into the ground and often end up contaminating groundwater. Leachates from waste are particularly problematic because of the risk of toxicity.

[2] i.e. disease-producing agents.

[3] i.e. suspensions of fine particles or droplets containing tiny biological organisms such as fungi, bacteria and viruses.

- Increased vermin and pests, especially in open air dumps and uncontrolled landfills, may lead to increases in vector-borne diseases.
- Odour nuisance may increase.
- Positive effects may also result, such as increased rates of microbial methane oxidation rates in cover materials[4] (which reduce odour nuisance as well as emissions of methane, a greenhouse gas – see Section 3 for further information).

Increased rainfall may affect landfills, waste dumps and centralised waste collection sites through:

- increased leachate production, leading to increased risk of soil and groundwater contamination;
- increased precipitation intensity, which may affect the stability of the slopes of landfill pits and thus increase occupational risks;
- increased flooding events on site due to rising groundwater table, leading to increased risk of offsite pollution from leachate and surface run-off of toxic materials;
- increased risk of erosion of the walls of landfill pits and of capping layers (i.e. layers of cover materials), leading to increased risk of on-site landslides, of vermin proliferation and littering.

Decreases in rainfall may affect landfills, waste dumps and centralised waste collection sites through:

- an increase in the concentration of leachates (which are less diluted), leading to increased risk of toxicity where groundwater is contaminated;
- altered waste decomposition rates (depending also on changes in temperature);
- reduced water availability for site management, and notably for dust suppression;
- increased risk of shrinkage of clay linings (which are laid at the bottom of landfill pits to prevent the seeping of toxic materials into soils and groundwater) and of capping layers (which are laid on top of landfilled waste), resulting in increased risk of groundwater contamination, vermin proliferation, odour nuisance and littering.

Many of the effects mentioned above will also apply to domestic and community waste collection points – formal ones and particularly informal ones. There will also be implications for the collection and transport of solid waste materials from these collection points to waste management sites (in particular, these operations may be affected by disruption in transport infrastructure as a result of extreme weather events).

At composting sites and in operations that involve a composting component (such as mechanical biological treatment), increased temperatures may increase the rates of biological decomposition processes, allowing for faster composting. This is a potentially positive effect, which can also reduce the risk of contamination by phytosanitary products (found for instance in crop residues) and pathogens.

Where thermal processing is used, combustion processes may be impacted by increased rainfall due to the higher moisture content of waste. Combustion may be slower and produce more noxious fumes and gases, with adverse consequences in terms of local air pollution.

Increased temperatures and rainfall, and the increased incidence of floods expected in some areas, are likely to make the consequences of inadequate waste management (or complete lack thereof) more acute, in particular as far as health consequences and vermin proliferation are concerned.

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[4] i.e. the materials used to cover layers of landfilled waste, for the purpose of preventing the proliferation of vermin (e.g. rats), preventing littering (which results when blowing winds take away plastic bags and other light waste and transport them offsite) and reducing odours.

The effects of climate change (especially increases in the frequency and/or intensity of extreme climatic events, as well as a reduction in viable rural livelihoods and possible increases in conflicts) may increase rates of migration, especially rural-urban migrations. Particularly in areas with existing high population densities and ineffective waste management systems, the resulting local population increases will directly lead to increases in waste production, which will cause an increased stress on existing waste management systems (or make their absence even more problematic). In the case of rural-urban migrations, non-organic waste production will also increase (the non-organic waste fraction is typically larger in urban than in rural areas).

Sea level rise may affect waste management through flooding of coastal waste management sites.

1.2. AGRICULTURAL, AGRO-INDUSTRIAL AND INDUSTRIAL WASTE MANAGEMENT

Compared with municipal waste, agricultural and agro-industrial waste are characterised by a higher proportion of organic materials of biomass origin. The techniques traditionally used to manage this waste (e.g. composting, landfilling, incineration) do not differ fundamentally from those used for processing the organic fraction of municipal waste. Potential climate change impacts are therefore similar.

Industrial waste (depending on its origin and nature), and the non-biomass fraction of agricultural and agro-industrial waste (e.g. used oils, chemicals), may be characterised by *higher concentrations of toxic products*. The projected increase in extreme weather events (storms, floods) and, in some regions, wildfires, is likely to increase the risk of environmental contamination (of soil, water and air) by toxic waste, unless specific precautions are taken to make industrial waste storage sites more resilient to such events. Intermediate treatment of industrial and assimilated waste may involve specific sorting, chemicals recycling and/or some specialised treatment to remove or reduce toxicity. However, the final stages of industrial waste processing are in principle similar to those of municipal waste management (e.g. landfilling, incineration). The impacts described above (and in particular those related to “centralised” municipal waste management) thus also apply to industrial waste management.

Note that the *export of toxic waste* from developed countries to developing ones, although restricted and strictly controlled notably under the Basel Convention, remains an existing practice. The risks of accidents and toxic pollution associated with this trade are increased if the host countries, in addition to having generally lower standards for waste management, are particularly exposed to some of the effects of climate change described above. Climate change may increase the risks associated with waste handling and disposal, as well as those associated with waste transport over long distances (e.g. shipwrecks as a result of sea storms).

2. ADAPTING TO CLIMATE CHANGE IN THE WASTE MANAGEMENT SECTOR

2.1. MUNICIPAL WASTE MANAGEMENT

Possible adaptation measures include:

- making municipal waste management infrastructure gradually as “climate-resilient” as possible (including in the choice of locations for new infrastructure – e.g. flood-prone areas should absolutely be avoided for landfills) – and ensuring that the public infrastructure on which adequate waste management depends (e.g. local transport infrastructure, which is crucial for waste collection, and local energy supply) is also upgraded to become more resilient;
- adapting waste management techniques and processes to take account of the potential adverse effects identified above; for landfills, this may include for instance better lining of the bottom of landfills (to reduce the penetration of leachates), improved (controlled) drainage of leachates,

strengthened control of vermin and pests, measures aimed at reducing odour nuisance, strengthening of the slopes and outer structures, use of more erosion- and/or drought-resistant materials for capping layers; where changing climatic conditions affect the degree of moisture in waste intended for incineration, the use of chemicals and reagents in flue gas treatment systems (i.e. the systems that remove toxic agents from the exhaust fumes before their release into the atmosphere) may have to be adjusted to match the characteristics of each batch;

- improving conditions at domestic and community waste collection points (e.g. provision of closed or partly closed waste containers to households, location of community waste collection points outside flood-prone areas);
- strengthening formal waste collection and management processes, to reduce informal practices;
- implementing policies that reduce the volume of waste at the source, promote other options than landfilling (which is the waste management practice most vulnerable to the effects of climate change) and in particular reduce the quantity of organic waste that ends up in landfills (to reduce the risk of vector-borne and water-borne diseases and the contamination of groundwater by leachates);
- where increases in migration, especially rural-urban migration, are expected, upgrading waste management systems to prepare for absorbing the expected increase in waste production; this also includes planning for waste management site creation and extension (obviously, no human settlements should be allowed on landfills – but they can be allowed in the vicinity of recycling facilities, which provide jobs).

2.2. AGRICULTURAL, AGRO-INDUSTRIAL AND INDUSTRIAL WASTE MANAGEMENT

All the adaptation measures proposed in relation to municipal waste management are also valid for agricultural, agro-industrial and industrial waste. Special attention should be dedicated to avoiding that toxic wastes stored on industrial premises and in specialised waste treatment facilities contaminate the environment as a result of floods or storms, or because of conditions that increase the risk of leaching of contaminants into soils. In addition, some more specific measures may be considered. For instance, focused studies of the implications of climate change for specific waste production and management chains, particularly for hazardous or potentially hazardous waste, could be undertaken to identify specific management practices to respond to the expected changes.

With regard to international movements of toxic waste, laws that ban export to and import by developing countries should be strengthened or more strictly enforced to reduce the risks associated with transport, handling and disposal.

3. OPPORTUNITIES FOR REDUCING GHG EMISSIONS IN THE WASTE MANAGEMENT SECTOR

The treatment and disposal of solid waste can be an important source of greenhouse gas emissions, mainly methane (CH_4) and carbon dioxide (CO_2) but also (to a minor extent) nitrous oxide (N_2O). The release of fluorinated gases (which are ozone-depleting substances as well as powerful greenhouse gases) may also result from the failure to recover these gases from refrigeration equipment, solvents and foam materials at the time they are disposed of.

Improved waste management practices can contribute to a reduction in GHG emissions while providing significant co-benefits in terms of public health (e.g. reduced exposure to toxic products and to contaminated water), environmental protection (e.g. prevention of water, soil and air contamination), quality of life (e.g. reduced impact on landscapes, reduced odour nuisance) and availability of renewable energy. Some technologies directly reduce GHG emissions or avoid their generation at the source; others contribute to indirect reductions through improved energy and material efficiency and/or avoided fossil fuel use.

The best way to reduce GHG emissions from the waste management sector is to promote waste reduction (e.g. lighter packaging of products), the re-use of products and materials (e.g. refillable bottles, re-use of one industry's waste as an input into another industry's production) and, for the waste that cannot be avoided, the adoption of modern waste management techniques. From the point of view of climate change mitigation, but also from a wider environmental and sustainable development perspective, the next best options to waste reduction and re-use are, by (indicative) order of preference[5]: recycling and composting; energy recovery with heat and power generation ("waste-to-energy"); and landfilling with landfill gas recovery. Landfilling without gas recovery should remain a solution of last resort, and increasingly be replaced by improved waste management systems. Unmanaged open-air dumping and low-temperature burning (common in developing countries) are the worst options of all: they are major sources of two GHGs, CH_4 and CO_2, and also generate atmospheric pollution and health hazards.

Shifting to controlled waste management options with energy recovery normally results in a reduction in net GHG emissions, even taking into account the transport fuel used for waste collection and the use of energy to power some other waste treatment processes. Switching to renewable energy sources to power waste collection and treatment of course helps reduce net emissions.

Waste segregation to allow the best mix of waste management options should normally be a component of waste management strategies, aiming at efficient systems and also allowing optimal reduction of GHG production. The simultaneous use of various technologies usually provides the best results, but the optimal "mix" varies according to local circumstances.[6] Public policies, development aid and external cooperation programmes can and should be used to provide incentives to switch to more efficient waste management practices. Planning regulations and tax incentives have a role to play in encouraging waste management behaviours that limit the production of GHG.

3.1. RECYCLING

Recycling helps reduce the use of fossil fuels whenever the processes involved for producing recycled materials (including the collection and transport of recyclable materials) are less energy-intensive than those for producing new materials. This is often the case: recycling is usually considered to be an energy-efficient option for materials such as paper, glass, steel, aluminium and magnesium. However, net effects on energy consumption and GHG emissions should be established using lifecycle analysis tools since they can vary significantly across materials, recycling techniques and recycling circuits, and may also depend on the fossil fuel content inherent in electricity consumption. Recycling can also increase carbon sequestration in forests through avoided deforestation (in the case of paper recycling). A co-benefit of recycling is that it contributes to materials efficiency.

3.2. COMPOSTING

Controlled aerobic composting (i.e. the decomposition of organic matter by bacteria in the presence of oxygen) fixes much more carbon than it emits[7] and is thus an option for reducing GHG emissions from organic waste (e.g. agricultural waste, but also human and animal sewage). A co-benefit of

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[5] This hierarchy of preferences is proposed by the UK Department for Environment, Food and Rural Affairs. In fact, there is no standard "order of preference" applicable everywhere: the optimal "mix" of waste treatment technologies is determined by the factors chosen to determine "optimality" and their weighting, by the nature and composition of the waste to be treated, by geographical factors and by financial and economic constraints (e.g. availability of land, availability of capital for investment).

[6] For instance, the rate at which some GHGs are produced from waste may vary by several orders of magnitude depending on temperature, moisture and pH conditions, available substrates, microbial composition and other factors. Mitigation potential, as well as mitigation costs, can thus vary significantly across countries and regions.

[7] Composting must be "controlled" because if left uncontrolled, anaerobic or semi-aerobic conditions (i.e. decomposition by other types of bacteria, in oxygen-free or oxygen-poor conditions) may emerge and produce CH_4 and N_2O, two powerful GHGs.

composting is that it contributes to nutrient recycling. Composting provides a soil conditioner and source of plant nutrients and requires much less energy for production than conventional inorganic fertilizers.

3.3. WASTE-TO-ENERGY THERMAL PROCESSES

"Waste-to-energy" thermal processes substitute waste for conventional (fossil) fuels for the generation of heat and/or power. Traditional techniques include:

- controlled incineration[8], which is not systematically associated with energy recovery, but should be in order to maximise the mitigation potential;
- combustion of refuse-derived fuel and agro-industrial waste (e.g. sugar bagasse) as a partial substitute for fossil fuels in power plants and boilers;
- and combustion in industrial processes (e.g. burning of waste in cement kilns).

Controlled incineration of organic waste, especially if associated with energy recovery, results in minor net CO_2 emissions, since: (i) the recovered energy generally substitutes energy generated from fossil fuels; (ii) the CO_2 emissions that inevitably result from the burning of organic material originate primarily from biomass, the growing of which initially extracted carbon from the atmosphere. The emissions taken into account in relation to thermal processes are limited to those resulting from the use of fossil fuels to get the incineration process started, as well as the burning of "synthetic" organic materials containing fossil carbon (e.g. plastics, synthetic textiles). Note that incineration must absolutely be "controlled" because waste burning at inadequate (too low) temperatures is a source of dioxin and heavy metal emissions. The prior sorting of waste (to remove those materials that are most likely to generate polluting emissions, such as batteries, electronic waste and PVC plastics) coupled with strict emission standards[9] and controls are necessary to make incineration and other thermal processes an environmentally sustainable option.

Electricity (produced using internal combustion engines, gas turbines or steam turbines) can be used to power industrial processes at or close to the source of production, and/or contribute to the local grid. Electricity generation is a financially attractive option in particular where electricity utilities are obliged by their regulator to purchase the electricity generated and not directly consumed by small power producers. Heat can be used to power industrial processes as well as municipal district heating systems. "Co-generation" designates techniques that combine heat and power generation.

Waste-to-energy solutions require considerable upfront investment and are more expensive to implement than landfilling. For this reason, they are not always suitable for developing countries. However, the financial burden can be significantly alleviated if reduced GHG emissions can be marketed as emission credits, in the context of the flexibility mechanisms of the Kyoto Protocol (Clean Development Mechanism and Joint Implementation Mechanism).

Note: An alternative to incineration/combustion is the production of biochar from biomass waste. Biochar is charcoal produced from biomass using pyrolysis techniques. Biochar itself is not generally used as a fuel, but the oil and gas that are the by-products of the pyrolysis process can be used as such. As for biochar, it can be used as a soil amendment, producing many benefits including the stable storage of carbon matter in soils. The production of biochar is thus another possible 'climate-friendly' use of the organic residues of agriculture, forestry and related industries. (Source: Wikipedia)

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[8] "Controlled" incineration refers to incineration that takes place in an incinerator working at optimal temperatures and equipped with appropriate filters, so as to minimise emissions of air pollutants.

[9] Compliance with strict emission standards is made possible by the use of advanced flue gas cleaning systems, which trap particulate matter, heavy metals, dioxins and other nasty substances contained in exhaust gases before they are released from chimneys.

3.4. ANAEROBIC DIGESTION

Another way of reducing GHG production from waste is to recover its carbon (and thus its energy) content by producing biogas by means of anaerobic digestion (i.e. decomposition by bacteria, in the absence of oxygen). The recovered gas can be used to generate heat and/or power, as in the case of waste-to-energy thermal processes. This technique has the advantage of stabilising the solid residues that remain at the end of the process: they can be landfilled but will not produce much methane, since most of the carbon content (the source of GHGs) will have been extracted in the controlled digestion process.

Anaerobic digestion is comparatively more expensive than landfilling. However, it is not unaffordable for developing countries and should not be dismissed upfront: China and India, for instance, have a long experience of using small-scale biowaste digesters with biogas recovery, as an affordable option for local energy production. And again, the extra financial burden compared with landfilling can be alleviated by both the use of energy so produced and the sale of emission credits on carbon markets.

3.5. LANDFILLING WITH ENERGY RECOVERY

Methane, generated by the anaerobic degradation of organic matter, is the main source of GHGs from the waste management sector. The production of landfill gas (which is primarily made up of methane) can continue for several decades after the waste is disposed of. With a 100-year horizon, methane is 25 times more powerful than carbon dioxide as a greenhouse gas – and 72 times more powerful with a 20-year horizon. Reducing methane emissions from landfills (as well as other sources) is thus a way of moderating global warming over the next few decades.

This can be achieved at the source by reducing the quantity of organic waste that is sent to landfills: depending on its nature and origin, better solutions for this type of waste include composting (e.g. for agricultural waste), anaerobic digestion for biogas production or incineration (e.g. for residues of sugarcane processing or from pulp and paper mills).

Another option is to recover landfill gas and use it as a renewable source of energy, for electricity and/or heat generation. The gas can be recovered by means of vertical wells and/or horizontal collectors. Ideally, this approach can be combined with the use of landfill cover soils that oxidise and capture some of the residual emissions getting to the surface[10]. “Bioreactor” landfill designs have been developed to accelerate the process of gas production and extraction.

Sometimes, landfill gas is processed to be used as a substitute for natural gas; however this application is not very frequent, and involves some difficulties (e.g. reluctance of natural gas distributors to allow the injection of landfill gas into their pipelines).

Note, finally, that landfills are not only a source of GHG emissions, but can also to some extent act as long-term (although not permanent) carbon storage facilities – due to the fact that some of the organic materials stored in them decompose very slowly (cellulose) or hardly (lignin) at all in anaerobic conditions. This should be taken into account when balancing various mitigation options.

3.6. MECHANICAL BIOLOGICAL TREATMENT (MBT)

MBT combines mechanical waste treatment such as sorting, shredding and crushing, with biological treatment in the form of aerobic composting or anaerobic digestion. The compost so obtained can be used as a soil conditioner/plant nutrient, or the biogas as a source of energy for heat and/or power generation; only residual waste, with reduced carbon content, is landfilled.

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[10] This technique is known as “methanotrophic oxidation”; it allows to convert landfill cover soils into carbon sinks, and also to capture some non-methanic organic compounds that, if released, also contribute (in a minor way) to global warming.

Again, this option is comparatively more expensive than landfilling, and its financial sustainability should be assessed on a case-by-case basis, based on the savings made thanks to the use of by-products and the possibility of selling carbon credits.

4. REFERENCES

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