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**BAT conclusions**

**For the**

**REFERENCE DOCUMENT ON BEST AVAILABLE TECHNIQUES FOR WASTE TREATMENT**

**Subchapter**

**BIOLOGICAL TREATMENT**

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**Acronyms used in this document**

# BEST AVAILABLE TECHNIQUES

Scope

Definitions

General considerations

Reference conditions

## General BAT conclusions

### Overall environmental performance

#### Environmental management systems

#### Monitoring

### Waste treatment performance

#### Reception, handling and storage

#### Compatibility to mix or blend

#### Input pre-treatment and output finalisation

#### Washing of waste containers

### Emissions to air

### Emissions to water and water consumption

### Consumption of raw materials and chemicals

### Energy consumption

### Noise and vibrations

### Prevention of soil and groundwater contamination

### Decommissioning

## BAT conclusions for biological treatments

(*Covering common issues for the biological treatment of solid waste, including the common directly associated activities dealing with only mechanical treatment of solid waste such as sorting activities.*

*Specific conclusions for hazardous waste may be proposed depending on evidence shown in the data collection.)*

### General primary techniques

**COMPOSTING**

 Outdoor

 Indoor

 Combined indoor & outdoor (maturation)

**AD**

 Wet

 Dry

 Batch wise

 Continous

 Without post composting of digestate

With post composting of digestate

 Outdoor

 Indoor

 Combined indoor & outdoor (maturation)

**MBT**

 **Bio-drying (indoor only)**

 **Biological stabilisation before landfilling**

 Aerobic treatment

 Indoor only

 Combined indoor and outdoor (maturation)

 **Composting**

 Aerobic treatment for CLO production

 Indoor only

 Combined indoor and outdoor (maturation)

**CONTAMINATED SOIL – AEROBIC TREATMENT**

 **Possibly shifted to physico-chemical treatment !**



Figure 1: Structured chart of main processes included in biological treatment

### General environmental performance

(*This section may include conclusions for OTNOC.)*

The environmental performance must be described in differentiation of:

**ECN comments**

1. the principal process (e.g. composting, AD, waste air treatment, shredding etc.)
2. the technique /technology applied (open or closed compostintg ; several AD techniques etc.)
3. the operation, maintenance and process / quality management implemented
4. waste stream(s) included (e.g. source separated biowaste including green waste, municipal sewage sludge, MSW)
5. the output produced which also has an influence on the process /steps/duration and performance : (matured quality compost, bio-dried SRF, stabilised MBT material for landfilling etc.; liquid digestate for direct use or after dewatering as feedstock for composting …)

Therefore this chapter would list the key processes and the most common / important techniques following (such as open and closed composting, the different AD techniques and treatment steps, the biological treatment within an MBT plant for the different purposes …) and describe the ranges of potential impacts caused by the standard emission categories as well as the process outputs)

1. **In order to prevent at source the generation of pollutants and to improve the general performance of the biological treatment of waste, BAT is to select and pre-treat the waste input feedstock by using the techniques given below.**

[BAT 66]

**To be checked = table from JRC guidace**

|  |  |  |
| --- | --- | --- |
| **Technique** | **Description** | **Applicability** |
|  | Selection of feedstock for biological systems | Active parts of the feedstock can be easily re-used or recycled after an early separation from the rest (e.g. glass, metals) | Generally applicable |
|  | Admissible waste adjustment | adjust the admissible waste types and separation processes according to the type of process carried out and the abatement technique applicable (e.g. depending on the content of non-biodegradable components) | Generally applicable |
|  | [other] |  |  |

### ~~Odour~~

This should be treated in the individual sections (composting, AD. MBT)

### General BAT conclusions for aerobic treatment (composting) of source-separated bio-waste and sewage sludge

*(Cross-references to the mechanical-biological treatment section are made whenever useful.)*

#### Monitoring

#### Input pre-treatment and output finalisation

#### Emissions to air including odour

#### Emissions to water and water consumption

#### Energy efficiency

#### Emissions to soil

### BAT conclusions specific to outdoor composting of source- separated biowaste and sewage sludge

#### Principal techniques and construction elements applied for the composting process

Open / outdoor composting is carried out in open space. Construction and facility components comprise, where obligatory or optional techniques respectively are indicted in the respective sub-chapters:

* Devices for pre-processing: shredding of bulky green waste; separation of impurities (screen, wind sifter, magnetic separator)
* Sealed or paved floor
* with or without roofing
* with or without positive or negative forced aeration of initial active decomposition phase
* biofilter in case of installation of negative forced aeration system
* with or without coverage with fabric fleece or semi-permeable membranes
* Devices for mechanical turning and mixing
* Devices for watering the compost piles
* Facilities and construction elements for process water drainage, collection and storage
* Devices for ready made compost (screen, wind sifter, magnetic separator)

#### Process steps included

The following process steps are included in an open composting:

1. Waste reception with receipt control, weighbridge and intermediate storage of feedstock materials
2. Pre-processing
* shredding,
* screening,
* blending of feedstock
* separation of impurities by means of
* screening
* wind sifting
* magnetic separtion
* manual sorting
* addition of water
1. Active decomposition phase (including sanitisation)
2. Maturation and curing
3. Final processing, confectioning of ready made compost and screening into desired output specifications
4. Storage of compost

The key stages during open windrow composting are illustrated in Figure 2.



Figure 2. Flow chart illustrating the key processing stages during open windrow composting of organic wastes

#### Quality management of operational process with a view to enhance environmental performance



Figure 3: Aerobic treatment (composting) of source separated biowaste and sewage sludge: subsequent process steps and general elements of quality management and traceable process documentation.

#### General management system of operational process with a view to enhance environmental performances requirements

**XX. In order to improve the environmental performance of composting installations, BAT is to adhere to an environmental management system to include the following features:**

|  |  |  |
| --- | --- | --- |
| **Techniques** | **Description** | **Applicability** |
| General  | * A maintenance schedule is included in the management system.
* Repairs are initiated within a time frame specified in the operator’s management system.
* ……..
 | Generally applicable |
| Operations and maintenance procedures | Effective operational and maintenance systems are in use for all aspects of the process especially where failure could impact on the environment, in particular there should be:* a defined procedure for identifying, reviewing and prioritising items of plant for which a preventative maintenance regime is necessary
* documented procedures for monitoring emissions or impacts
* a preventative maintenance programme covering all plant, whose failure could lead to impact on the environment, including regular inspection of major ‘non-productive’ items such as tanks, pipe work, retaining walls, bunds, ducts and filters. The maintenance system includes auditing of performance against requirements arising from the above and reporting the result of audits to top management.
 | Generally applicable |
| Competence and training procedures | * The plant employs a suitable qualified and experienced facility manager who is designated as the person in charge. The facility manager or a nominated, suitably qualified and experienced deputy is present on the facility at all times during its operation.
* The plant ensures that personnel who performs specific tasks is qualified on the basis of appropriate education, training and experience as required and aware of the requirements of the permit/licence. In addition, the facility manager and his/her deputy successfully complete a recognised specific training course relevant to the management of the facility.
* Training systems, covering the following items, should be in place for all relevant staff which cover:
* awareness of the regulatory implications of the permit/licence and how this impacts their work responsibilities and activities;
* awareness of all potential environmental effects from operation under normal and abnormal or extreme circumstances (e.g. extreme weather, plant failure, emergency)
* awareness of the need to report deviation from the permit/license
* prevention of accidental emissions and action to be taken when accidental emissions occur
* reporting and accountability procedures within the management structure of the facility.
 | Generally applicable |
| Accidents / incidents procedures | An accident plan is in place which:* identifies the likelihood and consequence of accidents and emergency
* identifies actions to prevent accidents and mitigate any consequences

The accident management plan considers and has procedures for dealing with events which effect the day to day operation of the facility e.g. risks and impact of flooding and fires.  | Generally applicable |
| Environmental Management Systems | A written management system is in place which provides the framework for the plant to deal with immediate and long-term environmental impact of its products, services and processes.A management system needs consider the location, waste types treated, size of your site, and complexity of your process. The operation of formal environmental management systems (EMSs) is equally accepted as non-certified systems. The level of information and control should be proportional to the risk each activity may have to the environment or on process control.  | Generally applicable |

#### Waste acceptance and storage

The handover, receipt control, tipping and short term intermediate storage of the composting feedstock is the first activity at composting plants.

Special attention needs to be directed towards the origin and quality of the delivered feedstock during acceptance. Feedstock need to be identified unambiguously in order to check if they comply with the list of admissible feedstock (wastes) according to the facility’s consent. This includes the traceability of quality as well as origin and the technological processes the materials stem from. Intermediate storage needs to be done in a way that facilitates adequate further processing and minimises potential emissions to air.

**Function and main activities carried out during waste reception and intermediate storage:**

* Handover of waste materials and other feedstock from a transport vehicle;
* Receipt control: identification of waste type according to the list of allowed feedstock pursuant to the facility consent;
* Identification and, if necessary separation and rejection of inappropriate batches and contaminated deliveries, especially if no further sorting for contaminants will occur;
* Intermediate storage of the different types of received feedstock;
* Handover of additives and auxiliary agents (such as stone dust, soil, wood ash);
* Quantity registration (weighbridge).

**XX. In order to improve the environmental performance of composting installations, BAT is to use the techniques below for WASTE ACCEPTANCE AND STORAGE.**

|  |  |  |
| --- | --- | --- |
| **Techniques** | **Description** | **Applicability** |
| **Requirements for construction and facility infrastructure** |
| Construction elements and design | * The reception area is appropriately sized to accommodate the expected volume of waste (including a buffer in the case of an operational breakdown and considering seasonal variation), a dedicated area for off-loading and inspections of input material loads, a dedicated quarantine area (containers) for unacceptable or rejected loads and any area allocated to pre-treatment;
* The reception area is designed to facilitate cleaning including drainage to allow discharge of wash waters into gullies and to a sump for use within the process or to be discharged to a sewer system.
* All reception areas have an impermeable surface with self-contained drainage, to prevent any spillage entering the storage systems or escaping off-site. The design should prevent the contamination of clean surface water.
* The tipping and intermediate storage areas need to be designed for complete emptying and cleaning;
 | Generally applicable for biological treatment |
|  | * **Exception from pavement** and waste water collection:
	+ A paved area is not obligatory for **woody green waste (tree cuttings), straw or bark**.
* **Roofing in areas with high rainfalls????**
* A **separate area** is reserved for **humid biowaste and woody green waste** in order to provide appropriate feedstock blending
* Separate tipping and intermediate storage areas should be maintained for municipal and industrial sludge;
* In the case of intermediate storage of source separated biowaste and food waste from households, physical protection against wind drifting of light fractions (contaminants such as plastics) must be installed (fences, walls, fleece coverage);
* The individual storage areas must be clearly designated.
 | Applicable to outdoor composting |
| Infrastructure and equipment | * The reception is equipped with a **weighbridge**
* Containers for the intermediate storage of sorted contaminants or batch failures awaiting disposal or further treatment. Those containers must be designated appropriately;
 | Generally applicable for biological treatment |
| **Requirements for process management and documentation** |
| Reception procedure  | * An authorised person needs to be on site to receive the waste materials during opening hours.
* A delivery is only defined as having taken place in a legal sense, after formal receipt control and approval of compliance by an authorised person.
* The quality and quantity of feedstock arriving at the installation is recorded at the time of delivery.
* Waste is only accepted at the facility if suitable for composting. The plant operator establishes and maintains detailed written procedures for the acceptance and handling of wastes. These procedures provide for the pre-clearance and characterisation of waste types proposed to be accepted at the facility.
* Some waste streams not already well characterised may require feedstock characterisation by sampling and testing, composition analysis or visual assessment to be conducted as part of establishing a supply contract.
* Some waste streams may require periodic verification of the initial characterisation.
 | Generally applicable for biological treatment |
| Waste pre-acceptance assessment  | * Waste is accepted at the facility from known customers or new customers subject to pre-acceptance procedures.
* The written records and document detailing this off-site waste pre-clearance are retained by the plant for all active customers and for a two year period following termination of plant’s licensee/customer supply contracts.
* The operator should have clear and unambiguous criteria for the rejection of wastes or any actions to be taken to remove or reduce physical contaminants or any other unsuitable content prior to processing, together with a written procedure for tracking and reporting non-conformance.
* Waste arriving at the facility are certified (as to source), weighed, documented and directed to the Waste reception area. Each load of waste arriving at the Waste reception facility is inspected upon tipping within this facility. Only after such inspections the waste is processed for recovery. If the inspection indicates that the wastes fail to meet the acceptance criteria, then such loads are stored in a dedicated quarantine area and dealt with appropriately.
 | Generally applicable for biological treatment |
| Intermediate feedstock storage | * The separate storage of different waste types is necessary to create distinct products (e.g. green waste compost, biowaste compost, bark compost, sludge compost);
* Removal of contaminants and other extraneous constituents. Plastic bags containing organic materials must be torn open and removed.
 | Applicable for outdoor composting |

#### Pre-treatment

The pre-processing of composting feedstock aims to optimise the compost batch for the composting process and to minimise uncontrolled biological transformation and emissions during early stages of composting. The *objectives* are to:

* Ensure the continuous decomposition at low material loss rates (i.e. to conserve organic carbon and nitrogen) (🡪 ratio of carbon and nitrogen sources which are available for the microbial transformation);
* Maintain gas exchange and heat transmission within the composting mass by means of an adequate ratio of structural material (🡪 free pore space, facilitating convection);
* Have a low level (preferably none) of contaminants, a balanced nutrient content with respect to the envisaged compost use and the formation of stable humus compounds (clay-humus complex).

**The main functions and measures of the pre-processing process are:**

* Removal of physical contaminants (impurities);
* Shredding of wood, tree and bush cuttings
* Mixing and homogenising the feedstock
* Adjustment the composting parameters:
* moisture, (blending of wet with dry materials, adding of water)
* C/N-ratio,
* Air filled pore volume (structure; blending with woody bulking materials),
* Mixing of additives and auxiliary agents in order to absorb odour and surplus water, optimise composting conditions and enhance final product quality.

**XX. In order to improve the environmental performance BAT is to use the techniques below for PRE-TREATMENT BEFORE COMPOSTING**

**FA: This table still needs to further developed and structured for the specific measures/processes/techniques!**

|  |  |  |
| --- | --- | --- |
| **General design and construction elements, techniques** | * All treatment areas with the exception of the shredding area for woody green waste have engineered impermeable surfaces with kerbed areas to allow collection of runoff and leachate
* Run off and leachate (dirty water) are collected in an engineered system and collected in a sump or lagoon.
 | Generally applicable |
| **Sorting of impurities** | * Permanent working places for manual sorting should only be placed in sorting cabins with air conditioning and effective air change systems.
* Doors of sorting cabins need to be kept closed, preferably have to close automatically. The air above the conveyer should be sucked off along the entire sorting line. The capacity of the aeration device should guarantee that the air inside the sorting cabin does not lead to any ill health of the workers. The ventilation facility has to be cleaned and maintained according to the producer’s manual, at least once a year.
* Any other automatic sorting or screening processes need to be installed outside of the sorting cabin.
 | Generally applicable |
| Pre-screening of the coarse, bulky fraction and bulky impurities, magnetic separation and wind sifting | * ????????
 | Optionally applicable in case of physical impurities of more than ca. 5% by weight in the feedstock acctepted |
| **Shredding of bulky / woody green waste - equipment** | * Shredding of woody raw materials may cause dust and bioaerosols to be emitted. Staff who have to work in the surroundings of a shredder will need to wear dust masks fitted with a P3 filter.
* The driver’s cab in materials handling vehicles must be equipped with an air conditioning system fitted with an aeration system that either works independently from the outside air or is fitted a suitable filter (filter class S, activated carbon filter).
 | Generally applicable to composting |
| **Operation requirements: shredding** | * Reduction of dust and bio-aerosols emissions can be achieved by spraying water or fogging onto the shredding process.
* ….
* ….
 | Applicable to outdoor composting |
| **Mixing/blending of organic feedstock for composting** | * In order to prevent uncontrolled fermentation the following feedstock shall be pre-processed and mixed for starting an accurate composting process at least within 24 hours after delivery:
	+ Source separated food waste and biowaste from households;
	+ Fresh grass trimmings;
	+ Catering waste from central kitchens and restaurants;
	+ Unpacked residues from food industries, former food stuff; and
	+ Odorous sewage sludge.
 | Applicable for outdoor composting |

#### Open (outdoor) composting: ACTIVE COMPOSTING phase

Irrespective of the chosen composting system the aim of the intensive composting phase is to ensure the continuous decomposition of the easily degradable organic substances including intermediate metabolites like organic acids etc. The main task is the creation of optimum composting conditions.

**The functions of the active composting phase are:**

* Ensuring the decomposition and transformation of easily degradable organic substances;
* Minimising potential odour emissions;
* Ensuring the needed moister in the rotting mass throughout the composting process
* Minimising the emission of greenhouse gases; and
* Ensuring that the entire material is exposed to the desired sanitising temperature over a defined time span (*hygienisation*)

**The potential emissions are:**

* Odour due to the degradation of organic primary substances 🡪 see Chapter 1.2.5.13.1;
* Liquids (e.g. process, condensate, precipitation water from roofs etc.) 🡪 see Chapter 1.2.5.15;
* Dust and bioaerosols predominantly during mechanical handling of the materials 🡪 see Chapter 1.2.5.13.2;
* Further gaseous emissions (VOC, NH3, N2O, CH4) 🡪 see Chapter 1.2.5.14;
* Noise caused by aeration and turning devices; and
* Material drifting during manipulation.

**XX. In order to improve the environmental performance of OUTDOOR composting, BAT is to use for the ACTIVE COMPOSTING**

#

|  |  |  |
| --- | --- | --- |
| **Techniques** | **Description** | **Applicability** |
| **Requirements for construction and facility infrastructure** |
| **Composting area**  | * The active composting area is designed with sufficient capacity for waste to be treated within the retention time of the treatment process or the relevant treatment step.
* The active composting area is constructed as an impermeable surface with self-contained drainage, to prevent any spillage entering the composting piles
* Run off and leachate (dirty water) is collected in an engineered system, collected in a sump or lagoon and where possible kept separate from clean roof or yard water.
 | Applicable to outdoor composting |
| **Machines and Equipment** | * Machinery suitable for charging, extraction and manipulation of a variety of materials;
* Machinery suitable for turning and material manipulation;
* Devices for temperature measurements;
* Devices for maintaining the optimum water content; this can be done by irrigation systems or by sprayers installed with the turning machine.;
* *Optional*:
	+ Fabric fleece and equipment for covering windrows with fabric fleece
	+ Forced aeration systems with or without coverage with semi-permeable membrane covers can be installed. In case of negative aeration, the waste air must be treated by a biofilter.
 | Applicable to outdoor composting |
| **Water supply** | * For optimised performance, the micro flora, which is active in a composting process, needs a sufficient moisture content from the beginning of the process on. Hence, infrastructure and equipment for adding water must be available throughout the process.
 | Generally applicable to all aerobic treatment |
| **Protection against heavy rainfalls**  | * In areas with a yearly precipitation of > 1.200 mm and triangle windrows of < 1,5 m in height either composting is done under a roof or fabric or semi-permeable fleece must be kept available in order to cover the windrows in the case of heavy rain falls.
 | Applicable to outdoor composting |
| **Leachate and rain water management** | * See 1.2.5.13 Emissions to water
 | Applicable to outdoor composting |
| **Requirements for process management and documentation** |
| **Windrow form and size**  | * The triangular windrow shape has been proven in practice to be the most ideal form of windrow composting. An optimal combination of windrow diameter, material blend, moisture maintenance, and regular turning allows a continuous biological transformation into compost. The ideal windrow dimensions without forced aertion are 3 to 3,5 m base width, by 1,2 to 1,5 m in height. The shape of the triangular windrow should not be bulbous, to keep the material pressure inside the core to a minimum.
* Large (> ca. 1.5 m of height) trapezoidal windrows are used mainly in green waste composting with a high proportion of shredded wood as structure/bulking agent. However because of the formation of zones showing deficits in pore space, moisture and oxygen supply, in this case continuous oxidative decomposition can only be maintained by means of intensified turning and/or forced aeration and thorough watering.
 | Applicable to outdoor composting |
| **Oxygen supply** | * Turning of compost windrows
	+ Appropriately sized turning machines must be permanently available and ensure that mechanical treatment of the windrows is possible whenever it is demanded by the process.
	+ Turning frequency is dependent upon the following parameters:
		- Cross-section / height of windrows
		- Proportion of bulking agents (density) and fresh feedstock with an high nitrogen content
		- Temperature and moisture level
		- Installation of a forced aeration system
* Windrows without forced aeration and with a piling height of > ca. 1.5 m should be turned 2 to 3 times per week during the initial high temperature composting stage (ca. 4 weeks).
* Windrow systems with forced aeration can reduce the turning frequency to one per week
* Smaller compost heaps require at least 1 turning per week, but profit also from several turnings per week at well adjusted moisture content.
* Structural/bulking materials must always be kept in stock in order to improve free poore space and structure stability of individual batches.
 | Applicable to outdoor composting |
| **Moisture, leachate and rain water management** | * Due to high evaporation rates, during the high temperature phase sufficient water supply to the rotting material is of crucial importance. The quantity of water added must be adapted to the water holding capacity of the material.
* Watering should be done in a way such that the formation of process and leachate water is avoided as far as possible.
* The spatial arrangement of the piles and windrows must ensure that leachate water stemming from the initial and non-sanitised composting materials does not run into areas with maturing or finished compost that will not undergo a further thermal sanitisation phase (> 55 °C). In this way cross contamination with pathogens can be avoided.
* ***See also 1.2.5.13 Emissions to water***
 | Applicable to outdoor composting |
| **Temperature control** | * After thermal sanitisation the temperature should be kept below 55 °C at a humidity of approximately 45 - 55 % (w/w) fresh mass.
* In order to reduce the formation of odorous substances and to support humus complexing, maintaining temperatures above 65 °C after hygienisation should be avoided.
 | Applicable to outdoor composting |
| **Record keeping and documentation** | * During the intensive composting stage the following activities and data must be recorded in the operational diary:
	+ Feedstock composition of the individual compost batches;
	+ Batch codes;
	+ Temperature profile;
	+ Moisture assessment (either a visual estimation or by using the squeeze test);
	+ Watering date and type of water used (well water, roof water; leachate water from intensive decomposition and tipping area; leachate water from maturation and compost storage area)
	+ Turning dates;
	+ If applicable aeration regime;
	+ Additional activities:
		- Intermediate screening;
		- Merging of compost batches; and
		- Location of compost batches.
 | Generally applicable to composting |

#### Open (outdoor) composting: MATURATION phase

Maturation is defined as the composting phase following the active decomposition and hygienisation phase, where stabilisation and humification are completed, resulting in a mature readily refined compost product.

The active decomposition phase is completed if the temperature can be sustained below 45 °C. This indicates that the biotransformation of the easily degradable organic compounds in the composting materials has been completed, hence the oxygen demand and the exothermic processes have reduced.

**The functions of the maturation phase are:**

* Decomposition and transformation of more stabile organic substances (cellulose, lignin) under mesophile (20 -45 °C) and psychrophile (< 20 °C) conditions;
* Synthesis of ligno-proteins and phenolic constituents that are precursors in the formation of humic substances. The synthesis of humic substances by polymerisation processes and formation of the clay-humus complex;
* Non-thermal hygienisation (stabilisation) by means of an intensive degradation of the microbial biomass;
* Adjusting compost properties (biological stability, moisture) for post treatment/confection of final compost products.

**The potential emissions are:**

* Odour 🡪 see chapter 1.2.5.13.1
* The potential and level of odour emissions during maturation are influenced by the biological stability achieved so far
* Particle size distribution 🡪 structural stability, free pore space for draining of surplus water and air diffusion
* Water content
* Temperature,
* Mechanical treatment (turning frequency); and
* Forced aeration
* Nitrous oxide (N2O) 🡪 see Chapter 1.2.5.14
* Methane (CH4) 🡪; see Chapter 1.2.5.14
* Liquid emissions
* As a rule process water may not be expected. Since the water holding capacity and extent of evaporation are continuously reduced during maturation, emissions mainly originate from rainfall or irrigation.
* Dust and bio-aerosols 🡪 see Chapter 1.2.5.13.2
* Wind drifting of dust and fine particles may occur when dry materials are turned, from traffic routes or from open dry material surface
* Noise
* by ventilation and turning devices
* Wind drifting of light plastics from the surface of non covered compost heaps

**XX. In order to improve the environmental performance of OUTDOOR composting, BAT is to use for MATURATION**

#

|  |  |  |
| --- | --- | --- |
| **Techniques** | **Description** | **Applicability** |
| **Requirements for construction and facility infrastructure** |
| **Composting area**  | * See 1.2.5.7 – Active composting phase
 | Applicable to outdoor composting |
| **Machines and Equipment** | * Machinery suitable for turning and material manipulation;
* Devices for temperature measurements;
* Devices for maintaining the optimum water content;
* *Optional*:
	+ Fabric fleece and equipment for covering windrows with fabric fleece
	+ Forced aeration systems can be installed. In case of negative aeration, the waste air must be treated by a biofilter.
 | Generally applicable to composting |
| **Windrow form and size**  | * See 1.2.5.7 – Active composting phase
 | Applicable to outdoor composting |
| **Protection against heavy rainfalls**  | * See 1.2.5.7 – Active composting phase
 | Applicable to outdoor composting |
| **Leachate and rain water management** | * See 1.2.5.13 Emissions to water
 | Applicable to outdoor composting |
| **Requirements for process management and documentation** |
| **Water supply** | * During maturation the water demand decreases and the moisture content has to be maintained according to the reduced evaporation and water holding capacity respectively.
* Otherwise see: 1.2.5.7 – Active composting phase
 | Applicable to outdoor composting |
| **Oxygen supply** | * Regular turning depending on windrow diameter and height, temperature evolvement and structure /free pore space)
* Mechanical manipulation creates new active surfaces and induces accelerated microbial activity. This consequently increases oxygen demand, and has to be considered carefully.
* Maintenance of the necessary structure (free pore space) requires to avoid too early screening of still biologically active material.
 | Applicable to outdoor composting |
| **Temperature control** | * After thermal sanitisation the temperature should be kept below 55 °C at a humidity of approximately 45 - 55 % (w/w) fresh mass.
 | Generally applicable to composting |
| **Record keeping and documentation** | * During maturation the following activities and data must be recorded in the operational diary:
	+ Temperature measurements
	+ Determination of the moisture content (squeeze test)
	+ Watering or irrigation and type/origin of water used
	+ Date of turning
	+ If applicable aeration regime
	+ Further measures such is covering windrows with fabric fleece, screening
 | Generally applicable to composting |

#### Post treatment

Post treatment is generally performed after the maturation phase. In case of producing so-called *fresh compost* post treatment and confectioning takes also place after the active composting phase, at least after sanitasation/hygienisation has been completed.

Final sieving using mesh sizes < 15 mm at process stages where the temperature level cannot be kept below 45 °C is not recommended. This may result in the formation of zones with distinct reductive (oxygen defficency) conditions. As a result, odour emissions may occur and denitrification processes can support the creation of ammonium, ammonia and nitrous oxide (N2O).

**The functions of final processing and post treatment are:**

* Production of marketable compost for defined applications and market sectors that require defined maximum particle sizes. Ideally non-decomposed bulking agents (oversize fraction) will also be removed during this screening stage;
* Separation of any remaining extraneous materials (physical contaminants) such as plastics, metals, glass etc.

**The main measures in post treatment are:**

* Mechanical sorting of excess particles (bulking agents);
* Mechanical sorting of impurities;
* Post process shredding;
* Adjusting the moisture content; and
* Packaging.

**The potential emissions are:**

* Odour (specifically if in the final processing is done with non matured, biologically active compost, shortly after the active composting/sanitasation phase) 🡪 see chapter 1.2.5.13.1;
* Dust and bioaerosols 🡪 see Chapter 1.2.5.13.2;
* Noise; and
* Wind drifting of light fractions (e.g. fine compost particles, plastics).

**XX. In order to improve the environmental performance of OUTDOOR composting, BAT is to use for POST TREATMENT**

#

|  |  |  |
| --- | --- | --- |
| **Techniques** | **Description** | **Applicability** |
| **Requirements for construction and facility infrastructure** |
| **Post treatment area**  | * The post-treatment area is constructed as an impermeable surface with self-contained drainage, to prevent any spillage entering the composting piles
* Run off and leachate (dirty water) is collected in an engineered system, collected in a sump or lagoon and where possible kept separate from clean roof or yard water.
 | Generally applicable to aerobic treatment |
| **Machines and Equipment** | * Obligatory facilities
	+ Stationary or mobile screening machine;
	+ Separate storage area for the screened over-size fractions;
	+ When the over-size fraction of source separated biowaste from households with high plastic contamination is recycled into the composting process: a wind separator is required to remove the light fraction;
* Optional/supplementary facilities
	+ Magnetic separator (can be used for the fine as well the over-size fraction);
	+ Ballistic/density separator;
	+ Loading and packaging facility; and
	+ Blending facility for the production of substrates and growing media.
 | Generally applicable to composting |
| **Requirements for process management and documentation** |
| **Ensuring quality compost production** | * Irrespective of the final application of the compost physical contaminants must be sorted out and the maximum particle size (mesh size of the screener) chosen accordingly.
* Adjustments need to be made to the water content
	+ The water content must be adapted in accordance with particle size and water holding capacity and the further storage marketing (bulk/big bags, plastic packaging).
	+ Only fresh / well water or separately stored runoff water from the curing area or from roofs may be used for watering
 | Generally applicable to composting |
| **Disposal of separated contaminants and regular storage** | * Separated contaminants must be stored in clearly designated containers; disposal must be well-documented in the operational records;
* Secondary contamination of refined compost must be avoided; specifically re-contamination with un-sanitised raw feedstock by using a loader which has not been cleaned properly or through process water from the waste water tank of the active decomposition phase.
 | Generally applicable to composting |
| **Low emission operation and worker protection** | * Odour
	+ As indicated above odour emissions may be only expected if final processing is carried out on compost that has not been sufficiently matured.
	+ Where this is the case the precautions described in Chapter 1.2.5.13.1 must be observed
* Dust and bioaerosols
	+ The higher proportion of fine particles and a low water content in fresh and matured compost may induce an increased dust formation and consequently potential emissions of bioaerosols. Thus it is important that the material at the time of screening has an optimum moisture content;
	+ The screening of immature, dry stabilised material has to be avoided
* Wind drifting of light fractions (e.g. fine compost particles, plastics)
	+ In exposed situations with frequent strong winds, barriers shall be established (earth walls, hedges, fences etc.)
	+ Screening and turning of dry composts should be avoided in case of strong winds.
 | Generally applicable to composting |
| **Leachate and rain water management** | * See 1.2.5.13 Emissions to water
 | Generally applicable |

#### Compost storage

During this final stage of the entire compost production process the compost should have reached a grade of biological stability (maturity) which suites the intended use. The majority of the nitrogen is bound to humic substances (> 90 %).

However, humification (mineralisation) and clay-humus complexion proceed at a low but steady activity level, especially if adequate moisture and oxygen levels are maintained.

This makes it necessary, even during the final storage of screened compost, to provide aerobic conditions. If the screened material (usally at a mesh size of 10 to 25 mm) is stocked in piles of > 1.5 in height, it compacts easily resulting in a reductive, anaerobic zones forming.

The consequences are (depnding on the achieved grade of biological stability):

* Denitrification; and
* Formation of ammonia, nitrous oxide (N2O), sulphides.

In addition exposing the compost to any excess of water (heavy rainfalls) must be avoided to prevent anaerobic conditions forming and plant nutrients from leaching and being drained off.

**The functions of compost storage are:**

* Maintaining a final product that is appropriate for the intended uses and market sectors without causing any odour emissions or fall into reductive, anaerobic conditions;
* Keeping an appropriate moisture content until the compost is used or marketed;
* Providing compost that has fairly completed the decomposition and biological stabilisation process; and
* Storage of ready-made compost in order to bridge market fluctuations.

**The main measures in compost storage are:**

* Protection against rainfall;
* Protection against drying out;
* Protection against contamination (wind drifted seeds, re-infection with not sanitised materials adhering to loaders etc.);
* Optional: Mechanical agitation (turning) or aeration;
* Depending upon the marketing concept, loading onto lorries or packing into sacks of different sizes; and
* Producing blends with mineral additives or natural fibres.

**The potential emissions are:**

* Surface water from rainfall which might be contaminated with compost particles. If stored under roof or covered with geo-textile no leachate water is produced;
* Dust – wind drifting of fine compost particles

**XX. In order to improve the environmental performance of OUTDOOR composting, BAT is to use for COMPOST STORAGE**

#

|  |  |  |
| --- | --- | --- |
| **Techniques** | **Description** | **Applicability** |
| **Requirements for construction and facility infrastructure** |
| **Storage area** | * Storage capacity for at least a quarter of the mean yearly compost production (external storage sites may be accommodated within this)
* Machinery suitable for turning and material manipulation;
* Devices for maintaining the optimum water content;
* Surface and site characteristics if not stored on paved area with :
	+ If not under roof or otherwise covered, the surface should be on a slight slope (ca. 3 - 5%)
	+ If stored on open ground without controlled surface water drainage and collection:
		- Minimum distance from surface waters: > 75 m
		- Minimum distance from a spring or well: > 100 m
		- Storage on open ground is not allowed on sites where there is the potential for landslides or floods;
 | Generally applicable to composting |
| **Requirements for process management and documentation** |
| **Duration of compost storage and turning** | * Depending on the intended compost use, maturation/stability, marketing in relation to the material throughput, storage of compost may last up to several months
* Compost, even when sieved and matured to a certain stability level is still a biologically active organic material. Regular mechanical manipulation/turning is necessary in order to provide the oxygen demand for the residual microbial activity. Sieved, fine compost may only be stocked in windrows or heaps > 1.5 m of height without regular turning if sufficient stability/maturity has been achieved, i.e. compost temperature is < 30 °C or otherwise at ambient temperature level. Otherwise turning should be provided every 2 to 4 weeks.
 |  |
| **Further requirements** | * Secondary re-contamination with pathogens should be avoided caused (i) by using machines contaminated with material which had not undergone thermal sanitisation or (ii) by using process water stemming from the tipping area or the active decomposition phase
* Unequivocal designation of the individual compost batches and a traceable allocation of the compost batches to declaration sheets, the quality approval (compost assessment), compost certification and labelling.
 |  |

#### Resource efficiency

Create a list of process steps where measures in terms of efficient resource use/consumption can be applied / required:

* Waste/material related resource management
* Separation techniques of impurities from oversize fraction after screening in order to recycle a high proportion of screened bulky wood/structure material into the composting process
* …………………… …

**Delete?**

#### Monitoring

**XX. In order to ensure stable process operation and optimisation and to minimise operational difficulties, BAT is to have a suitable monitoring system, both manual and instrumental. Parameters monitored may include, but are not limited to, the following:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Unit** | **Measurement frequency** | **Critical limits** |
| Temperature and temperature distribution | °C | Continuous or periodic monitoring. Frequency as specified in operators’ management system.  | As specified in operators’ management system / required by license. |
|  |  |  |  |
| CO2 / O2 | % | Continuous or periodic monitoring. Frequency as specified in operators’ management system.  | As specified in operators’ management system.  |
|  |  |  |  |

#### Emissions to air

Relevant potential emissions to air include:

* Odour
* Dust
* Bioaerosols (associated with dust)
* CH4, N2O, NH3

In open/outdoor composting all of those are diffuse emissions inherently providing no to little options for direct regular monitoring of channelled emission components. ~~Or the ability to mitigate their release.~~

Therefore, besides quality and operational process management aiming at the minimisation of emissions to air, specifically in the case of odour, dust and bioaerosols the selection of a suitable location for and outdoor composting plant is of utmost important.

In this respect, it is not only the potential level of diffusely emitted compound, but the potential to cause not tolerable impacts on the health or the also the subjective wellbeing of potentially affected neighbourhood.

The general approach towards managing diffuse emissions to air from open processing (outdoor composting including pre- and post treatment steps) are summarised in the following chart. As an important element, the licensing procedure should include a diffusion modelling specifically for odour and dust/bioaerosols taking into account

* the local climate and topographic conditions
* existence and location of potential sensitive receptors (permanent residents, permanent working places, public institutions, hospitals, schools, kindergartens, recreation areas, cure sites etc.).
* typical and worst case events of emission under routine plant management conditions

Based on the assessment results using standard methodologies approved by the competent authority, the licensing authority approves the suitability of the foreseen location of the composting site and key management/operation requirements aiming ad minimisation of the risk of unacceptable impacts stemming from emission events are included in the quality management manual as part of the permit.



Figure 3: Integrated approach to manage diffuse emissions of odour, dust and bioaerosols in outdoor composting by means of modelled assessment as part of the licensing and operation management tools.

##### Odour

Key criteria for controlling the formation and release (emission) of odorous substances are:

* Mixture of the initial feedstock blend;
* Temperature profile;
* Moisture content; and
* Free pore space for oxygen (fresh air) supply.
* C:N ratios

One of the most important measures aimed at effectively reducing odour emissions is the *homogeneous mixing of different raw materials* which helps establish adequate free pore space, continuous air exchange and, if optimised moisture level is provided, decomposition of the primary and easily degradable organic substances. The correct mixing of bulking agents therefore has to be managed carefully, and considered to be the most important pre-processing measure.

The *temperature regime* is another key factor influencing odours. High temperatures > 65/70 °C diminish the microbial diversity and thus slow down the decomposition process. Intermediate metabolite substances with high odour intensity are more likely to be generated. Intensified aeration or mechanical agitation, changing the heap diameter and watering can counter steer the effects of overheating. Thus periods with temperatures above 65 °C need to be kept as short as possible.

Optimised *water content at any stage of decomposition* is a pre-condition for proper odour management. Process water and condensates may constitute a significant source of odours. An excess of water may cause anaerobic conditions especially in the bottom of windrows. Therefore besides operating an effective watering system, sites also need to ensure continuous drainage of both process and surface waters. In *closed reactor systems* regular measurements of the water content together with water balances allow for optimised water management, thereby minimising odour potential.

Use of the ‘squeeze’ test as a mechanism to evaluate the correct moisture % is useful in ensuring that the process moistures are correct and assists in an optimised process.

Furthermore, the sufficient *supply of oxygen* to the microbial community must be guaranteed at all stages of composting. These are described in Table 7.

Table 1: Measures to prevent oxygen deficiency during composting (Bidlingmaier & Müsken, 1997[[1]](#footnote-2))

|  |  |
| --- | --- |
| **Measures against water surplus**  | Reducing the water input:* Choose dry feedstock with a high water retention capacity
* Add dry additives (chopped/shredded wood, bark, sawdust, dry compost etc.)
* Optional in case of heavy rainfalls: Cover open windrows with a geo-textile (drains off 80 to 90 % of rain water), a layer of shredded wood, mature compost or straw

Increase water release:* Intensify forced aeration
* Ensure initial ‘mix’ of materials is balanced
* Increase turning frequency without risking cooling down the process too rapidly
* Uncover the windrows on days with high evaporation potential
* Expose windrows to main wind direction
 |
| **Measures toimprove structure** | * Mix additional bulking agents (shredded bush cuttings)
* Increase bulking agents especially in the bottom of the heap. Create a basic layer with structure forming shredded wood
* Use some oversize as routine to ‘open’ the feedstock texture
 |
| **Composting technology** | * Set up loose, well structured windrows for the initial intensive degradation phase
* The maximum height of a pile/windrow depends on

decomposition age (the more mature, the higher the piles can be)structural stability of the whole mixture forced aeration system (alternating positive [blowing] and/or negative [sucking])* Through mechanical agitation (turning) new accessible surfaces are created and air exchange rates are increased.
 |

In *open windrow systems without forced aeration* operators need to ensure that there is sufficient and continuous air exchange reaching down to the central zone of the windrow. Those systems need to carefully balance windrow diameter, material composition (free air space, water content, and structural stability) and turning frequency.

In areas or seasons with *high precipitation*, reduced water evaporation can lead to water logging if windrows are not covered with hydrophobic geo-textiles or placed under roofing.

Natural aeration in open windrow systems is based on the *principle of convection* and do not require the waste air to be treated as long as the process is managed properly. However, during the preliminary decomposition stages, mechanical agitation can cause odour emissions if the described parameters are not observed carefully. Therefore in open windrow systems the site specific conditions have to be considered carefully together with the feedstock properties and daily process management operations.

Specific operational measures to reduce odour emissions from open windrow composting systems are:

* The immediate and efficient processing of delivered waste material with high potential of formation of odorous substances (e.g. food waste, fresh grass prunings);
* Using highly structured raw material (maintaining sufficient storage /supply of bulking agents);
* Managing the decomposition process, e.g.
* Regular turning to avoid anaerobic zones forming in windrows;
* Limiting the size of the windrows depending on structure-stability; and
* Keeping the facility clean (regular cleaning of surfaces, equipment and all traffic routes etc.); and
* Turning the windrows only when there is an advantageous wind direction relative to the possible affected neighbourhood.
* Ensuring that surface leachate is not encouraged and where there are leachate lagoons being used, these should be aerated to prevent H2S build up which in turn will produce unpleasant odours

An important factor in open windrow composting is the *annual extent and seasonal distribution of precipitation*.

On sites with high annual precipitation, covering windrows (e.g. with a fleece/geo-textile) must be considered if no roofing is available. The risk of exceeding the water capacity of the composting material is greatest with smaller windrows, especially during late decomposition/maturation stages (where at temperatures < 40/45 °C the evaporation rate is diminished). In that particular respect, and if not covered with geo-textile or under roof, due to their favourable surface area/volume ratio larger windrows (ca. > 1.20 m high) and table windrows are less vulnerable to water logging through precipitation.

Windrows with an inherently high water content run a greater risk of forming anaerobic zones (due to the pores filling with water, rather than allowing gasses to migrate) and of causing odour nuisance. Moreover wet materials handicap the final value-added stages of the composting process (sieving, segregation of impurities).

The use of covers for windrows is both costly and time consuming to work with as it has to be removed on every occasion when it requires turning.

The dimensions of windrows is a very important mechanism for ensuring that the compost piles retain their heat and moisture as required to optimise the process. In the summer when the ambient temperature is higher then narrowhigher windwos are favoured as they assist in promoting the ‘chimney’ effect and assisting with the convection process. Converesely in the winter when you are seeking to achieve active temperatures within the stack wider lower piles assist in optimising temperatures and convection.

In addition to the above, the following optional measures to prevent and manage odours can be considered:

* Adding clay soil or (dry) mature compost to the input material (up to ca 10/15 % (m/m)) thereby creating a sorption matrix for leachate water charged with odour active substances to bind to;
* Covering the stacks with shredded wood or mature compost is more effective than geotextiles as it costs nothing and can be turned without any manual intervention.
* Ensuring that the temperature of the composting material does not exceed 65 °C and should stabilise as soon as possible at about 50 to 55 °C even during the active decomposition phase;
* Covering smaller windrows (< 1,2 to 1.5 m high) with a water repellent fleece (geo-textile); or
* Maintaining a sufficient oxygen concentration in the free poore space of the composing mass ~~material~~.

**Monitoring … to be discussed!!!**

NOTE: Also the sum of CO2 and O2 concentration being repeatedly detected above 20,8 % (by volume) indicates that anaerobic conditions may be relevant.

 Experience shows that the O2 concentration in the composting mass should not fall below 5 % (by volume). Normal values during the initial rotting stages may be found between 7 and 12 % (by volume) O2, CO2 and CH4 concentrations should not exceed 10-12 % (by volume) and 1 % (by volume), respectively.

1. **In order to reduce emissions to air of odorous substances from the unloading, storage and handling of biodegradable waste, BAT is to use the techniques given below, in addition to BAT 16 and 17.**

[BAT 65]

**……… to be checked what of the above listed measures are suited for the BAT-C table here!**

|  |  |  |
| --- | --- | --- |
| **Technique** | **Description** | **Applicability** |
|  |  |  |  |
|  |  |  |  |
| 1.
 |  |  |  |
|  |  |  |  |
|  | [Other] |  |  |

##### Dust and Bioaerosols

Assessing the risks to human health from exposure to bioaerosols is inherently problematic, due to the lack of dose-response relationships (Böhm *et al*., 1998[[2]](#footnote-3)). As such, “acceptable” maximum exposure levels or occupational exposure standards cannot be established. Therefore composting facility operators need to establish measures (both technical and operational) to minimise bioaerosol and dust formation.

Effective measures are:

* An appropriate distance between a new plant and residential areas (sensitive receptors) should be established. Investigations have shown that in distances of 150 to 200 meters – depending on topography and dominant wind direction – natural background concentrations are attained (Amlinger et al. 2005[[3]](#footnote-4));
* It is recognised that at these distances, bioaerosol levels revert to ‘background’ levels which are deemed to be acceptable
* In in-vessel systems (box/tunnel) extremely high bio-aerosol concentrations occur – biofilters reduce these levels but discharge them continuously to the atmosphere. Moistening the exhaust gas with spray or sprinkler systems can reduce the aerosol load significantly;
* All materials handling areas and traffic routes need to be kept clean and moist (although water should not be allowed to build up and stagnate, as this will create an odour source);
* The following sub-optimal decomposition conditions in enclosed systems may lead to increased bio-aerosols emissions (e.g. Aspergillus fumigatus, mould spores) upon extraction of the pre-rotted material to an open maturation area.
* heterogeneous distribution of humidity, degradation and temperature,
* dry stabilisation, or pseudo-stabilisation by drying the material by means of intensive aeration; or
* a retention time of less than 14 to 21 days without any turning of the material.
* Turning and materials handling should only be carried out on moist windrows in open windrow systems;
* In order to reduce the formation of bioaerosols, a number of essential measures can be implemented:
* Primary mechanism to reduce emission is to reduce the frequency of turning!
* Moistening of the windrows before and during every turning. Fog sprays can be effective during manipulation, and some windrow turners allow spray systems to be incorporated.
* Maintaining appropriate levels of moisture in all composting materials and biofilters:
* In case of critical locations (distance to sensitive receptor is less than 200 m):
* Materials handling needs to take into account daily climatic conditions;
* Turning machines should be equipped with rubber aprons to reduce the emission of dusts;
* Covering small triangle windrows (< 1,2 to 1,5 m height) with fabric fleece/geo-textile in order to avoid desiccation; this reduces dusts and bioaerosols when the material is moved.
* All on-site regulations concerning the health and safety of employees need to be adhered to.
* Annual screening of workers to ascertain their health in respect to repiratory function is also seen as good practice and routinely carried out by operators in the UK
1. **In order to reduce diffuse dust and bioaerosols emissions from outdoor composting, BAT is to use the techniques given below, in addition to BAT 16 and 17.**

[BAT 65]

**……… to be checked what of the above listed measures are suited for the BAT-C table here!**

|  |  |  |
| --- | --- | --- |
| **Technique** | **Description** | **Applicability** |
|  |  |  |  |
|  |  |  |  |
|  | Exhaust air treatment by biofilter | An exhaust air from negative aeration is led through a biofilter Reference to closed composting or MBT !!! | Applicable only in case of negative forced aeration  |
|  |  |  |  |
|  | [Other] |  |  |

##### Ammoniak (NH3), Methane (CH4), Nitrous Oxide (N2O)

During outdoor composting the following framework conditions may influence the order of diffuse GHG emissions and ammonia:

* Bulking agents providing free pore space and a homogenous material blending;
* C/N-ratio;
* Turning frequency as well as aeration procedure;
* Water management, humidity control and distribution; and
* Temperature control and distribution within the composting mass.

In open/outdoor composting all of those are diffuse emissions inherently providing no to little options for direct regular monitoring of channelled emission components. Mitigation?

Quality and operational process management aiming at the minimisation of emissions to air, the selection of a suitable location for and outdoor composting plant is of utmost importance.

The quantity of GHGs emitted (*emission factor*) varies significantly; the following have been provided for guidance:

* CO2: 120 to 250 kg t-1 of feedstock composted. It is not considered as GHG since it is produced from natural organic residues equivalent to the natural short term C-cycle;
* CH4: 100 (good performance) to 250/400 (realistic) to > 800 to 2.000 (low performance) g t-1 of feedstock. The extraction of methane in the biofilter is, in average only 5 % to 15 %.[[4]](#footnote-5)
* N2O: The range of N2O emission factor very much depends on the C/N ratio, as a low C/N ratio (i.e. a mix with a surplus of N), will emit more than a high C/N mix where nitrogen is limiting. The formation tends to occur during mesophile composting and the maturation stages at temperatures below ~40 °C. Emission factors range between 20 and 180 g t-1, however, under poorly managed conditions, formation may be greater. Additional N2O may be formed during transformation of ammonia in the biofilter, where it cannot be decomposed further.[[5]](#footnote-6)
* NH3 emissions are typically in the range of between 500 and 600 g t-1. It occurs mainly during the intensive decomposition phase and rather parallel to methane at temperatures > 40 to 50 °C.[[6]](#footnote-7)

The percent contributions of composting to total GHG production are finally very low (0.01% to a worst-case estimate of 0.06% as calculated for Austria and Germany; Amlinger *et al.,* 2008).

Feedstock management related measures to reduce emissions of methane (CH4), nitrous oxide (N2O) and ammonia (NH3):

* C/N-Ratio: Within a narrow C/N-ratio, the NH3 emissions increase as the composting temperature and ventilation rates increase. A C/N-ratio of > 25 minimises NH3 and N2O emissions, however, as the ratio increases (to above 35) the rate of composting will slow down, as N will be rate-limiting;
* N-rich materials, (sewage sludge, fermentation residues, specific industrial wastes, poultry manure, household organic wastes [especially when kitchen waste and grass clippings are > 30 to 40 %]) must be blended homogenously with a sufficient amount of carbon-rich materials, to balance the C/N ratio;
* Water content: Ideally the moisture content should not be above 65-70% (m/m) at the start of the composting process, and should be maintained to between 50 to 60% (m/m) during the further process phases.
* Bulking/structural materials (These are required to maintain an adequate pore structure to allow air circulation): The ratio of structure-forming materials (shredded bush and tree cuttings, screen overflow, etc.) should – in dependence of C/N ration and structural properties of the individual constituents – be approximately 40 to 60 % (v/v).
* Mature compost – In order to facilitate the efficient formation of humic substances (humification) and the incorporation of volatile carbon- and nitrogen compounds into more complex compounds: the addition of approximately 10 to 15% (v/v) mature compost is beneficial.

Specific measures to optimise the composting process and reduce the formation of diffuse GHGs are summarised in the tables below.

Table 1: Specific measures to minimise gaseous emissions in open windrows without forced aeration

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure** | **CH4** | **NH3 \*** | **N2O** |
| **Increase fraction of structural materials, and / or more frequent turning** | **positive**, better O2-supply suppresses CH4-formation | **Slight increase in emissions** on account of increased aeration, causes: - increase of pH-value - more evaporation | **potentially negative**, increased O2-supply in combination with falling temperatures supports N2O-formation as an intermediate product of nitrification and denitrification |
| **Moisture optimisation through controlled water injection, use of protective covers for protection against precipitation.** | **positive**, prevention of wetting and the formation of anaerobic zones | Wetting causes **reductive conditions** (de-nitrification) with accumulation of NH4+Drying causes an increase in emissions of NH3 | Wetting may also cause O2-deficiency during the latter stages of the composting process, resulting in **de-nitrification** of NO2- and NO3-. This may lead to the formation of N2O |

\* In early stages emitted NH3 is not available for possible formation of N2O at a later stage

1. **In order to reduce diffuse CH4, N2O and NH3 emissions from outdoor composting, BAT is to use the techniques given below:**

[BAT 68, 69, 70]

**……… to be checked what of the above listed measures are suited for the BAT-C table here!**

|  |  |  |
| --- | --- | --- |
| **Techniques** | **Description** | **Applicability** |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  | [Other] |  |  |

#### Emissions to water

Waste water at a outdoor composting facility originates from the following process stages:

* Press water from fresh feedstock shortly after delivery;
* Process water (resulting from the metabolic activity inside the composting pile);
* Condensate on equipment and in pipes; only in closed or covered systems!!
* Waste water from cleaning activities;
* Precipitation water in open areas (run-off water from compost piles surface as well as from traffic routes); and
* Precipitation water from roofs.

Generally, leachate and run-off water may not be allowed to drain off into the soil without prior treatment, as it has the potential to pollute ground and surface waters.

~~This is routinely collected from maturation pads in open air lagoons. These are a potential source of odour and their might needs to be considered. Likewise the use of this waste water for irrigation can be useful but needs to be carefully applied to reduce any odour emissions through atomising the leachate when it is applied.~~

#### Construction elements of a wastewater drainage system

Two main elements have to be considered when constructing paved open windrow composting plants:

* The pad needs to be constructed out of a sealed pavement (hard standing) and capture waste water (leachate and run-off) in order to prevent any uncontrolled release of waste water to ground or surface water; and
* There also needs to be an adequate gradient on the concrete pad to ensure containment is effective normally a fall of ca. 2% is sufficient for this purpose.
* The appropriate dimensioning of the intermediate waste water tank taking into account the site size and rainfall in order to hold leachate (water that has percolated through the feedstock) and run-off from precipitation from all paved areas where compost or raw material is stored or treated.

In addition, a waste water management plan must ensure adequate treatment and reuse of the waste water.

The sealed area must cover the following sectors of the composting plant:

* The tipping and intermediate feedstock storage area for all input materials with the exception of woody materials (tree and bush cut-tings), straw, or similar biologically non active, carbon rich, dry feedstock;
* The storage area for non woody materials (food and kitchen waste, sludge, food processing waste, all materials with high water content and a high fermentability potential)
* The pre-processing area where feedstock are mixed, with the exception of the area where woody materials (tree and bush cuttings) only are shredded;
* The active decomposition area, irrespective of whether it is roofed or not
* The maturation area, irrespective of whether it is roofed or not; and
* The storage area for matured compost with the possible exception to be approved by the competent authority and taking into account at least:
	+ local precipitation
	+ ground and surface water protection
	+ coverage by water repellent fleece or roof

All storage and treatment areas must allow for the controlled drainage of all liquids to avoid water-logging at the windrow or feedstock base. This is achieved by constructing the composting pad on a slope to avoid water stagnating. The minimum slope of the site is determined by the windrow height, annual precipitation, existence of roofing, the method of aeration and the presence of drain/aeration tubes. Minimum slopes are summarised in Table 1.

Table 1: Minimum slope requirements (in %) for composting areas depending upon the annual rate of precipitation, windrow height, roofing, aeration method and discharge channels.

|  |  |
| --- | --- |
|  | **Minimum slope for windrow- systems [in %]** |
| **Windrow dimensions** | **open** | **roofing** | **submerged discharge channels**  |
| **Annual precipitation** |
| **< 800 mm** | **> 800 mm** |
| Composting site without aeration pipes | 2% | 3% | 2% | --- |
| Composting site with submerged discharge channels | 2% | 0,5 to 1% |
| Tipping and intermediate feedstock storage areas | 3% | 2% |  |

##### How to calculate the dimension of a waste water tank or basin

The amount of leachate water of the area covered with compost piles is estimated using the ration of 0.028 m³ leachate holding capacity / m² of hard standing. In addition two further precipitation data have to be taken into account:

* The two days ‘storm’ precipitation estimated on the basis of a one in five year event has to be accommodated within the volume of the waste water tank or basin; and
* The average annual rainfall in the area.

The calculation resulting in the largest tank size has to be considered for the planning of the compost site.

The calculations based on a number of different annual rainfall data are illustrated in Table 2.

Table 2: Minimum storage volumes for leachate and precipitation water from the sealed areas of a composting plant

|  |  |
| --- | --- |
| **Annual precipitation** **[mm]** | **Volume of tank or retention basin *[m³/m² sealed area]*** |
| **Precipitation** | **Leachate** | **Total** | **+ 20 % safety factor** |
| **< 700** | 0,03 | 0,028 | 0,058 | 0,070 |
| **up to 900** | 0,05 | 0,028 | 0,078 | 0,094 |
| **up to 1100** | 0,08 | 0,028 | 0,108 | 0,130 |
| **up to 1400** | 0,12 | 0,028 | 0,148 | 0,178 |
| **> 1400** | 0,17 | 0,028 | 0,198 | 0,238 |

For example, a location that receives an annual rainfall of 900 mm and has an unroofed composting pad of 4000 m² would need approximately 400 m³ storage volume for waste water.

Another approach taken is to estimate the minimum storage capacities following a one in five year 48 hour rainfall event. Examples are summarised in Table 3.

Table 3: Minimum storage volumes calculated on the basis of a one in 50 years 48 hour rainfall event. Volumes are shown in m3.

|  |  |  |
| --- | --- | --- |
| **2 days rainfall event within 5 years** | **Run-off factor** | **Sealed area in [m²]** |
| **500 m²** | **1000 m²** | **2000 m²** | **4000 m²** | **8000 m²** |
| **l/m²** | **m³/m²** | **ψm(0,75)1)** | **Storage capacity in m³:** |
| 50 | 0,048 | 0,75 | 19 | 38 | 75 | 150 | 300 |
| 70 | 0,061 | 0,75 | 26 | 53 | 105 | 210 | 420 |
| 90 | 0,072 | 0,75 | 34 | 68 | 135 | 270 | 540 |
| 110 | 0,083 | 0,75 | 41 | 83 | 165 | 330 | 660 |
| 130 | 0,095 | 0,75 | 49 | 98 | 195 | 390 | 780 |

1) Run-off factor for open asphalt or bitumen areas are usually 0,9 due to evaporation and adherence of water on the surface. A factor of 0.75 takes into account that 30% of the rotting area is covered with compost heaps and other organic material which absorbs further 15% of the entire precipitation volume.

#### Waste water treatment and discharge

Waste water needs to be collected and treated according to the requirements of water protection principles i.e. to prevent pollution of ground and surface wasters due to its high biological oxygen demand, the nutrient content (above all phosphorus and nitrogen) and potential pathogenic microorganisms.

It must be distinguished between qualitative criteria for

* Direct discharge into rivers
* Direct discharge onto land
* Indirect discharge in internal or extern waste water treatment plants

Figure 1 illustrates an overview of possible treatment and uses of waste water from composting plants.



Figure 4: Options for waste water collection, treatment and use from feedstock storage, active decomposition and maturation area respectively

#### Operational measures for waste water prevention and management

Quality management measures with respect to quantitative reduction and manage waste waters are:

* Covering open windrows with geo-textiles or composting under a roofed structure 🡪 this reduces the formation and the organic contamination of waste water caused by heavy rainfalls and helps improve run-off management;
* Mixing feedstock with additives that provide a good structure and water holding capacity (e.g. shredded wood, bark, straw, oversize screenings, sawdust, leaves at a percentage of, loamy soils and mature compost;
* Composting on an organic, structure-rich foundation (e.g. shredded wood, bark, straw, oversize screenings, sawdust);
* Turning windrows to increase the rate of evaporation of water; and
* Adjusting the initial moisture content of the feedstock best adapted to the water holding capacity
* Adapting watering and irrigation of composting piles to the continuously decreasing total water holding capacity of from initial intensive composting down to maturation phase.
1. **In order to reduce water consumption and prevent emissions to water of outdoor composting plants, BAT is to use the techniques given below, in addition to BAT 18.**

[BAT 69]

**……… to be checked what of the above listed measures are suited for the BAT-C table here!**

|  |  |  |
| --- | --- | --- |
| **Techniques** | **Description** | **Applicability** |
|  | Water management integration | ~~A close integration between the process and the water management by mean of the advanced computerised process control system allow to keep full control of the water consumption~~ | Applicable only in indoor/encapsulated composting systems |
|  | Waste water reuse | The waste water and leachate is recycled as water input to the maximum extent allowed by the process (e.g. high concentrations of some toxic compounds may cause negative effects). | Generally applicable |
|  | recycling process waters  | recycling process waters or muddy residues within the aerobic treatment process to completely avoid water emissions. | Generally applicable |
|  | [other] | t.b. continued |  |

**BAT-associated environmental performance levels**

Specific BAT-associated water consumption levels from aerobic treatment are presented in Table 1.13.

In open composting not relevant!

~~Table 1.13: BAT-associated water consumption levels from aerobic treatment~~

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **~~Waste stream~~** | **~~Parameter~~** | **~~Unit~~** | **~~Monitoring frequency~~** | **~~BAT-AEPL~~** |
| **~~New plant~~**  | **~~Existing plant~~** |
| **~~daily average~~** |
| ~~Sewage sludge~~  | ~~Fresh water consumption~~ | ~~m~~~~3~~~~/t~~ | ~~Continuous measurement~~ |  |  |
| ~~Biological waste from separated collection~~ |  |  |
| ~~mechanically pre‑treated MSW~~ |  |  |
| ~~[Other]~~ |  |  |

1. **In order to prevent or reduce emissions to water from outdoor composting plants, BAT is to use the techniques given below, in addition to BAT 18 and 19.**

[BAT 71]

|  |  |  |
| --- | --- | --- |
| **Techniques** | **Description** | **Applicability** |
|  | [tertiary techniques that remove nitrogen compounds] |  |  |

**BAT-associated emission levels**

The BAT-associated emission levels for emissions to water are presented in Table 1.15.

Here national indirect and direct discharge limit values apply … do we need AEL on EU level? Lets see result from our and JRC questionnaire

Table 1.14: BAT-associated emission levels for emissions to water from aerobic treatment

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Waste stream** | **Pollutant** | **Unit** | **Monitoring frequency** | **BAT-AEL****Monthly average** |
| [Sewage sludge, biological waste from separated collection, | P | mg/l | Continuous measurement |  |
| N (1) |  |
| NH3 |  |
| Nitrate |  |
| Nitrite |  |
| Cl |  |
| [Other] |  |
| (1) Total Nitrogen |

#### Energy efficiency

Energy Consumption might not be a relevant performance indicator. As a principle, better performance and product quality would consume also more energy!

1. **In order to use energy efficiently in outdoor composting, BAT is to use the techniques given below.**

[BAT 69]

|  |  |  |
| --- | --- | --- |
| **Techniques** | **Description** | **Applicability** |
|  | Renewable fuel  | Use plant oil for machines or other renewable fuel sources | Generally applicable |
|  | Adjusting aeration system | Select energy efficient fens and reduce air flow rates to the minimum needed in case of forced aeration systems  | Applicable only if forced aeration system is installed. |
|  | [Other]minimise turning frequency of windrows | Reduce turning and allow compost to work more naturally | Applied in systems where inoculants such as BAT 506 is used |

#### Noise and vibrations

???????? 🡺 should be included further up the hierarchy means in the common techniques for biological treatment?

### BAT conclusions specific to indoor composting of source-separated biowaste and sewage sludge

See separate document

#### Principal techniques and construction elements applied in indoor composting

#### Monitoring

#### Input pre-treatment and output finalisation

#### Emissions to air

#### Emissions to water and water consumption

#### Energy efficiency

### BAT conclusions for anaerobic treatment of source-separated bio-waste and mechanically-separated bio-waste

*(Anaerobic digestion of source-separated bio-waste; sludge and specific bio-waste types may be covered on the basis of the evidence shown in the data collection, with specific and/or common conclusions under this chapter.)*

#### Monitoring

#### Input pre-treatment and output finalisation

#### Emissions to air

#### Emissions to water and water consumption

#### Energy efficiency

### BAT conclusions for mechanical‑biological treatment (MBT) of mixed solid waste containing bio‑waste and source-separated bio-waste

*(Mechanical-biological treatment of mixed solid waste containing bio-waste (typically mixed municipal waste) and source-separated bio-waste – different sections or common sections will be adopted for different waste streams depending on evidence shown by the data collection. This section also covers the preparation/pre-treatment of mixed solid waste to be:*

* *used in other IED installations (as a raw material, as a fuel in (co-)incineration),*
* *landfilled,*
* *used in backfilling.*)

*Cross-references to the mechanical treatment section are made whenever useful, for example for sorting.*

*Cross-references to the aerobic treatment section are made whenever useful.)*

#### Monitoring

#### Input pre-treatment and output finalisation

#### Emissions to air

#### Emissions to water and water consumption

#### Energy efficiency

####  Noise and vibrations

1. Bidlingmaier, W., Müsken, J., 1997. Biotechnologische Verfahren zur Behandlung fester Abfallstoffe; in: Ottow, J. C. G., Bidlingmaier, W. (hrsg.), Umweltbiotechnologie, Gustav Fischer Verlag, Stuttgart [↑](#footnote-ref-2)
2. Böhm, R., Martens, W., Bittighofer, M. 1998. Aktuelle Bewertung der Luftkeimbelastung in Abfallbehandlungsanla-gen, Wissenschaftliche Expertise angefertigt für die SULO-Stiftung, Herford [↑](#footnote-ref-3)
3. Amlinger F., Hildebrandt U., Müsken J., Cuhls C., Peyr S., Clemens, J., 2005b. Stand der Technik der Kompostierung - Grundlagenstudie. Edt: BMLFUW, Wien. <http://www.lebensministerium.at/umwelt/abfall-ressourcen/behandlung-verwertung/behandlung-biotechnisch/richtlinie_sdt.html> [↑](#footnote-ref-4)
4. For example, the potential contribution of methane emissions by composting (if the entire organic waste material is composted) to the Austrian national methane inventory is only 0.1 %. [↑](#footnote-ref-5)
5. In Austria, the proportion of N2O emissions from composting operations relative to the national inventory can be estimated to be between < 1 to 3 %. [↑](#footnote-ref-6)
6. In Austria, the proportion of NH3 emissions from composting relative to the national inventory can be estimated to be between < 0.5 to 1 %. [↑](#footnote-ref-7)