Phytosanitary procedures
Procédures phytosanitaires

Guidelines for the management of plant health risks of biowaste of plant origin

Specific scope

This standard describes requirements for the treatment of biowaste of plant origin to ensure its phytosanitary safety.

Specific approval and amendment

First approved in 2005-09.

Introduction

In reaction to environmental concerns about the disposal of waste in landfill sites, many countries in the EPPO region (including those of the European Union) have introduced, or are intending to introduce, legislation to require disposal of waste by other means. The alternative options for disposal of organic waste ('biowaste') are incineration and decomposition. Decomposition, i.e. composting and/or anaerobic digestion, reduces the bulk of biowaste considerably (by approximately 65%) but the remaining material still requires disposal. Because of its nutritional nature, the resulting treated biowaste (in the form of compost or sludge) is particularly suited for addition to soil, and most such material is used in agriculture, horticulture, amenity gardening and private gardens. Already, millions of tonnes of treated biowaste have been produced and used each year in EPPO countries. There is also a growing international trade in treated biowaste.

Most treated biowaste derives from composting in which the material is maintained in heaps for several weeks to allow the decomposing organisms to break down the organic material. Composting is an aerobic and exothermic process in which the temperature rises above 50°C (and sometimes above 70°C) for several weeks or months, before dropping back again below 40°C as the decomposition process slows. The compost heaps are periodically re-mixed ('turned') during this period to ensure even decomposition, although systems without turning but with forced aeration also exist. In industrial plants, composting is most commonly performed in long heaps ('windrows') which are turned mechanically. The windrows may be maintained outdoors (preferably protected from rain) or kept indoors in vessels or halls. Other systems of composting have been developed.

In addition to the aerobic composting process, anaerobic systems are also used for decomposition of organic wastes. These systems, described as 'anaerobic digestion', may be wet or dry, thermophilic or mesophilic processes, and are maintained in closed tanks from which the gases generated are collected and used for energy production by combustion. After digestion, the solid residues may be subjected to a composting stage.

Most of the biowaste that is currently treated includes plant material and may initially be infested with plant pests of various kinds. Though the temperatures reached in composting should in principle destroy plant pests including weeds, there is clear published evidence (e.g. Sansford, 2003; Noble & Roberts, 2004) that certain pests survive some treatment processes. Examples are *Fusarium oxysporum* f.sp. *melongenae* and other *formae speciales*, *Olpidium brassicae*, *Plasmodiophora brassicae*, *Streptomyces scabies*, *Tobacco mosaic virus* (*tobamovirus*), *Tobacco rattle virus* (*tobravirus*), *Xanthomonas malvacearum*, some plant parasitic nematodes including *Globodera* spp. (potato cyst nematodes), and certain weed seeds. In many of these cases, scientific evidence indicates that survival of the pest resulted from failures in the treatment process or in the use of inadequate methods of treatment. There is therefore a need to establish safety targets and related minimum processing conditions to avoid such failure.

This standard describes:

- Requirements for the treatment process to ensure phytosanitary safety of treated biowaste
- Special requirements for biowaste that may contain quarantine pests or heat-tolerant pests
- Supervision, test procedures and validation methods to ensure that the treatment process and final product comply with plant health requirements

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- Documentation and labelling requirements during production and exchange of treated biowaste.

Aspects other than plant health (e.g. health rules for animal by-products in mixed composts, tolerances for heavy metals, physical contaminants such as glass, plastic, metal or stones, physical characteristics such as pH, salt, organic matter or dry matter, amount of waste allowed to be applied to land and other limitations on end use) are not covered by this standard. Treatment processes should comply with relevant national or international standards. Environmental risks related to residues of plant protection products are also not covered. NPPOs are encouraged to cooperate with the relevant governmental authorities responsible for composting and anaerobic digestion plants.

Explanation of terms used in the context of biowaste in this standard

Biowaste
Any plant or animal waste destined for 'end-use' (as defined below) that can be degraded by micro-organisms, soil organisms or enzymes. This standard is concerned only with biowaste of plant origin which may be derived from the following sources: kitchen (household or catering) waste, forest or wood-processing waste (e.g. bark, wood, sawdust), garden and park waste, waste from markets, waste from agricultural processes (e.g. husk and cereal dust, potato peelings and washings), waste feeding-stuffs, human food stored beyond its safety period, waste from industrial food processes (e.g. fruit pulp, spent hops, sludges). The European Waste Catalogue (EU, 2001) lists and indexes types of wastes. Plant residues generated on land used for agricultural, horticultural or silvicultural purposes, and remaining on that land, are not included in this standard but may be regulated by other national or international standards.

End use
Spreading of biowaste on soil, or mixing biowaste with soil, on agricultural, horticultural or silvicultural land or in landscaping; or mixing biowaste with other ingredients in the preparation of various plant growing media.

Heat treatment
Treatment of biowaste by raising its temperature under defined conditions, other than by the composting process itself.

Mixture
Treated biowaste which has been mixed with one or more of the following: other treated biowaste, untreated biowaste, farm manure, licensed fertilizers, soil, peat, minerals.

Sanitation
Any treatment that aims to minimize the risk of spread of pests when the treated biowaste is used.

Treated biowaste
Either: a) biowaste that has been subjected to an aerobic treatment process (compost); b) biowaste that has been subjected to an anaerobic treatment process (anaerobic digestion residues); or c) biowaste treated by other methods, including any mixtures with other materials after treatment.

Treatment processes

Before end-use in agriculture, horticulture, silviculture or landscaping, biowaste should be treated by the methods described below in order to destroy plant pests, and tested by the methods described below to determine their compliance with the requirement for freedom from the majority of plant pests or, where known or suspected to be present, freedom from quarantine pests and heat-tolerant pests. If the treated biowaste is mixed with other materials, the mixture components should, as relevant, comply with these requirements or be shown to be free from pests.

The treatment process will differ depending upon whether the waste is high risk or low risk. High risk waste is waste containing or suspected to contain quarantine pests or heat-tolerant pests. Other waste is considered to be low risk. Where there is any doubt about the phytosanitary risk posed by the waste the NPPO should be consulted.

Minimum requirements for the treatment process

Minimum requirements aimed at eliminating most plant pests are defined below. Additional specific requirements related to biowaste known or suspected to contain quarantine pests or heat-tolerant pests are presented in the next section.

In order to prevent potential contamination, all treated material should be stored in such a way as to avoid any contact with untreated materials (direct contact, or contact though run-off water, wind, machinery, tools, storage containers, etc.).

Composting
The processes at composting facilities should be managed in such a way as to guarantee a thermophilic temperature range and a high level of biological activity over a period of several weeks. This should be achieved under appropriate conditions of humidity and nutrients, as well as by optimum structure and optimum air conduction. In general, the water content should be at least 40%. In the course of the composting process, the entire quantity of materials being treated should be exposed either to a temperature of at least 55°C for a continuous period of two weeks, or to a temperature of at least 65°C over a continuous period of one week (or, in the case of enclosed composting facilities, at least 60°C). A minimum number of turnings may be required to ensure that the whole mass is exposed to this temperature.

Some composting processes which fulfil these minimum requirements are described in detail and have been validated at the national level for processing low risk waste e.g. for Germany, published by the Bundesgütegemeinschaft Kompost

e.V (Bundesgütegemeinschaft, 2003, http://www.bgkev.de/download/hbps.pdf). EPPO member countries should take account of national requirements for processing low risk biowaste.

The time/temperature combinations for composting mentioned above will eliminate most plant pests. However, there are reports in the scientific literature, based on various experimental methods, which have shown that some heat-tolerant organisms [organisms with hardy resting spores e.g. *Plasmodiophora brassicae*; heat-tolerant viruses, e.g. *Tobacco mosaic virus* (*tobamovirus*) and viroids e.g. *Potato spindle tuber viroid* (*pospiviroidae*)] have survived these time/temperature combinations. Therefore, further studies are needed to determine the necessary time/temperature combinations to eliminate these and other similarly hardy pests. For the verification of the sanitation effect of a composting process for heat tolerant organisms direct process validation (see below) is recommended.

Anaerobic digestion

There are few references on the effectiveness of anaerobic digestion against plant pests. Accordingly, biowaste which is processed by anaerobic digestion should be heat-treated (see below) either before or after processing. Alternatively, the digested residue may be subjected to an aerobic secondary decomposition (composting).

Heat treatment

Direct heat treatment of biowaste can be used to help destroy plant pests (this is used in conjunction with anaerobic digestion; see above). The recommended time/temperature combination is 70°C for 1 h, preferably by wet heat. Heat treatment with this time/temperature combination will destroy most plant pests. However, *Tobacco mosaic virus* (*tobamovirus*) survives this heat treatment, and other heat-tolerant organisms (e.g. other heat-tolerant viruses and viroids, fungi with hardy resting spores) may also do so (see specific requirements below).

For the heat treatment to be effective, the particle size of the biowaste should preferably not be larger than 12 mm. The biowaste should accordingly be homogenized. During the heat treatment, the moisture content of the biowaste should be sufficient to guarantee heat transfer between and inside the particles. The specified temperature should apply to the whole bulk of material over a continuous period of time.

Specific requirements for biowaste containing quarantine pests or heat-tolerant pests

Biowaste of plant origin known or suspected to contain any quarantine pests or heat-tolerant pests should receive a special heat treatment: 74°C for 4 h (Marcinisyn *et al*., 2003), 80°C for 2 h or 90°C for 1 h (Lorenz, 2006) using wet heat, either before or after processing. Where biowaste is known or suspected to contain any quarantine pests the treatment and the whole process should be authorized and supervised by the NPPO, including confinement conditions to prevent escape of any quarantine pest, testing of the resulting treated biowaste (which should be found free from the quarantine pest by appropriate methods i.e. EPPO Standards in series PM 7 Diagnostics when available) and, if appropriate, specification of a 'non-risk' outlet for the end-use. Exceptionally, the NPPO may decide not to apply the heat treatment and to rely on the minimal requirements for the treatment process described above if:

- The treatment process has undergone direct process validation and given the characteristics of the pest it can be concluded that this treatment is effective in eliminating it
  or
- There is pest-specific scientific evidence showing that the treatment process is effective in eliminating the pest of concern.

Authorization and supervision of the NPPO as described above apply.

Compliance

In general, both 'indirect process supervision' and 'product analyses' (see below) are used to determine whether treated biowaste complies with requirements. Treated biowaste should not be released for end-use unless all requirements are satisfied. Products having failed to meet any of the requirements should be treated again or should not be used for the end use specified in this standard. Direct process validation may be required if the untreated biowaste is known or suspected to be infested with a quarantine pest or a heat-tolerant pest (see above).

Heat treatment facilities should be verified before the first treatment and at regular intervals (preferably yearly) thereafter by a technical expert.

Indirect process supervision

'Temperatures should be recorded at regular intervals throughout the processing of the biowaste. If possible, these measurements should be continuous. They should be recorded in at least three representative zones of the biowaste unless the technical equipment of the process prevents access to these zones. During the thermal inactivation stage, the temperature should be recorded at least once every working day.'

If the biowaste is subjected to a specific heat treatment, the temperature should be monitored and recorded continuously and automatically for each treatment period.

Product analysis

The analysis of the product after treating biowastes (final product controls) should include tests to ensure that the final product meets specified phytosanitary standards. These tests mainly concern the detection of viable seeds or reproductive parts of plants (Appendix 1). If other validated test methods for the detection of specified plant pests in treated biowaste exist, the product may also be tested for these pests.

Product analyses should be carried out on appropriate samples at least every six months (for facilities with a capacity of up to

3000 t per year), or every three months (for facilities with a capacity over 3000 t per year), at every composting facility. If the product is stored before sale or distribution, product analysis should be done at the end of the storage period. The number of samples to be tested per year varies according to the capacity of the facility according as follows: 1) for facilities with a capacity of up to 3000 t per year, six samples; 2) for facilities with a capacity of 3000–6500 t per year, six samples, plus an additional sample for every 1000 tonnes or part thereof over 3000; 3) for facilities with a capacity of more than 6500 t per year, 12 samples, plus an additional sample for every 3000 tonnes or part thereof over 6500.

The number of samples can be reduced (by up to 50%) if an adequate level of indirect process supervision is maintained. If viable weed seeds or reproductive parts of plants are detected during product analysis, the number of analyses should be returned to the recommended level for at least one year before it can be reduced again. No viable weed seeds or reproductive parts of plants should be detected during this period.

Samples of approximately 3 kg should be taken, each composed of at least five different sub-samples per batch of finished compost or anaerobic digestion residue. The test result is considered satisfactory if none of the samples contain viable seeds or reproductive parts of plants. The presence of any viable seeds or reproductive parts of plants is considered to be evidence of failure in the treatment process. See Appendix 1 for details of the test.

Direct process validation

Direct process validation is a verification of a composting or other process to determine its efficacy in destroying plant pests in biowaste. It should be distinguished from quality control methods such as indirect process supervision or product analysis. It is carried out once for a treatment process. Indicator organisms are used to determine efficacy at all stages of the process. These organisms are buried in representative decomposition zones, or are introduced in the process stages responsible for their inactivation. After completion of the process, they are removed, and tested for survival or infectivity, by the methods of Appendix 2.

Each direct process validation should be carried out in two test series, separate in time. In the case of open-air facilities, one of these test series should take place in the winter months. For windrow composting, three indicator organisms are buried in three different zones (top, middle and bottom) as well as at four different points representing a total of 36 individual samples. For other treatment processes, at least the same number of samples of the indicator organisms are buried in zones representative of the temperature range within the biowaste. For small facilities with an annual capacity of up to 3000 tonnes, the number of samples may be reduced by up to 50%. In that case, the indicator organisms are only buried in the heap at two different points.

For adequate monitoring, the biowaste treatment facilities should have openings for burying and removing indicator organisms. If this is not possible, the process cannot be validated by the proposed method. Other efficacy test methods proposed by suitable experts may be considered. Alternatively, the process itself may be made efficacious by adding a heat treatment at 74°C for 4 h (preferably by wet heat) at the beginning or the end.

Direct process validation is not required for heat treatment processes.

Documentation/labelling

Verifiable records of temperature patterns and compost re-stacking times (composting) should be kept in the archives for at least five years and presented to supervisory authorities upon request. If treated biowaste is to be sold, distributed or exported, it should be accompanied by a 'compost passport', which should include the following elements:

- Name and address of the producer of the waste
- Quantity
- Description of the treated biowaste or mixture based on the nature of the materials used in unmixed form
- Batch number and date of treatment or an identification number allowing trace-back
- Assurance that the requirements of this standard are satisfied.

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Appendix 1

Product analysis

The content of viable seeds and reproductive parts of plants in the treated biowaste is determined. For this purpose, approximately 3 kg of the treated biowaste is sieved to a size < 10 mm and exposed to a temperature of 4°C for three days. After determination of the salt content (Bundesgütegemeinschaft Kompost, 1994, method 8), the test substrate thus produced is diluted with a suitable mixing component (which should contain no KCl and be free from viable seeds and reproductive parts of plants) so as to give the test mixture a salt content of < 2 g L^{-1} KCl. A suitable mixing component for this purpose is high-moor peat with approximately 4 g L^{-1} of aerated lime. The test mixture is spread in test dishes (plastic dishes with perforated bottoms, or any equivalent containers lined with a water-absorbent mat, and a perforated foil to keep them clean) in an even layer of approximately 10 mm; the mixture is then slightly pressed down and watered to saturation. The test containers are then kept for a period of 15 days, at an illumination of at least 1000 Lux and a temperature of 18–20°C, without direct exposure to sunlight. Loss of water is compensated by regular sprinkling. To prevent drying-out, the dishes can be covered with glass or transparent plastic sheets in such a way that gaseous exchange remains possible. The number of seedlings that appear within 15 days is recorded.

Appendix 2

Direct process validation

Of the variety of plant pathogens and seeds that may be present in input materials for biowaste treatment facilities, the following indicator organisms have been selected for use in direct process validation: *Tobacco mosaic virus* (*tobamovirus*) (TMV), *Plasmodiophora brassicae* (clubroot) and tomato seeds. If, in the case of samples which have been passed through the direct process validation, any of these organisms is found to have survived as indicated by any detectable level of infectivity for TMV *or* clubroot *or* germination of tomato seeds, the direct process validation is considered to have failed.

TMV test method

Testing is carried out using the method of Bruns *et al*. (1994), based on that of Knoll *et al*. (1980), and Ryckeboer (2001), Ryckeboer *et al*. (2002a,b).

Preparation of test samples

TMV is propagated in *Nicotiana tabacum* cv. 'Samsun' which become systemically infected by the virus. Tobacco plants are grown under normal glasshouse conditions up to the 5-leaf stage. For inoculation, extracts from TMV-infected tobacco plants are prepared in 0.05 M sodium phosphate buffer, pH 7, and rubbed with a brush, glass spatula or with a gauze wad onto two or three lower leaves which have been lightly dusted with an abrasive. Two to three weeks after inoculation, systemically infected leaves showing mosaic-like discolorations are harvested and can be used directly for the test (or can be stored frozen at about –20°C for later use). For every sample, 10 g of TMV-infected tobacco leaves are placed in non-decomposable gauze sacks (mesh size 1 × 1 mm). These samples are buried in the biowaste. It should be ensured that no sample material escapes into the surrounding compost. Control samples are TMV-infected leaves kept in the freezer at a temperature of approximately –20°C.

Testing samples for infectivity

The gauze sacks are removed from the composting facility and the 10 g samples of tobacco leaves are immediately taken out, chopped with a sterile pair of scissors, and ground in 30 mL of sodium phosphate buffer (0.05 M, pH 7.0) using a pestle and mortar or a sterilized blender. The resulting pulp is squeezed through a nylon net (mesh 1 mm). Plant sap is extracted from the control samples in a similar manner. To determine residual infectivity, the extracts are applied to the test plants *Nicotiana glutinosa* or *N. tabacum* cv. 'Samsun NN' using a modified half-leaf method. Four fully developed leaves (about 90 cm^2 in size) are detached from plants at the 6–8 leaf stage grown under constant conditions (Walkey, 1991) and used for inoculation of each sample. The leaves are lightly dusted with Celite (abrasive) and the extract is applied to one half of each of the four leaves, while the opposite leaf halves are treated with control extract. The extracts are uniformly rubbed onto the leaves with rotating movements using a glass spatula (Walkey, 1991). Soon after inoculation, the leaves are rinsed for 10 s with running tap water. The inoculated leaves are then placed on several layers of moistened filter paper in a Petri dish or similar vessel (e.g. flat styrofoam boxes about 35 × 50 cm that can be covered with a glass plate) and incubated in a growth chamber under controlled conditions (22–24°C; at least 16 h of lighting with approximately 4000 Lux). Since the test plants are resistant to TMV, they develop small necrotic local lesions (small, round spots with a necrotic centre). Local lesions are counted 6 days after inoculation. No lesions should be detected in the test samples, while the controls should show typical lesion development.

Plasmodiophora brassicae testing method

The test is carried-out using the method of Bruns *et al*. (1994), based on that of Knoll *et al*. (1980). Isolates of *P. brassicae* should be selected for heat tolerance (resistant to incubation at 65°C for one day) (Idelmann *et al*., 1998).

Buried samples

The test material is composed of galls from cabbage plants infected with *P. brassicae*. This material is deep-frozen at –25°C until the beginning of the test. Samples are made up from 30 g of gall material, 430 g of infectious soil and 200 g of biowaste to be tested, thoroughly mixed, and packaged in non-decomposable bags (maximum mesh size 1 × 1 mm). These samples are buried in the biowaste. No sample material should escape into the surrounding compost. For the control, sterile sand replaces the biowaste and the samples are stored in damp, sterilized sand at room temperature during the test period.

Test of infectivity by means of biotests

After being recovered from the treatment process, all samples are freed from coarse wood and stones and thoroughly ground. 325 mL of each sample is mixed with 275 mL of a sand/peat mixture (30:70 v/v; sand steamed for 5 h at 80°C). The pH, which has a strong influence on the infectivity of *P. brassicae*, should be about 6, and can if necessary be adjusted by increasing or reducing the proportion of peat. This mixture of sample, sand and peat is added to a container into which four seedlings of a susceptible cultivar of *Brassica juncea* are planted. As P and K concentrations in the compost are normally high, there is usually no need to add nutrients in the containers holding the test samples. Fertilizer should be added to the control samples (250 mg N, 100 mg P_2O_5, 300 mg K_2O and 100 mg Mg per L). The biotest is carried out in a randomized split-plot design with a 16 h day at 8000 Lux and at a temperature of 16–18°C in the first week, and 22°C from the second week onwards. The growing period for the biotest is 5 weeks, after which plants are examined for disease symptoms (root galling). No infection should be detected in the test samples, while the controls should show typical disease development.

Testing method for tomato seeds

Testing is carried out according to the method of Pollmann and Steiner (1994).

Buried sample

Seeds of tomato (*Lycopersicon esculentum*, cv. Saint Pierre, [synonyms S. Pierre, San Pedro]), 1 g or 400 seeds, are poured into a small bag made of non-decomposable gauze (mesh size 1 × 1 mm) and spread over the entire gauze surface as thinly as possible. The closed bag is put in a sample sack containing at least 5 L of fresh biowaste from the batch to be investigated. In the case of anaerobic digestion, a similar quantity of tomato seeds contained in a carrier with semi-permeable membranes is introduced into the process. The germination rate of the tomato seeds should be determined before testing and only seeds with a germination rate of at least 90% should be used.

Germination test

The germination test should normally start immediately after removing the samples from the compost. If the samples have to be transported or stored, they should be kept cool in an airtight container (cool box, refrigerator). 200 tomato seeds are counted from each bag. The remaining seeds are dried under room conditions (approximately 20°C and 20–50% relative humidity) and then placed into an airtight container and kept in the refrigerator as a reserve. The counted seeds (washed, if necessary) are divided into 4 lots of 50 seeds and spread on four layers of moist filter paper in four covered 9 cm Petri dishes, maintained at 25°C and exposed to light in a suitable room or growth cabinet. Germinated tomato seeds are counted at 7-day intervals, and removed from the Petri dishes. A seed is considered to have germinated if its root and/or shoot has visibly emerged. Counting continues until no more seeds have germinated. If no seeds have germinated after 21 days, the germinating capacity tests are concluded. The total number of germinated seeds should be recorded and expressed as a percentage of the seeds used in the tested aliquot (200 seeds). No germination should be detected in the test samples, while the controls should show normal seed germination.