Hygienic requirements in aerobic and anaerobic treatment of biological wastes

Besoins en hygiénisation lors du traitement aérobie et anaérobie de déchets biologiques.

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Abstract

Biological wastes generally contain various bacteria, fungi and viruses which are obligatory or facultative pathogens for man and animals or plants.
A strategy will be presented which with lead to a safe product from the point of view of human, animal and plant health as well as of undesired product side effects. The are main elements of this strategy are :

- validation of the aerobic and anaerobic process concerning the inactivation of representative bacterial, fungal and viral pathogens as well as weed seeds,
- continuos control of main process parameters leading to the inactivation of the pathogens and seeds, e.g. temperature, pH-value, exposure time.
- regularly control of the final product for the occurrence of representative indicator organisms like Salmonella.

Keywords**:** Biowastes, hygienic requirements, process validation

Résumé

Les déchets biologiques contiennent généralement diverses bactéries, champignons et virus qui sont des pathogènes stricts ou facultatifs pour les humains, les animaux et les plantes.
Une stratégie est présentée qui conduit à un produit sain du point de vue des individus, des animaux et des plantes. Les éléments principaux de cette stratégie sont :

- validation des procédés aérobie et anaérobie du point de vue de l'inactivation des bactéries, champignons et virus pathogènes, ainsi que des graines de mauvaises herbes.
- contrôle continu des principaux paramètres du procédé conduisant à l'inactivation des pathogènes et des graines, tels que la température, le pH, le temps d'exposition.
- contrôle régulier du produit final par raport à la présence de microorganismes indicateurs tels que les salmonelles.

Mots-clés : biodéchets, besoins en hygiène, validation procédés.

1. Introduction

The origin and nature of organic wastes is always causing a hygienic risk in storage, collection, handling, processing and utilization. Those risks are existing either if the organic wastes are collected and processed source separated (biowastes) or if they are collected together with other wastes from households or processing industries. Due to the fact that most organic materials collected from households or processing industries may contain pathogenic microorganisms which can affect the health of man, animals or plants as well as seeds or parts of plants which will cause undesired side effects in agricultural or horticultural use. Hygienic principles must be followed in collection, transport, processing, storage and distribution of raw materials as well as the final product.

- Three main types of risks mainly related to pathogens for man and animals have to be considered in collection and processing of organic wastes (BÖHM et al., 1996, BÖHM, 1995)
- occupational health risks
- environmental risks
- risks concerning the product safety.

2. Hygienic risks connected with products from biological wastes.

A compilation of bacterial, fungal, parasitic and viral pathogens for man and animals which may be present in organic wastes are given in Tab. 1. With regard to plant pathogens an extensive list of viruses, bacteria, fungi and seeds is given by MENKE (1992).

Bacteria	Citrobacter, Clostridia, Enterobacter, Escherichia coli, Klebsiella, Proteus, Pseudomonas, Salmonella, Serratia, Staphylococci, Streptococci, Yersinia
Fungi	Aspergillus-species, e.g. *Aspergillus fumigatus*
Viruses	Adenovirus, Coxsackievirus, ECHO-Virus, Enterovirus, Hepatitis A-Virus, Herpesvirus suis, Paramyxovirus, Parvovirus, Pestivirus, Poliomyelitisvirus, Reovirus

Table 1
A survey on obligatory and facultative pathogens for man and animals which had been isolated from biological and household wastes

Since it is impossible to supervise a product like compost for each of the pathogenic agents which may occur, other strategies have to be used in order to assure the hygienic safety of the processed material. The first step in such a strategy is to find out a representative indicator organism which may be used for checking the hygienic safety of the product as well as for evaluating the anaerobic or composting process for its capability to inactivate pathogens which are of epidemiological relevance. The second step which is necessary in this connection is to define hygienic requirements for the process itself, since due to the high volume of the product to be controlled as well as to the inhomogeneity of distribution of pathogens in the material only a final product processed in a validated process should be distributed to the consumer. This means, that the following two steps are necessary to assure the hygienic safety of the product:

- hygienic validation of the aerobic or anaerobic process,
- continuous control of main process parameters leading to the inactivation of the pathogens and seeds, e.g. temperature, pH-value, exposure time,
- investigation of the final product for the presence of representative indicator organisms.

3. Process validation

The validation of the process for the treatment of organic wastes with respect to hygienic safety for animals, man and plants may be done in several ways. Concerning the process of composting the German LAGA M10 (1995) offers a relatively broad approach in solving this problem,which is as follows:

Process safety concerning the inactivation of relevant transmissible agents for man and animals is validated in two steps. The first step is the validation of the process as designed by the producer of the technical equipment in a basic procedure, the second step is a bringing-into-service validation of a composting plant with the typical input material under practical conditions. In both validation procedures *Salmonella senftenberg* W 775 (H_2S negative) is used as test organism exposed in specially designed test carriers (RAPP, 1995, BÖHM et al., 1997). The test organisms used with respect to phytohygienic safety are Tobacco mosaic virus, *Plasmodiophora brassicae* and seeds of *Lycopersicon lycopersicum* (L) breed St. Pierre (BRUNS et al. 1994, POLLMANN and STEINER, 1994). Testing is done twice, in summer- and in wintertime. Concerning the phytohygienic validation the bringing-into-service procedure is repeated at least every two years as a consecutive validation.

This is a very complete and safe system designed for voluntary quality assurance. Due to economical considerations an obligatory system should be simplified and only a one step procedure should be the aim, which must be the bringing-into-service validation. Moreover the above mentioned system is limited to the composting process, a comparable procedure has to be invented for biogas-plants. A scheme how this validation could be organized taking into account the annual throughput of material in the plants is given in Table 2 from the draft of the German « Biological Wastes Ordinance ». The validation with pathogens and seeds may be regarded as « direct process validation » and must be accompanied by continuous recording of measurable process-data like temperature, pH-value, humidity etc. In order to detect deviations and disturbances of the process over the whole year, which may result in an insufficient microbicidal effect. The system of process validation has to be completed by a continuous supervision of the final product, at least twice a year.

INVESTIGATED PARAMETER		DIRECT VALIDATION OF THE PROCESS	INDIRECT PROCESS SUPERVISION	SUPERVISION OF THE FINAL PRODUCT
Hygienic safety concerning risks for man, animals and plants		- New constructed plants (within 12 month after opening of the plant) - Already validated plants if new technologies have been invented or if the process has been significantly modified (within 12 months after invention or modification - Existing plants without validation within the last five years before this validation strategy was invented (within 18 months)	- Continuous registration of temperature at three representative locations in the process, responsible for the inactivation of the microorganisms and seeds - Recording of process data (e.g. turning of windrows, moisture of material, starting and finishing data)	Regular investigation of the final product for hygienic safety [2), 3)]
Number of test trials		2 Test trials, at open air composting plants at least one in wintertime	Continuous data recording to be filed for at least five years	Continuously all over the year at least - semiannual (plants with =3000 t/a throughput) - quarterly (plants >3000 t/a throughput)
Number of test organisms	Human and veterinary hygiene	1 test organism (Salmonella senftenberg W 775, H_2S-neg.)	-	No salmonella in 50 g product detectable
	Phyto-hygiene	3 test organisms (Plasmodiophora brassicae, tobacco mosaic-virus, tomato seeds	-	Less than 2 seeds capable of germinating and/or reproducible parts of plants in 1 L of product
Number of samples Sample per test-trial: Human and veterinary hygiene Phytohygiene		 24 [1)] 36 [1)]	-	Throughput of the plants in t/a 1. = 3000 (6 samples per year) 2. > 3000-6500 (6 samples per year plus one more sample for every 1000 t throughput) 3. > 6.500 (12 samples per year plus one more sample for every 3000 t)
Total		60		

Table 2
Example of a validation and supervision strategy for biogas and composting plants and the resulting products

1) At small plants half the number of samples (= 3000 t/a)
2) Every statement concerning the hygienic safety of the product is always based on the result of the supervision of the final product together with the result of the validation of the process
3) Every sample is a „mixed sample“ (about 3 kg) based on five single samples of the final product

4. Hygienic Safety of the Product

As mentioned above, the investigation of the final product in order to detect every pathogen which may be present in the material is impossible, therefore representative indicator organisms have to be determined from the point of view of human and animal health as well as for the purpose of safe plant-breeding and production. Those indicator organisms must fulfill several requirements :

- they have to be present with a high probability in the raw materials
- the transmission via final product must be a factor in epidemiology
- the indicator should not be involved in the aerobic or anaerobic biotechnological process itself
- the indicator should not be an organism which is generally present in soil and soil related materials
- the method for isolation and identification must be simple, definitely and reliable if applied to a substrate with a complex microbiological matrix which will not be sterile.

With respect to public health and veterinary requirements several indicators and parameters are in discussion :

- *Salmonella* spp.
- Enterococci (Streptococci of group E)
- *Staphylococcus aureus*
- Enterobacteriaceae
- *Escherichia coli*
- *Clostridium perfringens*
- Sulfite reducing Clostridia
- Eggs of nematodes
- Larvae of nematodes.

Since compost for example is a product of a microbial degradation process and the knowledge about the microbiological ecology of compost and compost related materials is still limited, it must be warned to use isolation and identification techniques common in clinical microbiology without careful validation in combination with the involved sample materials. The knowledge about the microbial flora of products resulting from a mesophilic or thermophilic biogas process is even less, especially with respect to the selection of an anaerobic flora and growth inhibiting microbial byproducts. The variety of species to be present in environmental samples and the products of a composting- or biogas-process by far exceeds the limited number of species to be taken into account in se- and excreta as well as in body fluids and the variability in species is high and not yet fully understood. Moreover, microbial parameters which are used in the field of waterhygiene and food inspection are not applicable to substrates like compost because most of those indicators belong to the indigenous flora of agricultural soils (BÖHM, 1995). If the limited reliability and applicability of methods adopted from clinical microbiology and water inspection for the intended field of use is taken into account as well as the fact that the exclusion of organisms which generally may be found in normal soils makes no sense for a substrate and fertilizer resulting from an aerobic or anaerobic biotechnological process, the following microbial parameters are inapropriate: Enterococci, *Staphylococcus aureus*, Enterobacteriaceae, *Escherichia coli*, *Clostridium perfringens* and sulfite reducing Clostridia.

The only parameter which seems to be useful and reliable in this connection is the presence or absence of salmonellas. Salmonellas are found in a rate of up to 90 % in biowaste bins, this means, that due to mixing the content of many sources during transport the waste delivered at the biowaste treatment plant contains with a high probability salmonellas in various concentrations. Since it is known that the probability to identify a positive sample is basically related to the amount of investigated material a compromise between feasibility and reliability has to be found. It is proposed to investigate 50 g of compost for the presence or absence of salmonellas with the method described in principle in the LAGA M10 using a pre-enrichment in buffered peptone water and an enrichment step (EDEL and KAMPELMACHER, 1969, RAPPAPORT et al.; 1956, VASSILIADIS, 1983).

This leads to the problem of indicator organisms from the point of view of phytohygiene. No virus, fungus or bacterium pathogenic for plants has been found until now which is of comparable importance as salmonellas are for the above mentioned purpose. The only indicator which is widely distributed in biological wastes from households are tomato seeds. Even knowing, that this indicator will not cover totally all requirements, it seems to be reasonable and feasible to define the term « phytohygienic safety » of the product as follows: The final product should not contain more than 2 seeds capable to germinate and/or reproducible parts of plants in 1 l. A suitable test-method is described by BUNDESGÜTEGEMEINSCHAFT KOMPOST (1994).

5. Final Remarks

In order to assure hygienic safety of products treated by a biotechnological aerobic or anaerobic process deemed to be applied in agriculture and horticulture a three step control system is recommended which is based on approved methods and which is designed to minimize the costs and labour on one side and allows to come to an optimal product safety by using additive effects on the other side. Fig. 1 summarizes the strategies to be applied in order to reach this aim.

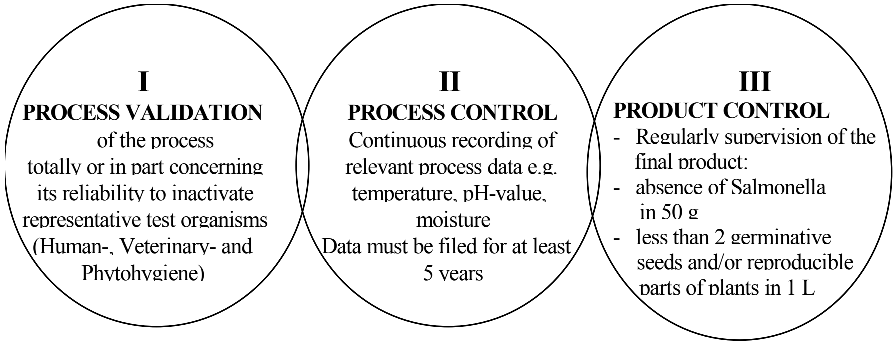

Figure 1
Hygienic requirements for aerobic and anaerobic treatment of organic wastes

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