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Practical implementation of a biofilter in a composting/vermicomposting plant: Failures and solutions

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ABSTRACT

Following a primary sorting in the industrially exploited process developed for vermicomposting of household waste the matter is subject to sanitization by a spontaneous moderate heating to about 70 °C aerobic composting, just before the vermicomposting operation. The ventilation system collects all gases and water vapor within the composting facility and exhausts them to the biofilter, for eliminating odours objectionable. The biofilter is simple to install as well as operate, requires little maintenance and has low energy requirements. Unlike others forms of odour control, biofilters adsorb, hydrolyse and oxidize odours in one process by simple biodegradation. Waste gases collected from the composting facility are passed through a perforated piping system located beneath the filter bed and are distributed evenly throughout the filter material. Odorous compounds within the waste gas are adsorbed into water droplets and then oxidized by microbes present within the water droplets. The high concentration of oxygen in the waste gas ensures that the biofilter operates continually under aerobic conditions. The end products of the oxidation process that are released to the atmosphere are carbon dioxide and water vapour, which are safe and odorless compounds. Biofilter has been pilot tested in the laboratory and shown to work under many different conditions in the vermicomposting plant. The data showed the effectiveness and the advantages of this odour control method.

Keywords: Vermicomposting, solid state fermentation, household waste, sanitization, offensive odours, biofilter, microorganisms, flow rate, residence time, biodegradation rate, absorption, adsorption, oxidation, effluent.

RESUME

Réalisation pratique d'un biofiltre dans une usine de compostage/lombricompostage. Difficultés et solutions.

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Après un tri primaire des déchets urbains, traités dans une usine de lombricompostage, subissent une hygiénisation par compostage aérobie vers 70°C puis sont lombricompostés. Au cours du compostage thermophile un système d'aération aspire l'air chargé de gaz et vapeur d'eau et le refoule dans un biofiltre pour éliminer les odeurs nauséabondes. Le biofiltre, d'installation et d'usage simple, ne nécessite qu'une maintenance et énergie réduites. A la différence des autres procédés de désodorisation le biofiltre absorbe, hydrolyse et oxyde les composés malodorants en une opération. Les gaz collectés depuis le compostage sont injectés par des tubulures perforées dessous la couche biofiltrante et traverse l'ensemble de celle-ci. Les composés odorants sont absorbés dans la phase acqueuse du filtre et biodégradés par les microorganismes qui y prospèrent. La richesse en oxygène de l'air traité assure une aérobiose et les produits finaux libérés par le procédé sont du gaz carbonique et de la vapeur d'eau, sans risques ni odeurs. La fiabilité du biofiltre a été éprouvée et maîtrisée en pilote puis pratiquée dans différentes conditions à l'échelle industrielle. Les résultats illustrent l'efficacité, les exigeances et les avantages de ce procédé de désodorisation.

Mots clés : Lombricompostage, fermentation en milieu solide, ordure, hygiénisation, odeurs nauséabondes, biofiltre, microorganismes, débit, temps de résidence, efficience de biodégradation, absorption, oxydation, effluent.

INTRODUCTION

Among air pollutions, odours are the less tolerated by the neighbourhood of the source. Noxious smell elements are also potentially toxic, though the odour is usually perceived at small levels and does not create real harmful effects. The molecules of the odour are diverse and there're only a few reports available underlying each activity, the quality and levels of the odour. The treatment of refuse by vermicomposting, developed by SOVADEC Technologies, requires a phase of aerobic fermentation of the organic waste which generates a noxious smell. Numerous techniques are available to treat odours and these involve the gas transfer in liquid with or without transformation of the product by oxidation or acid-base reactions, (Arnold, 1974 ; Faujour *et al*, 1979 ; Jarosz, 1979, 1980 ; Langlais, 1983 ; Caillet, 1984).

In addition, gas-solids transfer, based on adsorption phenomena, are widely used. Active coal is the most used material for its capacities of adsorption and regeneration (Tarrada and Boki, 1979 ; Perret, 1983 ; Koe and Seah, 1987). New processes involving biological techniques.are also known (Martin, 1984 ; Dalouche, *et al*, 1987).

The objectives of this study were to evaluate for a first time the levels of the odours, the different concentrations of noxious elements in the bisanitization building and choose the best available solution. The studies in the pilot unit allowed selection and determination of the performances on an industrial scale.

THE PRINCIPLES OF BIOFILTERS

Biofiltering is a process of purification of a noxious gas using biological filters. It is based on two phenomena: physical-chemical transfers (absorption-adsorption), and a biodegradation of noxious components by the micro-organisms present in the biological support.

The suction of the gaseous effluent from the fermentation unit is ensured by a ventilation system. The air is then forced under the mass of the biofilters. The scheme of this installation in shown in Fig. 1. Odorous compounds within the waste gas are adsorbed into water droplets and then oxidized by microbes present within the water droplets. The high concentration of oxygen in the waste gas ensures that the biofilter operates continually under aerobic conditions. The end products of the oxidation process released to the atmosphere are carbon dioxide and water vapour, which are safe and odourless compounds.

MATERIAL AND METHOD

BRIEF DESCRIPTION OF THE UNIT

The Sovadec unit in La Voulte, France, treats on an average of 30 tonnes of refuse per day. The chain of operations starts when the mixed-waste is poured into a pit, picked up by a grab to sorting chain, transfered where the bags are opened by thermofusion and sorted based on size using the autoselector (R).

The material of less than 160 mm in size is led towards the bisanitazation unit. The continued displacement of the matter, aeration and water sprinkling accelerate the fermentation. The temperature in the matter reaches 70 °C, and ensures destruction of most of the pathogenic germs.

The gaseous effluent coming from the ventilation of the fermentation unit has a flow rate of 10 000 m^3/h and a temperature between 20 and 40 °C. The gas is saturated with water and its composition is given in Table 1.

After 36 days, the matter cools down and undergoes changes to facilitate the action of the worms. The matter is then fed to the worms in a building where aeration and temperature are controlled to allow the best vermicomposting conditions. The lombricubator (R) is a high tower shapeed unit, in which the worms digest the organic content of the refuse. Two months after its introduction, the compost iscollected, dried and stored, before commercialization.

THE PILOT UNIT

The composition of the effluent (Le Cloirec *et al,* 1989),led to selection of the process using biological filters, because most components of noxious gas are biodegradable. The study was carried on in two stages, a) first on a small pilot unit to determine the time required for the purification of the gas and optimization of all the parameters to develop an industrial scale unit, and b) the work under many different conditions in a vermicomposting plant. Data demonstrate the effectiveness and advantages of this odour control method.

DIMENSIONS

The size of the equipment for air filtration depends on three parameters, i. e., the quantity of the airflow to be purified, the nature of the noxious elements to be eliminated, and the concentration of the pollutants in the gas

The components of the odours are numerous and a precise identification of each is difficult (Le Cloirec *et al,* 1988 ; Bouscaren, 1984). It involves aliphatic organic components, sulfurous or nitrogenous inorganic or organic components and aromatic cyclic compounds. The concentration varies according to the temperature, the speed of ventilation, and the quantity of air renewed from the building.

THE CENTRIFUGAL VENTILATOR

It was designed to have the capacity to extract a fixed airflow (10 000 m^3/h) and ensure a 20 cm of water column pressure (loss of pressure proportional to the height of the filters+loss of pressure due to the length of the pipe).

THE BIOFILTER

It consists of thermally isolated containers with a lateral way-in, without constriction, and a structural body inside to limit the phenomenon of metal dilatation. These are filled with a light organic material, either turf, or humidified (50-80 %) vermicompost.(Martin *et al,* 1989 ; Dalouche *et al,* 1989). The air pipes need be preserved underground between the building and the biofilter.

RESIDENCE TIME

For the gas to be purified, the time of contact between the air and the biofilter should be around 40 seconds, when the velocity of the air is considered to be 90 m/h (0,025 m/s). The biological reactions, being slower than the chemical ones, require relatively longer treatment in the bioelement. Thus, the installations required are fairly larger.

THE SURFACE OF THE FILTER

The computation of the surface was made in relation to the airflow treated (Q) at the surface of the filters (S) :

$$Q = SUo \qquad Uo : \text{travelling speed of the air}$$

$$S = Q/Uo = 10\,000/90 = 111\ m^2$$

THE HEIGHT OF THE FILTER

The height of the filtering element was estimated to be 80 cm, in order to avoid the compression and the agglomeration of the organic material and to guarantee a constant duration of the treatment of the gas.

THE DISTRIBUTOR

The distributer is an essential element of the filtering process. Its role is to distribute the gas as evenly as possible, throughout the organic material, and support this organic material.

Studies on perforated panels showed a number of limitations such as a) clogging of the panel by the organic material, b) poor distribution of the air and self-selection of preferred airways, c) condensation of the hot and humid air on the panel; the air becomes saturated with water and its temperature is between 20 and 40°C, and d) a risk of freezing in the winter.

For these reasons, a porous environment, such as a layer of pozzuolana of 15 cm, placed on a panel with holes of 5 to 10 mm and below the organic material, was chosen. This system avoids the clogging of the panel, the high humidification of the filter and eliminates the risk of frost.

THE CONDENSER

To avoid the condensation of water in the biofilter, a condenser was installed to dry the air from the bisanitization unit. Some of the noxious molecules soluble in water could also be eliminated and the dimensions of the filter reduced.

THE COST

The cost of an installation (material and maintenance costs) of this biofilter is much less than that of other purification techniques. A study conducted by SAPS Anticorrosion Society (Le Cloarec et al, 1988) gives a comparison between the biofiltering and other techniques of air purification (Table 2).

Table 2. Comparison of biofilters and other odour control methods.

Process	Catalytic oxidation	Thermal oxidation	Carbon sorption	Chemical scrubbing	Biofilters
Material costs (kF)	805	760	175	322	300
Maintenance costs for year(kF)	500	521	730	280	110
Removal rate for ammonia (%)	92	98	>95	>99	>95
Removal rate for amines (%)	98	99,9	>99	>99	>99
Removal rate for sulphur products (%)	96 à 99	99	98	95 à 99	>99

CONCLUSION

This study allowed to clarify the following points on the level of gaseous effluents from a composting unit (the bisanitization), as well as the efficiency of the biofilter to purify the air from its noxious elements. The gas contained alcohol in large proportion, aldehydes and amines. The mercaptans or hydrogen sulphide are present in small quantities. For the actual treatment, a biofilter gives efficient results, but this efficiency decreased quickly because the organic matter was clogged by water condensation. A condenser was introduced on the pipe in the filter, to prevent these phenomena. It allowed the elimination of a large part of the soluble molecules by absorption-condensation. This in turn, allows to increase the life-span of the biofilter, avoids the problems of condensation in the distributor and reduces the size of the installation. The biofiltering is not a new technique but is rarely installed properly. The strong point in the present case is to put together an efficient, low-cost system which is easily adaptable to the requirements.

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