EFFECTIVENESS AND ENVIRONMENTAL IMPACT OF SWINE MANURE COMPOSTING

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ABSTRACT

In the frame of CNR-MIUR National Program on "Recycling of agricutural-industrial wastes", three prototypes of turning machine were realized. The first and the second operated on the solid fraction of cattle, rabbit and poultry manure. The third prototype was further improved and operated on the solid fraction obtained from swine manure after liquid/solid separation.

Objectives of the trials on swine solid manure composting were to test the effectiveness of such a new prototype of turning machine, to make a qualitative evaluation of the process and of the final product by monitoring several chemical parameters and to study the environmental impacts on air during the process. Several parameters were monitored in order to accomplish these objectives: process temperature, oxygen concentration, emission of noxious gases (CH_4, CO_2, NH_3, N_2O), total and volatile solids, pH, C:N rate, respiration index, humification index and microbial load.

The turning machine has proved to be effective from the technical point of view. The aeration level deriving from the turning of the biomass showed to be very good. The high moisture level of the raw material did not interfere with the correct evolution of the process and the final compost had good qualitative characteristics. Gas emissions from compost windrow had a decreasing trend from thermophilic to curing phase.

In conclusion, this method of managing manure could represent an interesting opportunity for swine farms, however potential impacts on air have to be considered.

INTRODUCTION

Liquid/solid separation of swine manure is a technique which allows to transform the raw slurry into a *clarified fraction* that can be handled, stored, treated and transported with lower energy consumption, and a *thickened fraction* (separated solids), which can be easily handled. Moreover, composting of the separated solids could allow the agricultural exploitation of the wastes through an increase in their agronomic value. However, swine manure composting at farm level is a not-well-known process and only a few types of equipment are nowadays available.

In the frame of CNR-MIUR National Program on "Recycling of agricutural-industrial wastes", three prototypes of turning machine were realized. The first and the second operated on the solid fraction of cattle, rabbit and poultry manure. The third prototype was further improved and operated on the solid fraction obtained from swine manure after liquid/solid separation.

The objectives of composting trials of swine solid manure were to test the effectiveness of such a new prototype of turning machine, to make a qualitative evaluation of process and final product by monitoring chemical parameters and to study the environmental impacts in term of gaseous emissions.

MATERIALS AND METHODS

The composting equipment is represented by a mechanical turning device, derived from the machines used for the extraction from silos of corn silage for animal feed (figure 1). It features a front mill equipped with blades, characterized by a working width of 2.0 m, and an inclined elevator belt equipped with blades. The machine faces the windrow head-on and the mill draws the material from the windrow discharging it on the elevating belt. Once on the belt, the material is lifted and then discharged to form a new windrow (figure 2). Two rear deflectors help to shape the new pile. The machine is powered by a 15 kW hydraulic – electrical engine, for propulsion and for operation of the turning mechanism. Further characteristic of the turning machine are a feeding speed of 0.6 m min^{-1} and a working power of 32 m^3 h^{-1}.

Figure 1. *Composting equipment tested on separated solids from swine manure.*

Figure 2. *Compost windrow after turning operation during thermophilic phase.*

The composting experimental trial was carried out in 2002, during July and August. The monitored parameters were: process temperature, oxygen concentration into the biomass, emission of noxious gases (CH_4, CO_2, NH_3, N_2O) and humification index. Other parameters, such as total and volatile solids, carbon and nitrogen, pH and microbial load were monitored during the trial, but they are not discussed in the present paper.

In particular, gas emission rates (ammonia, nitrous oxide, methane, carbon dioxide) were evaluated three times (before turning, immediately after turning and 1 hour after turning) every 48 hours. A dome structure was used to cover a portion of the emitting surface, thus creating an airtight chamber. Gas concentration inside the chamber was continuously monitored for a period of about 0,5 hours with a photo-acoustic gas monitor (Bruel & Kjaer, Type 1302). The gas concentration inside the chamber increased as a result of the gaseous emissions, thus the emission rate was calculated as dC/dt (Hornig, 1999).

RESULTS AND DISCUSSION

Temperature process rapidly increased, reaching 60°C after 48 hours from the windrow formation. Thermophilic phase proceeded for about 35 days, successively process temperature slowly decreased (figure 3). During the first phase, turning operations had a positive effect in temperature growth and in compost aeration.

Humification index (figure 4) decreased from 0.75 to 0.50 during the thermophilic phase and settled below 0.30 at the end of the curing phase (75^{th} day).

CO_2 cumulative emission continuously increased during the process (figure 5); however, emission rates during the first days were higher than those measured during the following weeks. CH_4 and NH_3 emissions had an increasing trend during the first 18 days of process, then emissions did not grow up anymore (figures 6 and 7). N_2O emission continuously increased during the process, with the highest emission rates after the 18th day (figure 8). Ammonia emissions during the turnings ranged from 0.14 to 0.25 g NH_3 h^{-1} m^{-2}; they were considerable higher than those measured during the days after turnings (0.01 – 0.07 g NH_3 h^{-1} m^{-2}). However, since the duration of emission peaks was extremely short, their contribution to the total emission was limited.

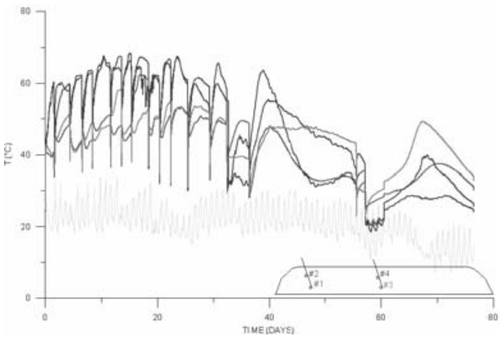

Figure 3. *Process temperature.*

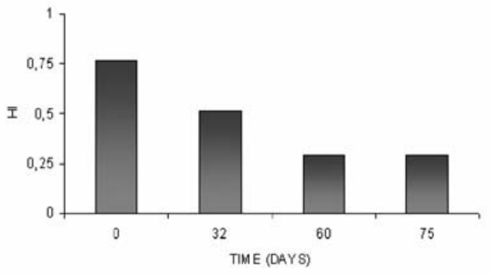

Figure 4. *Humification index.*

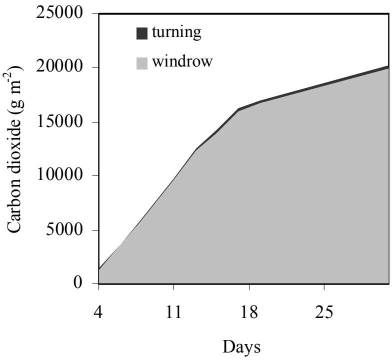

Figure 5. *CO_2 specific cumulative emission.*

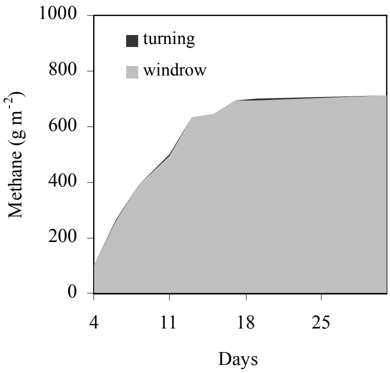

Figure 6. *CH_4 specific cumulative emission.*

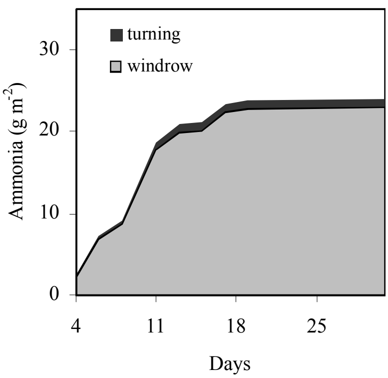

Figure 7. *NH_3 specific cumulative emission.*

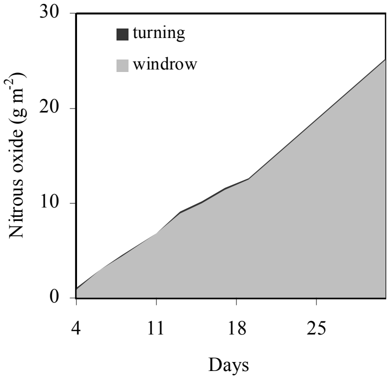

Figure 8. *N_2O specific cumulative emission.*

CONCLUSIONS

The turning equipment proved to be effective for composting the swine manure solid fraction. The high moisture level of the starting material did not interfered with the correct evolution of the process and the final compost had good qualitative characteristics.

Overall emissions of about 20 kg CO_2 m^{-2} and 0.7 kg CH_4 m^{-2} were calculated.

Nitrogen was released like both ammonia (about 24 g NH_3 m^{-2}) and nitrous oxide (about 25 g N_2O m^{-2}). Nitrogen lost in these forms amounted to about the 3.4% of the total nitrogen in starting material.

Gas emissions measured during and immediately after the turning operations did not seem to give appreciable contribution to the overall process emissions. Ammonia emission rate during the turning operations was higher than 0.2 g h^{-1} m^{-2}, but it rapidly decreased the first hour after turning. Ammonia emissions during the turning operations contributed for less than the 5% to the overall ammonia emissions.

Methane emissions from the windrow were probably due to the establishment of anaerobic conditions in the windrow core. In fact, oxygen level in the core decreased below 1% of saturation since 30 minutes after the first turnings. This suggests to more frequently perform turnings during the first days of process.

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