BEHAVIOUR OF ENTERIC MICRO-ORGANISMS DURING COMPOSTING OF RURAL SEWAGE SLUDGE

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Introduction

The spreading of sludge will only be possible on the condition of being able to guarantee to farmers and consumers the harmlessness of this practice. To minimize the potential risk for the health of humans and animals, it is necessary to coordinate sludge applications in time with planting, grazing or harvesting operations. For these reasons, sludge could not be applied continuously and must be stored in tanks during about 6 months before application. In this context, we studied the effect of sludge co-composting on survival of bacteria present in sludge stored in a tank of a rural water treatment plant.

Enumeration of bacteria covered one whole compost cycle lasting from fresh sludge to mature compost for a period of 7 months. Temperature and bacterial densities were measured in three relevant locations on the pile including the side of the incoming air flow (incoming air area), the bottom (in the middle of the pile) and the top of the pile (outcoming air area).

Material and Methods

A total of 8.1 tons of pressed sludge (15% of dry matter) were mixed with 1.4 tons of straw. The composting period carried out over 4 months with turning every month was considered as the fermentation phase, and the following 3 month period without turning, as the maturation phase.

The pile temperature profile was recorded by means of thermocouple probes inserted into the 3 areas of the pile and connected to a digital logger. The mixture was sampled upon settling, during each turning and at the end of the maturation period. Each sample was carried out in four replicates.

Enumerations of *Salmonella* and *Clostridium perfringens* were performed according to AFNOR methods[1, 2]. Enterococci, *E. coli* and *Listeria monocytogenes* were enumerated by the procedure previously described by Garrec *et al.* [5].

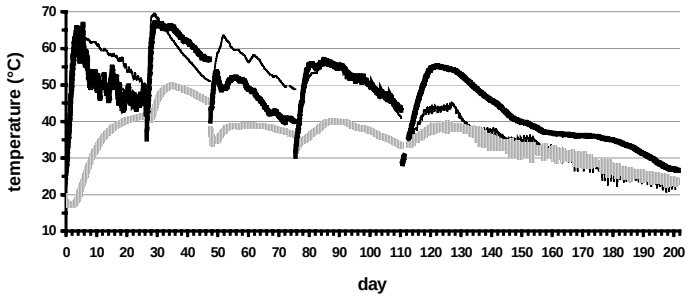
Results

During the fermentation phase, the peaks of temperature of the incoming and the outcoming air areas were rapidly reached after each turning and ranged between 53 and 69°C whereas the temperature of the bottom did not exceed 42°C except in the 2nd month (figure 1).

The maximum temperature decreased progressively during the composting process but still reached 55°C in the outcoming air area during the maturation phase. The maximum temperature decreased progressively during the composting process but still reached 55°C in the outcoming air area during the maturation phase.

Figure 1. *Temperatures inside the heap (incoming air area : — ; outcoming air area : Ƶ ; bottom : Ƶ). Days 0, 27, 48, 76, 111 and 202 correspond respectively to the settling, turnings and unloading of the heap.*

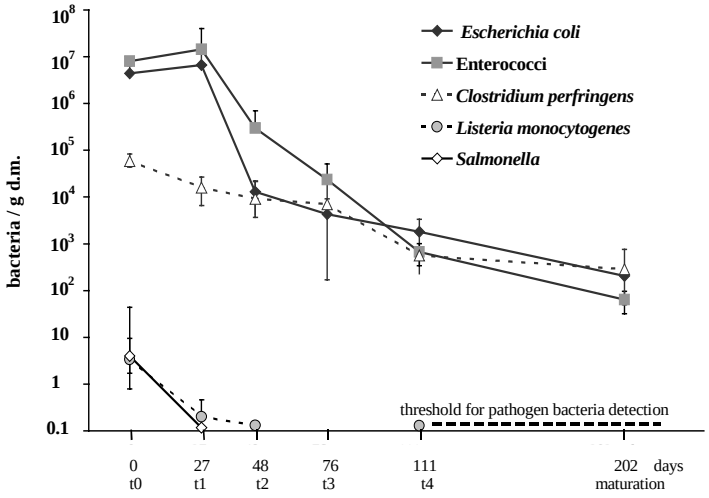
Faecal indicators, of which the concentrations slightly increased after the first turning (figure 2) were not totally inactivated although the temperature reached 66°C in the



pile. It was necessary to await the 2nd turning to observe a significant decrease.

The effect of composting on *C. perfringens* is reflected by the regular disappearance of approximately a factor 2 until the 4th turning.

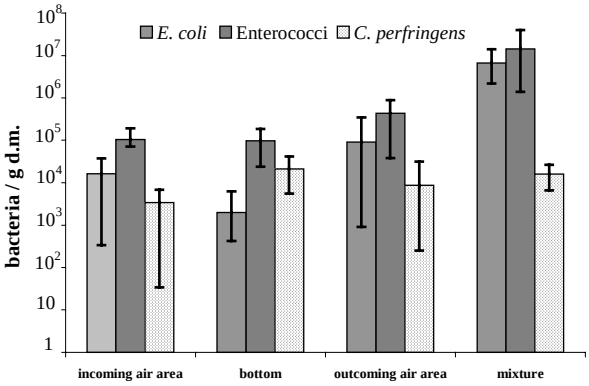
Figure 2. *Average concentrations of bacteria during the composting. Bars indicate minimal and maximal values.*



Salmonella was isolated only in one sample of the 1st turning and never afterwards whereas *L. monocytogenes* was still present in the 4 samples of compost carried out after one month of composting (data not shown).

Regardless of the period of composting, the densities of bacteria in the 3 areas of the pile before the turning did not significantly differ from one area to another as is shown in figure 3 for the 1th month of composting.

Figure 3. *Average concentrations of bacteria in the 3 areas and in the mixture before and after the 1th turning. Bars indicate minimal and maximal values*



The frequency of detection of the bacteria and their concentrations in the mixture carried out after each turning were systematically higher than those of the 3 areas. This phenomenon can be explained by the existence of zones of the compost in which concentrations of micro-organisms were probably higher. As a consequence, the integral mixture of the pile at the time of each turning could involve a slight increase in bacterial concentrations.

Discussion

In agreement with the results of Sesay *et al.* [6], we observed that both faecal indicators presented a similar length of survival during the composting of sludge, whereas longer survival of enterococci in relation to the coliforms during composting was reported by Tiquia and Tam[9]. It appears that the inactivation of micro-organisms depends not only on the type of bacteria but also on the composting process and on the origin of the biowaste.

Bacterial regrowth that we observed for faecal indicators had already been reported by Sesay *et al.* [6] who observed a regrowth of faecal indicators after each turning of compost which they put down to a contamination of the mixture by the external zone of the compost non affected by the rise in temperature. This hypothesis could explain why, in our study, the bacterial densities, after the turning of the compost, were always higher than those obtained in each zone of the pile.

Salmonella disappeared more quickly than faecal indicators as was previously observed[8] but the absence of detection of *Salmonella* is probably due to their weak level in the initial product which involves the threshold of detection being rapidly reached. In agreement with Watkins and Sleath[10], we observed that the survival of *L. monocytogenes* was greater than that of *Salmonella*. Given the high resistance of *L. monocytogenes* to environmental factors [3, 4], it is possible that the presence of *L. monocytogenes* up to the 4th turning is due to a better environmental adaptation of this species during the fermentation phase of composting.

Conclusion

The hygienic effect of composting of the sludge mixed with straw results in a significant reduction of enteric micro-organisms without however leading to the complete disappearance of faecal indicators. As reported by Sidhu *et al.* [7], the technique of composting does not guarantee the complete hygienisation of the end product obtained, insofar as it is necessary to take into account a potential regrowth of bacteria.

Furthermore, the use of *E. coli* or enterococci as indicators of hygienisation could be discussed as the survival of pathogen bacteria differs from one pathogen to another, as we have observed with *Salmonella* and *L. monocytogenes* in our study.

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