COMPARISON OF COMPOSING AND UREA TREATMENT FOR SANITISING OF FAECAL MATTER

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ABSTRACT

The second most nutrient-containing fraction from households, faecal matter, is highly likely to contain pathogens and thus requires some form of sanitising treatment. Two alternatives for this treatment, composting and urea treatment, were evaluated and compared to storage for 50 days. Thermal composting of faeces together with food waste (35% DM) resulted in a treatment temperature of over 65°C for 3 consecutive days. However, not all the material maintained this high temperature, i.e. close to the inlet of air. In the urea treatment, the added 3%N-NH_3 increased the pH in the faecal material (10% DM) from 8 to >9 within one hour of application and resulted in a good reduction in the indicator organisms for bacteria (Salmonella and E-coli D_r < 0.7 days), viruses (D_r <7.5 days) and parasites (no viable organisms after 50 days). The ammonia (added as urea) are not degraded further during the treatment, which results in no risk for regrowth and an improvement in the fertiliser value as the nitrogen content is increased. Storage of faecal matter (10% DM) only reduced the presence of faecal coliforms while the enterococci and the viruses were not reduced and viable salmonella and *Ascaris suum* were found throughout the 50 days of storage.
Keywords: *chemical disinfection, composting, faeces, sanitation.*

INTRODUCTION

Toilet waste fractions contain the major proportion of the nutrients from households (Vinnerås, 2002). These nutrients are clean with respect to heavy metal pollution as they reflect the food consumed. In a sustainable society, these nutrients have to be recycled. Toilet waste fractions are associated with a high risk of pathogen content. Diverted urine usually contains only small amounts of pathogens, mostly originating from faecal contamination (Höglund, 2001). Human faeces contain approximately 10^{10} microorganisms per gram dry matter (Lentner et al., 1981) and some of these can be pathogenic. The three main transmission routes for *Ascaris*, and probably for other pathogens too, are: transmission from faeces-contaminated surfaces and materials; transmission to workers in fields that have been fertilised with faeces or sewage; and transmission by consumption of vegetables fertilised with faeces or sewage (Feachem et al., 1983). If proper sanitation of the faecal matter were achieved, a distinct decrease in transmission of *Ascaris*-related disease would occur. The main transmission routes for other intestinal diseases are probably similar to those for *Ascaris* and by proper treatment the occurrence of intestinal diseases in general would decrease.

The objectives of this paper were to compare thermal composting and basic chemical treatment as faecal sanitation methods for production of faeces safe to use as a fertiliser on arable land.

METHODS

In the thermal composting, faecal matter was cocompost with kitchen waste and old compost in the proportions 31%, 60% and 9% of the dry matter, respectively. The composting was performed in a 90 litre compost reactor with 20 cm of foam plastic insulation. Throughout the composting process, the temperature was monitored at two locations, in the middle and next to the wall of the reactor. The method of the composting is more fully presented in Vinnerås et al. (2003a).

The second strategy was based on faecal matter watered down to a slurry of 10% dry matter content, urea was mixed into the sludge to a content of 3% N (wet weight) and then naturally degraded into ammonia and carbon dioxide by the enzyme urease, which is produced by faecal bacteria. The 50 days of treatment are closer described in Vinnerås et al. (2003b). A storage-only treatment was used as a reference method for the chemical treatment and samples were taken at the same times as for the chemical treatment.

RESULTS AND DISCUSSION

The thermal composting of the faeces mixture resulted in temperatures well above 60°C for several days between day 10 and day 15 (Figure 1).

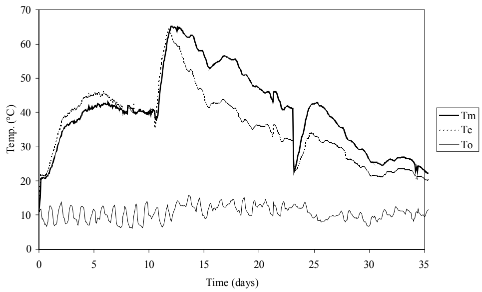

***Figure 1**. The average temperature at 10-minute intervals in the middle of the compost (Tm), at one of the walls of the compost (Te) and in the surroundings (To) for the pilot scale experiments.*

The compost did not reach really high temperatures (60°C) until day 10, before which the temperature was stabilised at about 40°C. At day 10 the material was mixed and the temperature rose to approximately 65°C within 2 days. Using the equations for disinfection level given by Vinnerås et al. (2003a) according to the inactivation time and temperatures given by Faechem et al. (1983) gave very high safety margins for total die-off.

However, the temperature at the air inlet did not maintain the same high temperature. Thereby, approximately 5% of the material did not have as high a rate of inactivation as the rest of the material. By turning the material three times during the high temp period, assuming total mixing according to equation 1 (Haug, 1993), it was possible to attain an inactivation corresponding to approximately 5 $\log_{10}$ times.

$$n_t = n_0 (f_l)^{N+1} \qquad (1)$$

n_t= number of surviving organisms; n_0= number of organisms initially present; N= number of pile turnings; f_1= fraction of compost material in low temperature areas

For bacteria, there is a risk that the number of pathogenic bacteria would increase in the area with lower temperature. In that case, the assumption of a 5 $\log_{10}$ decrease would be an over-estimation of the efficiency of the treatment. Regrowth of the pathogenic bacteria after the treatment can also occur as it is not possible to guarantee total inactivation during the treatment. However, studies have shown that the re-growth of pathogenic bacteria are smaller in matured compost compared to untreated material (Sidhu et al., 2001).

Chemical treatment

The storage of the faecal matter showed some inactivation of the monitored organisms during the 50 days of study. However, all monitored organisms except *E. coli* were detectable after the 50 days of treatment (Figure 2a), and viable *Ascaris suum* eggs were still found.

Addition of 3% nitrogen on a wet weight basis resulted in an increase of the pH to 9.2 within one hour after the addition, as the urea was enzymatically degraded to ammonia and carbon dioxide. After 5 days no faecal coliforms or salmonella were detected, after 20 days no enterococci were detected and after 50 days no viruses were detected (Figure 2b). No viable Ascaris eggs were found after 50 days of treatment.

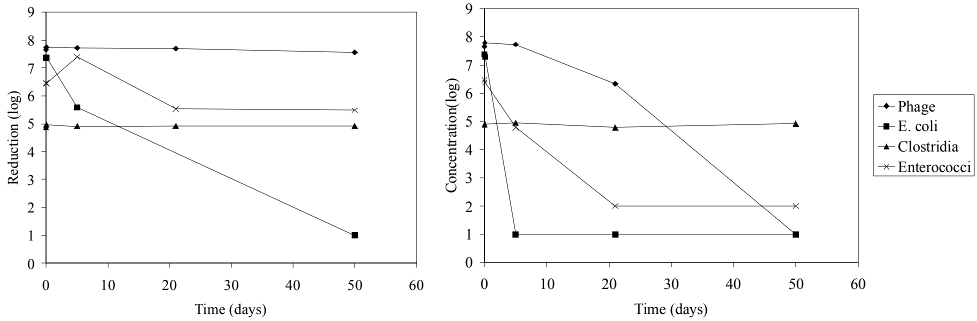

***Figure 2**. a) The reduction in bacteria and viruses in faecal matter during 50 days of storage in a closed container at 20 C. b) The reduction of bacteria and viruses from treatment with 3% ammonia nitrogen.*

The speed of reduction of the microorganisms investigated decreased throughout the treatment, mainly due to the time for the reduction of the urea to ammonia. Especially clear was it for the phage, as the D_r (decimal reduction) value decreased between each of the analyses. The decrease with time in D_r value is evident for the virus as the D_r value between day 21 and day 50 was <5.4 days compared to the average of <7.5 days.

The ammonia is not consumed during the chemical treatment. Therefore, as long as no ammonia is ventilated off the disinfection effect is not changed and there will be no risk for regrowth in the sanitised material. When the material is used as a fertiliser, the ammonia used for sanitation acts as a potent fertiliser component. Thus the fertiliser value of the faecal matter treated is increased and the actual cost for the sanitation, both economic and environmental, can be allocated to the return from the added nitrogen fertiliser.

GENERAL DISCUSSION AND COMPARISON OF THE TWO TREATMENT ALTERNATIVES

The system with chemical treatment can be used on both small and large scale as the only requirement is that the system be kept closed and mixed initially. However the material needs to be liquefied as the treatment depends on ion transport in the material, a process for which water is required. In the tests performed here, the dry matter content was set to 10%. In a study by Vinnerås (2004), a good effect on reduction of *Salmonella* in cattle manure using considerably lower urea dosages was shown. It would probably be possible to use lower urea addition for the faecal treatment to. Thereby, it would be possible to use time of treatment as a function of the urea addition to attain properly sanitised material.

Thermal composting is best performed at 35% dry matter, and high dry matter containing material has to be added to enable the faecal matter to be composted as the excreted material normally contains 15-25% dry matter. To get a homogeneous heat distribution in the material the composting process has to be performed in a well-insulated reactor. Addition of inert materials such as soil and ash during the collection of the faecal matter decreases the energy content and needs to be compensated for by addition of other energy-rich material if sufficient heat is to be produced.

If the incoming air is not preheated, there will be an area holding a lower temperature than the main body of the compost. In this low temperature area the reduction of pathogens is slower and there is also a risk for regrowth of bacteria. The heat released from composting the faecal matter with kitchen waste in the present study resulted in sufficient heat production to achieve temperatures of over 65°C for several days.

Both these treatment alternatives require handling of untreated faecal matter, but it would be possible to make chemical treatment of liquid material into a closed and mechanised system.

CONCLUSIONS

Not all the material was, during the composting heated to high temperatures and this meant that there was a risk for regrowth of bacteria or for contamination of the treated matter.

Storage of faecal matter (10% DM) only reduced the presence of faecal coliforms while the enterococci and the viruses were not reduced and viable salmonella and *Ascaris suum* were found throughout the 50 days of storage.

The most efficient treatment for attaining hygienically safe faecal matter of the three investigated was addition of urea, which was degraded into ammonia upon addition and which increased the pH from 8.0 at the start to 9.2 within one hour after addition.

Acknowledgements. The work was financed by Oscar och Lili Lamms stiftelse and by SIDA (Swedish International Development Aid).

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