Composting and the Fate of *Ascaris lumbricoides* Ova*

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Abstract

Viable *Ascaris lumbricoides* ova counts were used to assess the efficiency of laboratory, pilot plant, and full-scale composting experiments utilizing dried digested sewage sludge and raw domestic refuse. The results have indicated that the turning and watering of windrows should be undertaken weekly throughout the whole maturation process and that the period of maturation, providing that temperatures of 65°C are generated, should be maintained for at least seventy days to ensure *Ascaris* ova inactivation.

Introduction

Conventional methods employed for the disposal of sewage sludges are land disposal, sanitary landfill, incineration, ocean dumping and composting. Land application as practised in many countries, could create an hygienic risk, since microbial pathogens and parasite ova if present in the sludge are a distinct hazard to public health. The high cost of land prohibits many sanitary landfill or land disposal schemes and legislative proposals calling for stricter environmental pollution control measures reflect the increasing awareness of this problem in many countries.

Utilization of digested sewage sludge in the controlled composting of domestic refuse offers a less hazardous method of sludge disposal because heat development during the thermophilic stage (47 to 65°C, 70 days) of composting should inactivate any vegetative pathogens and parasite ova present. Furthermore, the addition of digested sludge improves the biological efficiency of the composting and the chemical quality of the product.

Golucke and Gotaas (1954) reported that the magnitude and duration of high temperatures, as well as the antibiosis characteristics of a mixed population of micro-organisms, offered sufficient basis for believing that no pathogens, parasites or parasite ova could survive the composting process. Unfortunately, Golucke and Gotaas based their assumption on the thermal death points of some common pathogens and parasites in aqueous solutions in the laboratory, which bore little resemblance to conditions in the compost heap.

The lack of knowledge of the helminthological and indeed the bacteriological quality of composts containing sewage sludges supplied to the general public led Krige (1964) to initiate an investigation into the problem. Matured compost samples from non-mechanized sources at various municipalities and the product obtained from a rotating drum pilot composting plant were investigated. The results showed that the product from non-mechanized methods contained *Ascaris lumbricoides* ova as well as coliform bacteria. Compost produced by the pilot plant was consistently free of *Ascaris* ova, but contained high numbers of coliform bacteria. Krige did not regard coliform counts as a suitable index of the hygienic quality and recommended regular examination for viable *Ascaris* ova. It was later found that the method used by Krige to determine *Ascaris* ova in compost did not always succeed in recovering the ova even though these were known to be present. The recommendation that the incidence of *Ascaris* ova should be used as an indicator test for the helminthological quality of sludge-enriched compost was very valuable (Keller, 1951) and was thereafter adopted by the National Institute for Water Research (NIWR).

The application of a modified method to recover *Ascaris* ova (Steer *et al.*, 1974) has shown that viable ova were at times not only present in freshly stabilized compost from mechanical plants but also in some samples of eight weeks old matured compost.

Research reported by Keller (1951) and in the Chinese Medical Journal (1975) on the thermal deathpoint of *Ascaris* ova also revealed many contradictions, as all results were obtained with *Ascaris* ova suspended in aqueous solutions in the laboratory. It is apparent that survival rates determined for *Ascaris* ova in aqueous solutions are not directly applicable to

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Ascaris ova in compost, especially in the case of full size plants where an irregular temperature distribution often occurs in the pre-fermenter and maturation windrows.

This report deals with the mortality rate of *Ascaris* ova in digested sludge-enriched compost in various laboratory, pilot-scale and full-scale composting systems. Recommendations have been made for procedures to be followed to ensure inactivation of the ova during windrow maturation.

Materials and Methods

Laboratory incubator tests

Milled domestic refuse was collected from the Bellville Municipality composting plant for the incubator experiment. This refuse was ground further in a sterilised hammer-mill to pass a 6 mm mesh. Samples with a moisture content of 50 per cent were then prepared by mixing 11,1 g of refuse with 7,9 m*l* of physiological saline (0,85 per cent NaCl) suspension of *Ascaris* ova. Each of these samples was introduced into a tube 35 mm in diameter and 140 mm long with a perforated bottom to allow proper aeration and was placed in an incubator into which air was pumped at a rate of 13 m*l*/min, the latter being calculated from the oxygen consumption rate of raw refuse (0,8 $l\ kg^{-1}\ h^{-1}$). Although the moisture content was adjusted twice daily to 50 per cent by injecting the required amount of sterile water into every sample, the low humidity in the incubator resulted in low moisture values between adjustments. Duplicate tubes were taken from the incubator every 24 h for a 15 day period in order to determine the number of *Ascaris* ova and the viable percentage thereof. Control samples were prepared by introducing 1 m*l* of the stock ova suspension into 9 m*l* of physiological saline. Control samples were kept in test tubes at a temperature of approximately 20°C and duplicate samples were analysed every 24 h.

The stock ova suspension was prepared according to Wiley and Westerberg (1969) and Brown (1928) with minor modifications. Three female *Ascaris lumbricoides* worms were collected from the Bellville sewage works and cut longitudinally down the midline. The last 75 mm of both uteri of each worm was then removed and homogenised for five minutes in a 0,001

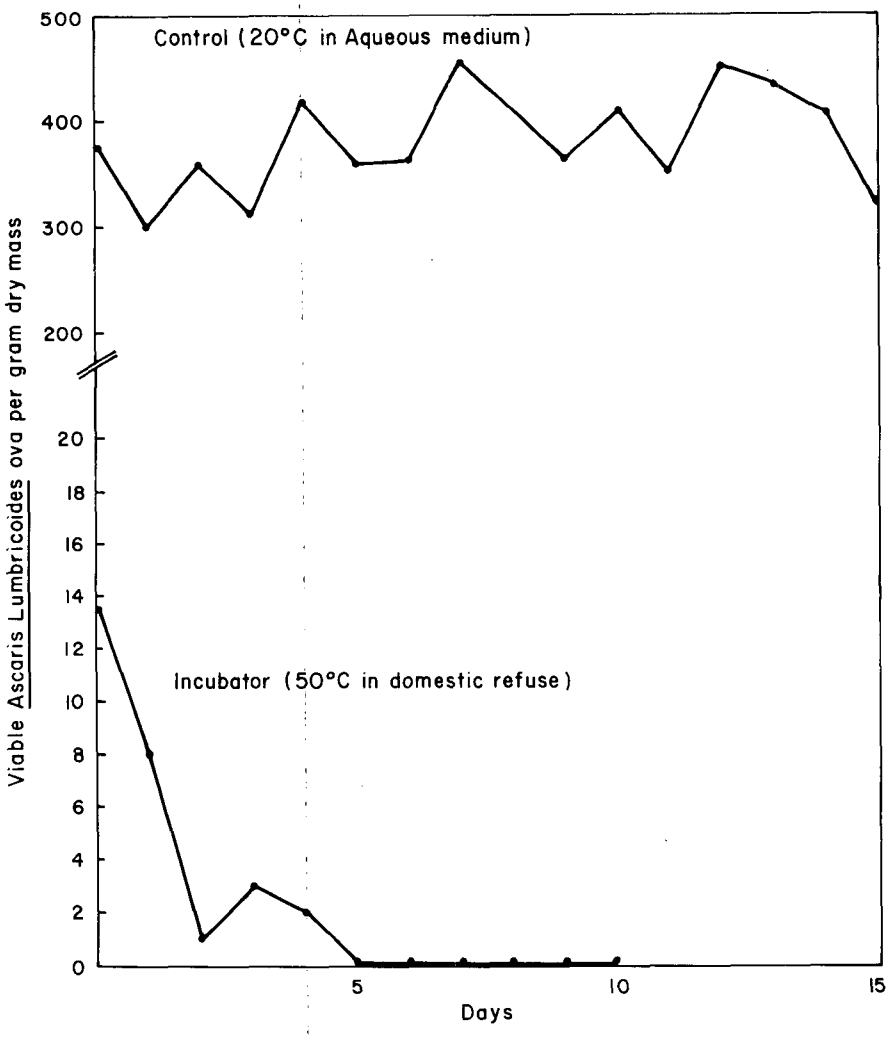

Figure 1
Mortality rate of Ascaris lumbricoides *ova during laboratory incubator experiment using domestic refuse only*

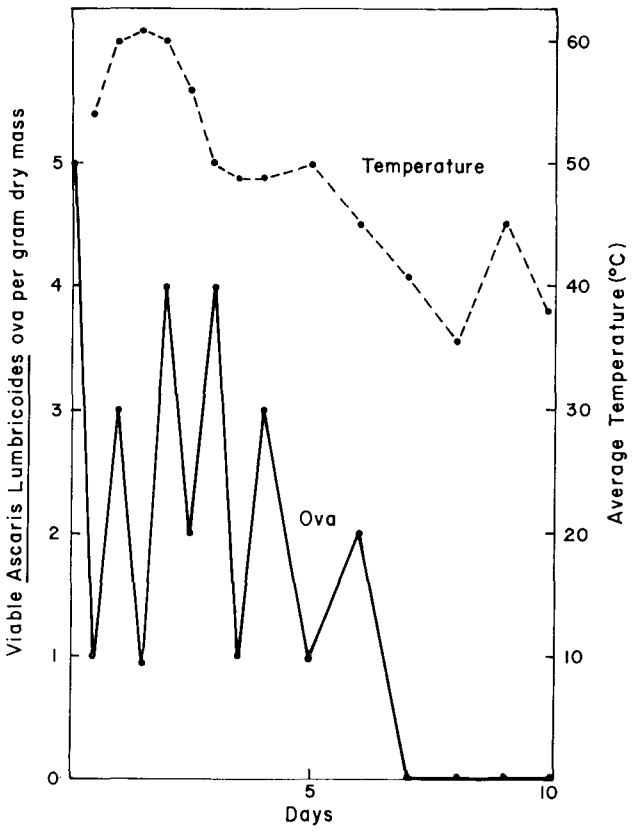

Figure 2
Temperature and mortality rate of Ascaris lumbricoides *ova during pilot scale pre-fermentation experiment with a mixture of domestic refuse and dried digested sewage sludge*
Ratio sludge:Refuse = 1:4 dry mass basis

per cent formalin solution. This procedure yielded a suspension containing 6 400 uniformly developed ova per m*l*, which is equivalent to 320 ova per gram of sample in the incubator and 640 ova per m*l* in the control samples.

Pilot plant experiment

Milled raw domestic refuse from the Bellville municipal composting plant was also used for the pilot plant experiment which was designed to simulate pre-fermentation conditions. The refuse was mixed with dried digested sewage sludge from the Athlone sewage works as a source of *Ascaris* ova in the ratio sludge: refuse = 1:4 on a dry mass basis. Moisture was adjusted to 50 per cent and the compost introduced into a rotating drum pre-fermenter of 0,3 m^3 capacity (Nell and Krige, 1971). The experiment covered a period of ten days during which time the residual oxygen concentration in the drum was controlled between 5 and 10 per cent. Samples were taken at twelve-hourly intervals.

Full-scale windrow composting with and without pre-fermentation

Two runs were conducted at the Worcester municipal composting plant where daily batches of refuse are normally treated in separate pre-fermentation drums after sorting. Aeration is provided by means of flap-doors on the octagonal sides of the drums. These doors cover screens with 50 mm openings and are opened at the end of each run for four to five hours to allow the compost to be screened out and intractable material to be separated.

During the experiment, drums 1 and 2 were filled with dried digested sewage sludge and refuse in the ratio of 1:13. After adjustment of the moisture content to 50 per cent, the total mass of the raw materials in each drum was approximately 29 tons. Pre-fermentation over a period of four days was then applied to run 1 while run 2 was screened from the drum immediately after compaction and mixing. The products of both runs were then matured in windrows for ten weeks, during which period the windrows were turned and watered once a week. During pre-fermentation and maturation, samples were taken daily and weekly respectively.

All samples taken during laboratory, pilot and full-scale experiments were analysed for the presence of viable *Ascaris* ova according to the method of Steer *et al.* (1974).

Results and Discussion

Figure 1 records the mortality rate of *Ascaris* ova in milled domestic refuse during the incubator experiment, as compared with the viable ova counts in the control. Ova counts in the control samples varied, but indicated no significant decline in ova concentration. However, no viable ova could be detected in the incubator samples after five days at 50°C.

The data in Figure 2 show that *Ascaris* ova survived conditions in the rotating drum pilot plant for six days, in spite of the temperature being higher than 60°C for a one day period and higher than 50°C for at least two days.

During the full scale experiment with pre-fermentation followed by windrow maturation, *Ascaris* ova survived for at least fifty four days, a zero count being observed on the sixty third day (Figure 3). In contrast the run without pre-fermentation (Figure 4), with generally similar temperature levels of 65°C, inactivated all viable ova within forty two days. This indicates that the inclusion of pre-fermentation during full-scale mechanical composting had no advantage as far as the elimination of viable *Ascaris* ova is concerned.

The results as depicted in Figures 1 to 4 clearly demonstrate that the smaller and thus the more controllable the apparatus used, the shorter the period of time required to inactivate *Ascaris* ova. It, therefore, emphasises the inaccuracy of using laboratory data to predict *Ascaris* ova inactivation rates during full-scale composting. From Figure 3 it can be seen that a period of the order of 70 days may be required to inactivate compost enriched with dried digested sewage sludge from *Ascaris* ova.

Dried digested sewage sludge was used for all the experiments referred to in this paper. However, a full-scale composting experiment was undertaken utilising liquid activated sludge, and raw domestic refuse. Unfortunately the amount of liquid sludge that can be used is limited by the maximum moisture content that can be tolerated in the composting material. In this instance it was calculated that 610 *l* of liquid activated sludge must be added to each ton of refuse to produce a compost containing a desirable moisture content of fifty per cent. The helminthological results from this experiment have shown that viable *Ascaris* ova could not be detected after a period of two weeks of maturation.

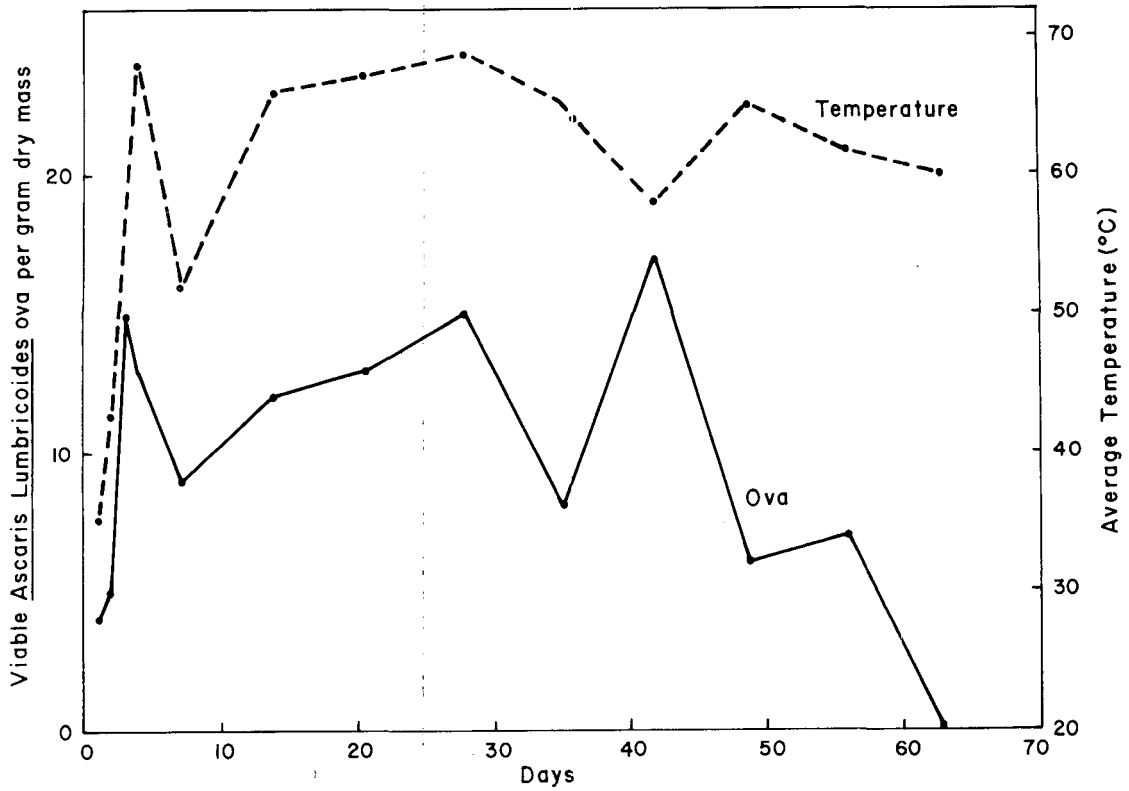

Figure 3
Temperature and mortality rate of Ascaris lumbricoides *ova during full-scale experiment with pre-fermentation followed by windrow maturation*
Ratio sludge:Refuse = 1:13 dry mass basis

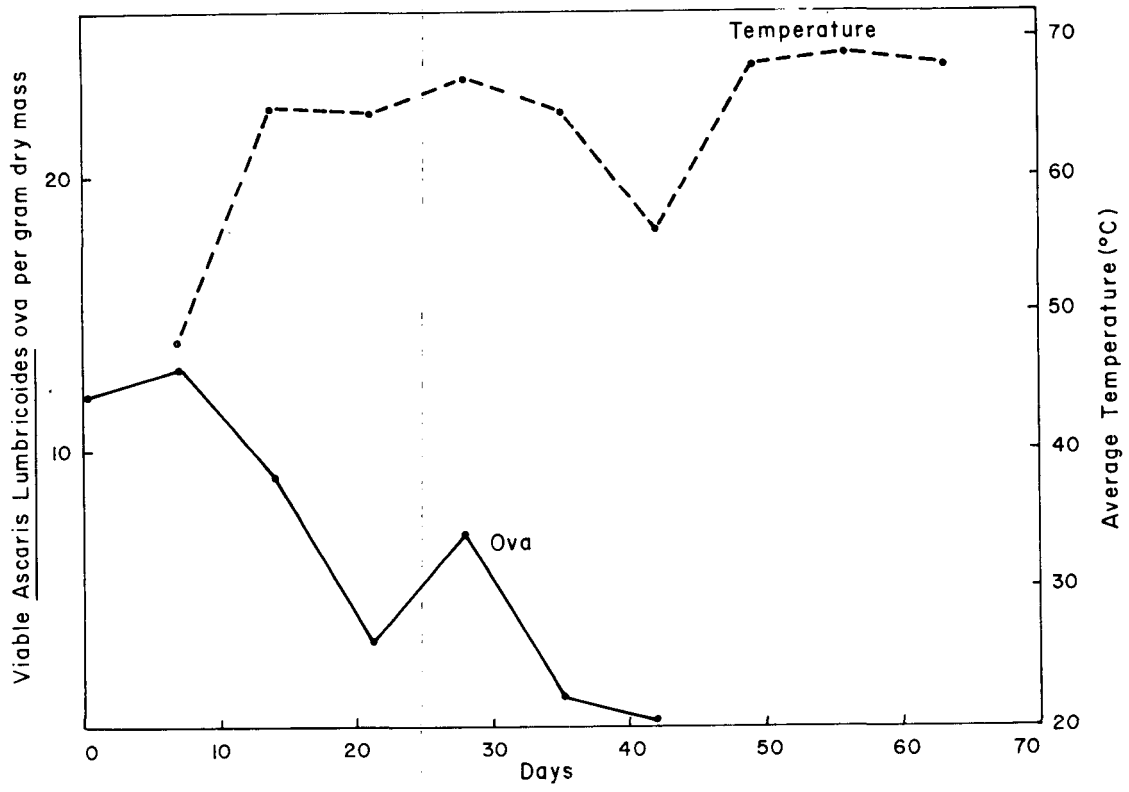

Figure 4
Temperature and mortality rate of Ascaris lumbricoides *ova during full-scale experiment with windrow maturation without pre-fermentation*
Ratio sludge:Refuse = 1:13 dry mass basis