Is an exposure time of 3 d at 60°C sufficient to sanitize VFY household bio-waste?

Aad Termorshuizen, 17 November 17 2017

Abbreviations used

FPR = Fertilising Products Regulation
SSO = source-separated organics

Introduction

The concept Fertilising Products Regulation (FPR) defines minimum temperature-time profiles for aerobic composting: 5 days at 65°C, 7 days at 60°C, 14 days at 55°C or 1 day at 70°C.

As explained in Termorshuizen (2017), this can be criticized from four points of view:

1. The scientific underpinning of these requirements seems poor,
2. Current scientific overviews on sanitation conditions for compost show contradictory results (Termorshuizen, 2017; Wichuk et al., 2011),
3. The more problematic pathogens clubroot and tabacco mosaic virus (TMV) are not only and primarily affected by temperature-time profile. For clubroot, a high moisture content during composting is essential. For TMV, microbial degradation is an important mechanism of inactivation which clearly is not optimal during the thermophilic phase of composting, and
4. Other activities at a composting plant needed to end up with compost free of pathogens are not included in the FPR (e.g. way of working with shovels, degree of material homogenization (which is affected by type of composting[1]), and avoidance of recolonization with pathogens.

Although the process is already in an advanced phase and a complete reassessment of the requirements of sanitation would be best, nevertheless, in this document we concentrate on the considerations for sanitation for 3 days at 60°C. This short note lists these arguments.

Conclusions review

- Increasing insight based on research as well as on developments in plant breeding (resistant cultivars) leads to modified conclusions on risk assessment as compared to previous studies.
- Source-separated organics (SSO) expectedly contain only few potentially problematic pathogens at only low to very low densities. The likelihood that these pathogens lead, after composting for 3 d at 60°C, to problems at places where the compost is applied is therefore limited.
- Provided that all the material is completely exposed to a temperature-time profile of 3 d at 60°C, this will lead to sanitized SSO.
- For monostreams[2], the advice is to organize ad hoc risk analyses, because in this case possible present pathogens may occur here in way much higher densities than in SSO.
- However, considering the multiple conditions that influence sanitation, a local process validation could be an alternative for a generic time-temperature profile.

[1] Tunnel composting has a much more homogeneous temperature distribution during composting than (outside) windrow composting.

[2] Industrial monostreams are defined here as bio-waste streams of homogeneous composition originating from agriculture or the food-processing industry, and thus, it is unequal from SSO household biowaste.

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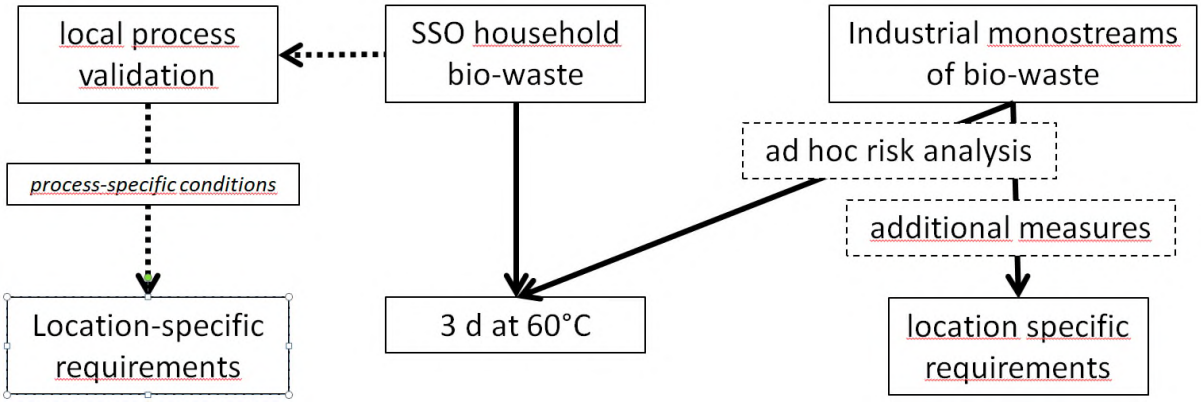

Figure 1. Illustration of the main findings of this note: SSO compost is safe after treatment for 3 days at 60°C. Industrial monostreams however need an ad hoc risk analysis which either leads to treatment of 3 days at 60°C, or, if there are additional risks, to elevated conditions. In principle, considering the multiple conditions that influence sanitation, a local process validation could be an alternative for a generic temperature-time profile.

Detailed comments

To answer the question how safe composting of SSO is at a minimum of 3 d at 60°C, I discuss here all plant pathogens that are considered as potentially problematic in one or more of the following studies: Noble & Roberts (2004), Noble et al. (2009), Termorshuizen (2001), Termorshuizen et al. (2005), Termorshuizen (2017), and Wichuk et al. (2013)[3]. In order to write a concise report, the background from the publications are not cited here again but only summarized. Only where new information is added, full references are provided.

- *Polymyxa betae* (pathogen of sugar beet causing rhizomania and, in addition, vectoring the virus BNYVV). More recent work (van Rijn & Termorshuizen, 2007) indicates that this pathogen has no risk. The temperature-time profile needed for inactivation in water was 30 min at 60°C or 4 d at 55°C. Survival at 40°C in compost leachate was about 10× less than in water, indicating that the inactivation conditions in composts are likely even less severe than those reported for water. In addition, most usually farmers grow sugar beet varieties that are resistant to *Polymyxa betae*.
- *Spongospora subterranea* (pathogen of potato causing powdery scab and, in addition, vectoring the virus PMTV). Powdery scab resides in the skin of potato tubers and is likely to be able to end up in SSO. It is however not easy to say how common powdery scab currently is. In any case, many new cultivars are resistant or tolerant to powdery scab but on the other hand, some old cultivars that are susceptible are still grown to some extent.

  There is only one reference to temperature-time inactivation profiles (Mackay & Shipton, 1983): powdery scab present on seed potatoes was controlled on average by 93% in a water bath after 10 min at 55°C. However, the variation was large: inactivation was 100% in 6 lots, 95% in 1 lot, 50% in 1 lot, and 0% in 2 lots.[4] Since strong inactivation was observed in the Mackay & Shipton (1983) study at relatively mild conditions (10 min at 55°C), it is quite likely that inactivation is acting also at 3 d at 60°C during

[3] Except at one place, no mention is made of survival under dry conditions since this is not relevant for composting conditions.
[4] In another study, Nielsen & Mølgaard (1997) reported that at at least 15 min at 90°C in a water bath powdery scab was inactivated, but they did not test more mild conditions. Although this reference may be used to indicate the high persistence of powdery scab this is incorrect, since in order to mention this a treatment leading to some survival of the pathogen should have been included also in the study.

composting, also since during composting also other inactivation mechanisms are active than only temperature. Still, more research is desired.

- *Fusarium oxysporum* (pathogen of various plant hosts, causing root rot and wilting). Termorshuizen et al. (2005) did not deal with this pathogen in detail, therefore this has been done recently in Termorshuizen (2017). The conclusion was that a temperature-time profile of 3 d at 60°C is likely sufficient. There is one scientific report in which survival was mentioned at 21 d at 65-74° but this can be critized[5]. In addition, the likelihood of bio-waste that is infected with the pathogen to enter SSO seems very low.
- *Plasmodiophora brassicae* (pathogen of cabbage crops causing club root). Termorshuizen et al. (2005) estimate that this potential problem is acceptable given the expected low levels of infected material to enter SSO. Research is needed to confirm that a high moisture content during composting (60% w/w) for some time in addition could even relax the current temperature-time profiles (Termorshuizen, 2017).
- *Olpidium brassicae* (vector of LBVV and TNV virus, pathogen of lettuce). Termorshuizen et al. (2005) estimate that these potential problems are acceptable given the expected, very low levels of infected material to enter SSO and the rare occurrence of the pathogen. However, the situation could be different for monostreams (see below).
- TMV (Tobacco and tomato mosaic virus, pathogens of multiple crops). Termorshuizen et al. (2005) estimate this problem as acceptable because of the rareness of the pathogen, and the fact that in practice resistant cultivars are used. In addition, an increase in the temperature-time profile will not improve a guarantee for complete inactivation. Rather, biological degradation could well be the primary mechanism of inactivation (Termorshuizen, 2017).
- CGMMV (Cucumber green mottle mosaic virus, a pathogen of cucumber). The disease is uncommon in the Netherlands and compost is not applied in substrate-grown cucumbers. Hence, the risks associated with the pathogen are considered low (Termorshuizen et al., 2005). The temperature-time inactivation profile of this pathogen is unclear. The only reference on this topic is from Avgelis & Manios (1992). In this study, it is reported that during composting of cucumber plant residues, the pathogen was still viable after 1, 2 and 3 days of composting but not after 4 or more days of composting. The temperature profile of these first 4 days was about 45, 62, 70 and 72°C. For judging monostreams (see below), more research is needed.[6]
- TRV (Tobacco rattle virus with a wide host range, vectored by some plant pathogenic nematodes including *Paratrichodorus* and *Trichodorus* spp.). Although TRV can survive at 3 d at 60°C, its vectors will be completely inactivated at these conditions, hence there is no risk (Termorshuizen et al., 2005).
- *Heterodera schachtii* (white beet cyst nematode, pathogen of sugar beets). Termorshuizen (2017) concluded that this pathogen is not an issue at 3 d at 60°C since several publications provide convincing evidence for that whilst the single publication indicating more severe inactivation conditions is less convincing[7].
- *Botryosphaeria obtusa* (wood pathogen with many hosts, only in S-Europe). According to Termorshuizen (2017)[8], there is only a single study on the survival of this pathogen during composting. In this study, in one composting instance, no survival was found and in the other

[5] In short and as explained in Termorshuizen (2017), this deals with a study by Christensen et al. (2001), where survival of *Fusarium oxysporum* f. sp. *lycopersici* (Fusarium wilt in tomato) strongly varied between 4 experiments. The authors were not able to explain this variation. The mechanism mentioned included biological degradation, which will be inactive during the thermophilic phase. Other studies, cited in Termorshuizen (2017), suggest lower temperature-time profiles needed for inactivation.

[6] The often-reported high temperature resistance of CGMMV as being able to withstand 2 d at 72°C is based on the survival of *dry* material (Avgelis & Manios, 1992) hence this information is not useful for estimating the survival during composting (Shlevin et al., 2012).

[7] The more doubtful results are from a 6-month incubation study of a hobby backyard composting heap. See Termorshuizen (2017).

[8] Lecomte et al., 2006.

the lowest detectable amount survived. The study is unclear about the prevailing composting conditions, including temperature-time profiles. Also, the study had been performed in closed incubation bags, which may have reduced the exposure of the wood material to the composting conditions. Hence, to base composting requirements based on this study is unrealistic.

- *Macrophomina phaseolina* (causing charcoal rot in many crops, only in S-Europe). A small-scaled composting with a not detailed temperature-time profile (maximum temperature reached was 60-62°C for an unknown duration) did lead to survival after an incubation of 21-28 d. However, a water bath study indicated complete inactivation at the much more mild conditions of 1.7 h at 50°C. In addition in soil, Sheikh & Ghaffar (1987) found complete inactivation at 3 d at 50°C during incubations of wet soil in an incubator. Thus, it is concluded that this pathogen is inactivated after 3 d at 60°C composting.
- *Microdochium nivale* (causing snow mold, foot rot and leaf spots in cereals and grasses). This species has been studied only once and only in a water bath. Seed transmission seems to be a much higher risk than soil contamination.
- *Rhizoctonia solani* and *Sclerotinia sclerotiorum* (both pathogens causing root rot in many crops). Against quite a significant body of information that these pathogens are inactivated even at conditions that are milder than 3 d at 60°C, for each pathogen there appears to be a publication that considers the opposite. Based on reasonings detailed in Termorshuizen (2017), these opposite results are considered useless.

For industrial monostreams[9], the advice is to organize an ad hoc risk analysis, because the possible presence of pathogens at significant densities is much higher in comparison with household bio-waste (Fig. 1). A possible workflow is:

- Determine the potential problem pathogens (e.g. for tomato residues: *Fusarium oxysporum* and TMV);
- Request a statement from the farmer/food processor on absence of potential problem pathogens[10]; OR
- Make sure that the application of composted tomato residues is harmless, even if part of the problem pathogens survives the composting process[11]; OR
- Increase the temperature-time profile to conditions that safely ensure pathogen inactivation; OR
- Carry out research on inactivation conditions of the potential problem pathogens[12].

[9] Industrial monostreams are defined here as biowaste streams of homogeneous composition originating from agriculture or the food-processing industry, and thus, it is unequal from SSO household biowaste.

[10] This could for example be done by indicating that the cultivars used were resistant to the potential problem pathogens. Or, if susceptible cultivars have been used, by an inspection report of an inspection authority, in The Netherlands e.g. Naktuinbouw (www.naktuinbouw.com).

[11] This would involve the separate composting and selling of this material in a way that other biowaste and compost streams are not contaminated.

[12] This evidently is not an ad hoc solution.

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