The fate of per- and polyfluoroalkyl substances (PFAS) through commercial composting facilities

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Transforming Biosolids

Abstract

Composting municipal solid waste (MSW) offers a sustainable solution by valorising organic residues; however, the presence of per- and polyfluoroalkyl substances (PFAS) in compost raises concerns about contamination in agriculture. This study investigates the fate of PFAS in solid, liquid, and dust samples from two commercial composting facilities using different systems. The results indicate that composting effectively reduces the levels of PFAS from an initial concentration of 28.4 μg kg^{-1} dry wt in feedstock down to 4.9 μg kg^{-1} dry wt in the final compost. These findings highlight potential strategies to mitigate PFAS contamination, ensuring the safe use of compost in agriculture and safeguarding both environmental and public health.

Introduction

Per- and polyfluoroalkyl substances (PFAS) have been extensively used in various industrial, commercial, and consumer applications that may end up in MSW. The use of compost as an organic fertiliser derived from waste is expected to recycle the nutrients within. However, it may also pose a risk of dispersing contaminants, such as PFAS, on agricultural soils. Additionally, PFAS can evaporate, attach to dust particles, or leach from the waste during the composting process. Due to their nature, PFAS have acquired alarming dimensions globally, raising significant concerns among scientists, regulators, and the public.

Aims/Objectives

This project aims to investigate the fate of PFAS in two different commercial composting systems, one using an open windrow system and the other in-vessel composting. Target analysis of 33 PFAS compounds will be assessed in solid, liquid and dust samples from two composting facilities.

Methodology

- Representative solid samples were collected at different stages during the composting process by tracking the same feedstock from two different composting facilities in Victoria, Melbourne. In addition, leachate and dust samples were collected (Fig. 1).

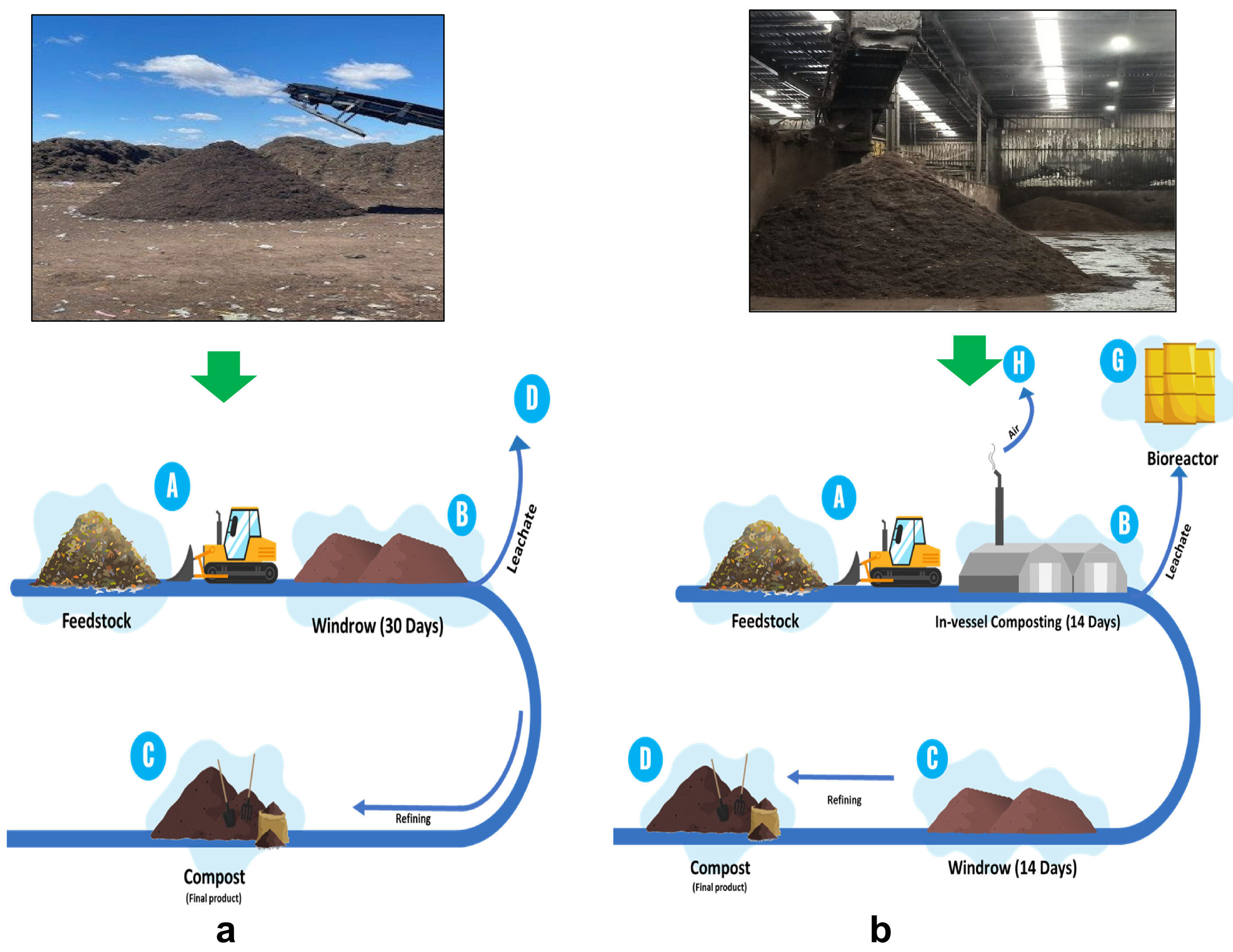

Figure 1: Images showing the windrow facility (a), the in-vessel facility (b) and the sampling points from each site.

- PFAS was extracted following the protocol described in USEPA 1633 and analysed using high-performance liquid chromatography (LCMS/MS) coupled to a tandem mass spectrometer (Fig. 2).

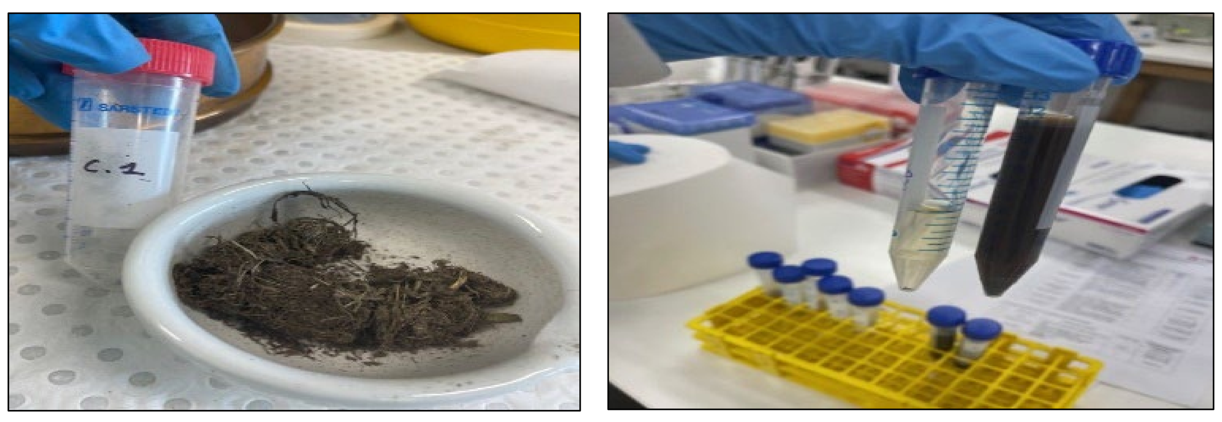

Figure 2: Photo of the freeze-dried sample (left), photo of the extracted sample (right)

Results

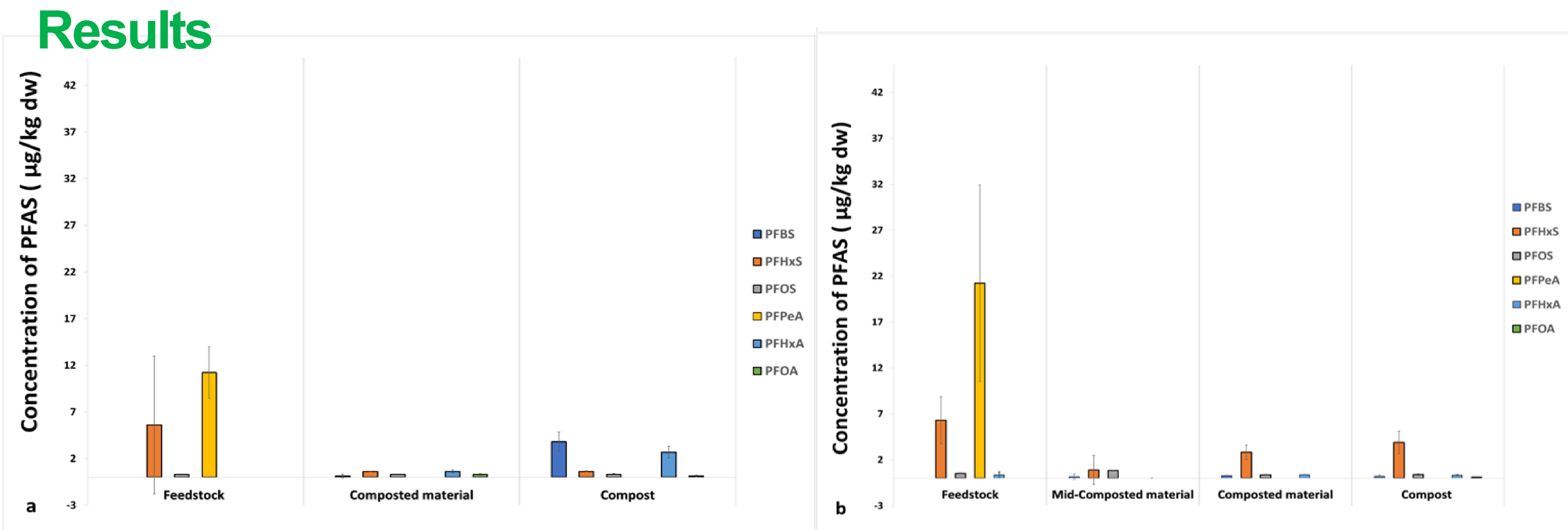

Figure 3: PFAS concentration of solid samples (μg/kg dw) at different stages from: a. Windrow (Feedstock, Composted material, Compost) and b. In-vessel composting systems (Feedstock, Mid-composted material, Composted material, Compost). Data is represented as mean (n = 3), and error bars represent standard deviation. PFBS ( ), PFHxS ( ), PFOS ( ), PFPeA ( ), PFHxA ( ), PFOA ( ).

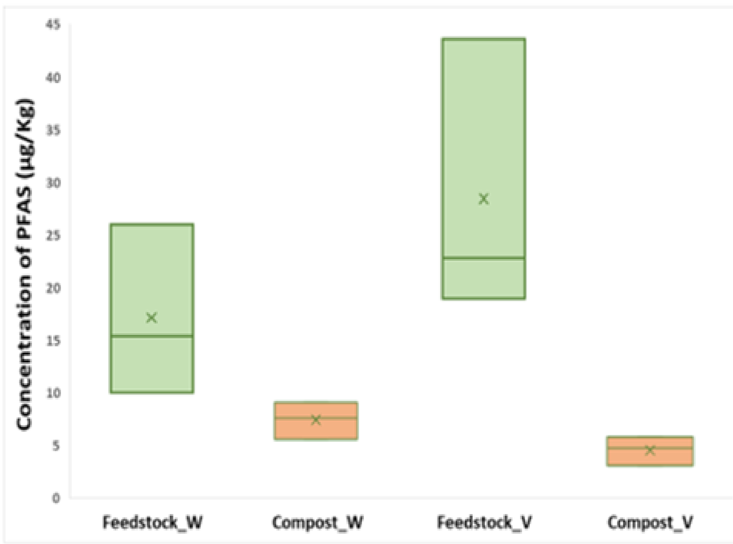

Figure 4: The sum of PFAS concentration of solid samples (μg/kg) from: a. Windrow (Feedstock_W, and Compost_W) and In-vessel composting systems (Feedstock_V, and Compost_V). Data is represented as mean (n = 3).

- Out of the 33 PFAS compounds analysed, only 6 were detected at different stages.
- Both composting facilities showed similar trends in PFAS presence and absence across the process.
- PFHxS and PFPeA were found at high concentrations in the feedstock.
- PFPeA was eliminated after composting.
- The total PFAS concentration (Σ33 PFAS) decreased in the final compost products.
  - Windrow facility: ~55.5% reduction
  - In-vessel facility: ~82.7% reduction

- Four PFAS compounds out of the 33 analysed were detected in leachate samples from both facilities.
- In the windrow facility, the total PFAS concentration in leachate was 2.1 μg/L.
- In the in-vessel facility, the total PFAS concentration in leachate was slightly higher at 2.2 μg/L.
- PFPeA, were initially present at high concentrations in the feedstock but were undetectable after the composting process in compost.

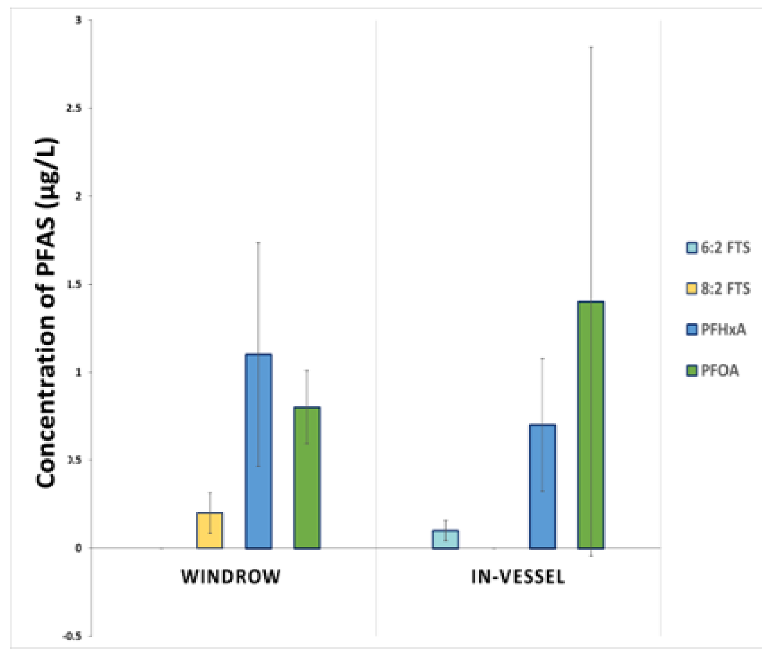

Figure 5: PFAS concentrations in leachate samples (μg/L) from Windrow Facility 1 and In-vessel Facility 2. Data is presented as mean (n = 3), and error bars represent standard deviation. 6:2 FTS ( ), 8:2 FTS( ), PFHxA ( ), PFOA ( ).

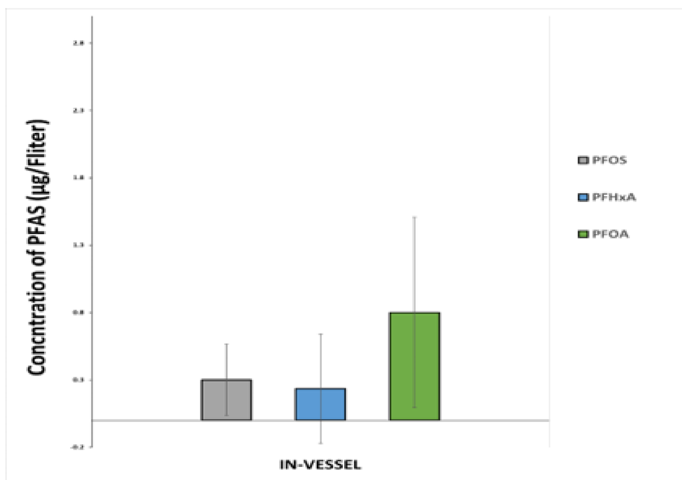

Figure 6: PFAS concentrations in dust samples (μg/filter) from In-vessel Facility 2. Data is presented as mean (*n* = *3*), and error bars represent standard deviation. PFOS ( ), PFHxA ( ), PFOA ( ).

- Samples were collected exclusively from an in-vessel facility
- Out of the 33 PFAS compounds analysed, only PFOS, PFHxA, and PFOA were detected in the dust samples.
- The sum concentration of these compounds was 1.34 μg/filter.

Conclusions

These results show that both composting systems exhibit a similar PFAS profile during the composting process. The findings indicate significant reductions in total PFAS concentrations after composting, with reductions of 88.3% and 86.3% in the windrow and in-vessel systems, respectively. This indicates the potential of composting to mitigate PFAS contamination in organic residue.

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References

De Silva et al., 2021; Ferronato & Torretta. 2019; Gaines, 2023; Khair Biek et al., 2024; Liu. 2020; Sivaram et al., 2022;

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