ECP 2025 Conference
The 4th International Electronic Conference on Processes
20–22 October 2025 | Online
MDPI

Limited Biodegradability of PHB in Alkaline Japanese Landfill Soils: Implications for Bioplastic Waste Management

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INTRODUCTION & AIM

Plastics are widely used in packaging, construction, and daily life due to their low cost and excellent properties; however, their persistence and large-scale disposal have caused serious environmental problems worldwide. In response, biodegradable plastics have attracted attention as sustainable alternatives. Among them, polyhydroxyalkanoates (PHAs) are microbially synthesized polyesters that can degrade under various environmental conditions. Biodegradable plastics, including poly(3-hydroxybutyrate) (PHB), the most extensively studied PHA, are expected to be increasingly disposed of in landfills as their use expands. However, studies on PHB degradation under landfill conditions remain very limited [1]. In Japan, where incineration is the primary waste treatment method, landfills contain large amounts of incineration ash, resulting in strongly alkaline conditions. Since PHB degradation occurs most efficiently near neutral pH but is suppressed under alkaline conditions, its degradation in Japanese landfills may be inhibited. This study aims to evaluate PHB degradation using active landfill soils and to clarify the effects of incineration ash, thereby revealing the potential and limitations of biodegradable plastic degradation in landfill environments.

METHOD

Experimental Materials

- The PHB film was fabricated using the solvent extraction method [2].
- Landfill soil was collected from the Nishi-Iburi Regional Union Final Disposal Site in Muroran, Hokkaido, Japan.
- As a control, uncontaminated soil (without a history of incineration ash) was collected from the Muroran Institute of Technology campus.

Soil degradation of PHB films

- Each soil sample was sieved through a 14-mesh screen to standardize particle size. Approximately 30 g of soil was placed in sterilized 50 mL polypropylene (PP) tubes, and sterilized PHB films were buried in each soil and sealed with breathable silicone caps.
- Samples were incubated at 30℃, and soil moisture content was maintained at 45% using a moisture checker (SK-940A, Sato Keiryoki Mfg. Co., Tokyo, Japan) by periodically adding sterilized deionized water.

Isolation of PHB-degrading bacteria

- Mineral salt (MS) agar medium containing PHB (SIGMA-ALDRICH, Tokyo, Japan) as the sole carbon source was prepared and supplemented with soil suspension, then incubated at 30℃.
- Colonies forming clear zones were isolated by streaking, and the length of the clear zones was measured.
- Strains that had lost PHB-degrading activity or showed weak activity were excluded from identification after repeated subculturing.

RESULTS & DISCUSSION

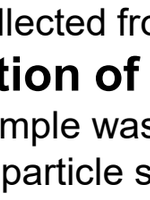
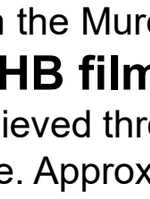
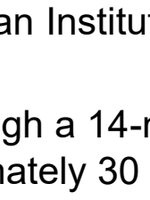
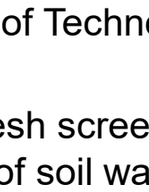
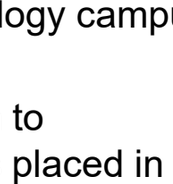
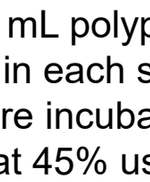
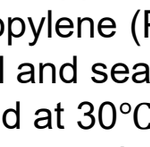
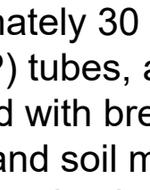
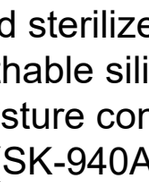
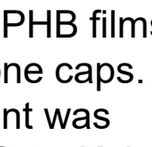
Conditions	0 days	14 days	28 days	42 days	56 days
Landfill soil					
Campus soil					

Fig. 1. Morphological changes in PHB film over time during the biodegradation process in each soil.

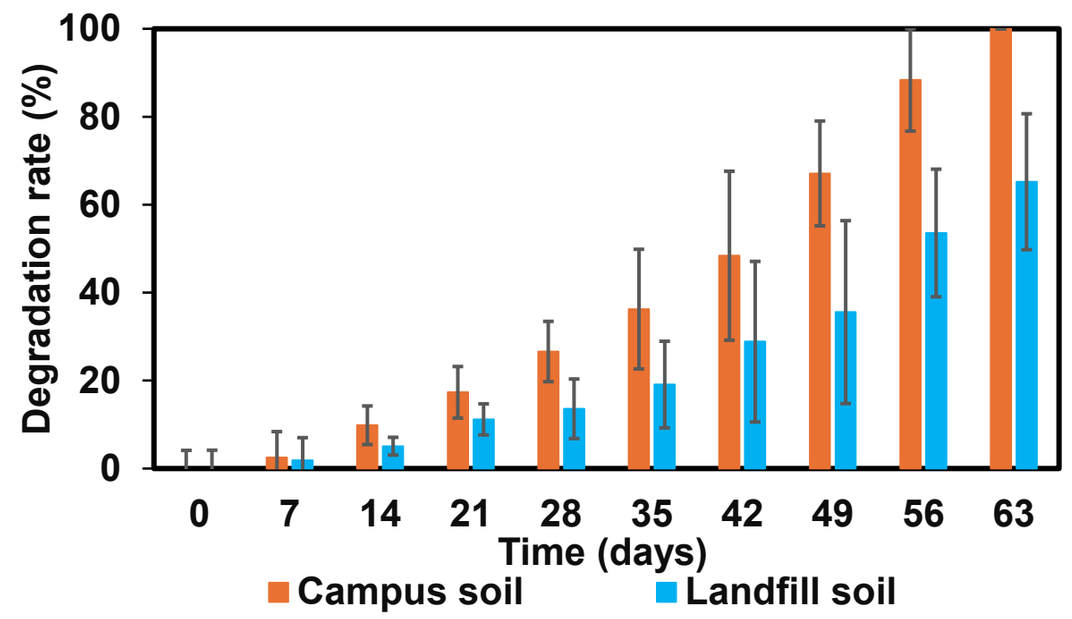


Fig. 2. Weight loss of PHB film during the biodegradation process over 63 days at 30℃ using landfill and campus soils.

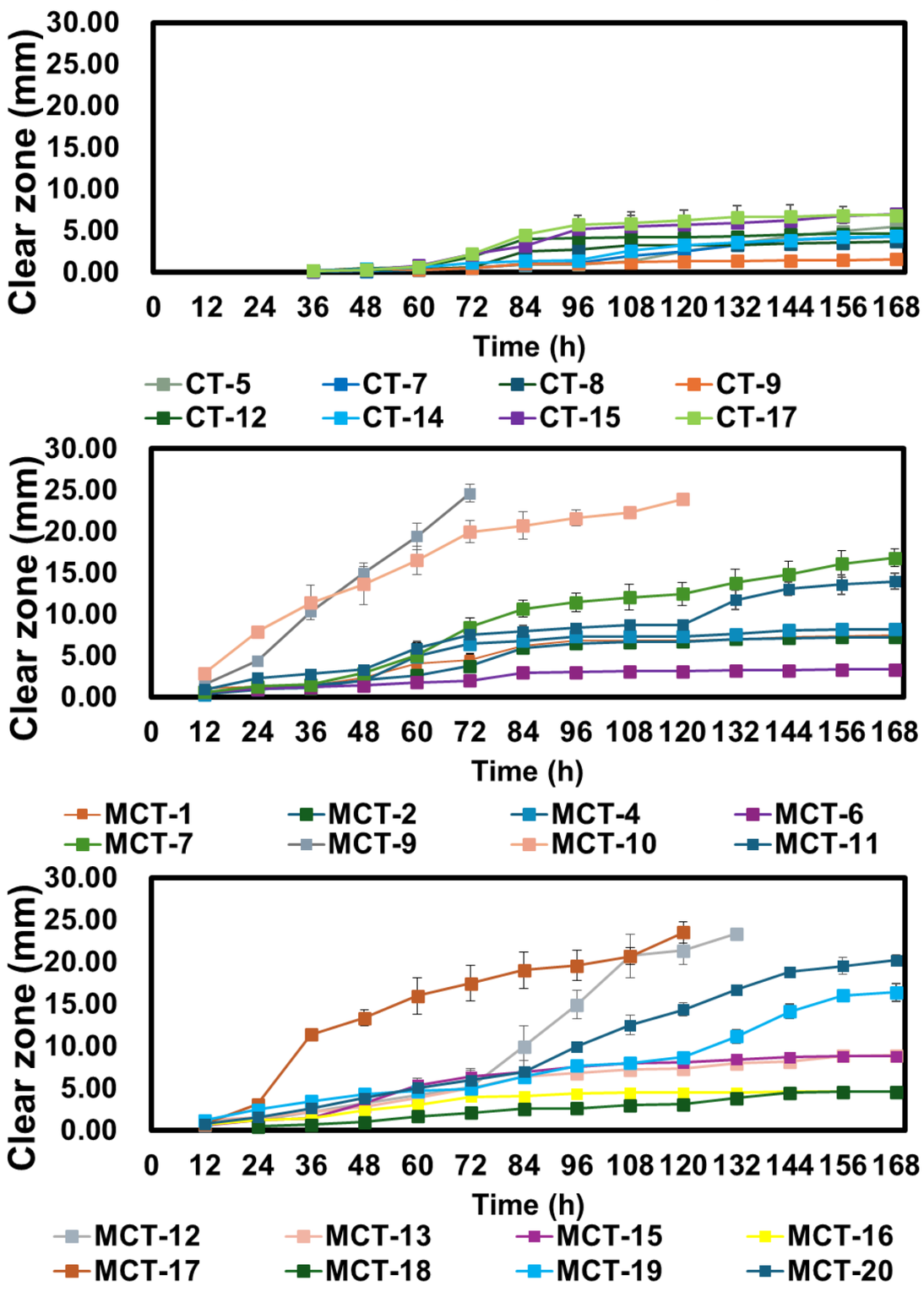


Fig. 3. Clear zone activity of PHB-degrading bacteria isolated from campus (MCT) and landfill (CT) soils.

CONCLUSION

The results of PHB soil degradation and the isolation of degrading bacteria suggested that the biodegradation of PHB, a biodegradable plastic, is likely to be delayed in Japanese landfill soils containing large amounts of incineration ash.

FUTURE WORK / REFERENCES

[1] Afshar, S.V., et al., 2024, *Journal of Cleaner Production*, 434, 140000
[2] Altaee, N., et al., 2016, *SpringerPlus*, 5, 762.