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Microbial methane cycling in a landfill on a decadal time scale

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Landfills generate outsized environmental footprints due to microbial degradation of organic matter in municipal solid waste, which produces the potent greenhouse gas methane. With global solid waste production predicted to increase 69% by the year 2050, there is a pressing need to better understand the biogeochemical processes that control microbial methane cycling in landfills. In this study, we had the rare opportunity to characterize the microbial community responsible for methane cycling in landfill waste covering a 39-year timeframe. We coupled long term geochemical analyses to whole-community DNA (i.e., metagenomic) sequencing and identified key features that shape methane cycling communities over the course of a landfill's lifecycle. Anaerobic methanogenic microbes are more abundant, diverse, and metabolically versatile in newer waste, fueling rapid methane production early in a landfill's lifecycle. Aerobic methanotrophs were repeatedly found in leachate where low levels of oxygen were present and exhibited adaptations that aid survival under steep redox gradients in landfills. The potential for anaerobic methane oxidation, which has historically been overlooked despite anoxic habitats dominating landfills, was prevalent in a 26-year-old landfill cell which was in a state of slow methanogenesis. Finally, we identified the metabolic potential for methane oxidation in lineages that are widespread in aquatic and terrestrial habitats, whose capacity to metabolize methane remains poorly characterized. Ultimately, this work expands the diversity of methane cycling guilds in landfills and outlines how these communities can curb methane emissions from municipal solid waste. For more information on this work, please see this link: https://www.biorxiv.org/content/10.1101/2023.01.20.524919v1.