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Prokaryotic diversity and dynamics in a full-scale municipal solid waste anaerobic reactor from start-up to steady-state conditions

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HIGHLIGHTS

- We identify and quantify microbiota of a full-scale MSW anaerobic reactor.
- Shifts in the diversity and abundance were observed from start-up to steady-state.
- Hydrogenotrophic methanogens dominated the methane production in the MSW reactor.
- *Methanosarcina*, *Methanimicrococcus* and *Methanosaeta* were identified in the reactor.
- Quantification of bacterial and archaeal by FISH and qPCR differ.

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ABSTRACT

The prokaryotic diversity of an anaerobic reactor for the treatment of municipal solid waste was investigated over the course of 2 years with the use of 16S rDNA-targeted molecular approaches. The fermentative *Bacteroidetes* and *Firmicutes* predominated, and *Proteobacteria*, *Actinobacteria*, *Tenericutes* and the candidate division WWE1 were also identified. Methane production was dominated by the hydrogenotrophic *Methanomicrobiales* (*Methanoculleus* sp.) and their syntrophic association with acetate-utilizing and propionate-oxidizing bacteria. qPCR demonstrated the predominance of the hydrogenotrophic over aceticlastic *Methanosarcinaceae* (*Methanosarcina* sp. and *Methanimicrococcus* sp.), and *Methanosaetaceae* (*Methanosaeta* sp.) were measured in low numbers in the reactor. According to the FISH and CARD-FISH analyses, *Bacteria* and *Archaea* accounted for 85% and 15% of the cells, respectively. Different cell counts for these domains were obtained by qPCR versus FISH analyses. The use of several molecular tools increases our knowledge of the prokaryotic community dynamics from start-up to steady-state conditions in a full-scale MSW reactor.

1. Introduction

The environmentally friendly management of municipal solid waste (MSW) has become a global challenge because of limited resources, an ever-increasing population, rapid urbanization and industrialization. An enormous quantity of MSW is produced daily in the European Union (400,000 tons). However, the separate collection of MSW fractions has increased significantly, and the biomethanization (anaerobic digestion, AD) of the organic fraction (OF) of the MSW has become an effective solution (Mata-Alvarez et al., 2000).

Among various biological treatments, the AD of OF-MSW in anaerobic digesters is frequently the most cost-effective. This process results in the reduction of the organic content of the waste, the production of an energy-rich biogas (CH_4, CO_2, and traces of N_2, H_2S and O_2) and a solid residue with a high nutrient content, which can be recycled to recuperate degraded environments. The potential of biogas production throughout Europe could reach in 2020 77.9 billion m^3 of methane, being 10 billion m^3 from biodegradable fraction from municipal solid wastes. (http://www.aebiom.org/IMG/pdf/Brochure_BiogasRoadmap_WEB.pdf).

In 1995, the first biomethanization plant for MSW began operation in Europe. Since then, many plants have opened in countries where the collection of MSW has been established, such as Spain, Germany, France, Denmark, and Belgium (IEA, 2003). Approximately 15% of the OF-MSW is biologically treated in Europe, and AD represents approximately 20% of all biological treatment capacity (http://www.waste-management-world.com). Spain produces 26.2 million tons of MSW

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