A Comparison of Methane Oxidation in a Compost Biocover and in a Conventional Soil Cover

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Introduction

Methane emissions from landfills are significant because of their potential to contribute to global climate change. In the U.S., landfills have been targeted for emission reductions through amendments to the Clean Air Act that established the Landfill Rule (U.S. Federal Register, 1996). More landfill gas collection is expected as a result of the rule, and other methods of landfill methane emission reductions are being actively investigated as well. This paper reports on work that was part of a larger study to evaluate the ability of a pilot scale compost biocover to reduce methane emissions at the Outerloop Landfill in Louisville, Kentucky.

Purpose

The focus of the work reported here is on measuring the methane oxidation activity in the biocover and comparing it to the activity measured in an adjacent soil cover that is serving as a control site. The findings will subsequently be used in a modeling strategy first reported by Czepiel et al., (1996) that incorporates field and laboratory data to estimate an annual methane oxidation rate. The field data collected includes methane fluxes, vertical gas profiles, soil moisture and soil temperature. The laboratory data includes analysis of cover samples to identify the depth of maximum oxidation activity, the relationship between moisture content and oxidation activity as well as temperature and oxidation activity. The maximum methane uptake rates of the most active layers are also measured. When these data are combined with soil moisture and temperature data, the fraction of methane that is oxidized and not emitted can be calculated for each cover type. Furthermore, when the laboratory and field data are combined with a model that uses climate data to predict soil temperature and moisture, an estimate of annual methane oxidation in each cover material can be deduced.

Methods

The biocover is a 1-1.5 m layer of yard waste compost underlain by 15-20 cm of tire chips and 15 cm of clay. All field data were collected when the landfill was operating with a gas collection system. Flux measurements were collected as a component of other study activities, and the data were provided to us. Gas gradients were analyzed using 0.25 in diameter stainless steel tubing with compression fittings and septa for sample withdrawal. Gas samples were withdrawn in syringes fitted with valves and analyzed with an SRI gas chromatograph. Four samples of the compost and soil cover materials were collected from each cover type at uniform depth intervals and stored in sterile plastic bags at 4^{o}C until testing. For all laboratory analyses involving measurement of methane uptake, samples were tested in gas-tight jars where headspace concentrations were adjusted by replacing a measured amount of air with pure methane gas. Prior to testing, samples were acclimated for 24 h to the test headspace composition, flushed with air, and reset to the test gas composition to commence testing. Samples were incubated at 24^{o}C. After incubation and before sampling, a manometer-type device was used to add helium to the headspace (if necessary) to restore atmospheric pressure.

Tests were also conducted to obtain depth profiles of pH, and exopolysaccharide, and work is ongoing to detect methanotrophs in the biocover and the soil cover. Methanotroph identification is being accomplished with the use of a fluorescent in-situ hybridization technique (FISH) that can distinguish between alpha and gamma methanotrophs.

Significance

Compost has shown a high capacity for methane uptake in laboratory and pilot field tests in Europe (Humer and Lechner, 2001). The experiments reported here will document the locus of microbial activity in a full-scale biocover in Louisville, Kentucky where climate conditions and compost characteristics may differ from those of previous studies. The methane oxidation capacity of the biocover and the local environmental conditions that develop in the compost will help to determine it's potential usefulness to landfill operators as a tool to help curb methane emissions to meet regulatory requirements. The location and abundance of alpha and gamma methanotroph types is of interest because the types differ in their ability to cometabolize other organic compounds that may be present in the landfill gas.

References

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U.S. Federal Register: 1996, Section 40 CFR Parts 51, 52, 60.