

Anaerobic biodegradation of organotin stabilizers

– degradation capacity of landfill microorganisms

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Research focus

The objective of this particular study was to determine whether organotin compounds used as stabilizers in PVC products, are degraded to methane and carbon dioxide by the microorganisms present in landfilled municipal solid waste. Important questions to rise are whether the PVC-stabilizers are important sources of organotin compounds in landfill leachates, what is the fate of PVC-stabilizers under landfill conditions, do they affect the landfill processes? To address these questions, a lysimeter study was conducted. Three lysimeters were started containing samples of a methyltin stabilized rigid PVC foil, a butyltin stabilized construction PVC sheet, and a control lysimeter without any PVC added, respectively. On two occasions waste samples were collected from each lysimeter to serve as inocula in anaerobic biodegradation assays. These six waste inocula were used together with organotin stabilizers containing either a mono- and dimethyltin mercaptide or a mono- and dibutyltin thioester in the assays. Analysis for the residual alkylated tin compounds was done to follow the degradation over time, together with methane production in order to determine the biodegradation potential by the landfill microorganisms for the organotin stabilizers.

Environmental relevance

PVC-stabilizers contain mono- and dialkylated organotin compounds (alkyl: methyl, butyl or octyl), which are used to prevent colour changes during manufacture and increase the long-term stability of PVC. Organotins enter the environment via different sources and applications, for instance they have been found in both leachate effluents and gaseous emissions from landfills. Some of the compounds are of anthropogenic origin, whereas others are produced in environmental settings either due to chemical transalkylation or due to biological methylation and hydride formation. Tin organic compounds have also been found in digested sludge and due to the given stability of organotins in digested sludge, there is a risk of accumulation of these compounds when sludge is landfilled. The alkyltin stabilizers are converted to the respective alkyltin chlorides as a result of the stabilization activity, and may disperse to the environment. Thus, the fate and origin of these compounds as well as their potential degradation products and leaching rates in landfills are targets for investigations, forming basis for environmental risk assessments.

Results

A partial or complete anaerobic degradation to methane and carbon dioxide was observed with time for the methyltin mercaptides and butyltin thioesters with all six inocula investigated. The methyltin mercaptides had an inhibitory effect on the degradation of the indigenous substrate supplied via the materials of all six waste inocula, from the start and up until 80 to 150 days of incubation (Fig. 1). However, the methane yields from the stabilizers were higher with inocula from the PVC-amended municipal solid waste lysimeters. A distinct formation of both trimethyltin- (TMT) and monomethyltin (MMT) compounds was observed during the incubation period showing that methylation processes took place. The butyltin thioesters gave rise to a longer initial inhibitory effect on the methane formation in three of the inocula up until 50 to 150 days. Simultaneously with the degradation of the thioester part, a decrease, however, not a total disappearance, of both dibutyltin (DBT) and monobutyltin (MBT) was observed during the incubation period with all six inocula investigated.

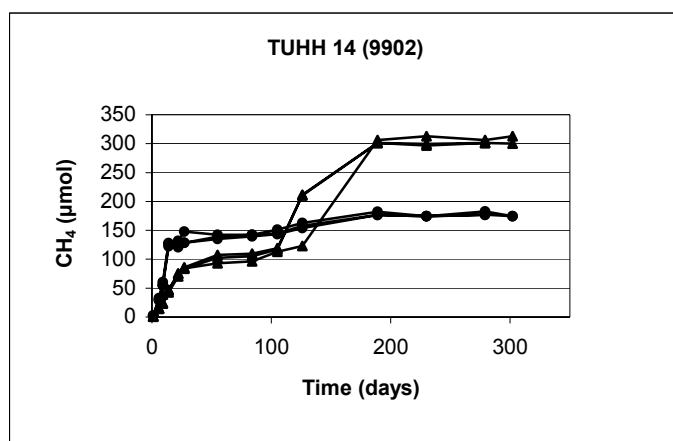


Figure 1. Accumulation of methane in bottles inoculated with waste TUHH 14 from the 1999-sampling. ▲ = bottles spiked with Me-Sn stabilizer and ● = control vessels without Me-Sn stab.

Discussion

Higher methane yields in the vessels containing PVC-amended MSW indicate that the microorganisms present in the PVC-amended waste had adapted to the organotin stabilizers during the lysimeter operation and, thus, were more efficiently degraded than the organotin stabilizers. The reason for the observed methane retardation in vessels spiked with PVC-stabilizer might be that the fermentative degradation providing the substrate for the methanogens has been affected and that the methanogens have been affected as well. Another possible reason for the preserving negative effect could be the appearance of alkyltins and organic moieties, hydrolyzed from the stabilizers. These might negatively affect the source of microorganisms in the inocula. It appears that not only the MMT and TMT concentrations are increasing with time in the test vessels, but also the total methyltins are greater than the initial amount. We might assume that the source of additional methyltins is methylated inorganic tin present in the municipal solid waste.