FT-IR Studies on the Generation of Carbon Monoxide during Anaerobe Fermentation

H. J. Hellebrand
Institute of Agricultural Engineering Bornim, Max-Eyth-Allee 100, D-14469 Potsdam

Introduction
Carbon monoxide (CO) can strongly influence tropospheric chemistry and, in particular, tropospheric ozone concentrations. The major sources of CO are incomplete combustion, biomass burning and the oxidation of hydrocarbons. It is estimated that about two-thirds of CO currently results from anthropogenic activities (IPCC 1994). There is a large uncertainty associated with the magnitude of the CO emissions from biogenic sources. Few biological sources of CO are known like certain plants and specialised micro-organisms (Conrad 1996). No information concerning emission rates of CO during composting could be found in the literature.

Material and Methods
For the composting of green waste, a trapezoidal compost heap was made of mixed herbage from land maintenance. The initial mass of the compost heap was 14 800 kg with a carbon content of 4 300 kg. Samples of compost air were pumped from the central parts of the heap via polyethylene pipes at nine different measuring points into evacuated polyethylene gas bags (Fig. 1). Then the concentration of CO and CO₂ was analysed by an FT-IR spectrometer. Emission rates were calculated by means of ratios of the concentration differences between compost air and fresh air and by evaluation of the carbon balance of the heap. Emissions from windrows of farm waste (dung-windrow of bedding with cattle manure) were measured using gas flux chambers and FT-IR gas analysis.

For laboratory experiments, the plant material (dried mixed herbage from land maintenance) was wetted up to a moisture content of 70% (w.b.). This substrate, pure or amended by nitrogen additives, was placed in a closed, tempered container and ventilated at a constant air rate. The composition of the input air and of the air leaving the container was analysed by FT-IR. Generation rates were calculated on the base of volume flow rates and concentration differences.

Results and Discussion
As shown in Fig. 1, the CO production was stimulated by the availability of oxygen. The thesis that CO generation depended on partial pressure of oxygen is supported by the concentration dependencies at the upper measuring tubes 1, 4 and 7, where the highest concentrations were found.

The mean of the concentrations measured at the nine tubes was utilised for the determination of the total emissions in connection with weighing and analysis of the rotted compost material. During the first three months of composting, 3250 kg carbon were released as CO₂-C and 1.5 kg as CO-C. In relation to the surface area of the heap, this emission corresponded to an average rate of about 20 mg CO m⁻² h⁻¹.
Fig. 1 Concentration of carbon monoxide at the different measuring tubes and scheme of compost heap with measuring tubes (mixed herbage from land maintenance on bare soil). Arrows indicate dates of turning the compost.

Fig. 2 Emission rate of carbon monoxide per kilogram substrate mass at a temperature of 35° C and its dependence on ventilation rate per kilogram (mixed herbage with moisture content of 70 % w.b., amended by 1.7 % lime saltpetre).
Similar emission rates were measured during composting of farm waste. At fresh dungwindrows (1-8 days), rates between 30 and 100 mg CO m\(^{-2}\) h\(^{-1}\) were observed. After three weeks, the emissions dropped down below 10 mg CO m\(^{-2}\) h\(^{-1}\). Windrows with an age of more than six weeks showed emissions in the range of 1 mg CO m\(^{-2}\) h\(^{-1}\).

By laboratory experiments, the influence of aeration on the generation of CO was verified. Increasing ventilation rates gave an increase in CO emissions (Fig. 2). There are two possibilities for the interpretation of the results. The first assumption is that CO is produced by chemical (enzymatic) reactions during biodegradation of organic materials as it is assumed for the majority of CO production in soils (Conrad 1996). The other biogenic source could be CO production by micro-organisms. More detailed studies are necessary for clarification.

**Conclusions**

Emissions of CO were detected during composting of green waste. The emission rates corresponded to an average rate of 20 mg CO m\(^{-2}\) h\(^{-1}\) in relation to the surface area of the heap. At fresh windrows of farm waste, CO emissions of 30 and 100 mg CO m\(^{-2}\) h\(^{-1}\) were observed. By laboratory experiments, the influence of aeration on the generation of carbon monoxide was confirmed. Although the source could not be identified, the CO production is clearly connected with the biodegradation of biomass. Therefore, biodegradation of biomass contributes to the atmospheric CO level.

**References**
