Predicting ammonia and carbon dioxide emissions from carbon & nitrogen biodegradability during animal waste composting

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Introduction

During animal waste composting, organic matter transformation leads to emissions of environmentally harmful gases like NH_3, N_2O, CO_2 and CH_4 (Houghton *et al.*, 2001). An experimental design (Fig. 1) was built with the four main factors responsible for gaseous emissions: biodegradable N and C (as % of total N or C), water content and free air space in the pile. The results given in this poster concern the influence of biodegradable N and C.

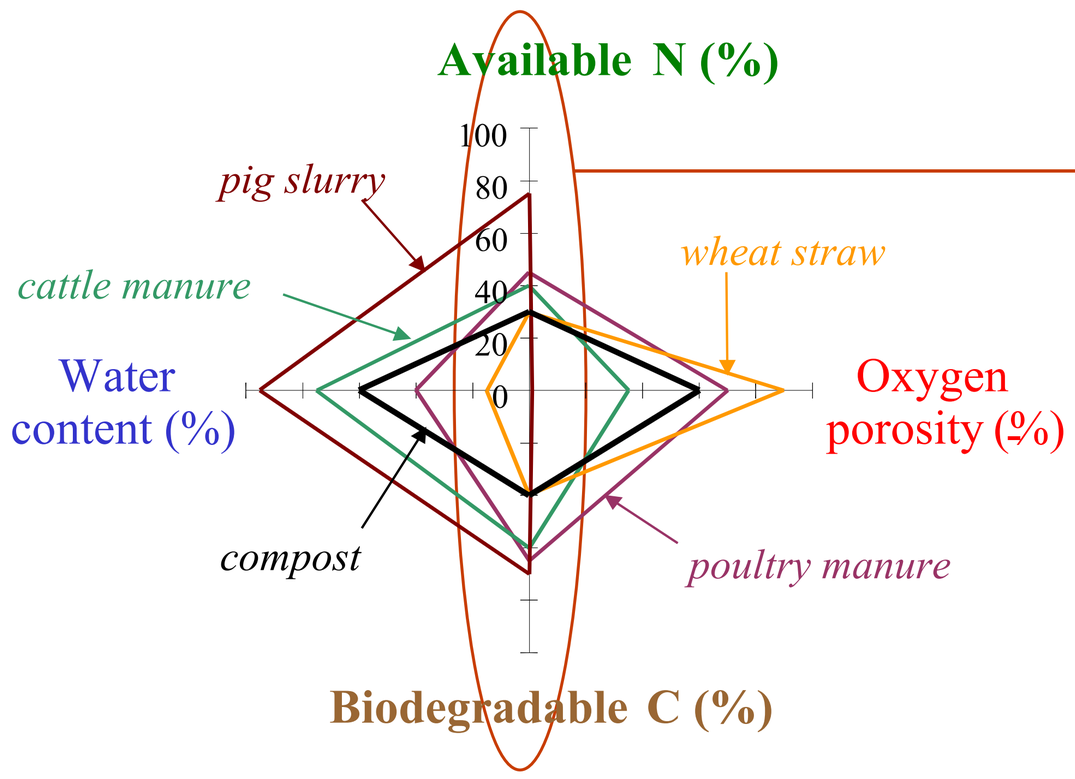

Fig. 1. Different composting situations within the four parameters studied.

Materials and Methods

Eight different mixtures of wheat straw, sawdust, pig slurry and manure, molasses, urea and water were made, in order to create a wide range of N and C biodegradability (Fig. 2). The eight compost piles (1.4 m^3) were checked during the thermophilic composting phase: emissions of NH_3, N_2O, CO_2, CH_4 and H_2O were measured with sensors and analysers from each compost pile.

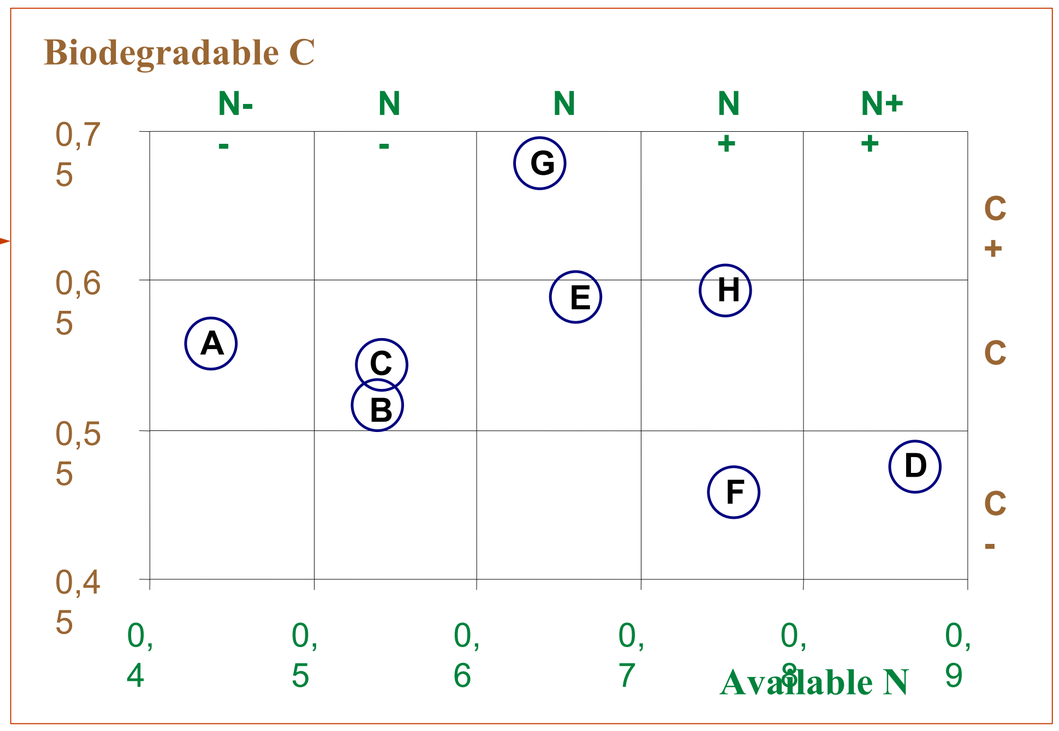

Fig. 2. Classification of mixtures from their available N (SN/TN) and biodegradable C (SH-VS/DM) fractions; SN and TN are soluble (4°C during 12 h in water) and total nitrogen, SH-VS are soluble and hemicellulose-like Van Soest fractions, DM is dry matter.

Results

In favourable conditions of free air space and humidity CH_4 emission is very low (Table 1). The N_2O emission is low (1 to 6 % of that of NH_3). The NH_3 emission can be described with four parameters (Paillat *et al.*, 2005) (Fig. 3): the highest emission rate (ER), the time taken to reach this value (TR), the emission duration (ED) and the cumulative emission (CE). TR depends mainly on the initial microflora (A, B and C piles with manure); ER depends mainly on C biodegradability (E *vs* G and F *vs* H) but also on microflora (C); ED depends mainly on available N (N- *vs* N+); CE depends on N and C biodegradability (Eq. 1).

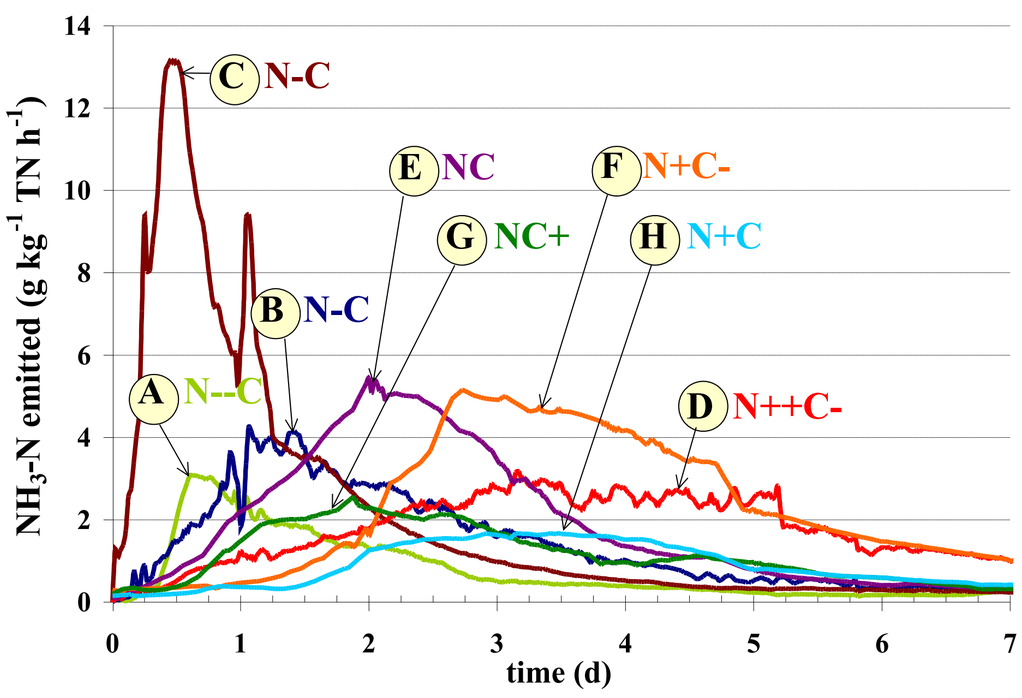

Fig. 3. Kinetics of NH_3-N emission for the eight piles (A to H) as influenced by microflora, N availability and C biodegradability of the initial substrate.

Table 1. Gaseous emissions after 56 days of composting, ranked according to NH_3-N emission.

Pile identification (Fig. 2)	A N--/C	G N/C+	H N+/C	B N-/C	E N/C	C N-/C	F N+/C-	D N++/C-
NH_3-N (g kg^{-1} TN)	165	248	249	275	362	387	479	489
CO_2-C (g kg^{-1} TC)	423	426	425	448	407	407	364	388
N_2O-N (g kg^{-1} TN)	11,3	12,0	10,3	10,6	8,1	10,2	7,7	7,1
CH_4-C (g kg^{-1} TC)	—	0,2	0,3	—	0,6	—	0,5	—

TN: total nitrogen, TC: total carbon.

Discussion

From the pile constitution, the ammonium pool in the solution is rapidly increased with the ammonification of easily degradable nitrogen compounds, depending on the initial microflora. Thereafter, volatilisation results in two consumption fluxes, nitrification and immobilisation in the microbial biomass (Kirchmann and Witter, 1989). The nitrification is a weak flux because the temperature in the pile is too high for the nitrifying bacteria (Schlegel, 1993) and the pile is saturated with CO_2 in the first stage of composting. So N_2O production, which is a by-product of nitrification and denitrification, remains low. The immobilisation is a major flux which depends mainly on the C biodegradability and on the effective microflora (Hellmann et al., 1997).

NH_3-N emitted at 56 d = 16,38 SN – 0,903 SH-VS + 643,7 [1]

(N=8; P<0,05 ; R^2 = 0,82)

CO_2-C emitted at 28 d = 0,683 SH-VS -58,92 [2]

(N=8; P<0,01 ; R^2 = 0,84)

with NH_3-N expressed in g kg^{-1} TN, CO_2-C in g kg^{-1} TC, SN and SH-VS en g kg^{-1} DM. NH_3.

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