Comparison of ammonia emission from composted swine farmyard manure and sewage sludge

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Introduction

Since the ‘80s increasing problems concerning management of both solid natural fertilizers and urban waste, in particular sewage sludge, have been observed in Europe. Many research showed that traditional, anaerobic storage of manure and sewage sludge is a non efficient method of its management, often leading to a negative impact on the environment as a result of gaseous emissions, input of pathogens into natural environment or leaking out of mineral compounds (Jensen Jepsen 2005, Harrison et al. 2006). Hence in the prescriptions of the European Commission, European Environment Agency (EEA) or governmental projects of EU countries the composting and then agricultural usage of obtained compost is recommended as one of the preferred methods of manure and sewage sludge valorisation (EEA 2005). However, the composting process can be a source of ammonia emission. As far as manure composting is concerned, many research have estimated the level of ammonia losses with the conclusion, that, in some conditions, aerobic technology can produce in total (during storage period, transport and spreading) lower N-losses than traditional, aerobic technology. In contrary, there are few literature references concerning nitrogen losses during sewage sludge composting. The Emission Inventory Guidebook (2006) did not mention any ammonia losses from composted sewage sludge (Dach Nicholson 2007). Meanwhile, some recent research suggests that sewage sludge composting can be a source of important ammonia emission (Czekała et al. 2006).

The aim of this paper was to evaluate the level of ammonia emission during sewage sludge composting with different carbonaceous materials addition and to compare the obtained ammonia losses with the N-NH_3 losses from composted farmyard manure.

The study presents the research results carried out in the frame of research project *Optimisation of parameters and microbiological changes during composting of sewage sludge with different biowastes* (2 P06R 005 29) financed by Polish Ministry of Science in the years 2006-8.

Material and Methods

The experiments were carried out with usage of 4-chamber (165 dm^3 each) adiabatic bioreactor at the Agricultural University of Poznan in 2007. Because of isolation layer and controlled air flow, the bioreactor guaranties the presence of thermophilic phase (Dach et al. 2007). The electric and electro-chemical sensor connected to data recorder and PC-computer let to control the main process parameters like temperature and gases content (NH_3, O_2, CO_2, CH_4, SH_2). The air flow through the chambers was electronically measured and all weeks controlled manually with rotameter. The physical and chemical parameters of composted mass (pH, moisture, NH_4-N, N_{tot}, C_{org}, ash content) were analysed under the standard procedures (Czekała et al 2006). Sewage sludge used for experiment was taken from a small sewage treatment plant Szamotuły (2500 t sewage sludge per year). Mixtures for composting were prepared in two proportions calculated in dry matter: 40% of sewage sludge, 25% of tree bark and 35% of sawdust (sludge 1) and 40% of sewage sludge, 5% of straw, 15% of sawdust and 40% of wooden chips (sludge 2). Farmyard manure was taken from swine farm. It was characterised by relatively high nitrogen content because of high protein content in the feed.

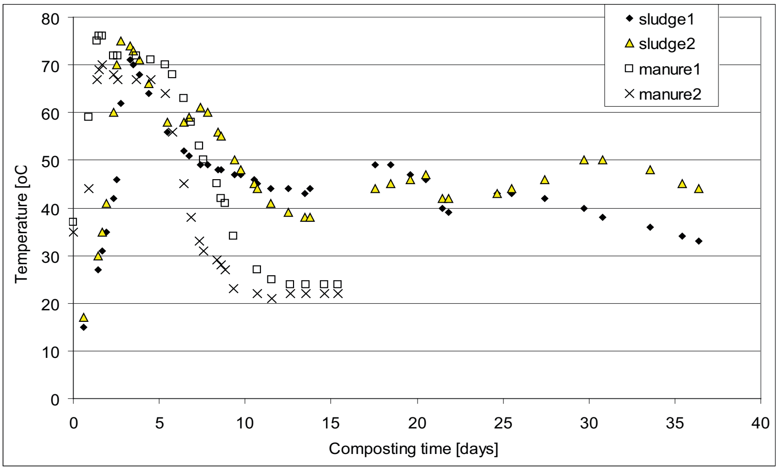
Both sewage sludge mixtures were aerated with the constant air flux 4 dm^3 min^{-1}. The manures were aerated on two levels: intensive – manure 1 (4 dm^3 min^{-1}) and ambient – manure 2 (2 dm^3 min^{-1}).

Results

The initial dry matter of all materials was similar (27,4-31%), however the manure pH was much higher (9,19 and 9,31) than in sewage sludge mixtures (7,2 and 7,4). Total nitrogen in manure (39,22 and 40,99 g kg^{-1} d.m.) was lower than in sewage sludge mixtures (57 and 51). The initial C/N ratio was similar in all materials (19-20,8).

All investigated materials passed thorough a clear thermophilic phase with maximal temperature higher than 70^{o}C (fig. 1). However, the thermophilic phase of manures was considerably shorter in comparison with sewage sludge mixtures. This can be related with the fact that manure contains carbonaceous material much easier decomposable (straw) than sewage sludge mixtures (tree bark, sawdust, wooden chips).

Fig. 1. Temperature changes in composted manure and sewage sludge mixtures



An essential parameter of a proper composting is to keep the aerobic conditions during the process. The measurements showed the oxygen concentration above the level of 7% O_2 during almost whole composting period except some short falls while the temperatures reached the maximal values (fig. 2). It is worth to highlight that the unfavourable, deep decreases of oxygen concentration happened only in the ambient aerated manure 2 (2 dm^3 min^{-1}).

Ammonia emission is directly connected with NH_4-N content in composted mass. However, a huge difference occurred between the ammonia nitrogen content in composted manure and sewage sludge mixtures. Initially in manure, the high NH_4-N content (9-11 g kg^{-1} dry matter) was observed. In contrary, in the sewage sludge mixtures this parameter value was close to 0. While composting, the changes of ammonia nitrogen content had completely different runs. After two weeks in composted manure, the NH_4-N content level decreased to a very low level (above 1 g kg^{-1} dry matter). Meanwhile in sewage sludge this value increased up to the level of 3-4 g kg^{-1} d. m. and maintained on a high level till the end of the experiment. These different courses of NH_4-N content influenced on a very dissimilar cumulative losses of ammonia in composted sewage sludge mixtures and manure (fig. 4). Results presented on figure 4. clearly show that ammonia emission from composted manure takes place during the first week of composting process. In contrary to composted manure, the ammonia emission from composted sewage sludge mixtures starts from 3rd -5th day of composting and maintained until the end of the process.

Fig. 2. Oxygen concentration in composted manure and sewage sludge

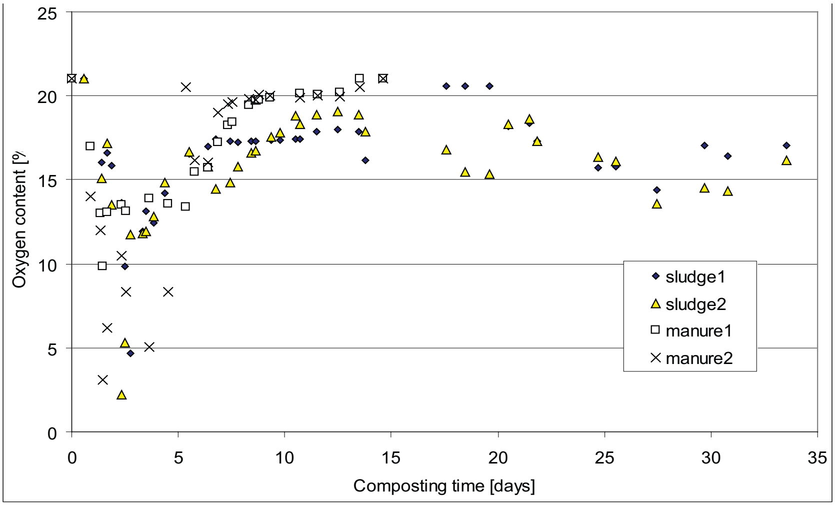
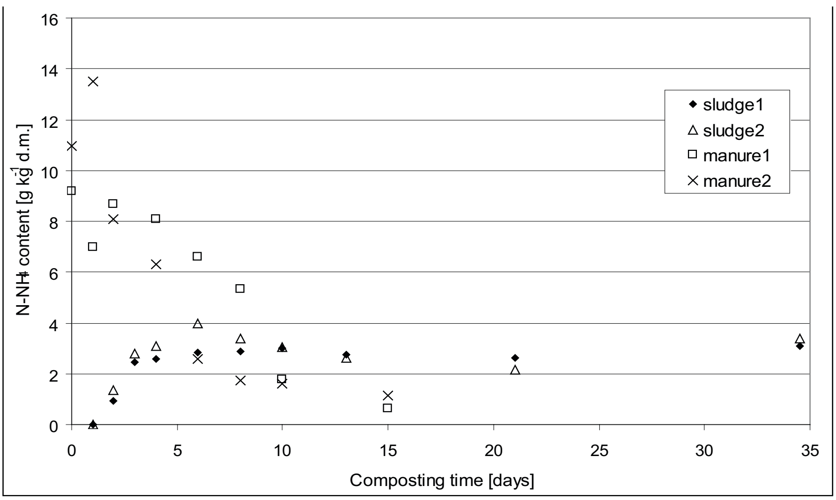
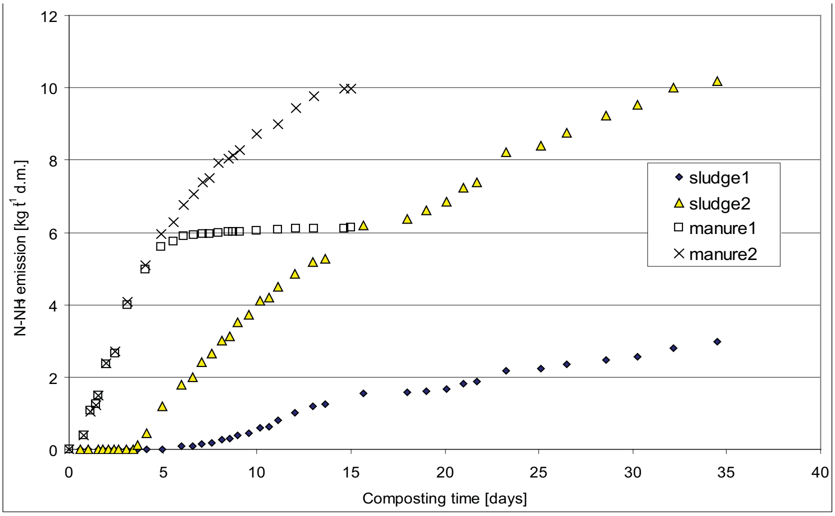


Fig. 3. Changes of ammonia nitrogen content in composted manure and sewage sludge



It is worth to mark that the usage of absorptive carbonaceous materials (like tree bark, sawdust) in sewage sludge 2 influences on a significant decrease of ammonia losses (fig. 4). In case of manure, the more intense aeration (manure 1) paradoxically influenced on lower losses of ammonia.

Fig. 4. Cumulated ammonia emission from composted manure and sewage sludge including ammonia caught in a condensate aqueous vapour



Conclusions

Composting of sewage sludge and manure let to obtain a high temperature during the thermophilic phase.

Changes of ammonia nitrogen content in composted manure and sewage sludge run in completely different ways.

The level of cumulated ammonia losses from composted sewage sludge and manure can reach similar value, but the dynamic of emission during composting process runs in entirely different manners.

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