Alternative utilization of the solid fiber fraction from separated animal slurry - composting as one opportunity

Karin Jørgensen, Jesper Luxhøi and Lars Stoumann Jensen
Email: karinj@life.ku.dk
Laboratory for Plant and Soil Science, Department of Agricultural Sciences, Faculty of Life Sciences, The University of Copenhagen

Introduction

The number of animal slurry separation plants in Denmark has increased over the past few years. In 2007 about 50 slurry separation plants were operating in Denmark, separating slurry into a liquid and a solid fiber rich fraction. The fiber fraction contains a substantial amount of the phosphorus and organic nitrogen from the slurry. Slurry separation constitutes a new opportunity for farmers to comply with strict environmental regulation. The nutrient rich fiber fraction may be utilized in many different ways: excess nutrients can be transported over longer distances to arable land low in nutrients, renewable energy can be produced from either anaerobic digestion (biogas) or direct incineration, or the fibers can be composted and used on areas outside arable land. The majority of the fiber is rich in phosphorus which is a non renewable resource. By incineration of the fibers, the phosphorus is incorporated in the bottom ash from where the P availability is very limited (Moller *et al*., 2007), which supports the fact that there is a need for developing alternative utilization methods of phosphorus-rich animal waste.

In our opinion composting of separated slurry fibers can be a worthwhile alternative for utilizing the excess nutrients. Compost of this type with a high content of nutrients would be relevant to use on areas where nutrients with a slow release pattern is recommended; e.g. as a top-dressing on golf courses and other turf grass areas, in plantations or in private gardens.

The aim of this project was to investigate the composting properties of fibers from separated animal slurry. Further, nutrient turnover during the composting process was determined.

Sampling and analyses

As a foundation for deciding which utilization method is the most suitable for the separated slurry fibers, an analysis campaign from a number of existing slurry separation plants in Denmark was carried out, in order to map out the variability in quality parameters of the fibers. From the existing 50 separation plants about 20 of them separates slurry by use of organic flocculants followed by a mechanical separation (CHEM), 10 of them separate by use of a decanting centrifuge, primarily separating de-gassed slurry from biogas plants (DEC/BIO) and the rest are low technology separation plants from 3 different companies that separates slurry mechanically (MEC). A total of 44 samples were collected from 33 different separation plants. The majority of the samples were collected fresh after separation, whereas a smaller amount was collected from stored stocks of fibers; some fibers had been stored up to 14 months on farm before sampling. In all samples common parameters like pH, electric conductivity (EC), total solids (TS), ash, total carbon, total nitrogen, ammonia-nitrogen and total phosphorous were determined.

In order to investigate composting as a suitable utilization of the fibers, a four week composting experiment with one representative of each fiber type DEC/BIO, CHEM and MEC was set up in small scale reactors (10 l closed containers, with actively forced, flow-through aeration). Each fiber type was mixed with rape straw at two different ratios on weight basis to test the optimal physical structure and dry matter content for composting.

The mixing ratios were for DEC/BIO and MEC fibers 10 and 25% rape straw respectively and for CHEM fiber the ratios were 25 and 40 % rape straw. The compost experiment with all 6 mixtures was carried out twice, in order to obtain real replicates. During the composting ammonia emission from the exhaust air of the reactors was collected in formic acid traps and determined periodically. Samples of the compost were collected before and after the composting process and analyzed for the same parameters as described above for untreated fibers. In addition, the water soluble inorganic phosphorous was measured by shaking wet compost in a 1:100 compost - de-ionized water suspension end-over-end for 16 hours.

Results and discussion

The results of the variability among untreated solids from separated animal slurry are presented in Table 1. The results are presented as mean values of samples from different separation technologies and the standard deviations are shown to indicate the variability within samples from the same type of technology. The purpose was in this study to get an overview of the variability among the samples, both within and among the different separation technologies.

Table 1: Quality parameters of 44 samples of fiber from separated animal slurry. All parameters are presented as mean values with standard deviation in parentheses

	TS %	Ash %	pH	EC dS m^{-1}	N total g kg^{-1}w.w.	NH_4-N g kg^{-1}w.w.	P total g kg^{-1}w.w.
DEC/BIO	31.9	33.7	8.1	4.7	10.53	3.35	10.10
(n=10)	(6.5)	(8.9)	(1.2)	(2.4)	(2.28)	(1.83)	(5.64)
CHEM	24.2	18.9	8.2	3.5	8.57	3.80	5.55
(n=22)	(5.3)	(6.6)	(0.5)	(1.4)	(2.56)	(1.37)	(1.76)
MEC	34.3	8.8	7.8	2.6	6.64	3.22	2.55
(n=20)	(8.8)	(3.4)	(1.1)	(1.5)	(2.58)	(2.03)	(1.56)

As seen in table 1 there was a large variation among samples from the same separation technologies, especially for the DEC/BIO samples. This indicates that not only among technologies there was variability but also within technologies the fibers were diverse. However despite the large variation within fibers from the same type of separation technologies there are some overall important differences among fibers from different technologies. Notably the highest ash content was found in DEC/BIO fibers, because the organic material in the fibers was more degraded due to the biogas procedure, up-concentrating the content of minerals. Therefore the highest P concentrations were also found in DEC/BIO samples with much lower values in CHEM and MEC samples. The same pattern was observed for total N contents; however it was less noticeable than for P. MEC samples generally had lower concentrations of nutrients and ash but a high content of total solids.

During the composting experiment all mixtures of fiber and rape straw were able to self-compost and reached a temperature maximum within the experimental period of four weeks. DEC/BIO reached 70°C within 1-2 days, CHEM reached 63°C after 8-13 days and MEC reached 40-55°C after 2-3 days (Figure 1).

The total weight loss after the 4 weeks of composting was between 6 and 21 %, lowest for MEC compost and highest for CHEM compost. The total carbon lost during composting was highest for CHEM 40 % compost that lost about 40 % C relative to the initial C content whereas DEC/BIO 25 % lost 18 % C as the lowest (data not shown).

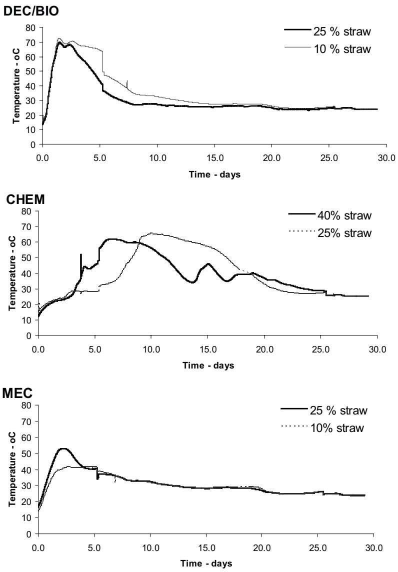


Figure 1. Temperature development during four weeks composting of DEC/BIO, CHEM and MEC fibers. Each fiber was composted in two different mixtures with rape straw. Each curve represents mean values from two replicates

The initial C:N ratios of all mixtures were between 11 and 14 with variation among duplicate composts at the same level as variation among differing composts. The nitrogen balance (mass-balance and ammonia loss measured directly) during composting showed in Figure 2, that the highest N loss was observed for CHEM 25%, however the highest ammonia emission was found for CHEM 40 % composts. In general, the nitrogen lost as ammonia during composting varied between 0.06 and 5.61 g NH_3-N kg $^{-1}$ initial compost w.w. which corresponds to NH_3 emission between 25 and 1830 g NH_3-N pr m^3 initial compost. In comparison Amon (2006) found NH_3 emission from storage of separated solid fraction at 288 g NH_3 pr m^3 (corresponding to about 224 g NH_3-N kg^{-1}) separated animal solid fraction. The highest ammonia emissions occurred from the compost with the highest initial nitrogen content, and the measured ammonia losses corresponds to between 0.4% and 17.5 % of initial total N. The temperature development was slower for CHEM samples and the amount of time where the compost had maximum temperature was longer than for MEC and DEC/BIO composts which may contribute to higher NH_3 emission. It has previous been shown that the emission of NH_3-N can be dependent on the content of biodegradable C fraction in the initial compost (Paillat et al., 2005) saying that the highest NH_3-N emission occurs from substrates with the highest amount of biodegradable C. This supports that the highest NH_3-N emission in this case was observed for CHEM composts, which had the highest initial C content and the lowest final C content, indicating a large pool of biodegradable C (data not shown).

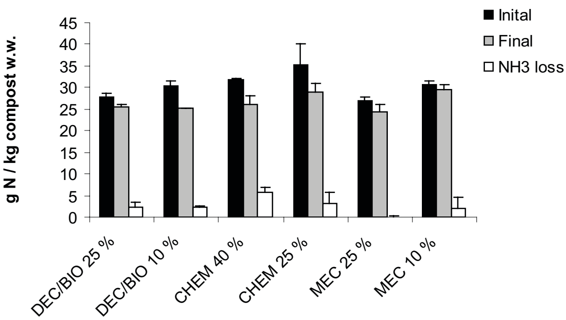
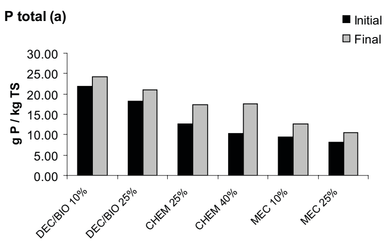


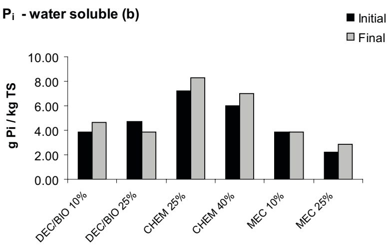
Figure 2. Total nitrogen in initial and final wet weight compost and the nitrogen lost as ammonia during four weeks of composting. Error bars indicate difference between mean of two replicates and maximum

Total P concentration in the initial compost (Figure 3a) differed within the three composts, as expected on the basis of knowledge on variability in raw fibers (Table 1). The highest total phosphorus content was found in the DEC/BIO 10% rape straw mixture (21.8 g P kg TS^{-1}) and lowest in MEC 25% rape straw mixture (8.15 g P kg TS^{-1}). After four weeks composting an increase in the total phosphorus content was observed in all composts. The increase in total P was most likely due to weight loss during composting. This is supported by the fact that the largest increase in total P was seen for the CHEM composts that also had the highest weight loss and C loss during composting (data not shown).

The water soluble inorganic P (Pi-H_2O) was measured as an indicator for the available P fraction in the compost (Figure 3b). The largest Pi-H_2O fraction was determined in CHEM samples (8.3 g kg TS^{-1} for final CHEM 25 %, despite the fact that the largest total P was observed for DEC/BIO composts. For almost all compost mixtures none or a small increase in the Pi-H_2O was observed after composting, only for DEC/BIO 25% compost a minor decrease was observed. In comparison an investigation of compost from house refuse compost, sewage sludge compost and food waste compost by Traoré et al. (1999) showed a systematically decrease in Pi-H_2O in all types after composting.

Figure 3. Total phosphorus (a) and water soluble inorganic P (b) initial and final compost after four weeks composting. Each column represents mean values from sample from two compost experiments





Conclusion and perspectives

There is a great variability among solids from separated animal slurry in many parameters like pH, EC, and nutrient content. Knowledge about this variability can lead to decision making about different utilization methods for the separated solids. Composting of the solids with a structural additive like rape straw is possible for all types of solids in lab-scale reactors. However ammonia emission is a significant contributor to green house gas emission and must in future experiments be further investigated.

Acknowledgements
Thanks to the Research School of Environmental Chemistry and Ecotoxicology, RECETO (www.receto.dk) for partly funding of the PhD education laying the foundation for this investigation.

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