CHEMICAL CHANGES IN POULTRY MANURE DURING COMPOSTING

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1 INTRODUCTION

The environmental problems associated with raw poultry manure application, such as release of gas pollutants or dissemination of pathogens, could be mitigated by stabilizing its nutrient and organic matter (OM) contents by composting before application to agricultural soils (Tiquia and Tam, 2002).

Processing, manipulation, storage and application of animal manure is associated with considerable nutrient losses, particularly nitrogen, that is released into the atmosphere in the form of ammonia but may also contaminate surface and grand water in the form of nitrates, and, together with phosphorus, may cause eutrophication of surface water (Burton and Turner, 2003; Bernal et al., 2009).

Composting of poultry manure reduces odour and pathogens and improves its quality as a soil amendment. Addition of organic material, e.g., sawdust, increases the C:N ratio so to achieve optimum degradation of organic C and retention of N through microbial biomass formation. However, the relative biodegradability of the organic material in poultry litter and the amendment are usually not known. It is assumed that as microorganisms metabolize organic compounds and produce CO_2, they increase in biomass and retain nitrogen (Atkinson et al., 2005).

The principal limiting factor when applying animal manures to agricultural soil is nitrogen loss in the form of ammonia (Turan, 2009). Even in the process of composting of poultry dropping nitrogen losses may vary between 47 % and 62 %(REF?). It is most important to ensure optimum conditions in the substrate during composting to prevent these losses and support optimum retention of nitrogen N through biomass formation. This will increase usability of compost as optimal soil amendment (Tiquia and Tam, 2000).

Reaching of appropriate composting temperatures (60-70^{o}C) will prevent survival and dissemination of pathogens and decrease germinating ability of weed seeds (Tiquia and Tam, 1998).

The aim of the present study was to investigate the processes taking place in poultry litter mixed with sawdust with regards to biodegradability of the mixture and the properties of the final products..

2 MATERIALS AND METHODS

The investigations were carried out on fresh droppings collected in one day from laying hens on a poultry farm in total quantity of 3.00 m^3. The experiment was conducted in winter in an open pilot-plant composting facility under a roof. Poultry droppings and straw used in the experiment were examined for basic physical and chemical properties (Tab. 1).

The substrate for composting was prepared by mixing poultry droppings and cut straw at a ratio of 1:1.63 by volume. The experiment lasted 114 days with mixing of the substrate on days 9, 21 and 94. During 114 days of composting the core temperature and 0.1 m below the surface were recorded daily. Samples were taken from the core of the substrate on days shown in FIGURE 1 to determine the relevant chemical parameters, namely pH, dry matter (DM), organic matter, NH_4^+, total nitrogen (N_t), total phosphorus (P_t) and C:N ratio. The methods used corresponded to the STN 465 735. The C content was calculated according to the content of organic matter by the method of Navarro et al., (1993). Results are reported per dry weight.

TABLE 1 **Physical and chemical properties of the basic materials**

	Straw	Solid poultry manure
pH	7.01	7.02
MC (%)	5	71,4
OM (%)	96.2	91.1
IM (%)	3.8	8.9
NH_4^+ ($g.kg^{-1}$ DM)	0.1	1.96
N_t ($g.kg^{-1}$ DM)	4.2	45.5
C:N ratio	117	10

3 RESULTS AND DISCUSSION

The present study focused on quantitative changes in physical and chemical properties of poultry manure and straw mixture during composting to contribute to the body of knowledge about the composting processes and to evaluate the suitability of the final product for application to agricultural soil. The poultry litter was composted in forced-aeration piles and the substrate was turned manually on days 9, 21, 94 of composting.

Our experiment showed that on day two of composting the core temperature reached 44.1^{o}C and increased to 59 ^{o}C by day 8. On day 9 after first mixing of the substrate it raised to 62 ^{o}C which was the highest temperature reached. After this day the core temperature decreased slowly with some small variations up to the end of the experiment. It persisted above 55 ^{o}C for 11 days.

The course of temperature measured 0.1 m below the surface was different. On day 2 it reached 37.7 ^{o}C and on day 8 it peaked at 59 ^{o}C and after that it continued to decrease till the end of the experiment. The temperature above 55 ^{o}C was recorded only for one day.

The core temperature indicates that the processes were most intensive in the initial period which was reflected also in values of other parameters.

The pH level increased with the progress of decomposition processes (Amanullah, 2007). Figure 1 shows the changes in pH during our experiment. The initial pH was 8.46 and increased to the highest level (9.23) by day 3 of composting after which it gradually decreased down to 8.2 by day 114. The increase may be ascribed to mineralisation of N and production of ammonia and the subsequent decrease may be related to decomposition processes accompanied by production of fatty acids. Guerra-Rodríguez et al. (2000) investigated composting of poultry droppings mixed with barley straw and found out that final pH in the compost reached 8.61.

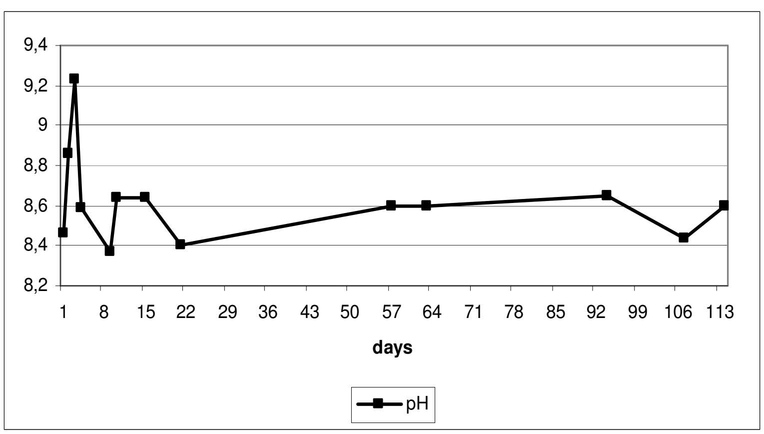

FIGURE 1 **The course of pH during 114-day composting of poultry manure mixed with straw**

The moisture content is one of the essential factors affecting rate of composting and maturity of the product. The initial moisture content in the composted substrate was 67.4% which is in the optimum range (50-70%). After initial increase it peaked at 72.9 % on day 3 and persisted at this level up to day 21 and then it decreased gradually down to 59.7 % (Fig. 2). The decrease occurs mostly due to evaporation of water from the substrate at elevated temperatures. According to Stentiford (1996) moisture content should remain in the range of 40-60% during most of the composting process.

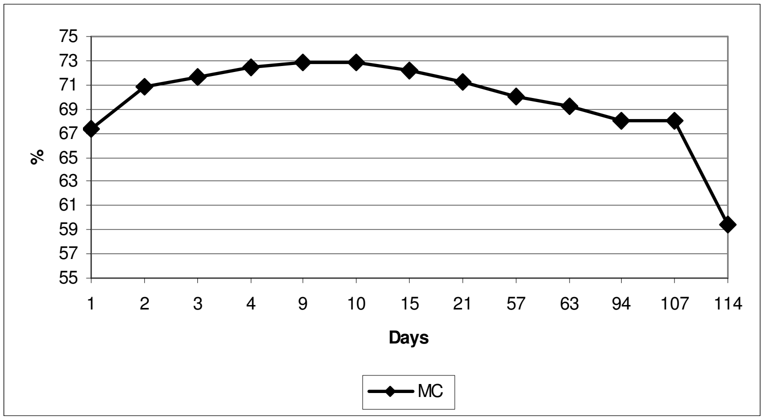

FIGURE 2 **The course of MC during 114-day composting of poultry manure mixed with straw**

The initial level of NH_4^+ was 13.3 g. kg^{-1} (Fig. 3) and increased in the process of composting, particularly on days 9 and 21 (mixing of the substrate) when it reached 22.4 and 17.4 g.kg^{-1} DM, resp. At the end of the experiment the NH_4^+ level was 3.9 g. kg^{-1}. The content of ammonia in the composted substrate increases initially due to increased microbial degradation of N-substances which is accompanied by increase in pH. If the temperature increases simultaneously, ammonia is increasingly released into air. This occurred also in our experiment up to day 21 when the core temperature continued to decrease (39.3 ^{o}C). Tiquia et al. (1998) observed that absence and/or decrease in NH_4^+ is an indicator of good composting and maturing process.

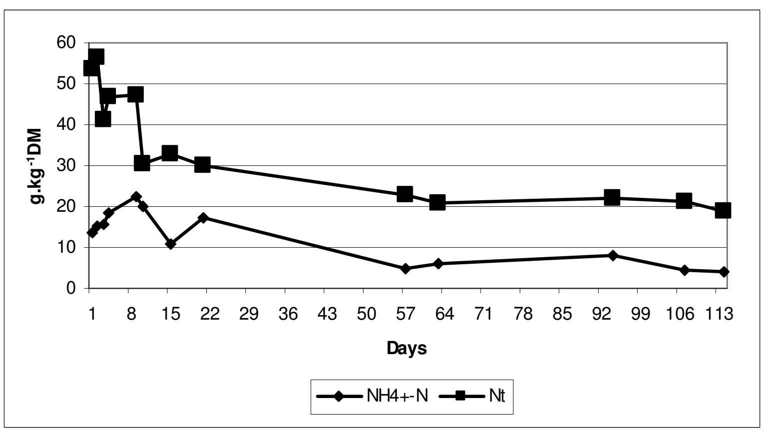

FIGURE 3 **The course of NH_4^+ and N_t during 114-day composting of poultry manure mixed with straw**

Transformation of nitrogen by ammonification processes in the first stage of composting of material rich in N usually occurs at high rates. Most of the nitrogen in this stage is lost as NH_3 emissions. This decreases the agronomic value of the final products and contributes to environmental pollution (Witter and Lopez-Real, 1988).

The N content in the manure declined linearly in the presence of straw and the reduction was slow. The loss of N_t could largely be attributed to volatilization of ammonia (Fig. 4). Other authors (Goyal, 2009) also observed losses of N in poultry waste resulting in initial increase in C:N ratio which reached 10:1 at the beginning of the experiment.

The parameter most frequently used to characterise composting conditions and compost quality is the C:N ratio. Organic material, e.g., sawdust or straw, is added to increase the C:N ratio to achieve optimum degradation of organic C and retention of N through microbial biomass formation (Atkinson et al., 2005). High initial ratio (35:1) may result in slower onset of composting process and longer time needed for composting (Martins and Dewes, 1992; Tuomela et al., 2000) while very low ratio (20:1) may lead to high losses of N in the form of NH_3 (Ogunwande et al., 2008). According to common agreement, C:N in the range 20:1 – 25:1 may indicate maturity of the final product. In our experiment the initial C:N ratio was 9.3:1 and increased to 22:1 at the end of composting which indicates suitability of the compost for application to soil.

In general, phosphorus content increases slightly during the intermediate phases of composting irrespective of the methods of aerobic decomposition. The initial level of total P in our experiment was 5.5 $g.kg^{-1}$ DM. It increased to 11.8 $g.kg^{-1}$ DM by day 57 and than decreased to the final level of 9.4 $g.kg^{-1}$ DM. Similar results were reported by Amanullah (2007) who observed an increase in total P content during aerobic decomposition.

4 CONCLUSIONS

During the 114 days of composting the chemical parameters in the composted substrate underwent considerable changes that corresponded to intensive decomposition. The final C:N ratio was 22:1 which indicated maturity of the final product (range 20:1 – 25:1 is considered appropriate) and its suitability for application to soil.

ACKNOWLEDGEMENTS

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