EFFECT OF BIOCHAR AND ZEOLITE ON THE AMMONIA PRODUCTION OF POULTRY LITTER

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Abstract

High amount of chicken manure (11.600 t/year) is produced in the five chicken farm of examined company (Gastor Baromfi Ltd.) because of deep litter breeding technology of broiler chicken. The triticale straw is the main bedding material. Presently the manure is composted, but it is required store in a larger storage place by a project of capacity-building. Otherwise the retention time of the process is cannot be guaranteed and high ammonium content is measured under the process in closed system compost pile and in the storage place area.
The aim of the research was to reduce ammonia emission during pre-treatment process of chicken litter in open and closed conditions by added zeolite and biochar as additives. The main aim was to determine the effectiveness of the different type and amount of additives on the reduction of ammonia emission. The experiments were set up in pilot plant scale in the composting area of Institute of Water- and Environmental Management. Under the pre-treatment process we examined the dry-, organic material content, temperature, particle size, pH value, NaCl-content, electric conductivity, gas components, nutrient- and toxic element content of chicken litter.
Based on our results that the additives (zeolite/biochar) mixing of stored manure has significantly reduced the amount of produced ammonia and the applying in larger ratio (5, 10%) increased the ammonia reduction and the degradation rate of organic materials.

Keywords: chicken litter, zeolite, biochar, pre-treatment

INTRODUCTION

One of the major problems facing modern agriculture is the large amount of waste products generated by intensive animal production. These wastes are generally considered to be a liability with little economic value. However, these wastes contain nutrients that could be substituted for more costly nutrients used in production agriculture (Fontenot et al., 1983). Poultry litter represents a major class of animal wastes and produce in impressive amounts (Stephenson et al., 1990). Poultry litter is a potentially underused fertilizer because it contains appreciable amounts of N, P, K, and micronutrients (Steiner et al., 2009). The composition of poultry litter depends on feed type, bedding material used and pest control methods (Stephenson et al., 1990; Gupta et al., 1997). Poultry litter is primarily disposed of by land application as a fertilizer over the world due to the presence of nitrogen (3.3% NO_3), phosphorous (3.4% P_2O_5) and potassium (1.7% K_2O) (Gupta et al., 1997). Composting is one of the most widely accepted technologies for the recycling of organic wastes in agriculture (Butler et al., 2001) so it is defined as a biological decomposition and stabilization of organic substrates, that produce a final product that is stable, free of pathogens and plant seed and can be beneficially applied to land (Haug, 1993). Composting is reduce weed seeds, and odour in poultry litter, which is often results in high losses of N through NH^3 volatilization (Steiner et al., 2009).

Natural zeolites nowadays are mostly used in catalysis, in air enrichment, as filers in paper and rubber industry, in soil benefication, as animal feed supplements, and in water and wastewater treatment for the ammonia and heavy metal removal (Zorpas et al., 1997; 1999). Materials like zeolite have been shown to adsorb NH_3, but they are more effective when applied on the surface than when mixed into poultry litter (Kithome et al., 1999). Adsorbed N is not available for crops if the zeolite is not land applied or if the adsorbed N is not plant available. Kithome et al. (1999) found the use of adsorbents such as zeolite and coir pith to be most suitable for reducing NH_3 losses during composting of poultry manure. They are reported that NH_3 loss was 47-62% of the initial total N after 25 day of composting poultry layer manure. The pre-treatment of poultry manure with straw could be reduced the nitrogen-content with 44% under the treatment (Kirchmann and Witter, 1989). Hansen et al. (1989) reported that during the composting of poultry manure could be achieved 33% the nitrogen-losses.

Nowadays, there is an increasing role of utilization of biomass, and mainly of the biochar. The activated carbon can be applied as ammonia and odour absorbent (Lehman and Joseph, 2015). Biochar's have been traditionally used as soil conditioners because of the benefits to crop yield (Steiner et al., 2007) and to the improving of the water holding capacity, pH, soil organic matter values and microbial activity of the soil (Chan et al., 2007). Steiner et al. (2009) produced three poultry litter compost mixtures that consisted of poultry litter without added biochar and with 5, 20% biochar in nine bioreactors. Biochar showed to act as an absorber of NH_3 and water-soluble NH_4^+ and therefore reduced losses of N during composting of manure.

The aim of the research was to reduce ammonia emission during pre-treatment process of chicken litter in open and closed conditions by added zeolite and biochar. Further object was to test the effectiveness of the developed methods and to determining the optimal rate of the additives in plant operating conditions.

MATERIAL AND METHOD

Experimental treatments

The pilot scale chicken litter pre-treatment experiments were set at the Institute of Water- and Environmental Management. The retention time was four and eight week, respectively. The experimental treatments shows the Table 1 and 2. The applied chicken litter was originated from the chicken farm of Gastor Baromfi Ltd. in Nyírbátor, where white broiler chicken are produced in six week rotation with an airspace deep litter based breeding technology.

Table 1

Open prism pre-treatment process

Experimental settings (20 kg chicken litter)	**Additives**
Control (0% zeolite/biochar)	0 kg zeolite/biochar
1 % zeolite/biochar	0.330 kg zeolite/biochar
2% zeolite/biochar	0.665 kg zeolite/biochar
5% zeolite/biochar	1.660 kg zeolite/biochar

Table 2.

Closed pre-treatment process

Experimental settings (5 kg chicken litter)	**Additives**
Control (0% zeolite/biochar)	0 kg zeolite/biochar
1% zeolite/biochar	0.05 kg zeolite/biochar
2% zeolite/biochar	0.10 kg zeolite/biochar
3% zeolite/biochar	0.15 kg zeolite/biochar
5% zeolite/biochar	0.25 kg zeolite/biochar
10% zeolite/biochar	0.50 kg zeolite/biochar

Four prism was set up in case of open windows pre-treatments with 20-20 kg chicken litter and additives in different ratios (0, 1, 2, 5 v/v% zeolite or biochar). In case of closed pre-treatments five kg chicken litter and 0, 1, 2, 3, 5 and 10 v/v% additives was mixed in containers.

Applied instruments, methods and standards

The observed parameters were as follows: moisture and dry matter content, particle size, organic-, carbon- and nitrogen content, temperature, pH, EC value, NaCl- and TDS content, gas composition, element- and heavy metal content. The dry matter content (%) was determined in oven on 105°C to constant weight for 24 hour under standard method (MSZ EN 21420-18:2005), until the loss on ignition (the organic matter content%) in furnace at 650°C (MSZ 9693-5:1978). From the dry-matter content (%) of original chicken litter was calculated the needed water-content of the pre-treatments process (60%). After drying, grinding and sieving process (2 mm> particle sizes) of samples a solution was made by 9:1 ratio water or 0.1N potassium chlorine solution (pH(dH_2O)/pH(KCl)) and shaking (KS-15 shaker) for 24 hours before analysing. Determination of Electric conductivity (EC) (mS/cm), pH, Total dissolved solution (TDS) (mg/l), Sodium chlorine (NaCl) (%) from the compost solution was observed with HANNA HI 2550 multi-parameter benchtop meter. Temperature was measured in two different depths in case of open window pre-treatments and in one depths in case of closed pre-treatments with Testo 925 type PT100 temperature probe. Once a week was determined the changes inside the prisms and inside the containers. MX21 multigas monitors were applied to detect different gas concentrations such as CH_4, O_2, H_2S, CO_2, NH_3, VOC, CAT in the chicken litter. It can detect 4 gases simultaneously, it contains an alarm if the gas concentration is on harmful levels (I1).

RESULTS AND DISCUSSION

We measured the pH, moisture-content, conductivity and the amount of organic matter in the chicken manure and in the applied additives before the pre-treatment process, which results are reported in Table 3.

Table 3.

Chemical attributes of the organic materials used for the composting mixtures

Raw materials	pH	Moisture (%)	EC (mS/m)	OM (%)
Chicken litter	7.40	48.0	8.96	82.59
Biochar	10.15	10.0	0.30	n.d.
Zeolite	7.74	20.0	0.33	n.d.
Poultry manure*	9.46	38.0	5.02	54.80
Biochar*	7.64	7.10	0.40	94.60

* Dias et al., 2010

** no data

Table 3. shows that pH value of applied chicken litter compared to results of Dias et al. (2010) was lower. The applied biochar samples were alkalinity in contrast the results of other literature, where were presented neutral pH values. The pH trend showed increasing in the period under review (Figure 1, 2.). The growing rate of Biochar addition increased in direct proportion the pH of manure. In the first week the pH value is shown around neutrality, followed by week four shifted towards alkalinity. The highest pH (8.76) was measured in the fourth week in case of closed, with 10 vol% biochar pre-treated experiment.

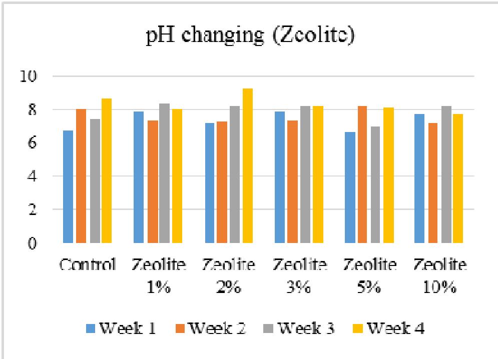

Figure 1. The pH changing in the closed, with zeolite pre-treated experiments

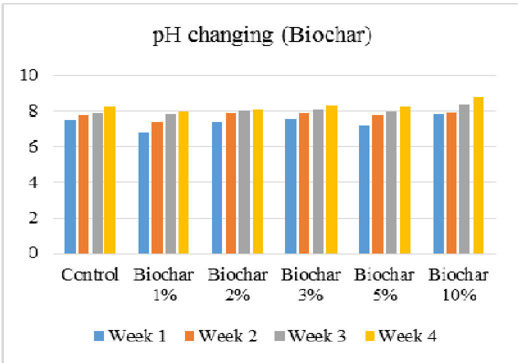

Figure 2. The pH changing in the closed, with biochar pre-treated experiments

The pH changing of the closed, with zeolite pre-treated experiments illustrated in Figure 4. The pH values in the studied period ranged from 6.7 to 8.7 in the closed experiments. The pH value was lower in the first three weeks by the control treatment, than the other treatments. At week 4. increased and became alkaline (pH 8.61).

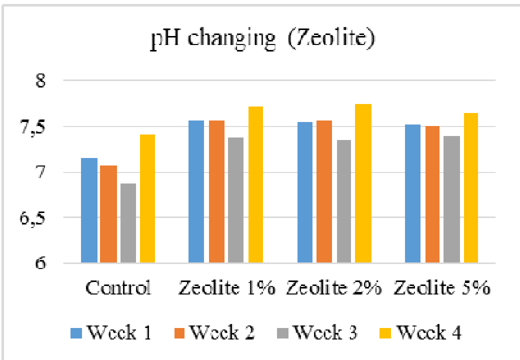

Figure 3. The pH changing in the open windows, with zeolite pre-treated experiments

The maximal pH value was 9.23 in the studied period by adding 2% zeolite as additives to the chicken litter. Figures 3. and 4. illustrate the change of pH in case of open, with biochar and zeolite (0, 1, 2, 5 vol%) pre-treated experiments.

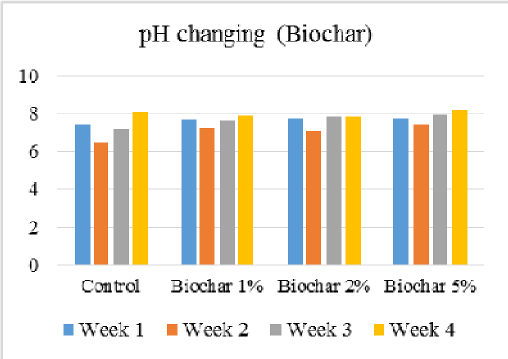

Figure 4. The pH changing in the open windows, with biochar pre-treated experiments

The tendency of the open and closed pre-treatments with biochar was different under the results (Figure 2, 4.). In the initial phase the pH of control treatments were low, and no significant differences could be determined (pH 7.0-8.2) between each prism and the retention time in the first four weeks. In case of open windows, with 0% zeolite mixed pre-treatments the pH showed neutral values during the first week, while the experiments treated by 1, 2 or 5 vol% zeolite the pH changed to slightly alkaline/alkaline direction (Figure 5. a-f). On the third week the samples showed a lower pH value, and this value was increased in the fourth week (pH 7.4-7.8). Based on these results we can concluded that the zeolite increases the pH of manure, however, the pH stabilized for each sample in the fourth week.

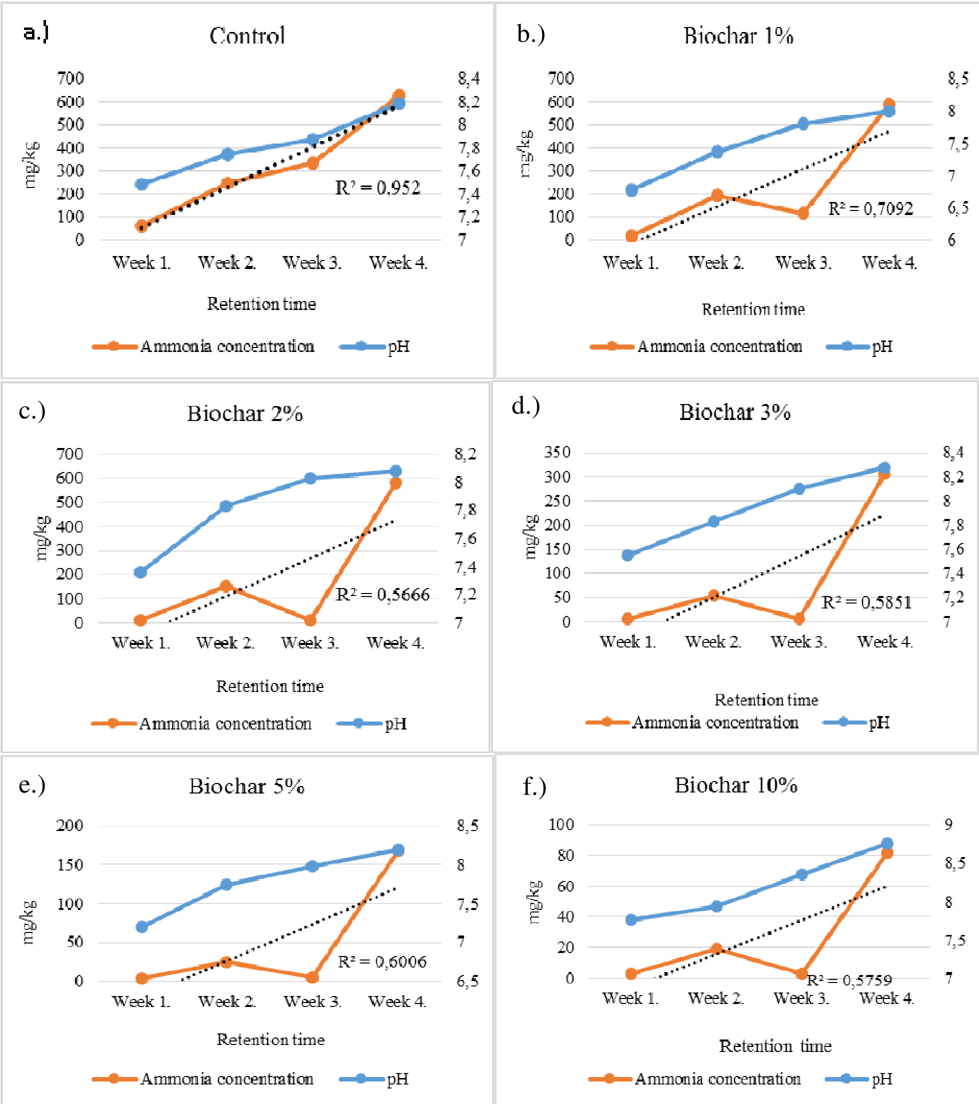

Figure 5. Changing of pH and ammonia concentration in the closed, with biochar pre-treated experiments

Low pH values (pH 6.8-7.2-7.5) were measured for the first week for each experimental treatments - compared to the fourth week -, and the fourth week changed the pH value to slightly alkaline/alkaline. A similar trend was observed in the change of the ammonia concentration. Between the first and fourth week ranged from 0 to 20 mg/kg of detectable ammonia concentration. The minimum ammonia concentration was measured by all of closed pre-treatments (1%, 2%, 3%, 5%, 10% Biochar) in the third week, except for the control treatment. However, the ammonia concentration was increased again on the fourth week (Figure 6.). We examined the relationship between the temperature and ammonia concentration in the case of open windows, with zeolite mixed chicken litter, that shown in Figures 6 a, b, c and d.

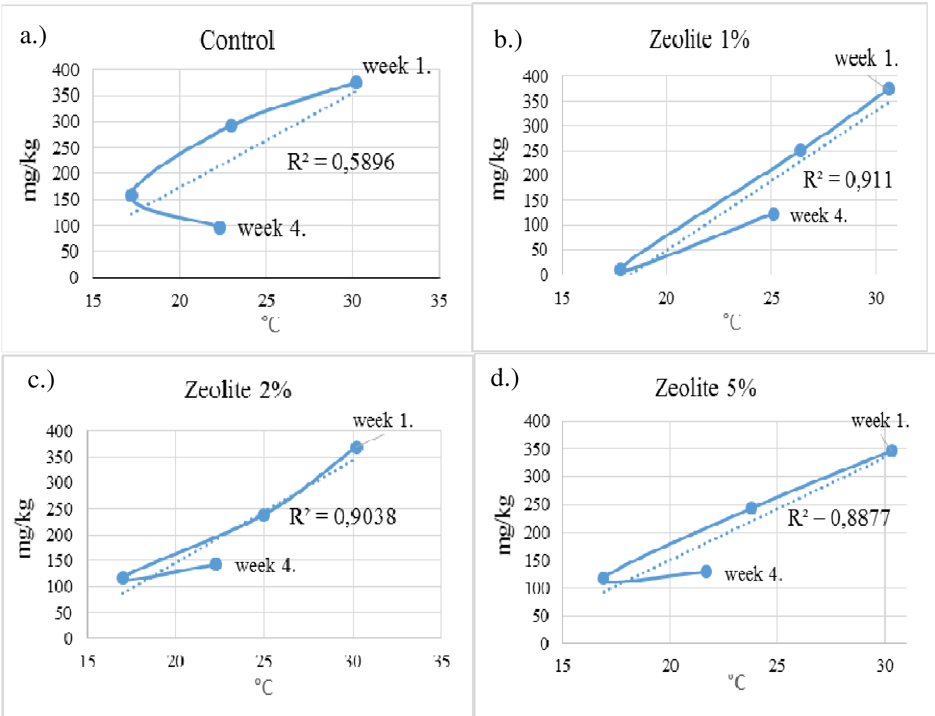

Figure 6. Correlation of temperature and ammonia concentration in case of open window pre-treatment

In the first three week was detectable strong correlation (R^2=0.58<) between the temperature and ammonia concentration, in this cases higher tempearture resulted higher ammonia emission.

CONCLUSIONS

The research focused on the examination of chicken litter pre-treatment and absorb of ammonia from manure by using different additives. In case of treatment with additives the pH increased under the pre-treatment process in higher level than by control group. Based on our results the additives (zeolite/biochar) reduced significantly the amount of produced ammonia and the degradation rate of organic materials. No significant differences were detectable between the two applied additives. The applying of additives in larger ratio increased the ammonia reduction more, therefore we recommended 5% ratio in plant operating conditions.

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