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Summary of Calcium Carbonate Equivalence Potential in Various Poultry Litter Types

Aaron Pettit[1,2*]

[1]*North Carolina Department of Agriculture, USA.*
[2]*US Department of Defense, USA.*

Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

The lab experiment was to evaluate lime potential of poultry litter being applied to agriculture fields for crop nitrogen and phosphors needs. Poultry litter lime potential was not being consider by farmer, even though soil pH increases were being noted in some fields were litter was applied. The experiment was conducted on poultry litter samples submitted to North Carolina Department of Agriculture (NCDA&CS) Plant/Waste/Solution/Media lab. Samples were divided and waste analysis with CCE% test was conducted from 1/23/2014 to 2/14/2015. Samples were divide into four types (PLB – Boiler, Turkey – PLT, Boiler Breeder – PBB, Layer – PLL). High level of Ca was found in correlation with high CCE% in both PBB and PLL litter. Where both PLB an PLT sample had low levels of Ca and CCE%. Inceasing Ca levels were found to be correlated with increasing CCE %, This correlation was not see with increasing Ca levels and litter pH.

Keywords: Poultry litter; calcium carbonate equivalence; CCE; manure application; soil pH; poultry litter pH.

**Corresponding author: E-mail: adpettit@ncsu.edu;*

1. INTRODUCTION

Poultry litter is commonly used as an inexpensive fertilizer source and is also a good source for building organic matter in mineral soils. Litter is typically applied to meet crop nitrogen demand unless other nutrients limit litter application rate [1]. The essential plant nutrients found in poultry litter are nitrogen (N), phosphorous (P), potassium (K), sodium (Na), calcium (Ca), magnesium (Mg), sulfur (S), manganese (Mn), copper (Cu), zinc (Zn), chlorine (Cl), boron (B), iron (Fe), and molybdenum (Mo). Nutrient levels vary depending on feed, supplements, medications, and water source consumed by the birds [2]. Calcium carbonate ($CaCO_3$) is one supplement fed to poultry especially when the operation focuses on egg production, such as breeder or layer poultry production operations [3]. The use of $CaCO_3$ aids in proper eggshell formation and maintains skeletal integrity [4]. The $CaCO_3$ supplement could potentially result in poultry litter with high Ca and carbonate (CO_3^-) concentration which could adversely affect soil pH.

As a good practice, most land applied poultry litter, are submitted to labs for analyzes to determine nutrient content and application rates. The Calcium Carbonate Equivalent percent (CCE%) test is rarely requested for poultry litter since the liming potential of litter is not fully understood and since the CCE% test requires an additional fee. The CCE% in waste reports can be easily converted to an agricultural lime equivalency (ALE) that indicates the number of tons of litter that are equivalent to one ton of agricultural grade lime (90% CCE) using the following equation: ALE (Tons) = 1800/((DM%/100)*(CCE/100)*2000; where DM% is the dry matter percent [5]. In a study, poultry litter applied according to CCE% displayed an increase in soil pH within all three soil types evaluated. Increases in soil pH were related to CCE% of the poultry litter; CCE% of the 3 poultry litter where 23, 30, and 36 CCE%. The results suggest that $CaCO_3$ in the poultry litter is just as effective in neutralizing soil acidity as an equivalent amount of lime [6].

Soil pH is usually adjusted predominately by applying agriculture grade lime ($CaCO_3$) or dolomitic lime ($MgCO_3$ & $CaCO_3$) to a specific target pH according to soil test report recommendations and the crop being grown. Litter application can be a source of lime which is not accounted for by most growers. Litter application rates vary with crop N demand and soil type, rates are often 4 tons per acre per application. Depending on the soil type, 4 tons of litter with a high CCE% can have an impact on soil pH. It would impact lighter sandy soil with potentially greater effect. Over liming can result in reduced nutrient uptake, especially micronutrient Fe, Mn, Zn, and Cu. With Mn deficiency concerned a major problem in sandy soils [7].

This study concerns the potential impact of poultry litter to increase soil pH. The concern came to my attention when communicating with growers and agricultural advisors around NC who noted Mn deficiency symptoms in their crops. Tissue samples confirmed low Mn concentration in the crop and corresponding soil test show elevated pH and low soil available Mn levels. This was observed predominately in winter wheat located in the sandy coastal plain soils of NC. Most of these growers/advisors had one thing in common – the application of poultry litter. Soil pH greatly regulates Mn availability; that is, as soil pH increases, Mn availability decreases. The possible influence of litter with high CCE% could be of great concern. The objects of this study is find a correlation between Ca concentration and CCE% in poultry litter, evaluate litter types for high levels of CCE%, and assess poultry litter pH and correlation with CCE%.

2. MATERIALS AND METHODS

During the period,1/23/2014 to 2/14/2015, 139 poultry litter samples were evaluated as waste samples by North Carolina Department of Agriculture and Consumer Service (NCDA&CS) Plant/Waste/Solution/Media lab for total nutrients (N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, B, Na), pH, and calcium carbonate equivalence (CCE%). Samples included 32 turkey litter (PLT), 34 boiler litter (PLB), 50 boiler breeder litter (PBB), and 23 layer litter (PLL). Samples were collect from route litter samples received by NCDA&CS Plant/Waste/Solution/Media lab. Grower samples were either divided and one half was used for this study, or the CCE analysis was analyzed on the original sample after routine analysis for grower. Prior to analysis, samples were dried for 12–24 hour at 80^{o}C, then processed through a stainless-steel grinder (Wiley Mini-Mill; Thomas Scientific; Swedesboro, NJ) with a 20-mesh (1 mm) screen [8].

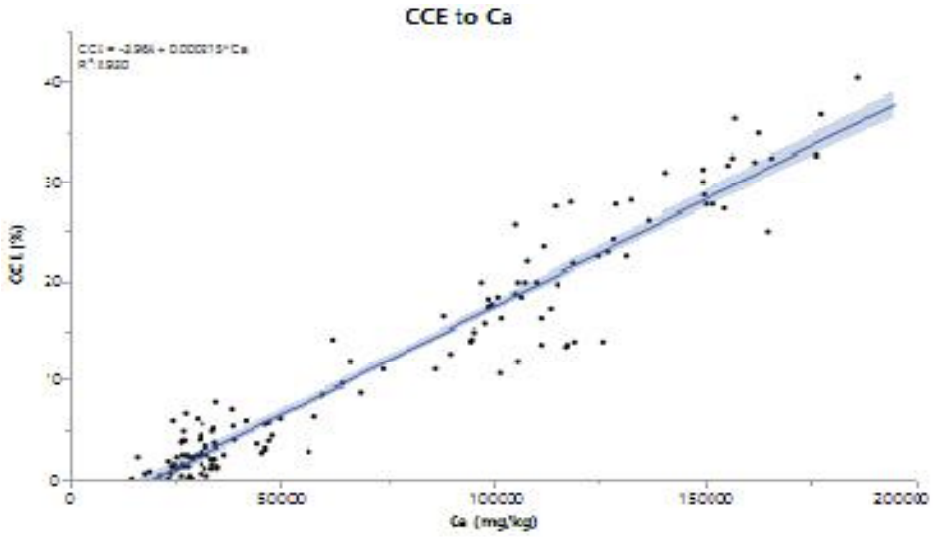

Fig. 1. Poultry litter correlation between Ca concentrations to CCE%

Total concentrations of P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, B, and Na are determined with an inductively coupled plasma (ICP) spectrophotometer (ARCOS EOP ICAP-OES, Spectro Analytical Instruments, Mahwah, NC) [9,10], after close-vessel HNO3 digestion in a microwave digestion system (MARS & MDS 2100 microwaves; CEM Corp.; Matthews, NC) [8]. Total concentrations were obtain by weighing 0.5-g, dried/ground aliquot of sample is digested in 10 mL 15.6 N HNO_3 for 5–30 minutes in a microwave, and the prepared sample volume is brought to 50 mL with deionized water prior to measurement. Results are expressed as mg kg^{-1}. CCE% is a measure of the acid-neutralizing capacity of a waste material. The process involves dissolving a 1 g aliquot of dried sample in 50 mL 0.5 N HCl (with heat at 350°C) and back-titrating to pH 7 with 0.25 N NaOH, according to the potentiometric titration method [11]. Results are expressed as percentage of pure calcium carbonate. Total N concentration was determined by oxygen combustion gas chromatography with an elemental analyzer (NA1500; CE Elantech Instruments; Lakewood, NJ) [12,8] on a 5 to 10 mg aliquot of the dried/ground sample. Poultry litter pH was determined using Orion 920A pH meter; Beverly, MA. Litter pH was analyzed using a 1 to 1 volume, consisting of 10 cc dried litter and 10 ml deionized (DI) water [13].

JMP Pro 10 (SAS software) was used for statistical analysis of all data. Analysis of variance (ANOVA) was used to obtain significance of treatment effect with mean separation using Tukey HSD. Coefficient of determination was also obtained with the analysis of variance in JMP.

3. RESULTS AND DISCUSSION

There was a significant increase in Ca levels found in poultry litter samples collected from PLL and PBB samples (Table 1). With PLL samples have the highest Ca levels which was significantly higher than PBB samples. As Ca levels increased, there was a significant increase in both CCE% and pH levels. There was significantly higher pH and CEE% found in PLL and PBB samples. Depending upon poultry litter source, CCE% ranged from 0-40 in all litter samples collected in this study. All PLB and most PLT samples collected contained relatively low or no CCE%. One PLT sample did have relatively high CCE%; however, turkey breeder houses were not identified in this study; so there is no way to know if this sample came from a turkey breeder house were Ca was being used to maintain egg integrity. Additional information that is important to consider is that poultry litter pH and CCE% both significantly increased with increasing Ca levels; however, the was only a high correlation coefficient noted with CCE% to Ca and only a miniscule correlated between litter CCE% to pH. Ca to CCE% was highly correlated with a R^2 of 0.93, and this high correlation was not observed with pH to CCE% with a R^2 of 0.34. Therefore, pH is would not be an accurate measure of poultry litter lime potential (Figs. 1 & 2).

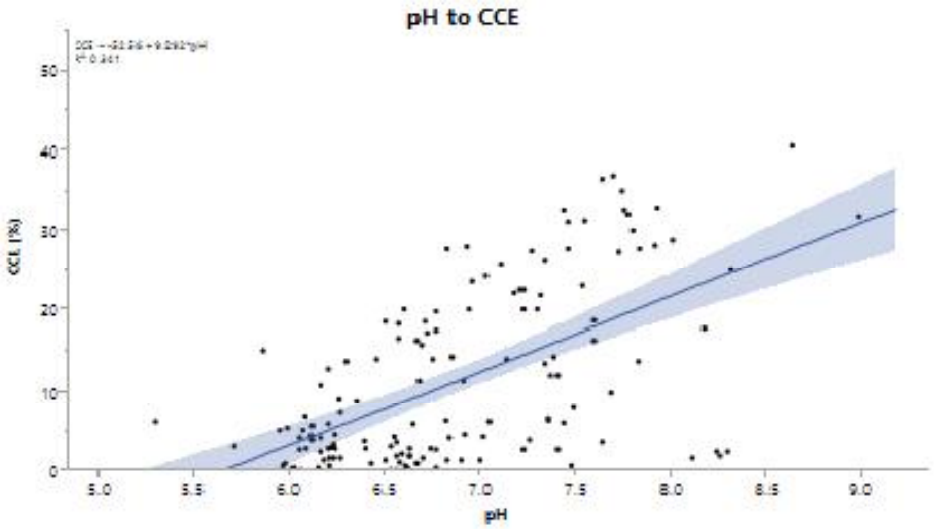

Fig. 2. Poultry litter correlation between pH concentrations to CCE%

Table 1. CA, CCE%, and pH levels of four poultry litter types

Litter	CA	CCE	Litter
TYPE	MG KG^{-1}	%	PH
PLL	122462A	22.09A	7.16A
PBB	98691B	17.64A	7.22A
PLB	29183C	2.91B	6.72B
PLT	37656C	3.26B	6.33B

Means within columns with the same letter(s) are not significantly different at p ≤ 0.05 by tukey's multiple pairwise comparison

4. CONCLUSION

In this study, the increasing Ca concentration was found to be correlated with increasing CCE%, and showed significant different in CCE% between poultry litter used for egg production and those not used for egg production. Based upon this regression curve, growers should consider that their litter has a noteworthy liming potential if the waste report indicates 60,000 mg kg^{-1} or great Ca levels. Using the regression curve, 60,000 ppm Ca equaled roughly to 9% CCE using the equation base on R^2 where CCE% = (Ca – 21368)/4250.8). If high calcium levels are observed in the poultry litter test reports, growers should consider testing CCE% to obtain an accurate measure of the liming potential. If the test is not available, a person can estimate CCE% by using the regression in this study. Dry Matter will need to be considered to know the ALE of the litter with the equation ALE = 1800 ÷ {(DM% ÷ 100) × (CCE% ÷ 100) × 2000)}. On average PLL litter samples has an ALE = 5. This means that 5 tons of litter equals 1 ton of agriculture grade lime. A few PLL and PBB litter samples had ALE of ≤ 3. Additional information that is important to consider is that poultry litter pH and CCE% both significantly increased with increasing Ca levels but there was irrelevant correlated between litter pH and CCE%. Therefore pH would not be an accurate measure of poultry litter lime potential. Also potential liming effect of litter with high CCE% leading to an increase in soil pH, could possibly be affected by nitrogen evolution such as ammonification or nitrification which may perhaps neutralize carbonate compounds found in litter once applied as a land application [14]. Evaluating Turkey breeder houses litter separate from general turkey houses litter would assistance in additional information; however similar result should be noted.

CONSENT

Authors declare that written informed consent was obtained from the patient (or other approved parties) for publication of this paper.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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