(Format No. 3)

SUMMARY OF DOCTORAL THESIS

Name: FARIDULLAH

Title: Characterization and Recycling of Poultry litter Ash as Potential Source of Phosphorus Fertility

リン酸質肥料としての家禽糞灰の特性と利用法

To meet the dietary demand of increasing population, poultry industry is playing very important role. This increase in production has also resulted in increase of co-products such as manure waste. Continuous disposal of poultry litter in agricultural field has rose sever environmental concerns especially in the areas with high number of poultry farms. Poultry industry has encountered increasing pressure to develop strategies to reduce the environmental impact of the large amounts of litter. Similarly, proper storage and handling of poultry litter (PL) in bulk is also a big concern of poultry industry. Burning of PL could be a one option of good poultry waste management practices. Poultry litter ash (PLA) will not only reduce the required space of storage but it will also reduce the cost of transportation and pave the way of PLA transportation to wider extent. Therefore a number of experiments were conducted to evaluate the effect of different temperatures on PL as P fertilizer.

In the first study, chicken and duck litter was burned at five temperatures i.e. 200, 400, 600, 800 and 900^{o}C and ash was analyzed for EC, pH, loss on ignition (LOI), total carbon (TC), total nitrogen (TN), and total calcium (Ca), magnesium (Mg) and potassium (K). Phosphorus was fractionated into readily plant-available P (H_2O-P), labile inorganic P ($NaHCO_3$-P), (NaOH-P) and Ca-associated P (HCl-P) by sequentially extraction methods. To find the fertilizer value of ash, Peterman's citric acid extraction was done and effective P was estimated by citric acid extraction. The experiment showed that weight loss was remarkably varied under different temperatures. As expected increasing temperature increased weight loss. The phosphorus fractionation of CL and DL showed that the P forms changed significantly during the ash process. For both CLA and DLA the sequential extractions were considerably varied for P release in the order of HCl > $NaHCO_3$ > NaOH > water. Irrespective of the poultry type, maximum P fractions ($\sum$ H_2O + $NaHCO_3$ + NaOH + HCl) were observed at 600^{o}C. Maximum percentage of HCl-P was recorded at 900^{o}C temperature in both CLA and DLA. The results of the study clearly showed that with the increase in temperature labile P fraction in the ash of both litters reduced and P is converted to more stable form i.e. HCl-P. The higher percentage of water-soluble P in the unburned CL and DL as compared to CLA and DLA may be resulted from the soluble P that had been added to the poultry diet and is readily removed by water from the litter, whereas the burning process of the litter reduced the solubility of P by forming insoluble P compounds with Ca. Phosphorus fractions extracted with HCl shows the P bound with Ca, which is more stable form.

The second experiment was carried out to compare changes in metals fractions in chicken and duck litter after incineration at temperatures ranging from 200 to 900^{o}C. The metals were stepwise fractionated into exchangeable, adsorbed, organically bound, carbonate precipitated and residual forms by extracting with 0.5*M* KNO_3, de-ionized water, 0.5*M* NaOH, 0.05*M* Na_2 EDTA and 4*M* HNO_3, respectively. Total metal extracted with tri-acid solution (HNO_3+$HClO_4$+H_2SO_4) were also higher in CLA than DLA. These differed metal concentrations may reflect the variability in the ash composition of chicken or duck litter

collected. Among the feed additives, metals are added as feed supplements to prevent diseases and improve weight gains, feed conversion and increase egg production. On the other hand, higher temperatures significantly reduced the levels of H_2O-soluble Mn, Zn and Ni and relatively increased Cu and Pb. The metal fractions extracted by EDTA and HNO_3 increased directly with increasing temperature while the fraction extracted with KNO_3 and NaOH decreased with burning. Amount of Cu, Mn, Pb and Ni, varied in the order EDTA > HNO_3 > NaOH > KNO_3 > H_2O but the absolute amounts differed between CLA and DLA. Higher concentration of heavy metal with EDTA and HNO_3 extraction shows that readily available heavy metal fractions were converted to relatively unavailable form which have important implications from environmental view point.

Third study evaluated the effect of CLA and DLA as nutrient sources for Japanese mustard spinach (*Brassica rapa* L. var. *perviridis*) grown on a sand dune soil. Chicken and duck litter ash obtained at five temperatures were mixed with soil at the rate of 100 kg P ha^{-1}. The results of the study showed that plant dry biomass was relatively higher in DLA burned at 400^{o}C, and no difference between DLA and PLA was observed at temperature of 600 to 900^{o}C rather dry biomass decreased. Phosphorus uptake by plants was higher in CLA than DLA burned at temperatures of 400 to 900^{o}C. Higher P uptake by plant in CLA shows the higher fertilizer value of CLA because Peter's man citric acid extractable P was higher in CLA at higher temperatures. Shoot Ca and Mg uptake was higher in DLA while K uptake increased in CLA. Though total, ammonium acetate and water extractable Ca, Mg and K greatly vary in DLA and PLA under different temperature but higher Ca and Mg uptake under DLA might be due to the higher water soluble Ca and Mg in DLA. Increases in EC and pH of the soil were noted after harvest due to litter ash application.

The fourth experiment was carried out to investigate the effect of CL and CLA burned at 600^{o}C on maize growth and nutrient uptake in sand dune and masa soils. Both CL and CLA were applied at the rate of 100, 200 and 300 kg P ha^{-1}. Results of the study showed that, in both soil types, nutrient uptake by maize was higher in the pots amended with CLA than CL. Data showed that total N contents of maize shoot were relatively higher in CL as compared to CLA. Low N content of maize in CLA treated pots might be due the fact that with burning litter, N content was significantly reduced. Except Mg, uptake of all other nutrients (P, Ca, K, Mn, Zn and Cu) was almost double in CLA in all application rates as compared to CL. Higher nutrient uptake under CLA amended pots might be due to the fact that with burning breakdown of organic materials occurred which releases the nutrient bound with different organic compounds and thus availability of nutrients increase. Higher availability of nutrients from CLA might be a reason of good plant growth.

The present study made it clear that the burning of poultry litter greatly affect not only the amount of different elements but also affect the form they are present. Results of the study showed that P forms present in litter are greatly influenced with burning at different temperature. Study made it clear that burning the litter not only reduce the most labile P form present in the litter but more stable P forms increase with increase in burning temperature. These results have important implication from environmental point of view because reduce labile P fraction in ash will help not only to reduce the P escape from agricultural lands through leaching and runoff but relatively stable P fraction might be converted slowly to plant available form over the passage of time which will help to avoid P deficiency. Not only this, burning litter also affect the forms of heavy metals present in PL. Our study showed that relatively soluble form of heavy metals were changed to more stable form by high temperature treatments which will also help to reduce the heavy metal contamination of fresh water resources. Crop studies also showed that use of burned litter could be good source of P fertilizer. It was found that the temperature of 600^{o}C is the best one to burn the litter to get ash with high P fertilizer value.