Soil Types Impacted Ammonia Emission from Soils for Potato Production in Florida and Washington

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INTRODUCTION

Ammonia (NH_3) emission from chemical nitrogen (N) fertilizers applied to farmlands causes a direct economic loss of $US 11.6 billion per year over the world (FAO, 2001). It also results in serious climatic and environmental problems. Dentener and Crutzen (1994) estimated that 4% (3 MT N/yr) of the globally emitted NH_3 can be converted into N_2O which is a potent greenhouse gas and about 300-fold more powerful than CO_2 in trapping heat in the atmosphere (IPCC, 1996). Florida and Washington are two of the main States producing potatoes in the United States of America but little information on NH_3 emission from potato production regions is available according to our available literature resources. To better understand and control NH_3 emission from agriculture, PCA is employed to recognize the principal components from 14 different variables such as soil pH and particle size distribution.

MATERIALS AND METHODS

❖ **Soils, chemicals, and methods**: four soils from Florida and Washington; 3 incubation temperatures: 11, 20, and 29°C; 2 water regimes: 20% and 80% FC; trapping solution including phosphoric acid, glycerol and water; 1 M KCl as extraction solution; 5 sampling dates: 1, 3, 7, and 28 days; duration of incubation: 28 days; and Auto Analyzer III for NH_3 determination as reported in Liu et al. (2007).

❖ **Geometric classification**: The NH_3-emission rates for 1800 samples from fertilized soil were sorted from minimum to maximum and numbered from 1 to 1800 using Microsoft Excel 2003. The data were plotted with the rates on y-axis and the sample numbers on x-axis, and were fitted to the following exponential function (Fig. 3).

❖ **Analysis Procedures**: The PRINCOMP package from the Statistical Analysis System (SAS) software (version 9.1.3) was used to perform the PCA in this study. These analyses included the following major steps (Ouyang, 2005): (1) coding all the variables (i=1, 2, …, p) and standardizing the observations to ensure that they are all equal in weights in the analyses. (2) calculating the covariance matrix C of and finding the eigenvalues λ1, λ2,…, λp and corresponding eigenvectors a1, a2,…, and ap; and (3) discarding any components which only account for a small proportion of the variation in datasets.

RESULTS

The dataset could geometrically classified into five distinct zones: Zones C, B3, B2, B1, and A

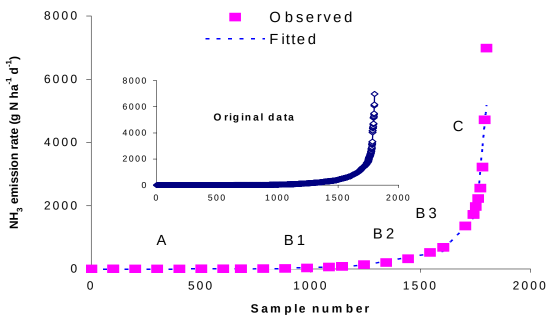

Figure 1. The observed curve of 1800 NH_3-emission rates on fertilized soils from Florida and Washington and its five linearly fitted lines: A, B1, B2, B3, and C. To make the figure clearer the data were thinned. The data-thinning was done by retaining the first and last points in each linear line and the first point of each 100 data for Samples 1 to 1741 or each 10 data for Samples 1742 to 1800. This yielded 32 representative points for either observed curve or the five lines. Inset was plotted from the rates against sample number. Zones C and A were the earliest and latest zones and hence the grand and tiny zones, respectively. Zones B3, B2, and B1 were the intermediate zones.

The 1st 4 principal components (PCs) contributed about 80% variance in the 5 zones

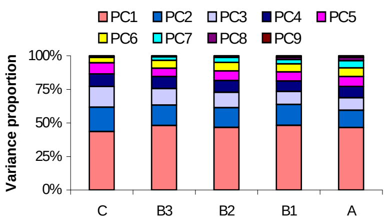

Figure 2. The 1st principal component (PC) contributed approximate 50% impaction to NH_3 emission in each of the 5 zones from the fertilized soils in Florida and Washington. The cumulation of the 1st 4 PCs basically explained the variance of the PCs on NH_3 emissions. The 5 zones are in backward order because Zones C and A were the earliest and latest zones.

Soil type always had the top influences on the PC1s in the five zones

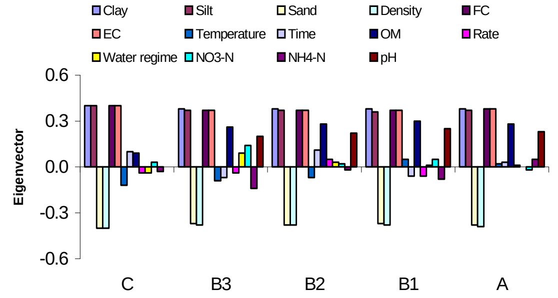

Figure 3. Soil particle size distribution (i.e. clay, silt, and sand), bulk density, field capacity (FC), and electric conductivity (EC) always had top 6 absolute characteristic values (i.e. eigenvectors) among the 14 variables in the five zones. These 6 variables formed a "Y" for each of the 5 zones.

Fertilizers basically made the highest contributions to the PC2s in the five zones

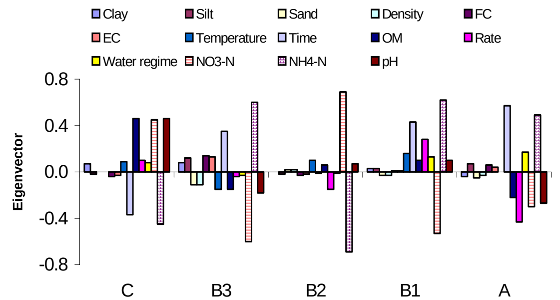

Figure 4. Ammonium and nitrate essentially presented the maximum absolute eigenvectors in each of the five zones.

Soil pH fundamentally served as the third factor in the five zones

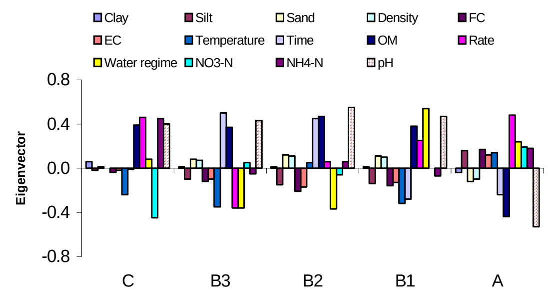

Figure 5. Among the 5 zones, soil pH as a whole determined the contribution of the PC3s to NH_3 emission from the fertilized soils in both Florida and Washington

Moisture and temperature primarily consisted of the 4th PCs in the zones

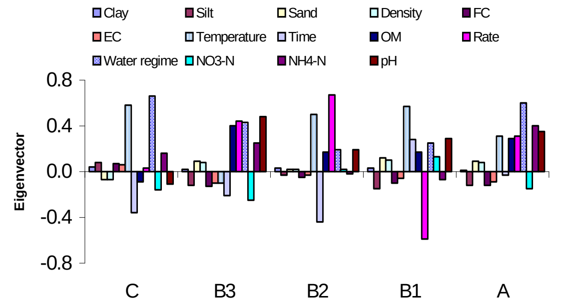

Figure 6. Soil water regime and temperature vitally contributed to the variance of NH_3 emission across the 5 zones.

CONCLUSIONS

- ❖ The dataset could geometrically be classified into five distinct zones i.e. five linear lines (Fig. 1) with significant differences in NH_3 emission rates. The slopes of the five linear lines classified were homogeneous within each of the zones but were substantially different across the zones.
- ❖ The first four PCs contributed about 80% of the total variance in NH_3 emissions (Fig. 2). PC1s were **soil type factor** with 47% contribution in average to the total variance across the five zones (Fig. 3). PC2s were **fertilizer factor** with 15% contribution (Fig. 4). PC3s were **pH factor** with 12% contribution (Fig. 5) and PC4s were **soil moisture and temperature factor** with 9% contribution (Fig. 6). Accordingly, more attention needs to be paid to soil characteristic to reduce N-loss from agricultural production systems via NH_3 emissions.
- ❖ The PCA analyses recognized the soil types as the main factors from the 14 variables influencing NH_3 emissions and provided deep insights to scientifically develop practical strategies to control NH_3 emissions from agriculture and improve both N fertilizer use efficiency and air quality.

ACKNOWLEDGEMENTS

This research was supported by the Florida Agricultural Experiment Station and a grant from USDA-ARS. The authors appreciate that the farmers allowed us to sample soil from their fields for this incubation experiment.

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