Ammonia Oxidizers in a Grazing Land with a History of Poultry Litter Application

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INTRODUCTION

- Poultry litter (PL), a mixture of excreta, bedding material and waste feed, is widely applied to grazing lands in Georgia, which is the top poultry producer in the US.
- Continuous application of PL improves soil fertility while it can lead to soil quality problems due to heavy metals added to poultry feed to control diseases.
- The rate limiting step of nitrification, which results in production of nitrate and nitrous oxide, is mediated by ammonia oxidizing bacteria (AOB) and archaea (AOA).
- The impact of repeated application of PL on soil ammonia oxidizers is not clear as previous studies have mainly focused on changes in nitrogen process rates.
- The combination of high ammonium and metal contents in PL might uniquely affect soil ammonia oxidizers as opposed to other animal wastes.

OBJECTIVE

- Examine changes in the function, abundance and community composition of ammonia oxidizers (AOA and AOB) after 15 years of PL application.

FIELD PLOTS AND METHODS

- Samples were collected from PL amended (F1, F2, F4 & F5) and control plots (F7 & F8) from two depths (5 and 15 cm) in 2009 & 2013 (Fig. 1).
- Samples in 2009 reflect 15 years of continuous PL application while samples in 2013 were collected after PL application had been discontinued for 2 years.
- PL rate of application was 10 Mg ha^{-1} yr^{-1}. Control (CL) plots received equivalent amount of N in Urea Ammonium Nitrate.
- The soil slurry method was used to quantify nitrification potential, which was used as an indicator of the function of ammonia oxidizers.
- Denaturing Gradient Gel Electrophoresis (DGGE) and *amoC-amoA* Intergenic Spacer analysis (AISA) were used to fingerprint the soil AOA and AOB communities, respectively.
- Quantitative PCR was used to determine the copy numbers of amoA gene in AOB and AOA.
- Statistical and fingerprint analyses were done with SAS and Bionumerics software.

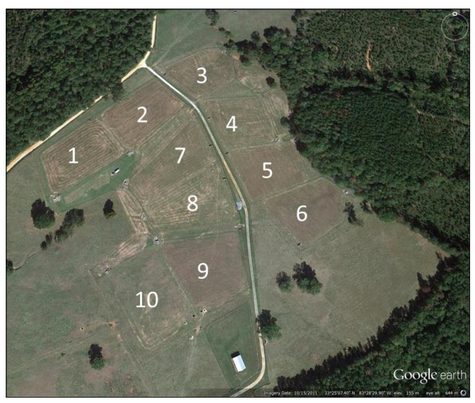

Fig. 1: Long term PL amended plots in Eatonton, GA

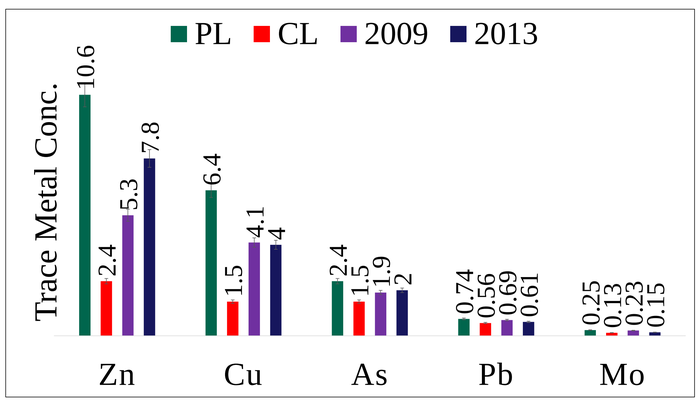

Fig. 2: Mechlich-1 extractable trace metals in PL amended and CL plots in the top 15 cm depth

RESULTS

Table 1: Abundance of amoA gene in AOB and AOA in PL amended and CL plots

Parameters	Soil Depth (cm)	Treatment		Year	
		PL	CL	2009	2013
Bacterial amoA (log copies/ g soil)	0-5	10.5a	9.9b	ND	10.2
	0-15	9.4a	8.4b	8.8a	9.0a
Archaeal amoA (log copies/ g soil)	0-5	8.3a	7.8a	ND	8.1
	0-15	8.4a	7.2b	8.0a	7.5b
Ratio of AOB to AOA	0-5	8.7	7.8	ND	8.3
	0-15	2.8	4.2	2.3	4.6

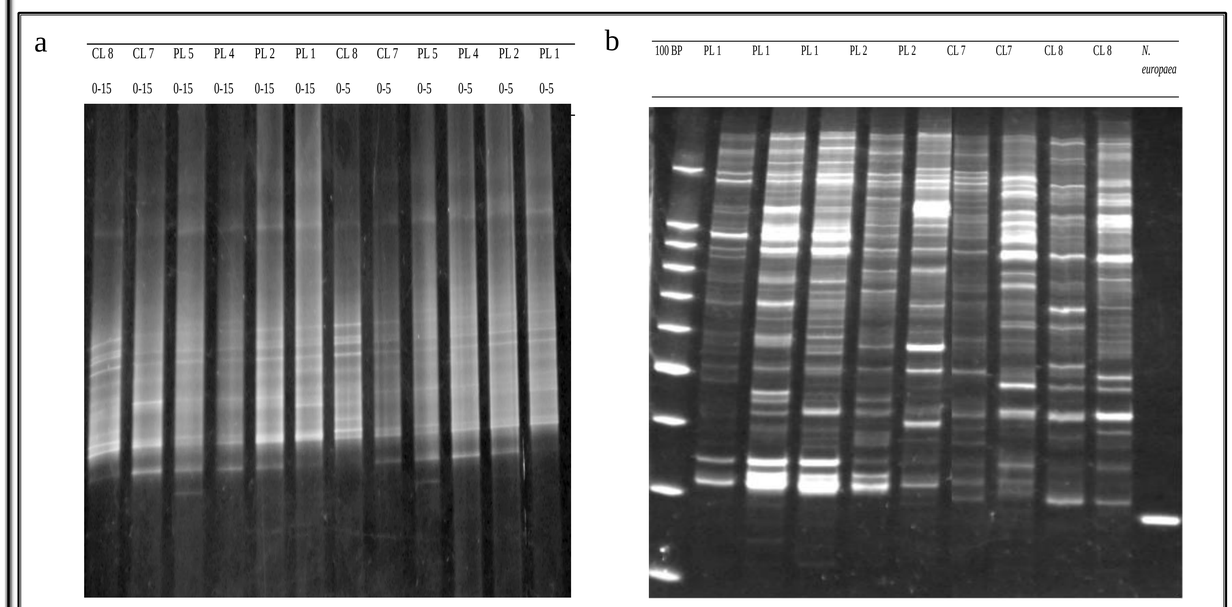

Fig. 3: (a) DGGE profile of AOA and (b) AISA profile of AOB in PL amended and CL plots in the top 15 cm depth after 15 years of PL application

Table 2: Nitrification potential and Shanon index of general diversity (H) for AOB and AOA in PL amended and CL plots in the top 5 and 15 cm depths

Parameters	Soil Depth (cm)	Treatment		Year	
		PL	CL	2009	2013
Nitrification Potential (mg NO_3^- $kg\ soil^{-1}$ hr^{-1})	0-15	0.56a	0.31b	0.64a	0.23b
H value (AOB)	0-5	3.53a	3.49a	ND	3.51a
	0-15	3.27a	3.24a	3.12b	3.41c
H value (AOA)	0-5	2.21a	2.27a	ND	2.24a
	0-15	1.90a	2.15b	1.80a	2.24b

SUMMARY AND CONCLUSIONS

- Trace metal contents were higher in PL amended than CL plots in 2009, and did not decrease significantly after PL application was discontinued (Fig 2).
- Fifteen years of PL application increased the abundance of ammonia oxidizers as compared to CL plots, AOB being numerically dominant over AOA (Table 1).
- PL application resulted in increased nitrification potential in spite of increased metal concentrations (Table 2).
- Impact of PL application was more pronounced in the top 5 than 15 cm.
- AISA & DGGE profile analyses showed no significant difference in AOB and AOA composition between PL and CL plots (Table 2 & Fig. 3).
- AISA profiling of AOB indicated that majority were from *Nitrosospira spp.* in both types of plots (Fig. 3b), which is consistent with previous studies.
- In conclusion, the effect of repeated application of PL was in changing the abundance and function of soil ammonia oxidizers but not their composition.
- Increased metal concentrations as a result of repeated PL application did not seem to have negatively impacted the abundance, function or the community structure of ammonia oxidizers.

REFERENCE

Habteselassie, M.Y., L. Xu and J.M. Norton. (2013) Ammonia-oxidizer communities in an agricultural soil treated with contrasting nitrogen sources, *Frontiers in microbiology*