Carbon and Nitrogen Sequestration in a Biosolids Application System

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Introduction

Application of biosoids from municipal solid waste facilities to farmland in Washington State has been practiced since the 1980s. Research done at these sites has shown that applications of biosolids are able to provide necessary fertility for broad acre crops, and lead to an increase in soil carbon and nitrogen (Brown et al., 2011; Cogger et al., 2013; Koenig et al., 2011).

Our objective was to identify the changes in labile and recalcitrant carbon and nitrogen fractions as a part of overall C and N gains in the system.

Materials and Methods

- GP-17 site
  - Conventionally tilled WW-fallow rotation
  - Biosolids applied every 4 years beginning in 1994
    - 2, 3, 4.5 dry tons/acre
    - Controls of anhydrous ammonia with no biosolids, and 0 biosolids, 0 N input
- 0-4'' soil depth hand sampled
- Total C, N analysis
  - ~0.25 g air dried, ground soil weighed for Leco analysis.
- Acid hydrolysis (recalcitrant fraction)
  - ~1.0g 2mm sieved, air dried, hand ground sample refluxed in 25mL 6 M HCl at 115°C for 16 hours.
  - Post-hydrolysis soil recovered and rinsed with DI water using grade F glass fiber filter and vacuum filtration.
  - ~0.2 post-hydrolysis air dried soil weighed for Leco analysis.
  - %NHC, %NHN calculate using equation from Plante et. al. 2006.

$$\%NHC, \%NHN = \frac{\left({}^{g\ of\ C,N}/_{kg\ of\ sample}\right)_{after} * \left({}^{mass_{after}}/_{mass_{before}}\right)}{\left({}^{g\ of\ C,N}/_{kg\ of\ sample}\right)_{before}}$$

- Light fraction procedure (highly labile fraction)
  - 25g soil agitated in 50mL of 1.7 g cm^{-3} NaI solution for 1 hour.
  - Shaken sample transferred to 50mL Erlenmeyer flasks and covered for a settling period of 24 hours.
  - Supernatant containing light fraction pipetted to vacuum filtration manifold (grade F glass fiber filter), rinsed 3x with 0.01 M $CaCl_2$ and 3x with DI H_2O.
  - ~0.1 g post-LF air dried soil weighed for Leco analysis.

Results and Discussion

Carbon and nitrogen levels in the soil have been positively influenced by the application of biosolids. The greater the application rate, the greater the carbon and nitrogen storage have been (Figure 1).

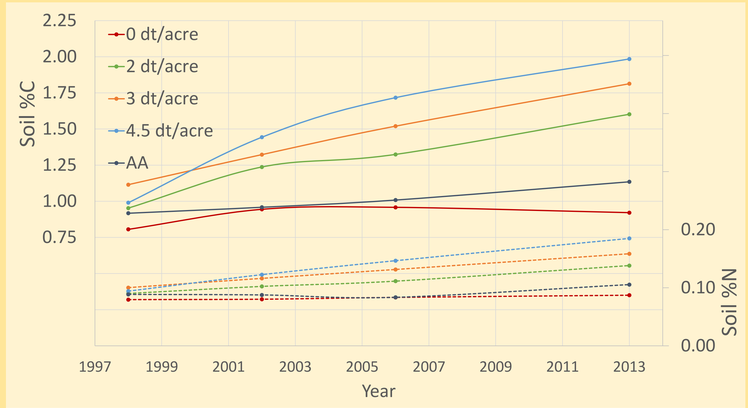

Figure 1: Total C% and Total N% series over time. All three biosolids application treatments (2, 3, and 4.5 dry tons/acre) have resulted in increases in total C and total N.

When soil C is evaluated as a function of soil N, the relationship is linear, demonstrating that soil carbon pools cannot be augmented unless soil nitrogen pools increase (Figure 2)

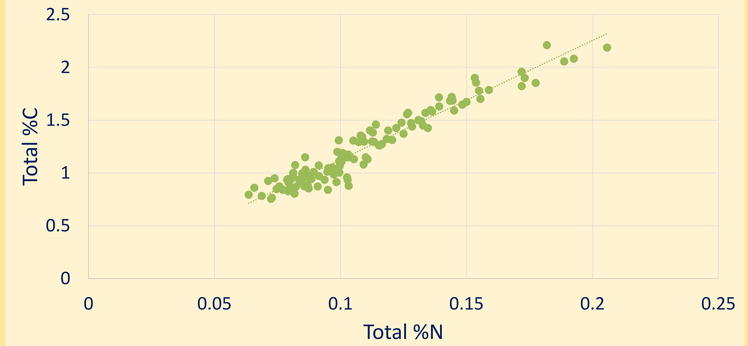

Figure 2: Total %C as a function of %N. R^2 value of 0.93.

Carbon fractionation allows us to better quantify the specific soil carbon pools that are being changed through the application of biosolids. As total carbon increases, carbon in the light and recalcitrant fractions also increase (Figure 3). C retention can be evaluated as the slope of the total soil carbon line (Table 1).

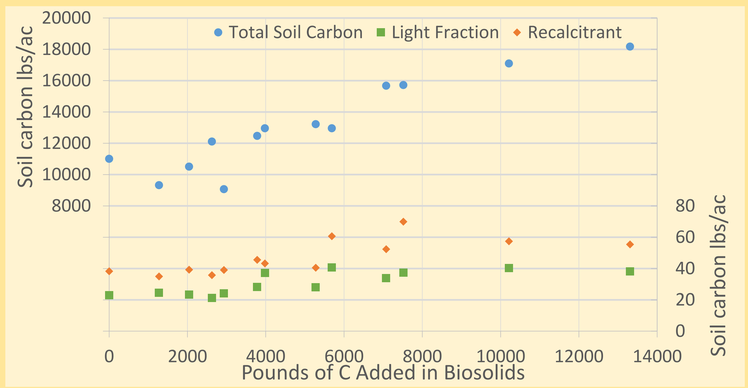

Figure 3: Soil carbon gains as a function of pounds of C added in biosoids.

Soil nitrogen can be fractionated just as soil carbon is, and we find that the light fraction more readily accumulates N than C (Table 1).

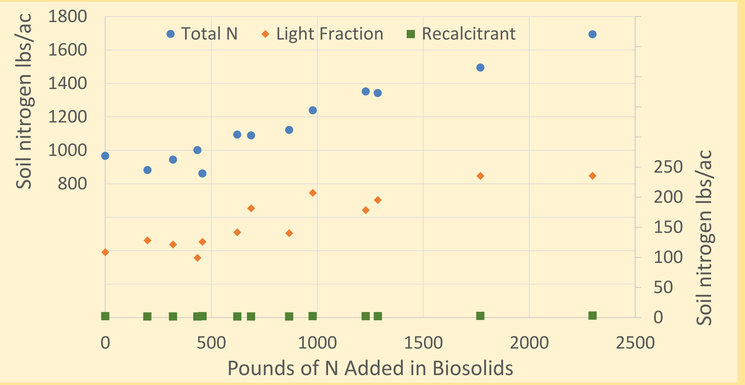

Figure 4: Soil nitrogen gains as a function of pounds of N added in biosolids.

	C Accumulation		N Accumulation	
	Slope	r^2	Slope	r^2
Total	0.7089	*0.86*	0.3729	*0.94*
Recalcitrant	0.0022	*0.54*	0.0007	*0.69*
Light Fraction	0.0015	*0.61*	0.0645	*0.81*
Heavy Fraction	0.7052	*0.86*	0.3076	*0.92*

Table 1: slope and r^2 of least squares lines for carbon and nitrogen accumulation data. Slope can be interpreted as retention, as it represents pounds of C or N stored per pound of C or N applied.

Conclusion

Soil C and N retention of biosolids application to wheat-fallow is extremely high, approximately 70% of the C and 30% of N added. Most of the new soil C and N is in the acid soluble, heavy fraction, with smaller but significant additions to the recalcitrant and light fractions. Lower soil retention of N than C is due to crop N uptake and grain N removal from the system.

References

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