Determination of Biosolids Phosphorus Solubility and its Relationship to Wastewater Treatment

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Introduction

Biosolids are land applied as a fertilizer and soil amendment. In NC, the USEPA Part 503 standards for beneficial reuse govern application rates based on biosolids plant-available N and the agronomic N needs of the crop on the receiving soil. Differences between biosolids and crop N:P cause N-based biosolids applications to surpass crop P needs, creating excess soil P and increasing the risk of surface water pollution and subsequent eutrophication, algae blooms (Fig. 1), and fish kills (Fig. 2). The NC Department of Environment and Natural Resources (NC DENR) is considering P-based guidelines for biosolids in some nutrient-impaired watersheds. The P Loss Assessment Tool (PLAT) will be used to estimate biosolids P-loss risk. To use PLAT, the soluble P fraction must be quantified. However, forms and quantities of P in biosolids depend on wastewater treatment plant (WWTP) influent and treatment processes. Land application based on both P and N will likely decrease application rates, reduce the number of eligible receiving fields, & shorten the time soils can receive biosolids, thus making land application more costly. Hence, widespread adoption of a P-based approach may foster development of alternative beneficial uses of biosolids other than land application.

Figure 1: Algae blooms

Figure 2: Fish kills

Assessing Phosphorus Loss Risk

The NC USDA Conservation Practice Standard for nutrient management (590) dictates that if applied P exceeds the agronomic rate, P-loss risk must be determined. PLAT was developed to do this for animal waste and commercial fertilizers. Once soluble P fractions are developed for biosolids, PLAT can be updated and used to guide P-based application rates in river basins containing nutrient impaired watersheds (Fig. 3).

Figure 3: River basins of NC

Operator in Responsible Charge (ORCs) of NC’s largest WWTPs were surveyed using an online tool (Qualtrics), with questions corresponding to a generalized WWTP flowchart (Fig. 4). We will use cluster analysis to see the extent to which WWTPs may be grouped by processes.

Figure 4: General WWTP Flowchart

Preliminary Results

Summer 2013 biosolids had a wide range of total P: 0.45 - 47.5 mg g⁻¹ biosolids (Fig. 5) with a quasi-uniform distribution with low skew and kurtosis. Most biosolids had low soluble P (Fig. 6) and low soluble P fraction (Fig. 7), although some had soluble P fractions >20%. The distributions of soluble P and soluble P fractions were similarly strongly skewed and kurtotic. The soluble P fractions were strongly correlated (r²=0.96, p <0.0001) with soluble P (Fig. 8). If these results are confirmed, they suggest that the soluble P fractions might be estimated solely on the basis of soluble P, i.e., without a total P analysis. It remains to be determined whether individual pooled soluble P fraction values can be allotted to groups of WWTPs with similar processes.

Figure 5: Frequency distribution: total P

Figure 6: Frequency distribution: soluble P

Figure 7: Frequency distribution: % Soluble P (P soluble / P total)

Figure 8: Soluble P vs. Percent Soluble P

Preliminary Conclusions

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