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Biosolids Phosphorus March 2011

TITLE: Phosphorus solubility in biosolids-amended farm soils in the Mid-Atlantic Region of the USA

Author: Maguire, R.O., J.T. Sims, and F.J. Coale.
Source: J. Environ. Qual 2000 29:1225-1233
Abstract: There have been increased environmental concerns about agricultural P management, including land application of biosolids (municipal sewage sludge). This study investigated the influence of current N-based land application practices for biosolids on soil P. We collected soil samples from 11 biosolids application sites and from adjacent setback areas that had never received biosolids. These samples were analyzed for oxalate-extractable phosphorus (Pox), aluminum (Alox), and iron (Feox); degree of phosphorus saturation (DPS = (Pox/ 0.61[Alox + Feox]) × 100), Mehlich-1 P; iron-oxide strip extractable phosphorus (FeO-P); and water-soluble phosphorus (WSP). In many cases Mehlich-1 P was excessive (>50 mg kg-1), but this occurred in both application sites and setback areas. Biosolids application sites had significantly greater Pox in the topsoils (0 to 20 cm) when averaged for all sites, with means of 589 and 296 mg kg-1 in the application sites and setback areas, respectively. However, biosolids applications also increased [Feox + Alox], which meant that the DPS was not always increased. There was a trend for higher Pox and FeO-P in the biosolids-amended soil profiles (60-cm depth) and highest P concentrations were consistently found at the 0- to 5-cm depth. The net effect of biosolids applications on Pox, relative to [Feox + Alox], was related to FeO-P. Our data suggest that adding biosolids according to current N-based guidelines will lead to an accumulation of P in soils, but the release of this P may be mitigated by the associated increases in soil [Feox + Alox].
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TITLE: Phosphorus leaching from biosolids- amended sandy soils

Author: Elliot, H.A., G.A. O'Connor, and S. Brinton
Source: J. Environ. Qual. 2002, 31:681-689
Abstract: Increasing emphasis on phosphorus (P)-based nutrient management underscores the need to understand P behavior in soils amended with biosolids and manures. Laboratory and greenhouse column studies characterized P forms and leachability of eight biosolids products, chicken manure (CM), and commercial fertilizer (triple superphosphate, TSP). Bahiagrass (Paspalum notatum Flugge) was grown for 4 mo on two acid, P-deficient Florida sands, representing both moderate (Candler series: hyperthermic, uncoated Typic Quartzipsamments) and very low (Immokalee series: sandy, siliceous, hyperthermic Arenic Alaquods) P-sorbing capacities. Amendments were applied at 56 and 224 kg PT ha−1, simulating P-based and N-based nutrient loadings, respectively. Column leachate P was dominantly inorganic and lower for biosolids P sources than TSP. For Candler soil, only TSP at the high P rate exhibited P leaching statistically greater ($\alpha = 0.05$) than control (soil-only) columns. For the high P rate and low P-sorbing Immokalee soil, TSP and CM leached 21 and 3.0% of applied P, respectively. Leachate P for six biosolids was <1.0% of applied P and not statistically different from controls. Largo biosolids, generated from a biological P removal process, exhibited significantly greater leachate P in both cake and pelletized forms (11 and 2.5% of applied P, respectively) than other biosolids. Biosolids P leaching was correlated to the phosphorus saturation index (PSI = [Pox]/[Alox + Feox]) based on oxalate extraction of the pre-applied biosolids. For biosolids with PSI ≤ approximately 1.1, no appreciable leaching occurred. Only Largo cake (PSI = 1.4) and pellets (PSI = 1.3) exhibited P leaching losses statistically greater than controls. The biosolids PSI appears useful for identifying biosolids with potential to enrich drainage P when applied to low P-sorbing soils.
Document#: BIN.PS.AV.5.2

TITLE: Relationships between Biosolids Treatment Process and Soil Phosphorus Availability

Author: Maguire, R.O., J.T. Sims, S.K. Dentel, F.J. Coale, and J.T. Mah
Source: J. Environ. Qual. 2001 30: 1023-1033.
Abstract: Laws mandating phosphorus (P)-based nutrient management plans have been passed in several U.S. Mid-Atlantic states. Biosolids (sewage sludge) are frequently applied to agricultural land and in this study we evaluated how biosolids treatment processes and biosolids P tests were related to P behavior in biosolids-amended soils. Eight biosolids generated by different treatment processes, with respect to digestion and iron (Fe), aluminum (Al), and lime addition, and a poultry litter (PL), were incubated with an Elkton silt loam (fine-silty, mixed, active, mesic Typic Endoaquult) and a Suffolk sandy loam (fine-loamy, siliceous, semiactive, thermic Typic Hapludult) for 51 d. The amended soils were analyzed at 1 and 51 d for water-soluble phosphorus (WSP), iron-oxide strip–extractable phosphorus (FeO-P), Mehlich-1 P and pH. The biosolids and PL were analyzed for P, Fe, and Al by USEPA 3050 acid–peroxide digestion and acid ammonium oxalate, Mehlich-1, and Mehlich-3 extractions. Biosolids and PL amendments increased extractable P in

the Suffolk sandy loam to a greater extent than in the Elkton silt loam throughout the 51 d of the incubation. The trend of extractable WSP, FeO-P, and Mehlich-1 P generally followed the pattern: [soils amended with biosolids produced without the use of Fe or Al] > [PL and biosolids produced using Fe or Al and lime] > [biosolids produced using only Fe and Al salts]. Mehlich-3 P and the molar ratio of P to [Al + Fe] by either the USEPA 3050 digestion or oxalate extraction of the biosolids were good predictors of changes in soil-extractable P following biosolids but not PL amendment. Therefore, the testing of biosolids for P availability, rather than total P, is a more appropriate tool for predicting extractable P from the biosolids-amended soils used in this study

Document#: BIN.PS.AV.5.3

TITLE: Phosphorus restrictions for land application of biosolids: Current status and future trends

Author: Shober, A.L. and J.T. Sims

Source: J. Environ. Qual. 2003. 32:1955-1964

Abstract: The application of biosolids (sewage sludge) to agricultural soils provides P in excess of crop needs when applied to meet the N needs of most agronomic crops. These overapplications can result in the buildup of P in soils to values well above those needed for optimum crop yields and also may increase risk of P losses to surface and ground waters. Because of concerns regarding the influence of P on water quality in the USA, many state and federal agencies now recommend or require P-based nutrient management plans for animal manures. Similar actions are now under consideration for the land application of biosolids. We reviewed the literature on this subject and conducted a national survey to determine if states had restrictions on P levels in biosolids-amended soils. The literature review indicates that while the current N-based approach to biosolids management does result in increases of soil P, some properties of biosolids may mitigate the environmental risk to water quality associated with land application of P in biosolids. Results of the survey showed that 24 states have regulations or guidelines that can be imposed to restrict land application of biosolids based on P. Many of these states use numerical thresholds for P in biosolids-amended soils that are based on soil test phosphorus (STP) values that are much greater than the values considered to be agronomically beneficial. We suggest there is the need for a comprehensive environmental risk assessment of biosolids P. If risk assessment suggests the need for regulation of biosolids application, we suggest regulations be based on the P Site Index (PSI), which is the method being used by most states for animal manure management.

Document BIN.PS.AV.5.4

TITLE: Runoff Phosphorus Losses from Surface-Applied Biosolids

Author: Elliot, H.A., R.C. Brandt, and G.A. O'Connor

Source: J. Environ. Qual. 2005. 34:1632-1639

Abstract: Runoff losses of dissolved and particulate phosphorus (P) may occur when rainfall interacts with manures and biosolids spread on the soil surface. This study compared P levels in runoff losses from soils amended with several P sources, including 10 different biosolids and dairy manure (untreated and treated with Fe or Al salts). Simulated rainfall (71 mm h^{-1}) was applied until 30 min of runoff was collected from soil boxes (100 × 20 × 5 cm) to which the P sources were surfaced applied. Materials were applied to achieve a common plant available nitrogen (PAN) rate of 134 kg PAN ha^{-1}, resulting in total P loading rates from 122 (dairy manure) to 555 (Syracuse N-Viro biosolids) kg P ha^{-1} Two biosolids produced via biological phosphorus removal (BPR) wastewater treatment resulted in the highest total dissolved phosphorus (13–21.5 mg TDP L^{-1}) and total phosphorus (18–27.5 mg TP L^{-1}) concentrations in runoff, followed by untreated dairy manure that had statistically ($p = 0.05$) higher TDP (8.5 mg L^{-1}) and TP (10.9 mg L^{-1}) than seven of the eight other biosolids. The TDP and TP in runoff from six biosolids did not differ significantly from unamended control (0.03 mg TDP L^{-1}; 0.95 mg TP L^{-1}). Highest runoff TDP was associated with P sources low in Al and Fe. Amending dairy manure with Al and Fe salts at 1:1 metal-to-P molar ratio reduced runoff TP to control levels. Runoff TDP and TP were not positively correlated to TP application rate unless modified by a weighting factor reflecting the relative solubility of the P source. This suggests site assessment indices should account for the differential solubility of the applied P source to accurately predict the risk of P loss from the wide variety of biosolids materials routinely land applied.

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