RELATIVE PHOSPHORUS AVAILABILITY IN BIOSOLIDS PREDICTION MODEL

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Introduction

The last decades have seen an increase in agricultural use of biosolids thanks to the efforts made to reduce the amount of phosphorus (P) concentration and other contaminants in surface waters and to increase recycling of biosolids rather than their disposal. However, biosolid-P loadings to soils should not exceed crop needs to avoid excess P accumulation in soil and subsequent P losses to surface waters.

Wastewater produced today goes through various treatment phases before becoming sewage sludge [1]. Chemicals such as aluminium (Al) or iron (Fe) salts as well as lime material are often used to precipitate and remove P from wastewater. Metal salts-stabilized biosolids used for crop production usually have large amounts of extractable Al, and Fe that influence P availability to plant. Determinations of biosolids P phytoavailability relative to inorganic P fertilizers are necessary when P-based rates are mandated [2].

The main objective of this work is to develop a model of P availability in relation to Al and Fe content of biosolids. This model will allow the agronomist to predict the relative agronomic effectiveness of a biosolid for crop production.

In this study, fifty-five data points were compiled from literature investigating agricultural efficiency in various biosolids and were used to build a model that predicts relative P availability (RPA, the plant availability of biosolid-P compared to fertilizer P) in any biosolid, using P, Al or Fe extracted by ammonium oxalate method [3, 4] (mmol P_{ox}, Al_{ox} or Fe_{ox}/kg biosolid) and expressed as degree of P saturation (DPS = $P_{ox}/(Al_{ox}+Fe_{ox})$).

Materials and Methods

Data was collected from literature to obtain both apparent P-recovery percentage (APR) and relative P- availability (RPA).

Biosolids: sewage sludge generated by the wastewater treatment plant (Al-, Fe- or Fe+Al-stabilized biosolids).

Soils: Typic Hapludults, Typic Paleudults, Typic Haplorthox, Tropeptic Haplorthox, Cryic Eutrochrept, Dystric Eutrochrept, Spodosol, Mollisol, Alfisol.

Plants: lettuce, beans, petunia, wheat, bahiagrass, Italian ryegrass, maize, beetroot, potatoes.

Degree of P saturation (DPS_{ox}) of biosolids = $P_{ox}/(Al_{ox}+Fe_{ox})$,
where P_{ox}, Al_{ox} and Fe_{ox} are oxalate-extractable P, Al and Fe, respectively.

Apparent recovery of applied P (from either biosolid or fertilizer) by plants (APR):
$APR_{biosolids}$ or $APR_{fertilizer}$ = [(P uptake $_{treatment}$ – P uptake $_{control}$) / P application rate] x 100.

Biosolids P phytoavailability relative to inorganic P fertilizers (RPA):
RPA = ($APR_{biosolids}$ / $APR_{fertilizer}$) x 100.

Results

Apparent recovery of applied P (APR)

- $APR_{biosolids}$ values are negatively correlated with ($Al_{ox}+Fe_{ox}$) content of biosolids (Fig. 1).
- It is known that Al and Fe in biosolids added during the treatment processes as metal salts contribute to the formation of insoluble P compounds that are unavailable to plants in the shorter term. Lu & O'Connor (2001) demonstrated that P sorption by soils increased proportionally to biosolids application rates due to Al and Fe oxides contained in tertiary sewage biosolids.

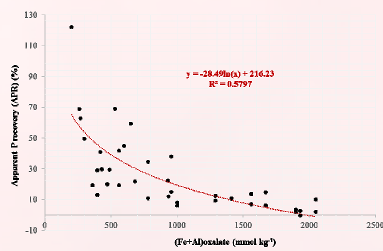

Figure 1. APR vs ($Al_{ox}+Fe_{ox}$) content of biosolids.

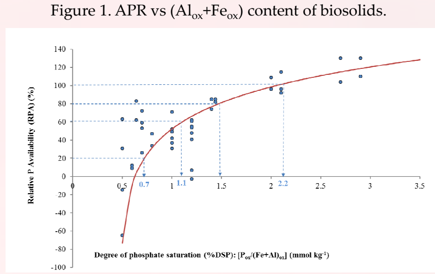

Figure 2. RPA vs [$P_{ox}/(Al_{ox}+Fe_{ox})$] values of biosolids.

Biosolids P phytoavailability relative to inorganic P fertilizers (RPA)

- RPA values varied greatly among biosolids and are strongly correlated with DPS (Fig. 2).
- The model followed a natural logarithm form with RPA = 40[ln (DPS-0.47) +2] with data showing evident tendency for RPA to increase with values of DPS over 0.65. The R^2 value of the model is 0.67, allowing the estimation of RPA values of any municipal biosolid with relative precision conceivable.

Groups of biosolids

Table 1. Classification of biosolids according to their DPS and RPA values.

Biosolid groups	Rating of P saturation	DPS	RPA (%)
I	Very High	≥ 2.2	≥ 100
II	High	1.5-2.2	80≤RPA<100
III	Normal	1.1-1.5	60≤RPA<80
IV	Moderate	0.7-1.1	20≤RPA<60
V	Low	0-0.7	<20

- For biosolids having DPS ≥ 2.2, RPA values are ≥ 100%. These results are similar to those obtained by Oladeji et al. (2008) [6]. RPA values ranged from 25 to 60% for biosolids with DPS values between 0.5 and 1, about 80% for biosolids with DPS between 1 and 2, and more than 90% for biosolids when the DPS exceed 2.

Conclusions

The degree of P saturation (DPS) of municipal biosolids is a good indicator of the phytoavailability of biosolids-P.

RPA could be used as an agronomic indicator of biosolid-P availability and can be easily calculated from data that is available through biosolid testing laboratories and national databases.

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