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Soil P status following annual paper mill biosolids application in eastern Canada

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Introduction

- Paper mill biosolids (PB) have been used as fertilizers and amendments in agricultural soils for many decades.
- Liming has been reported to increase (Murphy 2007), decrease (Curtin and Smillie 1983), or have no effect (Naidu et al. 1990) on the solubility, sorption, or plant availability of phosphorus (P).
- Little is known about the effects of their repeated application on soil P fractions.

Objective

- To investigate the effect of repeated annual applications of different PB and industrial liming by-products on soil P fractions.

Materials and Methods

- A 6-yr field study (2000-2005) was conducted on a loamy soil in the province of Quebec, Canada.
- Treatments were applied in post-seeding (mid-June) of each year.
- Each treatment was applied on a wet basis: treatment 30B, 60B and 90B refers to 30, 60, and 90 Mg PB ha^{-1}, respectively; treatment 30LM, 30WA, 30CL, 30MgD and 30MgSE refers to 30 Mg PB ha^{-1} plus 3 Mg ha^{-1} of lime mud (LM), wood ash (WA), calcitic lime (CL), Mg dissolution by-product (MgD), and Mg smelting and electrolysis work product (MgSE), respectively.
- Eight treatments (control, 30B, 60B, 30LM, 30CL, 30WA, 30MgD, 30MgSE) were used from 2000 to 2002 and seven (control, 30B, 60B, 90B, 30LM, 30CL, 30WA) from 2003 to 2005.
- The experiment was a randomized complete block design with four replicates.
- Soils (0–30 cm) were sampled before seeding in May 2003 and at harvest in October 2005.
- Soils were sequentially extracted by the Hedley procedure (Tiessen and Moir 2007) to determine the P fractionation.


Paper mill biosolids


Lime mud


Wood ash


Calcitic lime

Results and Discussion

• Effects of PB and Liming Materials on Soil P Fractions

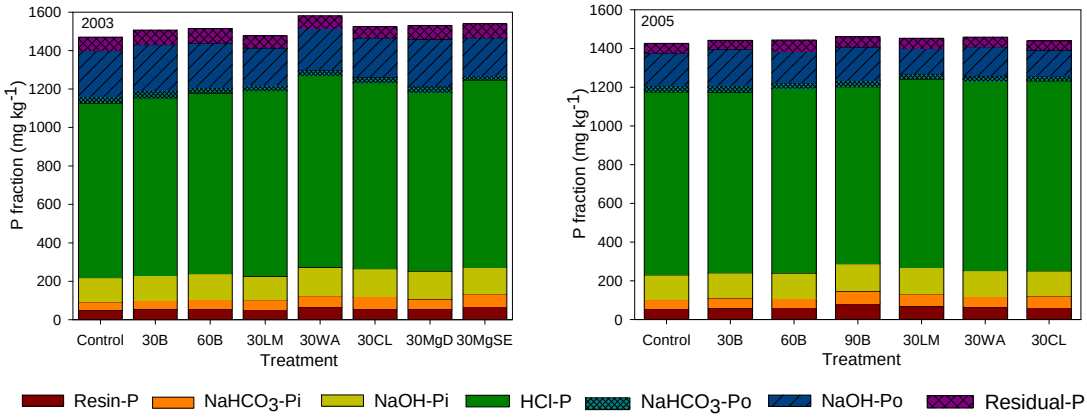

Fig. 1 Soil P sequential fractionation before seeding in May 2003 and at harvest in October 2005 as affected by paper mill biosolids and liming materials addition.

- HCl-P was the largest P pool, accounting for about 64% of the total P fraction, indicating that a large part of the P was adsorbed by Ca (Fig.1).
- Repeated applications of lime products (LM, WA, CL) significantly increased HCl-P and decreased the organic P pools ($P < 0.05$).
- In 2005, resin-P increased linearly with PB application ($P < 0.01$), suggesting that PB increased P availability.
- The PB applied may have contributed directly to the increase in the available P in soils, in conjunction with Po mineralization resulting from the decomposition of the materials (Simard et al. 1998).

• Variations of Soil P Fractions over Time

Table 1. Effects of PB and liming materials addition (*F-values*) on P fractions (2003 vs. 2005)

Treatment	Resin-P	$NaHCO_3$-Pi	NaOH-Pi	HCl-P	$NaHCO_3$-Po	NaOH-Po	Residual-P	P_{sum}
Control	0.70	0.18	0.02	1.03	0.05	5.32*	8.94**	1.11
30B	0.52	0.82	0.01	0.10	0.13	3.17(0.08)	26.66**	3.28(0.08)
60B	1.09	0.06	0.13	0.25	0.03	7.67**	9.21**	4.03*
30LM	7.28*	2.68	1.42	0.03	0.03	9.30**	4.05*	0.50
30WA	0.04	0.20	1.21	0.47	0.23	7.47*	8.03**	5.77*
30CL	0.53	0.00	1.69	0.21	0.01	12.54**	3.64(0.07)	11.97**

*, ** Significant at $P < 0.05$ and $P < 0.01$, respectively; P value given in parentheses when $0.10 < P < 0.05$.

- Repeated annual PB and lime products applications had no significant effect on soil Pi pools (Table 1).
- NaOH-Po was significantly lower after six years of annual application of PB and liming materials than three years of application, indicating that with long-term cultivation and no additional mineral P inputs, NaOH-Po may act as a primary P source for crops, or it may be mineralized to Pi and thus satisfy crop requirements.
- A significant decline in residual-P with time suggests that residual-P in soils may be transformed to more labile forms under long-term continuous cultivation.

References

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Conclusion

- **HCl-P was the largest P pool, accounting for about 64% of the total P fraction, and that the repeated applications of liming products significantly increased this pool and decreased the organic P pools.**
- **The NaOH-Po and residual-P were significantly lower in 2005 than in 2003, indicating that PB and liming materials application without supplemental P fertilizer inputs enhanced the mobility and/or mineralization of NaOH-Po and the transformation of recalcitrant P to more labile forms with time.**

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