Relationship between Phosphorus Forms and Phosphatase Activity in Soils Amended with Poultry Manure

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INTRODUCTION

Poultry manure (PM) contains large amounts of organic P (P_o), that requires enzymatic mineralization into inorganic P (P_i) prior to plant utilization. Phosphatases, including phosphomonoesterase and phosphodiesterase, are key enzymes affecting P availability in soils. Phosphatases can differ in substrate specificity and may be influenced by a number of controlling factors, such as the presence of specific P forms.

Soil amendment with manure generally increases soil phosphatase activity. Conversely, high levels of inorganic P from manure or other sources have been shown to inhibit enzymes. High concentrations of mineral-associated P_o in PM could offer a slowly mineralizable and more sustained P source; however, more information is needed on the fate of PM P after soil application and this affects soil fertility.

OBJECTIVE: Evaluate short-term effects of poultry manure on soil phosphatase activity and identify any correlation between activity and extractable forms of P.

MATERIALS AND METHODS

- 2 Maine soils, **Newport** (3 mg P kg^{-1}) and **Caribou** (6 mg P kg^{-1})
- Layer hen manure added at:
  0 (**Control**)
  100 mg P kg^{-1} (**PM100**)
  200 mg P kg^{-1} (**PM200**)
- Incubated 108 days at 25°C
- Sequential extraction to determine P distribution
  (Waldrip-Dail et al., 2009)
- Analysis of acid and alkaline phosphomonoesterase (AcPase and AkPase) and phosphodiesterase (PDase) activity (Tabatabai and Bremner, 1969)

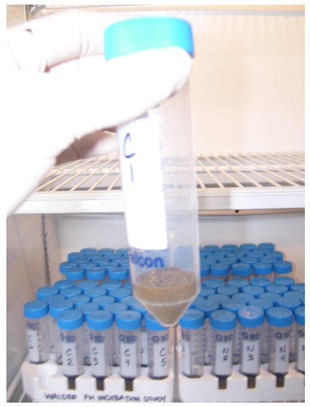
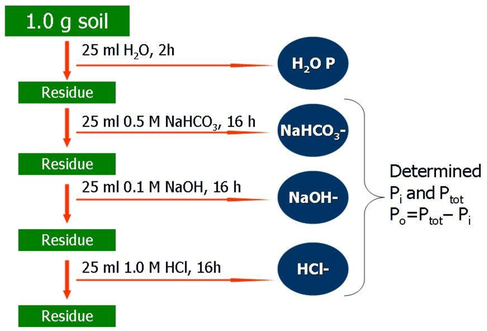


Table 1. Selected Soil and Manure Properties

	Newport	Caribou	Manure
Description	Silt loam	Sandy loam	Freeze-dried
Sand (%)	42	51	
pH (1:1)	5.9	5.7	8.0
CEC (meq/100 g)	4.6	7.3	
P (mg kg^{-1})	3.1 (mod Morgan)	6.2 (mod Morgan)	13,000 (total)
C (% dry weight)	2.5	2.2	34

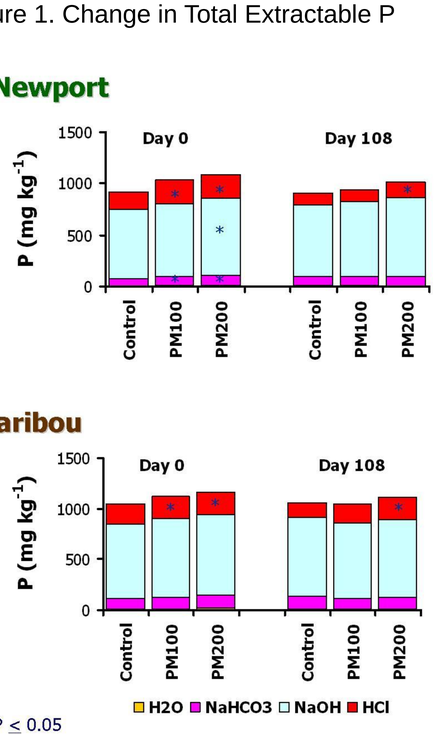
Selected references:
Tabatabai and Bremner (1969) Soil Biol Biochem 1:301-307
Waldrip-Dail et al. (2009) Soil Sci 174:195-201

Sequential Fractionation Procedure



RESULTS

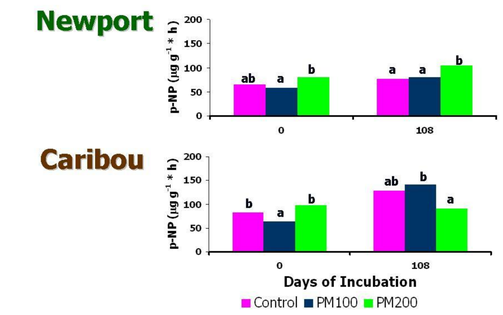
Figure 1. Change in Total Extractable P



* P ≤ 0.05

- Unamended Caribou soil contained higher P concentrations than Newport (Table 1)
- PM caused higher initial concentrations of HCl-P in both soils and increased $NaHCO_3$-, and NaOH-P in Newport
- By Day 108 only HCl-P with PM200 was elevated, indicating transformation of P to other forms/ fractions

Figure 2. Effect of PM on Enzyme Activities



Columns with different letters on each day of incubation indicate significant difference among treatments for each soil ($P < 0.05$) .

- PM increased both AcPase and AkPase activity in Newport soil
- In Caribou soil no change was seen in AcPase with PM while AkPase had initial increases that declined to Control levels by Day 108
- PDase activity increased in response to PM

Tables 2. Relationship between P forms and enzyme activity

Newport Correlations

r	HCO_3-P_i	HCO_3-P_o	NaOH-P_i	NaOH-P_o	HCl-P_i	HCl-P_o
Control						
AcPase	0.348	0.677***	-0.127	0.539**	0.250	-0.173
AkPase	0.187	0.568**	-0.057	0.385	0.029	-0.079
PDase	0.296	-0.187	-0.346	-0.081	-0.442*	-0.225
PM100						
AcPase	0.619**	0.856***	-0.590**	0.803***	0.116	-0.359
AkPase	0.398	0.856***	-0.315	0.822***	0.272	-0.260
PDase	-0.585**	-0.332	0.542**	-0.290	0.213	0.802***
PM200						
AcPase	-0.263	0.350	-0.041	0.266	-0.076	-0.357
AkPase	-0.279	0.134	-0.042	0.214	-0.270	-0.375
PDase	-0.625**	-0.431*	0.470*	-0.043	0.023	0.465*

Caribou Correlations

r	HCO_3-P_i	HCO_3-P_o	NaOH-P_i	NaOH-P_o	HCl-P_i	HCl-P_o
Control (None Significant)						
AcPase						
AkPase						
PDase						
PM100						
AcPase	-0.426*	0.278	-0.036	0.440*	0.180	-0.197
AkPase	-0.328	0.307	-0.235	0.412	0.230	-0.281
PDase	-0.071	0.322	0.139	0.466*	0.212	0.111
PM200						
AcPase	-0.466*	0.262	0.072	0.564**	-0.108	-0.048
AkPase	-0.008	0.376	-0.075	0.250	-0.124	-0.140
PDase	0.076	-0.400	-0.198	-0.086	0.027	0.543**

d.f. (n-2) = 22, *P≤0.05, **P≤0.01, ***P≤0.001

- AcPase and AkPase are positively correlated to $NaHCO_3$- and NaOH-extractable organic P in Control and PM100 in Newport soil but has little correlation with PM200 or in higher-indigenous P Caribou soil
- PDase activity is (-) correlated with $NaHCO_3$-P in amended Newport soil and (+) correlated with stable (NaOH and HCl) organic P in both Newport and Caribou soils.

CONCLUSIONS

- **Poultry manure stimulates short-term phosphatase activity**
- **Phosphomonoesterase and phosphodiesterase differ in their relationship to soil P forms**
- **Activity is related to soil P status up to a point but high concentrations of manure or soil P can decouple this relationship**
- **Fertilization with poultry manure at high levels may inhibit availability of some organic P**