Reducing Phosphorus Exports From Agricultural Soils in the Maumee River Basin to Lake Erie Using Gypsum

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ABSTRACT

Phosphorus (P) from agricultural and other sources contribute to water quality problems in Lake Erie. Gypsum ($CaSO_4 \cdot 2H_2O$) is effective in reducing P loss from agricultural soils by forming insoluble calcium phosphate. A demonstration project in the Maumee Basin of western Lake Erie is evaluating field-scale applications of gypsum for reducing P export in tile drainage water. Separate sections within a large field were either treated or not treated with gypsum at a rate of generally one ton per acre. Tile drain water samples were collected and soluble P was analyzed. Average reduction in P concentrations for gypsum-treated areas was 54%. The P reductions in tile drainage water persist at least 20 months after gypsum treatment.

INTRODUCTION

The Maumee River is an 8316 sq mi watershed that lies predominately in northwest Ohio and includes areas in northeast Indiana and southeast Michigan. The Maumee River is the largest single contributor of non-point source pollution to Lake Erie. More than 80% of the Maumee watershed is devoted to agricultural land uses, dominated by corn and soybeans (Richards et al., 2002). The agricultural lands in the Maumee River basin provide most of the P and N entering Lake Erie (Baker and Richards, 2002). The Maumee River contributes only 3% of the water that flows into the western basin of Lake Erie, but more than half the input of suspended solids (Herdendorf and Krieger, 1989) as well as an estimated 880 tons of soluble reactive P, the form that contributes most directly to eutrophication (Letterhos, 2010). Laboratory and research plot studies have shown that gypsum can reduce soluble P, the form that moves into rivers and lakes, by 40–70 percent (Stout et al.,1998; Franklin and Campbell, 2011). The objective of this project is to demonstrate, at the field scale, the practical application of gypsum to agricultural fields to reduce P loading to surface waters in the Maumee River watershed.

METHODS

Gypsum Powder

Field demonstrations were conducted as follows:

1. Select actively farmed fields with high soil P levels.
2. Apply FGD gypsum to portions of these fields.
3. Collect soil samples from gypsum-treated and untreated field areas.
4. Collect tile water samples from edge of fields treated or untreated with gypsum (**Table 1**).

The areas of the fields treated with gypsum varied from 6.0 to 35.6 acres (**Table 2**). Fertility treatments (e.g. N, P and K fertilizer applications) and other management activities were uniform with the only difference being FGD gypsum that was not applied to untreated control areas.

Table 1. Dates of water sampling events on each farm.

Farm	1 May 12	20 Dec 12	21 Dec 12	11 Feb 13	27 Feb 13	11 Jun 13	3 Jul 13	9 Jul 13	11 Jul 13	25 Jul 13	30 Dec 13	25 Mar 14	8 Apr 14	10 Apr 14	15 Apr 14	15 May 14	22 May 14	23 May 14	3 July 14
Hah					*		*	*				*	*	*	*	*	*		
Kin	*						*				*			*	*	*			*
Mil							*		*	*	*	*	*	*	*	*	*	*	
Per							*		*		*			*		*	*		
Stu							*			*									
TrH								*						*			*		
TrS														*			*		
Wol		*	*	*		*	*		*		*	*	*	*	*	*			

Hypoxic zones in the Great Lakes.

Table 2. Field sizes and soil P concentrations (M-3 = Mehlich-3).

Farm	Field Size (A)		Soil P (mg/kg for 0-15 cm depth)			
	+gyp	- gyp	+ gyp		- gyp	
			M-3	Bray-1	M-3	Bray-1
Hah	6.0	112	24	13	27	19
Kin	18.9	60.7	34	22.5	32	27
Mil	11.4	7.7	24		15	
Per	23.1	48	22	15	25	20
Stu	6.3	226	191	165	104	101
TrH	30.7	32.6	62	54	27	20
TrS	35.6		32	24		
Wol	26.5	42.4	19		24	

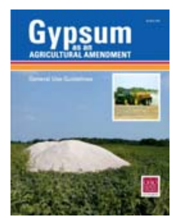
RESULTS

There were 55 total sampling events (153 total samples) from May 2012 through July 2014. Average reduction in P concentrations for individual gypsum-treated areas varied from 9.5 to 59% (Table 3). Average reductions for all gypsum-treated areas combined was 54% with a range from 0 to 93%. P concentrations in tile drain water for individual sampling events ranged from 0.01 to 0.11 mg L^{-1} (mean = 0.041) in gypsum-treated areas and from <0.01 to 0.43 mg L^{-1} (mean = 0.089) in areas without gypsum. Recent results have shown that P reductions in tile drainage water persist at least 20 months after gypsum treatment.

Table 3. Soluble P concentrations in tile drain water and P reduction in gypsum-treated areas (n = number of sampling events).

Farm	n	Orthophosphate Conc. (mg/L)				P Reduction (%)	
		Mean		Range		Mean	Range
		+ gyp	- gyp	+ gyp	- gyp		
Hah	9	0.02	0.02	0.01-0.11	0.01-0.06	9.5	0-33
Kin	7	0.02	0.03	0.01-0.04	0.01-0.09	17	0-56
Mil	13	0.04	0.07	0.02-0.08	0.0-0.14	40	0-66
Per	6	0.03	0.09	0.01-0.06	0.03-0.23	59	56-81
Stu	2	0.07	0.09	0.06-0.08	0.08-0.12	24	16-32
TrH	3	0.03	0.09	0.01-0.04	0.01-0.28	34	0-87
TrS	2	0.06	0.15	0.03-0.09	0.02-0.28	44	0-88
Wol	13	0.07	0.18	0.01-0.11	0.09-0.43	58	39-93
All	55	0.041	0.089			39	0-93

Tile water samples collected from Tile water samples from the Ken Hahn Farm (Antwerp, OH) on January 6, 2013.



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