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Effect of phosphorus and cadmium levels on glyphosate sorption

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http://en.wikipedia.org/wiki/Roundup

- Glyphosate [N-(phosphonomethyl) glycine] is a broad spectrum, non-selective systemic, post-emergent herbicide that controls weeds and other types of vegetation.
- It was first marketed in 1970 by Monsanto under the name Round up.
- It was first commercialized in 1974 by Monsanto and was registered in Canada in 1976 (Franz et al. 1997)

The use of glyphosate has increased dramatically because of glyphosate resistant crops e.g, canola, soybean, corn etc (Pocket Ks, 2012).

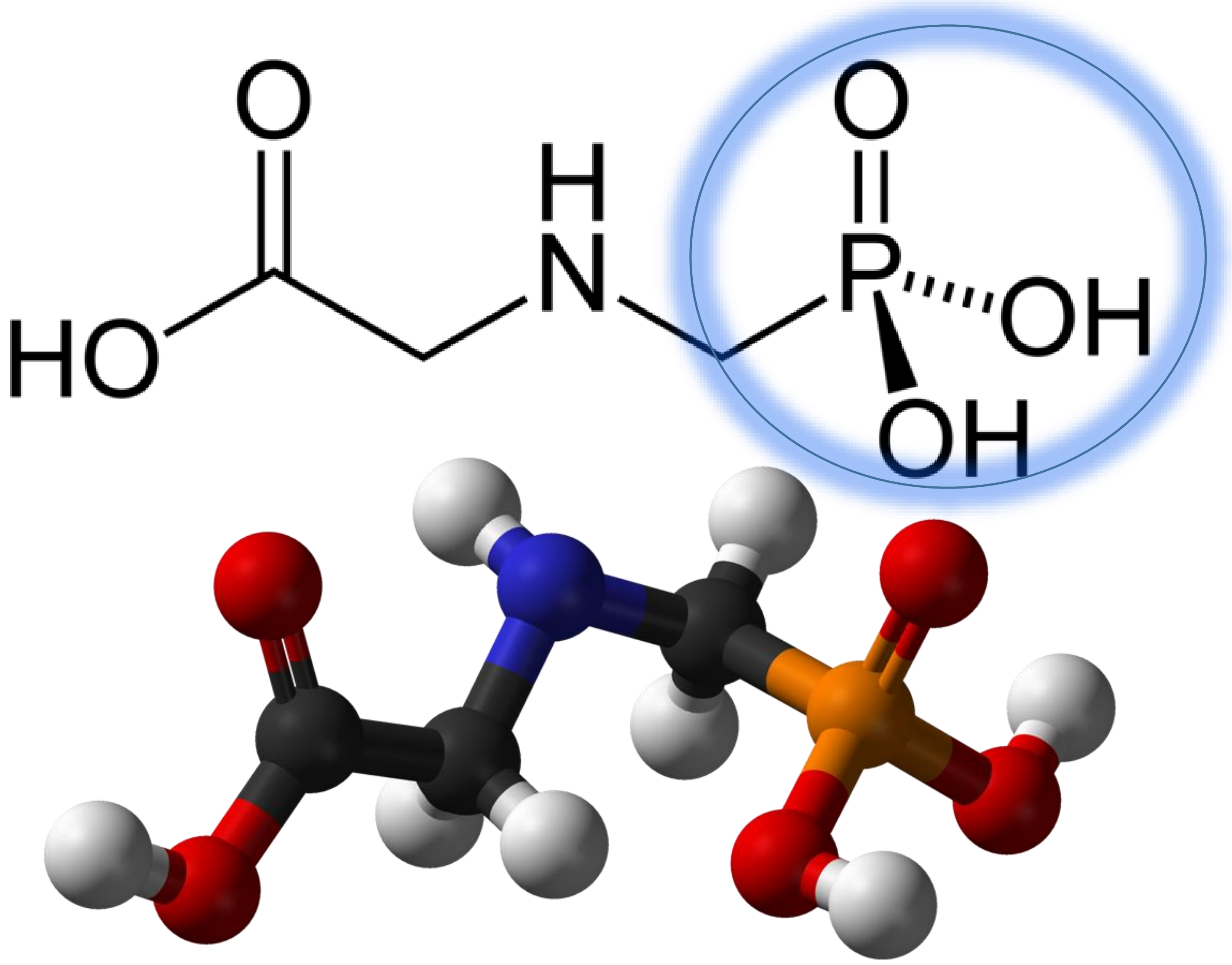


Figure 1: Molecular structure of glyphosate

http://en.wikipedia.org/wiki/Glyphosate

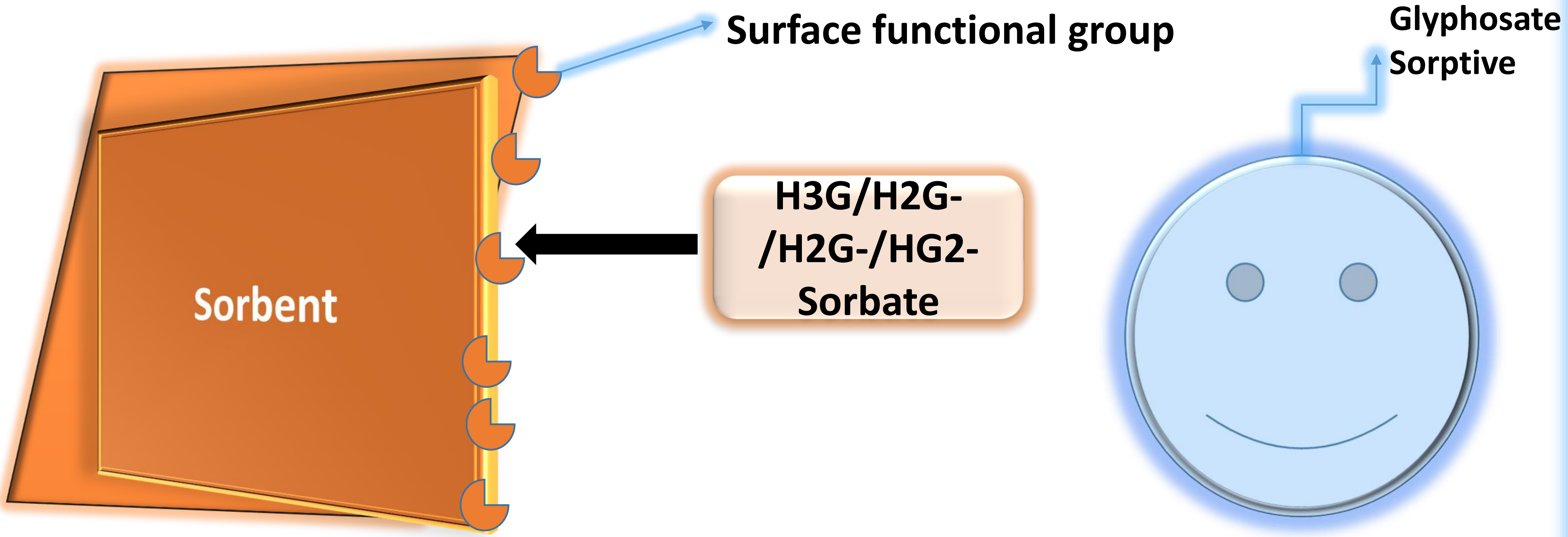
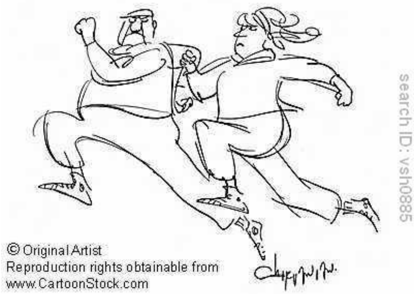
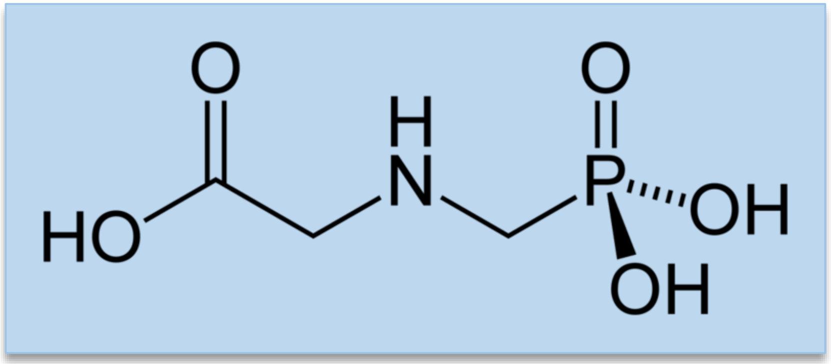


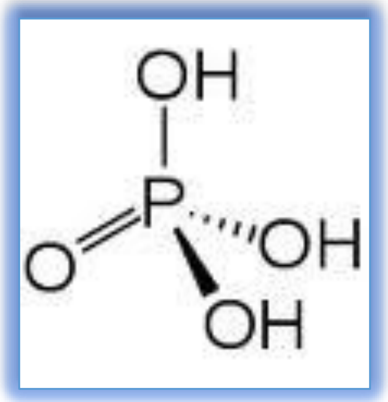
Figure 2: General concept of sorption mechanism

Ligand Exchange
Inner sphere complexes
Metal-Glyphosate-Complex



- ❑ **Glyphosate and phosphate competes with for its sorption site**





- ❑ **Phosphate fertilizer may contain Cd as a contaminant.**
- ❑ **Cd ion may increase glyphosate sorption**

- **Inorganic phosphate decreases glyphosate sorption**
- **Low tendency to bind to soil can result in leaching**
- **Show potentials for contamination of groundwater**
- **The requirements for risk assessment of glyphosate sorption with phosphorus around the world are surprisingly limited.**

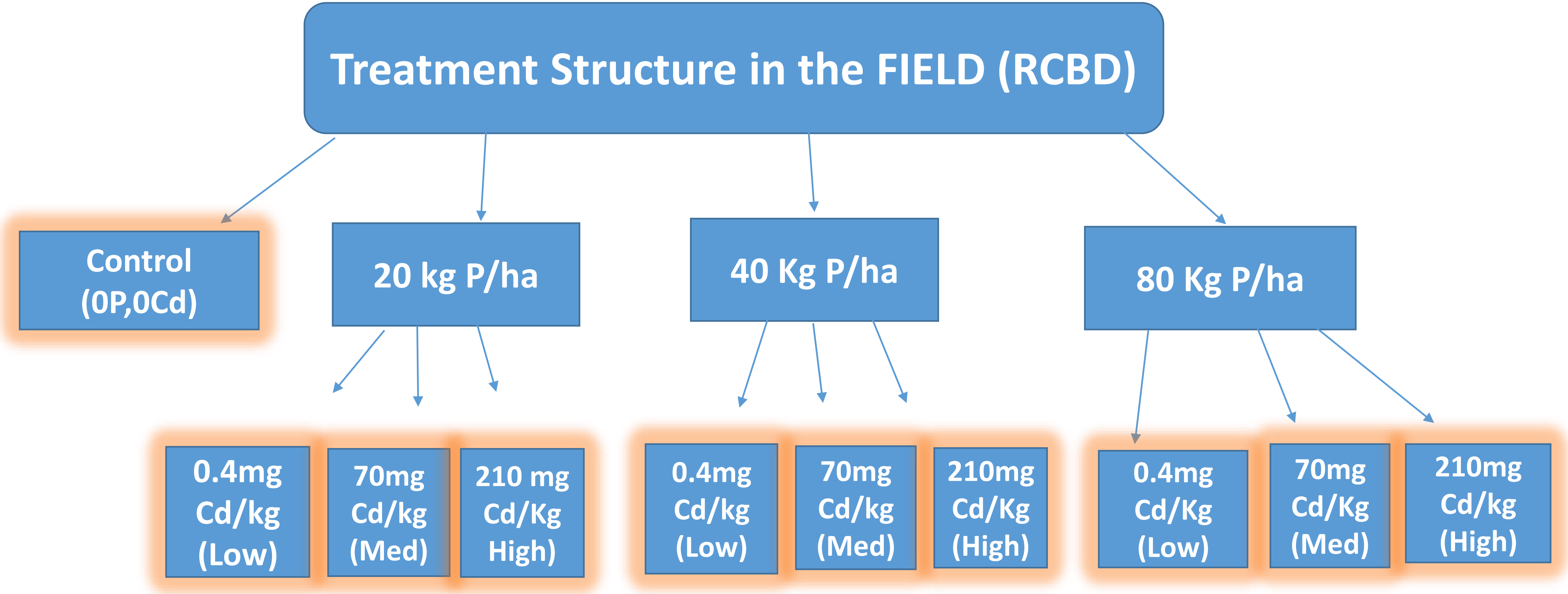
The objective of this study was to see the impact of phosphorus and cadmium levels on glyphosate retention in soil under a range of pH conditions

Materials and methods

Collection of sample:

- ❑ **Plot study is located near Carman, Manitoba.**
- ❑ **Plots were arranged in a randomized complete block design with 10 treatments and four replicates per treatment.**

Figure 3: Collection of soil sample near Carman



<u>Treatments (2002-2009 inclusive)</u>:

1. Control
2. 20P Low Cd
3. 40P Low Cd
4. 80P Low Cd
5. 20P Med Cd
6. 40P Med Cd
7. 80P Med Cd
8. 20P High Cd
9. 40P High Cd
10. 80P High Cd

- Soils were air-dried and sieved (<2mm). Various solutions were tested in the laboratory to modify the pH of the soils. Solutions used were 0.01M HCl (pH=3.6), 0.01M $CaCl_2$ (pH=4.7), 0.01M KCl (pH=5.00), d.H2O (pH=5.4), and 0.01M KOH (pH=7.3).

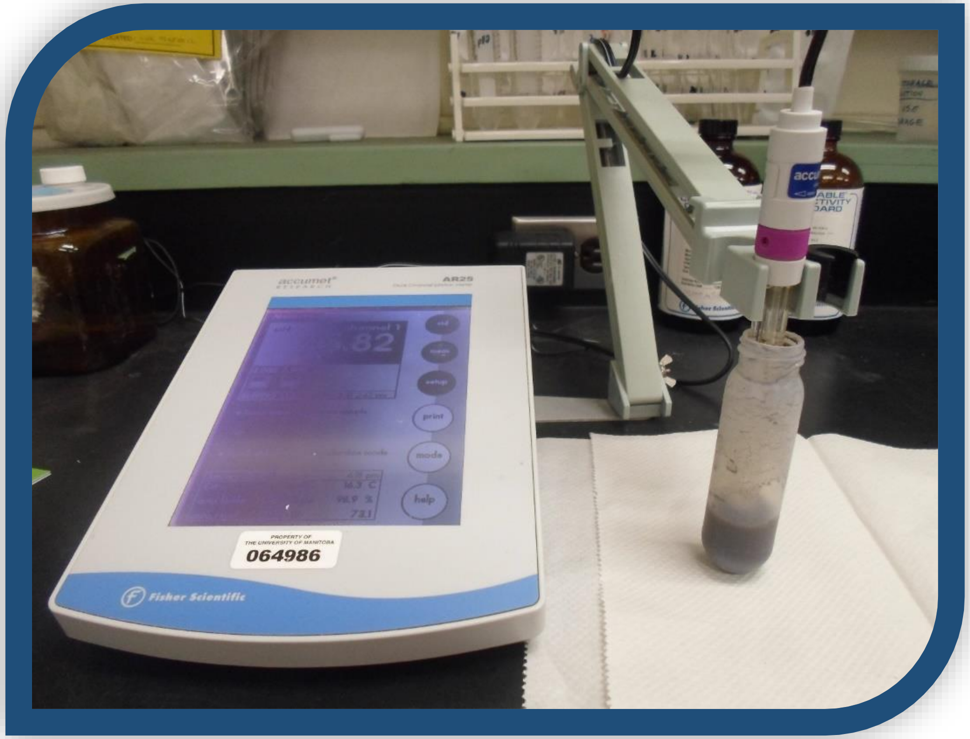


Figure 4: Soil Solution pH measurement

- **Solutions (10mL) containing 1 mg/L glyphosate were added to 2 g of soil in Teflon tubes to determine the sorption coefficient, Kd [L/kg], by the batch equilibrium method.**
- **Kd was calculated by Cs/Ce,**
- **whereby Cs = glyphosate sorption by soil at equilibrium (mg/kg), and Ce = glyphosate concentration of equilibrium solution (mg/L).**

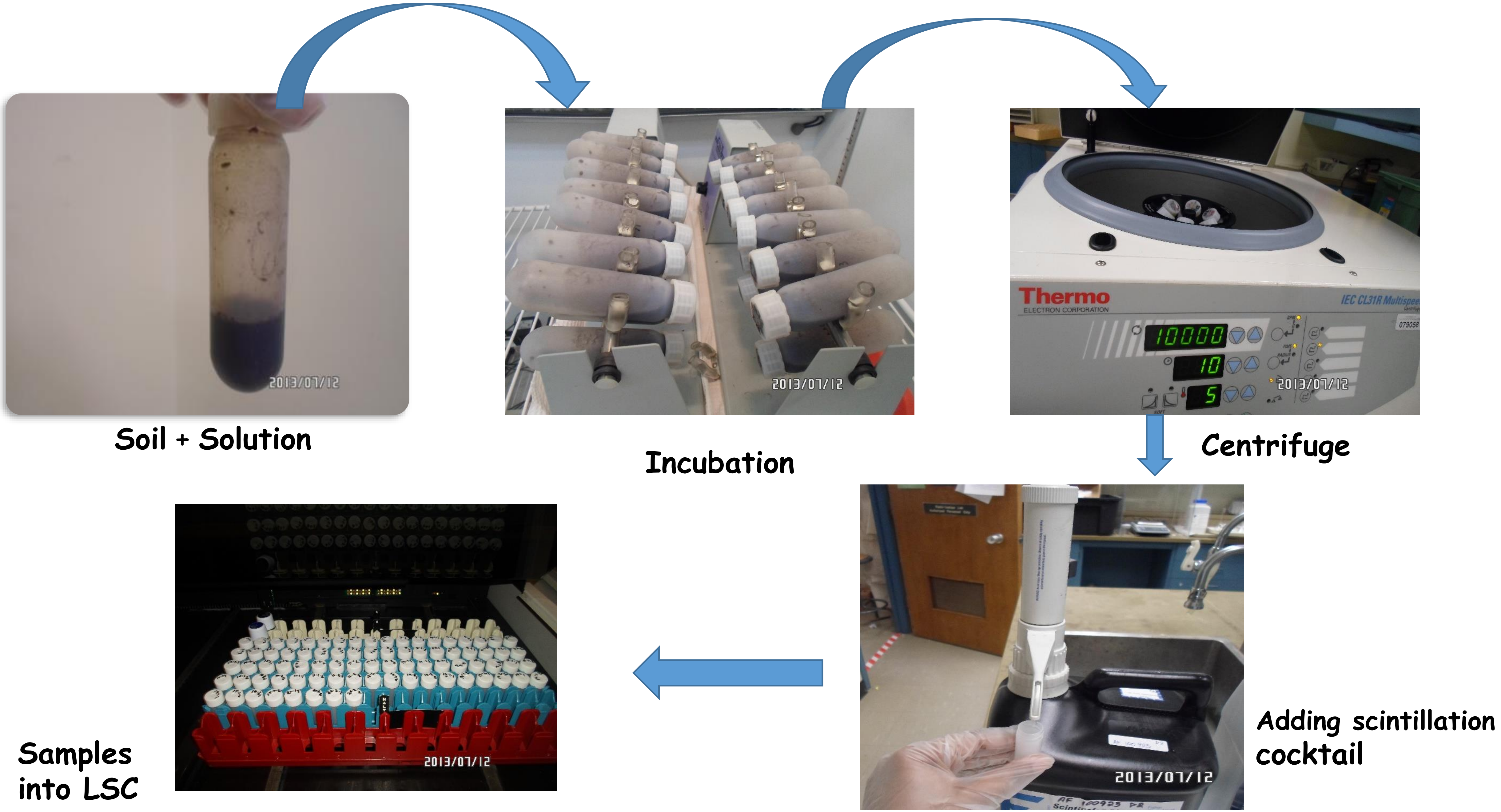


Figure 5: Flow diagram of batch equilibrium sorption study

	Table 1. Some physical and chemical characteristics of the soil under study										
Soil Type	[a] pH (1:5)	O.C %	CEC (cmol kg^{-1})	Clay %	Silt %	Sand %	Olsen P mg/kg	[b]Ca mg/kg	[c]Fe_2O_3 mg/kg	[d]Al_2O_3 mg/kg	[c]Cd mg/kg
Orthic Black Chernozem	3.6±0.01 4.7±0.02 5.0±0.03 5.4±0.02 7.3±0.03	2.8	16	20	20	60	46.18	2236.6	246.39	9.9	0.24

[a] 1:5 soil solution ratio and background liquid was 0.01M HCl, CaCl2, KCl, d.H2O and 0.01M KOH respectively, [b] Ammonium acetate extracted Ca, [c] DTPA extracted Fe oxide, Cd and [d] $CaCl_2$ extracted Al oxide

Results and Discussion

Cadmium had no significant effect on glyphosate sorption under a range of pH condition regardless of P levels.

Table 2. Effect of Cd on glyphosate sorption under different pH

pH	Kd (L/kg)		
	Low	Med	High
3.6	171.62 ± 8.96	170.61± 10.33	171.80± 8.63
4.7	354.18± 19.60	351.03± 18.26	351.50± 17.76
5	317.53± 20.45	303.86± 21.96	317.07± 19.41
5.4	69.64± 1.44	68.69± 1.76	72.07± 1.27
7.3	51.22± 1.70	51.02± 1.70	51.93± 1.17

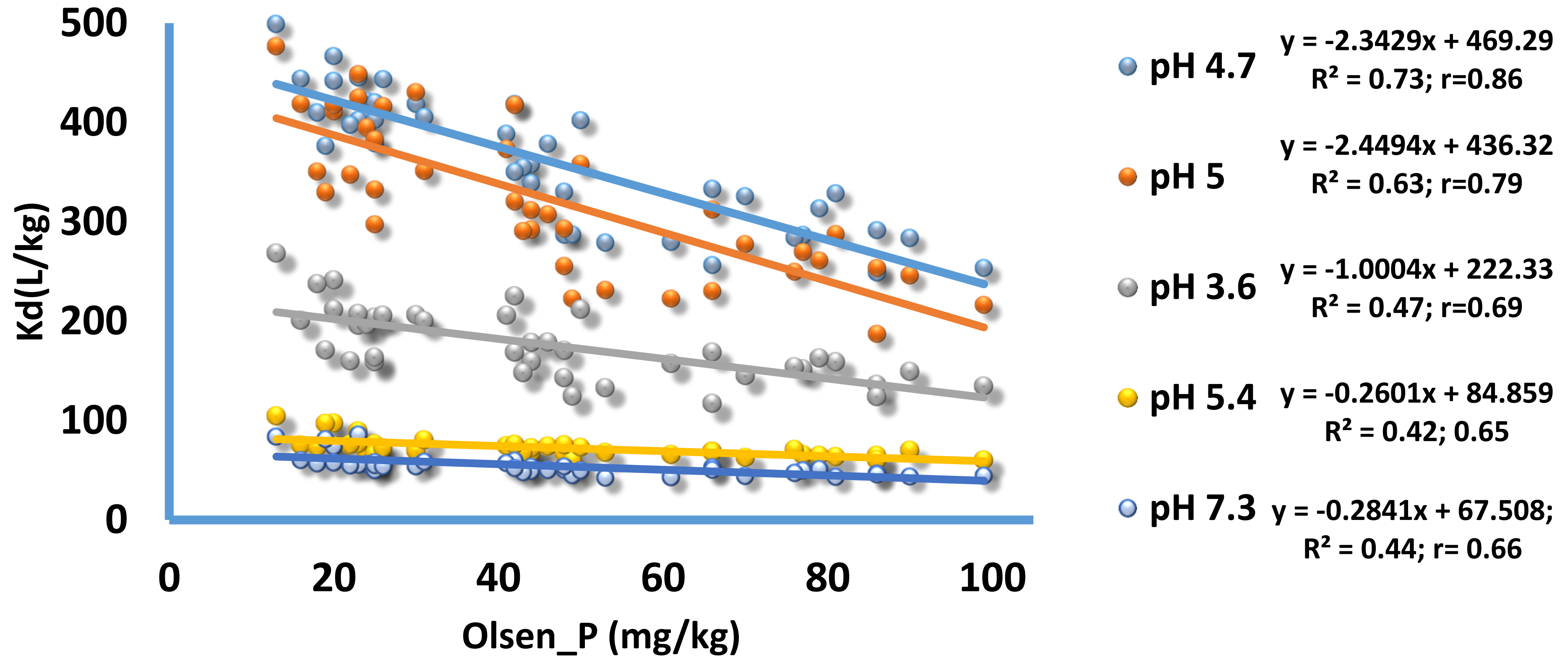


Figure 6: Sorption coefficient (Kd) as a function of Olsen-P level in the field at different pH level.

Regression of Kd with Olsen-P at all pH level is significant (P<0.0001).

- With increasing level of P sorption decreases

pH 4.7, (0 P = 20 P) > 40 P > 80 P

pH 5, 0 P > 20 P > 40 P > 80 P

pH 3.6, (0 P = 20 P) > (40 P = 80 P)

No effect at 5.4 and 7.3 pH

- Sorption pattern was

pH 4.7> pH 5.0> pH 3.6 > pH 5.4= pH 7.3

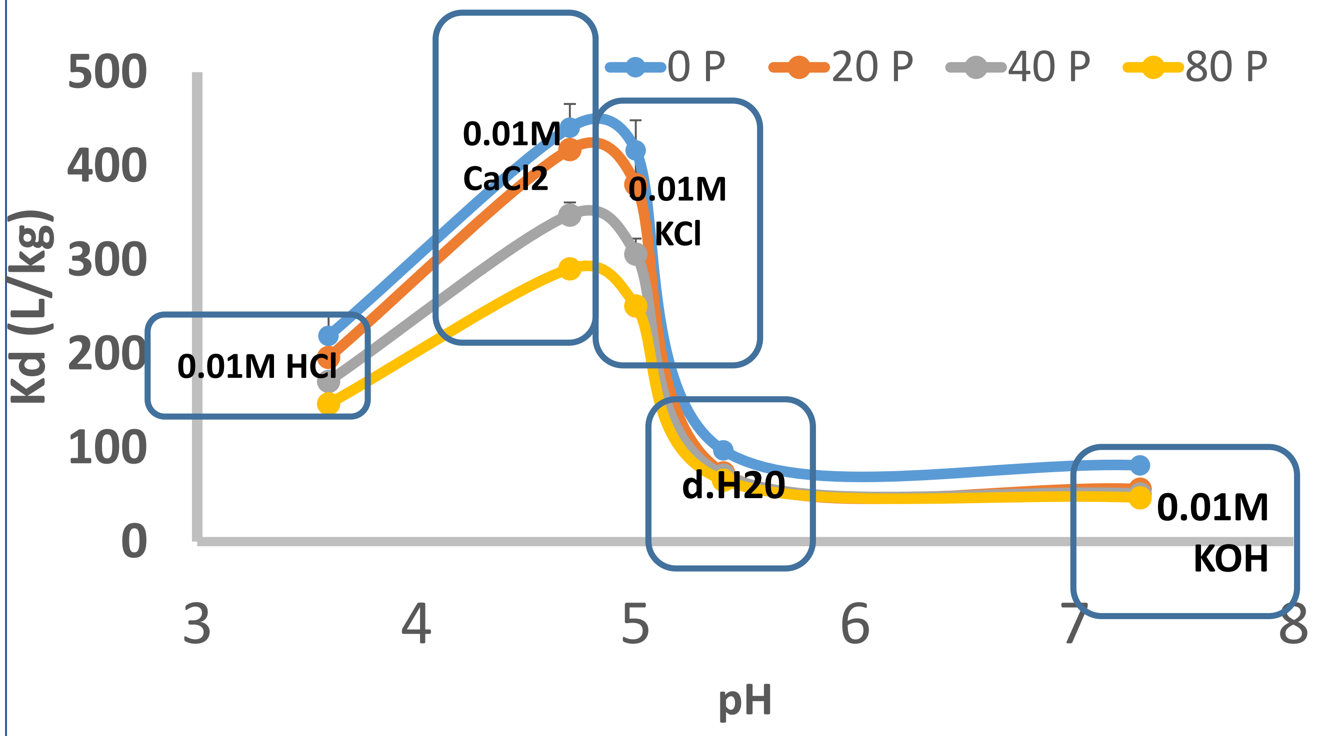


Figure 7: Effect of pH on glyphosate sorption with different P level

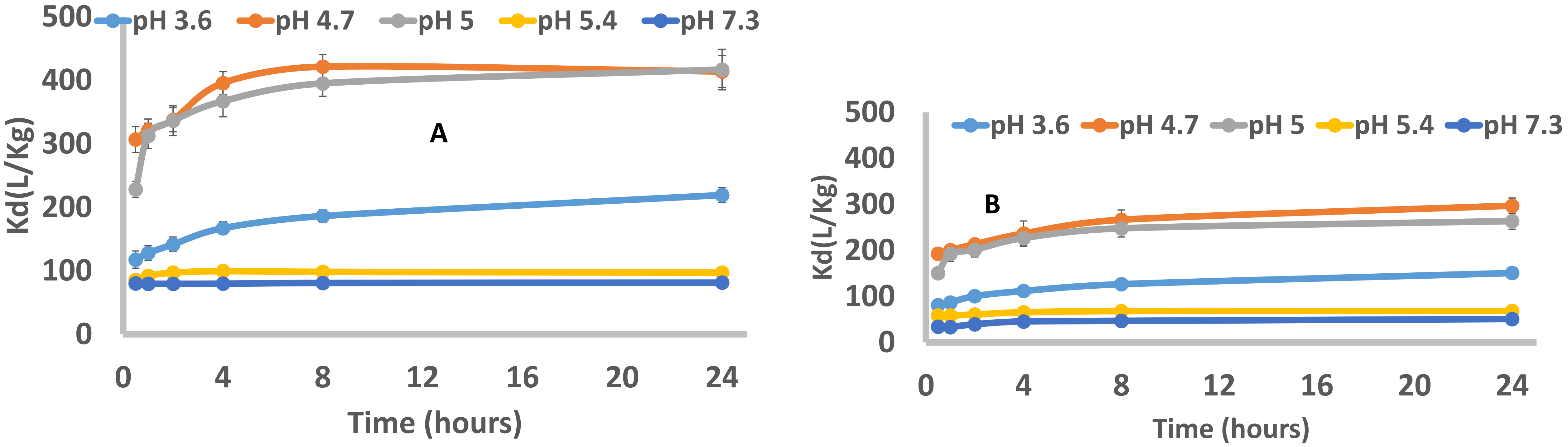


Figure 8: Time dependent sorption of control soil (A) and 80P high Cd (B) soil under different pH levels

✓ **Most rapid sorption within first four hour then approached equilibrium**

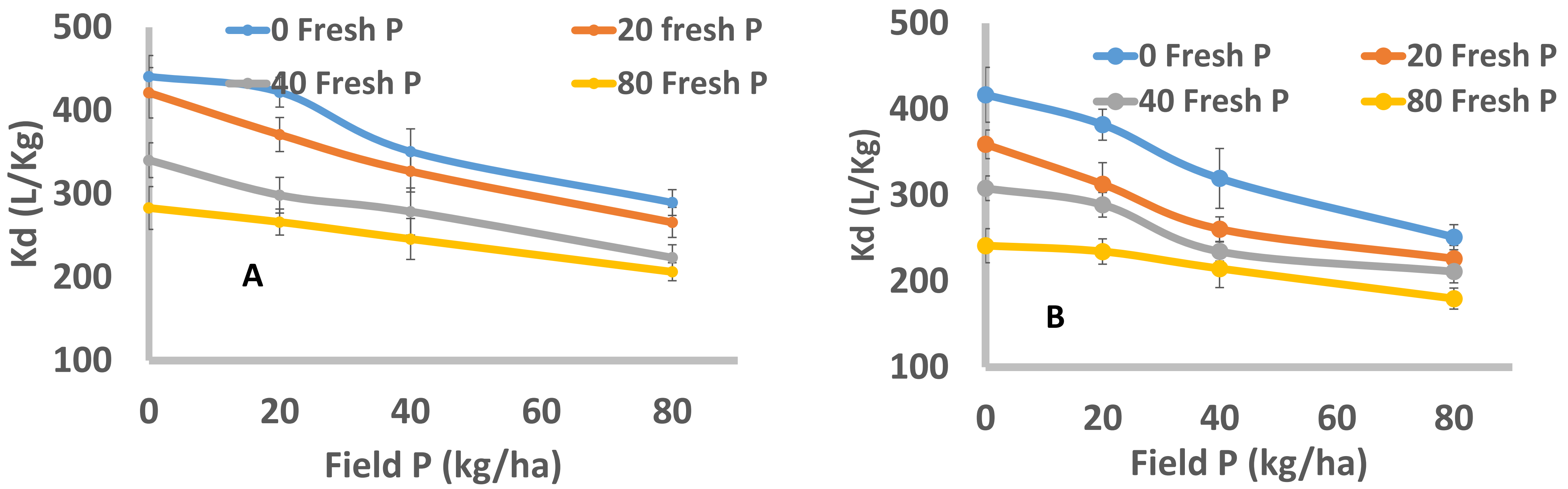


Figure 9: Effect of fresh P on glyphosate sorption at pH 4.7 (A) and 5 (B)

- ✓ Regardless of the field P level glyphosate sorption was largest in the soils that had not received fresh P additions and lowest in the soil that received fresh 80P kg/ha rate in solution

pH	Table 3: Sorption coefficient with analytical grade glyphosate and commercial formulation at different field P and pH level.							
	Analytical Grade Kd (L/Kg)				Commercial Formulation Kd (L/Kg)			
	0P	20P	40P	80P	0P	20P	40P	80P
3.6	219.32±21.97	192.98±11.70	176.81±17.82	145.07±5.74	211.07±16.27	187.51±12.45	174.59±16.69	148.60±5.56
4.7	440.90±25.13	422.09±17.92	350.85±27.15	289.61±15.44	434.03±34.54	408.45±21.58	343.19±38.35	275.07±19.25
5.0	416.81±31.94	381.98±17.95	319.48±34.78	251.13±14.67	432.14±26.90	372.96±32.50	311.99±32.12	243.28±15.72
5.4	97.30±3.09	73.09±1.57	71.09±1.86	64.73±2.03	92.05±2.88	81.05± 2.51	78.91± 3.28	72.83± 0.64
7.3	81.41±2.61	55.72±1.95	53.26±2.22	44.67±0.74	68.20±3.49	59.22± 3.40	53.98± 3.64	42.61± 2.22

- ✓ **Sorption of analytical grade and commercial formulation behaved similarly**

Conclusions:

- ✓ **Results showed that glyphosate sorption decreased with increasing P levels under several of the pH conditions studied, regardless of whether P levels arose from long-term applications in the field, or from fresh applications in the laboratory.**
- ✓ **Analytical-grade glyphosate (typically used in scientific studies) showed similar results as a commercially-available glyphosate formulation.**
- ✓ **Cadmium had no significant effect on glyphosate sorption.**

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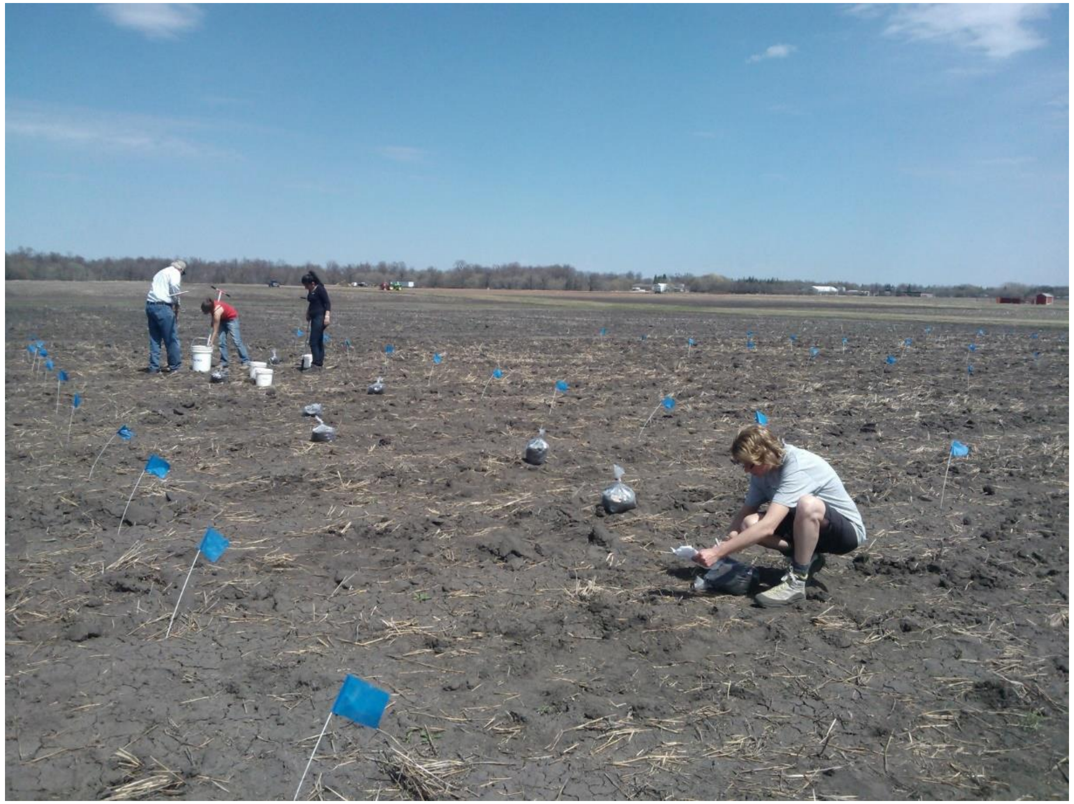


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