

Supplementary Materials for

Point of Zero Charge: Role in Pyromorphite Formation and Bioaccessibility of Lead and Arsenic in Phosphate-Amended Soils

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There are eight supplementary tables and three figures provided in this document.

Table S1: Recovery percentage for QA/QC samples during a) lead and arsenic IVBA extraction procedure (EPA Method 1340), and b) EPA 3051A acid digestion.

A.		
IKJ 583	Obtained values	Control limits
Reagent blank	<1 µg/L	<5 µg/L
Bottled blank	<5 µg/L	<50 µg/L
Blank spike	100-111%	85-115%
Matrix spike	82-112%	75-125%
Duplicate sample	88-110%	80-120%
NIST 2710A	57-69%	57-77%
NW		
Reagent blank	<1 µg/L	<5 µg/L
Bottled blank	<5 µg/L	<50 µg/L
Blank spike	95-112%	85-115%
Matrix spike	85-112%	85-115%
Duplicate sample	100-117%	80-120%
NIST 2710A	66-79%	57-77%
BO		
Reagent blank	<1 µg/L	<5 µg/L
Bottled blank	<5 µg/L	<50 µg/L
Blank spike	111-115%	85-115%
Matrix spike	100-104%	85-115%
Duplicate sample	99-101%	80-120%
NIST 2710A	54-62%	57-77%

B.	As _{Tot}	Pb _{Tot}
NIST SRM 2710a	103%	105%
IKJ Digestion Blank Spike	92%	99%
IKJ Matrix Spike	100%	103%
NIST SRM 2710a	102%	105%
BO Digestion Blank Spike	92%	101%
BO Matrix Spike	110%	102%
NIST SRM 2710a	101%	106%
NW Digestion Blank Spike	92%	100%
NW Matrix Spike	108%	106%

Table S2: Total dissolved elements measurement from effluent samples collected from IKS (IKJ 583) at 1-, 7-, 30, 90-, and 180-day of incubation using ICP-OES.

Treatments	pH	P	Stderr	Pb	stderr	As	stderr	Ca	stderr	Al	stderr	Mn	stderr	Fe	stderr
		mg/L													
IKS_LPH1 D-1	>PZC (7.0)	3.1	± 0.1	0.01	± 0.0	0.4	± 0.0	883.6	± 3.0	0.0	± 0.0	0.7	± 0.0	0.0	± 0.0
IKS_LPH2 D-1	PZC (4.0)	11.9	± 0.4	0.01	± 0.0	1.1	± 0.0	899.8	± 8.8	0.9	± 0.3	1.3	± 0.0	3.3	± 0.2
IKS_LPH3 D-1	<PZC (3.0)	18.0	± 0.1	0.01	± 0.0	1.7	± 0.0	918.4	± 7.3	7.3	± 0.1	1.3	± 0.0	7.8	± 0.4
IKS_MPH1 D-1	>PZC (7.0)	32.5	± 3.8	0.01	± 0.0	2.1	± 0.2	698.5	± 1.2	0.0	± 0.0	0.1	± 0.0	0.0	± 0.0
IKS_MPH2 D-1	PZC (4.0)	214.1	± 1.0	0.01	± 0.0	4.9	± 0.1	949.7	± 0.6	0.5	± 0.1	1.3	± 0.0	1.4	± 0.0
IKS_MPH3 D-1	<PZC (3.0)	213.0	± 2.1	0.01	± 0.0	5.5	± 0.0	947.4	± 7.7	4.7	± 0.1	1.3	± 0.0	5.2	± 0.0
IKS_HPH1 D-1	>PZC (7.0)	37.9	± 5.7	0.01	± 0.0	2.6	± 0.1	608.5	± 6.1	0.0	± 0.0	0.2	± 0.1	0.0	± 0.0
IKS_HPH2 D-1	PZC (4.0)	388.6	± 2.2	0.01	± 0.0	6.1	± 0.1	988.1	± 11.6	0.5	± 0.0	1.2	± 0.0	0.6	± 0.0
IKS_HPH3 D-1	<PZC (3.0)	379.5	± 6.1	0.01	± 0.0	6.9	± 0.0	987.3	± 19.8	4.9	± 0.1	1.3	± 0.0	4.3	± 0.1
IKS_PC (7) D-1	>PZC (7.0)	0.0		0.01		0.0		883.8		0-031		0.3		0.0	
IKS_PC (4) D-1	PZC (4.0)	0.0		0.01		0.1		928.4		8.5		1.3		9.5	
IKS_PC (3) D-1	<PZC (3.0)	0.0		0.01		0.1		934.0		11.3		1.3		22.9	
IKS_IC (7) D-1	>PZC (7.0)	42.4		0.01		2.5		562.6		0.0		0.0		0.0	
IKS_IC (3) D-1	<PZC (3.0)	208.3		0.01		5.6		660.5		4.9		1.3		5.0	
Expt. Blank	<PZC (3.0)	0.0		0.01		0.0		426.0		0.0		0.0		0.0	
Treatments	pH	P	Stderr	Pb	stderr	As	stderr	Ca	stderr	Al	stderr	Mn	stderr	Fe	stderr
		mg/L													
IKS_LPH1 D-7	>PZC (7.0)	1.8	± 0.0	0.01	± 0.0	0.4	± 0.0	852.3	± 3.0	0.0	± 0.0	0.3	± 0.0	0.0	± 0.0
IKS_LPH2 D-7	PZC (4.0)	6.8	± 0.0	0.01	± 0.0	0.8	± 0.0	891.5	± 0.4	0.8	± 0.0	1.3	± 0.0	0.0	± 0.0
IKS_LPH3 D-7	<PZC (3.0)	8.6	± 0.0	0.01	± 0.0	1.1	± 0.0	903.3	± 6.4	8.8	± 0.1	1.4	± 0.0	0.5	± 0.0
IKS_MPH1 D-7	>PZC (7.0)	11.4	± 7.5	0.01	± 0.0	1.3	± 0.5	672.6	± 19.7	0.0	± 0.0	0.0	± 0.0	0.0	± 0.0
IKS_MPH2 D-7	PZC (4.0)	209.2	± 1.0	0.01	± 0.0	5.8	± 0.1	921.1	± 3.8	0.3	± 0.0	1.3	± 0.0	0.0	± 0.0
IKS_MPH3 D-7	<PZC (3.0)	202.1	± 1.0	0.01	± 0.0	6.3	± 0.0	910.0	± 8.3	5.3	± 0.1	1.4	± 0.0	0.5	± 0.0
IKS_HPH1 D-7	>PZC (7.0)	27.5	± 5.6	0.01	± 0.0	2.5	± 0.1	578.2	± 23.1	0.0	± 0.0	0.1	± 0.0	0.0	± 0.0
IKS_HPH2 D-7	PZC (4.0)	381.3	± 1.4	0.01	± 0.0	7.3	± 0.1	972.3	± 7.5	0.3	± 0.0	1.3	± 0.0	0.0	± 0.0
IKS_HPH3 D-7	<PZC (3.0)	369.9	± 4.8	0.01	± 0.0	8.0	± 0.0	961.4	± 2.9	6.1	± 0.1	1.4	± 0.0	0.7	± 0.0
IKS_PC (7) D-7	>PZC (7.0)	0.0		0.01		0.0		866.2		0.0					
IKS_PC (4) D-7	PZC (4.0)	0.0		0.01		0.0		905.6		6.7					
IKS_C (3) D-7	<PZC (3.0)	0.0		0.01		0.0		925.9		12.9					
IKS_IC (7) D-7	>PZC (7.0)	4.9		0.01		0.9		530.3		0.0					
IKS_IC (3) D-7	<PZC (3.0)	198.8		0.01		6.2		670.2		5.8					
Expt. Blank	<PZC (3.0)	0.0		0.00		0.0		423.8		0.0					
Treatments	pH	P	Stderr	Pb	stderr	As	stderr	Ca	stderr	Al	stderr	Mn	stderr	Fe	stderr
		mg/L													
IKS_LPH1 D-30	>PZC (7.0)	1.8	± 0.0	0.02	± 0.0	0.4	± 0.0	852.1	± 0.7	-0.1	± 0.0	0.2	± 0.0	0.0	± 0.0
IKS_LPH2 D-30	PZC (4.0)	3.5	± 0.0	0.03	± 0.0	0.6	± 0.0	883.5	± 6.1	1.1	± 0.0	1.4	± 0.0	0.1	± 0.0
IKS_LPH3 D-30	<PZC (3.0)	2.2	± 0.0	0.03	± 0.0	0.4	± 0.0	892.5	± 6.4	11.9	± 0.0	1.4	± 0.0	1.7	± 0.0
IKS_MPH1 D-30	>PZC (7.0)	3.2	± 0.6	0.01	± 0.0	0.7	± 0.1	612.8	± 19.2	0.0	± 0.0	0.0	± 0.0	0.0	± 0.0
IKS_MPH2 D-30	PZC (4.0)	189.6	± 1.9	0.04	± 0.0	6.6	± 0.0	907.4	± 6.8	0.3	± 0.0	1.4	± 0.0	0.0	± 0.0
IKS_MPH3 D-30	<PZC (3.0)	180.9	± 1.6	0.04	± 0.0	6.9	± 0.1	885.8	± 34.8	7.5	± 0.3	1.5	± 0.1	0.7	± 0.0
IKS_HPH1 D-30	>PZC (7.0)	13.9	± 9.9	0.03	± 0.0	1.6	± 0.8	582.0	± 31.9	0.0	± 0.0	0.0	± 0.0	0.0	± 0.0
IKS_HPH2 D-30	PZC (4.0)	343.2	± 3.3	0.04	± 0.0	8.4	± 0.2	979.2	± 20.4	0.4	± 0.0	1.4	± 0.0	0.0	± 0.0
IKS_HPH3 D-30	<PZC (3.0)	342.8	± 16.8	0.04	± 0.0	8.8	± 0.0	960.7	± 29.3	9.0	± 0.2	1.6	± 0.0	0.9	± 0.0
IKS_PC (7) D-30	>PZC (7.0)	0.1		0.02		0.0		851.1		0.0		0.0		0.0	
IKS_PC (4) D-30	PZC (4.0)	0.0		0.03		0.0		842.6		5.6		1.3		0.5	
IKS_PC (3) D-30	<PZC (3.0)	0.0		0.03		0.0		886.5		14.1		1.4		7.2	
IKS_IC (7) D-30	>PZC (7.0)	3.5		0.02		0.1		516.0		0.0		0.0		0.0	
IKS_IC (3) D-30	<PZC (3.0)	173.0		0.02		6.7		609.6		8.0		1.4		0.7	
Expt. Blank	<PZC (3.0)	0.1		0.01		0.0		401.6		0.0		0.0		0.1	
Treatments	pH	P	Stderr	Pb	stderr	As	stderr	Ca	stderr	Al	stderr	Mn	stderr	Fe	stderr
		mg/L													
IKS_LPH1 D-90	>PZC (7.0)	1.5	± 0.0	0.01	± 0.0	0.5	± 0.0	823.0	± 10.8	0.1	± 0.0	0.2	± 0.0	0.0	± 0.0
IKS_LPH2 D-90	PZC (4.0)	0.5	± 0.0	0.01	± 0.0	0.1	± 0.0	841.6	± 3.3	2.3	± 0.1	1.4	± 0.0	0.3	± 0.0
IKS_LPH3 D-90	<PZC (3.0)	0.3	± 0.1	0.01	± 0.0	0.1	± 0.0	858.1	± 14.0	15.4	± 0.4	1.5	± 0.0	16.6	± 1.3
IKS_MPH1 D-90	>PZC (7.0)	2.0	± 0.2	0.01	± 0.0	0.6	± 0.0	623.7	± 9.4	0.0	± 0.0	0.0	± 0.0	0.0	± 0.0
IKS_MPH2 D-90	PZC (4.0)	181.8	± 1.1	0.02	± 0.0	7.9	± 0.0	914.6	± 11.0	0.3	± 0.0	1.5	± 0.0	0.0	± 0.0
IKS_MPH3 D-90	<PZC (3.0)	158.5	± 1.5	0.01	± 0.0	7.3	± 0.0	957.0	± 38.9	8.5	± 0.0	1.8	± 0.0	0.6	± 0.0
IKS_HPH1 D-90	>PZC (7.0)	7.2	± 5.1	0.01	± 0.0	1.3	± 0.6	538.0	± 18.4	0.0	± 0.0	0.0	± 0.0	0.0	± 0.0
IKS_HPH2 D-90	PZC (4.0)	396.5	± 1.8	0.02	± 0.0	10.3	± 0.0	964.2	± 13.3	0.3	± 0.0	1.6	± 0.0	0.0	± 0.0
IKS_HPH3 D-90	<PZC (3.0)	366.4	± 0.7	0.02	± 0.0	9.7	± 0.0	933.8	± 1.4	8.9	± 0.1	1.9	± 0.0	0.7	± 0.0
IKS_PC (7) D-90	>PZC (7.0)	0.2	±	0.01	±	0.0	±	835.7	±	0.1	±	0.2	±	0.0	±
IKS_PC (4) D-90	PZC (4.0)	0.0	±	0.01	±	0.0	±	842.0	±	6.2	±	1.4	±	0.5	±
IKS_PC (3) D-90	<PZC (3.0)	0.0	±	0.02	±	0.0	±	856.7	±	17.4	±	1.5	±	7.2	±
IKS_IC (7) D-90	>PZC (7.0)	2.8	±	0.02	±	0.9	±	526.5	±	0.1	±	0.0	±	0.0	±
IKS_IC (3) D-90	<PZC (3.0)	152.5	±	0.02	±	7.1	±	628.5	±	9.1	±	1.			

Table S3: Total dissolved elements measurement in effluent samples collected from BO at 37-day of incubation using ICP-OES.

		mg/L						
Treatments	pH	P	Pb	As	Ca	Al	Mn	Fe
BO_LPH1	>PZC (7.3)	1.97	0.02	0.30	25.00	0.07	0.19	0.03
BO_LPH2	PZC (5.8)	9.24	0.04	0.70	342.80	0.11	3.90	0.03
BO_LPH3	<PZC (4.3)	10.89	0.32	0.98	412.00	0.64	11.10	0.06
BO_MPH1	>PZC (7.3)	43.12	0.08	1.50	27.66	0.21	0.07	0.06
BO_MPH2	PZC (5.8)	150.58	0.02	1.85	278.20	0.12	2.49	0.03
BO_MPH3	<PZC (4.3)	171.48	0.13	2.18	395.20	0.72	10.10	0.05
BO_HPH1	>PZC (7.3)	237.60	0.25	2.17	17.39	0.82	0.17	0.26
BO_HPH2	PZC (5.8)	378.60	0.02	1.98	250.60	0.09	1.75	0.02
BO_HPH3	<PZC (4.3)	398.60	0.10	2.58	395.20	0.70	9.83	0.05
BO_POS_CTRL	>PZC (7.3)	0.08	0.03	0.04	309.00	0.14	0.52	0.05
BO_Master CTRL	>PZC (7.3)	-0.03	0.45	0.00	391.00	0.03	0.01	0.00

“L” stands for low P-amendment, “M” for medium P-amendment, and “H” for high P-amendment. “PH1” in the samples label represents >pH_{PZC} (pH 7.3) “PH2” represents pH_{PZC} (pH 5.8), and “PH3” represents <pH_{PZC} (pH 4.3).

Table S4: Total dissolved elements measurement in effluent samples collected from NW at 1-, 7-, 30, 90-, and 180-day of incubation using ICP-OES.

			mg/L											
Treatments	pH	P	stderr	Pb	stderr	As	stderr	Ca	stderr	Al	stderr	Mn	stder	Fe
NW_LPH1 D-1	>PZC (8.0)	4.81 ± 0.19	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	363.55 ± 0.05	0.02 ± 0.00	0.02 ± 0.00	0.08 ± 0.00	0.08 ± 0.00	<DL	
NW_LPH2 D-1	PZC (7.0)	16.21 ± 0.94	0.01 ± 0.00	0.01 ± 0.00	0.02 ± 0.00	0.02 ± 0.00	0.02 ± 0.00	393.60 ± 0.70	0.03 ± 0.00	0.03 ± 0.00	0.17 ± 0.01	0.17 ± 0.01	<DL	
NW_LPH3 D-1	<PZC (3.5)	51.47 ± 1.01	0.08 ± 0.01	0.08 ± 0.01	0.06 ± 0.00	0.06 ± 0.00	0.06 ± 0.00	586.50 ± 9.20	0.14 ± 0.02	0.14 ± 0.02	2.18 ± 0.05	2.18 ± 0.05	<DL	
NW_MPH1 D-1	>PZC (8.0)	18.52 ± 2.97	0.01 ± 0.01	0.01 ± 0.01	0.04 ± 0.00	0.04 ± 0.00	0.04 ± 0.00	72.69 ± 0.81	0.00 ± 0.01	0.00 ± 0.01	0.01 ± 0.00	0.01 ± 0.00	<DL	
NW_MPH2 D-1	PZC (7.0)	47.25 ± 0.46	0.01 ± 0.00	0.01 ± 0.00	0.05 ± 0.00	0.05 ± 0.00	0.05 ± 0.00	145.10 ± 3.70	0.01 ± 0.00	0.01 ± 0.00	0.02 ± 0.00	0.02 ± 0.00	<DL	
NW_MPH3 D-1	<PZC (3.5)	271.90 ± 0.50	0.14 ± 0.08	0.14 ± 0.08	0.08 ± 0.00	0.08 ± 0.00	0.08 ± 0.00	607.15 ± 6.55	0.91 ± 0.51	0.91 ± 0.51	2.32 ± 0.02	2.32 ± 0.02	<DL	
NW_HPH1 D-1	>PZC (8.0)	232.00 ± 4.00	0.01 ± 0.00	0.01 ± 0.00	0.08 ± 0.00	0.08 ± 0.00	0.08 ± 0.00	7.89 ± 0.55	0.00 ± 0.01	0.00 ± 0.01	0.00 ± 0.00	0.00 ± 0.00	<DL	
NW_HPH2 D-1	PZC (7.0)	234.25 ± 2.95	0.01 ± 0.00	0.01 ± 0.00	0.09 ± 0.00	0.09 ± 0.00	0.09 ± 0.00	28.12 ± 0.01	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	<DL	
NW_HPH3 D-1	<PZC (3.5)	473.30 ± 0.10	0.08 ± 0.00	0.08 ± 0.00	0.11 ± 0.00	0.11 ± 0.00	0.11 ± 0.00	613.45 ± 0.25	0.84 ± 0.11	0.84 ± 0.11	2.58 ± 0.07	2.58 ± 0.07	<DL	
NW_PC (8) D-7	>PZC (8.0)	0.17		0.02		0.00		444.00		0.04		0.36	0.36	<DL
NW_PC (7) D-7	PZC (7.0)	0.17		0.02		0.00		454.40		0.04		0.50	0.50	<DL
NW_PC (3.5) D-7	<PZC (3.5)	1.34		0.12		0.02		605.90		0.07		2.28	2.28	<DL
NW_IC (8) D-7	>PZC (8.0)	213.00		0.00		0.07		15.28		-0.01		0.02	0.02	<DL
Expt. Blank	PZC (7.0)	0.02		0.01		0.00		443.70		0.04		0.02	0.02	<DL
			mg/L											
Treatments	pH	P	stderr	Pb	stderr	As	stderr	Ca	stderr	Al	stderr	Mn	stder	Fe
NW_LPH1 D-7	>PZC (8.0)	2.67 ± 0.04	0.02 ± 0.00	0.02 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	362.75 ± 0.85	0.02 ± 0.00	0.02 ± 0.00	0.09 ± 0.09	0.09 ± 0.09	<DL	
NW_LPH2 D-7	PZC (7.0)	14.65 ± 1.36	0.02 ± 0.00	0.02 ± 0.00	0.02 ± 0.00	0.02 ± 0.00	0.02 ± 0.00	408.75 ± 0.15	0.02 ± 0.00	0.02 ± 0.00	0.09 ± 0.09	0.09 ± 0.09	<DL	
NW_LPH3 D-7	<PZC (3.5)	39.90 ± 0.58	0.51 ± 0.00	0.51 ± 0.00	0.07 ± 0.00	0.07 ± 0.00	0.07 ± 0.00	662.65 ± 1.95	1.50 ± 0.01	1.50 ± 0.01	4.85 ± 4.85	4.85 ± 4.85	<DL	
NW_MPH1 D-7	>PZC (8.0)	7.38 ± 1.42	0.01 ± 0.00	0.01 ± 0.00	0.03 ± 0.00	0.03 ± 0.00	0.03 ± 0.00	38.61 ± 5.07	0.00 ± 0.00	0.00 ± 0.00	0.01 ± 0.01	0.01 ± 0.01	<DL	
NW_MPH2 D-7	PZC (7.0)	20.11 ± 0.71	0.01 ± 0.00	0.01 ± 0.00	0.05 ± 0.00	0.05 ± 0.00	0.05 ± 0.00	95.82 ± 2.60	0.01 ± 0.00	0.01 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	<DL	
NW_MPH3 D-7	<PZC (3.5)	259.65 ± 1.15	0.18 ± 0.01	0.18 ± 0.01	0.10 ± 0.00	0.10 ± 0.00	0.10 ± 0.00	660.20 ± 3.50	1.67 ± 0.06	1.67 ± 0.06	4.46 ± 4.46	4.46 ± 4.46	<DL	
NW_HPH1 D-7	>PZC (8.0)	241.80 ± 1.40	0.00 ± 0.01	0.00 ± 0.01	0.10 ± 0.00	0.10 ± 0.00	0.10 ± 0.00	3.85 ± 0.27	-0.01 ± 0.01	-0.01 ± 0.01	0.00 ± 0.00	0.00 ± 0.00	<DL	
NW_HPH2 D-7	PZC (7.0)	232.85 ± 3.15	0.01 ± 0.00	0.01 ± 0.00	0.10 ± 0.00	0.10 ± 0.00	0.10 ± 0.00	20.91 ± 0.20	-0.02 ± 0.02	-0.02 ± 0.02	0.00 ± 0.00	0.00 ± 0.00	<DL	
NW_HPH3 D-7	<PZC (3.5)	467.65 ± 1.55	0.13 ± 0.00	0.13 ± 0.00	0.12 ± 0.00	0.12 ± 0.00	0.12 ± 0.00	656.50 ± 5.10	2.42 ± 0.06	2.42 ± 0.06	4.64 ± 4.64	4.64 ± 4.64	<DL	
NW_PC (8) D-7	>PZC (8.0)	0.83		1.80		0.01 ±		683.10		3.52		5.57	5.57	<DL
NW_PC (7) D-7	PZC (7.0)	0.17		0.01		0.00 ±		477.00		0.06		0.63	0.63	<DL
NW_PC (3.5) D-7	<PZC (3.5)	0.20		0.02		0.00 ±		452.90		0.03		0.29	0.29	<DL
NW_IC (8) D-7	>PZC (8.0)	209.10		0.00		0.08 ±		12.49		0.00		0.00	0.00	<DL
Expt. Blank	PZC (7.0)	0.03		0.01		0.00		439.30		0.02		0.02	0.02	<DL
			mg/L											
Treatments	pH	P	stderr	Pb	stderr	As	stderr	Ca	stderr	Al	stderr	Mn	stder	Fe
NW_LPH1 D-30	>PZC (8.0)	1.26 ± 0.08	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	368.40 ± 1.70	0.03 ± 0.00	0.03 ± 0.00	0.09 ± 0.01	0.09 ± 0.01	<DL	
NW_LPH2 D-30	PZC (7.0)	12.62 ± 0.08	0.02 ± 0.01	0.02 ± 0.01	0.03 ± 0.00	0.03 ± 0.00	0.03 ± 0.00	424.35 ± 4.75	0.03 ± 0.01	0.03 ± 0.01	0.00 ± 0.00	0.00 ± 0.00	<DL	
NW_LPH3 D-30	<PZC (3.5)	24.94 ± 0.38	0.77 ± 0.02	0.77 ± 0.02	0.06 ± 0.00	0.06 ± 0.00	0.06 ± 0.00	684.35 ± 2.75	3.41 ± 0.11	3.41 ± 0.11	6.02 ± 0.08	6.02 ± 0.08	<DL	
NW_MPH1 D-30	>PZC (8.0)	5.13 ± 0.85	0.01 ± 0.00	0.01 ± 0.00	0.03 ± 0.00	0.03 ± 0.00	0.03 ± 0.00	32.94 ± 1.84	-0.01 ± 0.01	-0.01 ± 0.01	0.00 ± 0.00	0.00 ± 0.00	<DL	
NW_MPH2 D-30	PZC (7.0)	13.90 ± 0.15	0.02 ± 0.01	0.02 ± 0.01	0.04 ± 0.00	0.04 ± 0.00	0.04 ± 0.00	90.79 ± 1.93	0.02 ± 0.00	0.02 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	<DL	
NW_MPH3 D-30	<PZC (3.5)	237.30 ± 1.00	0.18 ± 0.01	0.18 ± 0.01	0.11 ± 0.00	0.11 ± 0.00	0.11 ± 0.00	671.00 ± 8.90	2.97 ± 0.01	2.97 ± 0.01	5.71 ± 0.06	5.71 ± 0.06	<DL	
NW_HPH1 D-30	>PZC (8.0)	234.05 ± 1.15	0.01 ± 0.00	0.01 ± 0.00	0.12 ± 0.00	0.12 ± 0.00	0.12 ± 0.00	3.21 ± 0.09	-0.01 ± 0.01	-0.01 ± 0.01	0.00 ± 0.00	0.00 ± 0.00	<DL	
NW_HPH2 D-30	PZC (7.0)	224.70 ± 0.70	0.01 ± 0.00	0.01 ± 0.00	0.11 ± 0.00	0.11 ± 0.00	0.11 ± 0.00	18.94 ± 0.74	0.01 ± 0.00	0.01 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	<DL	
NW_HPH3 D-30	<PZC (3.5)	457.10 ± 1.10	0.12 ± 0.00	0.12 ± 0.00	0.13 ± 0.00	0.13 ± 0.00	0.13 ± 0.00	677.20 ± 3.50	3.91 ± 0.10	3.91 ± 0.10	5.84 ± 0.01	5.84 ± 0.01	<DL	
NW_PC (8) D-30	>PZC (8.0)	0.33		0.02		0.00		453.90		0.05		0.00		<DL
NW_PC (7) D-30	PZC (7.0)	0.20		0.02		0.00		495.00		0.02		0.00		<DL
NW_PC (3.5) D-30	<PZC (3.5)	0.63		3.44		0.01		690.50		11.50		6.55		<DL
NW_IC (8) D-30	>PZC (8.0)	202.10		0.01		0.09		10.18		0.03		0.00		<DL
Expt. Blank	<PZC (3.5)	0.00		0.01		0.00		443.50		-0.01		0.02		<DL
			mg/L											
Treatments	pH	P	stderr	Pb	stderr	As	stderr	Ca	stderr	Al	stderr	Mn	stder	Fe
NW_LPH1 D-90	>PZC (8.0)	1.08 ± 0.06	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	361.05 ± 10.80	0.04 ± 0.00	0.04 ± 0.00	0.16 ± 0.00	0.16 ± 0.00	<DL	
NW_LPH2 D-90	PZC (7.0)	11.04 ± 0.25	0.01 ± 0.01	0.01 ± 0.01	0.03 ± 0.00	0.03 ± 0.00	0.03 ± 0.00	407.70 ± 3.35	0.02 ± 0.00	0.02 ± 0.00	1.42 ± 0.01	1.42 ± 0.01	<DL	
NW_LPH3 D-90	<PZC (3.5)	14.56 ± 0.45	0.05 ± 0.04	0.05 ± 0.04	0.04 ± 0.00	0.04 ± 0.00	0.04 ± 0.00	681.25 ± 13.95	2.69 ± 0.06	2.69 ± 0.06	1.51 ± 0.03	1.51 ± 0.03	<DL	
NW_MPH1 D-90	>PZC (8.0)	3.14 ± 0.57	0.00 ± 0.00	0.00 ± 0.00	0.03 ± 0.00	0.03 ± 0.00	0.03 ± 0.00	33.80 ± 9.40	0.01 ± 0.01	0.01 ± 0.01	0.03 ± 0.00	0.03 ± 0.00	<DL	
NW_MPH2 D-90	PZC (7.0)	10.53 ± 1.20	0.00 ± 0.00	0.00 ± 0.00	0.04 ± 0.00	0.04 ± 0.00	0.04 ± 0.00	92.78 ± 11.00	0.01 ± 0.00	0.01 ± 0.00	1.53 ± 0.00	1.53 ± 0.00	<DL	
NW_MPH3 D-90	<PZC (3.5)	219.40 ± 0.80	0											

Table S5: Sulfate and phosphate measurements in IKJ 583.

	Sulfate														
<i>Treatments detail</i>	<i>day 1</i>			<i>day 7</i>			<i>day 30</i>			<i>day 90</i>			<i>day 180</i>		
IKS_LPH1 >PZC (7.0)	165	±	26	254	±	6	940	±	33	1049	±	2	1317	±	29
IKS_LPH2 PZC (4.0)	199	±	47	250	±	29	922	±	28	964	±	18	1811	±	35
IKS_LPH3 <PZC (3.0)	270	±	52	230	±	62	1402	±	12	1067	±	28	1942	±	142
IKS_MPH1 >PZC (7.0)	336	±	16	357	±	12	1961	±	5	1689	±	212	2148	±	435
IKS_MPH2 PZC (4.0)	202	±	46	251	±	1	985	±	49	1231	±	209	1719	±	8
IKS_MPH3 <PZC (3.0)	246	±	8	183	±		1211	±	200	1038	±	2	1796	±	78
IKS_HPH1 >PZC (7.0)	447	±	13	446	±	109	2284	±	140	2810	±	218	3233	±	649
IKS_HPH2 PZC (4.0)	254	±	67	265	±	58	1084	±	28	1208	±	108	1926	±	40
IKS_HPH3 <PZC (3.0)	287	±	20	211	±	5	1116	±	4	1316	±	192	1960	±	17
IKS_PC (7.0)	303			236			1044			1474			1793		
IKS_PC (4.0)	241			259			1220			1351			1701		
IKS_PC (3.0)	234			191			1350			1012			1809		

<i>Treatments detail</i>	Phosphate				
	<i>day 1</i>	<i>day 7</i>	<i>day 30</i>	<i>day 90</i>	<i>day 180</i>
IKS_LPH1 >PZC (7.0)	5 ± 0	4 ± 0	5 ± 0	2 ± 0	3 ±
IKS_LPH2 PZC (4.0)	7 ± 0	6 ± 0	41 ± 1	1 ± 0	1 ± 0
IKS_LPH3 <PZC (3.0)	9 ± 0	6 ± 0	43 ± 4	58 ±	1 ±
IKS_MPH1 >PZC (7.0)	16 ± 2	7 ± 2	9 ± 1	3 ± 1	62 ± 1
IKS_MPH2 PZC (4.0)	112 ± 19	124 ± 1	419 ± 20	385 ± 78	425 ± 0
IKS_MPH3 <PZC (3.0)	128 ± 2	85 ±	384 ± 63	245 ± 19	299 ± 20
IKS_HPH1 >PZC (7.0)	17 ± 2	13 ± 4	58 ±	45 ± 6	72 ± 9
IKS_HPH2 PZC (4.0)	257 ± 46	251 ± 37	960 ± 16	996 ± 133	1270 ± 44
IKS_HPH3 <PZC (3.0)	259 ± 45	218 ± 4	943 ± 28	909 ± 167	1012 ± 19
IKS_PC (7.0)	4		54	1	1
IKS_PC (4.0)			39	42	66
IKS_PC (3.0)					

Table S6: Sulfate and phosphate measurements in NW.

<i>Sulfate</i>					
<i>Treatments detail</i>	<i>day 1</i>	<i>day 7</i>	<i>day 30</i>	<i>day 90</i>	<i>day 180</i>
NW_LPH1 >PZC (8.0)	67 ± 3	70 ± 1	41 ± 2	73 ± 2	72 ± 2
NW_LPH2 PZC (7.0)	72 ± 0	72 ± 0	48 ± 0	74 ± 0	75 ± 0
NW_LPH3 <PZC (3.5)	75 ± 2	72 ± 1	50 ± 0	73 ± 2	71 ± 2
NW_MPH1 >PZC (8.0)	73 ± 2	70 ± 0	51 ± 1	77 ± 0	71 ± 2
NW_MPH2 PZC (7.0)	70 ± 0	71 ± 1	50 ± 1	74 ± 0	73 ± 1
NW_MPH3 <PZC (3.5)	69 ± 3	72 ± 1	49 ± 3	76 ± 2	77 ± 1
NW_HPH1 >PZC (8.0)	73 ± 1	73 ± 0	50 ± 2	78 ± 0	78 ± 0
NW_HPH2 PZC (7.0)	71 ± 2	72 ± 0	49 ± 1	76 ± 1	75 ± 1
NW_HPH3 <PZC (3.5)	75 ± 1	78 ± 2	57 ± 1	75 ± 3	73 ± 5
NW_PC (8.0)	73	75	59	76	78
NW_PC (7.0)	72	72	49	72	74
NW_PC (3.5)	71	127	57	73	75
<i>Phosphate</i>					
<i>Treatments detail</i>	<i>day 1</i>	<i>day 7</i>	<i>day 30</i>	<i>day 90</i>	<i>day 180</i>
NW_LPH1 >PZC (8.0)	57 ± 0	--	--	--	--
NW_LPH2 PZC (7.0)	67 ± 2	70 ± 2	63 ± 1	61 ± 2	58 ± 1
NW_LPH3 <PZC (3.5)	139 ± 5	124 ± 2	97 ± 2	75 ± 0	64 ± 1
NW_MPH1 >PZC (8.0)	75 ± 0	64 ± 2	64 ± 1	63 ± 0	57 ± 1
NW_MPH2 PZC (7.0)	112 ± 0	84	73 ± 1	64 ± 1	61 ± 0
NW_MPH3 <PZC (3.5)	582 ± 38	682 ± 11	602 ± 32	979 ± 424	497 ± 5
NW_HPH1 >PZC (8.0)	620 ± 22	642 ± 5	606 ± 7	618 ± 15	524 ± 15
NW_HPH2 PZC (7.0)	588 ± 13	607 ± 3	570 ± 20	563 ± 12	483 ± 9
NW_HPH3 <PZC (3.5)	1329 ± 51	1502 ± 65	1425 ± 24	1286 ± 21	1092 ± 127
NW_PC (8.0)	61		67	507	
NW_PC (7.0)			61	69	
NW_PC (3.5)			63		

Table S7: Sulfate and phosphate measurements in BO.

	<i>Sulfate</i>	<i>Phosphate</i>
<i>Treatments detail</i>	<i>Day 37</i>	
BO_LPH1 PZC (7.2)	17	65
BO_LPH2 >PZC (5.8)	16	72
BO_LPH3 <PZC (4.3)	16	81
BO_MPH1 PZC (7.2)	16	170
BO_MPH2 >PZC (5.8)	17	380
BO_MPH3 <PZC (4.3)	15	471
BO_HPH1 PZC (7.2)	17	836
BO_HPH2 >PZC 5.8)		1291
BO_HPH3 <PZC (4.3)		1196
BO_PC (7.2)	4	

Table S8: Treatment effect ratio (TER) for bioaccessible lead measurement at pH 1.5 and pH 2.5 for artificially spiked soil (CS).

	pH 1.5			pH 2.5		
Lead	<i>Day 1</i>	<i>Day 7</i>	<i>Day 30</i>	<i>Day 1</i>	<i>Day 7</i>	<i>Day 30</i>
Treatment	TER	TER	TER	TER	TER	TER
CS_MPH1 >PZC (8.5)	0.93	0.47	0.57	0.92	0.80	0.93
CS_MPH2 PZC (7.5)	0.88	1.06	1.02	0.88	0.94	0.92
CS_MPH3 <PZC (3.5)	1.30	2.59	3.46	1.24	1.35	1.19

Treatment effect ratio (TER) represents the bioaccessibility in amended soil divided by bioaccessibility in the untreated soil at that particular pH.

Figure S1: Bar chart represents the bulk Pb-XAS results obtained via statistical analyses; principal component analysis (PCA), and linear combination fitting (LCF) results showing % components of Pb-minerals in a) Medium P-amended (5%) of artificially lead-spiked soil >pH_{PZC} (pH 7.5, 8.5), and <pH_{PZC} (pH 3.5) for 1-, 7-, 30-day of incubation. CS in the label represents clean soil spiked with lead, “M” stands for medium P-amendment. “PH1” and “PH2” in the samples label represents >pH_{PZC}, and “PH3” represents <pH_{PZC}. “POS_CTRL” stands for positive control.

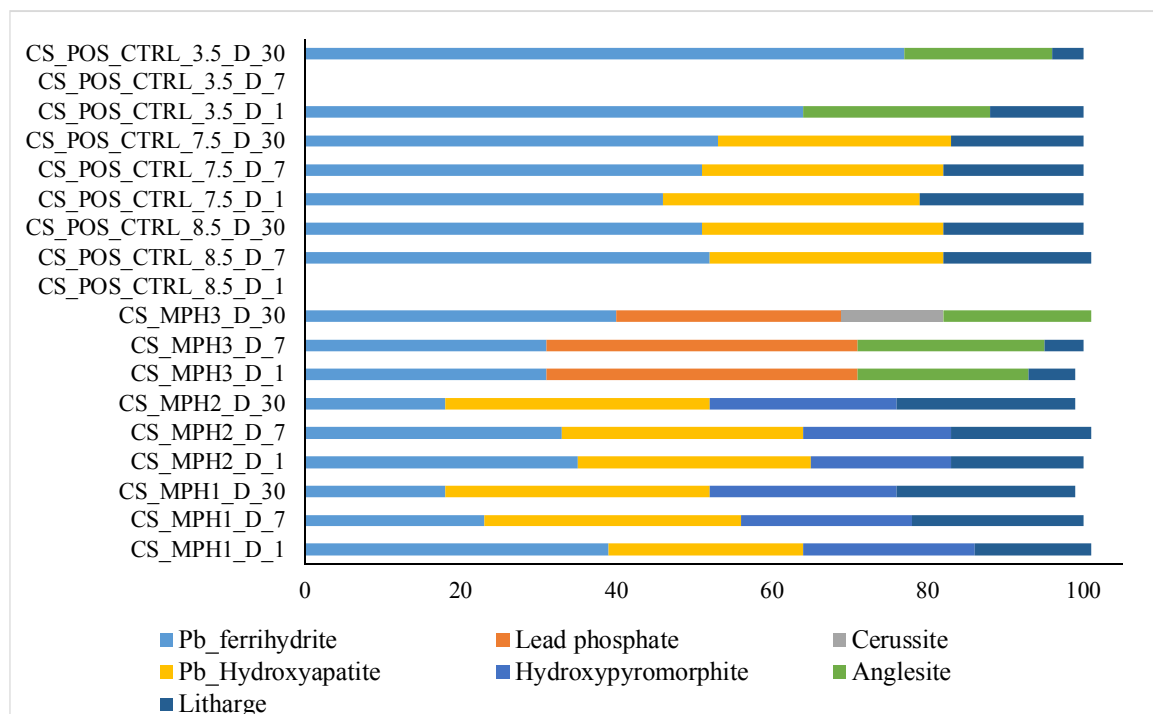


Figure S2: Box and whisker plots for the mean TER values for Pb and As as a function of soil type. The mean is represented by the symbol in each box and whisker plot. The box ends represent the 25th and 75th percentiles, while the middle line is equal to the median value. The whiskers are equal to one standard deviation from the mean value (symbol). A) Mean TER_{Pb} values, B) Mean TER_{As} values.

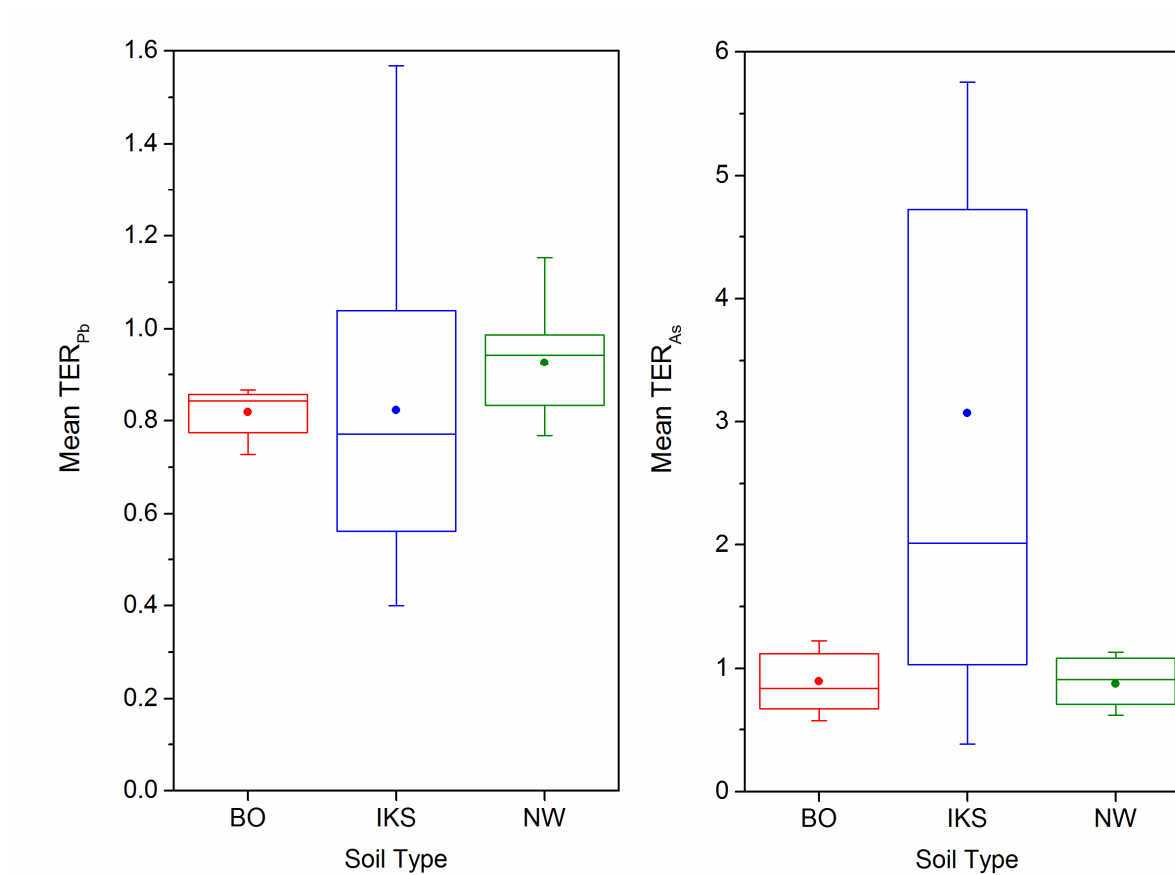


Figure S3: Dissolved Fe concentration for the IKS soil for each of the three pH-PZC relationships at the P-application rate of 1%

