Column Tests to Assess Flushing of Perchlorate from Soil

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Outline

- Site Background / Objectives
- Soil/Water Preparation / Characterization
- Column Construction / Procedures
- Results
- Summary / Conclusions

Site Background

- Industrial facility near Las Vegas, Nevada
- Perchlorate present in vadose zone and GW
- Depth to GW 10-30 ft bgs
- Soil flushing considered because
  - perchlorate will move into groundwater
  - GW pump and treat system already exists

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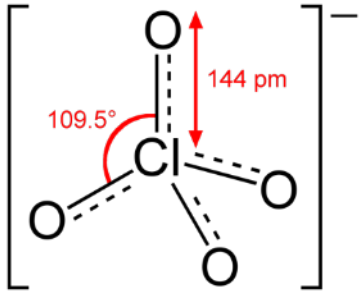
Perchlorate Basics

- Anionic: ClO_4^-
- Solubility in water: ~ 200 g/L
- Common uses: explosives, pyrotechnics, rocket fuel
- Health effects: can interfere with thyroid function
- Drinking water limits: 18 μg/L (NV Interim Action Level)



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Objectives

Conduct column tests to:

- Determine amount of perchlorate that can be leached from soil
- Determine volume of water required to leach perchlorate
- Identify other compounds that may also be flushed from soil

Soil Preparation

- 3 samples, each about 200 lbs (90 kg)
- For each sample
  - Sieve to remove rocks > 0.5 in (1.25 cm)
  - Homogenize
  - Analyze for various parameters including perchlorate, arsenic, metals, Cr(VI), TOC

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Site Water

- Stabilized Lake Mead Water (~25 gal/90L)
- Received in multiple containers
- Used as received
- Analyzed for perchlorate, arsenic, Cr(VI) and other parameters

Baseline Analytical Results

Analyte	Units	Soil 1	Soil 2	Soil 3	Water
Perchlorate	ppb	6,180	145,000	3,130,000	2.19
Alkalinity	ppm	n.a.	n.a.	n.a.	160
Arsenic	ppm	7.2	2.8	3.6	< 0.005
Cr(VI)	ppm	< 0.400	< 0.400	< 0.400	< 0.001
Moisture	%	4.7	8.3	8.3	n.a.
TDS	ppm	n.a.	n.a.	n.a.	620
TOC	ppm	5,900	5,000	7,600	2.8

- ppb = micrograms per kilogram or micrograms per liter
- ppm = milligrams per kilogram or milligrams per liter
- n.a. = not applicable

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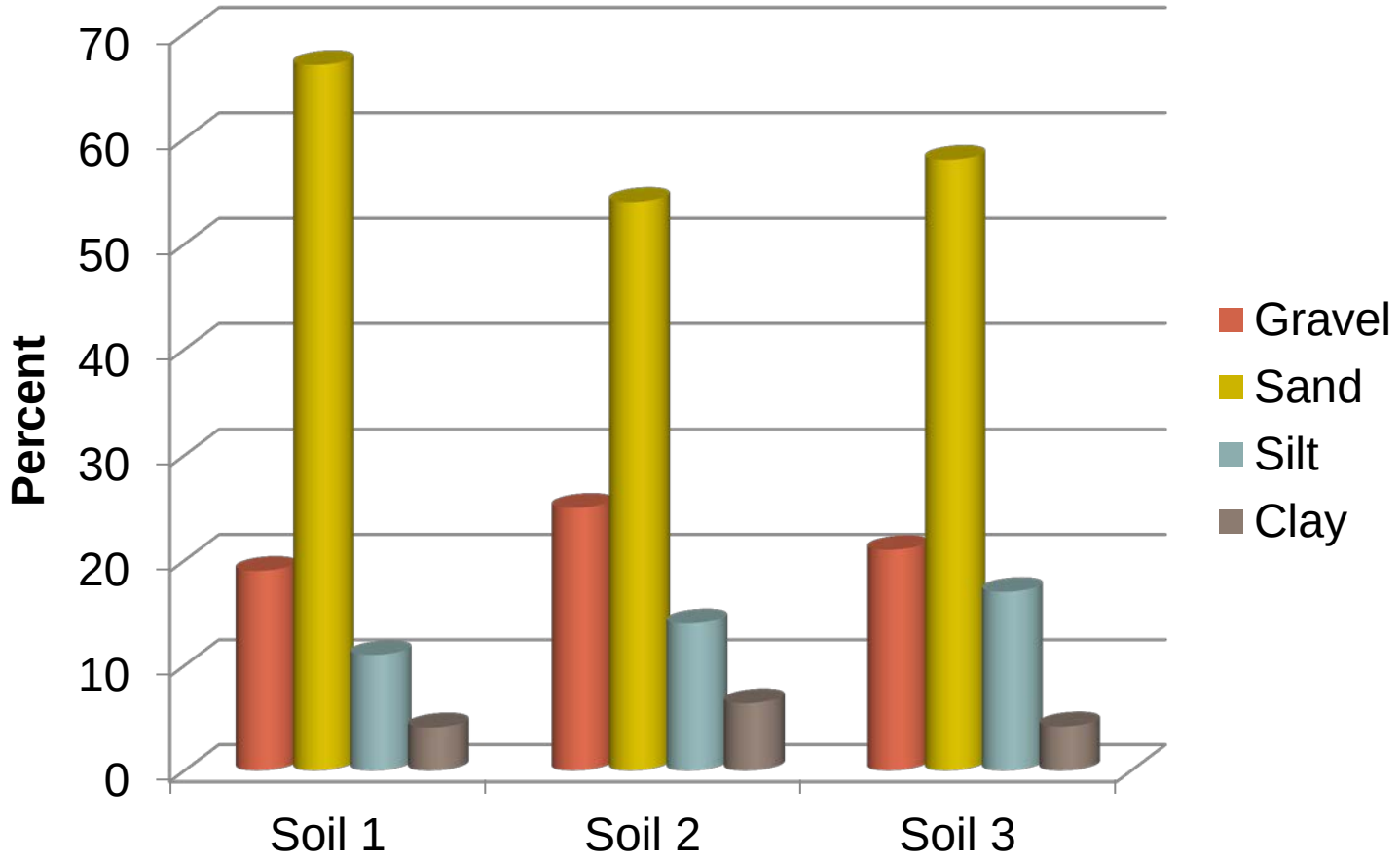
Physical Parameters BULK Soil



Column Construction

- Column design based on ASTM D 4874
- Clear PVC pipe
- 6 in diameter x 72 in tall
- 1 in thick acrylic endplates
- Top diffuser sintered glass
- Bottom diffuser SS, pore size 75 μm
- Soil added in 6 in lifts

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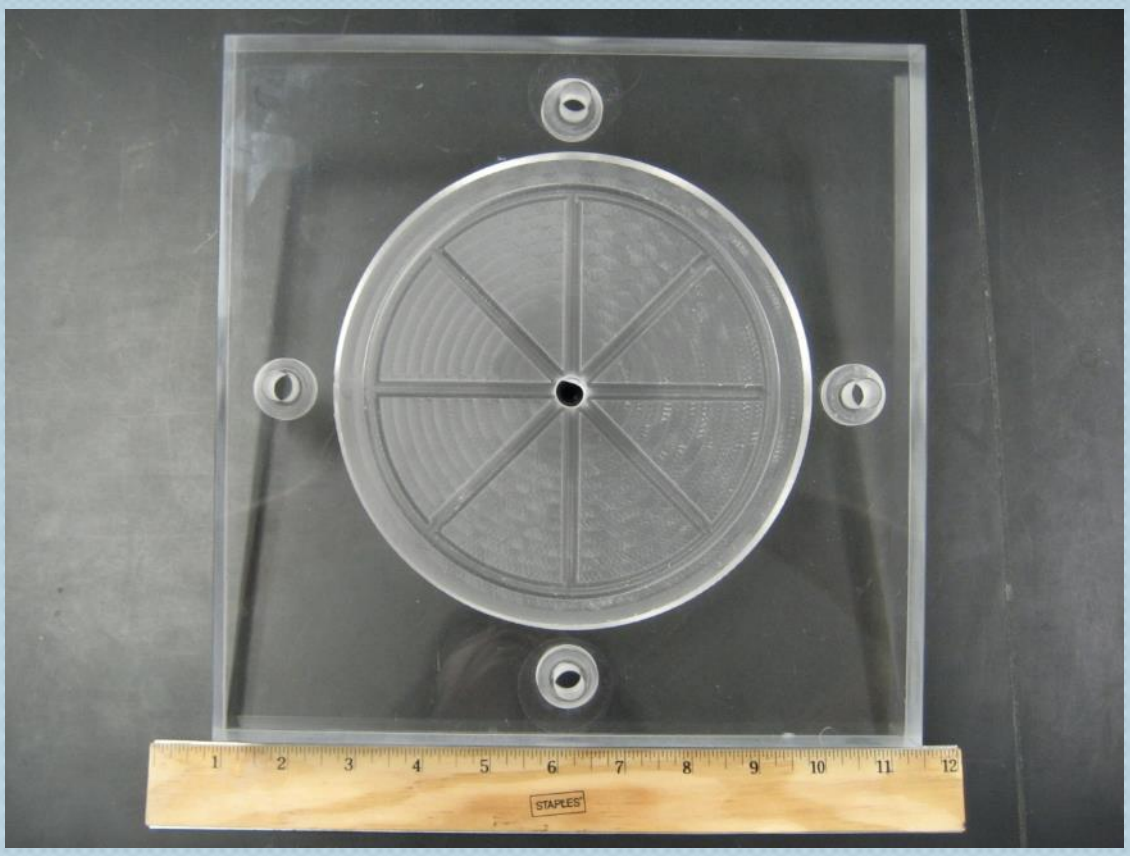
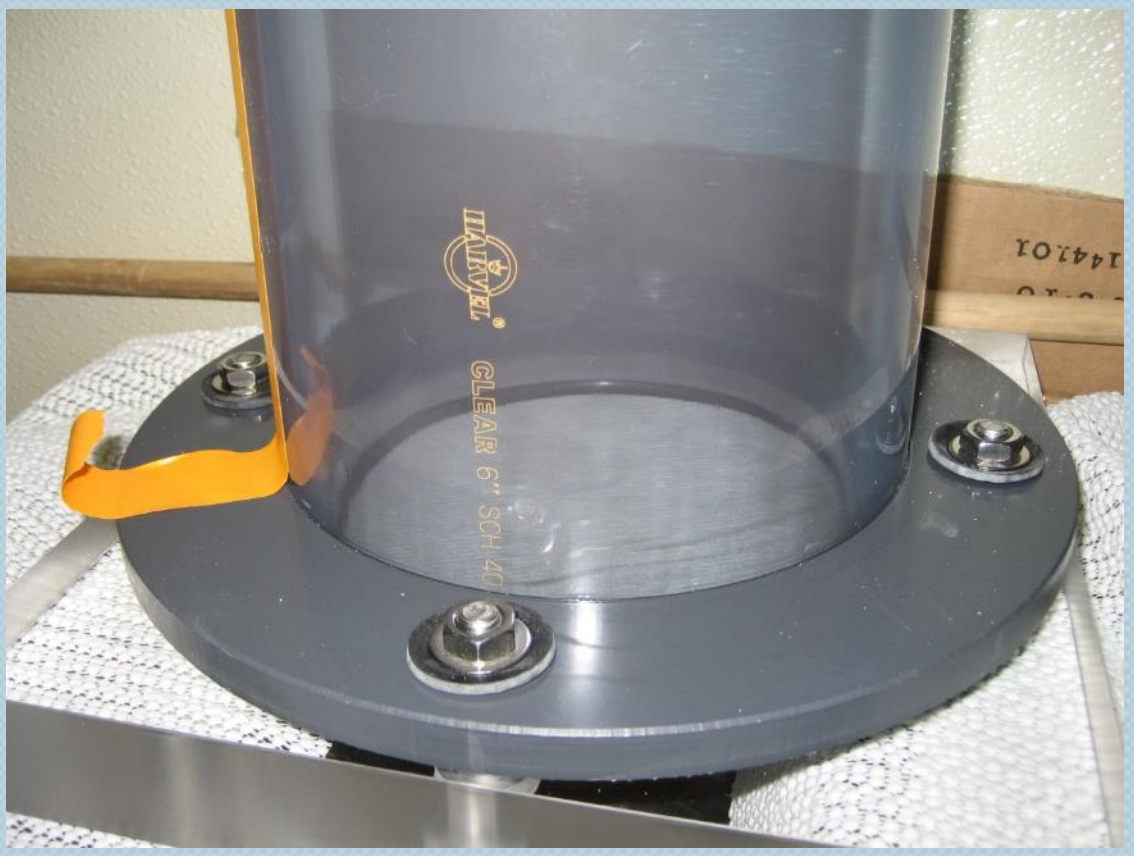
COLUMN CONSTRUCTION

End Plate



COLUMN CONSTRUCTION

Column Bolted to Endplate



COLUMN CONSTRUCTION

The First Lift

COLUMN CONSTRUCTION

Construction Complete

Column Parameters

Parameter	Soil -1	Soil-2	Soil-3
Diameter	6 in (15 cm)		
Bed Height	72 in (190 cm)		
Soil Mass	135 lbs (61 kg)		
Bulk Density	1.87 g/cm3		
Pore Volume, L	10.4	11.5	11.5
Flowrate, mL/min	1-2	2.1	2.0
Pore Volumes Put Through	2.3	2.1	2.1
Pore Volumes Recovered	1.6	1.2	1.6
Duration, days*	12	7.8	8.3

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Procedures

- Site water pumped into top of columns
- Wetting front noted
- Effluent collected for 24 hr periods
- Effluent analyzed for various parameters
- After final time point, columns sampled and soil analyzed for ClO_4^-

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PROCEDURES

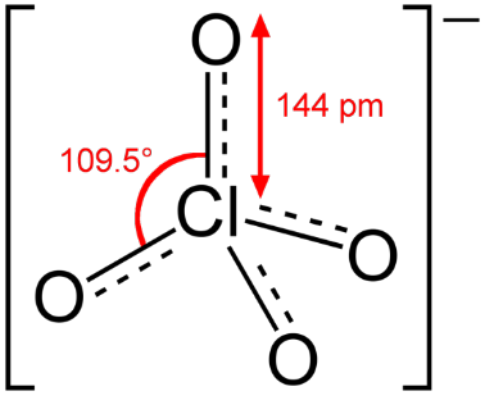
Sample Bottles

PROCEDURES

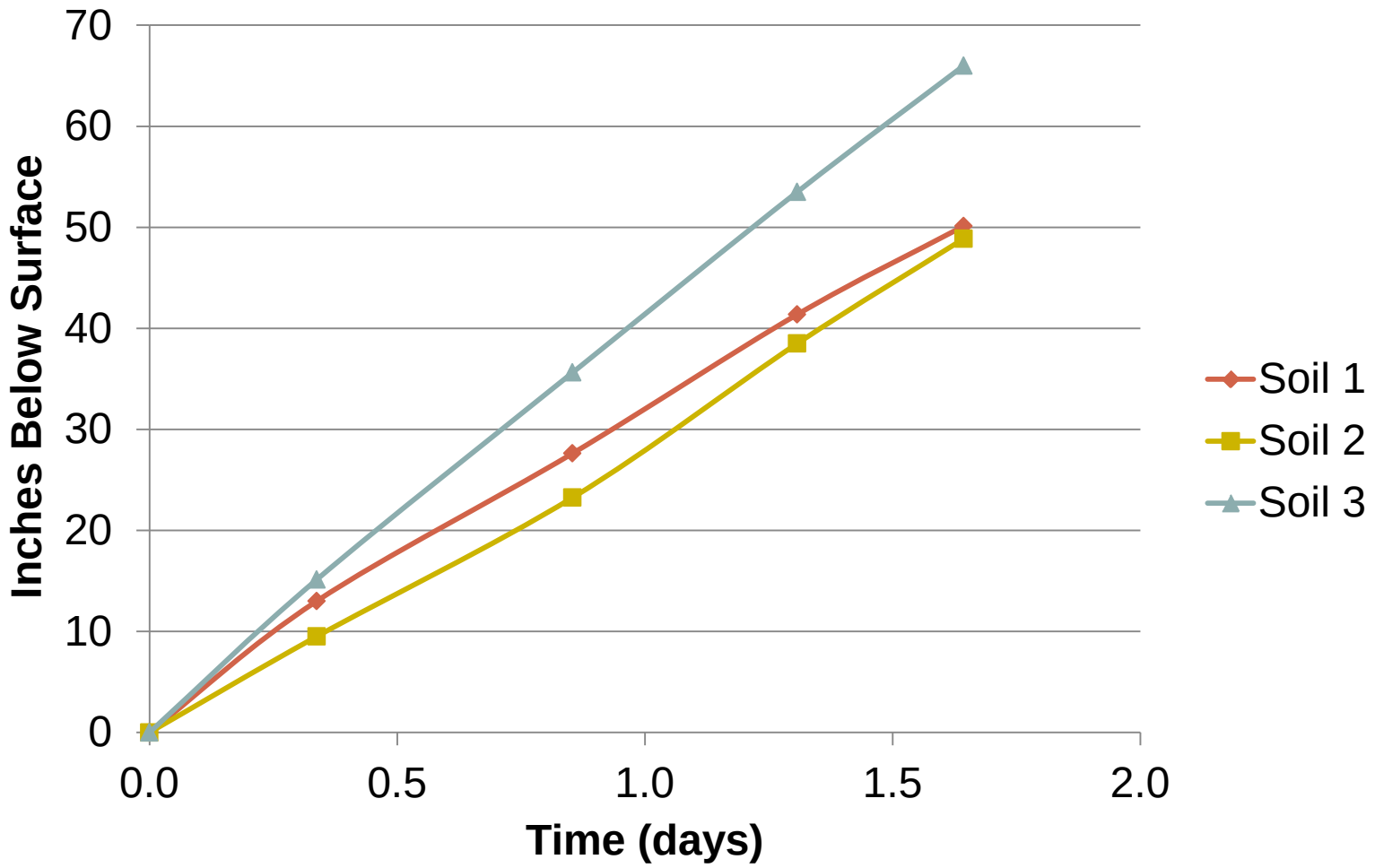
Sampling Soil at End of Test

Column Flushing

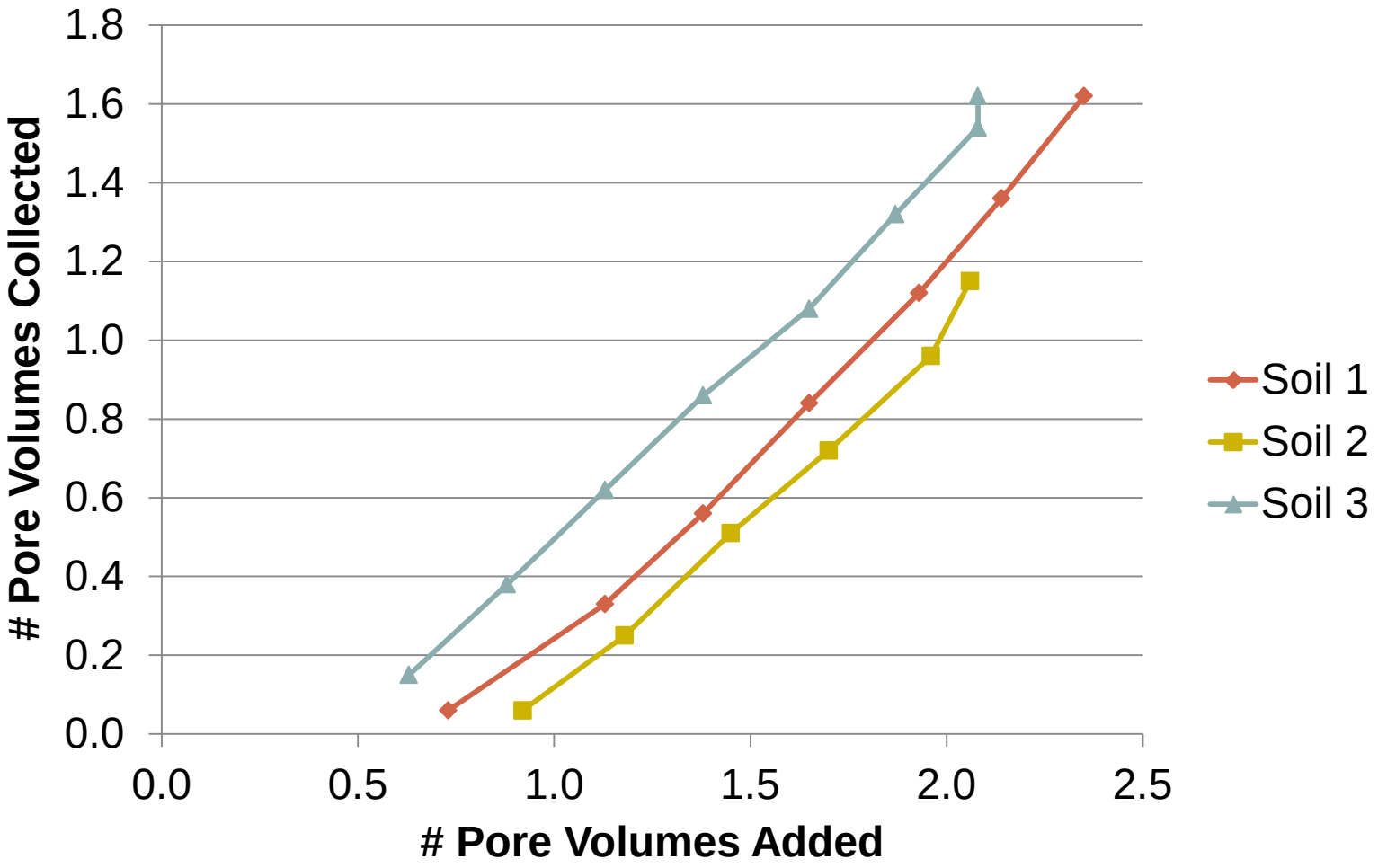
RESULTS



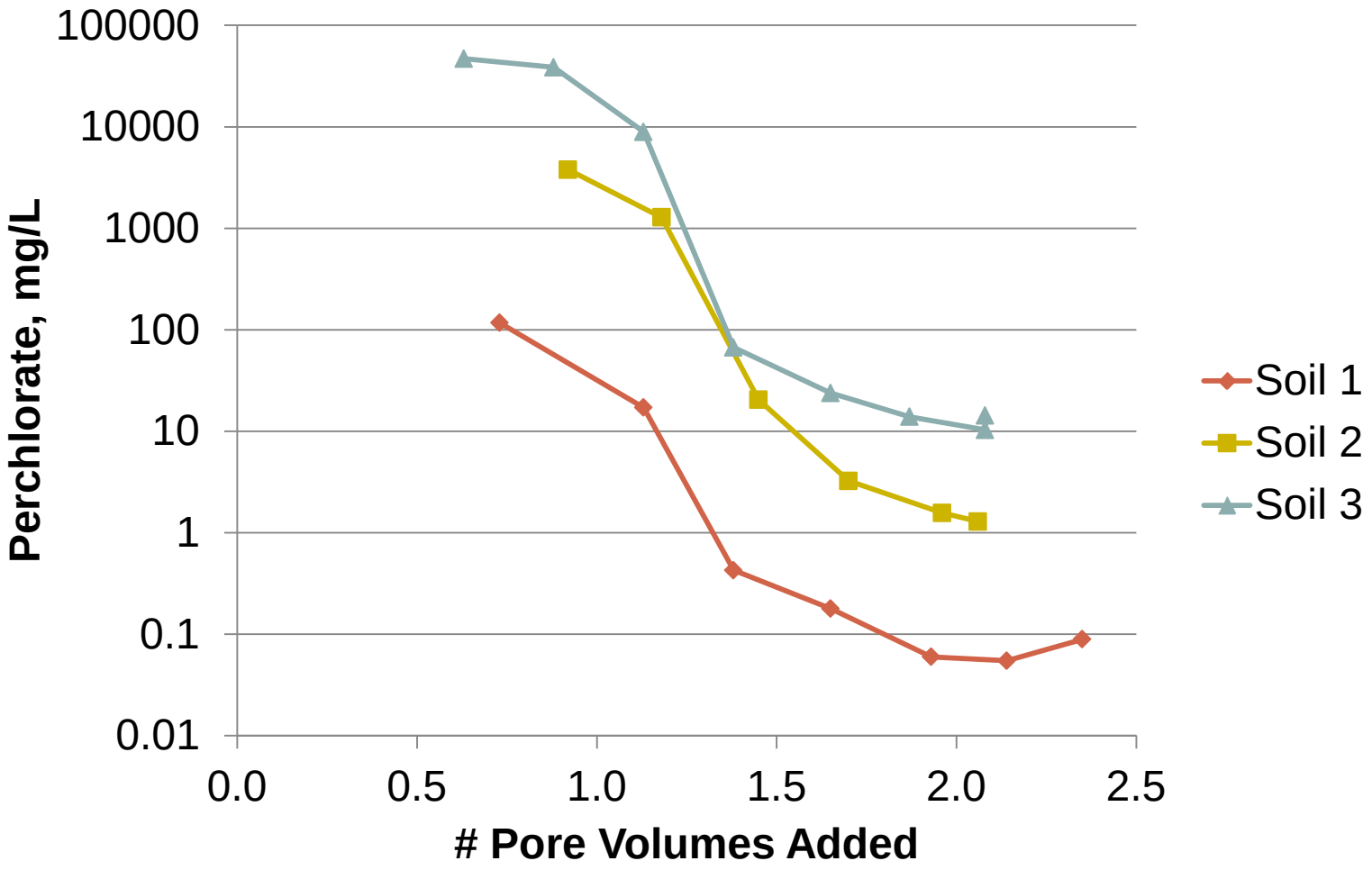
Wetting Front Progression



Pore Volumes Applied v. Collected



Perchlorate in Leachate



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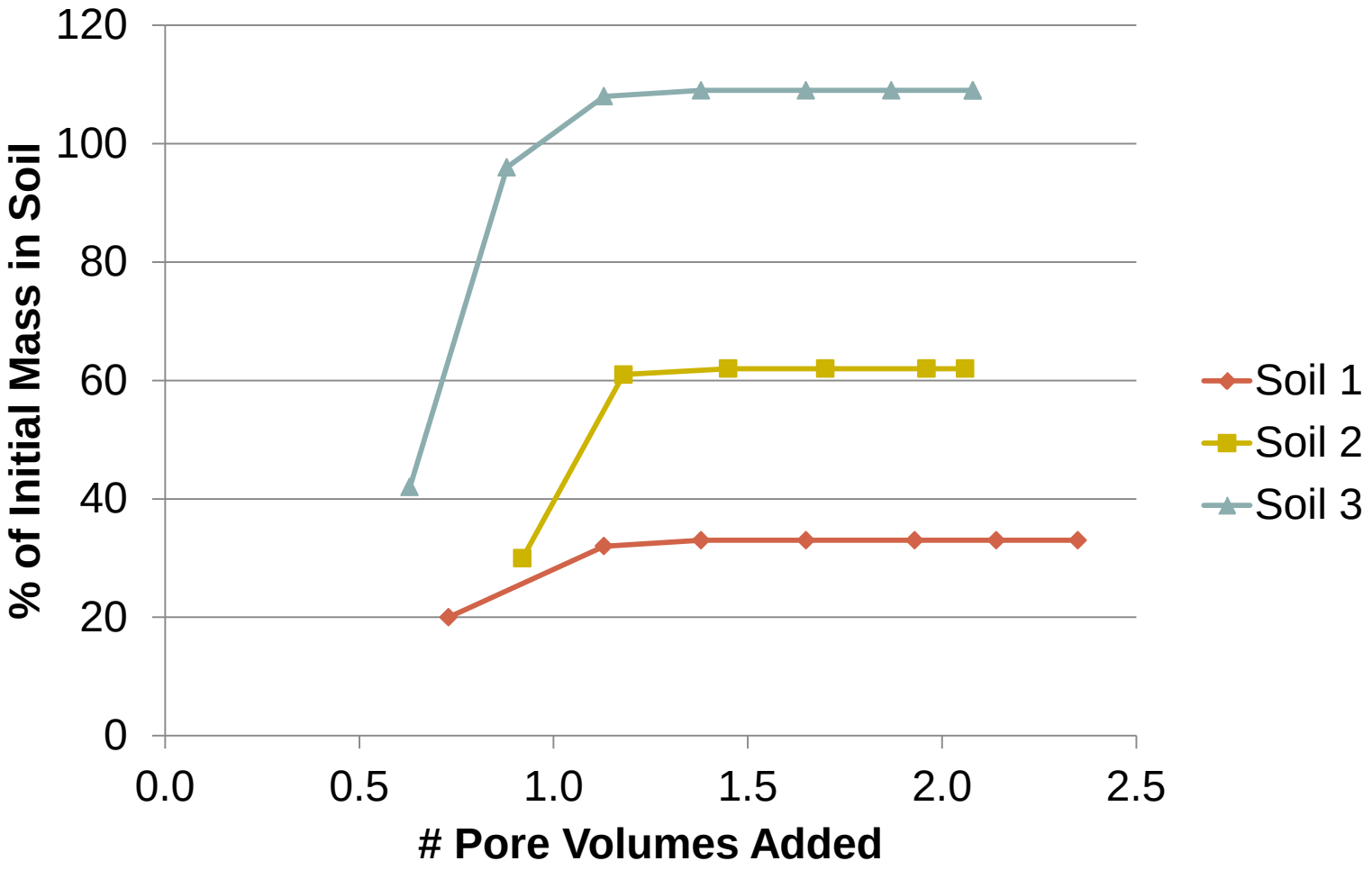
Perchlorate in Leachate



Perchlorate Balance

Perchlorate	Soil 1	Soil 2	Soil 3
Initial Mass in Column, g	0.38	8.88	193
Final Mass in Column, g	< 0.0013	0.00981	0.14
Mass Leached, g	0.126	5.5	208
% Removed from Soil	> 99.7	99.9	99.9
% Accounted for in Leachate	33	62	110

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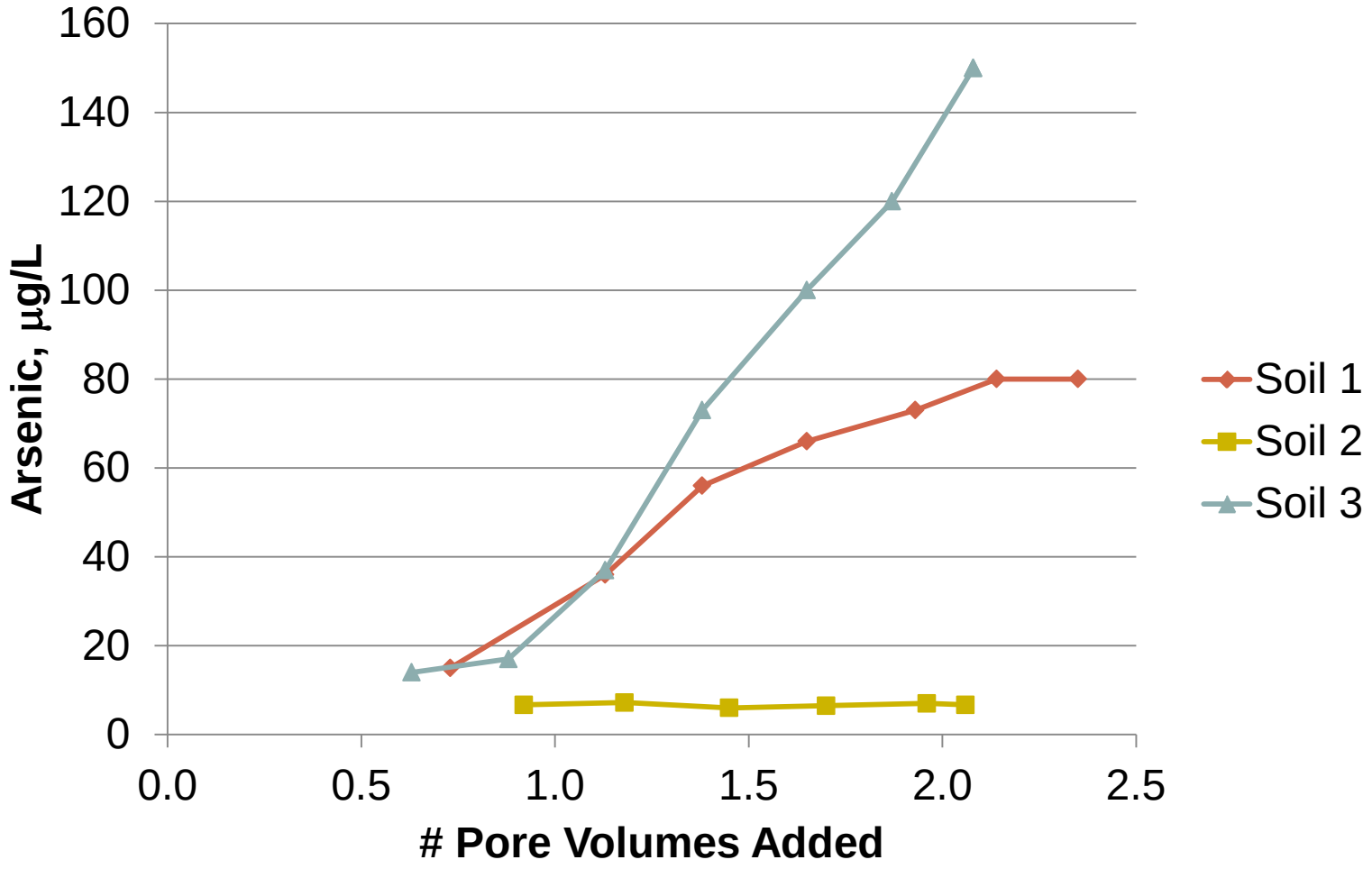
Arsenic in Leachate



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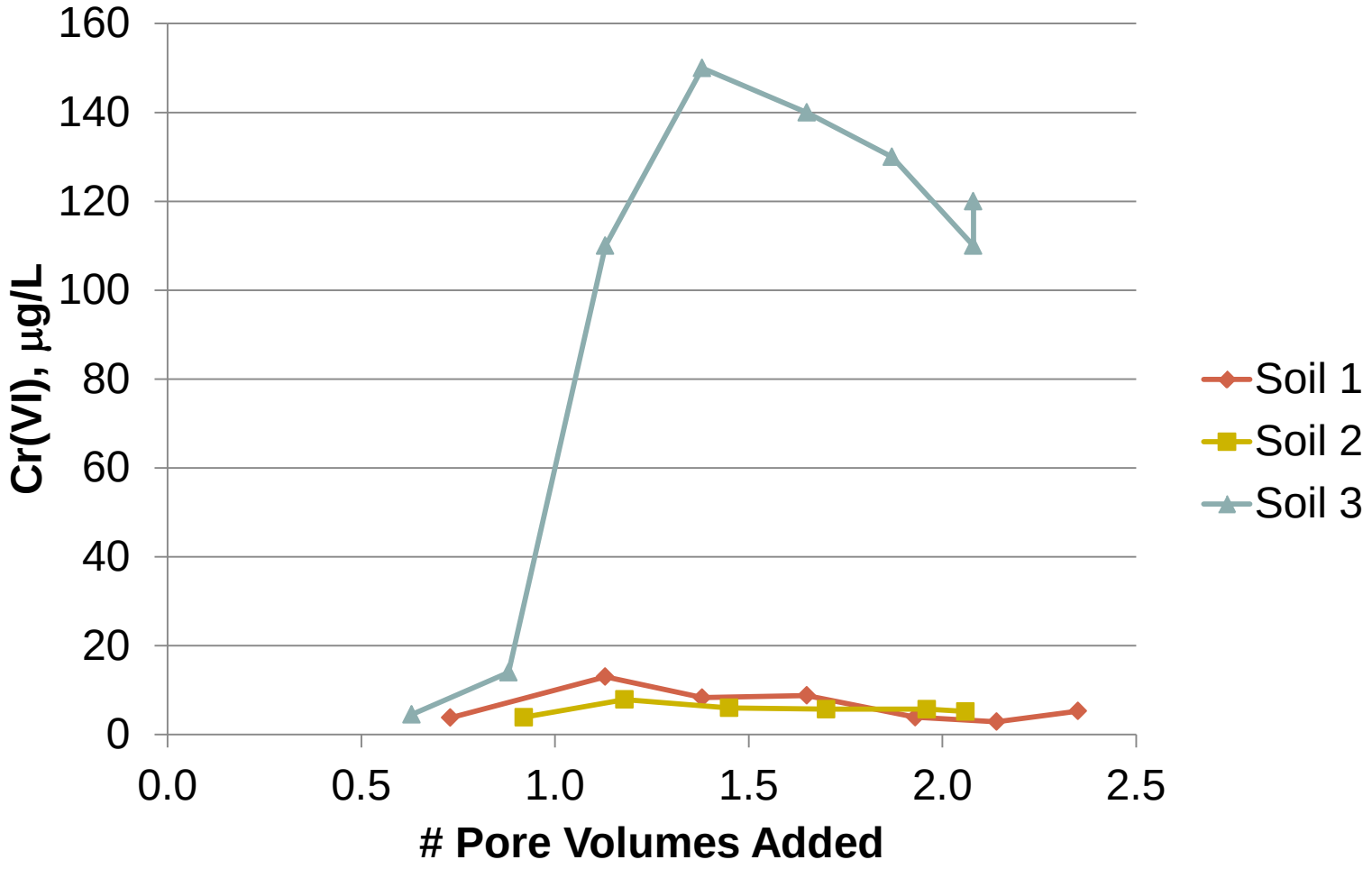
Cr(VI) in Leachate



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Summary & Conclusions

- Soil flushing effectively removed perchlorate
  - Application of 2 pore volumes removed > 99% of initial perchlorate
  - Most perchlorate leached was detected after application of 0.9-1.2 pore volumes
- Flushing also leached arsenic and Cr(VI)

Recommendations

- Full-scale application should be effective but
  - Must consider water availability
  - Must consider effect of high perchlorate, arsenic, Cr(VI) and other parameters on existing pump and treat system

Questions?

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