

Abrasion, weathering and mobility of lead in Florida shooting range soils

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Outline

- Physical abrasion of Pb bullets
- Field sampling of newly opened shooting range
- Weathering study involving abraded Pb
- Influence of soil properties and amendments on weathering of abraded Pb
- Desorption of Pb from intact soil cores taken from two Florida shooting ranges

Rationale

- Pb contaminations in soils of shooting ranges is under increasing scrutiny as source of Pb pollution
 - 80,000 tons/yr Pb used in production of bullets in US in 1990's
 - Deposition of Pb as ammunition reported in many countries
 - Soil contaminated with Pb shot could be labeled hazardous waste subject to RCRA
 - Pb is a known toxin

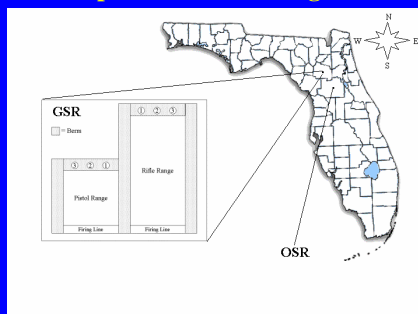


Pertinent to Florida

Sandy soils

- Low soil pH
- Low clay content
- Low organic matter content
- High amounts of rainfall
- Shallow groundwater

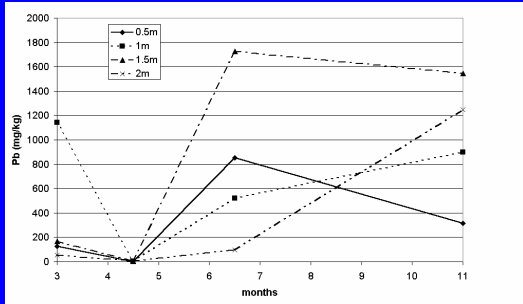
Location of the study sites in Gainesville (GSR) and Ocala (OSR), Florida, and schematic of GSR pistol and rifle range



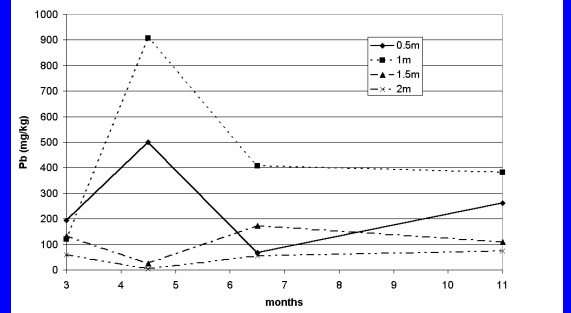
Total and SPLP Pb from field abrasion experiment

Sample	Total Pb (mg kg ⁻¹)	SPLP Pb (mg L ⁻¹)
Bucket 1	118 ± 32.7	71.7 ± 6.3
Bucket 2	126 ± 28.2	97.2 ± 4.6
Bucket 3	167 ± 30.3	109 ± 36.6
Bucket 4	14.9 ± 5.3	11.7 ± 0.6
Bucket 5	31.6 ± 5.3	15.9 ± 1.6

Changes in total Pb concentrations in a newly opened rifle range with time



Changes in total Pb concentrations in a newly opened pistol range with time



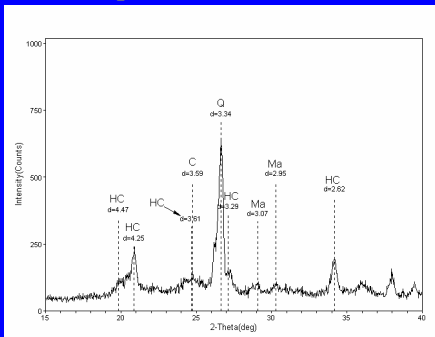
Summary 1

- **Field Abrasion Experiment**
 - Total mass of Pb abraded per 22-caliber bullet- 41.2 mg or 1.5% of bullet mass
 - All but one SPLP Pb conc. exceeded the USEPA 15 ug/L critical level of a hazardous waste
- **Field Sampling**
 - Total Pb concentration was high after only 3 months operation
 - Variability in total Pb concentration over time was possibly a result of hot spots

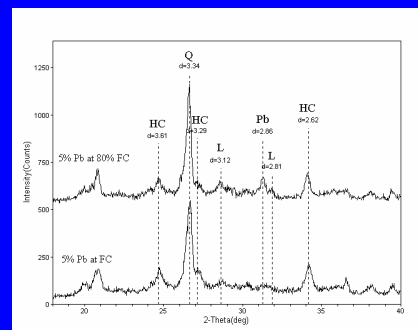
Weathering Study



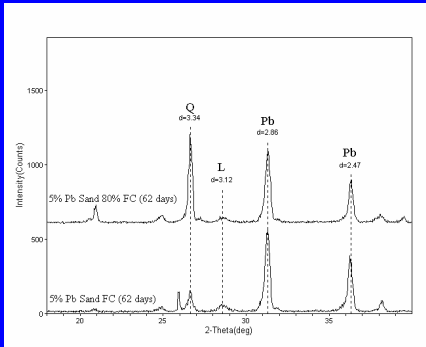
Pb powder after 7 days incubation in soil (pH-4.8, OM- 1.8%)



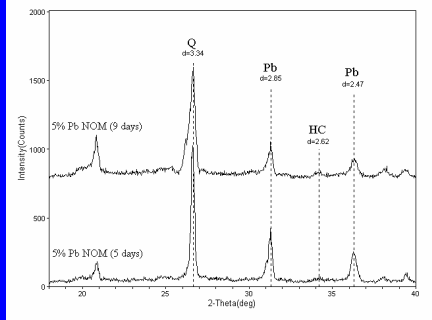
Pb powder after 5 days of incubation in soils at different moisture contents



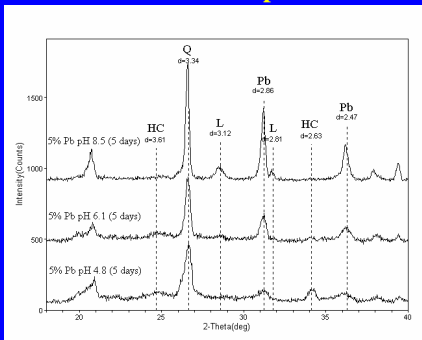
Pb powder after 62 days of incubation in sand



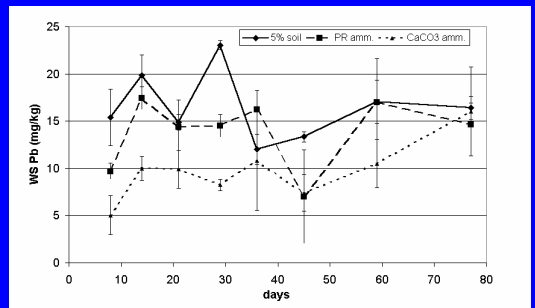
Pb powder after incubation in soil after organic matter had been removed (only 0.15%)



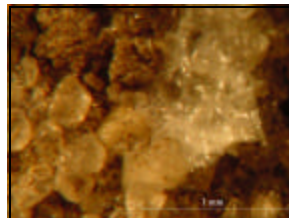
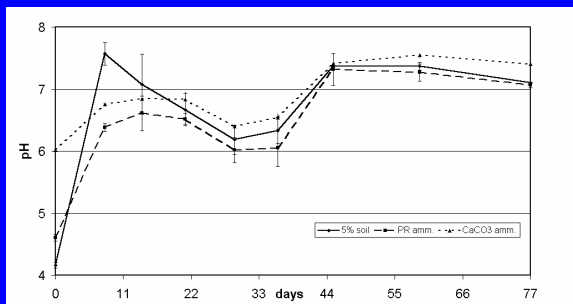
Pb powder after 5 days incubation in soils at different pH's



Water Soluble Pb as a function of time after incubation in soils at 80% field capacity with different treatments

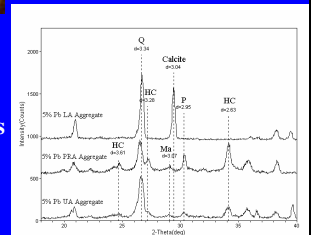


Soil pH as a function of time after incubation in soils at 80% field capacity with different treatments



Aggregate removed from soils after 11 weeks at 2x magnification

XRD patterns of aggregates



Summary 2

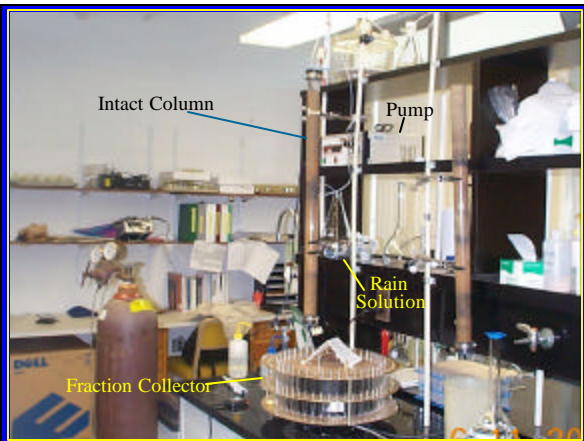
- Transformation of Pb powder occurs rapidly in soil
- Soil properties influence weathering rate
 - Moisture level - weathering rate -
 - SOM - weathering rate -
 - Soil pH - weathering rate -
- Soil amendments influence weathering products
 - Pyromorphite formed in PR treatment.

Location of the study sites in Sunrise (MSR) and Ocala (OSR), Florida where intact cores were taken



Site Soil Profile Characteristics

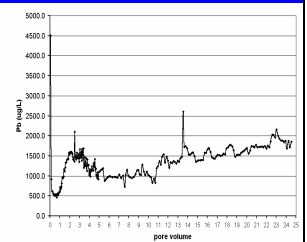
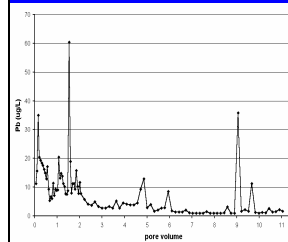
	Depth (cm)	pH	DOC (mg/L)	HA (mg/kg)	FA (mg/kg)	CEC (cmol (+)/kg)	Total Pb (mg/L)
OSR	0-10	6.74	12.8	-	-	7.30	2357
	10-30	5.88	9.23	-	-	5.30	83
	30-50	5.02	7.23	-	-	4.80	13
	50-100	4.80	6.00	-	-	4.70	9
MSR	0-10	6.73	26.7	418	810	26.6	2715
	10-30	7.47	9.66	6.6	160	12.6	276
	30-50	7.56	12.3	803	642	46.8	522
	50-100	7.69	8.93	666	605	52.0	262



Total Pb as a function of pore volume

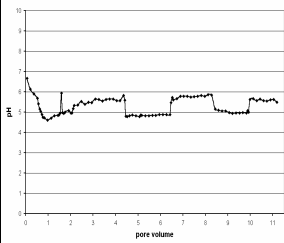
OSR

MSR

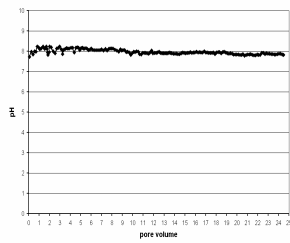


pH as a function of pore volume

OSR

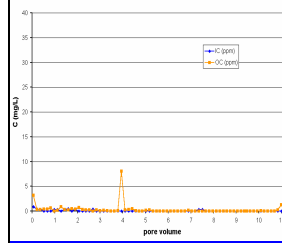


MSR

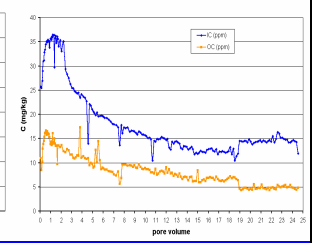


TOC & IC as a function of pore volume

OSR



MSR



Summary 3

- **There was significant desorption of Pb from MSR intact soil column**
 - This poses a concern for potential contamination of groundwater
- **Less desorption from OSR intact soil column, but several samples still exceeded EPA 15 ug/L drinking water limit**
- **Soil properties influence mobility of Pb**
 - IC and TOC appeared to be related to Pb mobility

Conclusions

- **Pb contamination occurs rapidly in soils of new shooting ranges**
- **SOM plays the most significant role in the weathering and mobility of Pb**
 - This is most likely due to an increase in microbial activity resulting in an increase in CO₂ concentration
- **In addition, pH and soil moisture content also influence the weathering of Pb**
- **It is important to develop best management practices to minimize the adverse impacts of Pb in all shooting ranges regardless of age**

Acknowledgements

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