

Welcome

Environmental Impacts of Lead Pellets at Shooting Ranges in Florida

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Acknowledgment






- Principle investigators
 - Lena Ma - Biogeochemistry of Trace Metals
 - Willie Harris- Soil Mineralogy
 - Jerry Sartain- Turf grass
- Research team
 - Dr. Ming Chen - Post-doctoral Scientist
 - Dr. Rocky Cao- Post-doctoral Scientist
 - Mr. Donald Hardison- M.S. student

Presentation Outline

- ◆ Background Information
- ◆ Research Objectives
- ◆ Progress To Date (last TAG meeting)
 - Total Pb and As concentrations
 - Pb concentrations in TCLP & SPLP tests
 - Weathering and mineralogical study
 - Publications and presentations

Background information

- ◆ Lead is a heavy metal of great environmental concern-1 in 11 US children suffers from lead poisoning
- ◆ EPA regulation
 - Soil Screening Level = 400 ppm
 - TCLP Pb = 5 mg/L
 - SPLP Pb = 15 µg/L
- ◆ FDEP Soil Cleanup Target Level
 - Residential soil = 400 ppm
 - Industrial soil = 920 ppm

Background information

- ◆ Arsenic is a known human carcinogen
- ◆ EPA regulation
 - Soil Screening Level = 0.4 ppm
 - TCLP As = 5 mg/L
 - SPLP As = 50 µg/L
- ◆ FDEP Soil Cleanup Target Level
 - Residential soil = 0.8 ppm
 - Industrial soil = 3.7 ppm

Background information

- ◆ Lead at shooting ranges
 - Annual lead deposition > 6,000 tons in the US
 - Lead concentrations > 5,000 ppm in soils
 - It is costly to clean up closed ranges
 - More ranges are opening on a daily basis

Florida environment

- ◆ Easily elevated due to low soil background Pb concentrations
 - Range = 0.18 -290 ppm
 - Geometric mean = 5.4 ppm
- ◆ Enhance chemical reactions
 - High temperature and humidity
 - Acid soil pH
- ◆ Favour chemical leaching
 - High rainfall
 - Sandy soil
 - Shallow groundwater
- ◆ Florida has a higher risk for Pb contamination in soil and groundwater

Research Objectives

- Lead concentrations in soil, plant and water
- Effects of soil properties on Pb retention capacity and bioavailability
- Impacts of weathering on Pb leachability and bioavailability in soil

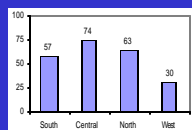
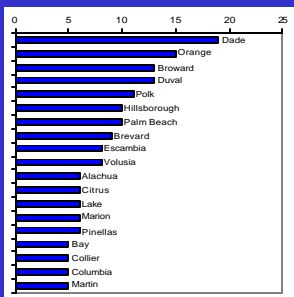
Progress to date

- ◆ Preliminary survey
 - Skeet shooting ranges were not included
- ◆ Metal concentrations
 - Shooting range: sampled 5 sites
 - Sample collection: 350 soil- and 20 water-samples from 5 sites
 - Total Pb and As for all samples
 - TCLP/SPLP test for selected soils
- ◆ Mineralogical study

Survey of Florida Shooting Ranges

- ◆ A database of 224 shooting ranges
 - Sent out survey forms to 79 skeet shooting ranges
 - Get 6 responses
 - No data analysis is done
- ◆ Geographical distribution
 - 46 of 67 counties
 - Dade County ranks No. 1 of all Florida counties

Distribution of Florida shooting ranges

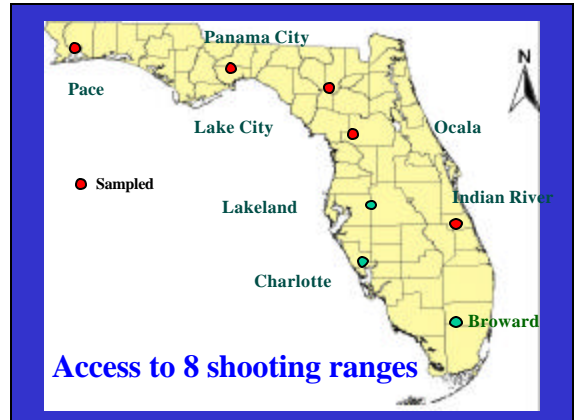


Typical Florida shooting ranges



Sample Collection

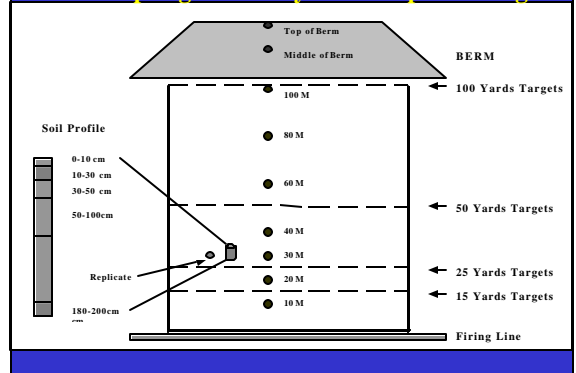
- ◆ Soil samples
 - Within ranges (0-10 cm)
 - From berm (top, middle, bottom)
 - Soil profiles (0-10, 10-30, 30-50, 50-100, >120 cm)
 - Background soils
- ◆ Surface water samples
 - From pond/puddle
- ◆ Method
 - Transect line
 - Grid method



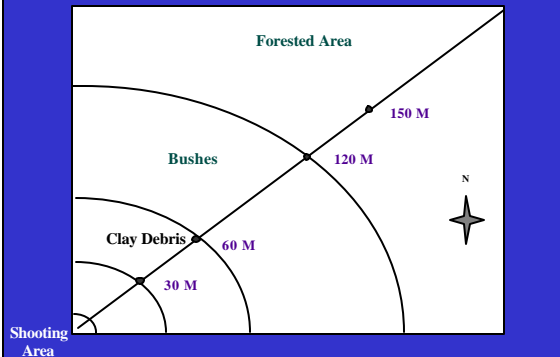
Sample collection at a 100-Yard Range



Soil sampling in a 100-yard rifle/pistol range



Soil sampling in a shotgun range



Sample Digestion and Analysis

- ◆ Sample preparation
 - Berm soil passed through 5 mm sieve to separate lead pellets and then 2 mm sieve
 - Other soil passed through 2 mm sieve
- ◆ Sample digestion
 - EPA Method 3051a using a microwave
 - Total recoverable Pb and As
- ◆ Sample analysis
 - Graphite furnace AA

Total Pb and As (ppm) in soils of a 50-yard pistol range

Distance (m)	Total Pb	Total As
1	143	2.14
16	749	1.21
36	172	0.02
41	1088	0.69
46	847	0.19
Berm	38,984	22.3

Concentrations of Pb and As (ppm) and pH in surface soil of 100-yard rifle/pistol range

Distance (m)	Total Pb	Total As	Soil pH
10	1,301	1.37	6.7
30	4,448	3.69	6.1
60	1,793	1.84	5.6
80	875	2.90	5.4
100	1,753	1.71	5.5
Top of berm	18,138	3.57	6.8
Middle of berm	17,850	6.12	7.7

Total Pb and As (ppm) in soils of a 200-yard rifle/pistol range

Distance (m)	Total Pb	Total As
3	715	2.82
43	336	2.75
83	754	1.58
103	147	0.23
143	366	1.02
183	16,903	1.64
Berm (Mean of 3)	18,322	33.8

Lead concentrations in berms of different ranges (ppm)

50-P		100-R		200-R
10-y	30-y	10-y	15-y	30-y
9,474	38,984	12,138	13,994	18,322

Concentrations of Pb & As (ppm) and pH in a soil profile of a 100-yard rifle/pistol range

Depth (cm)	Total Pb	Total As	pH
0-10	2,387	2.03	6.7
10-30	83.0	1.10	5.9
30-50	13.2	0.86	5.0
50-100	9.0	0.80	4.8
180-200	9.8	0.54	5.1

Concentration of Pb and As (ppm) and pH in surface soil of a shotgun range

Distance (m)	Clay (%)	Total Pb	Total As	pH
30	30	15,368	107.0	7.8
60	5	438	0.76	6.0
120	0	386	0.50	4.9
150	0	330	1.36	4.8
Clay	100	27	1.86	10.4

Pb and As levels (ppb) in water samples in a rifle/pistol range

Location	Total Pb	Total As
Pond water	11	3.3
Surface, near LCR berm	694	3.4
Surface, near LCP berm	76	7.5
Surface, near LCR firing line	19	1.2
Surface, near LCP firing line	121	2.1
Drainage, LCP range	83	3.2

Total Pb and As in Florida ranges

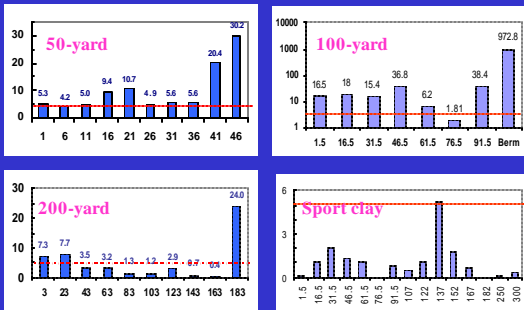
- ◆ Surface soils in shooting ranges contained elevated Pb (>400 ppm)
- ◆ Highest Pb levels were observed in surface soil (up to 1.7%) & in berms (1.0-3.9%)
- ◆ Elevated Pb was observed in surface water (11-694 ppb)
- ◆ Elevated As was observed in berms of some ranges (> 20 ppm)
- ◆ Elevated pH was associated with high Pb and As concentrations

LEACHING TEST TCLP and SPLP

TCLP/SPLP Tests

- ◆ Toxicity Characteristic Leaching Procedure (TCLP)
 - Hazardous waste determination under conditions of municipal landfills under RCRA
 - TCLP regulatory limit for Pb = 5 mg/L
- ◆ Synthetic Precipitation Leaching Procedure (SPLP)
 - Metal leachability under simulated rainfall
 - SPLP suggested limit for Pb = 15 ug/L

TCLP Pb (ppm) in surface shooting range soil



TCLP- & SPLP- Pb in Berm Soils of Shooting Ranges (ppm)

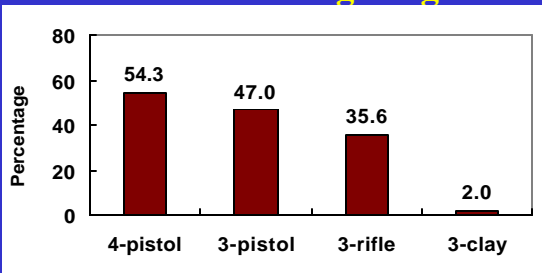
50-P-30y	1,568	13.4
50-P-10y	1,408	1.0
200-R-30y	544	6.1
100-R-6y	240	1.6

TCLP and SPLP Pb in ranges

- ◆ Surface soils in shooting ranges contained elevated TCLP Pb (>5 ppm)
- ◆ Highest TCLP Pb was observed in berm soil (240-1,568 ppm)
- ◆ Highest SPLP Pb was observed in berm soil (1.0-13.4 ppm)

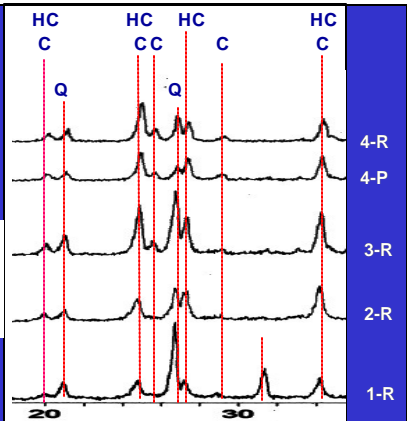
MINERALOGICAL STUDY OF THE WEATHERING PRODUCTS OF LEAD BULLETS

Pellet contents in berm soils of different shooting ranges

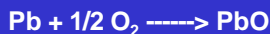


X-ray diffraction patterns of bullet weathering products

Q= Quartz
C= Cerussite (PbCO₃)
HC = Hydrocerussite
[Pb₃(CO₃)₂(OH)₂]



Possible Lead Reaction in Soils



Publications summary (6 up to date)

- Donald W. Hardison Jr., Lena Q. Ma*, Thomas Luongo, Willie G. Harris. 2002. Physical Contamination in Shooting Range Soils from Abrasion of Lead Bullets and subsequent weathering. *Sci. Total Environ.* In review.
- Cao, R.X., L.Q. Ma, M. Chen, D. Hardison, and W. Harris. 2002. Lead transformation and distribution in Florida shooting range soils. *Environ. Pollution.* In review.
- Cao, R.X., L.Q. Ma, M. Chen, S.P. Singh, and W.G. Harris. 2002. Impacts of phosphate amendments on lead biogeochemistry in a contaminated site. *Environ. Sci. Technol.* In press.
- Cao, R.X., L.Q. Ma, M. Chen, D. Hardison, and W.G. Harris. 2002. Chemical behavior and environmental impact of lead in shooting ranges of Florida. *J. Environ. Qual.* In press.
- Chen, M., L.Q. Ma, W.G. Harris, and X. Cao. 2002. Characterization of Pb in soils of a rifle/pistol shooting range in Central Florida. *Soil Sediment Contamination.* 11:1-17.
- Chen, M., L. Q. Ma, and Willie G. Harris .2001. Distribution of Pb and As in soil at a shooting range in Central Florida. *Soil Crop Sci. Soc. Florida Proc.* 60:15-20.

Presentation summary (12 up to date)

- Chen, M., L.Q.Ma, and W.G. Harris. 2002. Distribution of lead contamination in soils of Florida shooting ranges. *18th Annual Int. Conf. on Contaminated Soils, Sediments and Water*. Amherst, MA.
- Hardison, D., L.Q. Ma and W. Harris. 2002. Physical removal of Pb passing through berm soils and subsequent weathering of this abraded Pb in Florida soils. *SSSA 94th Annual meeting*. Indianapolis, IN.
- Hardison, D., L.Q. Ma and R.X. Cao. 2002. The relationship between the mobility of Pb and the mobility of Humic and Fulvic Acid in the soil profile of a Florida shooting range. *SSSA 94th Annual meeting*.
- Harris, W.G., L.Q.Ma, S. Singh, M. Chen, R.X. Cao, and D. Hardison. 2002. Lead carbonate formation in contaminated soils: chemical effects and remediation dilemmas *SSSA 94th Annual meeting*. Indianapolis, IN.
- Cao, R.X., L.Q.Ma, D. Hardison, and W.G. Harris. 2002. Weathering of lead bullets and their environmental impacts at outdoor shooting ranges in Florida. *SSSA 94th Annual meeting*. Indianapolis, IN.
- Chen, M., L.Q.Ma, and J. Sartain. 2002. Survey of arsenical herbicides use in Florida golf courses. *Soil and Crop Science Society of Florida Annual Meeting*. Clearwater Beach, FL.
- Hardison, D, R.X. Cao and L.Q.Ma. 2002. Abrasion and transformation of lead bullets in Florida shooting range soils. *3rd Research Forum of Soil and Water Science Department*. Gainesville, FL.
- Ming C., L.Q.Ma, and W.G. Harris. 2001. Determination and assessment of soil lead contamination in Florida outdoor shooting ranges. *The 8th Int. Conf. on Biogeochemistry of Trace Elements*. Guelph, Canada.
- Hardison, D, X. Cao and L.Q.Ma. 2001. Lead chemistry in shooting range soils. *2nd Graduate Research Symposium of Soil and Water Science Dept*. Gainesville, FL.
- Ming C., L.Q.Ma and W.G. Harris. 2001. Determination and assessment of soil lead contamination in Florida outdoor shooting ranges. *2nd Graduate Research Symposium of Soil and Water Science Department*. Gainesville, FL.
- Chen, M., L.Q.Ma, and W.G. Harris. 2000. Lead contamination in soils of Florida shooting ranges. *SSSA 92nd Annual meeting*. Minneapolis, MN.
- Chen, M., L.Q.Ma, and W.G. Harris. 2000. Distribution of Pb and As concentrations in soils of a shooting facility in Ocala National Forestry. *60th Annual Meeting of Soil and Crop Science Society of Florida Annual Meeting*. Tallahassee, FL.

Questions

THANK YOU

For more information, please visit <http://lqma.ifas.ufl.edu>