Growing Healthy Soil for Healthy Communities

A Community, Academic and Public Health Partnership to Build Soil Testing Capacity

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BACKGROUND

Bioavailability is defined as the portion of contaminants that are readily accessible to biota through physical contact or by ingestion. Understanding bioavailable fraction of lead (and any other toxic metal) rather than the total lead level, helps determining potential toxicity of soil upon exposure or intake through vegetables. Different extraction procedures (single or sequential) are used to extract "the bioavailable" metal fraction from soil, sediment, or suspended particulate matter (SPM). Those are:

- Extraction with 0.01M calcium chloride
- Extraction with 1M ammonium nitrate
- Extraction with 0.05M EDTA
- Extraction with weak acids (such as acetic acid)

Mehlich 3 extraction[1,2] is useful because it provides a good estimation of total lead (Pb) while being less expensive than a total Pb test, but also provides useful information about soil nutrients that can be used for gardening.

STUDY OBJECTIVES

- To utilize and validate the accuracy of Mehlich 3 method as a weak acid extraction to extract the fraction of lead, potassium, and phosphorus from urban backyard soil samples that "might be" available for plants' uptake
- To validate the ascorbic acid colorimetric method for the analysis of phosphorus concentration in soil following Mehlich 3 extraction
- To develop and validate analytical methods based on Flame Atomic Absorption Spectroscopy (FAAS) for the analysis of lead and potassium in urban backyard soil samples
- To validate the accuracy of the Loss on Ignition method (LOI) for the determination of organic matter in soil using certified reference material (CRM)

METHODS

1. **Sample Pre-treatment and measurements: Figure 1**
2. **Mehlich 3 Extraction:** Certified Reference Material was used to validate the accuracy of Mehlich 3 Extraction in house
3. **Phosphorus Analysis:** Ascorbic Acid Method (UV-VIS Colorimetry)[3-5]
4. **Lead and Potassium Analysis:** FAAS (iCE 3000, Thermo Scientific).
5. **Organic Carbon Analysis:** Loss on Ignition (LOI) method using a muffle furnace.

RESULTS

Figure 1. Flow Chart Illustrating Sample Handling & Treatment

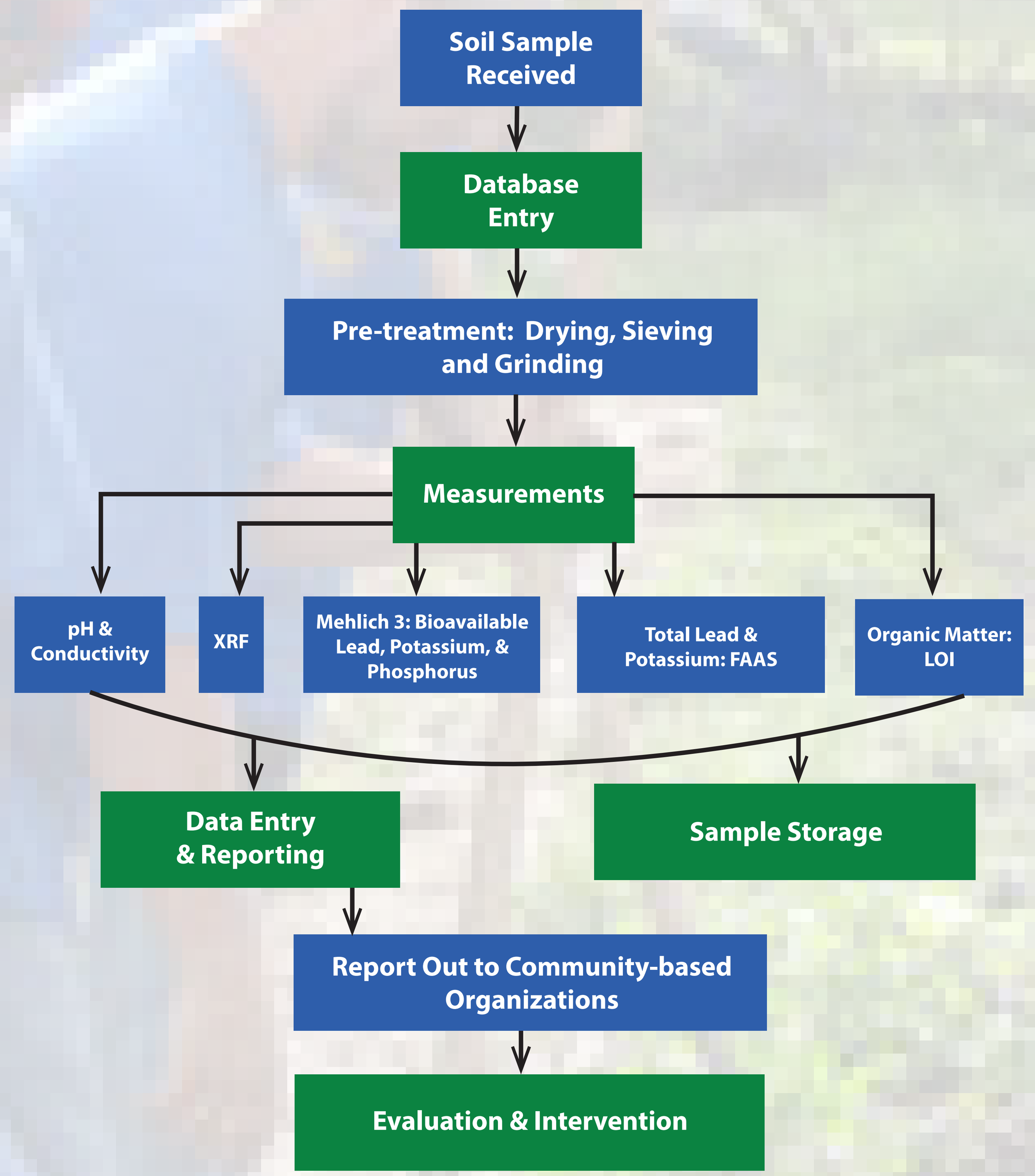

Table 1. Phosphorus QC Results Following Mehlich3 Extraction of Certified Reference Material (CRM)

R#	Wt (g)*	Volume Extracted (mL)	Target Conc. of P (mg P/L)	Df**	UV-Vis Spec Conc. of P (mg P/L)	Corrected Conc. of P (mg P/L)	% R
R1	2.0035	20	0.838	4	0.215	0.859	102
R2	2.0092	20	0.841	4	0.196	0.782	93

* Agro MAT Clay Soil AG-1-2 (SCP Science CRM)
** Dilution factor

Table 2. Potassium Results of Agro Mat Soil CRM Following Mehlich3 Extraction

R#	Wt (g)*	V-Extracted (mL)	Target Conc. of K (mg K/L)	Df**	FAAS Conc. of K (mg K/L)	Corrected Conc. of K (mg K/L)	% R
R1	2.0035	20	38.77	10	3.727	37.27	96
R2	2.0092	20	38.88	10	3.752	37.52	97

* Agro MAT Clay Soil AG-1-2 (SCP Science CRM)
** Dilution factor

Table 3. Potassium Results of NIST SRM Soil Following Nitric and Hydrofluoric Acids Digestion

NIST ID-R#	wt (g)	Volume (mL)	Target Conc. (mg K/L)	Df*	FAAS Conc. (mg K/L)	Corrected Conc. (mg K/L)	% R
2587-R1	0.50852	50	161.00	25	4.818	120.45	75
2587-R2	0.50354	50	159.42	25	4.732	118.30	74
2586-R1	0.50772	50	99.11	25	2.302	57.55	58
2586-R2	0.5021	50	98.01	25	2.362	59.05	60
2710-R1	0.49976	50	210.90	50	3.572	178.60	85
2710-R2	0.5088	50	214.71	50	3.538	176.90	82
2711-R1	0.48392	50	237.12	50	4.112	205.60	87
2711-R2	0.51523	50	252.46	50	4.569	228.45	90

* Dilution factor
Samples were digested (3 hrs @ 105°C with 9 mL HNO3 + 3 mL HF)

Table 4. Lead Results of NIST SRM Soil Following Nitric and Hydrofluoric Acids Digestion

NIST ID-R#	wt (g)	Volume (mL)	Target Conc. (mg Pb/L)	Df*	AA Conc. (mg Pb/L)	Corrected Conc. (mg Pb/L)	% R
2587-R1	0.50852	50	32.97	10	3.072	30.72	93
2587-R2	0.50354	50	32.65	10	3.241	32.41	99
2586-R1	0.50772	50	4.39	1	3.735	3.735	85
2586-R2	0.5021	50	4.34	1	3.892	3.892	90
2710-R1	0.49976	50	55.29	10	5.684	56.84	103
2710-R2	0.5088	50	56.29	10	5.862	58.62	104
2711-R1	0.48392	50	11.25	1	9.802	9.802	87
2711-R2	0.51523	50	11.97	1	10.872	10.872	91

* Dilution factor
Samples were digested (3 hrs @ 105°C with 9 mL HNO3 + 3 mL HF)

Table 5. Results of Organic Matter Analysis on Agro Mat Soil CRM Following Loss on Ignition Method

Replicate # Agro Mat Soil*	% Organic Matter**	Certified % Organic Matter	% Accuracy
1	3.55	3.74	95
2	3.75	3.74	100

* Agro MAT Clay Soil AG-1-2 (SCP Science CRM)
** Based on Loss On Ignition (LOI) for 4.5 hrs @ 450°C

CONCLUSIONS

- Mehlich 3 extraction has been validated in-house against Certified Reference Material (CRM)
- Analytical methods for the analysis of lead and potassium were developed and validated.
- Results of QC/QA analysis were within acceptable range (80-120%).
- LOI method for the analysis of organic matter was tested and validated.

FUTURE DIRECTION

1. Availability of bioavailable lead in soil and nutrient analysis for the community
2. Interpret soil testing results to the community-based organization enrolled in this grant study
3. Provide education, and assist in policy development towards risk and benefits towards home and urban gardening practices
4. Introduce Geographical Information System (GIS) mapping to identifying plots and use as indication of soils that may have a high soil lead content and may pose a risk for elevated blood lead levels (BLLs)
5. Implementation of GIS could be useful to track vacant lots that likely have high soil lead and minimal nutrient content, and thus need soil intervention before beginning an urban garden

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