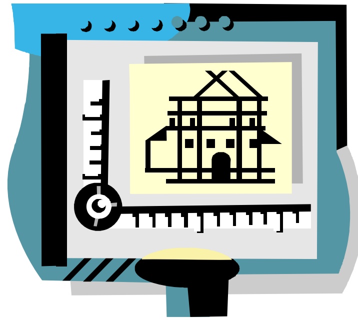
Department of Biological Environment

Polyacrylamide (PAM) for Runoff and Erosion Control: Case Studies

Sang Soo Lee, Yasser Awad, and Yong Sik Ok

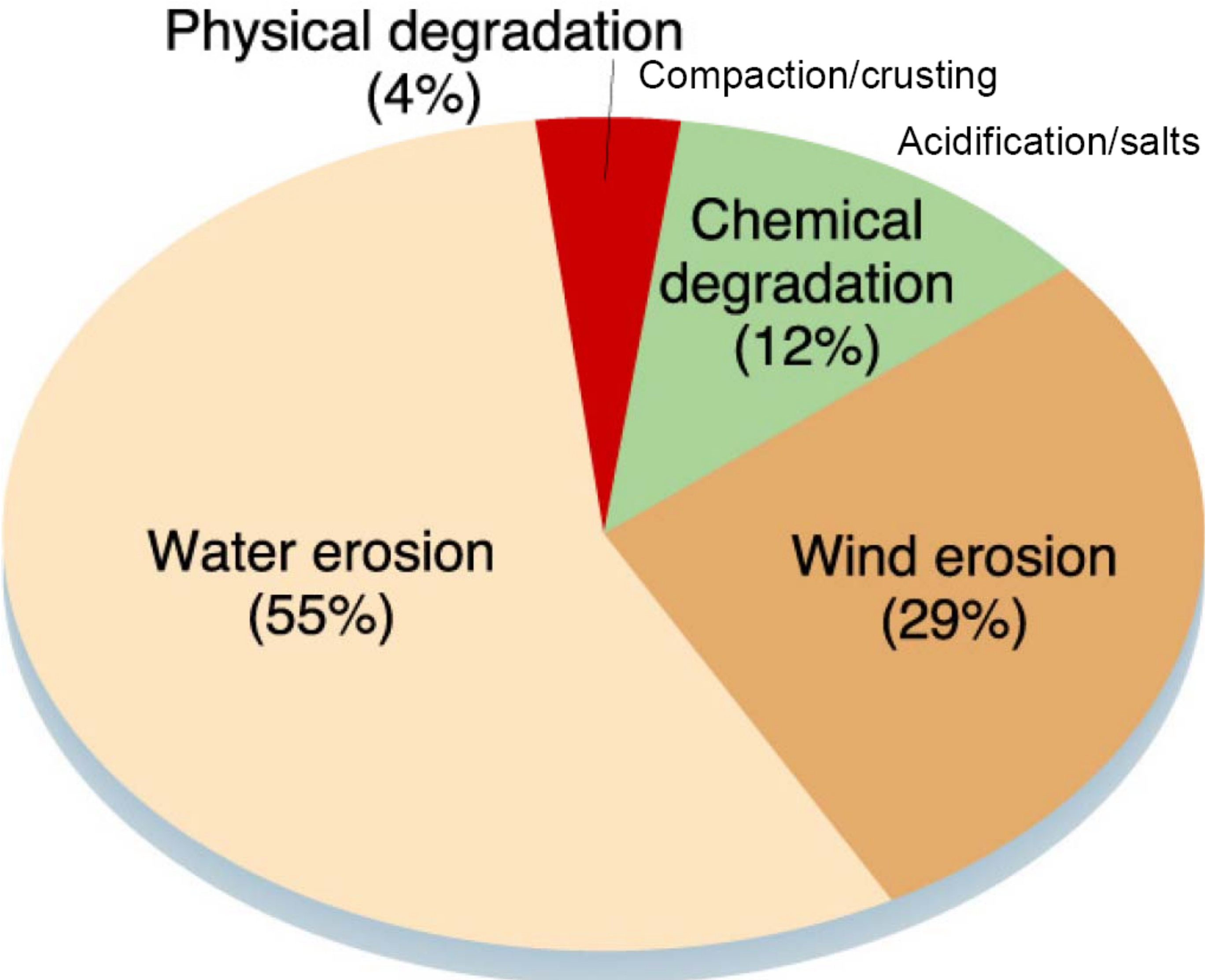
Kangwon National University, Korea

Outline



- Introduction
- Study I: PAM using CT
- Study II: PAM + Gypsum
- Study III: PAM + Slopes

Soil Erosion



Soil Erosion

Is Soil Erosion a Problem?

- On bare soils erosion may be >200 t/ac/y.

(Troeh et al., 2004; Pearson)

- Soil erosion pollution:

  1) The greatest single water pollutant.

  2) Erosion causes ~ $16 billion/y in environmental damage in the US.

(Mid-America Regional Council, 2008)

Erosion Control

How can we control this?

- Typical Erosion rates in the US:

  Cropland (5 t/ha/yr)

  vs. Uncovered land (20~>200 t/ha/yr)

- Vegetation is not an option for avoiding soil erosion by rainfall.

Erosion Control

<u>Silt fence</u> - a temporary barrier made of fabric supported by posts.

<u>Straw bales</u> - a barrier placed on contour to intercept concentrated flows. Straw bales help slow runoff, allowing sediment to settle.

Erosion Control

Drainage blocks

Anionic Polyacrylamide (PAM)?

- We propose an emerging way to control soil erosion using an anionic Polyacrylamide Monomer (PAM).
- A synthetic, high molecular weight (12-15 Mg/mole) organic anionic polymer.

Why is PAM of Interest?

Research results show that PAM is:

- An effective erosion control method for irrigated agriculture.
- Can sustain high infiltration rates.
- Can reduce soil surface sealing.

PAM's History

- In 1948, research was started to find a synthetic soil conditioner.
- In 1951, Krilium was manufactured.
- It was too costly for widespread agricultural use.

Two Sizes

1-lb. canister with handy shaker top. Convenient for indoor use – potted plants, window boxes.

5-lb. canister. Convenient for indoor and outdoor use – lawns, gardens, shrubs, borders.

Buy Krilium with confidence!

Buy Krilium at your local dealer's–use it with the confidence merited by the only time-tested and proved soil conditioner on the market today. MONSANTO CHEMICAL COMPANY, Merchandising Division, St. Louis 4, Missouri.

MONSANTO

*MONSANTO TRADE-MARK COPYRIGHT 1952, M.C.C.

SERVING INDUSTRY...WHICH SERVES MANKIND

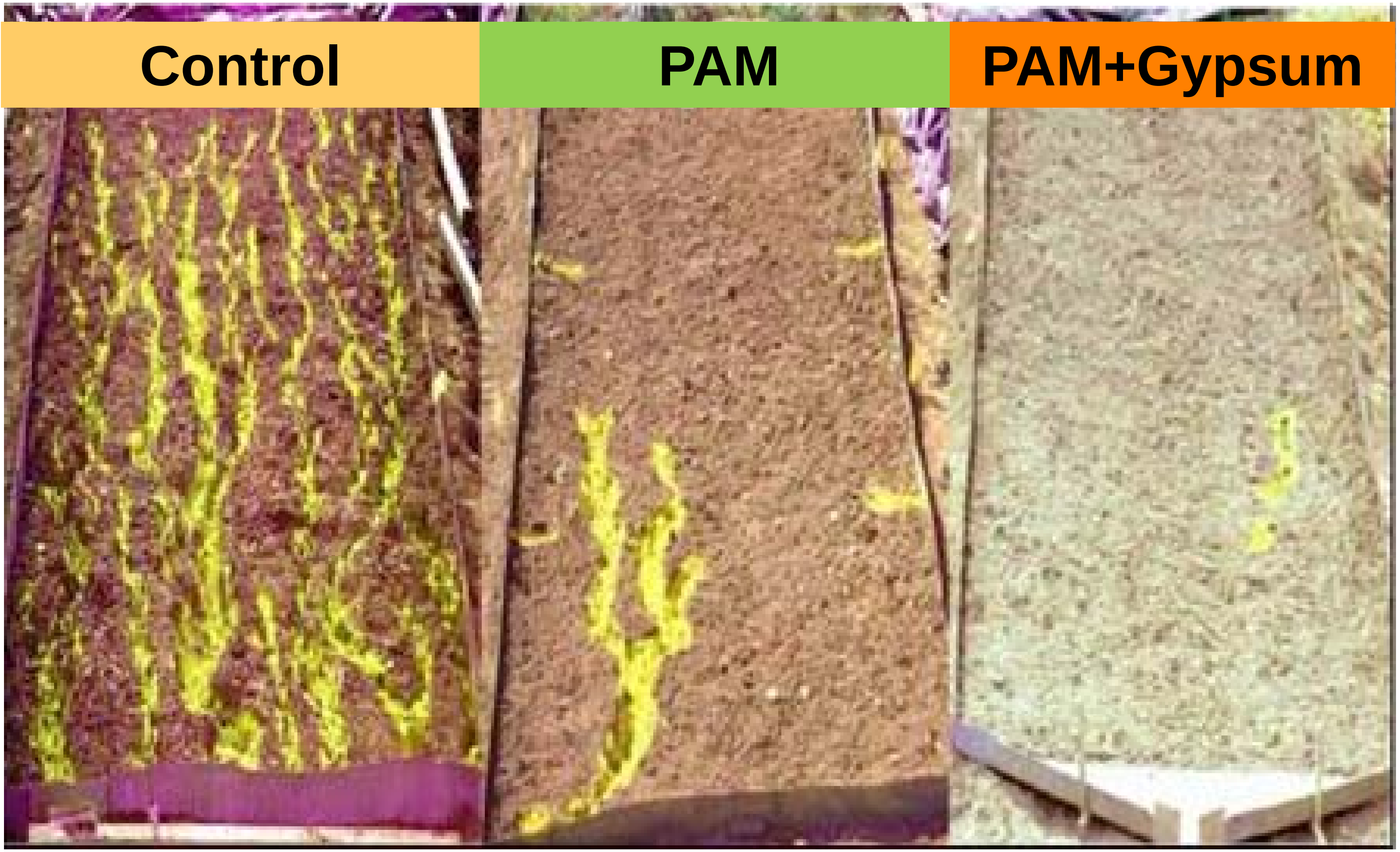
Erosion Control with PAM

PAM+Gypsum for Reducing Runoff and Erosion

- Increasing Ca^{++} levels with PAM reduced dispersion and erosion, and increased infiltration in soils with low Ca^{++}.
- Aqueous application of PAM and PAM+gypsum reduced total soil loss 40-54% compared to unamended soil.

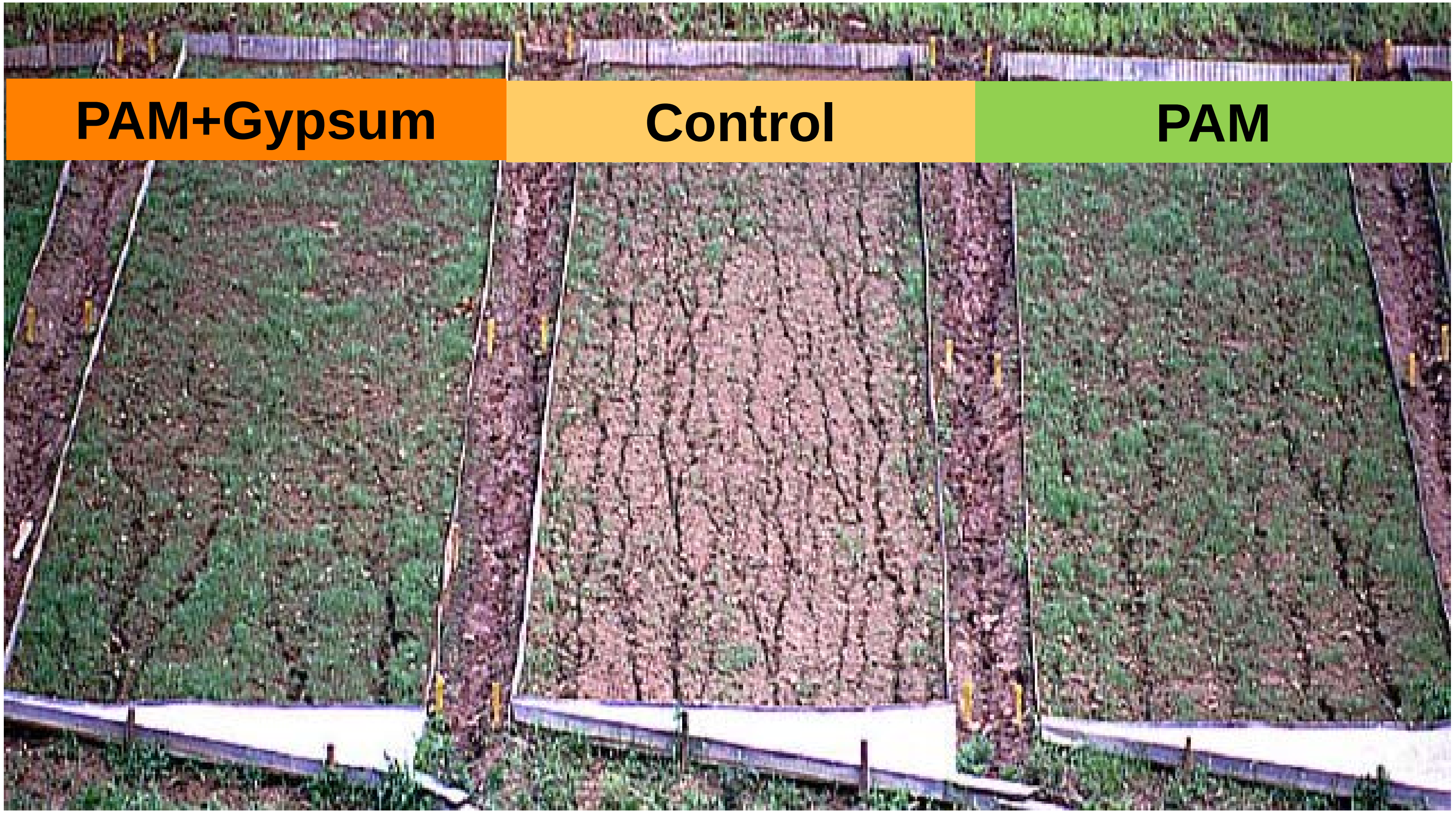
(Flanagan et al., 2002; Trans. ASAE)

Erosion Control with PAM



Differential erosion on silt loam plots at 35% slope under rainfall simulation. **(Flanagan et al., 2003; JSWC)**

Erosion Control with PAM



Differential erosion on silt loam plots at 45% slope under natural rainfall. **(Flanagan et al., 2002; Trans. ASAE)**

PAM: Environmental & Safety

Is it safety?

- **Virtually no toxicity to aquatic organisms. The polymer is too large to be absorbed into tissues.**
- **No potential to bio-accumulate, being soluble in water.**
- **Degrades at least 10%/y and becomes bio-available and bio-mineralized.**

(Wallace et al., 1986; Tolstikh et al., 1992; Sojka et al., 2007)

Study I:

Using High-Resolution Computed Tomography Analysis to Characterize Soil-Surface Seals

Lee, Sang Soo*, Clark J. Gantzer, Allen L. Thompson, Stephen H. Anderson, and Richard A. Ketcham

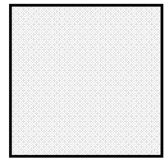
Published in 2008, Journal of Soil Science Society of America

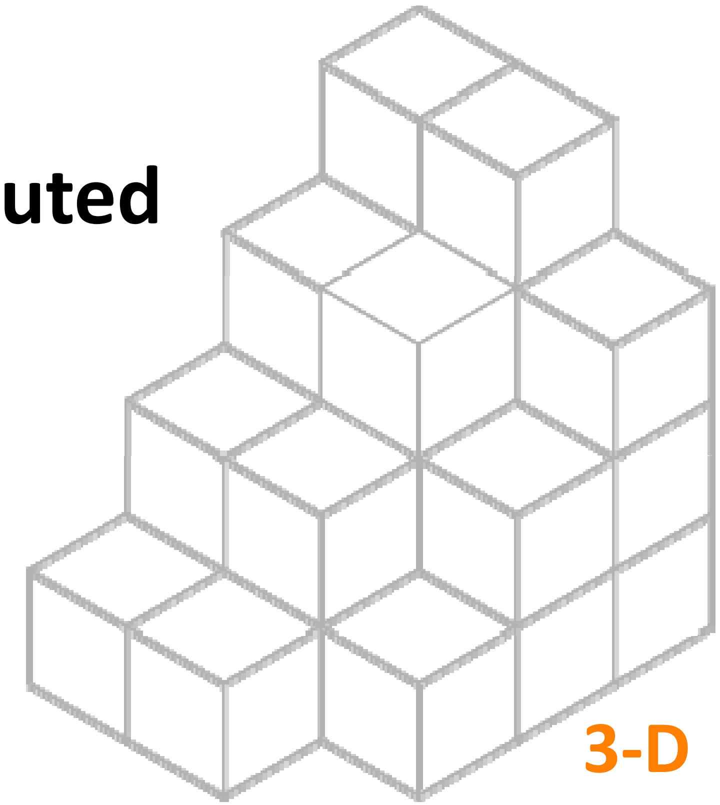
***Corresponding author**

Study Objectives

To evaluate the benefits of using PAM to reduce sealing by studying changes in soil properties determined using x-ray computed tomography

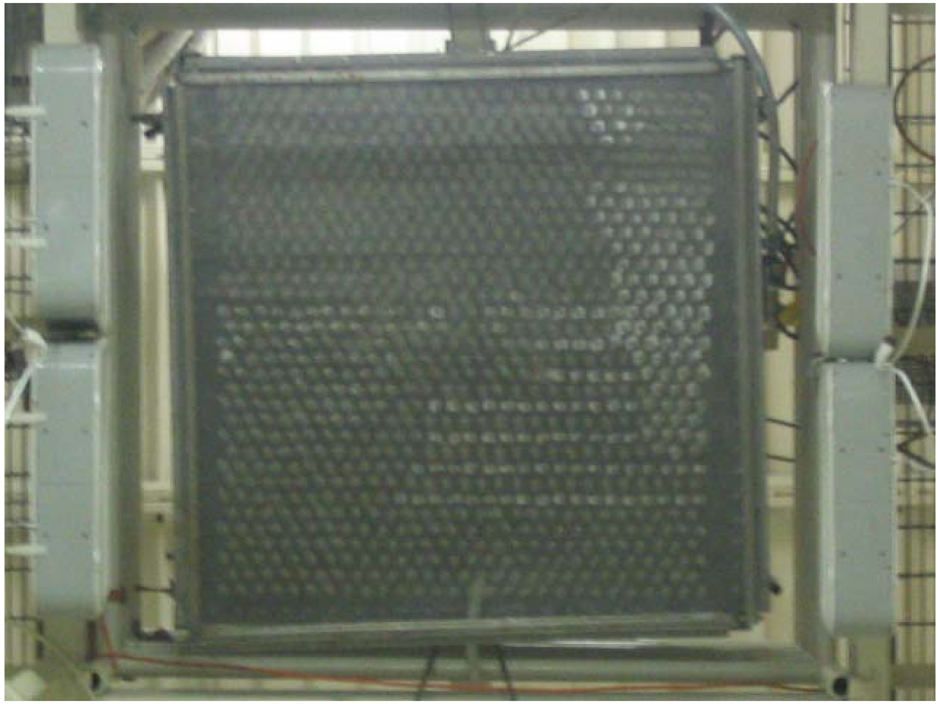
2-D



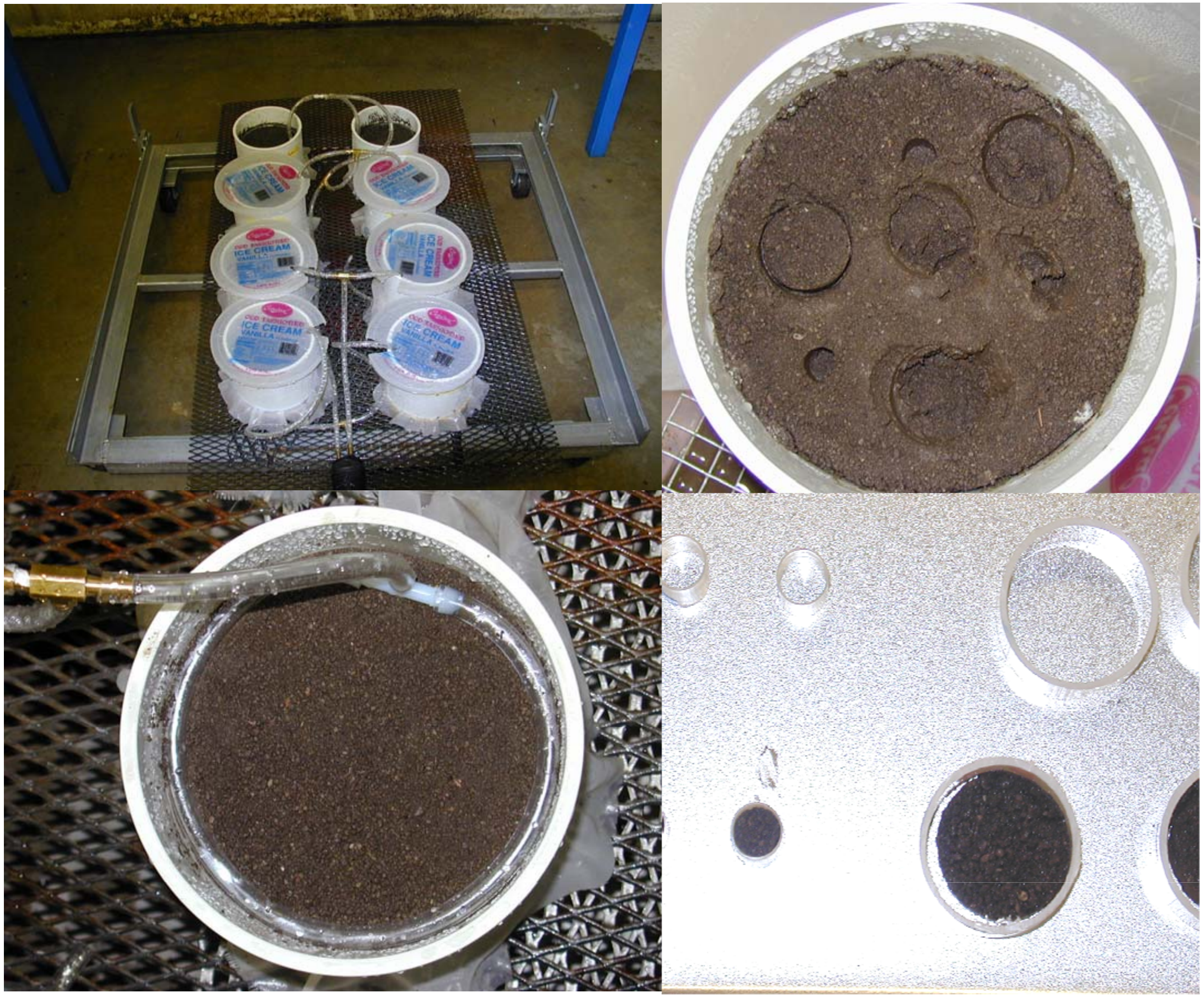


3-D

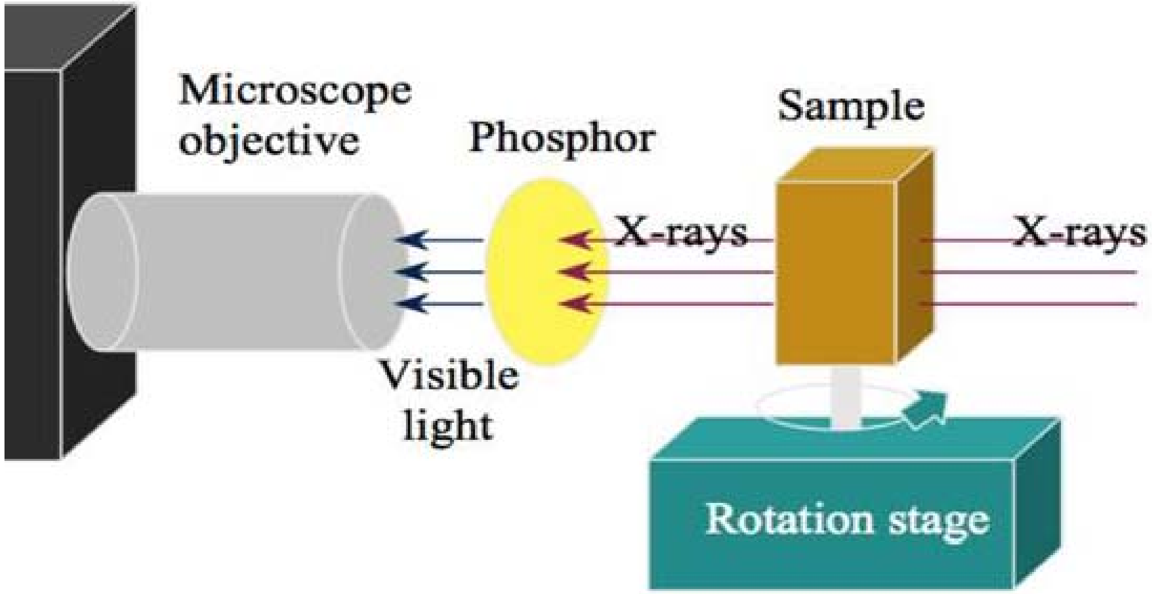


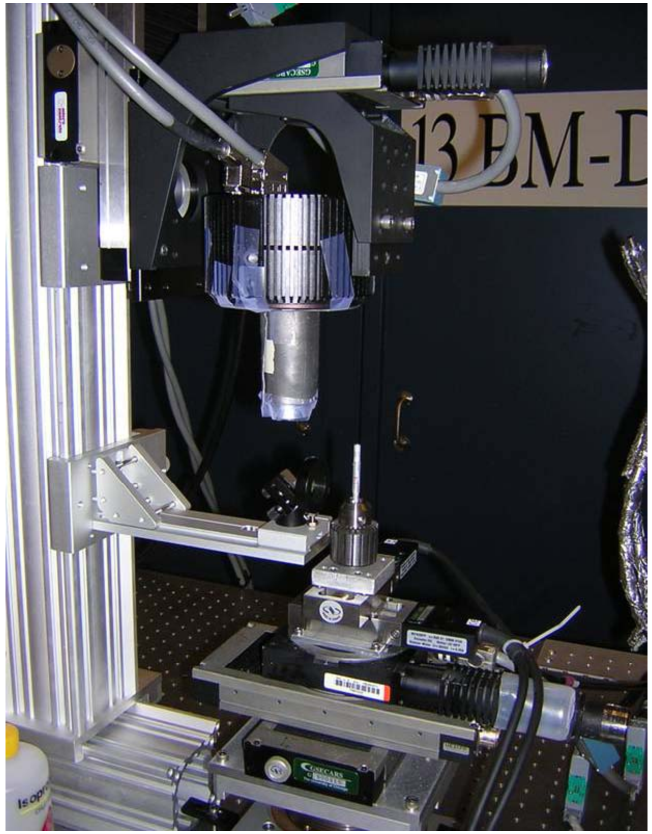



Sampling for CT



Ultra-High-Resolution CT



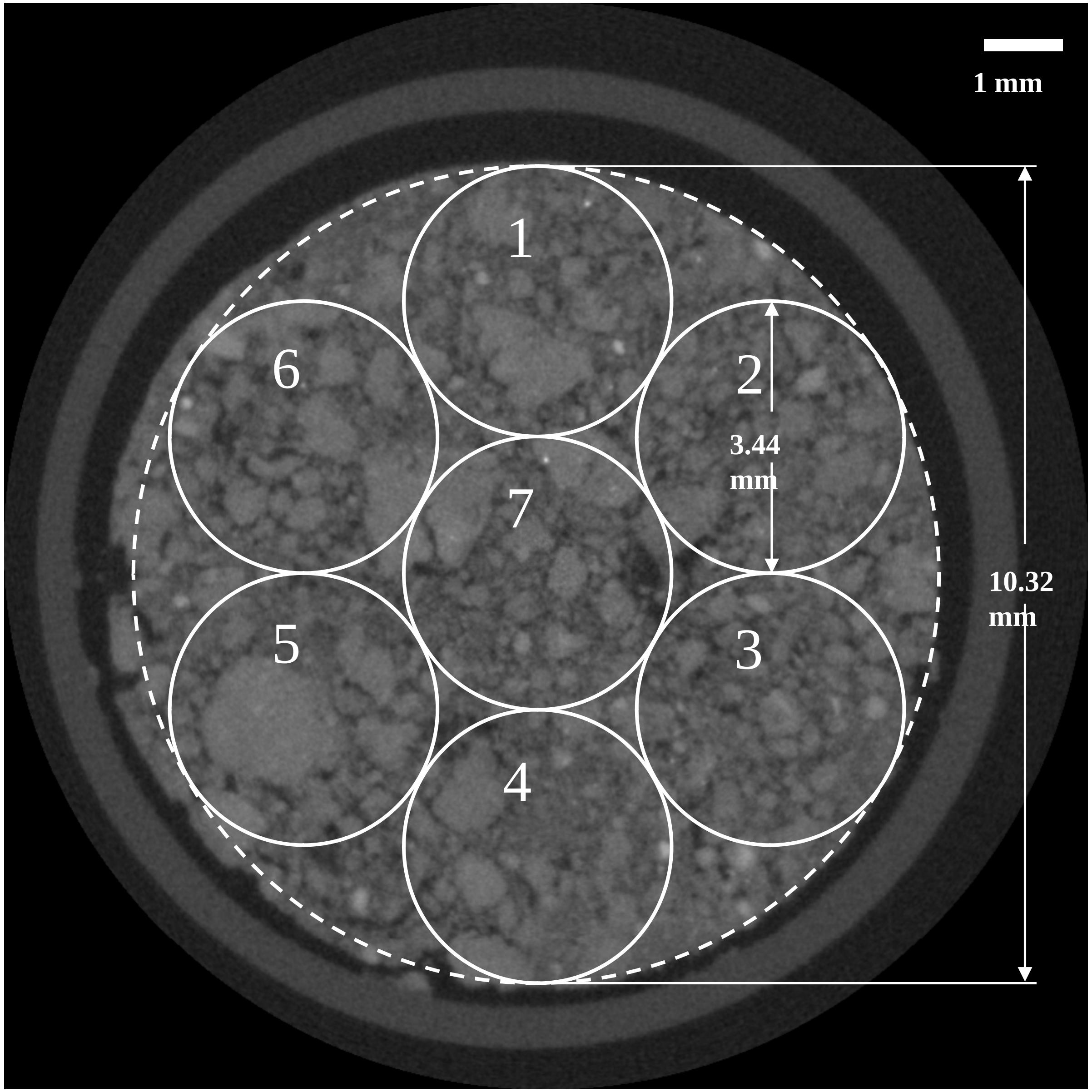


The resolution of scanning voxels or volume elements was 13.5- by 13.5- by a 14.8-µm slice thickness.

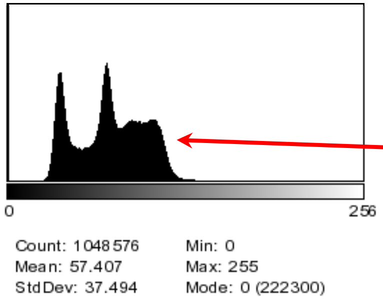
CT Analysis

All CT images were analyzed by dividing the sample into sub-regions.

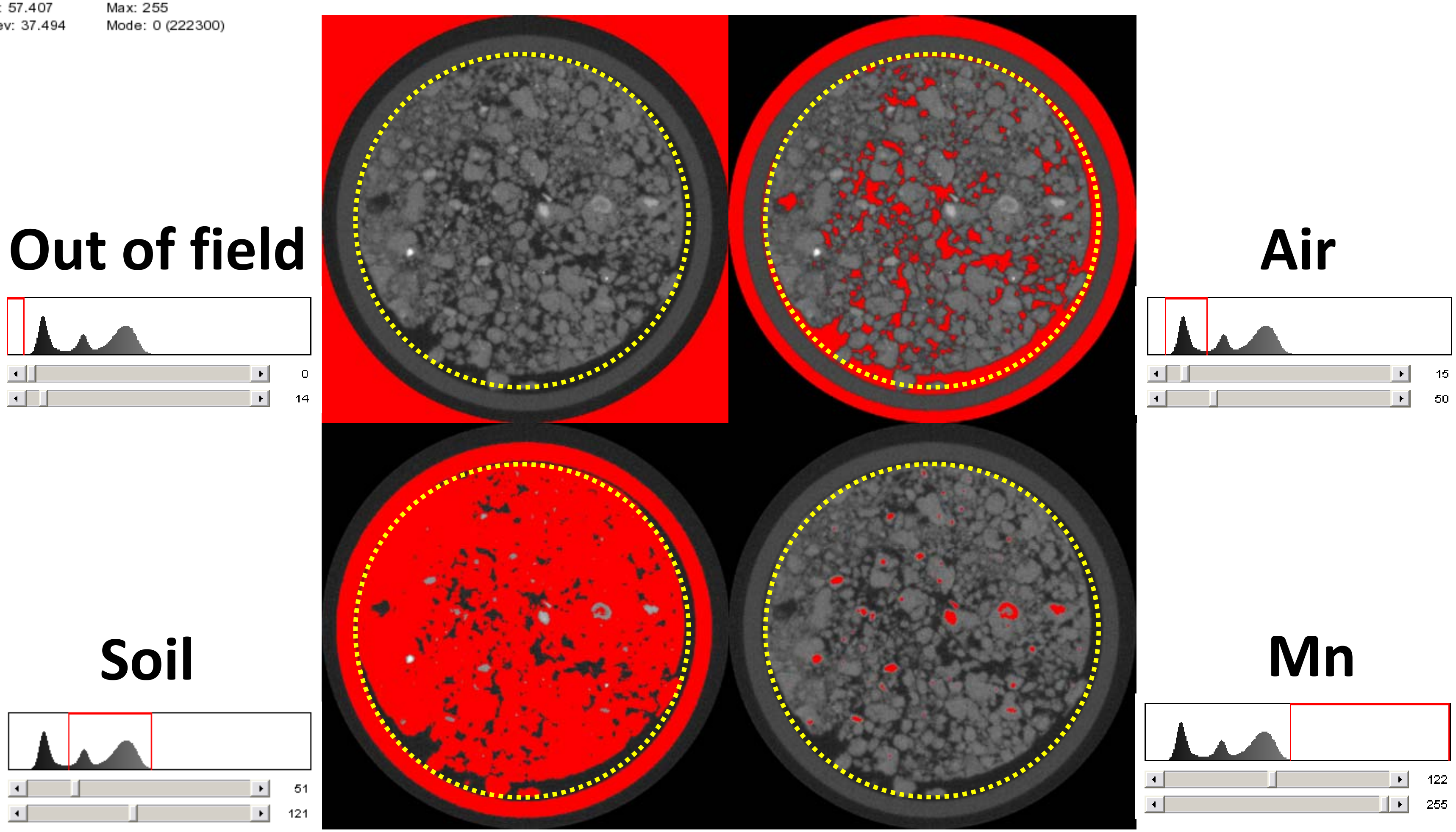
Images were measured for voxel gray-scale using *ImageJ* ver. 1.34s



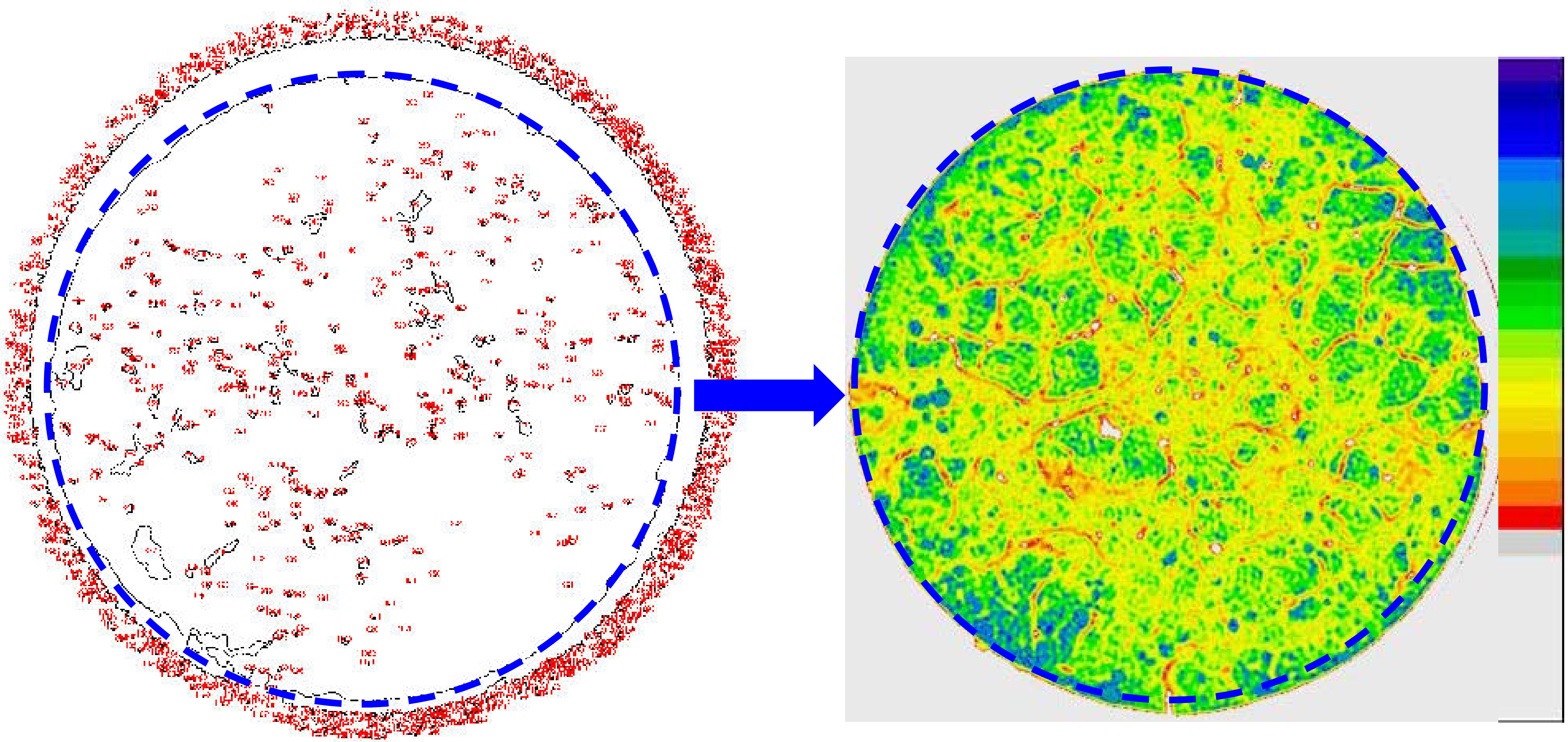
Determination of Threshold Values



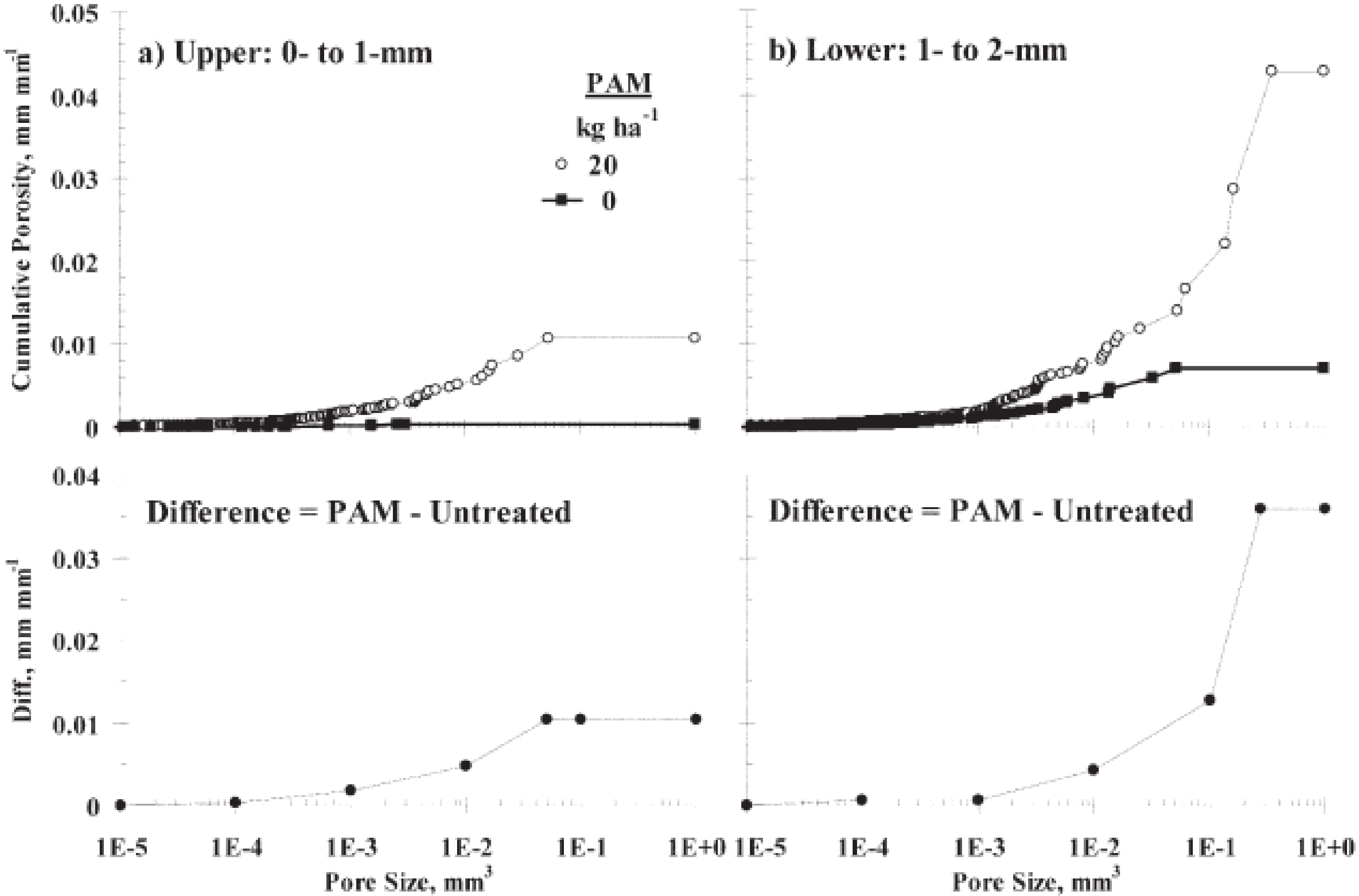
An example of a frequency distribution of gray-scale values from a CT image



CT Analysis



Porosity → Density



Cumulative porosity (*n*=68 for each upper soil-seal layer and *n*=68 for each lower soil-seal layer).

Conclusions

1) 20 kg/ha PAM treatment can maintained higher infiltration rate (vs. untreated soils).

2) Non-destructive UHCT measured total porosity and pore size distribution through soil seals were useful to measure soil-water relationships.

Study II:

Polyacrylamide and Gypsum Amendments for Erosion and Runoff Control on Two Soil Series

Lee, Sang Soo*, Clark J. Gantzer, Allen L. Thompson, and Stephen H. Anderson

In press, Journal of Soil and Water Conservation

***Corresponding author**

Rationale of this Study

- The US State Dep. of Transportation, the USDA-NRCS, and the USEPA have written on the benefits of PAM and have developed guidelines for erosion control.

  (USEPA, 1992; WDNR, 2001; WSDOT, 2008)

- However, little information is available on the effective application of PAM for soils of varying pH, texture, and clay content.

Study Objectives

1) Evaluate the benefit of PAM, gypsum or their combination on runoff and sediment loss among soil materials.

2) Explore the relationships among soil properties of texture, soil pH, and soil organic matter (SOM) with the amendment performance.

Factor A: Soils

- ***Knox series***, **a fine-silty, mixed, superactive, mesic Mollic Hapludalfs**
- ***Hoberg series***, **a fine-loamy, siliceous, active, mesic Oxyaquic Fragiudalfs**

Soils	Texture	Sand	Silt	Clay	Organic Matter	pH
		-------------	------------- $g\ kg^{-1}$	-------------	-------------	
Knox A1	Silt Loam	137	667	196	3.4	7.5
Knox Bt	Silty Clay Loam	196	504	300	5.1	7.6
Hoberg Ap	Silt Loam	156	730	114	37.4	5.0
Hoberg B1	Loam	434	301	265	1.7	4.1

Factor B: Amendments

1) 20 kg/ha PAM solution (*20P*),

2) 40 kg/ha PAM solution (*40P*),

3) 20 kg/ha PAM+5 Mg/ha gypsum (*20P+5G*),

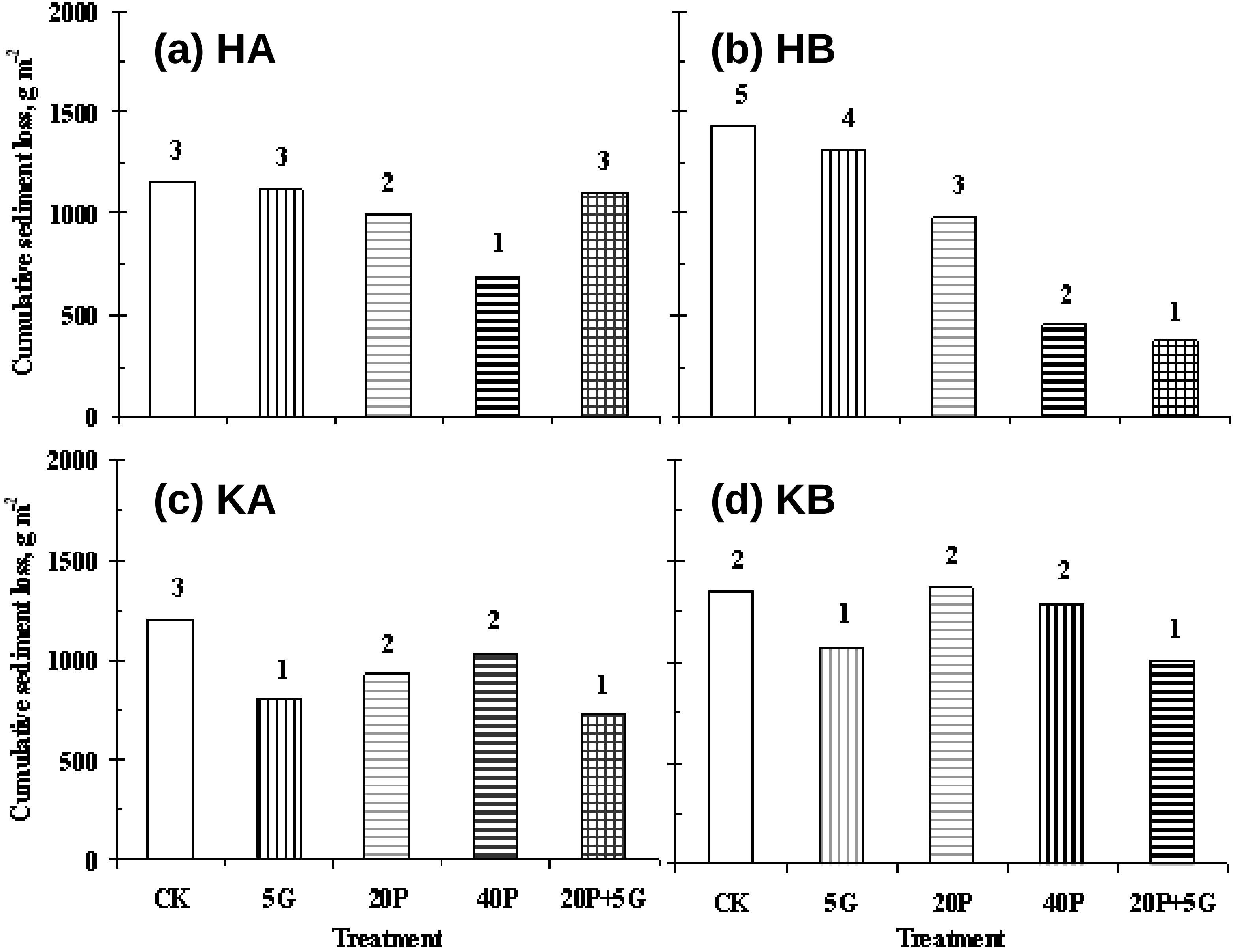
4) 5 Mg/ha gypsum (*5G*), or

5) unamended soil (*Control*).

Runoff & Sediment loss

Tests for measuring runoff & sediment loss

Results & Discussion: SL



Results & Discussion: SL

20P+5G treatment was most effective in reducing *SL* for the HB soil (pH≤4.1; 30% silt content).

Conclusions

1) Amendments were effective for some soils, but were ineffective for others.

2) Amendments effectiveness appear to be related to soil texture, soil pH, and SOM.

Study III:

Polyacrylamide Efficacy for Reducing Soil Erosion and Runoff as Influenced by Slope

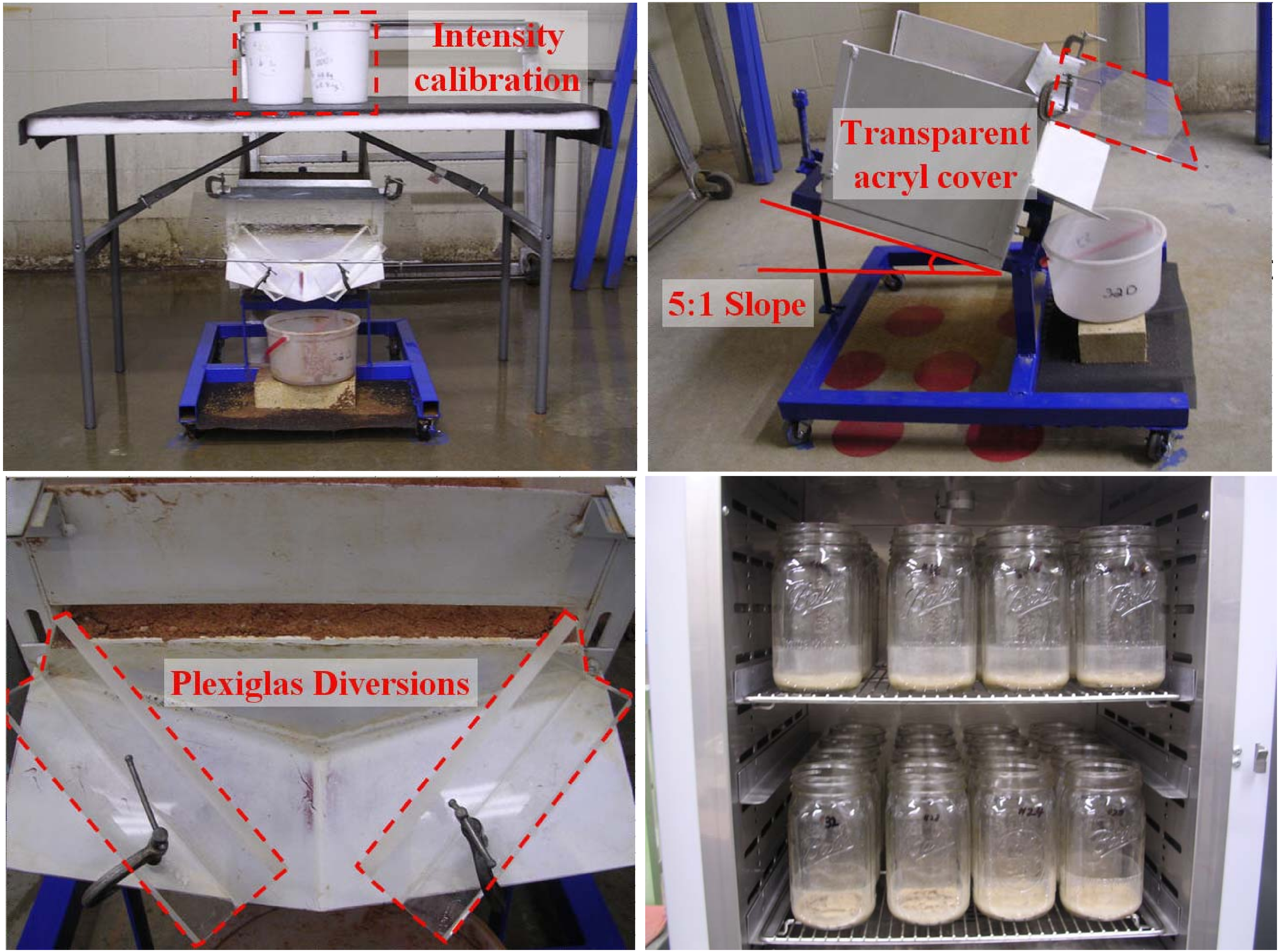
Lee, Sang Soo*, Clark J. Gantzer, Allen L. Thompson, and Stephen H. Anderson

In press, Journal of Soil and Water Conservation

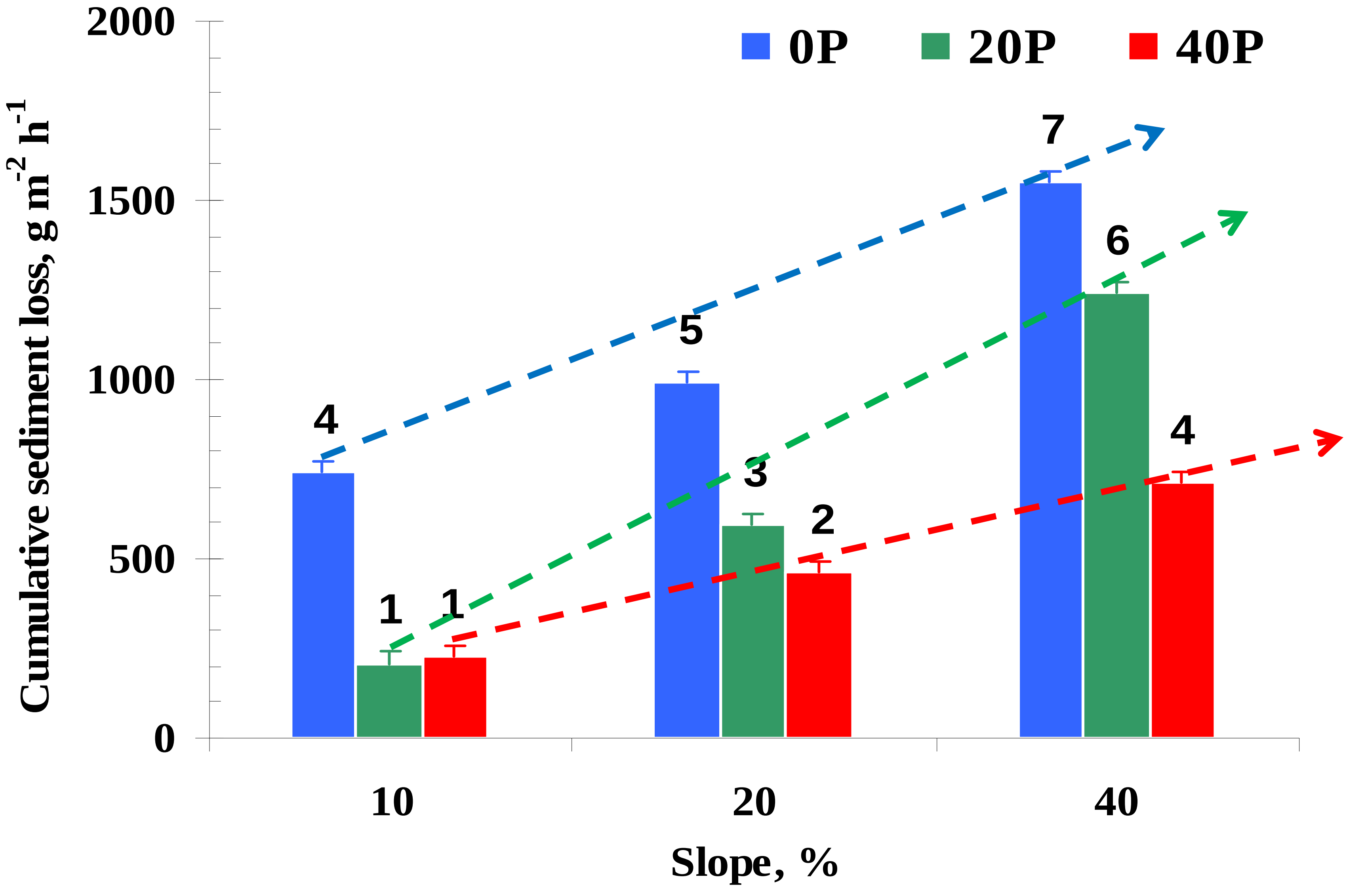
***Corresponding author**

Study Objective

To evaluate the benefit of PAM (20 and 40 kg/ha) for controlling erosion and runoff on slopes of 10%, 20%, and 40% vs. unamended (no PAM) Mexico silt loam soil with the same slopes.


Intensity
calibration
Transparent
acryl cover
5:1 Slope
Plexiglas Diversions

Results & Discussion: SL



Results & Discussion: SL

Sediment loss increased with slope. PAM reduced SL by up to 72% across all slopes vs. unamended soil.

Conclusions

Applications of either 20P or 40P reduced SL for all slopes. 40P was more effective for reducing SL than 20P at slopes ≥20%.

Comprehensive Summary

1) CT-analysis can be valuable to evaluate soil properties, especially thin soil layers.

2) Effectiveness of PAM varied with soil properties, but it's not worse.

3) Slope is a critical factor in choosing the level PAM for erosion control.

Future Works(TERRECO)

- **Evaluation of PAM effectiveness for reducing runoff and soil loss under different rainfall intensities, soil OM contents, and clay mineralogy,**
- **Effectiveness of PAM on plant growth and carbon sequestration in field study, cooperated with Soil Physics group, and**
- **Development of CT-analysis related to PAM field-scale studies.**

Questions? Comments?

Thank you

The impact of one large raindrop to move soil in a vulnerable field.

(USDA-NRCS)