Spring 2020

USING HYDROGEOPHYSICS & XRF TO PRODUCE A HIGH-RESOLUTION 3-DIMENSIONAL SOIL CADMIUM MAP FOR EVALUATING HYBRID WHEAT TRIALS

Thierry Bienvenu
University of Nebraska - Lincoln, thierry@huskers.unl.edu

Trenton Franz, Associate professor of Hydrogeophysics
University of Nebraska - Lincoln, trenton.franz@unl.edu

Nuwan Wijewardane, Post Doc research associate
University of Nebraska - Lincoln, nuwijewardane2@unl.edu

Yufeng Ge, Associate professor
University of Nebraska - Lincoln, yge2@unl.edu

USING HYDROGEOPHYSICS & XRF TO PRODUCE A HIGH RESOLUTION 3-DIMENSIONAL SOIL CADMIUM MAP FOR EVALUATING HYBRID WHEAT TRIALS

Thierry Bienvenu[1], Trenton E. Franz[1], Nuwan Wijerwardane[2], Yufeng Ge[2]

1. School of Natural Resources 2. Biological Systems Engineering

INTRODUCTION

Cadmium (Cd) accumulation in wheat decreases germination, growth, grain yield, and in higher concentration leads to adverse effects on human health (Liu et al, 2018). Due to wheat cultivars variation in Cd accumulation, wheat breeders aim to select those at low Cd concentration lines in a field. Hence the need to quantify the concentration of Cd at different parts of a field and visually represent on a high resolution Cd distribution map.

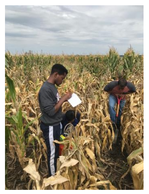
Various ways to quantify the concentration of soil Cd exist. However, the cost of equipment required make the process quite expensive and labor intensive. This work studied the feasibility of predicting the concentration of Cd and other soil chemical elements based on readily available environmental covariates collected at the site. These are electrical conductivity in shallow and deep zones (ECaS, ECaD), total gamma counts and elevation.

Soil samples were collected from Havelock farm, analyzed in the lab and then results were used to train and test different statistical models to predict the occurrence of chemical elements in the soil.

SAMPLE COLLECTION & PROCESSING

- 192 soil samples were collected at 64 different locations: 3 samples at different depths (10cm, 25cm and 40cm) in the fall of 2019

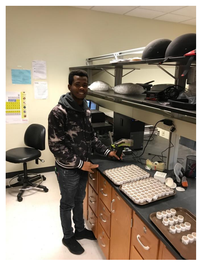
Havelock Farm in Lincoln



Soil samples left to air dry in laboratory

Sample preparation, crushing and sieving material

Sample analysis with Niton XL5 XRF Analyzer



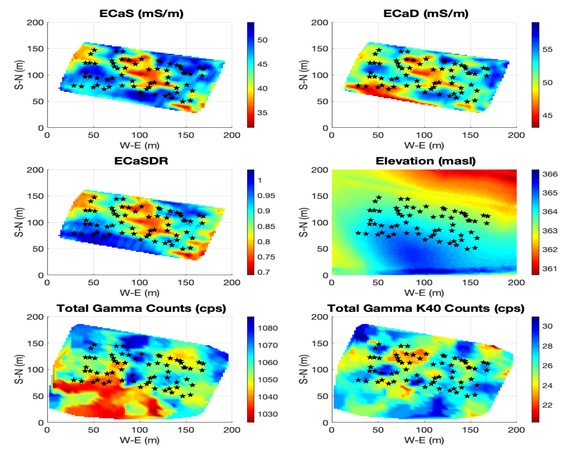
XRF RESULTS AND DATA ANALYSIS

XRF ANALYSIS RESULTS SUMMARY:

- All 192 soil samples were analyzed for different elemental composition (41 elements)
- Cd which was the targeted element, had low concentration in the samples collected
- Fe, Zn, As, V, Ca, Sr, Cu, Al, had significant concentration and variation within the samples. These were used to train and test models to predict the occurrence of different elements in the soil based on VNIR (Visible Near Infra Red) and the environmental covariates also collected on site.

DATA ANALYSIS:

- INPUTS:
  - ➢ Geophysical layers data by Dr. Franz at the site



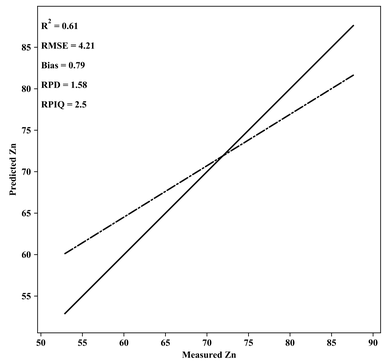
Black dots represent locations where samples were collected

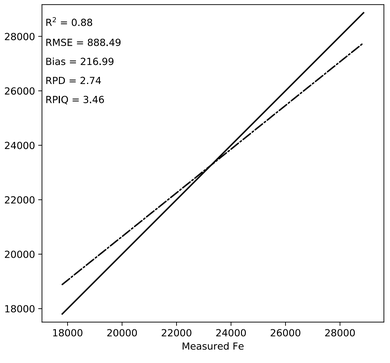
  - ➢ VNIR (visible near infra-red data), analyzed in Dr. Ge's lab
  - ➢ XRF data, analyzed in Dr. Franz's lab
- STEPS:
- Split the dataset as train (80%) and test (20%) using different statistical approaches (linear and nonlinear)
  - ➢ **Scenario 1:** VNIR only:
    - o Calibrate model using training XRF and VNIR spectra data
    - o Use model to predict test dataset and report summary statistics
  - ➢ **Scenario 2** (VNIR and Geo-covariates):
    - o Calibrate model using training XRF, VNIR and Geo-covariate data
    - o Use model to predict test dataset and report summary statistics

RESULTS

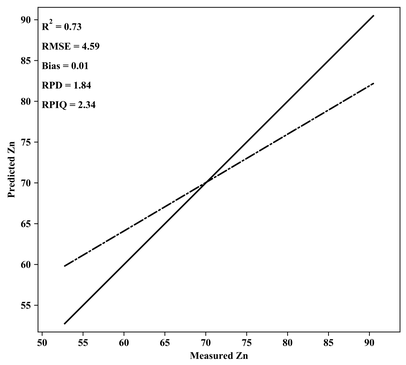
- Fe, Zn, As, Rb, V and As showed satisfactory accuracies with $R^2 > 0.51$ using nonlinear statistical approach with VNIR data only
- Models with VNIR + Geo-covariate data showed significant improvement in prediction accuracy

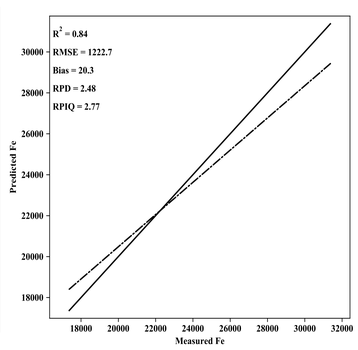
VNIR Sample Results (Zn & Fe):





- VNIR + Geo-covariates Sample Results (Zn & Fe):





CONCLUSIONS AND FUTURE WORK

- Showed statistical correlation between Geo-covariates and some soil element data (i.e. Zn & Fe) providing proof-of-concept for technique and warranting further investigation
- At Havelock Cd wad below level of detection
- Adding VNIR to Geo-covariates improves prediction accuracy in nonlinear statistical models

ACKNOWLEDGMENTS:

1. Trenton Franz, Associate professor of hydro-geophysics
2. Nuwan Wijewardane, Post Doctoral research associate
3. Yufeng Ge, Associate professor, Biological Systems Engineering

Reference: Liu, Caixia, et al. "Cadmium concentration in terminal tissues as tools to select low-cadmium wheat." *Plant and soil* 430.1-2 (2018): 127-138.