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Predicting soil cation exchange capacity for variable soil types with visible-near-infrared spectra

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Introduction

- Cation exchange capacity (CEC) is very important in agronomic, environmental and geotechnical applications
- However, laboratory determination of CEC is time consuming, expensive and hazardous, and new methods are required
- Visible-near-infrared spectroscopy (vis-NIRS) is a simple, rapid and non-destructive technique for determining several soil properties (e.g. CEC, clay content and organic carbon (OC) etc.)

Objectives

- To evaluate the potential of vis-NIRS (spectral range from 400 to 2500 nm) to predict CEC for soils from different geographic regions
- To compare the predictive ability of vis-NIRS and pedotransfer functions (PTFs) for CEC

Methods

Soils

- 235 soil samples from 21 countries
- Particle-size distribution
  Wet-sieving/hydrometer
- CEC (0.1-83 $cmol_{(+)}kg^{-1}$)
  Ammonium acetate at pH 7
  Barium chloride at pH 8.2
- OC (0.03-8.42 %)
  Elemental analyzer

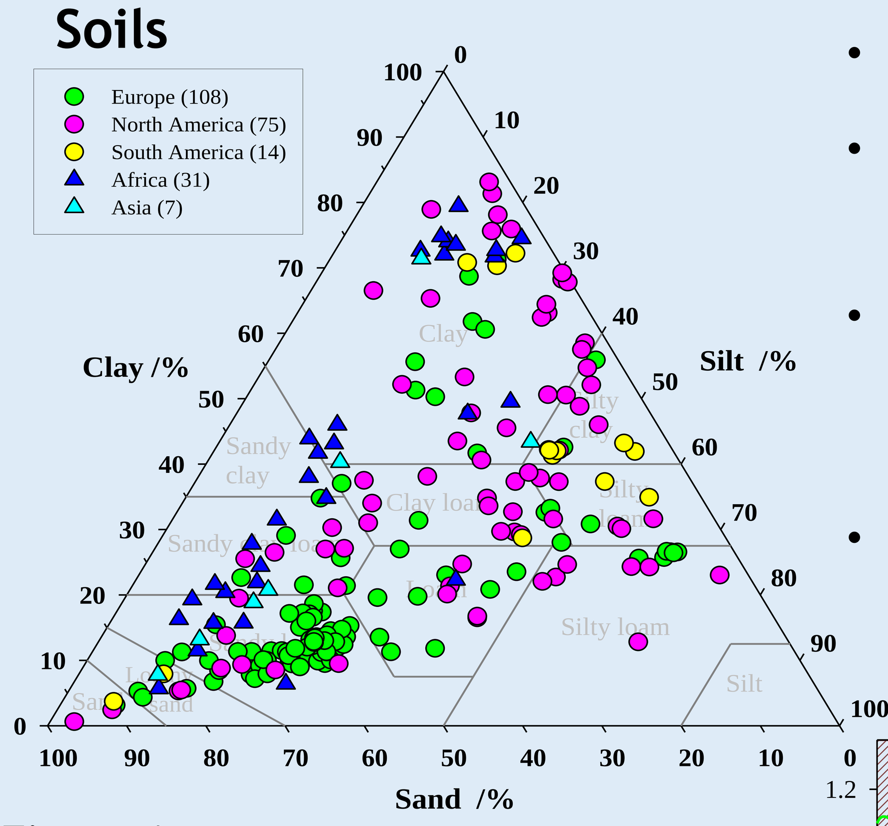
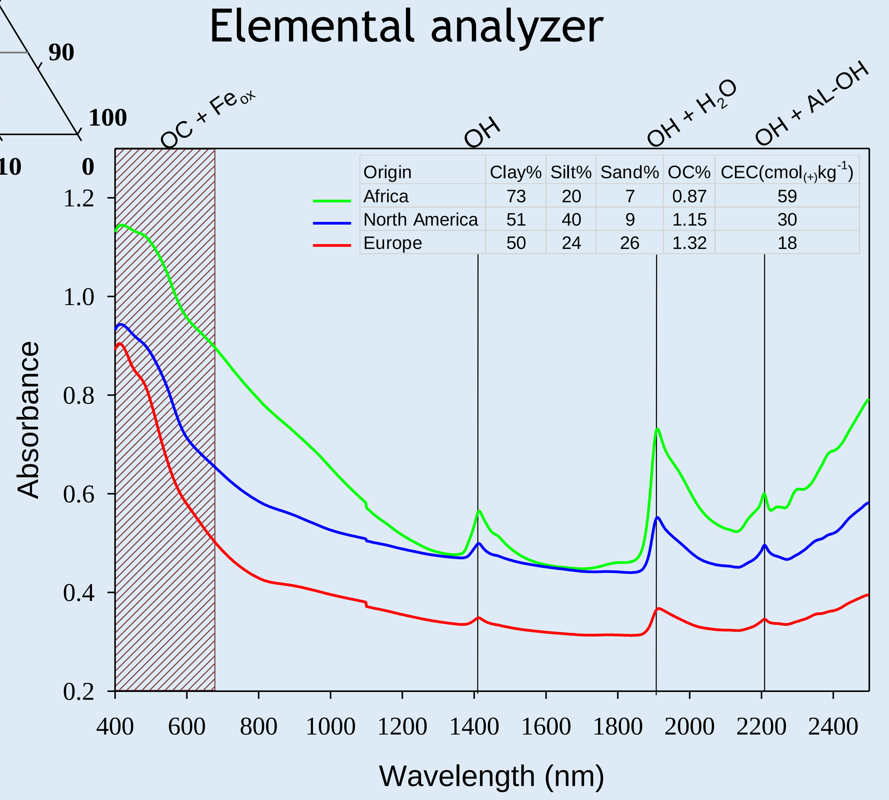


Figure 1. USDA texture of soil samples

Figure 2. Vis-NIRS™ spectrometer (DS2500)



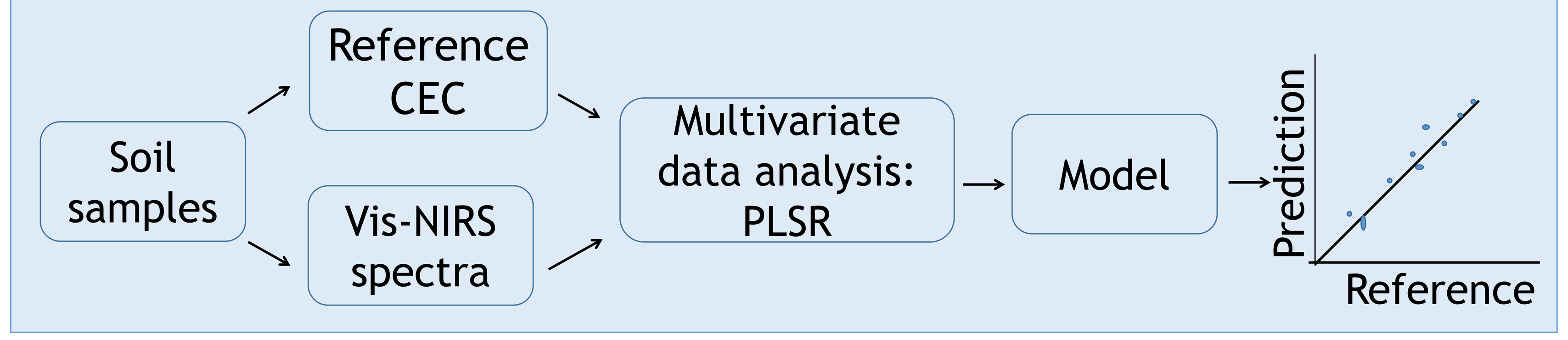
Origin	Clay%	Silt%	Sand%	OC%	CEC($cmol_{(+)}kg^{-1}$)
Africa	73	20	7	0.87	59
North America	51	40	9	1.15	30
Europe	50	24	26	1.32	18

Figure 3. Visible-near-infrared spectra of three representative soil samples

Methods

Multivariate data analysis

- Partial least squares regression (PLSR) analysis
- Calibration subset (80 %), 188 soil samples from 21 countries
- Independent validation subset (20 %), 47 soil samples from 11 countries



Results

- Peaks from 429 to 650 nm related to both iron oxide and soil organic matter (SOM)
- Peaks at 1400, 1412, 1907 nm linked to OH-bond and clay mineral
- Peaks at 2200-nm linked to Al-OH and at 2307-nm significant for OC
- CEC is directly linked with OC, clay type and content, which directly affects the ability of soil to absorb water and nutrients

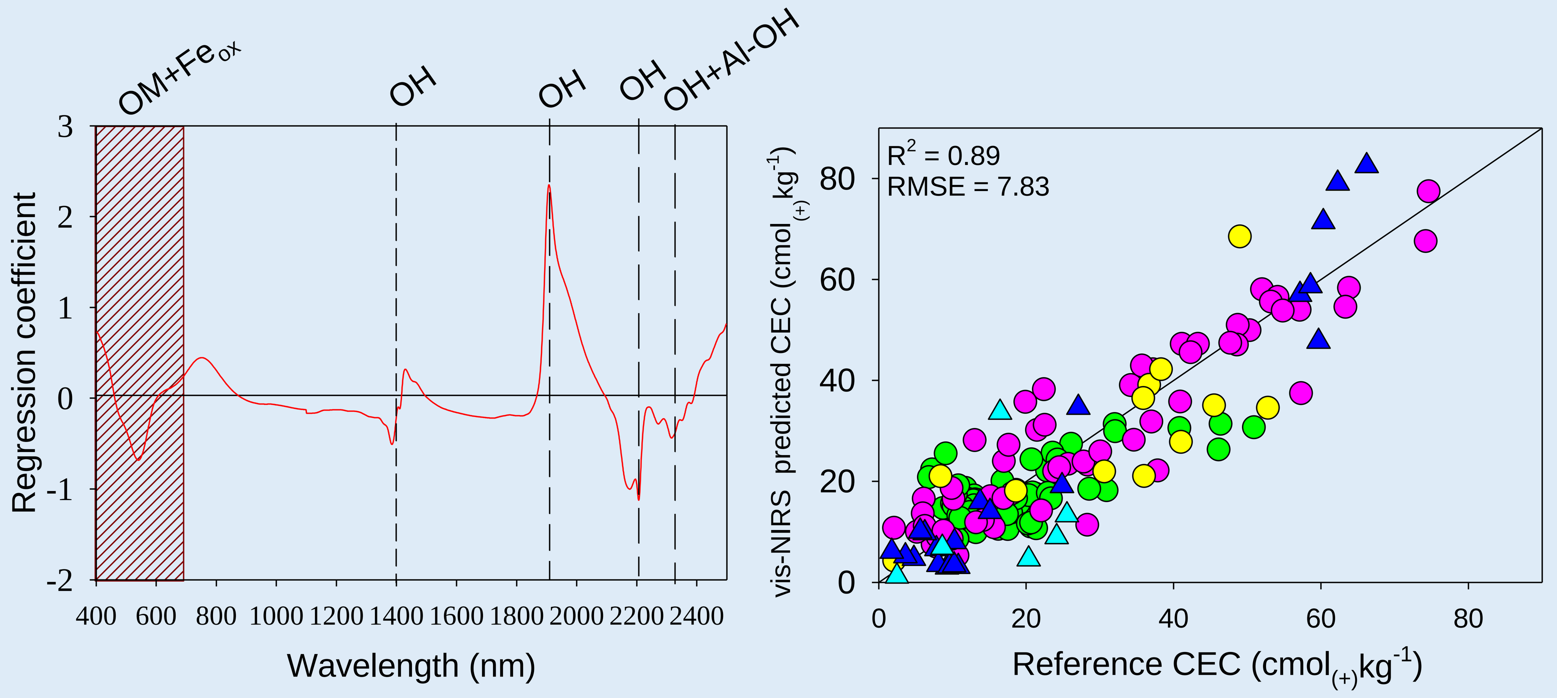


Figure 4. Regression coefficients for spectra wavelengths for calibration model, and full cross-validation of the calibration model for CEC.

Existing and new PTFs

Pedotransfer functions used to predict CEC from SOM, OC and clay

Existing PTFs

- PTF-1:- $CEC = 0.95 + (2.90\%SOM) + (0.53\%Clay)$ [1]
- PTF-2:- $CEC = -29.250 + (8.14\%Clay) + (0.253\%OC)$ [2]

New PTF was developed on calibration subset

- PTF-3:- $CEC = -0.430 + (0.665\%Clay) + (1.956\%OC)$

Results

Model performance

- Comparison of reference CEC vs vis-NIRS predicted CEC for the validation subset showed very good prediction accuracy (RMSEP=4.96 and RPIQ=4.6)
- PTFs (PTF:-1, PTF:-2 and PTF:-3) showed relatively lower predictive ability when compared with vis-NIRS

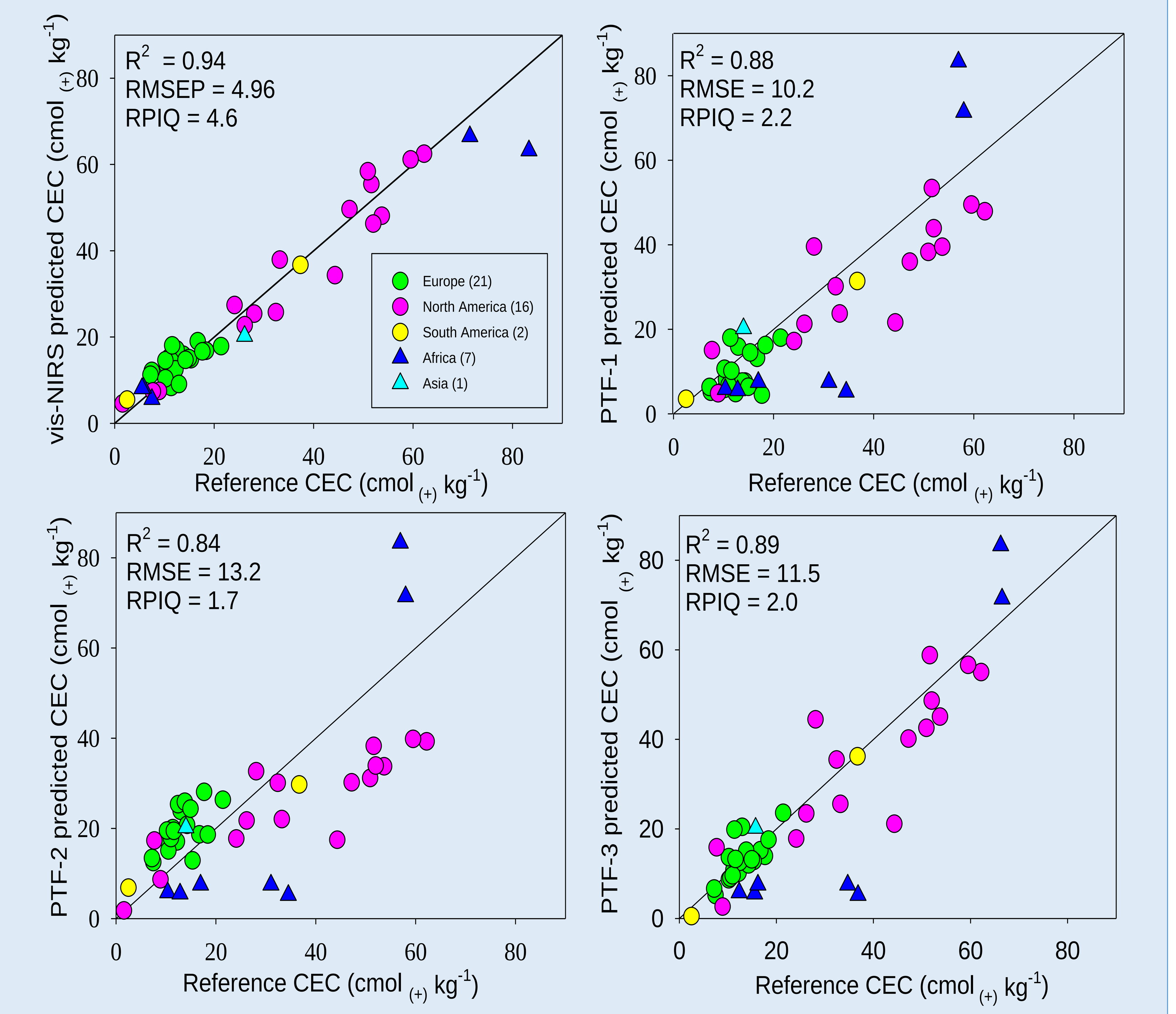


Figure 5. Comparison of CEC predicted by vis-NIRS and PTFs (PTF-1 & PTF-2; PTF-3).(RPIQ) Ratio of performance to inter-quartile range = (Q3-Q1)/RMSEP [3]

Conclusions

- Vis-NIRS successfully predicted CEC for a large variety of soil samples
- The CEC prediction performance of the vis-NIRS model was superior to that of the existing and the calibration dataset-based PTFs

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For more details

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References
[1]. Krogh, L., Breuning-Madsen, H. & Greve, M. H. 2000. Acta Agriculturae Scandinavica Section B-Soil and Plant Science, 50, 1-12
[2]. Mcbratney, A. B., Minasny B., Cattle, S. R. & Vervoort, R. W. 2002. Geoderma, 109, 41-73
[3]. Bellon-Maurel, V., Fernandez-Ahumada, B. Palagos, J.M. Roger and A. McBratney. 2010. Trac-Trend Anal Chem 29: 1073-1081