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Maryem Arshad
University of New South Wales, Biological Earth and Environmental Science, Australia
(maryem.arshad@student.unsw.edu.au)

Evaluating digital soil mapping approaches to predict topsoil exchangeable calcium and magnesium in a sugarcane field of Australia

Maryem Arshad[1], Dongxue Zhao[1], Tibet Khongnawang[1] and John Triantafilis[1*]

[1]School of Biological, Earth and Environmental Sciences, Faculty of Science, UNSW Sydney, Kensington, NSW, 2052, Australia

Corresponding

John Triantafilis, School of Biological, Earth and Environmental Sciences, Faculty of Science, UNSW Sydney, Kensington, NSW, 2052, Australia

Email: j.triantafilis@unsw.edu.au

Abstract

Knowledge about spatial distribution of exchangeable (exch.) calcium (Ca) and magnesium (Mg) is needed to maintain sugarcane biomass in north Queensland, Australia. To create digital soil maps (DSM), herein, we evaluated three approaches, including; geostatistical (i.e. ordinary kriging [OK]), statistical and hybrid. We first determined the number of samples (10 – 120) required to compute variogram by calculating nugget to sill ratio (NSR) and sum of squared error (SSE). We then used this variogram with OK to predict topsoil (0 – 0.3 m) exch. Ca and Mg. For comparison, four statistical models, including; one linear regression (LR) and three machine learning (ML) models (i.e. Cubist, support vector machine [SVM] and random forest [RF]) were used. Doing so, usefulness of two digital data, including; gamma-ray (g-ray) and soil apparent electrical conductivity (EC_a), either individual or combined, was tested. Regression residuals (RR) were then added to find out improvement in prediction performance (i.e. Lin's) and in hybrid approach. Influence of varying sample size (10 – 120) was also determined on all three DSM approaches. Comparisons were then drawn with a traditional soil type map and by calculating the mean square prediction error (MSPE). Finally, Digital soil maps (DSM) of exch. Ca and Mg were developed. Results showed that 50 samples were enough to compute a good variogram for exch. Ca (NSR =

11%, SSE = 0.39) and Mg (NSR = 33%, SSE = 0.005). Considering OK, exch. Ca and Mg were predicted with moderate agreement (Lin's = 0.65 – 0.80). Comparing statistical models and to predict exch. Ca, RF (0.64) and SVM (0.63) outperformed Cubist and LR (0.60) while to predict exch. Mg, SVM (0.79), RF and Cubist (0.74) outperformed LR (0.62). Combined and individual g-ray data performed best and equally well. Hybrid models i.e. RK and CubistRR improved prediction of exch. Ca (0.76) and Mg (0.81) using individual g-ray and EC_a data, respectively. Considering sample size, OK and statistical models required 80 samples while hybrid models required only 30 samples to satisfactorily (Lin's ≥ 0.70) predict exch. Ca and Mg. Comparisons based on MSPE showed that to predict exch. Ca, hybrid (RK = 1.44) was the best approach followed by geostatistical (OK = 1.94), statistical (Cubist = 2.15) and then traditional soil map (2.64). Same was the case for exch. Mg. DSM of predicted exch. Ca and Mg were consistent with contour plots of measured data. However, some poor predictions were apparent across field edges or areas where small scale variation in digital or soil data was prevalent.