Leveraging Machine Learning Approaches to Estimate Soil Compaction from Electrical Conductivity Data

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Abstract:

Soil compaction is an important element that influences crop output, yet traditional techniques of assessing it are labor-time-intensive and expensive. To overcome this, rapid and cost-effective estimating approaches are required. This research investigates the use of soil scanners—the Geonics EM38 and Veris 3100—in conjunction with four machine learning (ML) approaches; Multilayer Perceptron and Radial Basis Function neural networks, Support Vector Machine, and Extreme Gradient Boosting to construct prediction models of soil compaction (SC) across various soil layers (0 - 0.5 m). These models were created utilizing the scanners' data on electrical conductivity (ECa), infrared, and magnetic susceptibility (MS) measurements from Geonics EM38 and Veris 3100 scanners, as well as soil texture-related coefficients. The Support Vector Machine (SVM) algorithm produced the most accurate SC predictions for the 0-0.5 m and 0.3-0.4 m layers, with a mean absolute percentage error (MAPE) of 12%. Other soil layers' predictions were slightly less accurate. However, an increase or decrease in soil compaction does not always directly correlate with changes in electrical parameters. The findings suggest that integrating soil scanning data with ML offers a reliable and efficient method for predicting soil compaction, and soil health challenges, implementing targeted soil management practices, optimizing crop production, and improving sustainability in agricultural practices.

Keywords:

Soil electrical conductivity; soil compaction, magnetic susceptibility; Neural Networks; support vector machines; Extreme Gradient Boosting.