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SPECTRAL ANALYSIS FOR PREDICTION OF SOIL AGROCHEMICAL INDICATORS

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Abstract

The composition of the soil is essential for higher yields in agriculture. The assessment of agrochemical soil indicators is carried out in laboratories using standardized chemical methods, which are time-consuming and relatively expensive. In the present study, an approach for predicting agrochemical indicators (nitrogen, phosphorus, potassium, humus and acidity) using spectral characteristics of soil samples was investigated. 110 soil samples from fields in the area of the city of Ruse, Bulgaria were analysed. The classification with the SIMKA method is carried out in the Pirouette software platform, and three procedures for pre-processing the data - first derivative, second derivative and multiplicative scatter correction (MSC) - have been compared. The results obtained for the standard error of validation show that for the nitrogen the minimum SEV is for MSC and 10 factors. For phosphorus - 2-nd derivative and 6 factors. For potassium - MSC and 9 factors. For humus - MSC and 10 factors. For acidity - 2-nd derivative and 10 factors. The future work will be focus on models for prediction of the indicators and assessment of the accuracy.

Keywords: Spectral characteristics; Soil agrochemical indicators; Prediction; SIMCA; Multiscatter correction; Pirouette software

1. Introduction

The soil content is very important factor for farmers and for hire yield production [1]. In the recent years different techniques are used for quality assessment of different parameters in agriculture [2]. The computer vision-based quality inspection comprises of four main steps, namely, acquisition, segmentation, feature extraction and classification. The artificial intelligence techniques such as fuzzy logic are also widely used for the automatic analysis and detection of objects [3].

Our previous research works is related to quality assessment of soil using different sensor for measurement of the main quality soil parameters [4] and research of the influence of external factors on the measurement of a basic soil quality parameter [5]. These methods are time – consuming and are not suitable for express assessment of the whole field.

Some of soil properties as organic matter [6], fungal enzyme activities [7] and acidity [8] are objects of the other researches. Spectral analysis is not so popular method for assessment and prediction of the soil content.

The purpose of the research is to assess the possibility for soil agrochemical indicators prediction using spectral analysis.

2. Spectral characteristics acquisition

Spectral characteristics of the soil samples were acquired using NIR spectrophotometer GraiNit. The samples (110) are from the Ruse region, Bulgaria.

The spectrophotometer is AlbaNir. It is a portable Nir analyser incorporating the most advanced technology developed and designed for the agro-food and renewable energy sectors. The design of the device meets the requirements for a portable analyser for field measurements in any weather condition. Single InGaAs sensor is used with DLP technology (Texas Instrument) and programmable between 950-1650nm spectral range.

The sample is placed in a glass cuvette, covered with a transparent foil, on which the spectrophotometer is placed (Fig. 1).

Fig. 1. Spectrophotometer and soil sample

Spectral characteristics of the soil from three different field in Ruse region are shown in Fig. 2. The variable is the wavelength in nm.

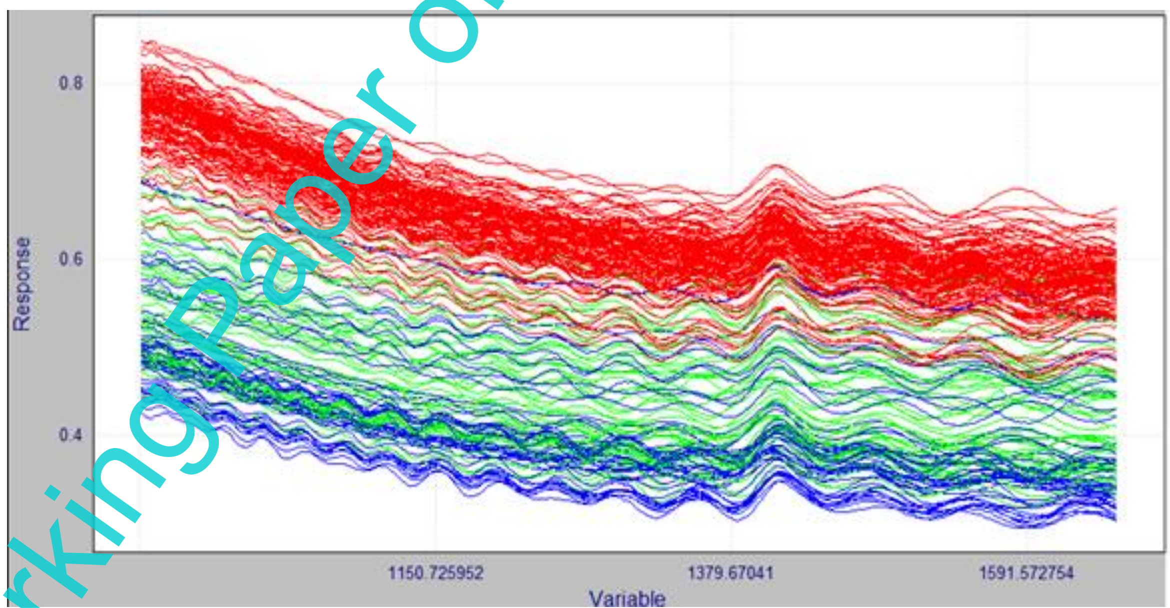


Fig. 2. Spectral characteristics of one pixel

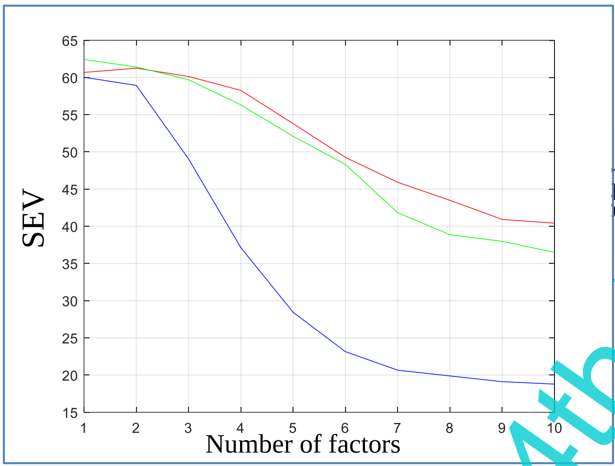
3. Pre-processing of spectral characteristics

Analysis of the spectral characteristics is done in software platform Pirouette. Partial Least Squares (PLS) regression models of the data is done. Three pre-processing procedures are used – first derivative, second derivative and multiplicative scatter correction (MSC). MSC is a standard approach to compensating for scattering by solids in NIR spectrometry. Each sample spectrum is regressed linearly against an ideal spectrum to yield a slope and intercept. The sample spectrum is then “corrected” at each wavelength by first subtracting the intercept, then dividing by the slope. The ideal spectrum is most often simply the mean of included samples.

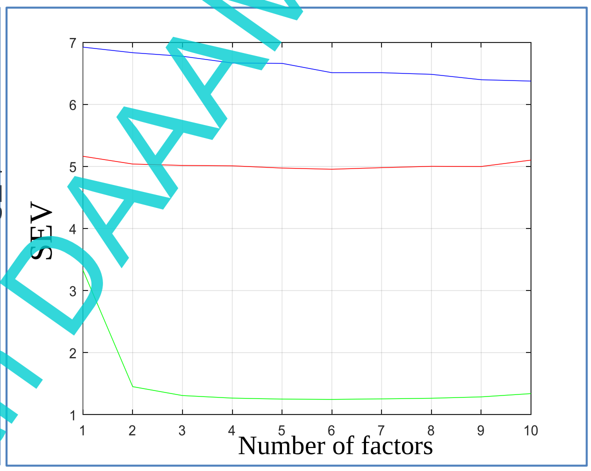
4. Results from analysis of the data from pre-processing procedure

The results were obtained for each of the agrochemical indicators: nitrogen, phosphorus, potassium, humus and acidity. The function standard error of validation from number of factors is shown on Fig. 3.

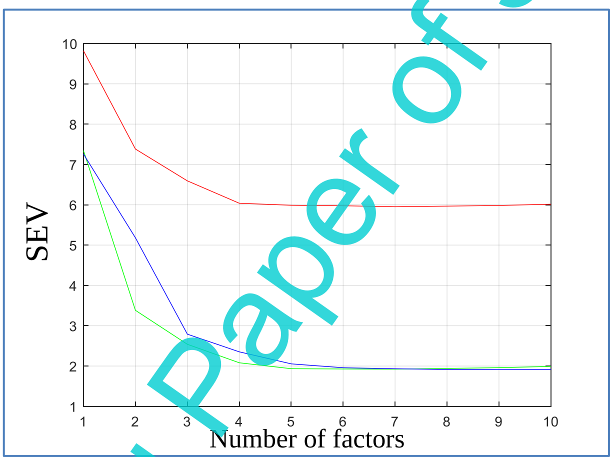
The results show that for the nitrogen the minimum SEV is for MSC and 10 factors. For phosphorus - 2-nd derivative and 6 factors. For potassium - MSC and 9 factors. For humus - MSC and 10 factors. For acidity - 2-nd derivative and 10 factors. It is shown on Table. 1.



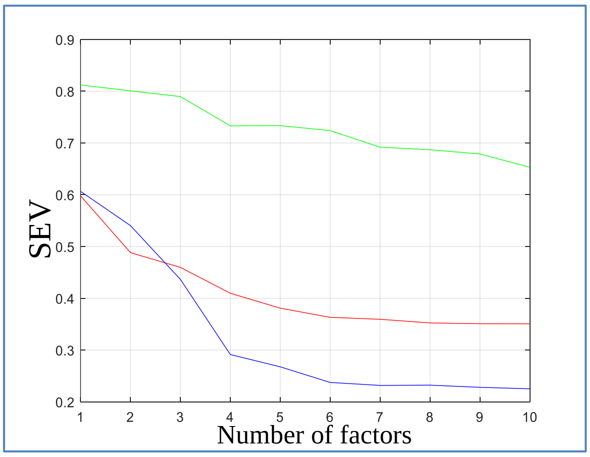
a)



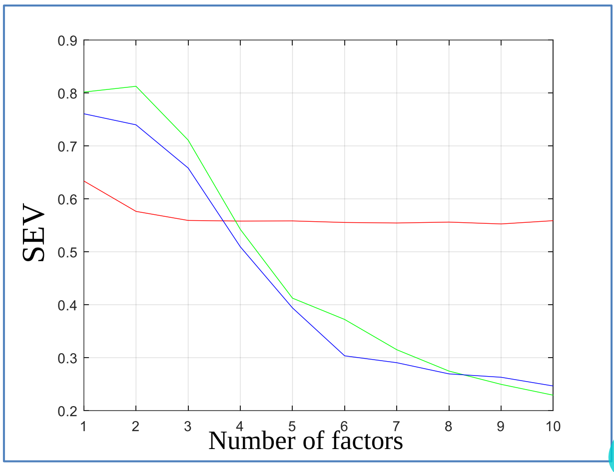
b)



c)



d)



e)

Fig. 3. Standard error of validation as a function of number of factors
a) for nitrogen, b) for phosphorus, c) for potassium, d) for humus, e) for acidity

	1-st derivative	2-nd derivative	MSC
nitrogen	40.4184 (10)	36.4910 (10)	18.7865 (10)
phosphorus	4.9550 (6)	1.2469 (6)	6.3757 (10)
potassium	5.9512 (7)	1.9233 (7)	1.9099 (9)
humus	0.3507 (10)	0.6531 (10)	0.2251 (10)
acidity	0.5526 (9)	0.2291 (10)	0.2465 (10)

Table 1. SEV and factors

5. Conclusion

The spectral characteristics of the soil could be used for soil agrochemical indicators prediction.

The experimental results shows that method PLS and appropriate pre-processing procedures as 1-st derivative, 2-nd derivative and MSC could successfully define the soil indicators.

For the agrochemical indicator nitrogen, the minimum SEV is achieved for MSC pre-processing procedure and 10 factors; for phosphorus - 2-nd derivative and 6 factors; for potassium - MSC and 9 factors; for humus - MSC and 10 factors; for acidity - 2-nd derivative and 10 factors.

These results are of significant importance for the subsequent treatment of soil fields with a view to obtaining high yields and low production losses.

The future work will be focus on models' development for prediction of the indicators and assessment of the accuracy and development of smart farmers information system.

6. Acknowledgments

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