EXAMINATION OF BACKGROUND VARIABLES DURING SOIL PH DETERMINATION BY REMOTE SENSING

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Introduction

Determining soil heterogeneity is an important part of the precision farming that is supported by geoinformatic systems. Our working group was focusing on the development of optical methods to determine the physical and chemical soil parameters. Soil pH is a basic determinant of soil nutrient supply capacity.

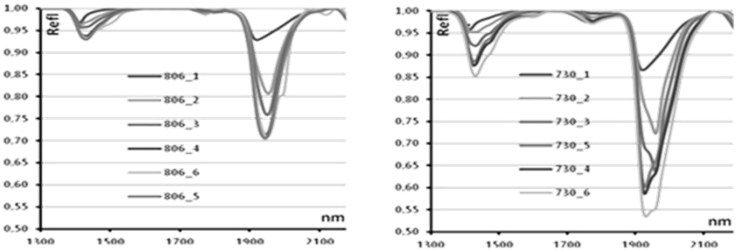
Our research focused on the indirect determination of soil acidity. The examinations were carried out by ASD Fieldspec R3 Max equipment of the Hungarian Institute of Agricultural Engineering, Gödöllő. The equipment was a portable hyperspectral spectroradiometer, by which reflection spectra could be detected on 350-2500 nm. The detections were carried out under precisely set conditions in the laboratory. Our long-term objectives were first to understand and clarify the relationships and then to utilize our experiences by the application of AISA DUAL airborne sensors under field conditions.

When the roots take up the potassium ion, equivalent amount of hydrogen is released at the same time. $K^+ + Cl^- + Root\text{-}H = Root\text{-}K + H^+ + Cl^-$

The acidification effect emerges during the nutrient uptake and results in a process where the equivalent hydrochloric acid replaces potassium chloride.

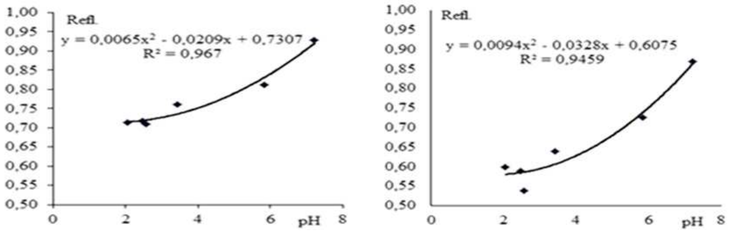
Results and discussion

When examining the effects of humic substances, the impacts are evaluated, ie. the difference between the values resulting from the treatments and the control values are evaluated.



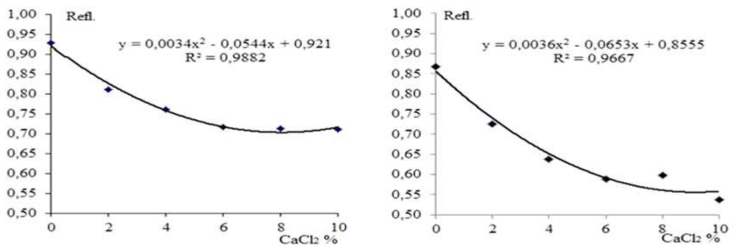
Continuum removed spectra of soil samples which were treated (1 - control; 2 - 25% of $CaCO_3$; 3 - 50% of $CaCO_3$; 4 - 75% of $CaCO_3$; 5 - 100% of $CaCO_3$; 6 - 100% of $CaCO_3$ and added 25% of $CaCl_2$) with acid. Left side: DR (dry soil), right side: AH (air humidity equivalent).

We examined the **correlation between the pH and the absorption peak height** generated by the treatments. We found close quadratic correlation in case of both moisture contents.



Correlation between the absorption maxima (1900-2000 nm) of treated samples and their pH value. Left side: DR (dry soil), right side: AH (air humidity equivalent).

The obvious question arises: whether these close correlations purely originate from pH change? Extremely strong correlation was found between the absorption maxima and the $CaCl_2$ content of the soil samples



Correlation between the absorption maxima (1900-2000 nm) of treated samples and their CaCl2 content. Left side: DR (dry soil), right side: AH (air humidity equivalent).

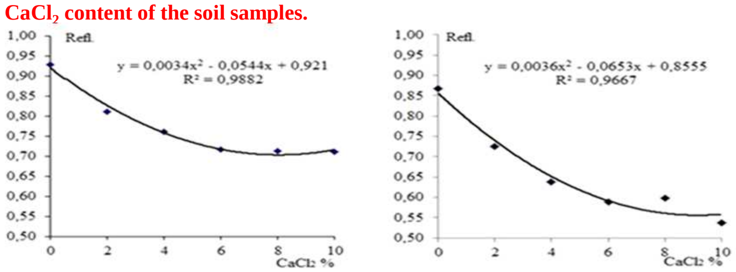
Materials and methods

Sandy soil samples from Fót, North-Central Hungary (Coords 47.617252N, 19.189166E) were applied for the treatments. The main properties of the soil are the following: K_A=28.3 (saturation percentage), lime content, $CaCO_3$% = 8.0 %, pH(KCl) = 7.2, humus content, H% = 1.4 %, AL-P_2O_5 = 95 ppm, AL-K_2O = 120 ppm. Treatments (calculated for 100 g of soil):

No.	Treatments	Added amount of HCl
1.	Control	Soil without any treatment
2.	Acidification	1.46 g HCl *(equivalent for 25% of $CaCO_3$ content)*
3.	Acidification	2.92 g HCl *(equivalent for 50% of $CaCO_3$ content)*
4.	Acidification	4.38 g HCl *(equivalent for 75% of $CaCO_3$ content)*
5.	Acidification	5.84 g HCl *(equivalent for 100% of $CaCO_3$ content)*
6.	Acidification + $CaCl_2$	5.84 g HCl + 2.22 g $CaCl_2$ *(equivalent for 100% + 25% of $CaCO_3$ content)*

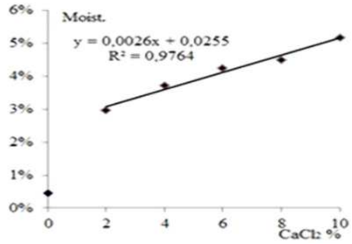
The reflectance spectra of all samples were examined in absolute dry (drying process at 105°C) (DR) and air humidity equivalent state (AH). The spectra were collected with ASD FieldSpec®3 MAX spectroradiometer by using ContactProbe sensor-head in three positions.

Extremely strong correlation was found between the absorption maxima and the $CaCl_2$ content of the soil samples.

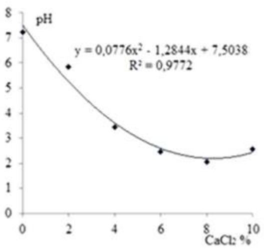

y = 0,0034x² - 0,0544x + 0,921
R² = 0,9882
y = 0,0036x² - 0,0653x + 0,8555
R² = 0,9667

Correlation between the absorption maxima (1900-2000 nm) of treated samples and their $CaCl_2$ content. Left side: DR (dry soil), right side: AH (air humidity equivalent).

Concerning the fact that $CaCl_2$ is a strongly hygroscopic material, these strong correlations refer to the fact that the relation between soil moisture content and optical absorption is behind pH dependence.

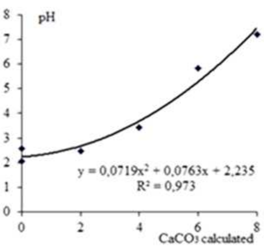


Correlation between the soil moisture content and their $CaCl_2$ content

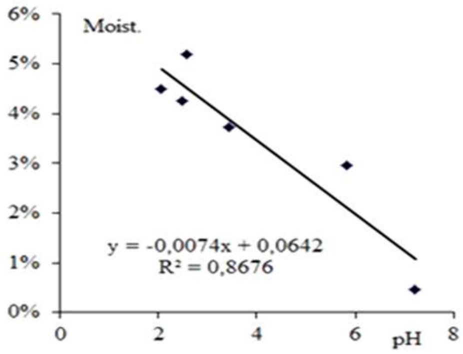


Correlation between the pH and soil $CaCl_2$ content.

Due to the $CaCl_2$ – which is strongly hygroscopic – that is produced as a result of the acid treatment, moisture content and pH value of soil samples cohere.



Correlation between pH and the calculated $CaCO_3$ content.



Correlation between the soil sample moisture content and pH.

Conclusions

It can be assumed that there is such a background variable behind the relationship between the IR absorbance and the pH value that shows strong correlation with both parameters. Based on our examined samples, this background variable can be the soil moisture content. To determine soil moisture by weighing in the laboratory is easy to carry out, however, if we want to develop a method that can be used in precision farming, then the soil moisture content has to be determined by remote sensing. Hyperspectral spectroradiometer can be utilized for such a purpose. However, the differences in soil moisture content result in the change of absorption peak height that can be evaluated well within several wavelength ranges. The most intensive and the most evaluable peak was within the range of 1900-2000 nm.

The general application is made more difficult due to the fact that generally the soil moisture content is even more strongly dependent on the soil humus and clay content.

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