SPECTRAL EVALUATION OF THREE ACIDIFICATED CHERNOZEM SOIL SAMPLES

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Abstract: The improvement of soil fertility plays cardinal role in the precision agriculture. The fertility - and so the nutrition-management – are affected by soil acidity. Based on scientific sources the direct pH assessment of soil with remote sensing technologies is not possible. Accordingly in our study we use an indirect approach of pH determination.
The change of pH value also affects the hygroscopic attribute of soil. In the IR wavelength bands the water shows characteristic absorption features. Based on this changes of moisture content of soil can be detected by means of remote sensing applications.
In our institute - in the University of West Hungary (NYME) - we are working to develop an optical based method for measuring physical and chemical properties of soils, which is suitable for online soil pH measurement. The measurements were made with ASD FieldSpec 3 Max spectroradiometer in the Hungarian Institute of Agricultural Engineering, Gödöllő (VM MGI). The portable spectroradiometer is capable of measuring the spectral reflectance in the wavelength of 350-2500 nm. Measurements were carried out under precisely set laboratory conditions, nevertheless, our long-term aim is to apply and expand the obtained correlations under field conditions, too.
Three acidified chernozem soil samples have been evaluated. We modified the pH or rather the calcium-carbonate content of soil with five different hydrochloric acid treatments and studied the absorption peaks of reflectance spectra in those wavelengths which refer to water. As a result of treatments - in the water content-sensitive range of recorded spectra - the peaks referring to the -OH group were dislocated in various scale. This can be in relation with the change of the quantity of hygroscopic salt (calcium-chloride) which was formed as a result of the acid treatment.

Keywords: remote sensing, hiperspektral, soil, pH, humidity

Introduction

It's important to develop remote sensing test methods for precision agriculture. The wavelength of infrared spectroradiometers used in remote sensing is from 350 to 2500 nm range. The determining information of the mineral composition of the soil can be found in the upper part of the wavelength interval (Kardeván et al., 2000; Kardeván, 2007).
Most of the Hungarian soils are acidic soils. It's important to estimate the extent of acidification because of the appropriate melioration and soil conservation (Várallyay et al., 1980; Várallyay, 2006; Husti, 2006).
Beside the pH examination, the total acidity of the soil can be identified even with direct titration method (Czinkota et al., 2002; Simon et al., 2006; Vágó et al., 2010).which is extremely essential for calculation of liming (Tolner et al., 2008; Vágó et al., 2008).
Determining the pH value of the soil with remote sensing can be a problem because the effects can be combined with the effects caused by the organic matter and clay content of the soil. (Chang et al., 2001). Chang et al. (2005) examined the correlations based on

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400 soil samples. Calibrations were based on partial least-squares regression (PLSR), using the first differentials of log ($1.R^{-1}$) for the 1100 to 2500-nm spectral range.
Based on experiments Seilera et al. (2007) proved that pH change causes change in the concentration of OH group. Acidic soils can contain $CaCl_2$. In these cases there are significant absorption differences in the interval of 1900-2000 nm if the humidity of the soil is different (Tolner et al., 2012).
The water content of the soil samples strongly influences the reflection spectrum (Neményi, 2008; Milics, 2004), so we paid great attention to the drying of the samples.

Materials and methods

We have carried out experiments with three types of chernozem soils from Mosonmagyaróvár. The most important features of the soils are in *Table 1*.

Table 1. The most important features of the soils

Code	$CaCO_3$%	pH(KCl)
T01	14.9	6.36
T05	28.3	7.01
T08	30.4	6.71

We applied hydrochloric-acid on five different levels. The solutions were completed with distillated water to 300 cm^3 in every case. To 500 g soil we used hydrochloric acid whose concentration was 6 $mol.dm^{-3}$ (*Table 2*.)

Table 2. The quantities of the treatments by hydrochloric acid (6 $mol.dm^{-3}$) on 500 g soil.

Treatment	T01 soil		T05 soil		T08 soil	
code	HCl cm^3	HCl/$CaCO_3$ %	HCl cm^3	HCl/$CaCO_3$ %	HCl cm^3	HCl/$CaCO_3$ %
1	0	0	0	0	0	0
2	61.8	50	61.8	26	61.8	24
3	111.2	90	111.2	47	111.2	44
4	123.6	100	234.9	100	252.5	100
5	136.0	110	258.3	110	277.8	110

After intensive mixing we dried the samples on 110°C and we prepared them with 2 mm sieve. We examined pH (KCl) values in KCl (6 $mol.dm^{-3}$) dilutions. The soil solution rate was 1:2.5. We repeated the spectrum recordings for half an hour, meanwhile we checked the mass increasing caused by increasing humidity with scales. The spectra were taken with a portable hyperspectral spectroradiometer ASD FieldSpec®3 Max. This device belongs to the Hungarian Institute of Agriculture Engineering. We applied continuum removal at data processing.

Results and discussion

During the half an hour measuring the change of soil mass is less than 0.03% due to the humidity from the air. That is why we did not analyze the effect of moisture during the

test. The average spectra after continuum removing are shown in *Figure 1*. (T01 soil, T05 soil, T08 soil)

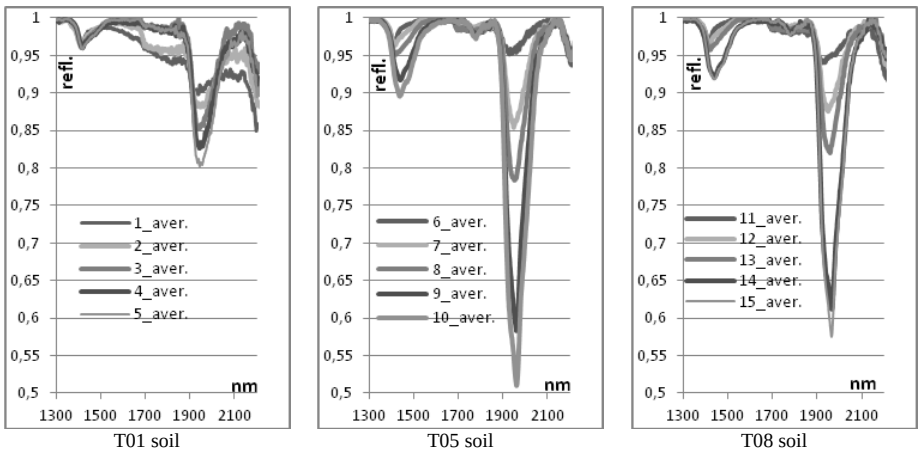

Figure 1. The average spectras after continuum removing spectra on three types of soils

We found increasing absorption in range 1900-2000 nm due to increasing acid treatments. We have examined the correlation between absorption maximum values and pH(KCl). We got the following linear function (*Figure 2.a*).

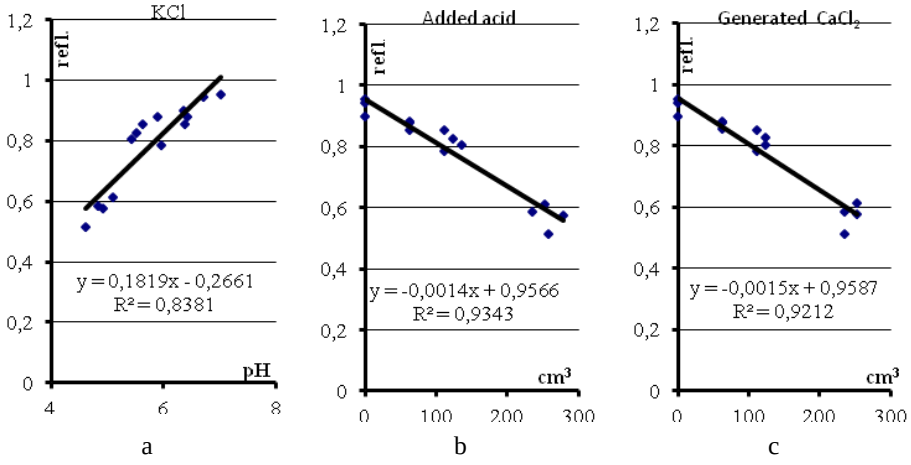

Figure 2. The correlation between absorption maximum values and the examined factors. The 3 examined factors are pH(KCl) (a), added acid (b), and the resulted $CaCl_2$ (c) quantities

The connection with pH is strong (R^2=0,8381) but the effect is due to indirect effects of other factors. The studied range of wavelength features an absorption peak characteristic for the water content of the sample. Studying the correlation between the absorption

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maxima and the additional acid or the quantity of $CaCl_2$ formed a stronger correlation (R^2=0.9343, R^2=0,9212) was established than that with the pH(KCl). (*Figure 2.b, 2.c*)

Conclusions

The moisture-preserving ability of the soil can be influenced by acid treatment. IR absorption can be utilized to study the water content of the soil, and from the data obtained we can draw conclusions about the pH of the soil.

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