Evaluating the effect of acidity on the optical characteristic of a soil sample

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Summary: Diagnosing soil parameters is very important part of geology, agriculture and environment protection, too. Compared to the conventional methods, the hyperspectral remote sensing makes possible to evaluate the topsoil of large areas in fast and economic way. The spectroraimeter of the Hungarian Institute of Agricultural Engineering is capable of gathering spectral information in the wavelength of 350 and 2500 nm. The spectral information referring to soils are usually studied in the upper range of this interval. Detection of soil acidity with remote sensing is not easy because practically we can only analyse the indirect effects of the pH change by measuring the characteristic of the reflected light from the surface of the soil. As a result of the chemical reaction during the pH change new formation of molecules, molecule parts and ions are modifying the reflection parameters of the soil and this alteration can be measured. Through these changing factors we can conclude to the level of the soil acidity. In the following experiment we are examining the reflectance spectrum of one soil sample in laboratory. In order to make various pH levels the soil samples were treated differently with hydrochloric acid. As a result of the treatment the spectrums had modified. The spectral interval referring to the OH group showed significant dislocation.

Keywords: hyperspectral technology, soil acidity

Intoduction

Diagnosing soil parameters is very important part of geology, agriculture and environment protection, too. Compared to the conventional methods, the hyperspectral remote sensing makes possible to evaluate the topsoil of large areas in fast and economic way. The hyperspecrtal equipments (AISA DUAL airborne sensors, ASD FieldSpec®3 Max portable field spectoradiometer) of Agricultural Engineering is capable of gathering spectral information in the wavelength of 350 and 2500 nm. The spectral information referring to soils are usually studied in the upper range of this interval (Kardeván 2000, 2007). Detection of soil acidity with remote sensing is not easy because practically we can only analyse the indirect effects of the pH change by measuring the characteristic of the reflected light from the surface of the soil. The experiments of Bruno (2007) proved that the quantitative changes of OH group are resulting changes in characteristic of light reflection, which can be measured. The quantity of the OH group is correlating with the amount of the acid groups of the soil, too. The differing pH value samples were generated with various hydrochloric acid treatments of one soil sample. In the course of the experiment we the changing of the water absorbing ability of the soil was observed. The water content of the samples strongly influenced the reflection (Neményi 2008, Milics 2004). Therefore we especially paid attention to the desiccation of the examined samples. In the following experiment we are examining the reflectance spectrum of different pH value template of one soil sample in laboratory.

Material and methods

The soil samples were collected from the experimental area (Kiszombor) of the Cereal Research Non-Profit ltd, Szeged. During the sampling process the soil was covered with wheat varieties therefore field evaluation of the soil was not carried out. The samples were grinded, dried and sifted to 2 mm granule size. Different pH value templates were made by various acid treatments by combining smoothly 100 g soil with 100 cm^3 hydrochloric acid, than dried them at 105 °C. The samples were cooled down and stored until the measuring in desiccator. The measuring was carried out with absolute dry samples. R eferring to 100 g soil the acid treatments were the followings: 0, 5, 10, 20 mmol. The spectrums was recorded in a light isolated laboratory box. The specially covered interior of the box (from 350 up to 2500 nm interval shows 0.02 reflectance) and the proper arrangement makes possible to minimize the unfavourable environmental effects. Though the dust, the heat of the illumination and the water absorption of the soil are present, they can be considered as constant, negligible factors. The experimental arrangement is presented on the following picture (*Figure 1.*).

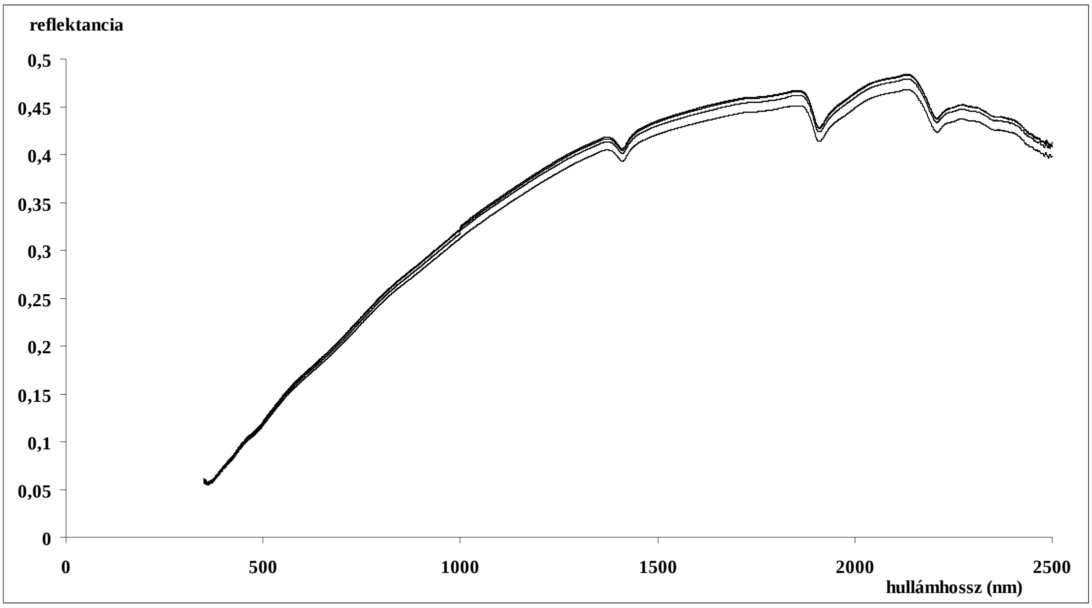
Figure 1.
Experimental arrangement: left side the target tray, above the sensor and right side the light source.

Every sample was measured four times by rotating them with 90 degrees (0, 90, 180, 270). 10 spectrums were recorded (in the whole wavelength of 350-2500 nm) per every measuring, each were composed from 50 scans. The reflectance measurements were calculated from the ratio of reflected light from the certain soil samples and the white reference values.

Results and discussion

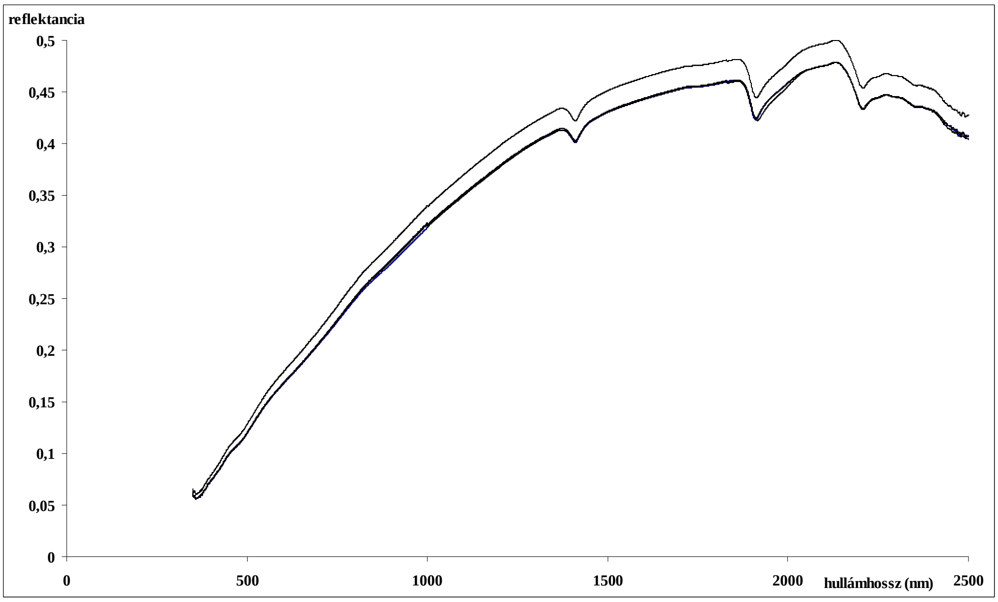
The means of the 50 scan were studied according to its deviations. The value of the standard deviation at the treatment of the distilled water was 0,0005 in reflectance. The same sample that was rotated by 90 degree resulted 0,0057 reflectance value. The difference is illustrated on the following graph (*Figure 2.*).

Figure 2.
The curves of the soil samples which were treated with distilled water and rotated four times by 90 degrees. (The lowest curve 0 degree, the next 90 degree, the upper shows the reflectance gained by 180 and 270 degree rotation)



The order of the difference is similar to the changes resulted by the various acid treatments which is presented on the following graph (*Figure 3.*), where the curves of reflectance are illustrating the 0, 5, 10 and the 20 mmol acid treatment referred to 100g soil sample.

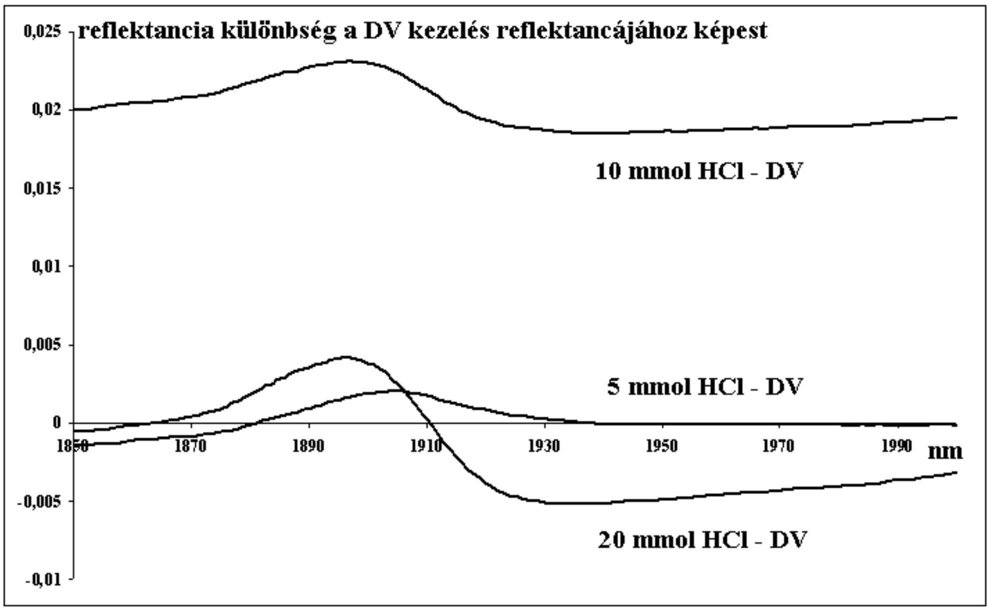
Figure 3.
Means of the recorded reflectance curves resulted by various hydrochloric acid treatments. (The lower curve represents the 0, 5 and the 20 mmol, while upper represents 10 mmol acid treatments)



This is proved by the result of the standard deviation between the four acid treatments 0,0093, which is not significantly higher than the on received between the rotated versions 0,0057. The highest reflectance curve was recoded at the treatment of 10 mmol hydrochloric acid, while the others, including the control were resulted coherent spectrums. At first sight there is no correlation between the treatments and the reflectance spectrums.

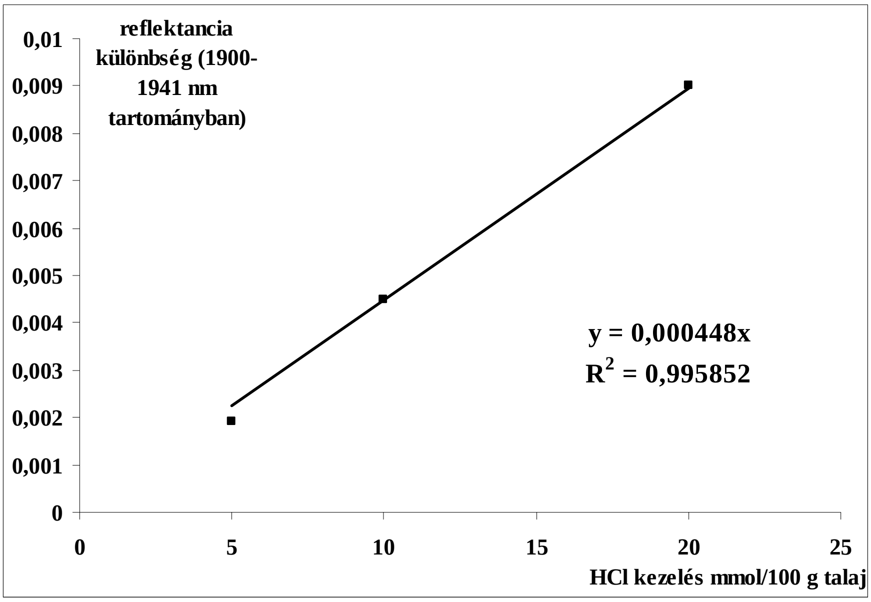
The analyses of the difference between the treated sample spectrums and the control spectrum (treated with distilled water) showed that a certain segment of the spectrum is very informative (*Figure 4.*).

Figure 4.
The informative segment of difference spectrums regarding the control treatment's spectrum



The absolute position of the difference spectrums referred to the x axis not, but the wave-like change is representative to the acid treatment. By evaluating the wavelength between 1900 and 1941, we found significant linear correlation with the levels of treatments (*Figure 5.*)

Figur 5.
Correlation between the treatments and the reflectance spectrums between 1900 and 1941 nm



Conclusions

As a conclusion it can be stated that in laboratory circumstances, working with absolute dry soil samples a wavelength characteristic to the certain soil acidity was identified. At this wavelength the treated soil sample's reflectance compared to the reflectance spectrum of the control (distilled water) treatment are correlating with the rate of the hydrochloric acid treatment.

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