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

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Gábor Baross programme

Established by the support of the National Office for Research and Technology.

NKTH

Intoduction:

Finding diagnostic soil parameters is equally important in geology, agricultural and environmental sciences. The hyperspectral remote sensing technology makes possible to evaluate the topsoil of large areas in a fast and economic way as compared to the conventional methods. The airborne hyperspectral imaging sensor AISA DUAL and the ASD FieldSpec®3 Max portable field spectroradiometer operated in the Institute of Agricultural Engineering are capable of gathering spectral information in the wavelength range of 350nm to 2500 nm. The spectral information referring to the soil's is specific to the mineral composition and can be found usually in the upper range of this interval (Kardeván 2000, 2007). Detection of soil acidity with spectral remote sensing is not easy, because indirect effects of the pH changes can only be analysed by measuring the reflectance spectra from the surface of the soil. The experiments of Bruno (2007) proved that the quantitative changes of OH group concentration cause changes in reflectance spectra, which can be measured. The quantity of the OH group is correlating with the amount of the acid groups of the soil, as well. The samples with different pH value were produced with varying hydrochloric acid treatment of the soil samples. In the course of the experiment, a change in 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 experiment described below, we have analysed in laboratory the reflectance spectra of different pH values of the same soil sample.

Materials and methods:

The soil samples were collected from the test area Kiszombor, of the Cereal Research Non-Profit Ltd, Szeged. During the sampling process, the soil was covered with wheat varietys, therefore field evaluation of the soil spectra was not carried out. The samples were grinded, dried and sifted to a grain size of 2 mm. Different pH values were produced by various acid treatments by mixing smoothly 100 g soil with 100 cm3 hydrochloric acid, than dried them at 105 °C. The samples were cooled down and stored until the measuring in desiccator. The spectral measurement was carried out on dry samples. Referring to 100 g soil, the acid treatments with parameters of 0, 20, 40, 100 mmol were used. The spectra were recorded in a closed laboratory space, in which external light sources were totally excluded. The specially covered internal walls of the closed space showed an overall reflectance factor of 0.02 (from 350nm up to 2500 nm)). With proper geometrical arrangement, minimization of the undesired environmental effect could be achieved. Though the dust, the heat of the illumination source and the water absorption of soil are present, they can be considered as constant factors during measurements. The experimental arrangement is presented in Figure 1.

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

Each soil samples were measured in four positions by rotating them with 90 degrees (0, 90, 180, 270). Soil sample measurements covered 10 individual spectral sampling each being composed of 50 scans. The reflectance factors were calculated from the ratio of radiance reflected from the soil samples to the ones of a white reference panel.

Results and discussions:

The reflectance spectra of the soil samples was measured in 4 positions. We calculated the averages of these spectra. First we analysed the dry samples. In Fig 2, the effect of changes in reflectance spectra resulted by the various (0, 20, 40 and the 100 mmol) acid treatments are shown.

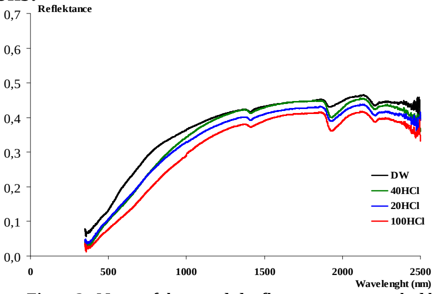

Figure 2. Means of the recorded reflectance curves resulted by various hydrochloric acid treatments on dry samples. (The upper curve represents the Distilled Water , while lower represents 100 mmol acid treatments)

The highest reflectance curve was recoded at the control treatment of distilled water, while the others were resulted in spectrums with different off-sets. At first sight, there is no correlation between the treatments and the reflectance spectra. The analyses of the difference values between the acid treated sample spectra and the control spectrum (treated with distilled water) showed, however, that a certain segments of the spectrum is very informative (Figure 3.).

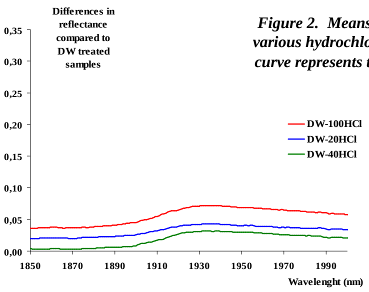

Figure 3. Informative segments of difference spectrums regarding the control treatment's spectrum on dry samples.

The wave-like variation of the difference curve is representative to the acid treatment. By evaluating the differences in the wavelength range between 1900 and 1930 we found non linear correlation with the levels of treatments (Figure 6.).

After that we also analysed the wet samples. In Fig 4, the effect of changes in reflectance spectra resulted by the various (0, 20, 40 and the 100 mmol) acid treatments are shown.

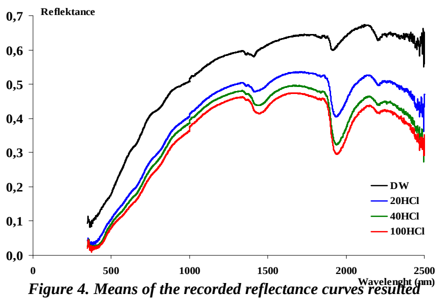

Figure 4. Means of the recorded reflectance curves resulted by various hydrochloric acid treatments on wet samples. (The upper curve represents the Distilled Water , while lower represents 100 mmol acid treatments)

In the cases of the wet samples the highest reflectance curve was also recorded at the control treatment of distilled water, while the others were resulted in spectrums with different off-sets. At first sight, there are no correlations between the treatments and the reflectance spectra. The analyses of the difference values between the acid treated sample spectra and the control spectrum (treated with distilled water) showed, however, that a certain segments of the spectrum is very informative (Figure 5.).

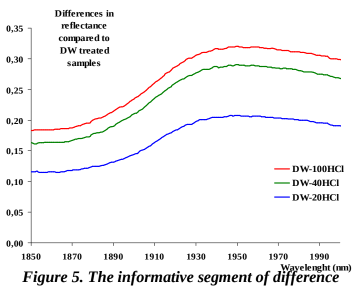

Figure 5. The informative segment of difference spectra regarding the control treatment's spectrum on wet samples.

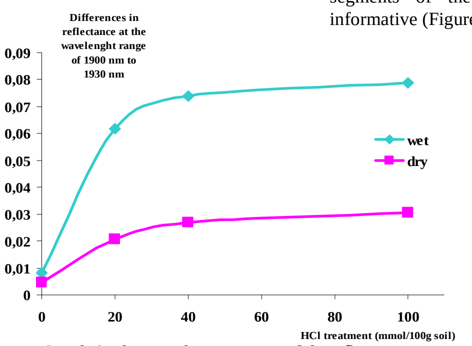

Figure 6. Correlation between the treatments and the reflectance spectra 1900 nm and 1930 nm on dry and wet samples.

The wave-like variation of the difference curve is representative to the acid treatment. By evaluating the differences in the wavelength range between 1900 nm and 1930 nm we found non- linear correlation with the levels of treatments (Figure 6.) too.

Conclusions:

As a conclusion it can be stated that in laboratory, working with dry soil samples suitable wavelengths can be identified. At this wavelengths the reflectance factor differences of the treated soil sample's compared to the ones with control (distilled water) treatment are correlating well with the rate of the hydrochloric acid treatment