INVESTIGATION ON THE INDIRECT CORRELATION AND SYNERGISTIC EFFECTS OF SOIL pH AND MOISTURE CONTENT DETECTED BY REMOTE SENSING

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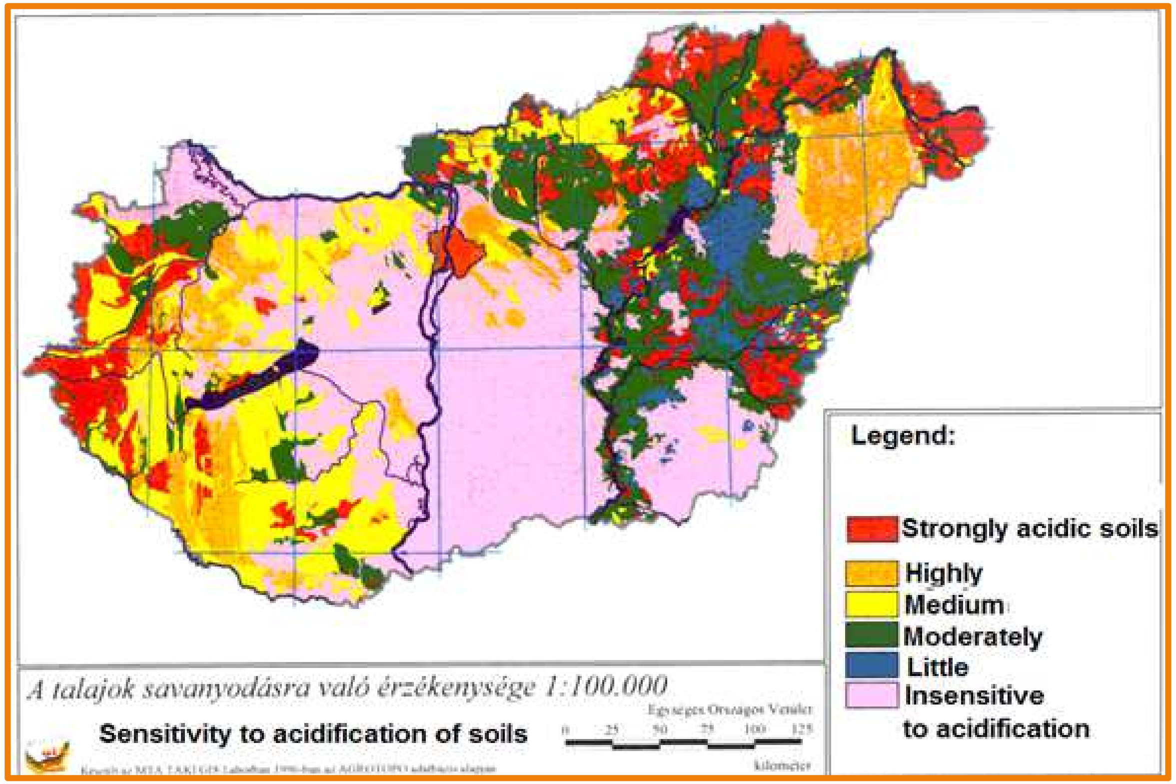
15th ALPS - ADRIA SCIENTIFIC WORKSHOP - FROM SOIL TO FOOD

I. Introduction

- The vast majority of Hungarian soils are acidic.
- In order to the appropriate amelioration and soil conservation it is important to estimate the extent of acidification



source: http1

Soil pH

- Sources of acidity
  - High rainfall
  - Fertilizer use
  - Plant root activity
  - Weathering of minerals
  - Acid rain

- Importance of soil pH:
  - Direct: Nutrient availability, chemical reactions, microbiological activity, mobility of pollutants
  - Indirect: Effect on behavior of colloids, effects on soil structure

- Conventional laboratory tests:
  - Total acidity can be measured by the titration of soil suspension
  - Principle of this methods: pH level of the suspension is kept at constant level during the titration

About remote sensing

- Advantages of remote sensing for land evaluation
  - Relatively cheap and rapid method of acquiring up-to-date information over a large geographical area
  - There is no direct link between the meter and the test object
  - Phenomena can also be observed even which are invisible to the human eye
  - We can measure in various highs, any time desired and at any wavelength ranges
  - Condition changes in time scale can be tracked easily
  - It enables homogeneous sampling on a large area
- By the spread of precision agriculture the development of analytical methods using remote sensing has become important

II. Materials and methods

- Measuring device: ASD FieldSpec ® 3 Max **spectroradiometer** with ContactProbe sensor-head
  - From the Hungarian Institute of Agricultural Engineering
  - Can collect data from the soil surface on large area
  - Spectral wavelength range from 2500 to 3500 nm
- Measured parameters:
  - Soil pH
  - Moisture content
  - + caclulated: $CaCO_3$ content

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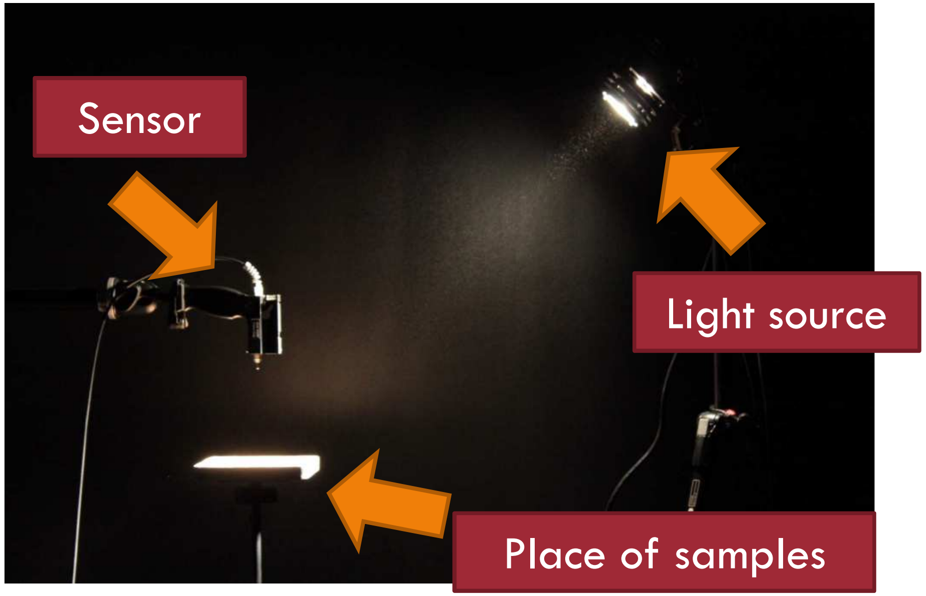
Measuring method

- The measurements were done in laboratory in, the device was set up in a darkroom
- Average spectra was composed from ten measurements in three positions with twenty scans each
- During processing the reflectance spectra we performed continuum removal



ASD FieldSpec ® 3 Max spectroradiometer by using ContactProbe sensor-head

Soil

- **Soil** samples were taken from Fót, North-Central Hungary, with main properties:
  - Sandy soil
  - Saturation percentage: K_A=28.33
  - lime content: $CaCO_3$% = 8.0 %
  - pH(H_2O)= 8.2, pH(KCl) = 7.2
  - humus content: H% = 1.4 %
  - AL-P_2O_5 = 95ppm, AL-K_2O = 120ppm

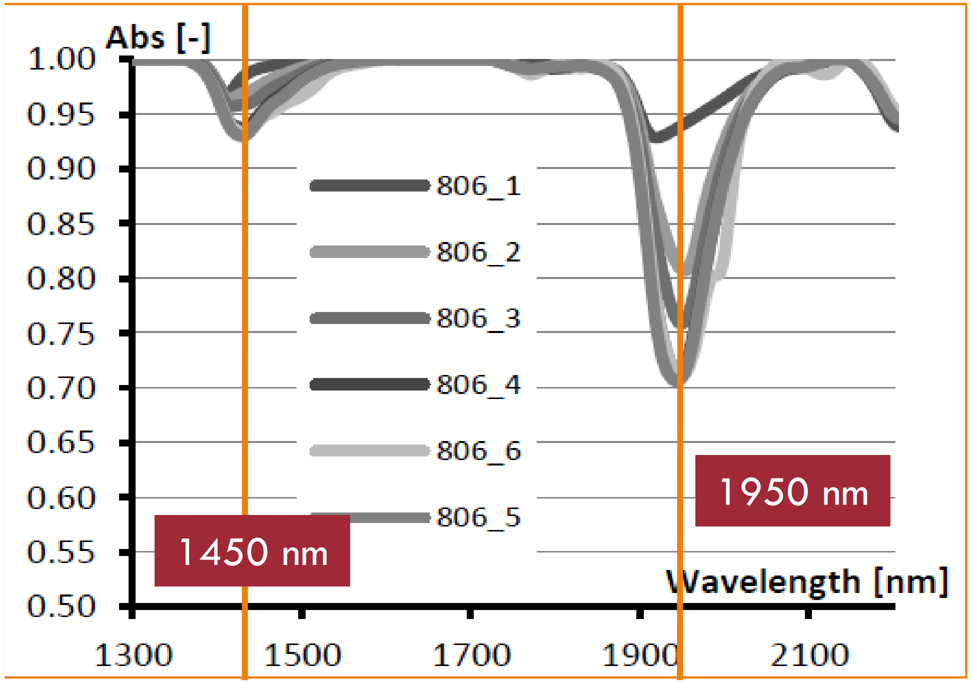
Treatments

- Reflectance spectra of all samples were examined
  - In absolute dry state (drying process on 105°C for 24 hours) and
  - In air humidity equivalent state (in balance with the laboratory's air humidity)
- All measurements were carried out in duplicates
- The treatments (calculated for 100 g of soil) are summarized in the following table:

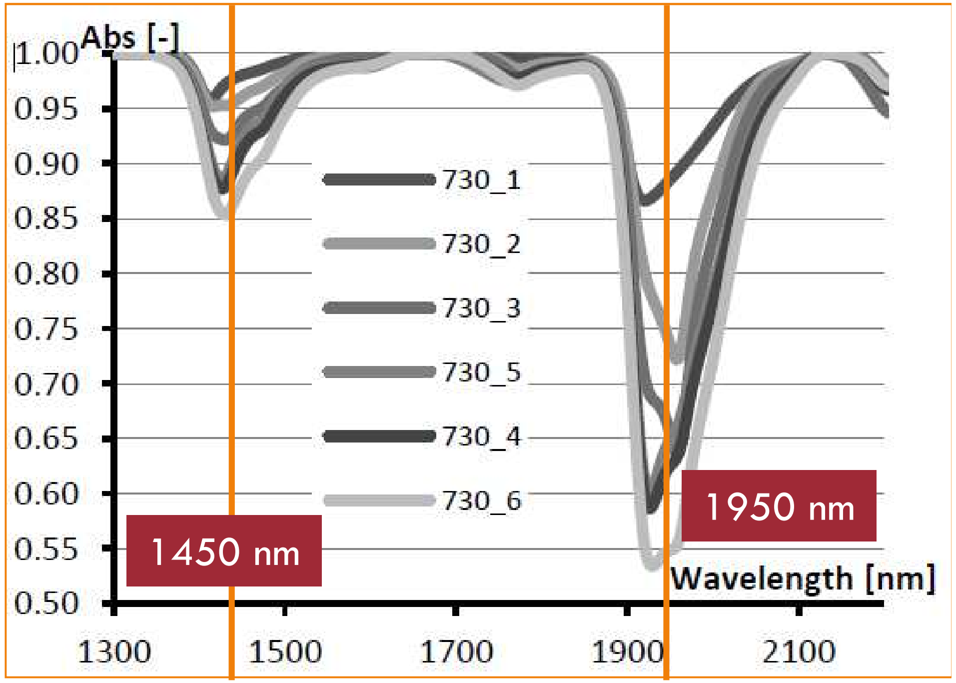
No.	Treatments	Added amount of HCl
1	Control	Soil without any treatment
2	Acidification 25	1.46 g HCl (equivalent for 25% of $CaCO_3$ content)
3	Acidification 50	2.92 g HCl (equivalent for 50% of $CaCO_3$ content)
4	Acidification 75	4.38 g HCl (equivalent for 75% of $CaCO_3$ content)
5	Acidification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

III. Results

Continuum removed spectra of soil samples



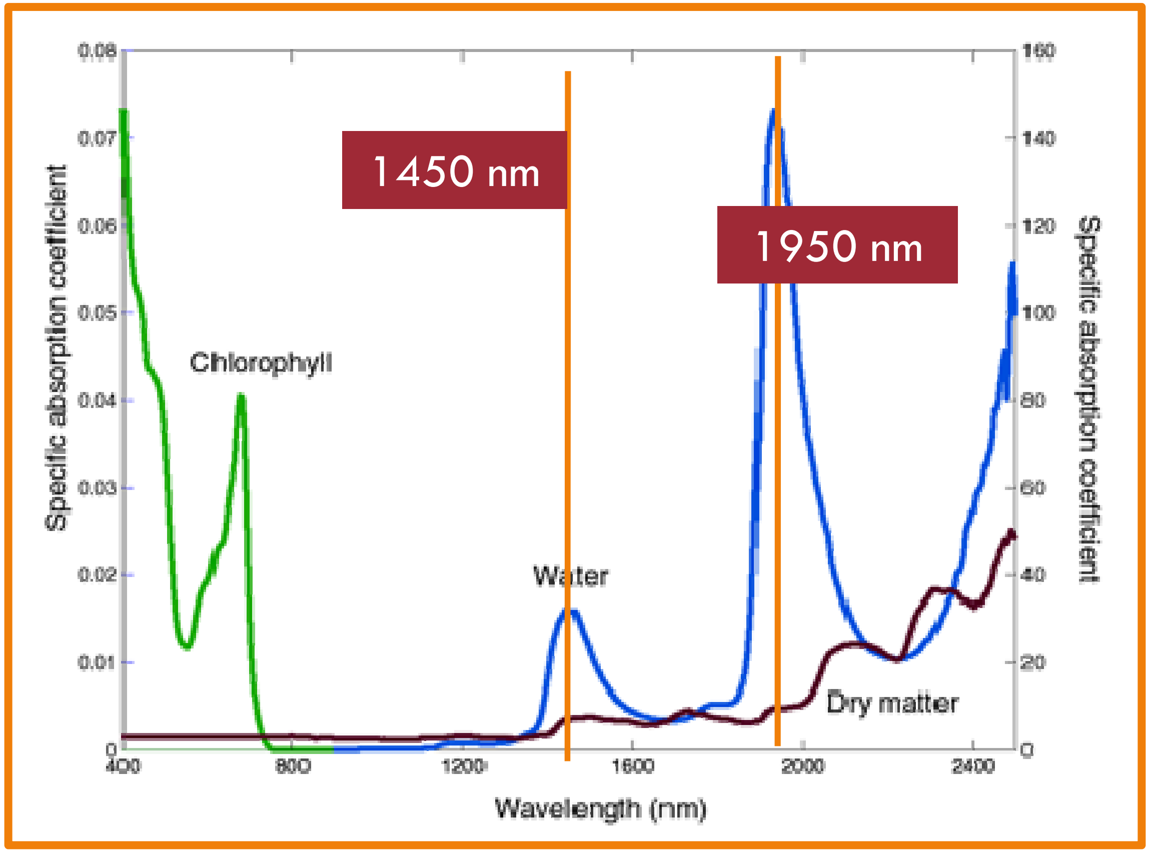
Dried soil samples



Air humidity equivalent soil samples

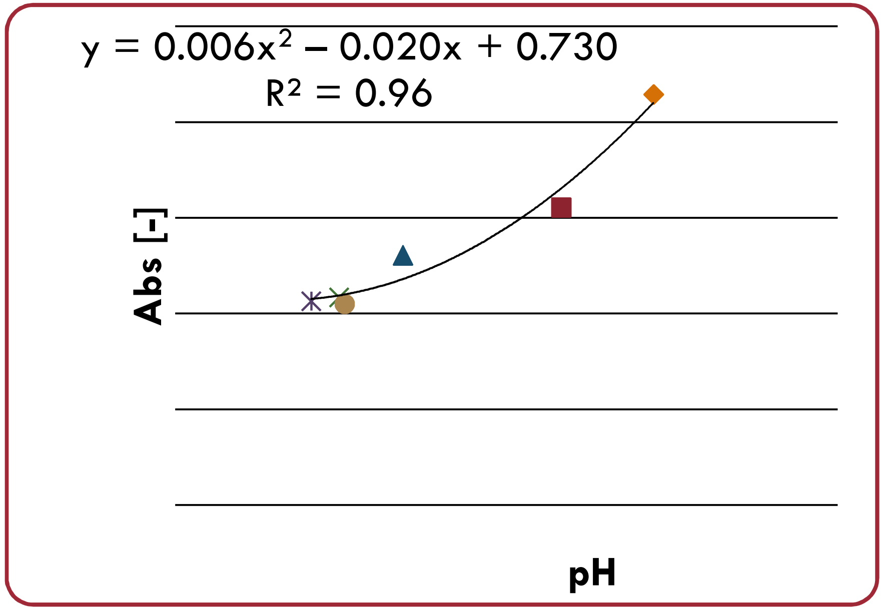
- We applied approximately proportional hights to the area under the peaks in order to the quantification
- Typical water characteristic adsorption peaks were found between 1900 and 2000 nm
- These were dependent on the definite treatment

Specific absorption coefficient of water

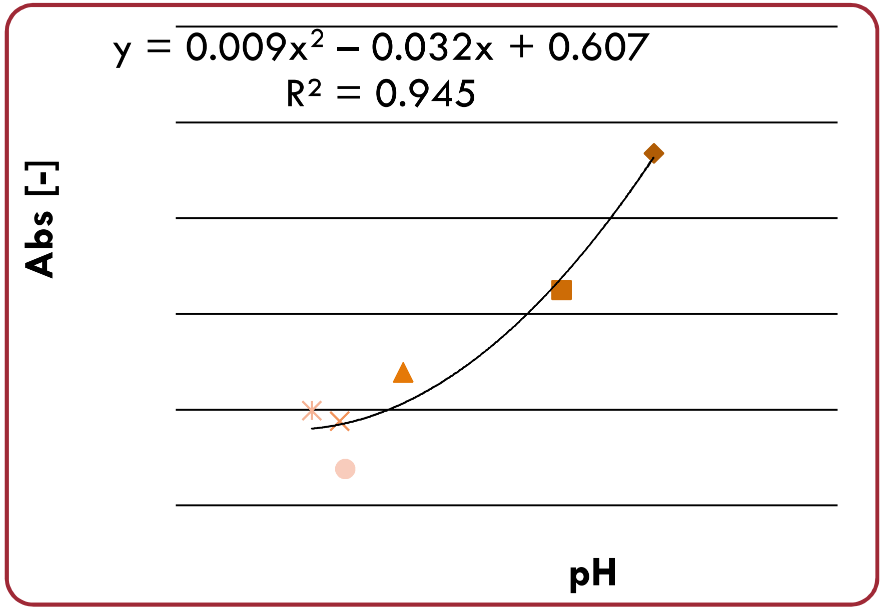


Source: Jacquemoud & Ustin (2008)

Absorption maxima and pH



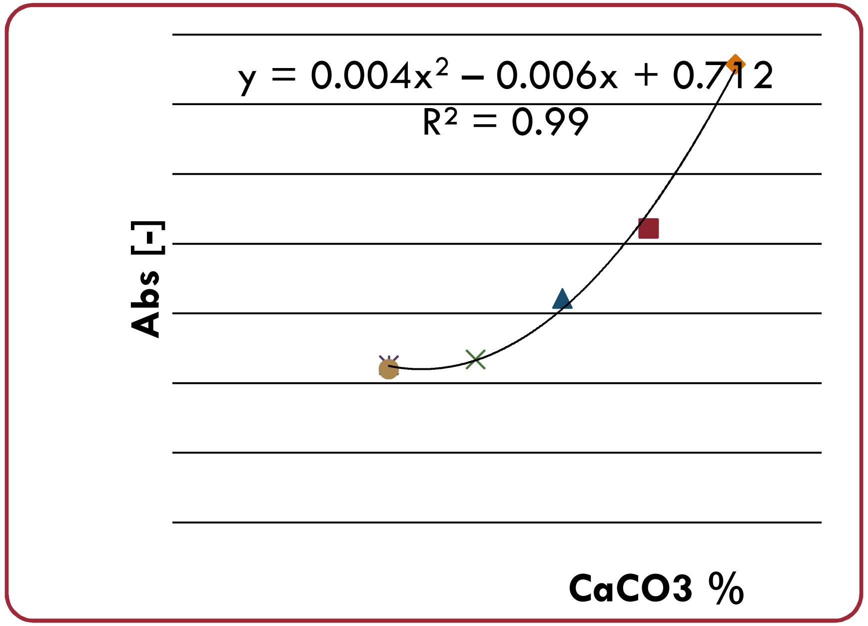
Dried soil samples



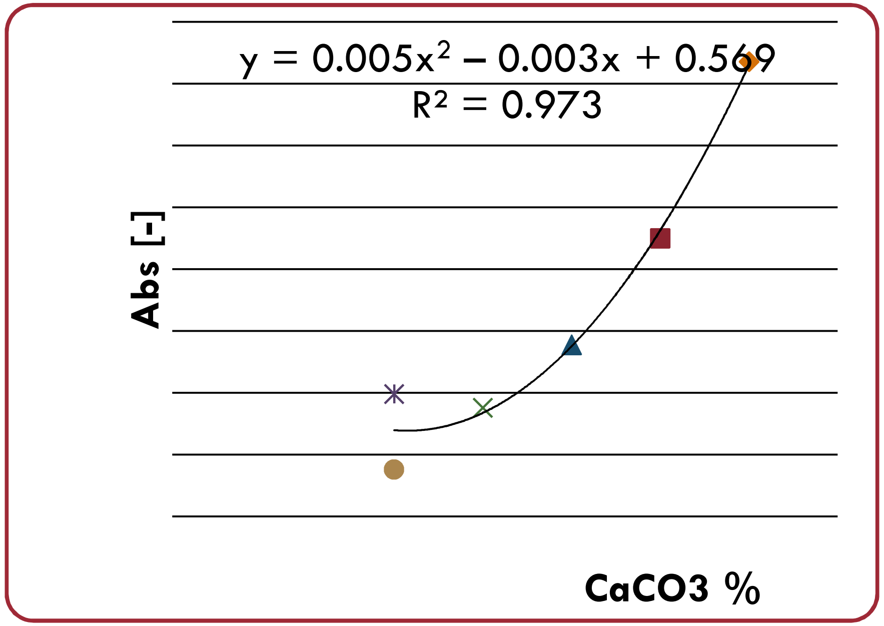
Air humidity equivalent soil samples

- A close quadratic correlation was found in case of both moisture contents
  - (R^2=0.967, R^2=0.946).
- The question may arise rightfully: can this correlation be attributed clearly to pH?

Absorption maxima and calculated $CaCO_3$



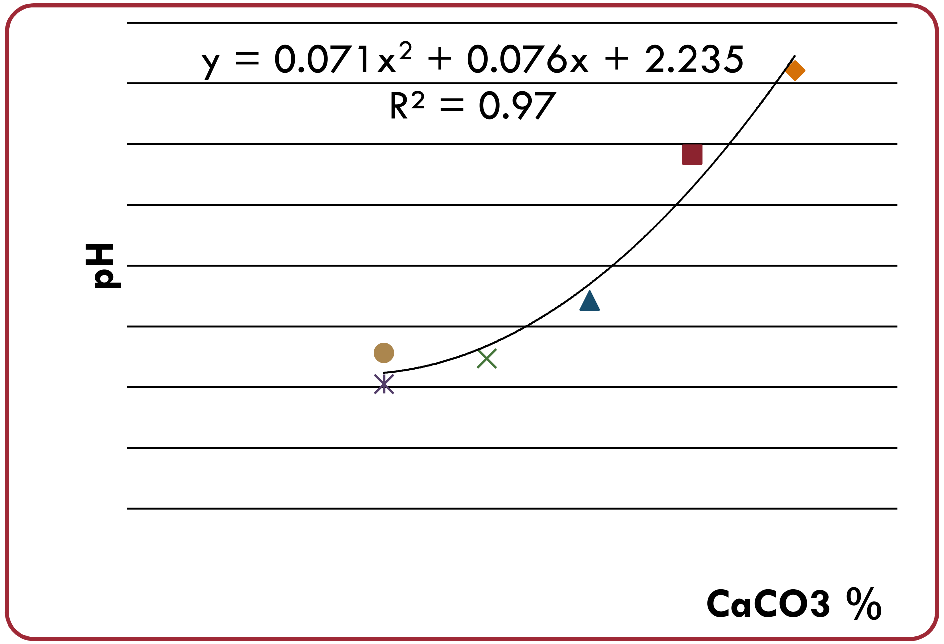
Dried soil samples



Air humidity equivalent soil samples

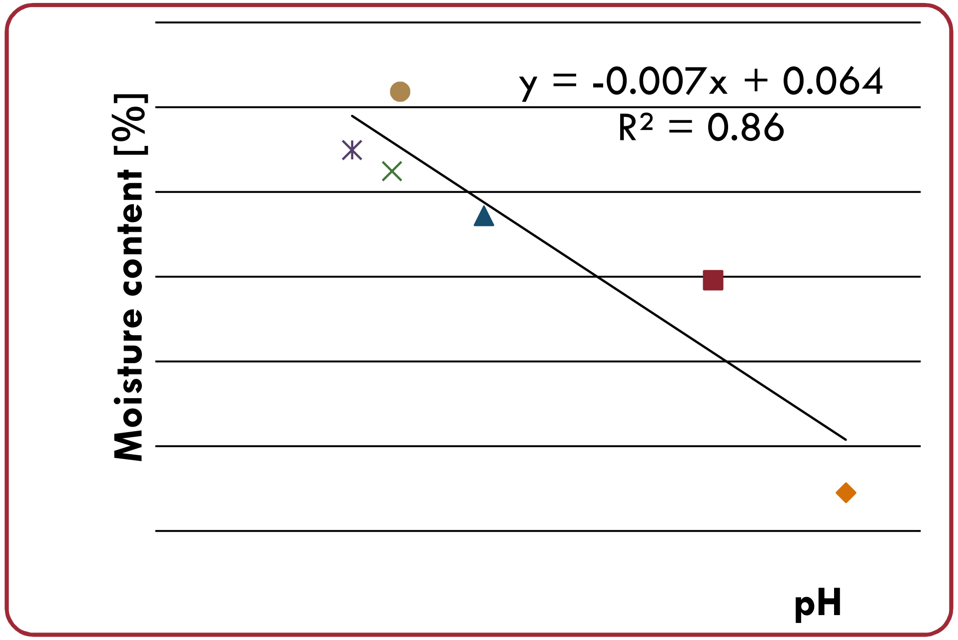
- According to our results we examined the correlation with some other factors too. Acidic treatment resulted a decrease in CaCO3 content of soil samples. We also found a very close correlation between this calculated date and the height of the absorption peaks

Correlation between pH and the calculated $CaCO_3$



- It is well known that lime content and pH of the soils have a strong correlation which was detected on our samples too

Correlation between pH moisture content



- Since $CaCl_2$ is formed during the acidic treatment there is a correlation between the pH and moisture content of soil samples also resulted by the dehydrating effect of $CaCl_2$

IV. 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

V. Acknowledgement

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- The instrument used for the measurements was provided by the Hungarian Institute of Agricultural Engineering, Gödöllő.

Thank you!

VI. List of references

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