MODERN TECHNIQUES FOR INVESTIGATION OF SOME OF THE SOIL PHYSICAL PROPERTIES

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Abstract

The protection of soils and thus maintaining the ability to perform their ecological function requires careful analysis of the soils properties. The diversification of protection and de-pollution techniques of the soil determines the development of investigation techniques, both of the composition and of the soil characteristics.In this regard, experiments performed in the Laboratory of Soil Science from the Technical University "Gheorghe Asachi" University, and other institutions with which the University has collaborative relationships represents an important contribution to the development of research methodology of soil for various purposes. Some of the most significant results were obtained in soil physics and refers to: the use of infrared spectrometry in research of soil matrix composition, the study of soil porosity by electron microscopy and medical imaging technique, the experimental determination of hydraulic conductivity of soil and the use of mathematical models in research on aero-hydric soil regime.Themineralogical composition of the clay in soil was studied using IR spectra obtained with a Shimadzu spectrophotometer Iraffinity-1. Colloidal inorganic matrix or clay, as it is commonly called, has a number of properties which are a result of the characteristics of its components. The quality of the clay can be established by identification of these components and their proportions. Clay minerals identified in studied clay soils are: illite, smectite (montmorillonite), kaolinite and chlorite. In addition, spectrometry revealed the presence of vermiculite elements or poorly expressed inter-stratifications.QUANTA electron microscope 3D Dual Beam 200, used in the study of the soil porosity, is a combination of two systems:- SEM is an electron microscope that produces enlarged images of a variety of samples performing a magnification of over 100,000x at a high resolution digital format.- FIB is an ion beam system that provides high resolution images.In the field of soil science, for research on porous environment, axial tomography using X-ray (X-ray computer tomography - CT) or Gamma is a highly effective and innovative method for investigating soil structure, spatial distribution of porosity and ground water content.Experimental determination of the soil hydraulic conductivity was made on a modern complex installation, having the possibility of recording data and their automatic processing.Land MOHID software was used to simulate water flow through porous media (soil). It solves the Richards equation for saturated and unsaturated porous media. Currently, soil hydraulic properties are described by using the Van Genuchten equation. However, the model is prepared, where appropriate, to include any model which describes water content and the hydrostatic pressure or the relationship between the conductivity and hydrostatic pressure, respectively. The simulation results showed that the MOHID Land computer program, with adjustments made by Porous Media Module Properties, PREEQC and Sediment Quality, is a pertinent tool for analysing issues like: soil water dynamics, transport of solutions and transformations undergone by the different substances and some components of the air from the soil.For the soil water dynamics simulation using Land MOHID software, it is necessary that the input data such as rainfall, irrigation and soil characteristics (hydraulic parameters) to be representative in the studied area and obtained as result of high rank analysis and quality studies. The conclusions emphasize the importance of results and contributions to the development of knowledge, which are appreciated as result of a coherent and relevant analysis of the scientific literature.

Key words: soil, properties, MOHID, software, microscopy.

INTRODUCTION

The physical properties of the soil have a decisive role on the water and air regime in the soil. In recent decades, for this reason, the research in the area aimed, among other things, a continuous improvement of their investigation methods. Out of these properties, porosity, hydraulic conductivity and matrix composition represented priorities for research in the laboratory of Soil Science, Faculty of Hydrotechnics, Geodesy and Environmental

Engineering from Technical University "Gheorghe Asachi" of Iasi.

RESEARCH IN SOIL POROSITY

1. Study of soil porosity by electron microscopy

1.1. Description of Quanta 200 3D Dual Beam microscope

The electron microscope QUANTA 200 Dual Beam 3D (Figure 1) is a combination of two systems:

- SEM is an electron microscope that produces enlarged images of a variety of samples giving a magnification of 100000 x at a high resolution and in digital format.

Figure 1. Quanta 200 3D Dual Beam Microscope

The integration of the two systems provides a powerful analytical tool for obtaining any information, from any sample, in three dimensions.

Users can switch between the two beams for a fast and accurate navigation and grinding. SEM and FIB convergence to a shorter working distance allows an accurate "slip and watch" of the analysed section at high resolutions. The workstation provides an optimum between processed materials, resolution and automation. The standard presentation of Quanta 200 3D system is based on a dedicated controller microscope together with power supply panel of the microscope's console (vacuum gun, column and platform).Computer's support contains various other parts that are generally accepted as essential or are dedicated to particular applications such as forensic analysis and material defects. User interface devices

are the peripherics of microscope's controller, the software and the hardware.

The FIB/SEM workstations provide a wide range of possibilities that would not be possible with FIB and SEM separate tools:

- High resolution images of the electron beam FIB section, without erosion of interest characteristics;
- Photos and videos of the real-time electron beam sections during milling with ion beam;
- Neutralization of focused electron beam charge during FIB milling;
- Elemental high resolution microanalysis of cross-sectional defects;
- Surface imaging of samples with electron beam during navigation without erosion or implantation of gallium ion beam;
- On site preparation of TEM Samples by conductive coating.

Increasing the desktop image size - scanned area ratio of the sample. A higher magnification is achieved by reducing the size of the scanned area of the sample.

Quanta 3D supports two visualization sizes: Quad and Full Screen modes. Zoom for current display is always set in data bar, so a 500x image in Quad mode is 1000x in full screen mode, the size being thus doubled.

Digital Scanning provides a complete digital image, the image capture being performed by scanning, in a fraction of time, at a high resolution in pixel format. The samples are replaced through a chamber door that, when opened, provides access to the sample platform (Figure 2). Replacing the sample takes a few minutes.
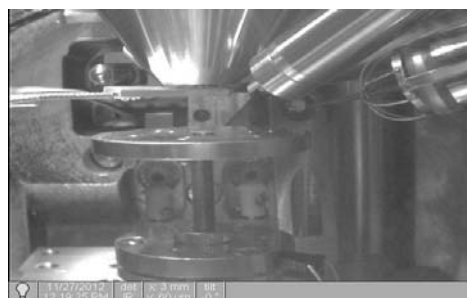

Figure 2. Preview of Sample Platform

- FIB is an ion beam system capable of rapid and precise milling of various geometries (up to

μm) of the sample material, revealing the sub-surface structure, getting sections, deposition of layers, etc. Ion system also provides high resolution images.

1.2 Description and "SEM image processing"
With the microscope were analysed soil samples taken from Podu Iloaiei, Iasi County, at different resolutions.
SEM is an instrument that produces a magnified image greatly by using electrons instead of light. A beam of electrons is produced at the top of the microscope by an electron gun. The beam follows a path down through the microscope. It travels through electromagnetic fields and lens then focuses on the lower floors of the microscope, towards the sample. Once the beam hits the sample, electrons and X-rays are ejected from the sample, recaptured and analysed, thus, the images being recorded (Figure3):
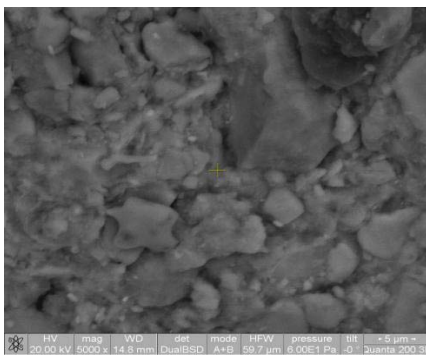

Figure 3. Picture of the soil sample zoomed 5,000 times

Investigation of the soil samples with the scanning electron microscope (SEM) shows a great variability of shapes and sizes of pores generated by the composition of the analysed sample.
Figure 4 presents the analysed soil sample from Podu Iloaiei, where its composition and porosity can be seen. It consists of pores of different sizes. Also, it can be seen some gravel and of course some natural cracks.
The SEM images were processed using a program called ImageJ, which allows the calculation of porosity. This is a public domain Java application dedicated to image processing. It is conceived by the National Institutes of Health, USA. The platform provides all the basic functions already implemented for the analysis and image processing, and also read/write functions for all standard image formats.
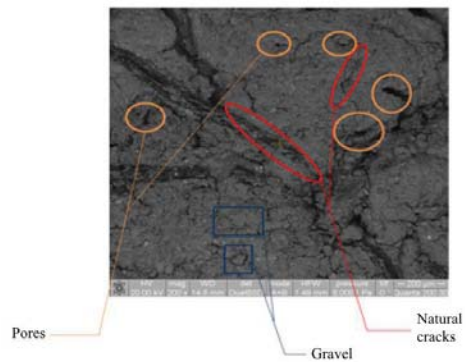

Figure 4. The SEM image View of the soil sample

The histogram in figure5 represents a simple frequency chart that can express the percentage of entities (classes). Thus, the Y-axis shows the variation of the number of pixels in the analysed image and the X-axis shows the variation of the grey tints. For the zero value of X-axis the tint is black, and the tint is white for the X-axis value of 255.
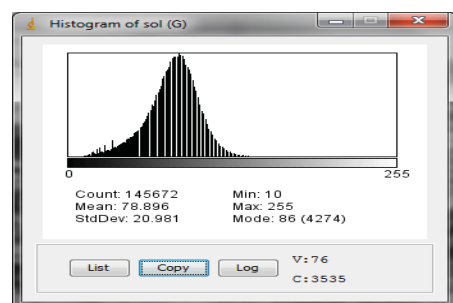

Figure 5. The Histogram of the soil sample

2. Soil porosity study using medical imaging technique

2.1. Description of the equipment
The scanning process of the two studied soil samples was held in Na Homolce hospital in Prague, the Laboratory of Computer Tomography Images of the Department of Neurology from the Czech Republic (Figure 6),

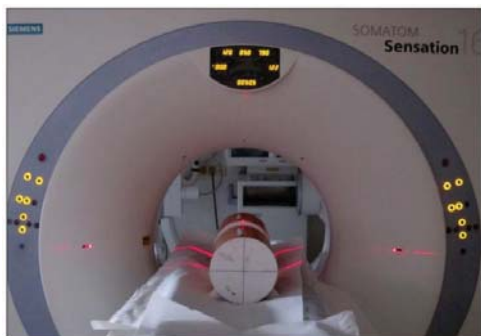under the guidance of Professor Specialist, Dr. M. Tuma.

Figure 6. Positioning the soil sample for computed tomography

The internal structure of the two soil samples were analysed using a standard Siemens Somatom Sensation 16 (Siemens, Forchheim, Germany) CT scanner. The 25 cm height soil sample, that has previously been dried naturally, was placed on the bed of the medical device and secured by means of plastic holders. In Figure 7 is presented the lateral and frontal scanning of the soil sample.

Figure 7. Scanning the soil sample

Making CT images using magnetic resonance was necessary for getting information about the internal structure of the two studied soil samples.

2.2. Obtained results

Figure 8 shows the CT image of the number 17 soil sample, revealing its internal structure, composed of pores of various sizes that are characteristic for the property of the heterogeneity of the soil. Also, one can notice the existence of different sizes gravel, which is part of the composition of the samples. We can distinguish here also numerous natural cracks that can represent potential preferential flow pathways.

On the perimeter of the sample, it can be seen how the gaps in the soil were filled with silicone, to create a good tightness between it and the tube, hence to preserving intact its natural structure. CT image processing was performed using ImageJ software that allowed the calculation of the average, minimum and maximum of the surface of gravel fragments existing in the ground section.
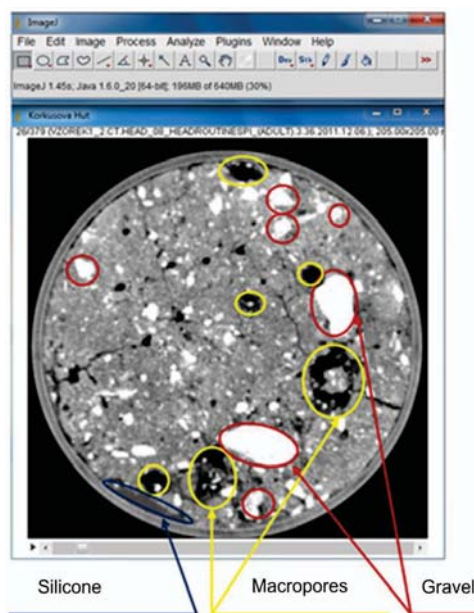

Figure 8. CT image of the soil sample

1. Soil sampling

At first, the ground surface is cleaned by removing residual plant, roots and rocks.
Then a T-shaped steel cross is placed on the ground having mounted 3 steel cylinders at its ends (Figure 9).
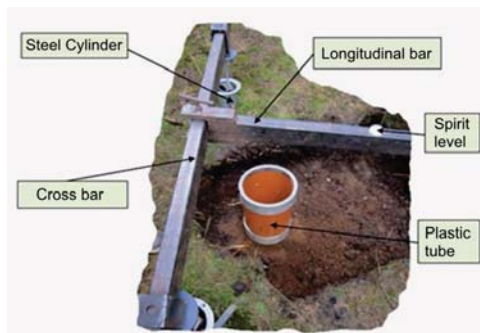
Figure 9. Field positioning of the equipment
and soil sampling

2. Preparation of soil samples and carrying out the experiments

Before starting the experiments concerning the infiltration of water, soil samples were transferred from a plastic tube to another and treated with silicone in order to prevent the phenomenon of water by-passing along the probe walls. Soil samples were subsequently equipped with tensiometers and TDR-es and positioned in the facility designed for carrying out the research (Figure10).
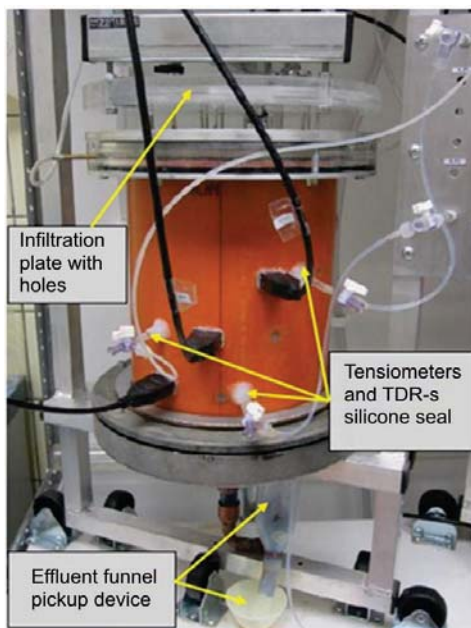

Figure 10. Equipping the soil sample before
starting the experiments

To conduct the experiments and record all the parameters specific to the ground water hydraulic flow and transport processes were used CR850 Datalogger Control Measurements, SN 5384, Model RJ1816HPL, type 4X, Campbell Scientific Ltd. Leicestershire, UK and CR23X Micrologger, SN 7673, RS 232, Campbell Scientific Inc., Utah, USA (Fig. 10) which includes: CR23X_RenMat, CR23X_TenzoMass, CR850_Control, CR10X_ TDR.

These advanced devices are activated automatically using LoggerNet 4.1 software that allows transmission of the start and stop signals at time intervals set by the user. It can record and collect data on any computer that is connected to a Local Area Network - LAN or Wide Area Network - WAN and it is also able to operate on different types of micro-loggers such as: CR500, CR510, CR10, CR10X, 21X, CR23X, using PakBus types of operating systems or CR databases, such as Series CR200, CR1000, CR3000, CR800 series, CR5000, CR9000 and CR9000X.

3 Obtained results

The first part of the experiment began on 25 January 2012 at 13:38:33 and ended on January 26, 2012 at 5:21:57 pm. The total time of infiltration was 15 hours, 43 minutes and 24 seconds. The second part began on January 27, 2012 at 07:17:18 pm and ended on the same day at 22:00:17. The total infiltration time was 14 hours, 42 minutes and 59 seconds. The last part of the experiment began on February 2, 2012, at 12:28:40 and ended in the same day at 20:12:00. It lasted only 7 hours, 44 minutes and 20 seconds since degassed solution was used, thus obtaining a significant decrease in infiltration time.

Infiltration conditions for the three experimental part are the following:
Initial conditions:
Constant pressure:
- For the first experimental stage: - 10.2 bar;
- For the second experimental phase: - 10.0 bar;
- For the third experimental stage: -10.0 bars;
b) The variation of the initial content of water in the ground:
1) For the first experimental stage:

- tensiometer P1 = - 344.3 cm col. water;
- tensiometer P2 = - 351.2 cm col. water;
-tensiometer P3 = - 326.9 cm col. water;
2) For the second experimental stage:
- tensiometer P1 = - 24.5 cm col. water;
- tensiometer P2 = - 18.9 cm col. water;
- tensiometer P3 = - 11.8 cm col. water;
3) For the third experimental stage:
- tensiometer P1 = - 33.7 cm col. water;

- tensiometer P2 = - 26.7 cm col. water;
- tensiometer P3 = - 19.4 cm col. Water.
The following figures (v. 11, 12 and 13) show the variation of water pressure in tensiometers: P1 (blue), P2 (red) and P3 (green), inserted into the KH soil sample, at depths of -7.5 cm, -12.5 cm and -17.5 cm implicitly, for all the three experimental part.
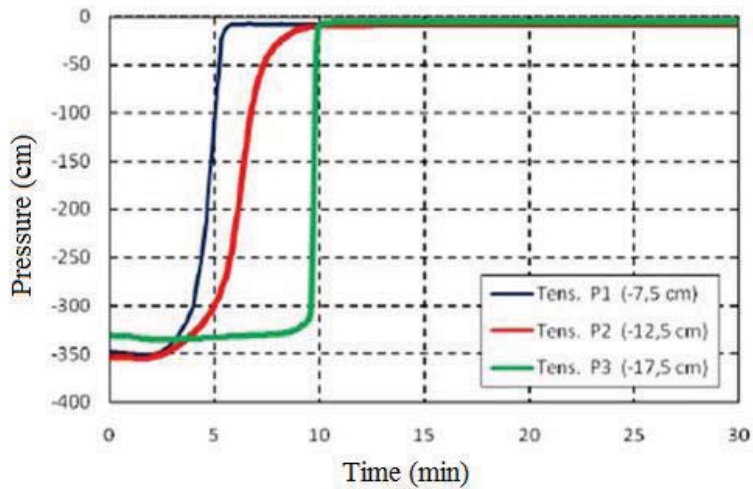

Figure 11. The pressure variation in the P1, P2, P3 tensiometer for the infiltration experiment phase 1
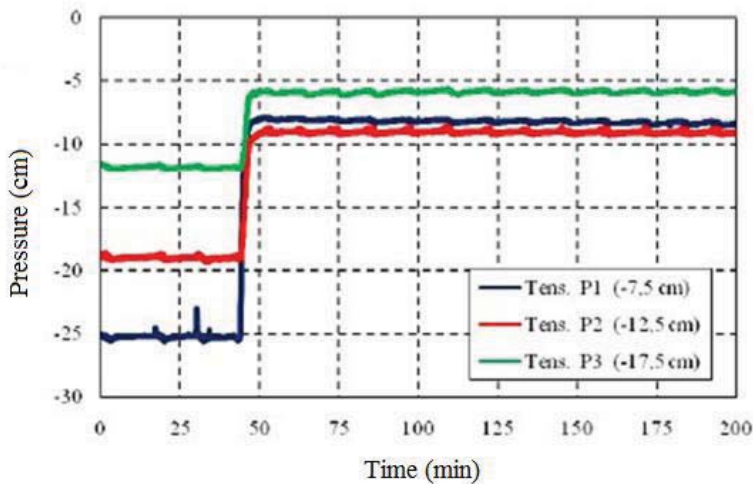

Figure 12. The pressure variation in the P1, P2, P3 tensiometer for the infiltration experiment phase 2
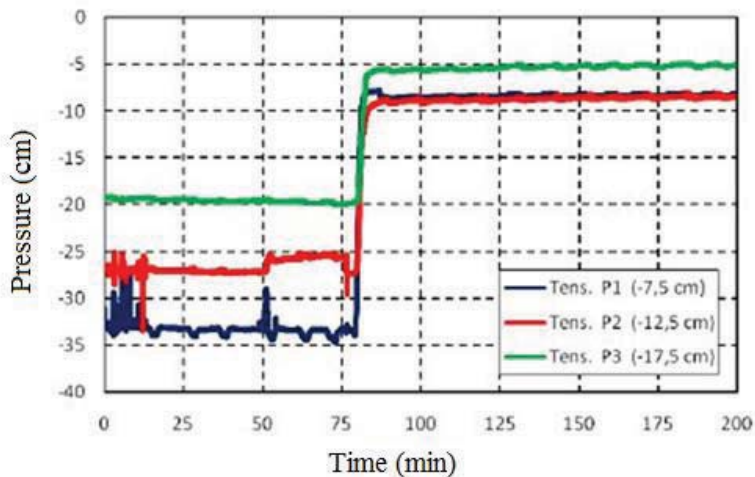
Figure 13. The pressure variation in the P1, P2, P3 tensiometer for the infiltration experiment phase 3

In Figure 11, it is observed that the initial values of P1, P2 and P3 tensiometer are close, but immediately after starting the infiltration experiments (after about 5-10 minutes) there is a spectacular increase of them towards 0 (which represents the reaching of maximum saturation level where suction value is null).

For the second round of infiltrations, highlighted in Figure 12, it can be noted that the initial values of the three tensiometer devices varies according to depth (P1 = - 24.5 cm. water col. at the depth of -7.5 cm P2 = - 18.9 cm. water col. at the depth of -12.5 cm and P3 = -11.8 cm. water col. at the depth of -17.5 cm) which confirms the hypothesis that the soil is drying starting from surface towards depth and the suction values are higher at the surface and hence they decrease with depth. After about 45 minutes from the start of the experiment no. 2 a rapid increase of pressure values is signaled, towards a value close to 0, which in this case leads to supposition of not achieving the maximum level of saturation in the soil column.

It should be stressed that these charts were made for the time span of 200 minutes, which represents a detailing of the experimental process, needed for emphasize the variations of suction values for the three analysed tensiometers.

The determination of the effluent flow was possible due to repetitive recording the number of cups in Data logger, of the tilting device, where the effluent has been retained. It is the result of the three infiltration experiments conducted on the soil sample. Knowing the starting position and the volume of each cup, its intensity was calculated. Figure 14 shows the effluent flow (cm/min) for all the experimental parts of the infiltration.

Carefully analyzing this figure, an extension of the lower ends of the flow can be seen, which indicates the start of the drainage phenomenon after completing the experiments.

In the first experimental condition, "the effluent flow" 1 (blue color) has a slight instability of the linear path due to the occurrence of an air blockage leading to the decrease of the infiltration process. After a period of time of 120 minutes, the initial flow conditions are re-established.

For effluent flow 2 represented by color red, there is an initial increase of its intensity, followed shortly by a sharp decline, which remains constant throughout the experiment. This is explained by the fact that through the dry soil, the flow phenomenon and transport of liquids takes place in a lesser time, and in conditions of saturation, it becomes extremely slow.

In the last case, there is an accelerated growth of the effluent flow 3 defined by green colour mainly due to the effects of using degassed solution. The use of this innovative method

reveals that the reduction of the infiltration time is based on dissolution of macro-pores air from the soil, which leads to a considerable increase in its permeability property, of approximately 50-70%.

At the determination of the infiltration rate, the pumping rate of the solution was considered, of ISMATEC 1 (for the first and last experimental stage) and ISMATEC 2 (for the second experimental stage) pumps, expressed in ml/s, which was reported to the surface area of the infiltration plate fixed on top of the soil column. From Figure 15, it is found that infiltration rate for the first two experiments (infiltration 1 - blue and infiltration 2 - red) shows the same trajectory, the infiltration rate as 3, with green colour, has an increasing trend and hence its duration halved compared to the other two. The justifications of these differences are attributed to the use of degassed solution for the last experimental part.
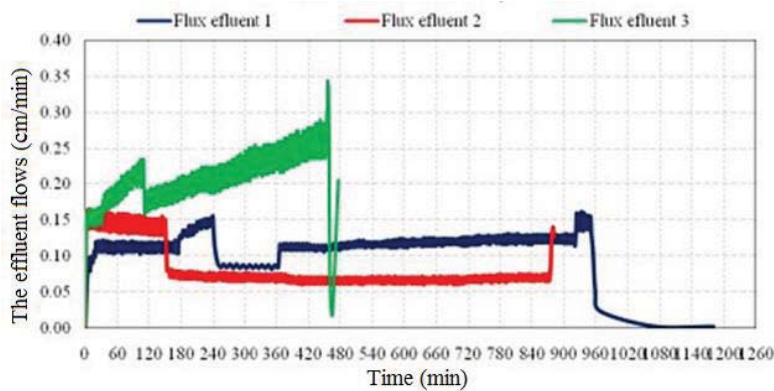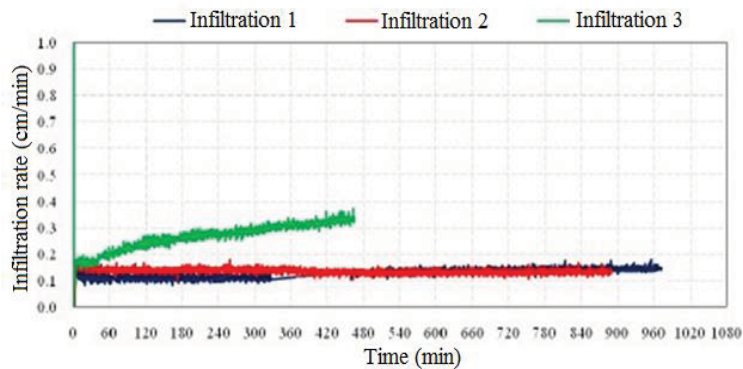

Figure 14. The effluent flows

Figure 15. Infiltration rate

THE USE OF INFRA-RED SPECTROMETRY IN SOIL RESEARCH

1. Equipment presentation

Shimadzu spectrophotometer Iraffinity-1 (Figure 16), provides the best S/N ratio in its class, a maximum resolution and compact size. In addition, the high-performance software IrSolution, which focuses on interoperability and analysis of support programs, makes it easier to perform analyses and data processing. The IR domain currently serves both for chemical analysis and qualitative recognition of

inorganic, organic and natural combinations as well as for determination of the chemical structure.

IR absorption is due to interactions of the incident electromagnetic radiation (the electric component thereof), with the electrical dipoles of a molecule.

It is assumed that the IR radiation energy causes an increase in vibration energy of the molecules because the corresponding dipole oscillates at a frequency close to the above mentioned electrical component.

Figure 17. Grinding of KBr (potassium bromide)

Figure 18. Grinding of the soil sample

Figure 16. IR spectrophotometer
Shimadzu IR Affinity 1

2. The method

The KBr pills method was used with IRAffinity-1 spectrophotometer. Soil samples and KBr (potassium bromide) were ground to a particle size <2µ mixed and homogenized in a ratio of 1: 100 (1 mg to 100 mg soil sample KBr) (Figures 17 and 18).

Both the soil used to make the pills and KBr, were each dried at 105ºC, then at 230°C and grinded.

Pills used to record spectra were obtained by molding the mixture sample with KBr in a stainless steel mold using a force of 10 to 12 tf/cm^2 (Figure 19).

Prior to and during the application of pressure using the hydraulic press shown in Figure 20, the air from the mold is removed, to avoid cracking.

Pills thus obtained should be transparent and slightly translucent. They had a diameter of 15 mm and a thickness of 0.3 mm.

Figure 19. Stainless steel mold

Then they were placed in the spectrometer and recording of spectra was performed automatically using KBr as blank, at a moisture content <10%.

The spectra of each analysed sample was obtained using a total of 20 scans (considered optimum number) at a resolution of 4.0 for wavelengths of 4000 cm^{-1}-400 cm^{-1}.

Figure 20. Hydraulic press

3. Obtained results

Obtaining a background spectrum (Figure 21) plays an important role in the analysis of the samples spectra. The background spectrum is obtained without any sample placed in the device, then the IR spectra of the KBr is done in order to be used in comparing the samples.

The spectra were obtained for samples dried at 105°C and 230°C, one for each drying temperature (Figure 21).

The studies aimed at analysing both water retention in the soil, and for the presence of clay and organic compounds. Since absorption peaks were low, the soil does not have high organic carbon content, which means that the soil is mineral, predominant in carbonates, phosphates and silicates. For this reason, the water present in the soil is mainly linked to its inorganic components.

Due to the influence on the physical and chemical properties of the soil, as well as to its substantial involvement in pedogenetic processes, clay remains the main factor in the analysis of soil texture. The colloidal inorganic matrix or clay, as it is commonly named, has a number of properties which are a result of the characteristics of its components. Identification and proportions of these components establish the quality of the clay. The clay minerals identified in studied clay soils are illite, smectite (montmorillonite), kaolinite and chlorite. In the addition, spectrometry revealed the presence of vermiculite elements or the presence of poorly expressed inter-stratifications.

The mineralogical composition of clay in Msdarjac and Visani soils was studied using IR spectra, and the results are shown in Table 1.
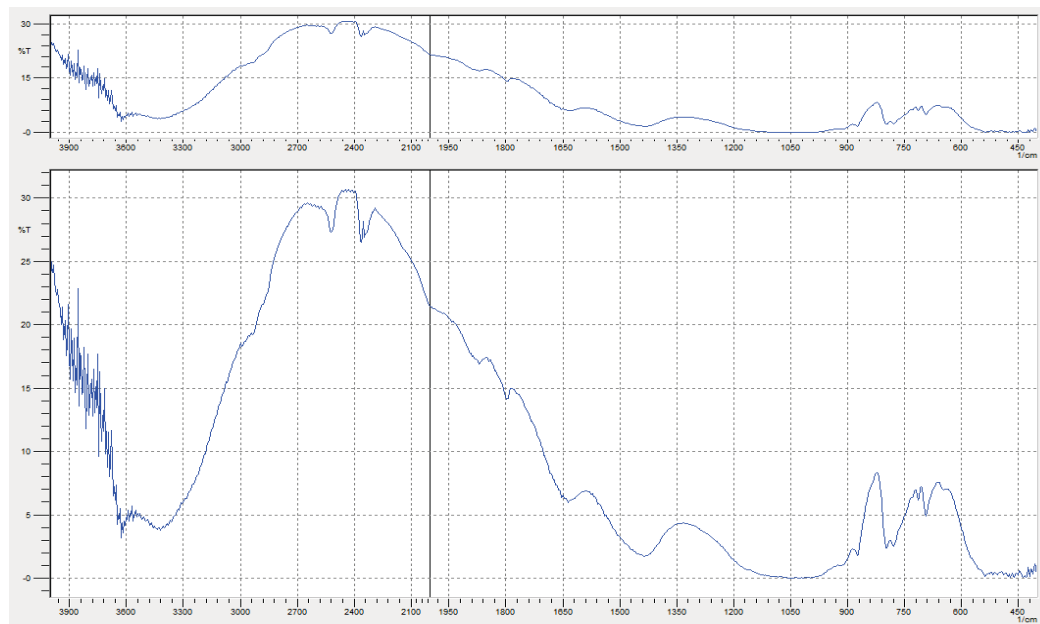

Figure 21. The IR spectrum of Visani soil sample, at 0-20 cm depth, dried at 105ºC

Table 1. The average mineralogical composition of the clay in the studied soils

Perimeter	Depth	Smectit	Illit	Caolinit	Other
Viş ani	0-20 cm	43	50	5	2
	20-40 cm	37	52	7	4
	40-60 cm	42	51	5	2
Mădârjac	0-20 cm	47	46	4	3
	20-40 cm	46	47	5	2
	40-60 cm	46	46	6	2

THE USE OF MATHEMATICAL MODELS IN RESEARCHING AERO-HYDRIC SOIL REGIME

The modelling is an attempt to describe the dynamic processes of soil in mathematical terms. Most models are simulation models, attempting to predict soil behaviour or performance. Mathematical models, on the other hand, uses empirical and observational data to provide quantitative values for gains, losses, substances transfer and their quantity contained in one or more tanks, as a function of time. Models can be local, regional or global as area of application.

1 Description of MOHID Land Software

MOHID Land is a basic executable program from the MOHID frame. So far, it was applied for studies in some river basins, but it is not as developed as the MOHID Water executable.

Within it was also integrated the MOHID Soil executable which simulates water flow through porous medium. It solves the Richards equation in saturated and unsaturated porous medium. This mode is used to simulate the flow of water from the porous medium. Currently, hydraulic properties are described using Van Genuchten function. However, the model is prepared, where appropriate, to include any model which describes the relationship between water content and hydrostatic pressure, and conductivity and the hydrostatic pressure.

Some modules developed in this software are related to specific processes that occur within river basins on a specific environment, creating a modular structure. These modules are:

Porous Media Module – calculates the infiltration, saturated and unsaturated water movement;
the transport and changes in the soil;
Porous Media Properties module - calculates transport and transformation in soil;
Sediment Quality module – calculates the soil transformations due to microorganisms (mineralization, nitrification, denitrification)
Preeqc module – calculates the soil transformations by chemical balance;
Runoff Module - calculates the surface water runoff;
Runoff Properties Module - calculates the transport property in runoff;
Drainage Network Module - which is investigating the conditions of movement, capture and water directing toward stream;
Vegetation Module - processing data on plant growth and agricultural practices;
Basin Module - correlating information between modules while determining flows between the atmosphere and soil.

2 Description of the modelling steps

The first step in developing applications with Mohid Land is setting the working directory and the title of the new project. The next step is to give a name to the application. Then is selected the research area, for this study PoduIloaiei, Iasi County. From the icon "Map" choose "Web Tiles" (Figure22). The program shares the same database with Google Maps.
Each Mohid Land project contains a file called "**General data**", which in turn contains additional 4 sub-files called "**Boundary conditions**", "**Digital Terrain**", "**Initial Conditions**" and "**TimeSeries Location**".
In the file called "**Boundary Conditions**" there

are data on humidity, rainfall, fertilization, temperature and radiation. The boundary conditions need to be introduced because we cannot run the modelling unless known these conditions. If they are wrong it will be a warning at the beginning of the simulation by error messages which will allow us to continue the simulation until they are corrected.

Figure 22. Choosing the study area Podu Iloaiei, Iasi County

In "**Digital Terrain**" data can be found, for instance those related to soil geography. In our case, the column is 3 meters high, is divided into four horizons and has 50 layers. After checking if these data have been set, the simulation can started.

Since it was intended to highlight the impact of porosity on the aero-hydric regime of the soil, the "Porous Media" module was used (Fig. 23). In this module there are data about soil horizons, and also data about the number of cells allocated to each horizon. Also, in this module, is needed to specify the soil hydraulic parameters for each horizon.

The soil hydraulic parameters are required for many studies, but most often they cannot be measured due to financial restrictions and practices. They can be measured directly or can be indirectly estimated using data about the soil texture and the bulk density. In this study Rosetta computer program was used. This program has 5 pedo-transfer functions for determining soil hydraulic properties: Theta_s – the water content at saturation (m^3/m^3); Theta_r - the residual content of water (m^3/m^3); Ks - saturated hydraulic conductivity (m/s);

Alpha - the inverse of the pressure at the point of entry of the air (when the gas phase become continue) (m^{-1}); L - empirical index of pore conductivity (m); n - dimensionless index that refers to the pore size distribution.

The next module, called the "**Porous MediaProperties**" is one that controls the transport (depending on the calculated flow in PorousMedia) and the transformation process (Quality sediment and PreeqC which refers to the biological and chemical processes in the soil).

The "**PreeqC**" module performs several functions. The first is to read the structure of the simulation, a kind of frame that will be used to prepare the database and run the model. The second function is to convert the units of the properties that will be used in simulation to units that are required by the model PhreeqC and after the calculations, the conversion of results back to the units used by Mohid Land. Finally, the module runs a number of calculations required to use the database.

Among the features of PhreeqC implemented in the database, the most important is the ability to achieve the chemical equilibrium between the solution and the soil variables, i.e. to carry the process of cations exchange.

"**Sediment Quality**" module. By using this module, the intention was to approximate the simulation results to those in the field, and thus getting close to reality. This is a module dealing with the processes of biological sediment achieved by bacteria such as mineralization of organic matter, nitrification, de-nitrification and immobilization. This module allows the monitoring of the nutrient evolution NO_3^-, NH_4^+, P and CO_2 in the soil.

The next modules are "**RunOff**", "**RunOff Properties**" and "**Basin**". Runoff module calculates the surface runoff, RunOff Properties calculates the transport properties during flow and Basin module manages the information among modules.

Once the data entering is completed, the simulation is "Run".

3. Obtained Results

Simulation results are structured on each individual module, representing the soil column

through graphs and maps, in the two-dimensional system, in vertical section, and in .hdf format.

The changes resulted in soil columns, depending on the boundary conditions, are represented by means of a colour palette, in video or pictures format.

Some results of simulations are presented below. Thus, in Figure 24 is represented relative humidity in the soil column. The program allows making a correlation between soil moisture and precipitation rate (Fig. 25). In Figure 26, notice the variation of the CO_2 content of the soil profile (the amount of CO_2 is higher in depth and lesser at the surface). The decrease of the percentage of oxygen in the soil air is accompanied by an increased amount of CO_2, which adversely affects the root growth and the water and nutrients penetration into the plant.
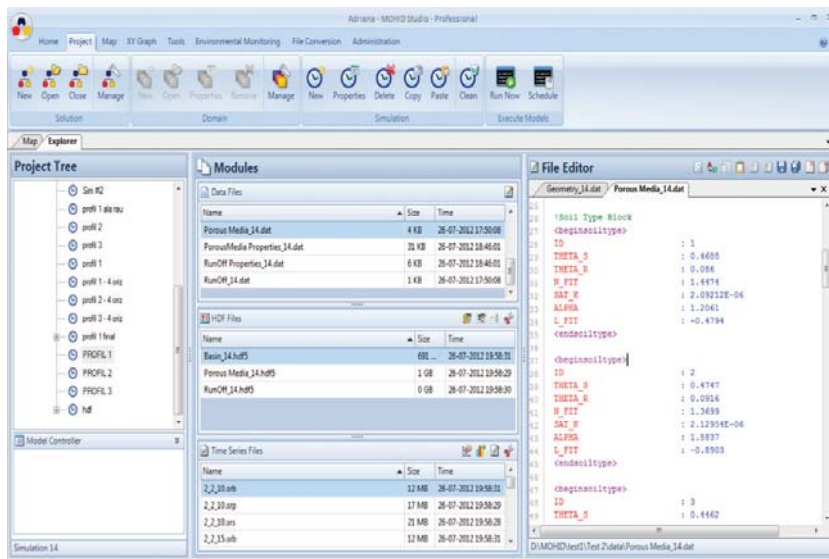

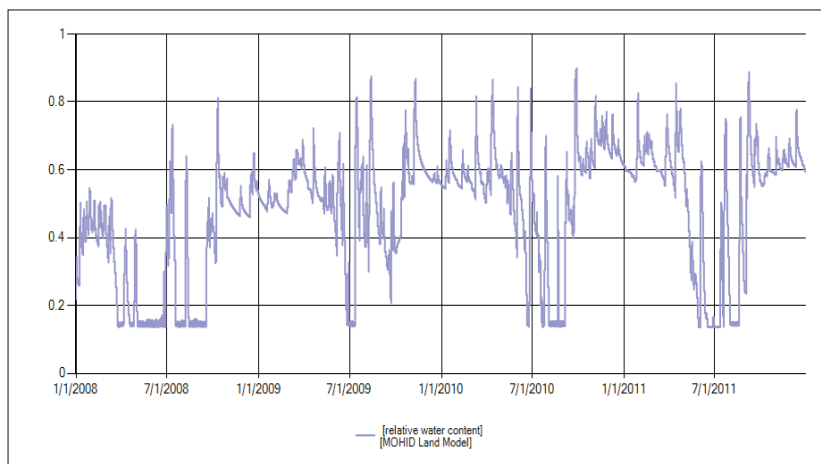Figure 23. Definition of soil horizons

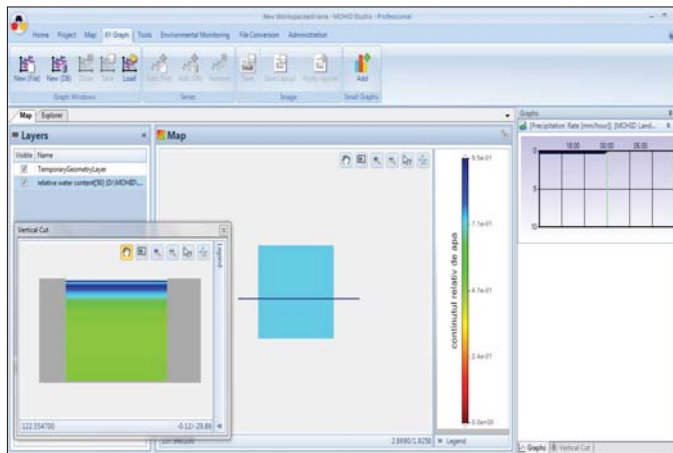Figure 24. The relative humidity of the soil column

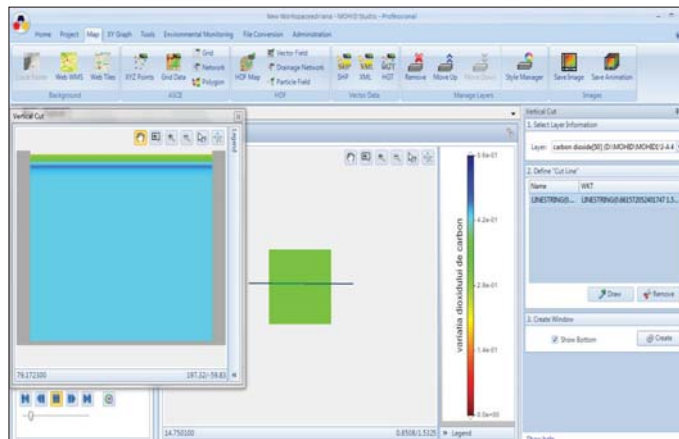Figure 25. The relative humidity correlated with the precipitations rate

Figure 26. CO_2 Variation on soil profile

CONCLUSIONS

Modern research techniques regarding soil physical properties and the obtained results have a very wide range of applicability. Environmental engineering, land reclamation, hydrogeology, hydrology are just some of the areas where the topic of this article are of particular interest.

Accurate quantification of soil physical properties is a prerequisite in modelling the processes taking place in the soil. Infiltration, advection, diffusion, dispersion are just some of the many processes influenced by the physical properties of soil.

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