RESEARCH ON THE INFLUENCE OF SOIL PARTICLES SHAPE ON THE RETENTION CAPACITY OF SOILS FROM DANCU STUDY AREA

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Abstract

This paper wants to remarked the impact of the relationship between soil particles characteristics (shape, size and pores surface) and retention capacity (soil suction).
The analized of this relation wishes to observe and to notice any change that may occur in the hydrological regime of soils in researched areas. Checking of the soil particles characteristics was obtained by: a) particle size analysis and b) SEM analysis type. Research the soil suction was accomplished using the sandbox, sand/kaolin box and pressure membrane apparatus.

Key words: water regime, particle size analysis, microscopic analysis

According to classical literature soil suction has required always a special attention because of the importance it has when you want to determine soil fertility as a soil with a balanced distribution of the sand, silt and clay contents will encourage the development and maintenance of conditions vital to develop both flora and fauna as solului- considered as one of the most important environmental components.

The study of the influence of the shape and characteristics of corresponding to soil particles on soil suction is an important factor in determining the variation of retention rate of chemical compounds that once you get in rural unsaturated and saturated represent a real threat for the groundwater quality that at today represents one of the most primordial sources of pure water without the human factor to intervene in order to purification for daily consumption.

Soils in general are composed of mineral fragments with different sizes which have most often hydrological regimes differ according to a number particularities such as shape, size and the size of constituent elements. For this reason the determination of these traits requires a complex analysis based on a comparison with a particle witness some ellipticity (Santamarina J.C. *et al*, 2001).

On this occasion we remember that in specialty literature the particles of irregular shape (compared to those with regular shape) occurs in three main staircase of sphericity (Wadell 1932 Krumbein W.C., 1941; Powers, 1953; Krumbein and Sloss, 1963; Barrett, 1980).

Sphericity can be quantitated as the ratio between the diameter of the largest and lowest scores within the district. Roundness is measured as the average radius of curvature of the surface in relation to the maximum radius of the sphere which can be entered in particle. Refers to the characteristics of surface roughness that can be much smaller than the particle diameter (Santamarina J.C. *et al*, 2003).

In the present study the peculiarities analysis which was above mentioned was performed using SEM technique to use as a pillar research the digital image analysis have been provided.

The digital analysis image facilitating the systematic evaluation of the mathematics descriptors that take account of particle shape, including Fourier analysis, used hybrid techniques to achieve an analysis on level fraction (Meloy, 1977; Clark, 1987; Hyslip and Vallejo, 1997; Bowman *et al*, 2001).

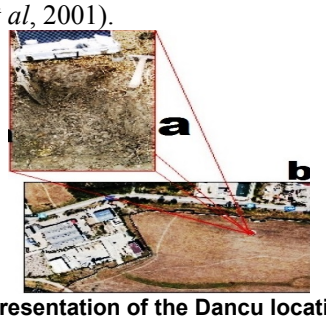

Figure 1 **Presentation of the Dancu location study a) samples harvested, b) zone of sampling soil**

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MATERIAL AND METHOD

All research was conducted on soil samples disturbed one for each depth (stored in labeled bags) and undisturbed harvested one for each depth from Dancu study area (*figure 1 b*) (collected by the method of metallic cylinders with a volume of 100 cm^3) shown in *figure 1 a.*

Soil particles morphology analyses were achieved by: a) size analysis (*figure 2.1 a*) and b) SEM (Scanning Electron Microscope) microscopic type.

Microscopic research was performed using scanning electron microscope Quanta 200, manufactured by FEI COMPANY. All samples (total samples = 24, 6 for each depth) were analyzed in Low Vacuum, approximately 60 Pa to 20 Kv shown in *figure 2.1 b*).

Suction was determined on a value range between pF 0 and pF 4.2 using experimental plant comprising: sandbox (pF 0 – pF 1.8) remarked in *figure 2.2 a*), sand/kaolin box pF 2 – pF 2.7) shown in *figure 2.2b*), and the pressure membrane apparatus (pF 3 –pF 4.2) noticed in *figure* 2.2 c) (Dumitru. 2006).

Figure 2 **The tools used in research:**
1: equipment used to analyze the morphology of mineral particles: a) shaker electromagnetic; b) equipment used in microscopic analysis SEM; 2: all equipment used in the study of hydraulic properties a) sandbox; b) sand/ kaolin box; c) pressure membrane apparatus

Determination of soil particle shape was achieved after analyzing SEM images provided by Quanta 200 scanning electron microscope, manufactured by FEI. The research focuses on particle shape classification categories particulate form by form factor he mentioned in other studies conducted on the subject.

Last aspect taken into calculation of soil particle shape analysis was rapotul size between the largest and smallest - determined using Autocad and microscope mentioned above. In this case study considered valid only ends particles compared to the second stage which took into account only the dimensions that microscope has been determined according to the focused area (*figure 4*).

In 2011 Stanisław Ż. is those achieved a study on the influence of particle shape on soil hydraulic propreties. For example, if the granules have the shape of a sphere having a d diameter, where b = d, and A = 6. The value of the shape factor is also 6, where the particle has the shape of a cube of side b and a cylinder with a base diameter B and height b. However, if the particles are oblong and the flattened, the value of A is raised.

In our study we did not find out the desired the A shape factor value, but only the particles in the classification of certain types listed in *figures 3 and Table. 3*. In the present study it was observed these and other forms such as: irregular shape.

In analyzing of this relationship between the morphological characteristics associated particles of different fractions directly related to pore system that lies across the surface of their ability to note the water of mineral particles to focus only on two categories of pores (macropores and nanopores shown in *figure 5*).

Suction lowest (pF 0 - pF 2.0) thresholds were associated with macropores because they can store a higher amount compared to nanopores that can retain water volume much smaller at higher pF values (pF 2.3 - pF 4.2). This relationship between that particularites of soil fragments and soil suction is presented in *figures 6.*

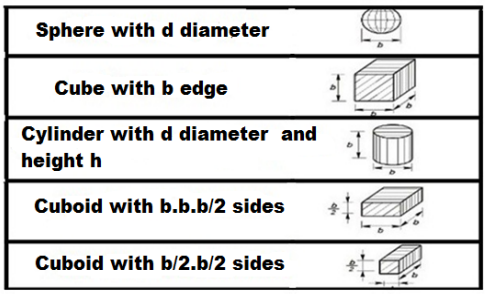

Figure 3 **Form factor A for various forms of particle adapted after Stanisław Ż., 2011**

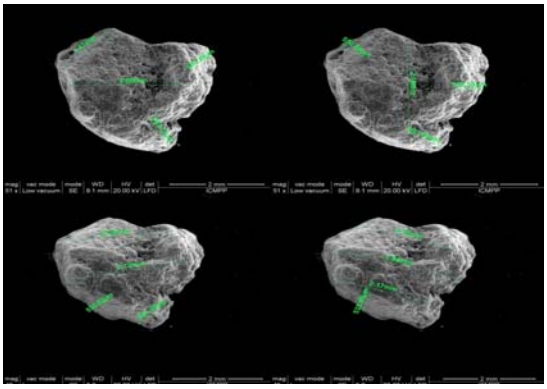

Figure 4 **SEM image at 51 x of 1mm soil particle corresponding D 0-20 cm - A shape factor**

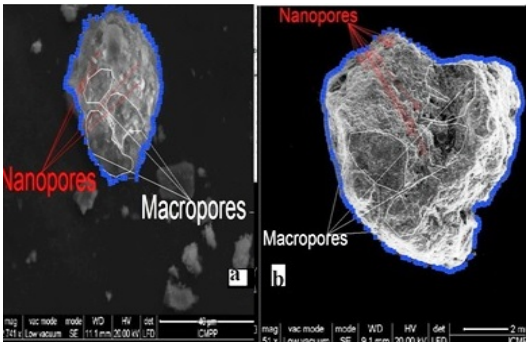

Figure 5 **SEM image at 2741 and 51 x - morphological particularities of mineral fragments from Dancu 0-20 cm a: particle < 63 µm - distribution of soil particle pore surface. b) particle 1 mm - distribution of soil particle pore surface**

CALCULATION PROCESS

The dates of water retention curve in the soil were obtained using the relation 5 (Ahuja L.R., 1998):

$$W = \frac{weiht\ of\ soil\ water \cdot 100\ \%}{weigt\ of\ soil} \quad (3)$$

$$\rho_d = \frac{\text{dry soil weight (without ring.canvas)}}{\text{weight of soil}} \quad (4)$$

$$\theta = W \cdot \rho_d \quad (5)$$

where:
θ - volumetric water content;
W - soil humidity;
ρ_d - bulk soil density.

RESULTS AND DISCUSSIONS

In *Table 1* are shows the values of size mineral particles on study section and in *Table 2* are mentioned the of θ (%) water content at all suction thresholds for soil to Dancu site and SEM analysis results will be presented in (*Tables 3*) which will be presented in the morphological characteristics soil mineral fragments for example: 1 mm, 250 µm and 63 µm to 0-20 cm and 60-80 cm depths - the shape of fragment, the size and the particle surface area (done with AutoCAD 2007) and for other depths was similary.

Table 1

Particle size distribution of Dancu site

µm	D 0-20 cm (%)	D 20-40 cm (%)	D 40-60 cm (%)	D 60-80 cm (%)
63	6.5	4.5	7	13
125	9.5	7	11	20
250	15	12	18	25
500	44	45.5	36	42
1000	100	100	100	100

Table 2

The values of θ (%) water content at all suction thresholds for soil to Dancu site

pF (kPa)	θ (%) D 0-20 cm	θ (%) D 20-40 cm	θ (%) D 40-60 cm	θ (%) D 60-80 cm
0	52.21238938	45.16129032	48.33333333	42.70833333
0.4	51.32743363	43.68340944	47.5	40.625
1	50.44247788	43.5483871	45.83333333	37.5
1.5	48.67256637	41.93548387	45	35.41666667
1.8	47.36842105	41.12903226	42.5	33.33333333
2	46.90265487	39.51612903	35.86156112	30.33333333
2.3	46.49122807	36.14916286	27.90868925	27.42342342
2.7	44.73684211	33.77703827	26.11940299	24.78832117
3	37.57225434	33.59375	25.37313433	20.05839416
3.4	30.1300578	32.8125	23.88059701	16.59854015
4.2	15.39017341	31.25	12.22385862	8.454608455

Table 3

Results of the morphological analysis for particles of different size fractions with macropores and nanopores system for Dancu site

Dancu	Fraction size	The pore surface (max) P.S. (mm^2)	The type of pores	A shape factor
D 20-40 cm	1mm	1.037	Macropores	irregular shape
D 20-40 cm	500 µm	0.251	Macropores	cuboid with b.b.b/2 sides
D 20-40 cm	250 µm	0.008	Macropores	cuboid with -b.b/2.b/2 sides
D 20-40 cm	125 µm	0.0011	Macropores	cuboid with -b.b.b/2 sides
D 20-40 cm	63 µm	0.00028	Macropores	cuboid with - b.b.b/2 sides
D 20-40 cm	< 63 µm	0.00009	Macropores	sphere with d diameter
D 40-60 cm	1mm	0.762	Macropores	irregular shape
D 40-60 cm	500 µm	0.738	Macropores	irregular shape
D 40-60 cm	250 µm	0.346	Macropores	cuboid with -b.b.b/2 sides
D 40-60 cm	125 µm	0.0014	Macropores	cube with b side
D 40-60 cm	63 µm	0.00058	Macropores	cuboid with b.b.b/2 sides
D 40-60 cm	< 63 µm	0.00026	Macropores	cuboid -b.b/2.b/2 sides
Dancu	Fraction size	The pore surface (min) P.S. (mm^2)	The type of pores	A shape factor
D 20-40 cm	1mm	0.0012	Nanopores	irregular shape
D 20-40 cm	500 µm	11.389	Nanopores	cuboid with b.b.b/2 sides
D 20-40 cm	250 µm	5.544	Nanopores	cuboid with -b.b/2.b/2 sides
D 20-40 cm	125 µm	0.0711	Nanopores	cuboid with -b.b.b/2 sides
D 20-40 cm	63 µm	0.015	Nanopores	cuboid with - b.b.b/2 sides
D 20-40 cm	< 63 µm	0.0058	Nanopores	sphere with d diameter
D 40-60 cm	1mm	0.0019	Nanopores	irregular shape
D 40-60 cm	500 µm	8.442	Nanopores	irregular shape
D 40-60 cm	250 µm	6.147	Nanopores	cuboid with -b.b.b/2 sides
D 40-60 cm	125 µm	0.086	Nanopores	cube with b side
D 40-60 cm	63 µm	0.0012	Nanopores	cuboid with -b.b.b/2 sides

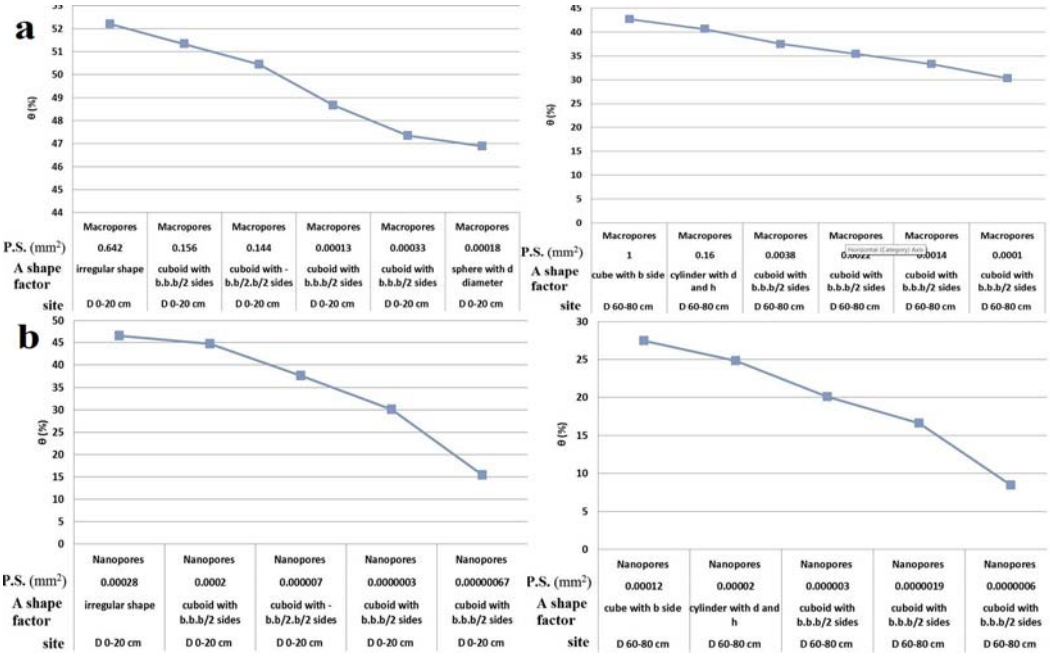

Figure 6 **The relationship between morphological characteristic of particle at different particle size fractions and soil suction for D 0-20 cm and D 60-80 cm a) macropores; b) nanopores**

The results of size analysis can highlight a variation of the percentages corresponding to each particle size fractions in direct proportion with increasing depth of soil sampling analysis.

Following the analysis of SEM type, we can achieve an overview on the morphological characteristics of soil particles for each particle size. The morphological characteristics of soil particles ranged in depth from six different particle.

The particles that make up soil from the Dancu site have highlighted some aspects of the shape factor A. The soil sample D 0-20 cm was composed of particles following form: ~ 50%, cuboid with bbb /2 side and irregular shape and cuboid withside bb/2 b/2, D 20-40 cm - b cube with b side, ~ 50% cuboid with bbb/2 side and spherical particles. Regarding soil sample D 40-60 cm (*table 3*) was observed a relatively uniform distribution of A shape factor for all six particle size fractions. D 60-80 cm (*figure 6. a*) holds a sizeable percentage of particles shaped like a cuboid with b.b.b/2 sides ~ 50%, cube with b edge (side) and cylinder with d diameter and h height.

Soil samples collected from the Dancu area the first level of suction exhibited a range of values of the water content were particularly the location and depth to the other but not in direct proportion to the increase in depth.

It noted a lower content in soil sample as compared to the depth D 20,...,40 cm D 40,...,60 cm. The highest value 52.21% was obtained in the first depths, has the highest total porosity compared to the lowest found in soil D 60,...,80 cm.

The highest rate was determined on soil samples collected from the first depth, and the lowest rate was observed in soils extracted from a depth of D 60,...,80 cm. If things change value of pF 4.2, suction does not change from depth to another depth as if pF 2, but shows varying values depending on soil type, so the lowest values of θ water content 34.25% were observed at D 20,...,40 cm soil.

The maximum was observed in D 0,...,20 cm soil, and the medium in D 40,...,60 cm.

When you looked at the relationship between morphological characteristics of the soil particles at various dimensions and soil suction was considered only two kinds of pores (macropores and nanopores)

If it notices a decrease in the macropores water contents with decreasing values of morphological characteristics of mineral fragments.

Regarding the situation nanopores, it could highlight a change in the form of suction of curves for the four depths. The curve shapes change according to the size of each particle fraction retention, different size and surface (*figure 6. b*).

Water contents fell as the two types of pore surface began to decrease depending on size fraction. As with hydraulic conductivity

this relationship has changed from a depth to another.

CONCLUSIONS

The distribution of shape and morphological characteristics of soil particles on study section greatly influenced hydric regime of soil from the Dancu site. When we are referring to the soil we relate at a homogeneous formation composed by well-structured aggregates which are formed to particles with different diameters, sizes and shapes.

The primary characteristics of particles mentioned above are taken in to account when we want to determine the transport mode of all fluids types.

The SEM analysis type help us in making accuracy determination of possible relationship between morphological characteristics (parameters) representative for each particle and the most important hydraulic properties of the soil with a major impact on water regime corresponding with the each type of soil from that four depth.

This paper has centered on how the variation of certain of shape and basical characteristics of particles shows the possibility of changing the storage regime for the various fluids when you want to determine the main particularities of agricultural soils.

REFERENCES

Ahuja L.R., 1998 - *Changes in soil water retention curves due to tillage and natural reconsolidation* Soil Sci. Soc. Am. J., 62,1228-1233.

Barrett P.J., 1980 - *The shape of rock particles, a critical review",* Sedimentology, vol. 27, pp. 291-303.

Bowman E.T., Soga K., Drummnond W., 2001 - *Particle shape characterization using in hydraulic conductivity determination.*

Clark N.N., 1987 - *A new scheme for particle shape characterization based on fractal harmonics and fractal dimensions*. Powder Technology, vol. 51, pp. 243-249.

Dumitru E., 2009 - *Metode de analiză utilizate în laboratorul de fizică a solului*. Sitech. Craiova.

Krumbein W.C., Sloss L.L., 1963 -*Stratigraphy and Sedimentation.* Second Edition, W.H. Freeman and Company, San Francisco, p. 660.

Krumbein W.C., 1941 - *Measurement and geological significance of shape and roundness of sedimentary particles.* Journal of Sedimentary Petrology, vol. 11, No. 2, pp. 64-72.

Powers M.C., 1953 - *A new roundness scale for sedimentary particles.* Journal of Sedimentary Petrology, vol. 23, No. 2, pp. 117-119.

Santamarina J.C., Cho G.C., 2003 - *The Omnipresence of Localization in Geomaterials",* Deformation Characteristics of Geomaterials, Lyon,

Santamarina J.C., Klein K., Fam M., 2001 - *Soils and Waves.* J. Wiley and Sons, Chichester, UK, pp. 488.

Stanisław Ż., 2011 - *Correlations between Hydraulic Conductivity and Selected Hydrogeological Properties of Rocks.* Developments in Hydraulic Conductivity Research, Dr. Oagile Dikinya (Ed.), ISBN: 978-953-307-470-2, InTech.

Stătescu F., Chiriac C, 1998 - *Bazele ştiinței solului - Fizica solului.* Editura Sam - Son's. Iaşi.