

PHYSICAL CHARACTERIZATION OF SOILS AFFECTED BY SALINITY FROM IASI COUNTY, ROMANIA

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Abstract

Salinized soils are soils with very low fertility because of physical and chemical negative attributes. They are used as meadows, but these have a poor nutritional value and give reduced productions. These soils can be improved by amendments and irrigation wash application. This paper had been aiming to analyze soils affected by salinity, from the village Prisacani, Iasi County. In this regard, soils from two places was analyzed: the first soil was collected from a place that is currently cultivated with corn (Zea mays), and the second soil was collected from an area of uncultivated, which has not suffered agricultural work for about seven years. Batch experiment where conducted in order to determine physical characteristics of soil, such as: particle size analysis, soil density (D), bulk density (DA), total porosity (PT), aeration porosity (PA), compressibility, the initial moisture content of the soil (W), the content of Water Stable Aggregates (WSA) and pore index (e0). The methods for analysis of physical characteristics of salinized soils are important research for the diagnosis, monitoring and quality control of soils with agricultural uses.

Key words: salinity, soil, monitoring, soil fertility

1. INTRODUCTION

Salinization is a process that involves accumulation in soil with excessive quantities of sodium salts, calcium, magnesium, potassium; particularly accumulations of chlorides, sulphates, carbonates and bicarbonates, which give a negative fertility to soil (Eckelman et al. 2006). This accumulation of salts, especially sodium salts, it is the first physiological threat when we speak about ecosystem.

Saline and alkaline soils are found on almost all continents, having a higher spread in arid areas and the semi-arid as well as the relatively wetlands or where favorable terms of the manifestation of factors which determine their formation and evolution are found.

Soils affected by salinity class called salsodisols (Florea N., 2012) are represented by Aquisalids and the Solonetz. These soils are characterized through an increased content of slowly soluble salts in the saline soils (Aquisalids), or by the high content of exchangeable sodium in alkali soils (Solonetz), or both processes may be found in aquisalids -alcalinizzate.

For physical characterization of the saline soils it is necessary to know physical properties: grain size distribution and texture of the soil, bulk density, porosity, moisture content, the dynamics of aggregate stability, the degree of compaction, as well other features such as the depth of the accumulation of salts, the content of salts present, the quality and the quantity of water available for the leaching, the quality and depth of groundwater, the topographic characteristics of the land, the nature of vegetation cover and the climate conditions. Salinized soils which present a fine texture are characterized by the presence of large quantities of water, but who is unreachable for the plants. From the mechanical point of view, these soils are working hard, because the presents high capacity for shrinkage and the swelling and the optimal period to carry out of agricultural works is very low.

Knowledge of soil bulk density provides data that cannot be deduced from other properties. In other words, a soil which belong to a genetic type with a certain texture, and specific chemical properties may have very differing bulk density values (Canarache A., 1990). Knowledge of this indicator has a special importance in the calculation of water, nutrient elements, salts, of the necessary fertilizers and amendments. It is estimated that the permeability and porosity differentiated analysis are indispensable in soil studies, to characterize pedogenetic conditions and to explain the processes of soil

pedogenetical formation under specific conditions. (Dumitru E. et al. 2009). When we speak about salinized soils, the highest values of bulk density can be found in the horizons heavily compacted, as B_{tna} horizons of the Luvisols or Solonetz. The saline soils have in generally a lower porosity less than 50% in the A_o horizons, and this value decreases with the soil depth profile, the horizons of B_{tna} take values from 30 to 40%.

The measurement of soil aggregate stability is important because it can give general information about soil conditions. The aggregate stability is the ability of the aggregates to resist when is exposed to stressors which causing their disintegration.

Salinized soils are soils with very low fertility because of physical and chemical negative attributes. Are used as meadows, but these have a poor nutritional value and give reduced productions. These soils can be improved by amendments and irrigation wash application.

2. MATERIAL AND METHODS

2.1 Description of the research perimeter (Site)

The area in which the research was carried out and the soil samples were taken, (Figures 1, 2 and 3) is part of Iași County, Prisacani village, common meadow Prut and Jijia. The village is located in the eastern part of the county. Common meadow and Prut rivers Jijia consists of alluvial deposits with sandy-clayey facies or sandy loam, tens of meters thick argillized surface, instead of the old river bed or lake bottoms, these layers are deposited on a bed of marl.

Moldova has a continental climate with cold winters and mild summers moderately warm, with maximum rainfall in late spring and minimum in autumn and winter. Annual rainfall varies between 500-600 mm. The most important affluent of the Prut River on the right part is Jijia (Figure 1); in this area has a deep riverbed, with single meandering, Jijia waters are discharged into the Prut, in Oprișeni village area upstream of the experimental field.



Fig 1. Jijia confluence with the Prut River



Fig. 2. Clogged soil profile, with the presence of groundwater to surface

According to the literature (Nitu et al., 1985), the soils from the common meadow Jijia and Prut rivers, occur as alluvial, calcareous and saline marshy grounds. Alluvial soils are clayey, fallow, or becoming fallow, some evolved, other less developed, with morphological differentiation and clear texture. In the formation of these soils an important role has been the influence of groundwater, located at depths of 1-2 m and its mineralization till 5 g/L (Figure 2).

2.2. Methods and techniques of analysis

2.2.1. Soil Sampling

Soil sampling was carried out from 25 to 25 cm to a depth of 100 cm, in disturbed sample and undisturbed sample from two areas: a control region, uncultivated, (denoted in the paper by M) and an area that was converted from grassland to arable land, currently being planted with corn (noted in the paper by Sa). Soil sampling in the undisturbed sample (Figures 3 and 4) was performed with the metal cylinder, defined volume (100 cm^3), made of stainless steel, having the walls with a thickness of about 1 mm. The rings are pointed at one end, thus facilitating the penetration into the soil and to avoid disturb of soil during sampling. On the soil surface have been removed residual traces of plant, roots of the plants and the rocks. After cleaning the soil surface, the metal cylinders have been introduced in the soil with a hard plastic hammer, their position is kept vertically. The excess of soil from the metal cylinders has been removed carefully with a pedological knife. To be able to carry and preserve the soil samples in optimal conditions, the cylinders were covered on both ends with plastic covers. Soil sampling has been carried from 25 to 25 cm to a 100 cm depth, in disturbed sample and undisturbed sample.

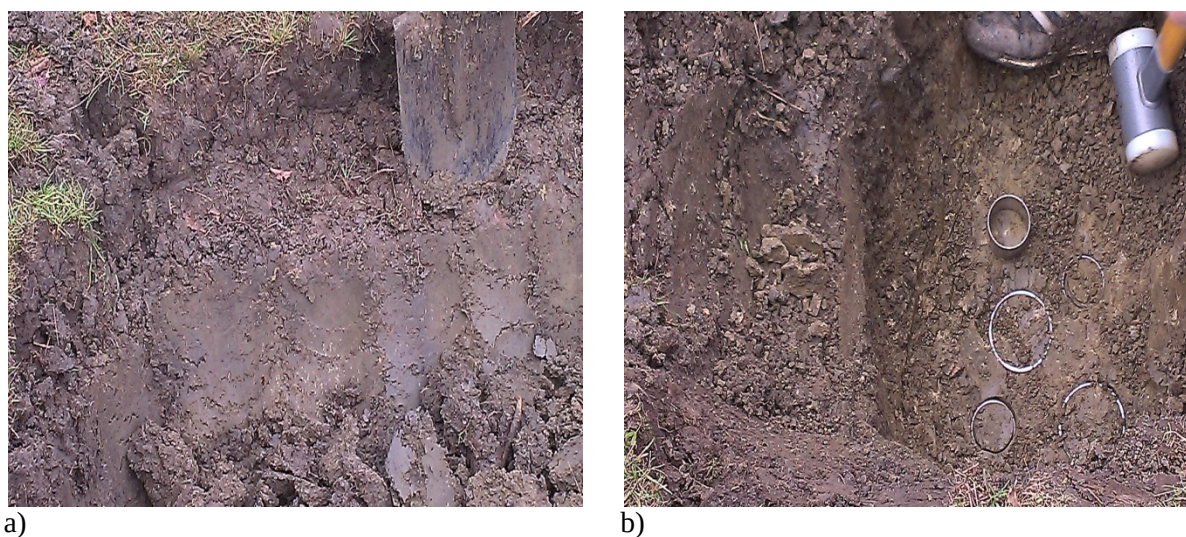


Fig. 3. The soil sampling in the the natural state: a- scraping the soil, b- introducing of rings in the soil

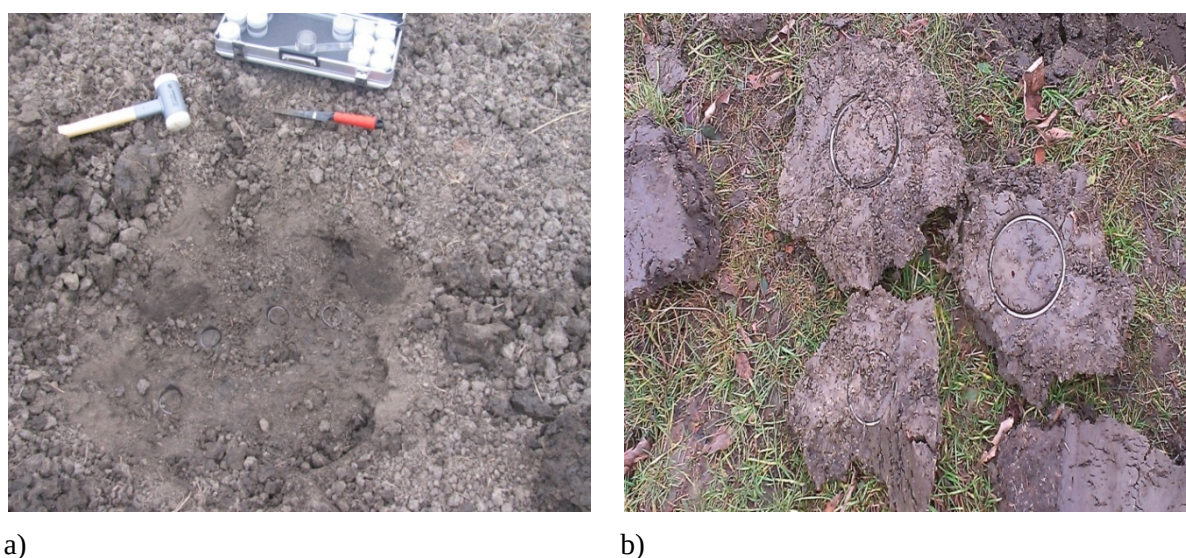


Fig. 4. Materials necessary sampling: a - hammer, cylinders with caps and spade to extract the cylinders, b - soil with cylinders

The samples were taken from the ground with the spade of 25 to 25 cm down to a 100 cm and where placed into plastic bags. Preparation of soil samples, taken in a modified settlement, for laboratory analysis, consisted in organic debris removed and skeleton, followed by grinding and the sifting through a sieve of 2mm Ø (except soil samples collected in natural settlement). The physical properties of the soil were determined in the laboratory.

2.2.2. Laboratory tests

Particle size analysis

In the general texture of the soil analysis, organic matter (humus) and the mineral constituents (carbonates, sulfates, soluble salts) were take into consideration. In case of determining the texture of fine mineral material (<2 mm) these components must be totally eliminated by different methods (using a furnace). The soil was air dried and the organic debris and the soil skeleton was removed. Afterwards, the soil was crushed and sieved through 2 mm meshes. The method is based on the principle of total dispersion of the soil structural formations.

Pretreatment was done in relation to the composition of the sample, so that, samples with carbonate content > 2% and organic matter <5% was treated with 1N hydrochloric acid solution and dispersion solution of tetrasodium pyrophosphate (concentration 4%).

Determination of particle size fractions was carried out through: sedimentation method for fractions <0.02 mm and wet and dry sieving method for fractions and sub-fractions included between from 2 to 0.02 mm. The results were expressed in percentage to material remaining after the pretreatment, being 100% the sum of the fractions. For the classification into classes and subclasses of texture, the methodology presented in Soil Assessment Study (ICPA, 1987) was used.

Soil density (D) has been determined by the pycnometric method, and the results are expressed in g/cm³.

Bulk density (DA) has been determined using the metal cylinder of 100cm³ volume and momentary soil moisture, expressed in g/cm³

$$DA = \frac{m_2 - m_1}{V_t} \quad (1)$$

Total porosity (PT) has been calculated with eq. 2 and the results are expressed in % by volume (% v/v).

$$PT = \left(1 - \frac{DA}{D}\right) 100 \quad (2)$$

Aeration porosity (PA) was determined by mathematical calculation according to eq. 3 and the results are expressed in % by volume (% v/v).

$$PA = PT - CC \cdot DA \quad (3)$$

Compressibility of soil has been determined in the laboratory by the test in the endometrium method (Lungu and Stanciu, 2013). The main feature of the compressibility test is the fact that lateral deformation of soil sample is completely prevented. On the basis of test results, compressibility in the endometrium can be drawn as compressive-compaction curve. Using this curve, specific compaction can be calculated (eq. 4).

$$\varepsilon_i = \frac{\Delta h_i}{h_0} \cdot 100 \quad (4)$$

where:

ε_i - compaction for each level of loading stage, is expressed in%;

Δh_i - compaction sample recorded on microcomparator, under the load stage;

h_0 - initial height of the sample.

The initial moisture content of the soil (W) or the water content in the soil, it is amount of water which is physical linked with the soil matrix and which was evaporated at 105°C. The soil was dried at 105°C till constant weight and then was weighed. The weight difference obtained before and after drying, is the humidity expressed as a percentage.

The degree of humidity (Sr): the initial degree of moisture is defined as the ratio between the volume of water contained in the soil pores and the total volume of the pores in that soil and was determined during the endometrium test.

$$S_r = \frac{\rho_s}{e_0 \rho_w} \cdot \frac{w}{100} \quad (5)$$

where:

ρ_s - skelett density;

e_0 - the index of the initial pore;

ρ_w - the density of water;

w - humidity of the soil sample in their natural state.

Pore index (e0) had determined by mathematical calculation according to formula:

$$e_0 = \frac{PT}{100-PT} \quad (6)$$

where: PT - the total porosity of the soil.

The content of Water Stable Aggregates (WSA) was also determined. These tests was carried out according to the methodology for the Wet Sieving Apparatus, which is similar to that proposed by Kemper and Rosenau (1986) and standard DIN 19683-16 (Diaz-Zorita et al. 2002).

Weight of 4.0 g of 2–5 mm air-dried aggregates were placed on the sieves of Wet Sieving Apparatus and washed in cans with distilled water for 3 minutes. Afterwards these cans were replaced with cans with a dispersing solution (containing 2 g sodium hexametaphosphate/L for soils with pH > 7 and 2 g sodium hydroxide/L for soils with pH < 7) and the sieving continued until only the sand particles (and root fragments) were left on the sieves. Both sets of cans were placed in an oven and dried at 110°C. After drying, the weight of materials of unstable and stable aggregates was determined. Dividing the weight of the stable aggregates over the total aggregate weight (without sand particles > 0.25 mm) gives an index for the aggregate stability (equation 7):

$$WSA = \frac{Wds}{Wds + Wdw} \quad (7)$$

where:

WSA - is the index of water stable aggregates;

Wds - is the weight of aggregates dispersed in dispersing solution (g);

Wdw - is the weight of aggregate dispersed in distilled water (g).

The pH was measured potentiometric using combined glass and calomel electrode in aqueous suspension to the ratio of soil / water 1/5.

3. RESULTS AND DISCUSSION

The obtained results by the laboratory analyzes and mathematical calculations, give the possibility to define the both soils studied in terms of: texture, total porosity, degree of compaction, moisture and pore index. These results are showed in Table 1. The notations Sa1, Sa2, Sa3, Sa4 represents soil samples from cultivated area, on the depths of 0-25 cm, 25-50 cm, 50-75 cm, 75-100 cm. Samples of the soil control, had taken from the perimeter which was not cultivated, had denoted with M1, M2, M3 and M4, for the depths of 0-25 cm, 25-50 cm, 50-75 cm, 75-100 cm.

After analysis of particle size, the both soils had denoted Sa and M, had classified as belonging to the textural clay and clay-loam classes (cf. Methodology for Development of Soil Survey, 1987). The soil is characterized by a content of clay between 48,60 to 65%, of cultivated soil. For the control soil the clay content values falls between 56 and 69.2%. The resulting data are in agreement with the specialty literature, which describes broadly, the soils of common meadow the Prut- Jijia river as fine textured soils.

Bulk density values range between 1.66 to 1.81% for the cultivated soil and 1.79 to 1.89 for the control soil. It was observing that the density values increase with the depth, and the fact that the cultivated soil density has values lower compared to control soil, confirm that the tillage have a role in improving the physical properties of the soils.

Table 1. Analytical data on the physical properties of soils in the studied area

	UM	Sa1 (0-25 cm)	Sa2 (25- 50 cm)	Sa3 (50- 75 cm)	Sa4 (75- 100 cm)	M1 (0-25 cm)	M2 (25- 50 cm)	M3 (50- 75 cm)	M4 (75- 100 cm)
Gravel (>2mm)	%g/g	-	-	-	-	-	-	-	-
Coarse sand (0,5mm<d<2mm)	%g/g	-	-	-	-	-	-	-	-
Medium sand (0,25mm<d<0,5mm)	%g/g	-	-	-	-	-	-	-	-
Fine sand (0,05mm<d<0,25mm)	%g/g	8,17	8,17	6,14	4,85	4,25	2,60	4,25	4,25
Silt (0,005mm<d<0,05mm)	%g/g	43,21	43,35	29,93	35,99	39,20	63,34	26,23	30,04
Clay (0,002mm<d<0,005m m)	%g/g	23,58	20,37	18,92	16,31	41,19	26,81	23,11	25,48
Fine clay(<0,002mm)	%g/g	25,04	28,12	45,01	42,84	15,36	7,25	46,41	40,23
Textural class	-	Clay	Clay	Loam y clay	Loam y clay	Clay	Silty - clay	Loam y clay	Loam y clay
Degree of compaction	%v/v	10,4	6,85	5,3	6,3	10,3	4,85	2,7	5,85
Bulk density	g/cm ³	1,69	1,81	1,66	1,70	1,79	1,81	1,89	1,84
Total porosity	%v/v	49,86	42,27	47,31	48,24	49,79	44,88	42,06	42,89
Pore index	%	0,99	0,73	0,90	0,93	0,99	0,81	0,73	0,75
Content of moisture	%	25,19	16,10	16,59	21,84	32,12	21,79	20,73	19,02
The degree of humidity	%	0,68	0,59	0,50	0,63	0,87	0,72	0,77	0,68
pH	pH.u.	8.07	7.85	7.7	7.81	6,83	6,9	6,92	6,99
WSA - index of water stable aggregates		0,40	0,42	0,15	0,12	0,70	0,70	0,58	0,83

The soil with porosity values of less than 50%, large values of density and a fine texture, will negatively affect the retention capacity of the water, the permeability, aeration and the ratio drainage / water infiltration (Thomsen et al., 1999). Total porosity values for the cultivated soil is between 42,27 to 49,86, the highest value being recorded in the 0-25 cm layer.

The porosity values of the control soil are smaller than cultivated soil and decrease with the depth. This happens because the cultivated soil becomes loose and also increase the organic matter content.

The soils with a high clay swells strongly in the presence of water, which reduces the water permeability. The low permeability leads to stagnation of water in the soil and at the soil surface. This is accompanied by a number of processes and transformations under anaerobic conditions. The results obtained regarding the soil moisture and soil the degree of humidity, confirms this assertion.

The analyzed soils can be considered as having medium stability according to the mechanical breakdown test.

Results obtained after the determination of compressibility, allowed drawing compressive-compaction curve (Fig. 5), respectively compressive-porosity (Fig. 6). Based on the results for all eight soil samples analyzed, the soils were classified as soft plastic clays with high compressibility.

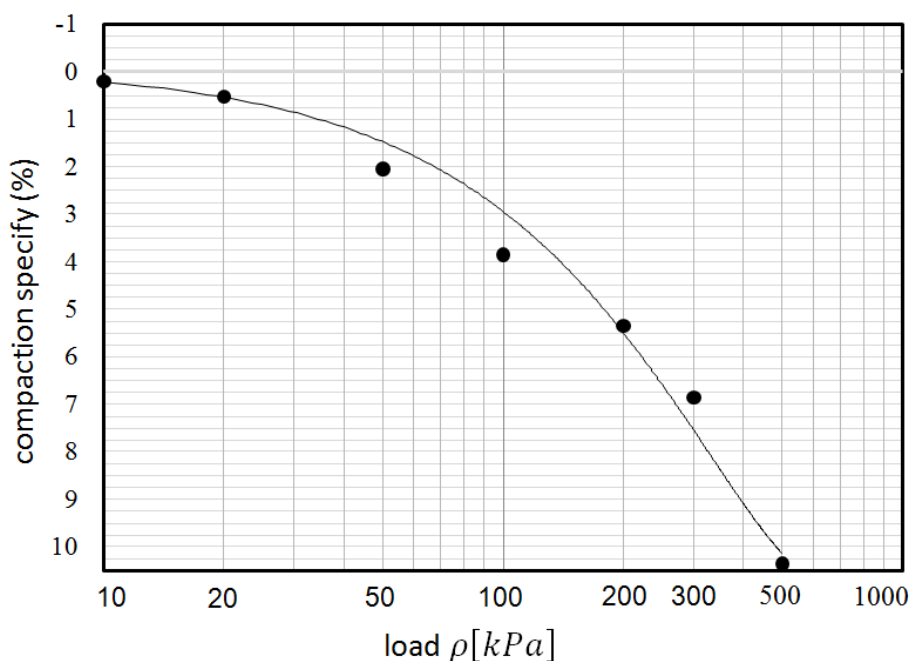


Fig. 5. The compressive-compaction curve for sample S1

NATURAL

Load[kPa]	10	20	50	100	200	300	500
Readings [$10^{-2}mm$]	4	10,5	41	77	107	137	207
Compaction specify [%]	0,2	0,53	2,05	3,85	5,35	6,85	10,4

UNLOADING

Load[kPa]	500	200	100	50	20	10
Readings [$10^{-2}mm$]						
Compaction specify [%]						

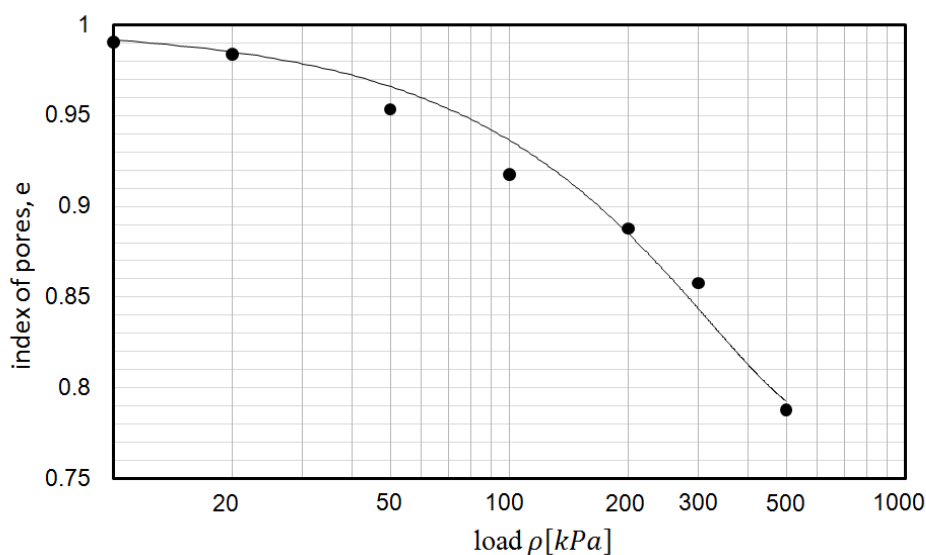


Fig. 6. Compressive-porosity curve for sample S1

NATURAL

Load[kPa]	10	20	50	100	200	300	500
Readings [$10^{-2}mm$]	4	10,5	41	77	107	137	207
Compaction specify [%]	0,2	0,53	2,05	3,85	5,35	6,85	10,4
Index of pores, e	0,99	0,98	0,95	0,92	0,89	0,86	0,79

UNLOADING

Load[kPa]	500	200	100	50	20	10
Readings [$10^{-2}mm$]						
Compaction specify [%]						

Index of pores, e

4. CONCLUSIONS

The analysis of the results obtained from conducted research, allow us issuance the following conclusions:

According to the analysis of particle size, the soil present fine texture.

The soils presents high values of bulk density, lower value of porosity, with high degree of compaction, these qualities printing a low water a permeability of soils.

Soils are characterized by a high degree of humidity, water stagnation at the surface and inside the soil horizons.

The results of this study support the conceptual model of aggregate turnover developed by Six et al. (1999): tillage practices disrupt large macroaggregates.

Corroborating these dates allow us the characterization of these soils from the physical features point of view of. Same dates are used in the calculation of the water stocks, chose agrotechnical applications and in the calculation of the amendments.

REFERENCES

- Ahuja, L. R. Naney, J. W., Williams, R. D., 1985, "Estimating soil-water characteristics from simpler properties or limited data", *Soil Science Society of America Journal*; vol. 49, no. 5, pp. 1075-1082.
- Arah, J.R.M., Ball, B.C., 2006, "A functional model of soil porosity used to interpret measurements of gas diffusion", *European Journal of Soil Science*, vol. 45, no 2, pp. 135-144.
- Barden L., Pavlakis G., 1971, "Air and water permeability of compacted unsaturated cohesive soil", *Journal of Soil Science*, vol. 22, no. 3, pp. 302-317.
- Canarache A., 1990, "*Guidelines for the study of the soil in field and in the laboratory* ", Ed. Agro-Forestry, Bucharest.
- Dumitru E., Gus P., R. Enache Dumitru M., 1999, "*Effects of residual agricultural practices on soil physical condition*", Ed. Risoprint, Cluj-Napoca.
- Eckelmann W., Baritz R., Bialousz S., Bielek P., Carré F., Houšková, B., Jones J.A., Kibblewhite. R. J.A., 2006, "*Common Criteria for Risk Area Identification according to Soil Threats*", Research report no. 20, Soil Information Working Group (SIWG), European Soil Bureau Network.
- Florea N., 2003, "*Degradation, protection and improvement of soil and the land*", Bucharest.
- Florea N., Munteanu I., 2012, "*Romanian System of Soil Taxonomy*", Ed. Sitech, Craiova.
- Gardner W.H., 1986, "*Methods of Soil Analysis. Part1. Physical and Mineralogical Method*", ed. A. Klute, ASA-SSSA, Madison, WI, USA, Agron. No. 9, 2nd ed., ch. 21, pp. 493-544.
- ICEPA, 1987, *Research Institute for Soil Science and Agriculture*- code GAEC.
- Nițu, I., Dracea, M., Răuță, C., Rizea, A., 1986, "*Improvement and exploitation of the salty soils of R. S. România.*", Edit.Ceres, Bucuresti.
- Thomsen, I.K., Schjonning, P., Olesen, J.E., Christensen, B.T., 1999, "Turnover of organic matter in differently textured soils: II. Microbial activity as influenced by soil water regimes", *Geoderma*, vol. 89, no. 3-4, pp. 199- 218.
- Six, J., Elliott, E.T., Paustian, K., 1999, "Aggregate and Soil Organic Matter Dynamics under Conventional and No-Tillage Systems", *Soil Science Society of America Journal*, vol. 63, pp. 1350-1358.
- Stanciu, A., Lungu, I., 2013, "*Geotechnical, works for laboratory* ", Ed. Politehniun, Iasi, Romania.
- Stătescu, F., Pavel, VL, 2011, "*Soil Science*", Ed. Politehniun, Iasi, Romania.

Sumner, M.E., 1993, "Sodic soils: New perspectives", *Australian Journal of Soil Resurces*, vol. 31, pp. 683-750.