Scientific Papers. Series A. Agronomy, Vol. LIX, 2016
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

SOIL CHARACTERIZATION FROM OSOI - MORENI AREA, IAȘI, BY ANALYZING CERTAIN INDICATORS OF SALINITY

Maria Cătălina PASTIA, Florian STĂTESCU, Adriana Nicoleta STAN

"Gheorghe Asachi" Tehnical University of Iasi, Faculty of Hydrotehnical Engineering, Geodesy and Environmental Engineering, 65 Prof. dr. docent Dimitrie Mangeron Blvd., 700050, Romania

Corresponding author email: mariapastia@yahoo.com

Abstract

Saline soils are characterized by an excess amount of soluble salts and sodium, which can be changed in the soil water. This excess of salt changes the physical and chemical properties of soil, creating an environment that inhibits crops. Therefore, the accumulation of salts in the soil is one of the main reasons for a low level of agricultural production. At this point, one of the most pressing issues worldwide is overpopulation, which highlights further the issue of sustainable food production.
As a result, in recent years, more emphasis has been placed on research and soils affected by salinity on finding ways to improve them. To effectively address this problem it is necessary to research in terms of the physical properties of these soils chemical and microbiologycal and the effective implementation of scientific discoveries and the sustainable management. This paper investigates some indicators of salinity and the correlation between them, to characterize the soils affected by salinity and to show that it creates problems in agriculture, and presenting some plant species tolerant to salt.

***Key words**: saline soils, salt tolerance, crop.*

INTRODUCTION

Salinity is a process where we have accumulation in soil with excessive quantities of sodium salts, calcium, magnesium, potassium, particularly accumulations of chlorides, sulphates, carbonates and bicarbonates, which give us a negative fertility soil (Eckelman et al., 2006).
This accumulation of salts, especially sodium salts, it is the first physiological threat when we speak about ecosystem.
Salinity related land degradation is becoming a serious challenge for food and nutritional security in the developing world. As per FAO/UNESCO soil map of the world, a total of 953 million ha covering about 8 percent of the land surface is suffering from salinity / sodicity (Szabolcs I., 1971).
Salt-affected soils are reported to comprise 42.3 percent of the land area of Australia, 21.0 percent of Asia, 7.6 percent of South America, 4.6 percent of Europe, 3.5 percent of Africa, 0.9 percent of North America and 0.7 percent of Central America (El-Mowellhey N., 1998). Excess of salts in a soil can bring drastic changes in some of the soils physical and chemical properties resulting in the development of an environment unsuitable for growth of most crops.
Soils having salts in the solution phase and/or sodium ions (Na^+) on the cation exchange sites exceeding the specified limits are called salt-affected soils. Major captions in salt-affected soils are sodium (Na^+), calcium (Ca^{2+}), magnesium (Mg^{2+}), and to a lesser extent potassium (K^+).
The major anions are chloride (Cl^-), sulphate (SO_4^{2-}), bicarbonate ($HCO_3{}^-$), carbonate ($CO_3{}^{2-}$), and nitrate ($NO_3{}^-$). These soils are generally divided into three broad categories: saline, sodic and saline-sodic.

MATERIALS AND METHODS

Description of the research perimeter (Site)

<u>Study area</u>

The area in which the research took place and the soil samples were taken, (Figure 1) is part of Iaşi County, Prisacani village, common meadow Prut and Jijia. The village is located in the eastern part of the county.

Common meadow Prut and Jijia rivers consists of alluvial deposits with sandy-clayey facies or sandy loam, tens meters of thick argillized surface, instead of the old river bed or lake bottoms, these layers are deposited on a bed of marl.

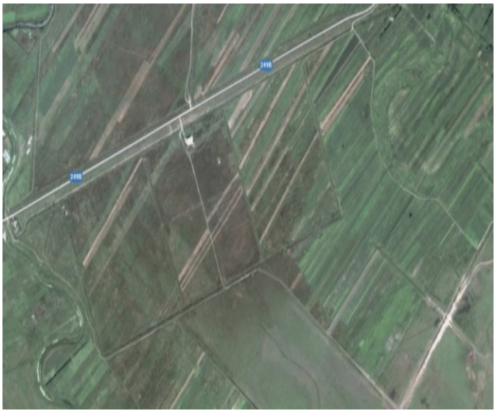

Figure 1. Locating the research base perimeter of Osoi-Moreni, Prisacani village

According to the literature (Nițu 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.

Laboratory tests

To describe some soil physical and chemical properties i.e. grain size and texture, pH, electrical conductivity and measurements on the ion content of (Na^{+}), calcium (Ca^{2+}), magnesium (Mg^{2+}), SAR (Sodium Absorption Ratio) and soil ESP (Exchangeable Sodium Percentage) of the soil samples were using laboratory tests as described by Chemical and microbiological analysis methods of National Institute of Research and Development for Soil Science, Agrochemical and Environmental Protection of Bucharest and Geotehnica - laboratory tests (Stanciu and Lungu, 2013; ICPA Bucharest, 1987).
For the classification into classes and subclasses of texture use the methodology presented in Soil Assessment Study (ICPA Bucharest, 1987).
Soil density (D) has been determined by the pycnometric method, and the results had expressed in g/cm^3.
Bulk density (DA) has been determined by the metal cylinder of known volume (100 cm^3) momentary soil moisture, expressed in g/cm^3.

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

Total porosity (PT) has been determined by mathematical calculation according to formula:

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

and the results has been expressed in % by volume (% v/v).

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

$$S_r = \frac{\rho_s}{e_0 \rho_w} \cdot \frac{w}{100} \quad (3)$$

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.

Four different criteria are currently recognized in the scientific literature as indicators of salinity. These are denoted by the electrical conductivity (ECe), which describes the salinity of the aqueous extract at 25 °C; the sodium absorption rate (SAR), which is the ratio of sodium cations to the soil compared to the combined concentration of calcium cations (Ca^{2+}) and magnesium (Mg^{2+}) in the soil; exchangeable sodium percentage (ESP) is used to determine the level of sodium in the soil and the pH of the soil.
Two of these criteria are defined in equations (4) and (5) (Sumner, 1993; Rengasamy, 1999; Quirk, 2001):

$$SAR = \frac{Na^+}{\sqrt{(Ca^{2+} + Mg^{2+})/2}} \quad (4)$$

were:
SAR - Sodium Absorption Ratio, $(cmol\ kg^{-1})^{0.5}$
Na^+, Ca^{2+}, Mg^{2+} - Mesured exchangeable Na^+, Ca^{2+}, Mg^{2+}, respectively, cmol kg^{-1}

$$ESP = (Na^+ /CEC)100 \quad (5)$$

were:
ESP - Exchangeable Sodium Percentage, %
Na^+ - Mesured exchangeable Na^+, cmol kg^{-1}
CEC - Cation Exchange Capacity, cmol kg^{-1}

An ESP of 15 (SAR<13) is generally considered the threshold below which soils are classified as non-sodic, and above which soils are dispersive and suffer serious physical problems when water is applied (http://www.soils.org/sssagloss/, 2006).
However, considerable data exist on infiltration rates and hydraulic conductivities that show that sodic soil behaviour may occur at ESP values of less than 5 if ECe is lower than 4 dSm^{-1} (Sumner and al., 1998).
Therefore, the principal factor determining the extent of the adverse effects of Na^+ on soil properties is the ambient electrolyte concentration in the soil solution, with low concentrations exacerbating the harmful effects of exchangeable Na^+. The SAR has been widely used as a proxy for ESP within the range 0-40 (the ESP range which is most common in agricultural soils).
Therefore a soil having electrical conductivity of the saturated paste extract (ECe) ≥ 4 dS m^{-1} and sodium adsorption ratio (SAR) < 13 is called a saline soil. Soils having (ECe) < 4 dS m^{-1} and sodium adsorption ratio (SAR) ≥ 13 is are designated as sodic soils. If a soil has (ECe) ≥ 4 dS m^{-1} and sodium adsorption ratio (SAR) > 13 it is categorized as a saline-sodic soil (Table 1). Saline-sodic and sodic soils are generally treated together because of similar amelioration practices are used for these soils.

Table 1. Classes depending on the variation salinity indicators SAR, ESP, pH and ECe

Type of soil	The property of soil			
	SAR	ESP	pH	ECe (mS/m1)
Non-saline, non-sodic	< 13	< 15	< 8.5	< 4
Saline	< 13	< 15	< 8.5	≥ 4
Sodic	≥ 13	> 15	> 8.5	< 4
Salin-sodic	> 13	> 15	> 8.5	≥ 4

RESULTS AND DISCUSSIONS

The results obtained by the laboratory analyzes and mathematical calculations, give us the possibility to define the soil studied in terms of: texture, total porosity, the degree of humidity, pH, ECe, $Na^+, Ca^{2+}, Mg^{2+}, Na^+$, SAR, ESP. These results are showed in Table 2.

Table 2. Analytical data on the physical and chemical properties of soils in the studied area

	UM	(0-25 cm)	(25-50 cm)	(50-75 cm)	(75-100 cm)
Gravel (>2 mm)	%	-	-	-	-
Coarse sand (0.5 mm<d<2 mm)	%	-	-	-	-
Medium sand (0.25 mm<d<0.5 mm)	%	-	-	-	-
Fine sand (0.05 mm<d<0.25 mm)	%	4.25	2.60	4.25	4.25
Silt (0.005 mm<d<0.05 mm)		39.20	63.34	26.23	30.04
Clay (0.002 mm<d<0.005 mm)	%	41.19	26.81	23.11	25.48
Fine clay (<0.002 mm)	%	15.36	7.25	46.41	40.23
Textural class	-	Clay	Silty - clay	Loamy clay	Loamy clay
Bulk density	g/cm^3	1.79	1.81	1.89	1.84
Total porosity	%	49.79	44.88	42.06	42.89
Content of moisture	%	32.12	21.79	20.73	19.02
The degree of humidity	%	0.87	0.72	0.77	0.68
pH	unit. pH	6.83	6.9	6.92	6.99
ECe	dS/m^{-1}	93.3	85.,4	103.3	110.7
Na^+	m.e/100 g	25.96	25.34	0.81	3.22
$Ca^{2+} + Mg^{2+}$	m.e/100 g	7.12	8.78	8.01	9.46
SAR	m.e/100 g	13.57	11.44	12.87	11.88
ESP	%	63.08	59.66	63.92	60.94

After analyzing the size particle, the soil has been classified as belonging to the textural clay and clay-loam classes (www.soils.org, 2006).
The soil is characterized by a content of clay 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 and Jijia rivers as fine textured soils.
Bulk density values range between 1.79 to 1.89 for the soil. It was observed that the density values increase with the depth.
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 (Tanji, 1990). The porosity values of the soil are small. 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 (Maas and Hoffman, 1977). The results obtained regarding the soil moisture and soil degree of humidity, confirms this assertion. Exchangeable of sodium percentage quantifying the relative abundance of sodium (mainly) as compared to the complex of divalent cations in exchange cation and provides a means of assessing the risk of structural instability of the soil vulnerable in this conditions. The electrical conductivity of the solution is correlated with the degree of soil salinization. So, the data resulting from the analysis performed in the laboratory shows that the soil has a high degree of salinity, which can be grown only with plants of highly tolerance to salinity.
These characteristics are useful to improve the saline / alkali soils, the irrigation, sewage and waste water.

Problems created in agriculture

Crops on this saline soils are characterized by small plants. "Dwarf" plant is the first visible effect of the action of soluble salts in agriculture.
Some of physical characteristics of saline soils, the classification as clay textural classes and clay-loam, bulk density with high values, the porosity values below 50% will adversely affect water retention capacity, permeability, aeration and report leakage / seepage water.
Other features such as high content of clay, which will swell strongly in the presence of water reduces their permeability for the water. Low permeability leads to stagnation of water in soil and soil surface, which is accompanied by a number of processes and transformations under anaerobic conditions. All these features makes it difficult for the cultivation of these soils and shortens the period in which you can perform agricultural work.
The high concentration in salt contents disrupts the quality of water and nutrients, plant metabolism, and the absorption by plants and soil biota. The water which contains a large amount of salt dissolved brought into contact with the plant cells, with protoplasmic mucous membrane, leads to reducing, shrivelling and the loss of the cell viability. Plant physiology research is required for tolerant salinity plants, for achieve the best results in the desalination of soil, remediation, preservation of these characteristics and for economic optimization.
Plant tolerance to salinity is their ability to resist on the effects of concentrated soluble salts in the root.
Salinity tolerant plants have a strongly ameliorative character. Through their ability to extract large amounts of soluble salts, especially Na^+ and Cl^- or $NaCl_2$ and to accumulate in the leaves. These plants contribute along with the other specific measures to improve salinity with the condition to remove the whole mass of the vegetation.
The lower limit of saturation extract electrical conductivity (ECe) of these soils is conventionally set at 4 dS m^{-1} (at 25^oC). Actually, sensitive plants are affected at half this salinity and highly tolerant ones at about twice this salinity.
The salt tolerance of a crop is not an exact value. It reflects the ability of a crop to resist the adverse, non-specific effects of excessive root zone salinity. Although the capacity of a crop to endure salinity cannot be stated in absolute terms, the relative crop responses to known salinities under certain conditions can be predicted.
The tolerances of crops to salinity are generally divided into four classes i.e. sensitive,

moderately-sensitive, moderately-tolerant and tolerant (Akhtar et al., 1994). Generally, the threshold and linear slope for a crop remain within one class. Where the linear curve for a crop crosses division boundaries, the crop was classified based on the tolerance at lower levels at which yield was commercially acceptable.

Bean (*Phaseolus vulgaris* L.), strawberry (*Fragaria x ananassa* Duch.), peas (*Pisum sativum* L.), lentil (*Lens culinaris*) are sensitive tolerance to salinity.

Soya (*Glycine max*), peanuts (*Apios americana*), onion (*Allium cepa*), millet (*Pennisetum glaucum*), flax (*Linum usitatissimum*), garlic (*Allium sativum*) are moderately-sensitive tolerance to salinity.

Indian mustard (*Brassica juncea*), wheat (*Triticum aestivum*), sunflower (*Helianthus annuus*), barley (*Hordeum vulgare*) rise (*Oryza sativa*) and cotton (*Gossypium hirsutum*) are moderately-tolerant to salinity.

Canola (*Brassica napus* L.), sugar beet (*Beta vulgaris* L.), Rhodes grass (*Cynodon gayana*), Kallar grass (*Leptochloa fusca*), Bermuda grass (*Cynodon dactylon*), are tolerant to salinity.

Various approaches have been taken to improve the salt tolerance of these crops by introducing genes for salt tolerance into adapted cultivars, including screening of large international collections, extensive testing of selected cultivars under field conditions, conventional breeding methods and unconventional crosses with the crop-specific relatives. The aim has been to exploit variation in salt tolerance within a particular crop and its progenitors or close relatives to produce new cultivars with more tolerance than the existing cultivars.

Another issue in cultivating soils affected by the salinity, is the choice of crops used as an amelioration tool, to resist the absence of oxygen when excessive irrigations are applied to leach salts from top soil to lower depths. Root zone salinity in conjunction with oxygen deficiency greatly increases salt uptake compared with saline non-waterlogged conditions (Maas and Hoffman, 1977). This effect may cause failure in active transport and exclusion processes in the root membrane (Drew, 1983; West and Taylor, 1984; Dagar et al., 2004).

There seems to be a need to evaluate salt tolerant crops for their resistance again hypoxia. The genotypes showing greater tolerances against the combined effects of salinity and hypoxia may be a better choice for soil amelioration. Thus genotypes of increased tolerances to salinity and hypoxia should be investigate or developed through genetics and bioengineering processes. Use of suitable rotations of the salinity-hypoxia-tolerant crops during soil amelioration may help promote lowering of the water table-leaching of salts and soil aggregation.

CONCLUSIONS

The analysis of the results obtained from conducted research, allow us to take 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 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.

SAR values above 13 correlated with saturation in sodium (ESP) greater than 15% (of T) on a minimum thickness of 10 cm, it identifies a Natric horizon. SAR values between 4 and 13 correlated with saturation in exchangeable sodium (ESP) 5-15% (of T) on a minimum thickness of 10 cm, identify us a hiponatric horizon.

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

Crop diversification and production systems based on plant species resistant to salinity, are likely to be the key to the future agriculture and economic.

This is relevant for arid and semi-arid countries less developed, where most farmers cultivate salt-affected land and the resources are poor and the communities experiencing severely unemployment, poverty and male population migration.

REFERENCES

Akhtar et al., 1994. Combined effect of salinity and hypoxia in wheat *Triticum aestivum* L. and wheat *Thinopyrum amphiploids*. Plant and Soil 166, 47-54.

Dagar J.C., Tomar O.S., Kumar Y., Yadav R.K., 2004. Growing three aromatic grasses in different alkali soils in semi-arid regions of northern India. Land Degradation and Development, 15, (2), 143-151.

Drew, 1983. Plant injury and adaptation to oxygen deficiency in the root environment a review. Plant and Soil 75, 179-199.

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.

El-Mowellhey N., 1998. Proceedings of the International Symposium on Sustainable Management of Salt Affected Soils in the Arid Ecosystem. Cairo, Egypt, 21-26 September 1997, 1-2.

Maas E.V., Hoffman G.J., 1977. Crop salt tolerance - current assessment. J. Irrigation and Drainage Division, ASCE 103 (IRI), 115-134.

Niţu I., Dracea M., Răuţă C., Rizea A., 1986, Improvement and exploitation of the salty soils of R.S. Romania. Ed. Ceres, București.

Quirk J.P., 2001. The significance of the threshold and turbidity concentrations in relation to sodicity and microstructure. Australian Journal of Soil Research, 39, 1185-1217.

Rengasamy P., Churchman G.J., 1999. Cation exchange capacity, exchangeable cations and sodicity. Reuter. Soil Analysis: an Interpretation Manual, CSIRO Publishing, Collingwood.

Stanciu A., Lungu I., 2013. Geotechnical, works for laboratory. Ed. Politehnium, 95-103.

Sumner M.E., Rengasamy P., Naidu R., 1998. Sodic soils: a reappraisal in sodic soil distribution. Management and Environmental Consequences, Oxford University Press: NY, 3-17.

Sumner M.E., 1993. Sodic soils: New perspectives. Australian J. Soil Res., 31, 683-750.

Szabolcs I., 1971. European Solonetz Soils and their Reclamation. Ed. Akadémiai Kiadó, Budapest, 204 p.

Tanji, 1990. Nature and extent of agricultural salinity. In Agricultural Salinity Assessment and Management, Tanji KK (ed) Manuals and Reports on Engineering Practices No. 60 American Society of Civil Engineers, New York, 1-17.

West, 1978. Water use and sodium chloride uptake in apple trees II The response to soil oxygen deficiency. Plant and Soil, 50, 51-56.

West and Taylor, 1984. Response of six grape cultivars to the combined efects of high salinity and rootzone waterlogging. Journal of the American Society of Horticultural Science 109, 844-851.

***ICPA, 1987. National Institute of Research and Development for Soil Science, Agrochemical and Environmental Protection of Bucharest, GAEC code.

***Soil Science Society of America, 2006. Internet Glossary of Soil Science, Available at www.soils.org.