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RISKS OF SOIL DEGRADATION THROUGH SALINIZATION DUE TO INADEQUATE QUALITY OF THE WATER USED IN IRRIGATION ARRANGEMENTS FOR THE WESTERN PART OF ROMANIA*

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Abstract

Irrigation arrangements in Romania mainly use as a source of water, surface water. Although Romania has adopted a series of regulations on the use of irrigation, we do not have the framework to compel the users of surface water for irrigation to water quality monitoring, limitations or restrictions in this area are only quantitative.
Monitoring water quality and quantity had an upward trend since 2000 due to the Water Framework Directive, which provided the legal framework for the transition to a new stage of development in sustainable water management. The concept of monitoring required by the Water Framework Directive, for water in general and in particular for irrigation water, regards water primarily as a resource for complex uses, and secondly as an ecosystem with high ecological value. Globally, irrigated agriculture is dependent on a supply of good water quality. Romania's accession to the European Union requires compliance with European agriculture, irrigated agriculture playing an increasingly important role in environmental protection in rural areas.
The increase in soil salinity causes enlargement of the osmotic pressure in the soil solution and the occurrence of water stress plant culture. In such situations, the cultivated plant has the capability to extract soil water necessary for growth and development in optimal conditions. Also unbalanced balance the ratio of monovalent cations (sodium) and those with higher valences negatively affect organic matter content and soil structural stability.

Keywords: irrigation arrangements, ground water, surface water, water quality, water pollution

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1. Introduction

Worldwide emergence and expansion of negative processes of soil degradation through salinization has constituted a warning to the scientific community long time ago. Researches on the factors and processes that caused the expansion of areas affected or potentially risk the appearance of degradation by salinization were initiated five decades ago. Soil salinity is characterized by the high content of cations and anions which generally influence the physical, chemical and biological properties of the soil.

The main problem in these soils is the balance between the amount of salts introduced unevenly or freed from the soil and which results in an increase usually inadequate concentration of soluble salts in the soil. The term "salts" includes all compounds which are present in native soil and which are not potential contaminants.

The saline or salty soils term means all land affected negatively by the presence of slightly soluble salts, in whatever form and intensity in which they occur; are included in this category, both saline soils and alkalized in varying degrees and saline soils and acidity at the same time, regardless of the salinity - alkalization. The main mechanism that determines the accumulation of salts in soils irrigated agriculture is the evapotranspiration, which has the effect of salt concentration in the remaining water in the soil (Corwin et al., 2007).

This situation is common especially in semiarid and arid regions. In such areas the water supply is a limiting factor for the growth and development of cultivated plants. If the lack of water is supplied in sufficient quantities from irrigation water, does not mean that there is a potential risk of accumulation of salts in the soil.

2. Method

A first step in risk assessment is to identify the general areas that are at threat and the risk of negative process, after the analysis of existing data (Table 1). Then it should be identified the high-risk areas to salinity, preferably using models based on processes at high resolutions (Eckelmann et al., 2007).

Table 1. Surface of soils affected by salinization in the western part of Romania (Vest Plain) (thousand ha)

Region	*County*	*Soils*							
		Saline		*Affected*		*Total*		*Potential*	
		ha	*%*	*ha*	*%*	*ha*	*%*	*ha*	*%*
Vest Plain 2814.30 ha (100%)	Arad	25.00		31.00		56.00			
	Bihor	9.00		21.00		30.00			
	Satu-Mare	4.05		14.95		19.00			
	Timiş	31.70		38.50		70.00			
	Total	69.75	2.45	105.25	3.71	175.00	6.16	400	14.08

3. Experimental

Salinization, alkalization of the terrains from the Timis - Bega Low Plain by increasing pedo-phreatic intensely mineralized water is a real phenomenon that occurred over large areas after the land improvement works started in 1718 in the Banat. Saline soils are defined as soils exceeding an electro conductivity of 4 dSm^{-1}. Based on this classification, the total area of saline soils on Earth is 351.5 million hectares.

The decision on what level of sodium in the soil exchangeable Na^+ is a degree of excessively saturation is complicated by the fact that there is no obvious change in soil properties as Na^+ saturation level increases. However in the US and worldwide value exchangeable sodium (ESP) greater than 15 is the criterion of separation sodic soils, while in Australia the value used ESP> 6 is used. Two important parameters are used to define sodic soils (Eqs. 1, 2).

ESP (exchangeable sodium percentage) – exchangeable sodium percentage describing adsorbed sodium levels in the soil.

ESP = (exchangeable sodium / cation exchange capacity)·100 (1)

$$Exchangeablesodiumpercentage = \frac{ExchangeableNa(me/100gsoil)}{CationExchangeCapacity(me/100gsoil)} \cdot 100$$

SAR (sodium adsorption ratio) – report indicating the adsorbed sodium irrigation water in the soil solution Na, Ca, and Mg are expressed in milliequivalents per liter.

$$S.A.R. = \frac{Na^{+}}{\sqrt{\frac{1}{2}\left(Ca^{2+}Mg^{2+}\right)}} \qquad (2)$$

In many soils sodification comes from the parent material nature and pedogenetic processes. There are also sodic soils where due to anthropogenic processes sodification appears, this is called secondary sodization. Sodizate irrigation waters without a corresponding drainage and other land improvement can quickly lead to secondary sodization. The fraction that significantly affects soil physical behavior is colloidal clay. Intensity of swelling and dispersion processes as adverse effects on the soil become more severe with increasing soil sodization. Sodification - related to degradation of soil structure leads to increasing soil water transmission, susceptibility to crust formation, draining and erosion (Rogobete and Constantinescu, 2008).

The discovery that hydraulic conductivity in soils depends on SAR and electrical conductivity of the solution percolating soil has led to the development of "threshold concentration" which is defined as the electrical conductivity needed to prevent a decrease in hydraulic conductivity for a soil with ESP or SAR clarified solution. This explains the decrease of hydraulic conductivity in soils, even soils with Ca and soils with low ESP exposed to low salinity waters. The decrease in hydraulic conductivity occurs because the concentration of salts in the soil solution is not sufficient to prevent swelling and dispersion of clays. When the dispersion appears clays, clay particles dispersed moves down the soil profile and may even cause complete blockage of pore conductivity and hence an irreversible change in the hydraulic conductivity.

Sodic soils containing minerals ($CaCO_3$ and other primary minerals) that are rapidly releasing soluble electrolytes will not be quickly dispersed by washing with distilled water at moderate values of ESP, since as a fairly high concentration of the electrolyte (~ 3 $mmol_c^{-1}$) may be maintained to prevent dispersion of clays. In addition to the ESP will decrease because most divalent cations are released (Ca and Mg). In calcareous soils hydraulic conductivity is declining, while in the non-calcareous soils Mg causes a decrease in hydraulic conductivity soil over the system Na/Ca.

Sodic conditions can lead to nutritional imbalances and deficiencies of micronutrients that can destroy the redox potential, pH and concentration of dissolved organic carbon. Phosphorus and potassium do not pose any nutritional problem in sodic soils, but may suffer due to inadequate availability of nitrogen.

More specific, Timis River that borders the south Timis-Bega Low Plain has a low slope and fills with high level the phreatic (0.4 to 1.4 m). The bed consists of groundwater horizons composed of acvitarde clay and marl that do not allow lateral transport of water. The amplitude of multiannual oscillation piezometric gradient varies between 1-2 m levels maintained for 6-7 months.

The amount of dissolved salts in pedo-phreatic water varies between 0.5-1.5 g/L, lower concentrations occur in the border area of the river Timis, Timisat and Bega and higher concentrations occur in the areas of Cruceni-Foeni-Giulvaz-Diniaa. Conditioned by a exudation hydric regime, with phreatic waters rich in carbonates and bicarbonates of Na and Mg, which after evaporation on the surface of the soil enrich the soil profile in salt, in various types of soil salinization occurs. Therefore on the territories from the west part of Romania moderately to strong salinization occurs over a large area.

To describe the areas affected by salinization processes, and to identify the spatial catchments of our country has been developed at this stage, a specific methodology by National Institute for Research and Development Institute for Soil Science, Agrochemistry and Environment Protection (ICPA, 2010). Facilities were used in ArcView GIS provided for achieving the intersection of spaces within basins and soil map, scale 1: 200,000, developed within Geographic Information System of Soil and Land of INCDPAPM system called SIGSTAR-ICPA.

The Romanian soil map scaled at 1: 200 000 was developed in the period from 1964 - 1994 and published under the direction of N. Cernescu initially and subsequently by Florea (1976). Each of the 50 sheets from this paper includes a geomorphological - lithological, a geobotanical cartogram, climatological data for some weather stations in the area and some pedo-morpho-graphic profile regarding representative cross-sectional profile in the area.

The 50 sheets georeferenced were digitized and aggregated into a single coverage throughout Romania. Original sheets were mapped in Transverse Mercator projection - the Krasovski ellipsoid, which is a transverse cylindrical projection, consistent, useful for the scale of the maps were originally made. After aggregation of the 50 map sheets, resulting layer (the coverage) was passed in stereographic projection, azimuthal projection is a secant or tangent plane on the ellipsoid, is also a projection line. In Romania is mostly used for small-scale maps, 1: 1 000 000 (ICPA, 2010). Each soil mapping unit (polygon) on the soil map of SIGSTAR is described by a set of attributes (characteristics or properties of the unit), such as soil type and subtype, surface texture horizon, skeleton, processes affecting soil degradation namely: water erosion by wind, alkalization, gleyzation, pseudo gleyzation. From this map this map were identified salty soil and salinization risk, taking into account the type and subtype of soil and degradation processes affecting them for the western part of Romania. The data were centralized in Table 2.

4. Results and discussion

The initial direct source of salts in the soil is constituted by the primary minerals that are found in soil and rocks of the earth's surface exposed. During the process of chemical alteration are involved hydrolysis, solution, the oxidation, carbonation and the salts are gradually released and solubilized. There are some cases where the accumulated salts from this single source and saline soils were formed. Saline soils typically occur in areas that receive salts from other locations and water is the main carrier. Usually the direct source of salts is water is used for irrigation and raising the groundwater near the soil surface (Rogobete and Constantinescu, 2008).

Table 2. Repartition of salinization territories affected by soil salinization inside the Banat hydrographical area

Land moderate to severely affected or at risk of salinization (ha)		**29 853**	**Geomorphology**				
			Meadow			**Plain and terraces**	
Salinity (g/L)			**1.5-2**	**1.5-2**		**>2**	**1.5-2**
Depth of groundwater (m)			**1-3**	**1-2**		**1-2**	**1-2**
Texture (ha)	***Fine***	2 106	688	1 418			
	Medium	27 747		6 513	14 084	503	6 647
The land affected by salinity, which are necessary measures and intensive work to recover land (ha)		**37 311**	**Geomorphology**				
			Meadow			**Plain and terraces**	
Salinity (g/L)			**< 1.5**	**0.5-2**	**1.5-2**	**1.5-2**	**>2**
Depth of groundwater (m)			**1-2**	**1-2**	**1-2**	**1-2**	**1-2**
Texture (ha)	***Fine***	12 318	2 210	9 001		1 107	
	Medium	24 993		7 995	3 816		13 182

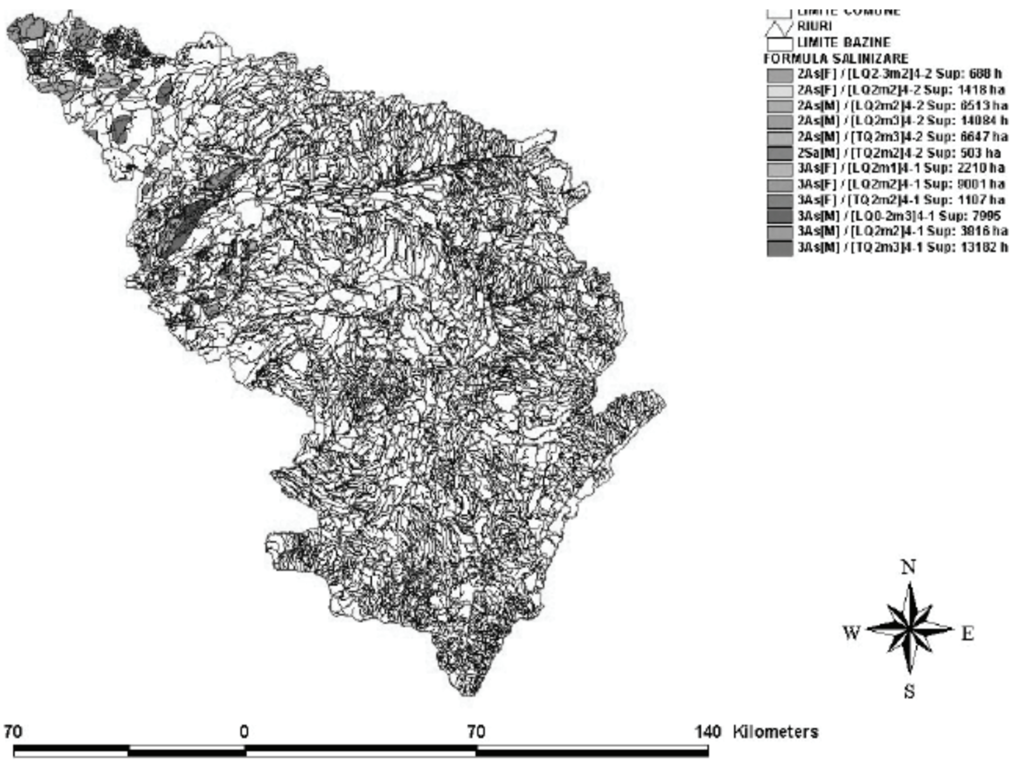

Fig. 1. Banat hydrographical area 4 (ICPA, 2010)

According to the data provided by studies of Institute for Studies and Designing for Land Reclamation Bucharest irrigation works for the western part of Romania were performed mostly before 1990, on an area of 16 379 ha, structured on the following types of facilities (Balteanu et al., 2013):

- irrigation arrangements with a surface greater than 1 000 ha - totalizing 7 216 ha;
- irrigation arrangements with a surface less than 1 000 ha - totalizing 1.000 ha;
- local facilities - totalizing 8.163 ha.

The state of the irrigation works is as followed (Giurgiu et al., 2011):

- Beregsau arrangement spreading within a gross area of 542 ha, which in the years 1990-1992 was completely devastated, (the two pumping stations pressurizing and containing hydrants and antennas). According to GD 1574, (2008), this arrangement was proposed for withdrawal of recognition of public utility and conservation is scheduled to be decommissioned according to the national regulations.
- Periam arrangement with a gross floor area of 640 ha is partially running. Pressurizing station is functional as well as some of the pipes and hydrants. The station is proposed for withdrawal from public utility recognition and in 2010 was initiated the procedure of giving free use of an organization under the national law.
- Sag-Topolovat complex irrigation arrangements consist of 8 irrigation plots. Before being removed from the agricultural circuit appeared after 1990 the total gross area of 8 747 ha and the agricultural area of 8 614 ha. At the end of 2010, as a result of the land removing from agricultural circuits the gross total area was of 8 387 ha and the agricultural land – 8 093 ha. It is the only large arrangement system in Timis County, made before 1989 from centralized funds.

Following current legislation (Law 138, 2004), the whole arrangement was sent to the Organization of Water Used for Irrigation, action completed in 2009. In addition to these two facilities there are local irrigation facilities belonging to private owners such as SC Sinagro, SC Emiliana West Rom, SC Handel, SC Aqua Mures, SC. Genagricola Romania, with a total irrigated area up to 20 000 ha and rising.

Fig. 2. Localization of Irrigation arrangements from Timis County (Giurgiu et al., 2011)

Considering all the facts regarding the irrigation facilities in the Western region of Romania that have recently experienced a period of expansion due to modernization of older irrigation systems or due to designing and execution of completely new systems, it is necessary for all the users a closer water use monitoring depending on the water sources and its distribution to the plant. The fact that these users are currently charged only for quantities of water taken without being conditioned by regular assessment in terms of its qualitative can bring great disservice to the terrestrial ecosystems impoverishing them from perhaps the most fragile of their resources and one with the lower recovery rate, namely the soil.

Salinization affects plant growth through three mechanisms:

- osmotic effects limit the ability of plants to absorb water from the soil solution;
- specific ion toxicity;
- changing physical and chemical properties of soil.

Currently on a national level, there is no unified approach to quantitative and qualitative dimensions of irrigation water, both as a resource and as pumping station equipment. With existing equipment pumping stations can only measure and meter volume and pump flow. Water quality strongly influences soil fertility and agricultural production and therefore the benefits that they bring to irrigation. To assess water quality is required to make periodic physico-chemical analysis of water, because water quality changes over time, under the influence of various environmental and anthropogenic factors.

The content of the irrigation water soluble salts should be the range of 0.15 to 3 g/L. If the content of soluble salts is 4 g/L, water is harmful to the plants. The most damaging are the carbonate salts, and sodium chloride that should not exceed 1 g/L.

5. Conclusions

To assess the risk of salinization, a water sample should be analyzed for three major factors: the total content of soluble salts, content of sodium adsorption (SAR) and toxic ions. Toxic ions include items such as chloride, sulfate, sodium and boron. Sometimes, even if the salt level is not excessive, one or more of these elements can become toxic to the plant. Many plants are very sensitive to boron.

In general, it is best that in well determinate time interval to require an analysis of the water that lists the concentrations of all cations (calcium, magnesium, sodium, potassium) and major anions (chloride, sulfate, nitrate, boron) so that the levels of all elements to be evaluated.

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