THE SPATIAL DISTRIBUTION AND MOVEMENT OF SOLUBLE SALTS FROM ROMANIAN SOILS

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Abstract

The objective of this paper is to present a sketch map of the accumulation of soluble salts in soils from Romania, as a support for improving saline soils or preventing undesirable anthropogenic salinization phenomena.

The map highlights the spatial distribution and movement of easily soluble salts in soil at the scale of the entire country, It is an overview on origin, sources and pathways of migration and accumulation of easily soluble salts in interdependence with natural factors and conditions.

Taking into account the movement pathways of easily soluble salts in soil, two geochemical zones were separated on the map: the eluviation - transit zone and the transit - accumulation zone. In the last zone, areas where the accumulation of salts becomes dominant have been delimited, their transit being insignificant. The movement directions of easily soluble salts in soil are also highlighted on the map.

From a naturalistic point of view, the map highlights the close connection between areas with accumulation of salts and areas where geological, geomorphological and hydrogeological conditions lead to a poor drainage. It also highlights the connection and importance of salt sources from geological deposits or salt masses in the hilly area in the formation, expansion and chemistry of saline soils in the plain or floodplain areas located in the neighbouring lowlands.

Key words: saline soils, soluble salts, distribution, accumulation

INTRODUCTION

The salt accumulation in groundwater tables has been studied in several papers (Kovda, 1946; 1947). In Romania, previous studies on the mineralization of groundwater tables carried out in plains and floodplains (Bucur, Măianu, Florea, Oprea, Stepănescu, Miclăuş, Sandu, Colibaș, Teşu, Niţu şi alţii) highlighted a quite large range of values (0.1 – 80 g/l). The movement and accumulation of mineral salts in soils occur in close correlation with their hydrothermal regime; in turn, this regime depends on the physical-geographical, as well as on climatic conditions.

Research on the improvement of soils affected by salts is relatively numerous, especially for the areas of the north-eastern Romanian Plain (Guștiuc et al., 1959; Măianu, 1964; Florea, 1970; Sandu, 1984; Nițu et al., 1983; 1985; Nițu and Drăcea, 1988; Coteț et al., 2010) and for the Banato-Crisană Plain (Oprea et al., 1961; 1962; 1971; Colibaș and Colibaș, 1968; Colibaș, 2016; Stepănescu et al., 1983; Vlas et al., 1983; 1984), but also in the Moldavian Plain (Bucur, 1956; 1958; Bucur et al., 1960; Merlescu et al., 1979; Tesu et al., 1979a; 1979b). A synthesis of these researches was presented by Ionescu-Șișești (1964), Măianu (1984), Sandu (1984), Nițu et al (1985), Florea and Dumitru (2002).

The objective of this paper is to present a sketch map of the accumulation of soluble

salts in soil in Romania, as a support for improving saline soils or prevention of undesirable anthropogenic salinization phenomena.

The map highlights three distinct but closely related aspects: the spatial variation of the soluble salt content of the sediments reflected by the distribution of the sediment groups according to this content, the geochemical zones of salt migration and accumulation and the directions of salt movement.

MATERIALS AND METHODS

The map was carried out by processing numerous analyses on the content of easily soluble salts in different soil types and sediments widely, distributed on the entire Romanian territory.

The Romania's soil map at the 1:1 000 000 scale and geological maps, at 1:200 000 scale, have been used as input databases.

RESULTS AND DISCUSSIONS

1. *Groups of surface sediments according to the content of easily soluble salts*

The existing data and especially the results of the studies carried out in relation to the soluble salts from the surface deposits were generalized and extended over the entire territory of the country based on the soil map and the geological map. Therefore, ten groups of sediments were distinguished, as following:

- sediments with a range of 8 – 20 mg salts/100 g sediment, with an average of about 15 (sometimes reaching 40) mg salts/100 g sediment; mainly corresponding to surface deposits in the humid mountain area developed on crystalline, usually skeletal rocks;
- sediments with 10 – 40 (60) mg salts/100 g sediment (an average of 25 mg salts/100 g sediment); especially continental and skeletal sandy deposits, with deep groundwater table;
- sediments with 20 – 80 mg salts/100 g sediment, with an average of about 50 mg salts/100 g sediment; corresponding to loessoid deposits or medium-heavy deposits in the humid area, and sandy or sandy-clay deposits influenced by groundwater table;
- sediments with 40 – 100 mg salts/100 g sediment (an average of about 65 mg salts/100 g sediment); the loessoid sediments and loess from the semi-humid - semi-arid area and the medium - heavy deposits from the humid area influenced by groundwater table;
- sediments with 40 – 150 mg salts/100 g sediment (an average of about 80 mg salts/100 g sediment); corresponding to marine sandy deposits, clay-marly deposits from the semi-humid – semi-arid zone (Moldova, Transylvania), meadow deposits from the humid area, gleyic sandy deposits and medium-heavy gleyic deposits from the humid area;
- sediments with 60 – 150 (250) mg salts/100 g sediment (an average of about 100 mg salts/100 g sediment; mainly corresponding to the loessoid deposits influenced by the groundwater water table in the western Romanian Plain and to some alluvial deposits in the Danube Flood Plain;
- sediments with 60 – 250 (400) mg salts/100 g sediment; including loessoid deposits influenced by the groundwater table from the Central Romanian Plain, Dobrogea, the Banato-Crișan Plain and the Moldavian Plateau, as well as some gleyic sediments from the Banato-Crișan Plain and Transylvania;
- sediments with 60 – 600 (1200) mg of salts/100 g of sediment; corresponding especially to the loessoid deposits influenced by the groundwater table or even gleyic ones from the north-eastern Romanian Plain and some alluvial deposits from Moldova and the Banato-Crişan Plain;
- sediments with 60 – 1,000 (2,000) mg of salts/100 g of sediment; some alluvial sediments from the north-eastern Romanian Plain and the Danube Flood Plain;
- sediments with 150 – 2,400 mg salts/100 g of sediment; corresponding to the saline marls, as well as the deposits

accompanying them or resulting from their alteration.

The first four groups are not salinized sediments, they could even be considered poor in salts; the following two groups are also not salinized, but having contents close to the salinization limit; while the last four groups include the salinized sediments occurring only in the relatively dry area and with groundwater table close to the surface, excepting the last group (marls or saline clays) which can also occurr in wet areas and outside the influence of groundwater table.

Table 1 shows some characteristics of the sediment groups described above; the predominance of NaCl is noticeable in the sediments very poor in salts, bicarbonates predominating in the poor and weakly salinized sediments.

Table 1. Characteristics of sediment classes, according to the content and nature of soluble salts

Class, according to the content in soluble salts		The dominant anionic composition	The order of cation dominance and their association
Non-saline sediments	0 – 20	chloride-sulphate, mixed-chlorine	Na, Mg, Ca
	20 – 50	mixed-chloric, mixed-bicarbonate	Na, Ca (Mg)
	50 – 100	predominantly bicarbonate, sometimes bicarbonate-mixed	Ca, Mg Ca, Mg, Na Ca, Na, Mg
Saline sediments	100 – 250	bicarbonate and mixed-bicarbonate	Na, Ca, Mg Ca, Na
	250 – 600	mixed (bicarbonate, chloride or sulfate) and chloride-sulfate or sulfate-chloric	Na (Ca, Mg)
	600 – 1000	sulphato-chloric, sometimes chloride-sulfatic	Na (Ca, Mg)
	> 1000	dominant sulfate	Ca, Na (Mg) Na, Ca (Mg)

2. *The geochemical zones of salt migration and movement*

Two main geochemical zones of the movement of easily soluble salts in soil were separated on the Romanian territory: a zone of intense elution and intense transit of salts and a zone of transit with moderate-slow movement associated with an accumulation, an enrichment in salts of waters and sediments.

Within the second zone, areas were separated as a special situation where the accumulation of salts is dominant, their transit being insignificant. We mention that we considered that on the Romanian territory these areas do not form a zone, but represent special situations with a more or less local character against the background of the transit-accumulation zone. Lakes, also functioning as salt collectors, were also represented on the map.

The eluvium-transit zone, characteristic of drained regions from the humid climate, actually represents the areas with intense alteration processes, release of various salts, their transition into solution and percolation and their transport through infiltration water bodies, groundwater table and surface water bodies. It has been subdivided into two subzones according to the nature of the rocks that are subject to alteration:

- the subzone of proto-eluviation that includes the areas with crystalline rocks that are subjected to alteration and eluviation processes for the first time and those with chemical precipitated rocks that are able to release important quantities of salts; and
- the neo-eluviation subzone which includes the other sedimentary rocks, rocks which are currently undergoing a new cycle of alteration and eluviation and generally release relatively fewer salts.

The transit - accumulation area, specific for the lower regions with varied drainage from the semi-humid-semi-arid climate, actually represents the area through which the salts are passing by different pathways towards the main salt accumulation basins: the sea and the lakes. Their movement is done through groundwater tables or surface water bodies. In this area, there are also obviously processes of alteration,

release of salts and their elution. The slow transit of salts and their easy accumulation are also specific to this area. This accumulation phenomenon intensifies in certain local conditions and are therefore characterized by a weak to deficient drainage, leading to the accumulation of easily soluble salts in the sediment, soil and groundwater tables in that area.

As a rule, the local movement of salts, especially frequent in the second zone, which is done in the sense that the easily soluble salts are leached, moving from the higher and more drained places, either in depth, or towards the low places where the respective salts or a part of them accumulate. The areas and sub-areas mentioned also correspond to different situations from an ameliorative point of view.

Therefore, for the geochemical eluvial - transit zone with a relatively humid climate, with intensely leached eluvial soils and more or less demineralized, a continuous and intense enrichment in bases is characteristic, and they must be supplemented by calcareous amendments; mineral fertilizers are also relatively quickly removed from these soils.

For the transit and accumulation area, with a semi-humid - semi-arid climate, with less leached and demineralized soils, calcareous amendments are no longer necessary; on the contrary, there is a tendency for sediments and groundwater tables to be enriched in salts.

In the moderate transit and weak accumulation subzone, which characterizing the areas drained with deep groundwater tables, these processes are poorly developed; on the other hand, in the slow transit subzone, specific for poorly drained territories, an accumulation of salts in groundwater and sediments is clearly observed, and the danger of secondary salinization is accentuated. In this subzone, measures are needed to prevent the intensification of salinization and/or alkalization phenomena that can be increased for irrigation applications.

In the case of the areas of current accumulation of salts, which usually correspond to practically undrained areas with saline or salinized soils and mineralized groundwater tables, it is necessary to take energetic measures to improve the natural drainage of the land and soil and to stop the influx of easily soluble salts; only in this way can the respective soils be improved.

3. *Directions of movement of easily soluble salts*

The movement of easily soluble salts in soil is done by means of groundwater tables and river waters, to which is also added the runoff water on the soil surface and subsurface. In a purely indicative way, the main directions of movement of the salts were shown on the map (figure 1) using arrows.

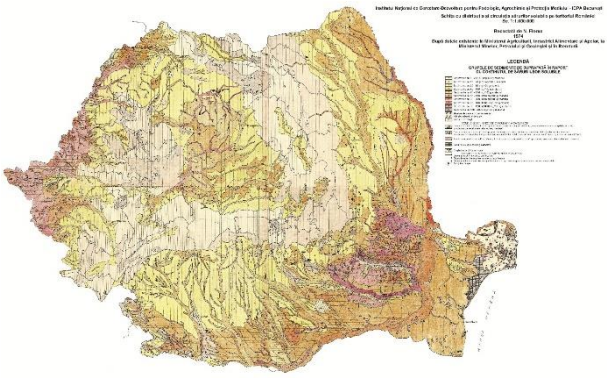

Figure 1. Romania – Map of the soluble salts distribution and movement

For the eluvial - transit zone where surface waters play the main role in the salts movement, the hydrographic basins of the main rivers were delimited and the direction of water flow and with it the direction of the salts was noted.

For the transit-accumulation area, in which groundwater tables have a main role in the salts movement, the main directions of their movement together with groundwaters were shown, differentiating a more intense movement in the fragmented lands and a slower one in the lower, poorly fragmented and drained plains. Also, the sectors where the rivers supply salts to the groundwater tables were marked on the map.

The arrows orientation highlights the general tendency of the easily soluble salts to move towards the lowest parts of the landforms or towards the collecting arteries of the hydrographic network.

CONCLUSIONS

- On the salinity map of the surface deposits, groups of surface sediments are separated according to their content in easily soluble salts; 10 groups were distinguished, from the poorest (8 - 20 mg/100 g soil) to those with over 1,000 - 2,000 mg/100 g soil. One could be noticed that soils very poor in salts are usually acidic soils in which carbonates no longer appear, because they cannot coexist (CO_2 is released).
- Taking into account the pathways of movement of easily soluble salts, two geochemical zones were separated on the map: the elution - transit zone and the transit – accumulation zone; within the last zone, areas were delimited where the accumulation of salts becomes dominant, their transit being insignificant. The directions of movement of easily soluble salts are also shown on the map.
- The knowledge of the distribution and movement of easily soluble salts highlighted on the map at the country level is important because it presents in a synthetic form a country-wide overview of the origin, sources and ways of migration and accumulation of easily soluble salts in interdependence with natural factors and conditions.
- From a naturalistic point of view, the map highlights the close connection between territories with accumulation of salts and geological, geomorphological and hydrogeological conditions that determine poor drainage; it also highlights the connection and importance of salt sources from geological deposits or salt masses in the hilly area in the formation, expansion and chemistry of saline soils in the plain or floodplain located in the neighbouring lowlands.
- The geochemical and naturalistic importance of the study is doubled by a practical importance related to the foundation of the overall concept and solutions regarding the complex development of the lowland territories in our country.

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