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Quantitative and qualitative differenttiation of soil salinity in Poland

PIOTR HULISZ[1], 2008

Introduction

The occurrence of salt-affected soils (SAS) in Poland is connected with the impact of different natural and anthropogenic factors, from which the climate has relatively smallest importance. In spite of some similarity to typical solonchaks and more rarely to solonetzes, these soils have very specific properties (Hulisz 2005). Most habitats with SAS are rated among very rare and valuable objects, protected in the framework of Nature 2000 Network (Piernik et al. 2007).

It is possible to distinguish the following soil salinity sources: marine waters (Baltic coastal zone), waters contacted with Zechstein salt deposits (Central and NW Poland), waters contacted with Miocene salt deposits (Carpathian Depression, Nida Basin), soda industry wastes and brines (Central Poland), mine waters and mine waste dumps (Upper and Lower Silesia). Polish salt-affected soils are distinguished by spot spatial distribution (Fig.1). The estimated area of SAS is about 5.420 ha. However, it undergoes continual changes mainly caused by the disappearance of mineral springs, drainages, transformations of land use and the chemical factories closing.

The aim of this paper is to characterize chosen chemical properties of Polish salt-affected soils with reference to the salinity sources and their taxonomy position. Author used both the results of own studies (Hulisz 2005) and the literature data.

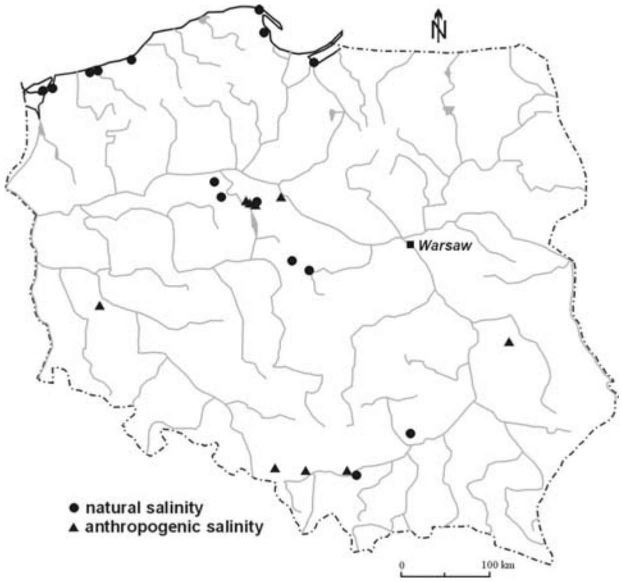

Figure 1: The distribution of salt-affected soils in Poland (Hulisz 2007b, modified)

Characteristics of groundwaters

The data presented in Table 1 show distinct differentiation of groundwater properties. Electrical conductivity (EC) of waters under influence of natural salinity usually did not exceed 15 $dS{\cdot}m^{-1}$ and mineral content was below 10 $g{\cdot}dm^{-3}$ (with the exception of some samples from Nida Basin). It is possible to explain it by brackish properties of the Baltic Sea and some dilution of long-residence time mineral deep waters by young fresh waters in ascent zone (Krawiec 2002). Extreme salinity level was exclusively noted in groundwaters contaminated by soda industry wastes (EC up to 102 $dS{\cdot}m^{-1}$, mineral content to 96.8 $g{\cdot}dm^{-3}$).

The hydrochemical types determined according to Schukarev-Priklonski classification (Macioszczyk 1987) emphasized the predomination of chloride and sodium in the ion composition. The occurrence of others ions was mainly dependent on the chemical composition of the salinity source. Type Cl-SO_4-Na reflected the influence of chloride-sulphate and sulphide springs in Nida Basin, Cl-Ca-Na – the pollution of soda industry wastes, Cl-HCO_3-Mg-Na – the contact with seawater.

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Salinity source	EC $dS \cdot m^{-1}$	Mineral content $g \cdot dm^{-3}$	Hydrochemical type
marine waters*	0.6 - 9.5	0.4 - 5.6	Cl-Na, Cl-HCO_3-Mg-Na, SO_4-Cl-Na
mineral waters (Central and NW Poland)	1.4 - 12.0	0.9 - 7.8	Cl-Na, Cl-Na-Ca
mineral waters (Carpathian Depression, Nida Basin)	12.2 - 37.6	7.7 - 26.6	Cl-SO_4-Na
soda industry wastes	80.8 -102	69.4 - 96.8	Cl-Ca-Na
mine waters	0.48 - 22.7	0.3 - 14.4	Cl-Na, SO_4-Cl-Na

*according to Pracz (1989)

Table 1: Properties of groundwater taken from soil pits with reference to salinity sources

Soil salinity state

The salinity level of Polish SAS is strictly correlated with the properties of the groundwaters described above. The range of electrical conductivity values determined in the saturation extract (EC_e) can be very wide – from 1.83 to 97.2 $dS \cdot m^{-1}$. EC_e of soils polluted by brine can even reaches 193 $dS \cdot m^{-1}$.

Two directions of saline water migration were observed in analyzed soils (Fig.2). The water infiltration from soil surface was connected with brine contamination (profile 1) and spring backwaters (profile 2). The second direction was caused by the fluctuation of shallow saline groundwater level and the capillary uprise (profiles 3-4).

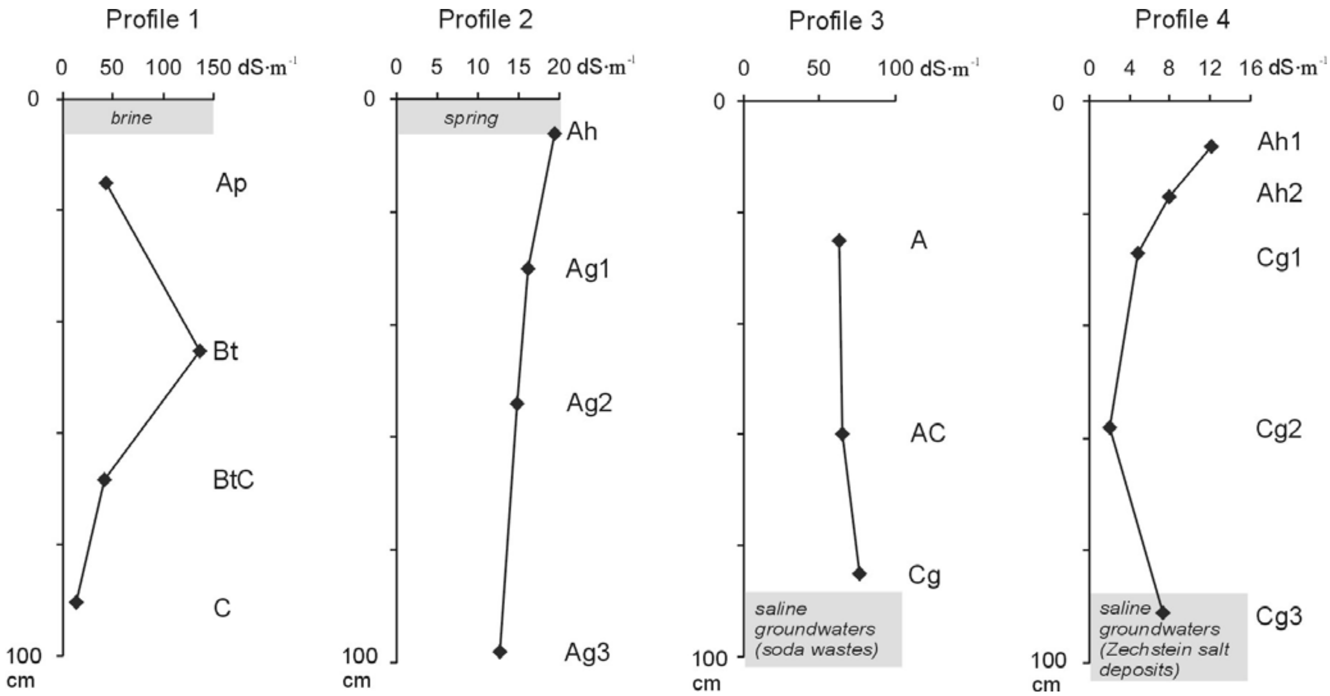

Figure 2: Variability of the salinity level in the selected soil profiles

An endopercolative water regime predominates in Polish soils. That is why the salt accumulation in SAS is completely dependent on the permanent supply of groundwaters with high mineral content.

The distribution of salts in soil profile can be modified by such properties like texture and/or organic matter content (Fig. 2).

All studied soils showed the predomination of sodium and chloride in 1:5 extract. It was confirmed by statistical analysis (Table 2). Spearman's rank correlation coefficient (rs) for Na-Cl pair was between 0.942 and 0.991. In case of soils under soda waste impact very strong correlation between Ca and Cl ions was also stated (rs = 0.945). However, soils affected by mineral water in Nida Basin were characterized by very strong correlation between Mg and SO_4 ions (rs = 0.951).

Equivalent Cl : SO_4 ratio in soil horizons was between 0.1 and 217. It allowed to distinguish a few salinity types according to Bazylevich and Pankova classification (1969):

1. chloride (Cl : SO_4 > 2.5) – soils under the influence of soda industry wastes and brines,
2. sulphate - chloride (Cl : SO_4 1 - 2.5) – surface horizons affected by mineral waters,
3. chloride - sulphate (Cl : SO_4 0.2 - 1) – gleyic horizons of soils affected by mineral waters,
4. sulphate (Cl : SO_4 < 0.2) – some soils of coastal zone (Pracz 1989).

Exchangeable sodium percentage (ESP) in Polish SAS ranged from 2 to 87%. Highest sodium level was stated in soils affected by brine. Because of predomination of natrium chloride in soil solution ESP values distinctly corresponded with EC_e values.

Table 2. Spearman's rank correlation coefficient for ions determined in 1:5 extract

Soils under soda wastes impact

	HCO_3^-	SO_4^{2-}	Cl^-	Na^+	K^+	Ca^{2+}	Mg^{2+}
HCO_3^-	1.000						
SO_4^{2-}	0.714*	1.000					
Cl^-	0.541	0.682*	1.000				
Na^+	0.575	0.700*	0.991*	1.000			
K^+	0.491	0.653*	0.927*	0.941*	1.000		
Ca^{2+}	0.642*	0.682*	0.945*	0.936*	0.868*	1.000	
Mg^{2+}	0.231	0.711*	0.437	0.446	0.341	0.424	1.000

Soils affected by mineral waters (Central and NW Poland)

	HCO_3^-	SO_4^{2-}	Cl^-	Na^+	K^+	Ca^{2+}	Mg^{2+}
HCO_3^-	1.000						
SO_4^{2-}	0.217	1.000					
Cl^-	0.033	0.283	1.000				
Na^+	0.117	0.367	0.950*	1.000			
K^+	0.283	0.317	0.833*	0.750*	1.000		
Ca^{2+}	0.433	0.400	0.333	0.233	0.767*	1.000	
Mg^{2+}	0.367	0.500	0.433	0.317	0.800*	0.967*	1.000

Soils affected by mineral waters (Carpathian Depression, Nida Basin)

	HCO_3^-	SO_4^{2-}	Cl^-	Na^+	K^+	Ca^{2+}	Mg^{2+}
HCO_3^-	1.000						
SO_4^{2-}	0.393	1.000					
Cl^-	0.396	0.797*	1.000				
Na^+	0.459	0.914*	0.942*	1.000			
K^+	0.604*	0.881*	0.804*	0.879*	1.000		
Ca^{2+}	0.418	0.853*	0.818*	0.865*	0.860*	1.000	
Mg^{2+}	0.523	0.951*	0.790*	0.893*	0.951*	0.867*	1.000

* *significance level $p \leq 0.05$*

Taxonomic position of salt-affected soils

Taking into account U.S. Salinity Laboratory Staff criteria (Richards 1954) about 63% of Polish SAS can be classified as saline-sodic (EC_e > 4 $dS \cdot m^{-1}$, ESP > 15%, pH_e < 8.5) and the rest as saline soils (EC_e > 4 $dS \cdot m^{-1}$, ESP < 15%, pH_e < 8.5).

The results obtained by Hulisz (2007b) showed that the salinization in Poland concerns mostly mineral-organic and organic soils which are characterized by lack of visible salinity features in their morphology. Salt crusts on the soil surface can form very rarely (Hulisz 2003) and columnar or prismatic structure was not observed as yet (no *natric* horizon). Under Poland climatic conditions only the occurrence of halophytes can give some information about the range and quality of soil salinity (Piernik 2003). All these facts suggest the secondary character of salinization as soil-forming process in Poland. The taxonomic position of Polish SAS according WRB system (IUSS Working Group WRB 2006) seems to confirm it. The salinity features can be expressed on the lower level of a classification. Most of natural salt-affected soils can be described as Salic Histosols (Sodic) or Salic Gleysols (Sodic). However, anthropogenic SAS can be classify as Technosols.

Criteria for SAS included in Systematics of Polish Soils (1989) need some revisions. The proposal concerned the changes in the nomenclature and the general modification of the diagnostic horizon definitions was published in Soil Science Annual (Hulisz 2007a). Author hopes that it will take into consideration during the elaboration of the new version of Systematics of Polish Soils.

Summary

1. Occurrence of Polish SAS is not conditioned by climate condition but by the stable inflow of waters with high mineral content (of natural or anthropogenic origin).
2. In the chemical composition of studied soils NaCl predominated and the contribution of other salts depended on the influence of specific environment features.
3. The salinity level was connected not only with the kind of salinity sources and also distinctly corresponded to such soil properties, like particle size distribution and organic matter content.
4. The salinity process in Polish salt-affected soils has a secondary character in relation to other soil forming processes.
5. The specificity of Polish salt-affected soils needs the separate systematic approach.

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