HYDRIC SOILS OF BANAT

SOLURILE HIDRICE DIN BANAT

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Abstract: *Hydric soils have formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions. Reduced soil materials have a gleyic colour, bluish to greenish and Gr is present in the first 50 cm in the upper part of soil. Oximorphic properties apply to soil materials at surface layers of soils with fluctuating ground water level, marked by reddish brown, orange or yellowish mottles.*

Rezumat: *Solurile hidrice s-au format în condiţiile saturării cu apă, a inundării şi stagnării pentru lungi perioade de timp ceea ce a cauzat procese de anaerobioză. Ca urmare, în primii 50 cm de la suprafaţa solului se dezvoltă un orizont Gr ce are o coloraţie specifică, vineţie - albăstruie - cenuşie. Acolo unde stratul freatic are fluctuaţii de nivel hidrostatic se formează un orizont oximorfic, identificat prin prezenţa unor concreţiuni şi pete de culoare gălbuie, roşiatică sau portocalie.*

***Key words*:** *Gleysols, oxidation, reduction, potential, redox*
***Cuvinte cheie*:** *Gleiosol, oxidare, reducere, potenţial, redox*

INTRODUCTION

Hydric soils are most often defined as soils that have formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part. Iron and manganese minerals are chemically reduced from the ferric to the ferrous state, giving the soil a bluish – grey colour when permanently saturated. Where reducing and oxidizing conditions alternate, a characteristic orange – brown mottling develops. Saturation or inundation when combined with microbial activity in the soil causes a depletion of oxygen. This anaerobiosis promotes biochemical processes such as the accumulation of organic matter and the reduction, translocation with accumulation of iron and other reducible elements. The characteristic morphologies persist in the soil during both wet and dry periods, making them particularly useful for identifying hydric soils. In accordance with WRB Reference Group soils, the soil saturated by groundwater near the surface for long periods are Gleysols. In the Romanian classification there are three types of soils in the Hydric Soils: Gleiosol, Limnosol and Stagnosol.

The name Gleysols is from the Russian “gley”, meaning “mucky mass”. Common international names are Gleyzems (Russia), Gley (Germany), Aquents, Aquolls, Aquepts (USA), Rego Gleysols (Canada), and Lăcovişti (Romania) with a total area of 720 million hectares.

In the Soil Maps of Europe (1:500000), Gleysols have the follow soil types: Calcaric, Dystric, Dystri-stagnic, Eutric, Eutri-fluvic, Eutri-stagnic, Eutri-vertic, Fluvi-mollic, Humic, Mollic, Calcari-mollic, Fluvi-mollic and Thionic Gleysol. As soils types there are: Gleyc Acrisol, Albeluvisol, Andosol Cambisol, Cryosol, Luvisol, Phaeoziom, Podzol, Solonchak, Solonetz, Vertisol, and also: Stagnic Albeluvisol, Cambisol, Luvisol, Phaeoziom and Podzol.

In Romania Soil Taxonomy System, Gleyosol has subtypes: Dystric, Eutric, Calcaric, Mollic, Cernic, Umbric, Psamic, Pellic, Cambic, Aluvic, Histic and Thionic.

Stagnosol has subtypes: typic, luvic, albic, vertic, gleyic, planic, histic.

MATERIAL AND METHOD

This article will present and discuss the main types of Gleysols from the low plane of Banat and the important chemical reactions, like the reduction of oxygen, nitrogen, iron and manganese and some aspects of the characteristics of Gleysols. The paper relies on a detailed soil survey effectuated in 2005 year in the communal territories Foeni, Giulvăz and Uivar.

RESULTS AND DISCUSSION

Gleysols typically occur in humid or semihumid environments in footslopes and low-lying situations on the landscape. By definition, they do not occur in recent alluvial materials. Hydric soils are soils that support or are capable of supporting wetland ecosystems, i.e., soil modifications are not needed to maintain or restore a wetland. A reduced soil is one in which redox reactions have caused reduced forms of O, N, Mn, Fe or S to be present in soil solution. Common reduced forms found in Hydric soils include: H_2O, N_2, Mn^{2+}, Fe^{2+} and H_2S; their oxidized forms are: O_2, NO_3, Mn^{4+}, Fe^{3+} and SO_4^{2-}, respectively.

Oxidation occurs when bacteria and other micro-and macroorganisms decompose organic matter and produce electrons (e^-) and protons (H^+). Oxidation is the norm; however, when a soil starts to become wet and eventually saturated, reduction reactions begin at microsites, if the soil is wet enough for a long period (some weeks) spread through the soil.

As long as air is present in soil water, all electrons produced by organic matter decomposition are consumed by O to make water:

$$24e^- + 6O_2 + 24H^+ = 12H_2O$$

When most of the O has been reduced, a soil is said to be anaerobic. Anaerobiosis results in the reduction of nitrates (NO_3^-) to form N (N_2) followed by Mn from Mn^{4+} to Mn^{2+}, Fe from feeric (Fe^{3+}) to ferrous (Fe^{2+}), sulphates (SO_4^{2-}) to form hydrogen sulphide (H_2S) and carbon dioxide (CO_2) to form methane (CH_4).

Nitrate in soil can be destroyed by the action of denitrifying bacteria when oxygen is in short supply. Under anaerobic conditions the nitrate ion can be used instead of O_2 as the acceptor of free electrons produced during respiration:

$$NO_3^- \rightarrow NO_2^- \rightarrow N_2O \rightarrow N_2$$

In soils, organic matter (CH_2O) is the primary source of electrons.

$$\begin{gathered} 4Fe(OH)_3 + 12H^+ + 4e^- \rightarrow 4Fe^{2+} + 12H_2O(reduction) \\ CH_2O + H_2O \rightarrow CO_2 + 4H^+ + 4e^-(oxidation) \\ 4Fe(OH)_3 + CH_2O + 8H^+ \rightarrow 4Fe^{2+} + CO_2 + 11H_2O \end{gathered}$$

Soils that are oxidized most all of the time are usually red in colour, and soils that are reduced most all the time are usually greyish in colour.

Soils, with intermittent wetness can be a mixture of reds and greys. Redox concentrations are zones (reddish) where Fe/Mn is concentrated. There are three types: (1) concretions; (2) masses, which are soft bodies with in the soil matrix; (3) pare linings, which are coatings on a natural soil surface (ped face, air pore, root pore). Pore linings are the most reliable evidence of contemporary wetness; concretions reflect prior wetness.

For most of the world, wet soils are microbial active when air temperature is above approximately 5°C. If microbes are active, if Fe/Mn oxides are present in the soil, if the soil is saturated, if the water is stagnant, if there is a source of usable organic water in the soil, and if O and N have been reduced then the electrons will reduce and translocate the Fe/Mn present and redox features will result.

The redox potential (Eh) of soil and water is a measure of electrochemical potential or electron availability within these systems.

$$E_h(mV) = E^0 - \frac{59}{n}\log\left(\frac{(Rd)}{(Ox)}\right) + 59\frac{m}{n}pH$$

Typically in wetland soils, E_h values range from -300 to 700 mV with a total range of approximately 1000 mV. In aerobic soils where the O_2/H_2O redox couple functions, the E_h range is between 300 and 700 mV.

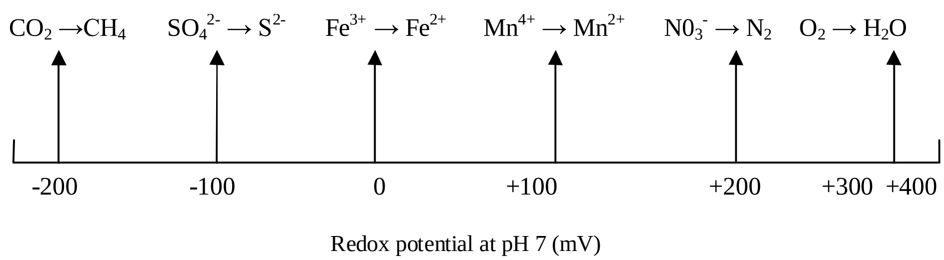

Figure 1. Critical redox potential

As indicated previously, nitrate is utilized first after oxygen disappears followed by manganese, ferric iron, sulphate and finally carbon dioxide.

Redox conditions of soil also govern heavy metal chemistry.

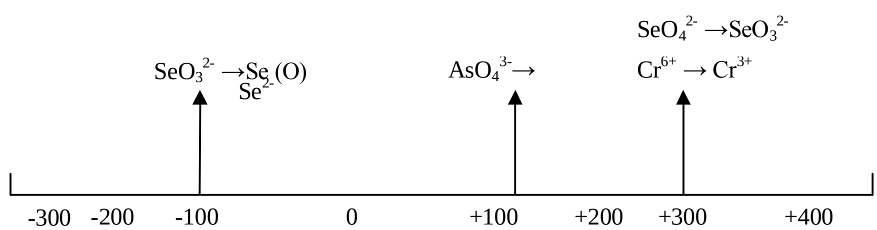

Figure 2. Redox potential – metal chemistry

The main characteristics of the three profiles from Foeni –Uivar will be presented.

1. Mollic – Vertic Gleysols (Gleisol cernic-pelic)

Foeni – Profile description

0-21 cm (Apy) mollic horizon; dark brown, dark greyish brown mottled clay loam with moderate subangular blocky structure.

21-38 cm (Az Gr) mollic horizon; dark greyish brown with bluish mottled clay loam with strong subangular blocky structure; gleyic properties.

38-80 cm (ACz Gr) dark grey bluish mottled clay loam with fine angular blocky structure; gleyic properties.

80-120 cm (CnGr) bluish - grey mottled clay loam; gleyic properties.

Table 1

Analytical data

	Apg	AzGr	ACzGr	CnGr
Clay	38.1	40.7	39.2	40.4
Silt	28.0	27.9	28.7	25.5
Bulk density	1.55	1.60	1.58	-
Field capacity	24.48	23.23	23.0	-
Ksat mm/h	0.65	0.45	0.50	-
pH	7.54	8.10	8.16	8.25
Humus	2.82	2.04	1.38	-
Pmobile,ppm	128.34	14.90	7.91	-
Kmobile,ppm	107	96	92	-

2. Mollic Gleysols, semihistic (Gleiosol cernic, semihistic)

Cruceni – Profile description

0-27 cm (Amg) mollic horizon; brown blackish, granular structure, mottled clay loam.

27-55 cm (AmGr) mollic horizon; dark brown mottled clay loam with moderate subangular blocky structure; gleyc properties.

55-68 cm (AcGr) dark grey bluish, mottled clay loam with moderate subangular blocky structure; gleyc properties.

68-150 cm (CnGr) grey mottled clay loam.

Table 2

Analytical data

	Amg	AGr	ACGr	CnGr
Clay	33.7	40.6	35.4	35.3
Silt	24.8	25.7	21.0	21.3
Bulk density	1.20	1.35	1.48	1.44
Field capacity	25.50	24.24	23.16	22.54
Ksat mm/h	5	0.80	1.50	0.65
pH	6.05	7.17	7.67	7.39
Humus, %	4.32	2.58	1.98	-
Pmobile, ppm	20.8	3.79	1.65	-
Kmobile, ppm	147	114	103	-
BSP	77.92	83.60	85.75	-
CECs	26.59	23.55	21.18	-

3. Verti – gleyic Cambisols (Pelosol gleic)

Foeni – Profile description

0-34 cm (Az) vertic horizon; dark brown greyish loamy clay with moderate subangular blocky structure.

34-50 cm (AzGo) pellic horizon; dark brown bluish loamy clay, mottled with angular blocky structure.

50-100 cm (CzGo) grey mottled loamy clay

100-145 (CGr) loam

Table 3

Analytical data

	Az	AzGo	CzGo	CGr
Clay	48.0	49.5	43.1	22.8
Silt	22.6	22.0	26.0	24.9
Bulk density	1.41	1.48	1.7	-
Field capacity	26	25	23.8	-
Ksat mm/h	0.80	0.55	0.75	-
pH	6.50	7.47	7.89	7.83
Humus, %	2.28	1.38	-	-
Pmobile, ppm	3.84	1.92	-	-
Kmobile, ppm	110	103	-	-
BSP	76.44	82.37	-	-
CECs	28.45	28.65	-	-

It is important to distinguish Gleysols from gleyic and stagnic subunits of other reference Soil Groups or types of soil, which also have gleyic properties but have a different hydrology and morphology. Stagnic subunits normally have a slowly permeable dense layer in the solum above which water stagnates. Gleysols have a permanent groundwater table, at 0.5-1.5 m depth and are found in valleys and low plane.

Chemically, Gleysols are rather fertile, but physically they are saturated with water for long periods during the year. Repeated wetting and drying may also cause an increase in soil density. This results in poor aeration of the routing environment and unsuitable conditions for most fauna. They can be used for arable cropping when the groundwater table is lowered by drainage.

CONCLUSIONS

Gleysols, or soils with gleyc properties, are either permanently or temporarily wet or reduced at shallow depth. Reduced soil materials that are permanently saturated have a characteristic gleyic colour pattern (white to black or bluish to greenish) in the soil matrix. In loamy and clayey materials blue – green colours dominate. Oximorphic properties apply to soil materials at surface layers of soils with fluctuating groundwater level. The oximorphic properties are evidenced by the presence of reddish brown (ferrihydrite), orange (lepidocrocite) or bright yellowish brown (goethite) mottles. Soil morphology that results from redox reactions is used to identify hydric soils in the field.

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