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ASPECTS REGARDING THE SOIL HEALTH STATUS FOR SOME FLUVIC GLEYSOLS FROM DRAIN AREAS CĂLARAȘI FLOODPLEIN

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Abstract

After draining activities, the lands present a series of specific vulnerabilities: textural heterogeneity, decrease in organic matter content, secondary salinization. These may constitute limitations in the exercise of soil functions. The study focused on an area in the Călărași Floodplain, which was formed after extensive drainage projects. Soil analyses show organic carbon reserves reduced by almost half in the first 50 cm (53%) compared to the storage potential, and organic carbon reserves of approximately 67% compared to the storage potential in the first 30 cm. Total nitrogen reserves are distributed similarly to those of organic carbon. The total salt content shows a tendency to accumulate up to the soil surface, with larger quantities below the first 30 cm. The values of bulk density and packing density, as indicators characterizing the state of soil compaction, do not highlight the existence of secondary compaction processes.

***Key words**:soil health, organic carbon, soil salinization*

INTRODUCTION

Soil constraints significantly affect agricultural productivity and food security, with reduced soil health posing a major threat to global food safety, biodiversity, and climate (Panagos et al., 2024). Assessing soil health is complex due to the soil's intricate nature and the lack of complete evaluation solutions, despite numerous existing approaches (Lehmann et al., 2020, Păltineanu et al., 2024).

The European Soil Monitoring and Resilience Law (SML, 2023) defines soil health as the "physical, chemical and biological status of soil that determines its capacity to function as a living system and to provide ecosystem services". Another definition states that a soil is healthy if its natural functions relative to the type of land use are not subjected to degradation in any significant way (Alewell et al., 2025). Increased awareness of climate change has highlighted the necessity of soil protection, which requires knowledge and tools to evaluate soil integrity. Consequently, much research aims to find a unified framework for assessment.

The European Soil Law proposes thresholds for indicators to uniformly evaluate soil health across Europe, allowing for adjustments based on national specificities. Research efforts, such as those by Păltineanu et al. (2024, 2025), are being conducted to evaluate soil health at the national level, focusing on aspects like carbon/nitrogen stocks, organic carbon sequestration potential, and the evaluation of soil functions (e.g., organic matter, nutrient, biodiversity support, water, and contaminant cycles) relative to land use. Results often indicate an average state of health. The present paper aims to analyze aspects concerning the state of health of selected soils located within a drained enclosure in the Călărași Floodplain.

MATERIALS AND METHODS

The study area is located in the Călărași Floodplain, in anarable drained polder (Fig. 1). The absolute altitude is 10 m, the groundwater table ranged between 0.9 m and 1.5 m, the mean temperature is 10.9°C, and the multiannual mean precipitation is 485 mm.

Figure 1. Location of the study sites

For the study area, eight soil profiles were analyzed (table 1), all belonging to the Hydrisols Class (SRTS, 2012).

Table 1.Soil profiles list

No.	Soil name (SRTS, 2012)	Cod
1	Gleiosol calcaric hiposalic lutic	GSka sc-LL/LL
2	Gleiosol calcaric hiposalic lutic	GSka sc-LP/LL
3	Gleiosol calcaric hiposalic psamic	GSka sc-NF/TT
4	Gleiosol calcaric hiposalic lutic	GSka sc-LL/NF
5	Gleiosol calcaric hiposalic lutic	GSka sc-LL/LP
6	Gleiosol calcaric hiposalic psamic	GSka sc-NF/NF
7	Gleiosol calcaric hiposalic lutic	GSka sc-LL/NF
8	Gleiosol calcaric hiposalic psamic	GSka sc-NG/NF

GSka sc - Fluvic Gleysols (Calcaric, Salic)
LL- medium clay; LP - silty clay, NF- Fine sand; NG - coarse sand; TT - clayey clay

The following parameters were analyzed: soil particle size distribution (texture), soil reaction (pH), organic matter content, total nitrogen, available phosphorus and potassium, and total soluble salts contents. Indicators regarding the soil physical state (bulk density, hydraulic conductivity, and total porosity) were also analyzed,using MESP (1987) and national standards.

For the purpose of this paper, the analytical results were processed and presented as constituent stocks (organic carbon, total nitrogen) for the 50cm depth, according MESP (1987), and for the 30cm depth following international regulations (SML, 2023).

Furthermore, the values for clay content and total salt content were presented as mean values for the 30and 50cm depth increments.

The organic carbon stock was calculated using equation (1). The nitrogen stock was calculated using the same equation, replacing SOC with the total nitrogen content.

$$SOC_{stock} = SOC*BD*Depth \quad (1)$$

SOC_{stock}- *Soil Organic Carbon Stock (Mg/ha)*
SOC - Soil Organic Carbon (%)
BD - Bulk Density (g/cm^3)
Depth - thickness of the horizon (cm)

The saturation potential of soil organic carbon (SOC_{pot}) was calculated as a soil content using Hassink's formula (Hassink, 1997)equation (2).

$$SOC_{pot} = 4.09+0.37(Clay+Silt)(2)$$

SOC_{pot} - *Soil Organic Carbon potential (%)*
Clay - Clay content (%)
Silt - Silt content (%)

The storage deficit was calculated usingequation (3):

$$SOC_{defstock}=SOC_{potstock}-SOC_{stock} \ (3)$$

The soil compaction state was characterized using the values of bulk density and, indirectly, using packing density. The latter was calculated using the formula (4):

$$PD = BD+(0,009*Clay)(4)$$

PD - Packing density (g/cm^3)
BD - Bulck density (g/cm^3)
Clay - Clay content (%)

RESULTS AND DISCUSSIONS

The identified soils are Fluvic Gleysols (calcaric, salic), withdifferent textures in topsoil(medium loam to fine and coarse sand) (SRTS, 2012). The presence of a shallow groundwater table is the main factor influencing the formation and evolution of these soils.

The soil packing state (degree of compaction) varies from slightly compacted to very loose. This stratification leads to a differentiated circulation of water and nutrients throughout the soil profile.

The soil reaction (pH) across all analyzed samples is slightly alkaline, with variations ranging from 7.86 to 8.44. The nutritional element supply is variable in the study soils. The organic matter content varies depending on the texture, with humus stock classified from low to high.

In the arable layer, the total nitrogen (Nt) content is medium, exceptingsites 3, 6, and 8, where the content is low. These contents are closely linked to the soil texture and organic matter content.

For a unitary assessment, organic carbon stocks and total nitrogen stocks were calculated for the 0-30 cm and 0-50 cm depths for each soil profile. The values for clay content, total salt content, bulk density, and particle density were expressed as mean values over 0 – 30 cm and 0 – 50 cm (Table 2).

Table 2. The soil indicators for 0-30 cm and, respectively, 0-50 cm

Soil profile	SOC_{stock}	$SOC_{pot\ stock}$	$SOC_{def\ stock}$	Nt_{stock}	SC	Clay	BD*	PD**
	Mg/ha				mg/100 g	%	g/cm^3	
0-30 cm								
1	58.00	92.40	34.40	6.23	164.00	29.8	1.32	1.59
2	66.82	99.10	32.28	7.35	111.00	26.0	1.31	1.54
3	39.04	45.00	5.96	4.30	43.29	4.80	1.37	1.41
4	56.96	95.20	38.24	6.41	46.00	27.40	1.36	1.61
5	60.90	96.40	35.50	6.55	57.00	29.60	1.38	1.65
6	29.35	53.70	24.35	3.61	156.00	4.90	1.5	1.54
7	41.82	82.50	40.68	5.17	53.00	23.40	1.42	1.63
8	35.32	44.90	9.58	3.91	293.00	3.30	1.51	1.54
0 – 50 cm								
1	78.52	146.30	67.78	8.58	184.00	28.9	1.27	1.53
2	95.52	157.40	61.88	10.04	187.00	26.8	1.29	1.53
3	49.72	93.70	43.98	6.70	44.3	13.4	1.25	1.37
4	83.76	157.30	73.54	9.92	83.00	26.9	1.36	1.60
5	91.26	160.70	69.44	10.12	110.00	30.1	1.3	1.57
6	35.56	89.90	54.34	4.97	153.00	5.5	1.49	1.54
7	65.27	133.30	68.03	8.63	70.00	20.8	1.39	1.58
8	41.80	75.90	34.10	5.30	274.00	3.6	1.51	1.54

*Bulk density, ** Packing density

The distribution of the organiccarbon stock within the 0-50 cm depth interval indicates a medium reserve in medium-textured soils and a large reserve in coarse soils.

In relation to the potential organic carbon stock($SOC_{potstock}$), it is noticed that for the 0-50 cm interval, the storage potential is satisfied by an average of 53%, whereas for the 0-30 cm interval, this storage potential issatisfied at a proportion of 66% (Fig. 2 and 3).This distribution is natural, as the main root mass is concentrated in the top 30 cm.These data emphasize the need of implementing measures to preserve and increase the soil organic carbon stock (appropriate tillage, land cover, vegetal resources, and fertilizersmanagement).

The total nitrogen reserve is distributed similarly to the organic matter content.

Regarding the Total Salt Content (SC), a tendency for salts accumulation towards the soil surface is observed.

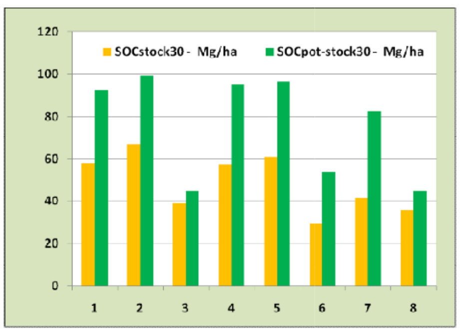

Figure 2. SOC_{stock} and $SOC_{pot\ stock}$ for 30 cm

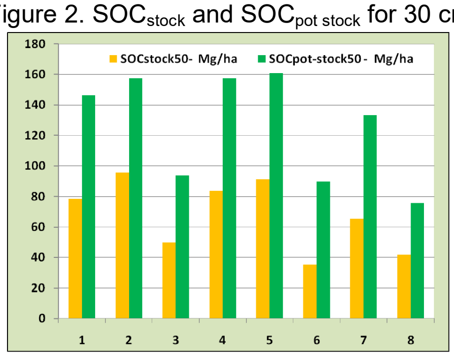

Figure 3. SOC_{stock} and $SOC_{pot\ stock}$ for 50 cm

Half of the analyzed profiles have a total soluble salt content exceeding 100 mg/100 g of soil, with higher amounts below the first 30 cm. Five of the analyzed sampling sites have concentrations ranging between 110 and 274 mg/100 g of soil (Fig. 4).

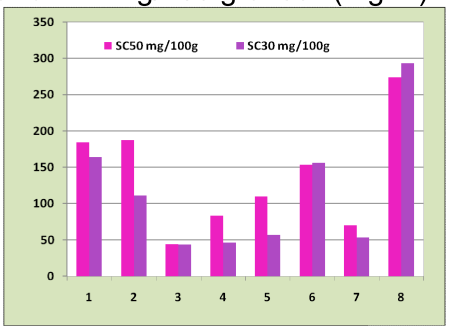

Figure 4. Average total salt contents (SC) for 30 and 50 cm

These values highlightthe tendency of salt accumulation throughout the profile, therefore pointing out the need to monitor the evolution of salt content across the profiles and maintaining the irrigation-drainage channels in good conditions.

The soil structure, characterized by two indicators (bulk density and packing density)does not indicate anthropic impact. The soil is slightly compacted/loosened.

Analytic data are usually presented based on pedogenetic horizons. Using instead the stocks or average values over standard depths could be a solution for the uniform evaluation of indicators characterizing soil health.

CONCLUSIONS

The soils within drained polders exhibit a series of vulnerabilities due to the fast loss of organic matter, textural heterogeneity, the risk of salinization and over-drying.The data indicated organic carbon stocks lower than the soil's storage potential in both the 0-30 cm and 0-50 cm intervals.The total salt content emphasizes an incipient secondary salinization process, with larger accumulations of salts below 30 cm. Half of the profiles have a total soluble salt content exceeding 100 mg/100 g of soil in the first 30 cm, with five of the analyzed points showing concentrations between 110 and 274 mg/100 g of soil.Bulk density and packing density do not indicate anthropogenic compaction.Expressing the analyzed values as stocks or as mean values over standard depths could be a solution for a unitaryassessment of indicators characterizing soil health status.

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