



ASSESSMENT OF PHYSICAL AND MECHANICAL SOIL CONSTRAINTS IN SÂNANDREI, WESTERN ROMANIA

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Abstract: This study analyzes the physical and physico-mechanical properties of two representative soils from Sânanndrei (Timiș County, Romania): molic preluvosol and eutric gleysol. The research is based on detailed pedological data, including granulometric composition, bulk density, total porosity, aeration porosity, water retention capacity, and soil compaction indicators.

The results indicate that both soils belong to the fine-textured class (clayey-loam), which significantly influences their water retention capacity and aerohydric regime. The molic preluvosol is characterized by high bulk density (1.46–1.60 g/cm³), low total porosity (38–42%), and reduced aeration porosity, indicating significant compaction and limited permeability. In contrast, the eutric gleysol shows lower bulk density (1.28–1.42 g/cm³) and higher total porosity (43–49%), but negative aeration porosity values, reflecting excessive water saturation and poor oxygen availability.

Water retention capacity is higher in gleysol, with field capacity values reaching up to 44%, compared to 22–24% in preluvosol. However, this advantage is offset by poor drainage and reduced biological activity. The comparative analysis highlights that preluvosol is mainly limited by mechanical constraints, while gleysol is affected by hydric excess.

The study emphasizes the importance of adapting soil management practices to specific physical limitations. Recommended measures include deep loosening and organic amendments for preluvosol, and drainage and controlled tillage for gleysol.

These findings contribute to a better understanding of soil functionality in the Banat Plain and provide a scientific basis for sustainable agricultural management.

• Introduction

Soil is one of the most complex and valuable natural resources of the biosphere, being essential for sustaining agricultural production, maintaining biodiversity and regulating global biogeochemical cycles (BRADY&WEIL, 2016; LAL, 2015; LAL&STEWART, 2012). Globally, soil functionality is closely related to its physical and physico-mechanical properties, which control the processes of infiltration, water retention, aeration, and root development (HILLEL, 2004; HORN&FLEIGE, 2009). In the current context of climate change and agricultural intensification, the degradation of the physical properties of soils, especially compaction and reduction of aeration porosity, is a major problem for global food security (LAL&STEWART, 2012; FAO, 2015; MIRCOV ET AL., 2025; MIHUȚ ET AL., 2018).

In Romania, soil research has highlighted the importance of physical and hydrophysical properties in assessing soil fertility and suitability for different crops (FLOREA & MUNTEANU, 2012; MIHUȚ ET AL., 2023). The soils in our country have a high diversity, determined by variations in climatic, geomorphological and geological conditions, which leads to a wide range of physical and mechanical behaviors (IANOȘ ET AL., 1997; FLOREA ET AL., 2014). In particular, fine textures, frequently found in lowland soils, determine a high water retention capacity, but are also associated with high risks of compaction and poor aeration (STROIA ET AL., 2025; BLAGA ET AL., 2005).

In the western part of Romania, especially in the Banat Plain, soils are predominantly formed on loessoid deposits and fluviatiles, which favors the development of preluvosols and gleisols, characterized by distinct physical properties (FLOREA ET AL., 2014). Under these conditions, the clay and glazing processes play an essential role in differentiating the soil profile and in determining the aerohydric regime (BĂLTEAU&BADEA, 2007). Preluvosols have a denser structure and a tendency to accumulate clay in the subsurface horizons, which leads to reduced permeability and increased mechanical strength (Ianoș et al., 1997). On the other hand, gleisols are influenced by the high level of groundwater, which causes the appearance of hydromorphic conditions, characterized by pore saturation and oxygen deficiency (BLAGA ET AL., 2005; FLOREA & MUNTEANU, 2012).

• Material and method

The study was carried out in the area of Sânanndrei commune, located in the north-western part of Timiș County, about 15 km from Timișoara, within the geomorphological unit of the Banat Plain, an integral part of the Tisa Plain. From a geographical and pedogenetic point of view, the analyzed area is characterized by a poorly fragmented relief, specific to the accumulation plains, in which the subsidence processes and the dynamics of the groundwater had a decisive role in the formation and evolution of the soil cover.

The geological conditions are dominated by loessoid deposits and fluviatiles, with medium and fine textures, which constitute the parent material for the studied soils. These deposits favored the development of soils with specific physical and hydrophysical characteristics, influenced by processes such as clay and glaciation. From a climatic point of view, the region falls into the temperate-continental climate, with sub-Mediterranean influences, characterized by average annual temperatures of about 10–11°C and annual rainfall of 550–600 mm, which causes a variable water regime and, under certain conditions, the appearance of temporary excess humidity (MIHUȚ ET AL., 2023; BRADY & WEIL, 2016; MIRCOV ET AL., 2025).

From a pedological point of view, two representative types of soil were selected in the study, namely soft preluvosol and typical eutric gleisols, considered relevant for the comparative analysis of physical and physico-mechanical properties. The soft preluvosol is developed on loessoid deposits, having a well-differentiated profile, characterized by clay accumulation horizons (Bt), while the typical eutric gleisols is formed on fluvial deposits and has obvious hydromorphic features, generated by the influence of groundwater.

The data used in the analysis come from the detailed pedological study carried out in the Sânanndrei area, which includes the morphological description of the soil profiles and the determination of the main physical and physico-mechanical indicators. The following categories of parameters were analyzed during the research:

– particle size indicators (coarse sand, fine sand, dust, clay and physical clay), used to establish the textural class and the degree of differentiation per profile;– indicators of the physical condition (apparent density, total porosity, aeration porosity), which reflect the organization of the porous space and the capacity of water and air circulation;– physical-mechanical indicators (degree of compaction, withering coefficient, field capacity, water capacity), relevant for the assessment of the hydrophysical regime and the availability of water for plants.

The data processing was carried out by descriptive and comparative statistical methods, being calculated the variation intervals and trends per profile for each analyzed parameter.

The methodological approach adopted makes it possible to highlight the relationships between physical properties and dominant pedogenetic processes, as well as to assess their implications on soil functionality and agricultural use.

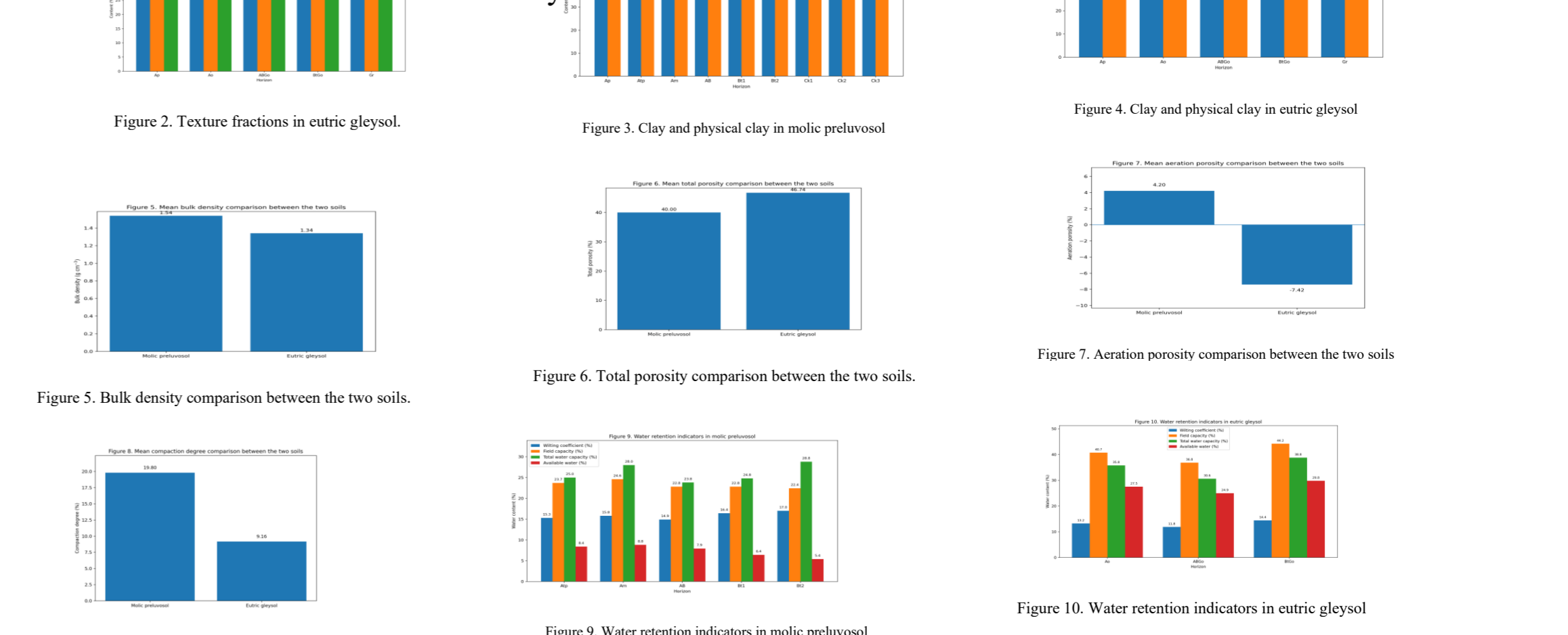
• Results and discussions

The comparative analysis of the two soils in Sânanndrei, the soft preluvosol and the typical eutric gleisols, highlights important differences in profile organization, particle size and physical-mechanical behavior, although both fall into the category of fine-textured soils. This aspect is particularly important from a pedological and agronomic point of view, since the fine texture largely controls the water retention capacity, the infiltration rate, the susceptibility to compaction, aeration, as well as the degree of accessibility of the edaphic volume for the roots. The data in the profile tables show that both soils have a high potential for water retention, but the way in which this water is stored and made available to plants differs significantly, as a result of the dominant pedogenetic processes: clay flooding in the preluvosol and gleiation in the case of gleisols.

In the case of the soft preluvosol, the graphic representation of the textural fractions on the profile, shown in Figure 1, clearly shows that this soil has a more pronounced vertical particle size differentiation. It is observed that the fine sand has relatively high values in the Ap horizon, where it reaches 33.0%, after which it decreases slightly in the intermediate horizons and shows small oscillations in depth. The dust has a maximum in the ATP horizon, of 31.7%, followed by a gradual decrease towards the base of the profile. In contrast, clay grows from 36.3% in the surface horizon to 44.7% in the AB horizon, then oscillates, while remaining at high values of 39.5–48.2% in the lower horizons. This distribution confirms the existence of a textural differentiation specific to soils affected by migration and accumulation processes of fine particles, with higher concentration of clay in the subsurface and deep horizons. From a pedological point of view, this tendency supports the preluvosol character and explains, to a large extent, both the higher consistency and the lower permeability of the profile (Figure 1).

Figure 2 shows that the distribution of particle size fractions in the typical eutric gleisols highlights a different situation. In this case, the texture is much more uniform on the profile, with fewer variations in the content of fine sand, dust and clay. Fine sand is between 25.6 and 29.2%, dust between 26.2 and 32.6%, and clay between 37.4 and 41.4%. This textural homogeneity is characteristic of soils formed on relatively uniform fluvial deposits and suggests that the physical properties of gleisols are less influenced by internal textural differentiation and more by excessive water regime. In other words, if in preluvosol the compaction and I

restriction is so much by of excess



• Conclusions

The comparative analysis of the physical and physico-mechanical properties of the soft preluvosol and the typical eutric gleisols from the Sânanndrei area highlighted the fact that, although both soils belong to the fine textural class and have a relatively high water retention capacity, their functional behavior differs significantly as a result of the dominant pedogenetic processes and the specific water regime.

In the case of soft preluvosol, the distribution of the particle size fractions and the increase of the clay content in the subsurface horizons indicate an active clay-alluvial process, which determines a denser structure and reduced permeability. The high values of the apparent density, associated with low total porosity and limited aeration porosity, lead to a poor aerohydric regime, characterized by difficulties in infiltration and circulation of water, as well as insufficient aeration of the root system. Under these conditions, the preluvosol shows a marked tendency to compaction, which affects root development and the efficiency of water and nutrient use.

On the other hand, the typical eutric gleisols stands out for a relatively uniform texture on the profile and for lower values of apparent density, but with a higher total porosity. However, the defining feature of this soil is the excess moisture, evidenced by the negative values of aeration porosity, which indicate an almost complete saturation of the porous space with water. This situation generates anaerobic conditions, unfavorable to microbiological activity and normal plant development, leading to low physical fertility, despite a high water retention capacity.

Comparatively, it can be stated that the main limitation of preluvosol is of a physico-mechanical nature, through compaction and high mechanical strength, while gleisols is predominantly limited by excess water and poor aeration. Thus, the two soils present different constraints, which impose distinct strategies of agricultural use and management.