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CLASSIFICATION OF THE SOILS OF RIVER ISLAND MICRO-DEPRESSIONS (GREAT WAR ISLAND, SERBIA)

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Abstract: Great War Island (GWI) is a river island formed at the confluence of the Sava and Danube rivers, heavily exposed to groundwater and flooding and is therefore suitable as a case study for the investigation of hydromorphic soils. The aim of this study was to classify the soils in two different micro-depression on Great War Island according to the local (Škorić 1985) and international (WRB 2022 and USDA Soil Taxonomy 1999) systems, with particular attention to the soil-forming factors that influenced the classification of the soils. The results obtained could help to improve the existing local classification system or to create a new system in the future. The soil of the closed (less flooded) micro-depression is Eugley, Hipogley, Mineral, Calcareous (Škorić 1985) or Calcaric Oxygleyic Gleysol (Loamic, Humic) (WRB 2022). The soil of the micro-depression open to the Danube (more flooded) is Humogley, Calcareous, Weakly alkalized, Loamy (Škorić 1985) or Calcaric Oxygleyic Mollic Tidalic Gleysol (Loamic, Fluvi-Loaminovic) (WRB 2022). The both soils are Typic Endoaquolls (USDA Soil Taxonomy 1999). The high level and amplitude of the groundwater and the duration of the flood caused by the topography, as well as the texture of the alluvial sediments, are the main soil-forming factors that have influenced the classification of the soils. The local soil classification mostly corresponds to the two international soil classifications with regard to the influence of pedogenetic factors/characteristics. To increase its accuracy, quantitative thresholds for soil type and lower levels are required.

Key words: WRB, soil taxonomy, eugley, humogley, gleysols, typic endoaquolls.

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Introduction

Hydromorphic soils are formed when there is an excess of water, which can cause anaerobic conditions in the soil in whole or in part. Saturated and waterlogged soils occupy about 6% of the Earth's surface (2.1 million km^2) (Zhang et al., 2016). These hydromorphic soils are mainly distributed along coasts, lakes, shores, river deltas, river islands and their tributaries, and their properties have been studied worldwide (Bandyopadhyay et al., 2017). The formation of the hydromorphic soils is primarily the result of the interaction of topography and hydrological processes under specific geological and geomorphological conditions (Lin et al., 2007). Parent material and bedrock, groundwater table fluctuations, past and present river flow velocities, relief positions and anthropogenic factors are summarized by Yakovenko et al. (2023) as the most important factors for the formation of hydromorphic soils in river valleys.

Hydromorphic soils have long been recognized by morphological and chemical characteristics, but in the past different criteria were used for their classification, and the different soil classification systems were not satisfactorily interchangeable (Okusami, 1985). The World Reference Base (WRB) soil classification was introduced as an international soil correlation and communication system, which was approved and adopted from 1998 to 2022 (fourth edition) (IUSS Working Group WRB, 2022). The soils traditionally referred to as hydromorphic belong to soils that differ in Fe/Al chemistry and belong mainly to the WRB reference soil groups (RSGs) Gleysols (groundwater influenced, submerged or tidal), Planosols (stagnant water, abrupt textural difference) or Stagnosols (stagnant water, structural difference and/or moderate textural difference). The RSG of Fluvisols (stratified fluviatile, marine or lacustrine sediments) is categorized under soils with little or no profile differentiation. By using well-defined and quantified diagnostic horizons, properties and materials, the WRB has become one of the applied international soil classification systems. Hydromorphic soils, i.e., the wettest soils, are classified at the second level of the United States Department of Agriculture (USDA) Soil Taxonomy (Soil Survey Staff, 1999) as wet (Aqu) suborders within various soil orders or as subaqueous (Wass) suborders of the orders of Entisols and Histosols (Rabenhorst et al., 2017).

The soil classification system developed in the former Yugoslavia (Škorić et al., 1985) is still used in its original or modified version in Serbia (Đorđević and Radmanović, 2018) and other countries that emerged from Yugoslavia (Filipovski, 2001; Resulović et al., 2008; Husnjak, 2014; Repe, 2020). Hydromorphic soil is one of the four soil divisions (the highest level unit), which is subdivided into the classes Surface water gley, Undeveloped, Semigleys, Gleys and Histosols, each containing one or more soil types. In general, the classification units are qualitatively defined and have few quantitative boundaries.

At the turn of the 18th and 19th centuries, extensive river regulation was carried out in Europe and in the late 18th and during the 19th and 20th centuries in Serbia, in order to minimize flood damage (Prokofʹeva et al., 2010; Đorđević and Radmanović, 2018). Drained floodplains have been converted into agricultural, forestry or urban areas (Prokofʹeva et al., 2010; Łabaz and Kabala, 2016). The prevention of flooding and groundwater recharge significantly alter soil conditions and soil formation, leading to a change in soil morphology and other properties and their classification (Łabaz and Kabala, 2016; Kawalko et al., 2021). Great War Island is a river island (Figure 1) with little topographic variation, yet highly exposed to groundwater and flooding, making it a suitable case study for the study of hydromorphic soils. The aim of this study was to classify the soils in two diverse micro-depressions of the Great War Island, according to the local (Škorić et al., 1985) and international WRB 2022 (IUSS Working Group WRB, 2022) and the USDA Soil Taxonomy (Soil Survey Staff, 1999) systems, with particular reference to the pedogenetic factors that affect soil classification. The results obtained will contribute to increase the knowledge on the basis of which the existing local soil classification system could be improved or a new system created in the future.

Material and Methods

The GWI is located (Figure 1A) at the contact of the Carpatho-Balkan Massif and the Pannonian Plain and at the confluence of the Sava and Danube rivers. The rivers connect at an obtuse angle, their water slows down and leads to the deposition of transported material. These Holocene alluvial sediments are about 25 m thick. The process of sedimentation is still ongoing and is changing the shape and surface area of the island. As a result of the uneven accumulation effect of the flood waters, there are zones of micro-elevations (the highest 73.5 m a.s.l. on the upstream part of the coast), micro-depressions (~ 69.5 m a.s.l.) and generally flat areas (~ 72 m a.s.l. on average). The Great War Island currently covers an area of 2.11 km^2. The land is covered with natural forest or grass-herbaceous vegetation. Since 2005, the GWI has been declared an area of importance for the protection of the environment and cultural and historical heritage (JKP Zelenilo-Beograd, 2018). For the period 1991–2020 (RHSS, 2024), the average annual precipitation was 698.9 mm, with the lowest monthly value being 43.5 mm in February and the highest value being 95.6 mm in July. The average annual air temperature was 13.2°C, with the warmest months being July and August (average 23.8°C) and the coldest January (1.9°C).

The field investigation (creation and description of profiles) was carried out using the field guide required for soil classification according to WRB (IUSS Working Group WRB, 2022). The groundwater level was visually estimated in the soil profiles. The soil color was determined using the Munsell color charts. Disturbed soil samples were taken from genetic horizons and their layers (if present). Laboratory analyses were carried out using standard methods: particle size distribution by the sieve and pipette method, preparation with Na-pyrophosphate, soil texture class according to IUSS Working Group WRB (2022), soil organic carbon by the Tiurin method, $CaCO_3$ by the volumetric Scheibler method and pH in distilled H_2O (soil/water = 1/2.5).

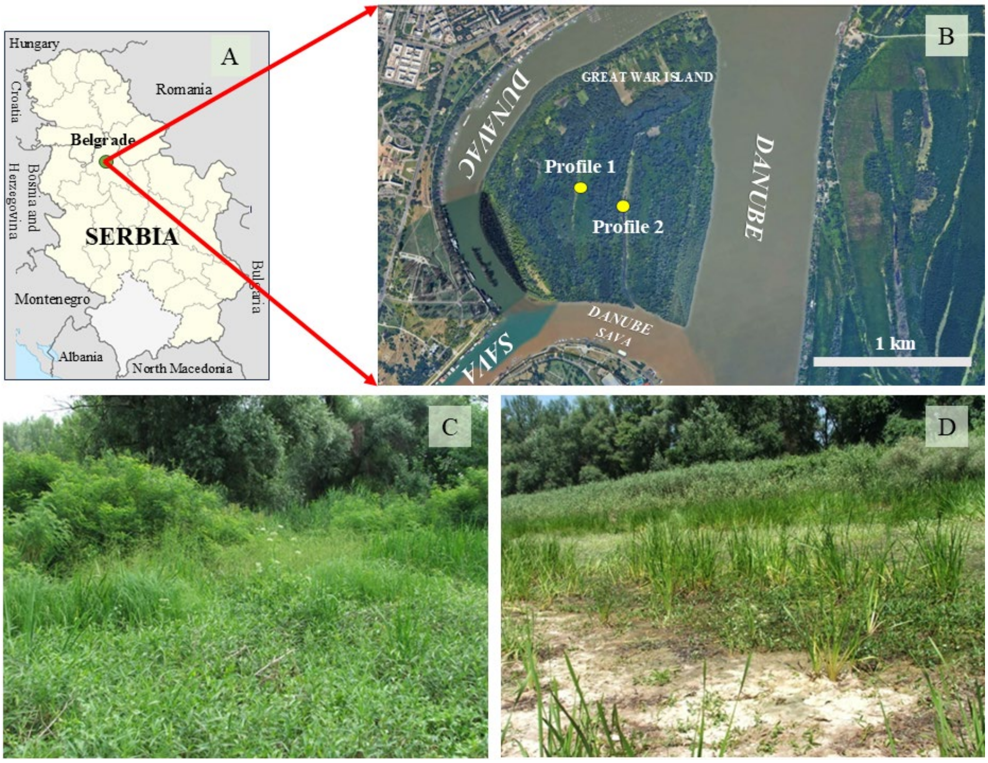

Figure 1. A – Geographical position of the study area; B – Great War Island, profiles 1 (44° 49' 47.60" N/20° 26' 4.44" E) on closed micro-depression (CMDS), and 2 (44° 49' 54.16" N/20° 26' 13.27" E) on open micro-depression (OMDS); C – vegetation of CMDS; D – vegetation of OMDS.

The soil profiles were created in two existing micro-depressions (Figure 1B), which differ in altitude, i.e., the presence of groundwater and floodwater, causing soil hydromorphism. Profile 1 was opened in a closed micro-depression (CMDS in the following text) in the central part of the GWI, where the groundwater level rises to the soil surface for most of the year. The micro-depression is occasionally flooded in wet years and when the water level of the Danube is high. The ground surface is flat. Profile 2 is located in the Veliki Galijaš canal micro-depression open to the Danube (OMDS in the following text). The Veliki Galijaš canal was at times in history a canal and a lake, which was last reunited with the Danube in 2007. In addition to the high groundwater level (up to soil surface, except in the driest part of the year), the OMDS profile has been flooded and inundated in the past and is currently flooded every year. The ground surface slopes gently to the south-east towards the Danube. The parent material consists of fluvial and lacustrine sediments, especially sands and clayey sands in the closed micro-depression (CMDS) and sands and silts in the Veliki Galijaš lake/canal (OMDS) (Marković et al., 1984). The vegetation of the CMDS in the closed micro-depression consisted mainly of herbs and grasses and only rarely of aquatic (non-woody) plants (Figure 1C). Aquatic (non-woody) plants and bare soil surfaces formed by a layer of tin litter were present in the Veliki Galijaš canal, OMDS (Figure 1D).

The determination of the genetic horizons and the classification of the soils were carried out in parallel according to Škorić et al. (1985) (Škorić 1985 in the following text) and IUSS Working Group WRB (2022) (WRB 2022 in the following text). The soils were also classified according to the USDA Soil Taxonomy (Soil Survey Staff, 1999) (USDA Soil Taxonomy in the following text).

Results and Discussion

The soil properties required for classification are presented in Table 1. Figures 2A and 2B represent the CMDS and OMDS, respectively. The soils were wet from the surface, and the water table was stabilized in the CMDS and OMDS at depths of 90 and 75 cm, respectively.

Table 1. Morphological, physical and chemical properties of the soil studied.

Depth	Genetic horizons		Soil matrix color		Texture	SOC	$CaCO_3$	pH
cm	a[2]	b[2]	dry	moist	class	%	%	H_2O
CMDS[1]	[a]**Eugley**, Hipogley, Mineral, Calcareous; [b]Calcaric Oxygleyic **Gleysol** (Loamic, Humic); [c]Typic Endoaquolls							
0–20	A/Gso	Al1	2.5Y 4/2	2.5Y 3/2	clay loam	2.1	11.3	7.4
20–40	A/Gso	Al2	2.5Y 5/2	2.5Y 4/2	clay loam	1.3	13.6	7.6
40–60	Gso	Bl1	2.5Y 6/2	2.5Y 4/2	clay loam	1.0	14.5	7.8
60–80	Gso	Bl2	2.5Y 6/3	2.5Y 4/3	clay loam	1.1	11.5	7.7
80–90	Gso	Bl3	2.5Y 7/2	2.5Y 5/2	clay loam	1.0	18.1	7.7
OMDS[1]	[a]**Humogley**, Calcareous, Loamy; [b]Calcaric Oxygleyic Mollic Tidalic **Gleysol** (Loamic, Fluvi-Loaminovic); [c]Typic Endoaquolls							
0–20	Amo/Gso	Al	10YR 4/2	10YR 3/2	clay loam	2.4	14.6	7.8
20–35	Amo/Gso	2Alb1	10YR 3/2	10YR 2/2	clay loam	3.7	11.0	7.7
35–55	Amo/Gso	2Alb2	10YR 5/2	10YR 3/2	clay loam	2.0	11.9	7.9
55–75	Gso	3Bl	10YR 5/3	10YR 4/3	clay loam	1.0	15.4	8.0

[1]CDMS – closed micro-depression soil; OMDS – open micro-depression soil. [2]Horizons and classification according to: a – Škorić et al. (1985); b – IUSS Working Group WRB (2022); c – Soil Survey Staff, 1999.

The surface A horizon of the CMDS is divided into two layers (Table 1, Figure 2A), with the upper Al1 containing redoximorphic features. The lower layer (20–40 cm), which has more pronounced redoximorphic features, is referred to as Al2. The layer below A (40–90 cm) is designed as the Bl horizon and is divided into three layers. These layers are calcareous, contain about 1% SOC and have very pronounced redoximorphic features (reductimorphic features predominate over oxymorphic features at a soil depth of about 60 cm).

Figure 2. Genetic horizons according to Škorić et al. (1985) (left) and IUSS Working Group WRB (2022) (right) of the soil from: A – the closed micro-depression (CMDS) and B – the open micro-depression (OMDS).

The decrease in the humus content and the change in the frequency of oximorphic and reductimorphic features with soil depth led to a change in soil color. The color of the soil matrix was: dark gray-brown, gray-brown (A), light brownish gray, light yellowish brown, light gray (B), and moist: very dark gray-brown, dark gray-brown (A), olive brown, gray-brown (B). Although the proportion of sand decreases with increasing depth and silt and clay increase, the texture class remains the same over the entire soil depth. The subangular blocky structure in the A horizon changes to an angular blocky structure in the B horizon. Only a few roots are present in the lower part of the soil profile.

According to Škorić 1985, CMDS with an A – humic genetic horizon of less than 50 cm depth and a genetic G – gley horizon with clearly differentiated subhorizons Gso and Gr (not registered up to a depth of 90 cm) belongs to division – Hydromorphic, class – Gleys, type – Eugley, subtype – Hipogley (process of gleysation by groundwater), variety – Mineral, form – Calcareous.

Figure 3. Redoximorphic features of the soil of: A – the closed micro-depression (CMDS) (Gso or Bl horizon, 40–60 cm depth) and B – the open micro-depression (OMDS) (Gso or Bl horizon, 55–75 cm depth). The soils are 20 cm high.

According to WRB 2022, CMDS shows gleyic properties and reducing conditions in some part of the soil material, calcareous and mineral material, SOC, and no diagnostic horizon. Gleyic properties in the upper 60 cm were confirmed with 50% oximorphic features found predominantly on the biopore walls and aggregate surfaces, fine to very coarse, non-cemented, reddish brown in color

(2.5YR 5/4), moist (Figures 2A and 3A). Reductimorphic features, light gray (2.5Y 7/1) in color, moist, were distributed throughout the layer and surrounded areas of oximorphic features. Reductimorphic features predominated over oximorphic features deeper than 60 cm from the soil surface and were gray in color (2.5Y 5/1 and 6/1). With gleyic features at the soil surface and reducing conditions in some parts of each sublayer, the CMDS meets criterion 1 of the RSG Gleysols. Since there is no layer with ≥ 95% reductimorphic features within 100 cm of the soil surface, the Oxigleyic principal qualifier fits with the CMDS. As the CMDS also contains over 11.3% primary carbonate, it meets the criteria for the Calcaric principal qualifier. The Loamic supplementary qualifier results from the texture class of clay loamy over the entire soil depth and Humic with a SOC content of ≥ 1.46% as a weighted average up to a depth of 50 cm from the soil surface. According to WRB 2022, the CMDS is therefore classified as Calcaric Oxygleyic Gleysol (Loamic, Humic).

A very thin (1 cm) litter layer has been formed on the soil surfaces of the OMDS (Figure 2B), under flood water and probably at high groundwater levels. The genetic A horizon is a first mineral layer, calcareous, 55 cm thick (Table 1). The A horizon is divided into three sub-layers, which differ in color, humus content and redoximorphic features. Below the Al horizon is a layer with a higher humus content and a darker color as well as more redoximorphic features. This is obviously a buried A horizon, which is divided into two sub-layers, 2Alb1 and 2Alb2. Sublayer 2Alb2 has a lower humus content and a lighter color. Below 55 cm, the humus content decreases, the redoximorphic features are strong, but the color remains dark, probably due to the hydrogenic conditions caused by the high water table during most of the year. This layer is referred to as the genetic 3Bl horizon. The color of the soil matrix changes with depth as follows: dry – dark gray-brown, very dark brown, gray-brown, brown, and moist – very dark gray-brown, very dark brown, very dark gray-brown, dark brown. The horizons differ in sand, silt and clay content (no trend is apparent), but the soil texture class remains the same over the entire soil depth. Soil aggregate structure was weak, fine to medium across the depth. Few (coarser in the upper layer) roots are present on the soil. Snails in deeper layers and earthworms in the surface layers (< 10 cm) were the observed soil fauna.

According to Škorić 1985, the OMDS with a genetic mollic humus horizon above 50 cm and a predominantly oximorphic gley horizon (Gso) up to the soil profile (75 cm) belongs to the division – Hydromorphic, class – Gleys, type – Humogley, subtype – Calcareous, form – Loamy.

According to WRB 2022, the OMDS has a mollic diagnostic horizon, gleyic properties and reducing conditions in some part of the soil materials, calcaric and mineral materials and SOC. The mollic horizon is characterized by a granular aggregate structure with an average aggregate size of 3 cm, ≥2%

SOC and a Munsell color value of ≤ 3 moist and 4 dry as well as a chroma value of ≤ 2 moist, a very high base saturation (pH ≥7.7) and a thickness of 55 cm. The gleyic properties are expressed from the soil surface to the bottom of the soil profile. Oximorphic features were present > 50% of the exposed area, predominantly on biopore, walls and aggregate surfaces, and were red in color (10R 5/8 and 4/8), moist (Figures 2B and 3B). Reductimorphic features, gray in color (10Y 4/1 and 5/1) moist, were distributed throughout the layer and surrounded areas with oximorphic features. The OMDS met criterion 2 of the RSG Gleysols: a mollic horizon 55 cm thick and gleyic properties and reducing conditions in some parts from the soil surface to the soil profile (75 cm). The principal qualifiers associated with the OMDS are: Tidalic, Mollic, Oxigleyic and Calcaric. The Tidalic qualifier is the result of tidal water from the Danube River (Veliki Galijaš canal) acting on the ground surface every year and causing the formation of a tin litter layer (Figure 2B). The Mollic qualifier requires a mollic diagnostic horizon. As in the OMDS, there is no layer with ≥ 95% reductimorphic features within 100 cm of the soil surface, so the Oxigleyic principal qualifier matched the OMDS. With a primary carbonate content of over 11%, the OMDS meets the criteria for the Calcaric principal qualifier. The clay loamy soil texture caused the Loamic supplementary qualifier. The surface layer (20 cm), which has a lower SOC content than the subsurface (20–40 cm), is obviously of fluvial origin, but does not fulfill the criteria for Fluvic material (>25 cm required) and the Fluvic principal qualifier. Therefore, the loamy clay fluvial surface layer already implies a Fluvi-Loaminovic supplementary qualifier. The subsurface layer (20–40 cm) of the A horizon in the OMDS, which has a higher SOC content than the surface layer, is referred to as buried, but does not fulfill the criterion of the Panpaic horizon, which has no lithic discontinuity at its upper boundary. Finally, the OMDS is classified as Calcaric Oxygleyic Mollic Tidalic Gleysol (Loamic, Fluvi-Loaminovic) according to WRB 2022.

According to USDA Soil Taxonomy, both soils exhibit a mollic epipedon and satisfactory base saturation at depth, meeting the criteria of the order Mollisols. With chroma 2 and pronounced redox concentrations in the lower part of the mollic epipedon, the soils belong to the suborder Aquolls. The great group Endoaquolls refers to soils with endosaturation. The groundwater level is located at or near the soil surface during wet periods (winter, spring and early summer in the study area) and is deeper during dry periods (late summer). The subgroup is Typic Endoaquolls. In summary, the two soils investigated are Mollisols, Aquolls, Endoaquolls, Typic Endoaquolls.

As is well known (Collins, 2005), the water supply in soil wetland depression comes from groundwater discharge (high groundwater table), precipitation, surface runoff and possibly spring water. It is obvious that the investigated soils belong to the same RSG of Gleysols due to the dominant influence of groundwater on their formation and the resulting gleyic properties. The gleyic properties develop in layers that are saturated with groundwater for a period of time that allows reducing conditions to occur (several weeks) and in the overlying capillary fringes that are saturated long enough for the soil to become partially anaerobic. The gleyzation process leads to an underlying highly reduced layer and an overlying layer with oximorphic features on or adjacent to the surface of the soil aggregates (IUSS Working Group WRB, 2022). In the studied Gleysols, there are no strongly reduced layers with permanently wet conditions (with ≥ 95% reductimorphic features) at the bottom of the soil pits. The oximorphic features over the soil depth indicate oxidizing conditions, i.e., high groundwater level fluctuations. Consequently, the Oxygleyic principal qualifiers are characteristic of the both soils. Iron oxides/hydroxides were concentrated on the surfaces of the soil aggregates and the walls of larger pores (e.g., old root channels), which is typical for these Gleysols with a clay loamy texture according to the IUSS Working Group WRB (2022). In addition, the Calcaric principal qualifiers and the Loamic supplementary qualifier are characteristic of the stand.

In contrast to the CMDS, the OMDS, which is located in a canal normally subject to a high level of groundwater and flooding, is characterized by two more interconnected principal qualifiers, Mollic and Tidalic. In general, the Tidalic is more characteristic of the soils of the marine intertidal zones, which cover the largest area compared to the fluvial zones (Gröngröft et al., 2020). The A horizon of the OMDS, which has mollic attributes, is so deep because it contains the buried humus horizon above which the river flood has deposited the alluvial layer, also enriched with humus. The dark color of the two layers, the buried and the novic, is a consequence of the humification process, which partly takes place under saturated soil conditions. In addition, the aquatic plants produce more slowly decomposable litter compared to herbs and grasses, which leads to an increase in the humus content. The process of accumulation of already humified organic matter transported by the river water probably also took place.

Gleysols are widespread (more than 720 million ha worldwide) at all latitudes and climatic zones (perhumid to arid), on low elevations in landscapes with high groundwater tables, tidal areas, shallow lakes and seashores (IUSS Working Group WRB, 2015). Consequently, various principal and secondary qualifiers can be assigned to these WRB RSGs. For example, Rubinić et al. (2020) reported on Eutric Reductigleyic Stagnic Gleysols along the Sava and Drava rivers, where the stagnic properties, i.e., periodically stagnant surface water (precipitation), are caused by a heavy clay texture. In the Dnipro River valley in Ukraine (Yakovenko et al., 2023), most of the Gleysols are Fluvic and Calcic, which is mainly due to the relief and sediments variances formed by fluvial and eolian processes. Zhangurova et al. (2023) reported Reductaquic Gleysols in the mountain tundra of the Ray-Iz massif in the polar Urals, while Łachacz and Nitkiewicz (2021) classified some soils formed from deposits of bottom lakes in north-eastern Poland as Eutric Gleysols. According to a national Romanian soil classification, the calcaric mollic subtype of Gleysols is found in a poorly drained lower part of a Danube river basin (Moraru et al., 2020).

According to Škorić 1985, the differences between the soils were manifested on the third level, the soil type, chiefly due to the thickness of the humus-accumulative horizons. One of several quantitative limits in Škorić 1985 is the thickness of the A horizon, less than 50 cm for Eugley and over 50 cm for Humogley. In addition, for Humogley, a mollic form of the A horizons was required, based on soil color and base saturation. Soil properties that are important for distinguishing soil types according to the Škorić 1985 system came to the fore at the second level of the WRB 2022 system, resulting in the Mollic principal qualifier for the same soil.

The amplitude of underground water fluctuation is another criterion at the soil type level. The authors are not aware of any data on the height of the GWI groundwater table. The long-term averages of the mean groundwater level on the surrounding left (Banat) and right (Ušće) coasts are 68 m a.s.l. (Tošović, 2002). Furthermore, the frequency and duration of floods have not been quantified. Therefore, as usual (Lin et al., 2005), soil morphology is used as a method to indicate drainage conditions and pedogenetic processes in the field. However, the relationships between water regimes and the resulting morphological properties are often complex, and interpretation can be more complicated than simplified schemes offer (Bouma, 1983). For example, the OMDS, which is wetted by groundwater and floodwater for a certain time of the year, could have an amfigley character (Škorić 1985), meaning a surface layer with stagnic properties, a bottom layer with gleyic properties and a less gleyic intermediate layer. A layer with clearly pronounced stagnic properties is not recognisable in either soil. Some lighter tubular features are observed, but these are not sufficient for WRB 2022 Stagnic principal or Uterquic supplementary qualifiers, or for Škorić 1985 Amfigley subtype of Eugley.

Determining the genetic horizons of the soil was one of the challenges of morphological observation. A layer with redoximorphic features as a result of excessive wetting with groundwater, traditionally referred to as the G horizon (Table 1, Figure 2), is still used in many national and regional soil classifications (Pollmann et al., 2018; Moraru et al., 2020; Łachacz and Nitkiewicz, 2021; Zhangurova et al., 2023). According to the international systems USDA Soil Taxonomy and WRB 2022, some master horizons (H, A, B or C) were changed by the gleyization process. The layers below the A horizons in the studied Gleysols are referred to as B horizons, which is due to the formation of a soil aggregate structure.

As the area has been declared a protected area, the direct impact of agriculture, forestry and urban development on the future development of the soils under investigation should be limited. The groundwater level and flooding, as crucial pedogenetic factors that depend on the water level and flow velocity of the Danube and Sava rivers, can be altered by anthropogenic and natural influences. The Đerdap dam already influences the water flows of the Danube and Sava rivers (JKP Zelenilo-Beograd, 2018), and future regulation could do the same. The predicted climate change, leading to rising temperatures, melting ice, rising sea levels and oceans, and a change in precipitation regimes, with global and local impacts (Đorđević et al., 2020; Trajković and Milanović, 2021), will certainly affect the water balance of the studied soils. The changes caused by waterlogging will affect plant composition and diversity, primary production, soil properties, i.e., nutrient status, humus accumulation (Collins, 2005), will certainly change the taxonomy of soils as well.

Conclusion

On the Great War Island, which was formed at the confluence of the Sava and Danube rivers, the soils from two micro-depressions were classified according to the local system of Škorić 1985 and the international systems WRB 2022 and USDA Soil Taxonomy 1999. The soil from the closed micro-depression is a Eugley, Hipogley, Mineral, Calcareous (Škorić 1985) or Calcaric Oxygleyic Gleysol (Loamic, Humic) (WRB 2022). The soil of the micro-depression open to the Danube is Humogley, Calcareous, Loamy (Škorić 1985) or Calcaric Oxygleyic Mollic Tidalic Gleysol (Loamic, Fluvi-Loaminovic) (WRB 2022). The both soils are Typic Endoaquolls (Soil Taxonomy 1999).

Groundwater (high level and amplitude), caused by topography, is the main soil-forming factor that has caused the gleyzation process and redoximorphic features that have influenced the classification of soils at the higher levels of the local (division, class, type) and WRB system (RSG and Oxygleyic principal qualifier) and the second level (suborder) of the USDA Soil Taxonomy in the both micro-depressions. In addition, prolonged flooding periods have led to principal (Mollic and Tidalic) and supplementary (Fluvi-Novic) qualifiers of the soils in the open micro-depression. Alluvial sediments as parent material have produced the Calcaric principal and the Loamic supplementary qualifiers for the two soils.

The local soil classification reflects most of the soil-forming factors and properties as the two international soil classifications. In order to increase accuracy, quantitative limits for the soil type and lower levels are required. The results obtained should contribute to the expansion of knowledge, on the basis of which the existing local soil classification system could be improved or a new one created.

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KLASIFIKACIJA ZEMLJIŠTA U MIKRODEPRESIJAMA REČNOG OSTRVA (VELIKO RATNO OSTRVO, SRBIJA)

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R e z i m e

Veliko ratno ostrvo, nastalo na ušću reke Save u Dunav, veoma je izloženo podzemnim i poplavnim vodama i stoga pogodno za istraživanje hidromorfinih zemljišta. Cilj ovog rada je detaljna klasifikacija zemljišta iz dve različite mikrodepresije na Velikom ratnom ostrvu, prema lokalnom klasifikacionom sistemu (Škorić 1985), Svetskoj referentnoj bazi za zemljišne resurse (engl. *World reference base for soil resources*, WRB 2022) i američkoj taksonomiji (engl. *USDA Soil Taxonomy* 1999), sa posebnim osvrtom na faktore pedogeneze koji su uticali na klasifikaciju. Zemljište zatvorene mikrodepresije je euglej, hipoglej, mineralni, karbonatni (Škorić 1985) ili kalkarični oksiglejični glejsol (loamični, humični) (engl. *Calcaric Oxygleyic Gleysol* [*Loamic, Humic*]) (WRB 2022). Zemljište mikrodepresije otvorene prema Dunavu je humoglej, karbonatni, ilovasti (Škorić 1985) ili kalkarični oksiglejični molični tidalični glejsol (loamični, fluvi-loaminovični) (engl. *Calcaric Oxygleyic Mollic Tidalic Gleysol* [*Loamic, Fluvi-Loaminovic*]) (WRB 2022). Oba zemljišta su tipični endoakvolsi (engl. *Typic Endoaquolls*) (Soil Taxonomy 1999). Pozemne vode (visok nivo i amplitude) uzrkovane topografijom, glavni su faktor formiranja zemljišta, što je dovelo do procesa oglejavanja i redoksimorfnih osobina (engl. *redoximorphic features*) koje su uticale na klasifikaciju zemljišta na višim nivoima lokalnog sistema (red, klasa i tip) kao i sistema Svetske referentne baze za zemljišne resurse (referentne grupe zemljišta [engl. *reference soil group* – RSG] i oksiglejni [engl. *Oxygleyic*] osnovni kvalifikator) kao i na drugom nivou (engl. *suborder*) američke taksonomije zemljišta u obe mikrodepresije. Pored toga, produženi periodi poplava doveli su do osnovnih (molični [engl. *Mollic*] i tidalični [engl. *Titalic*]) i dodatnih (fluvi-loaminovični [engl. *Fluvi-Loaminovic*]) kvalifikatora zemljišta u otvorenoj mikrodepresiji. Aluvijani sedimenti kao matični supstrati prouzrokovali su kalkarični (engl. *Calcaric*) osnovni i loamični (engl. *Loamic*) dopunski kvalifikator za oba zemljišta. Lokalna klasifikacija odražava većinu faktora pedogeneze/karakteristika kao i dve međunarodne klasifikacije. Da bi se povećala njena preciznost, neophodne su kvantitativne granice na nivou tipa i nižih klasifikacionih jedinica. Dobijeni rezultati treba da doprinesu sakupljanju znanja na osnovu kojih bi bilo moguće unaprediti postojeći lokalni sistem klasifikacije zemljišta ili formirati novi.

Ključne reči: svetska referentna baza za zemljišne resurse, američka taksonomija, euglej, humoglej, glejsoli, tipični endoakvolsi.

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