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Ecological Characteristics and Functions of Histosols: Implications for Sustainable Wetland Management in Côte d'Ivoire

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Short Research Article

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Abstract

This study examined the ecological characteristics and functions of Histosols in a floodplain of Songon Municipality, southern Côte d'Ivoire, to support sustainable wetland management. Morphological and pedological observations were carried out in two contrasting parts of the site: a hydromorphic zone, where a soil pit was described, and a shallow water zone, where an undisturbed soil core was collected using a PVC pipe. A composite sample from the 0–20 cm horizon was prepared from five subsamples collected from the four corners and the centre of the plot and was analysed for selected physicochemical properties. The field

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description identified hydromorphic conditions and organic horizons associated with water saturation. In the hydromorphic zone, two horizons were observed: a dark A1 horizon from 0 to 20 cm and an underlying Ag horizon from 20 to 40 cm, with the perched water table occurring at about 40 cm. In the shallow water zone, an O horizon from 0 to 15 cm and an H horizon from 15 to 35 cm were described, with visible partially decomposed roots. Laboratory results indicated the absence of mineral fractions in the analysed sample and showed high organic matter and organic carbon contents of 78.25% and 45.39%, respectively. The soil was acidic, with a pH of 4.72, total nitrogen content of 2.18%, a C/N ratio of 20.79 and a low cation exchange capacity of 3.42 cmol kg-1. Iron, potassium, zinc, calcium, aluminium and phosphorus occurred in low quantities. These findings indicate a peat-rich Histosol with important ecological functions, particularly carbon storage and water regulation, but with limited mineral fertility. Sustainable management should therefore consider both conservation requirements and carefully controlled agricultural use.

Keywords: Histosols; organic soils; floodplain; hydromorphic soils; wetland management; carbon storage; water regulation; physicochemical properties; soil fertility.

1. Introduction

Histosols cover approximately 1% of the world's land area (Buol et al., 2003). Their total global area is estimated at 325–375 million hectares, most of which is located in the boreal, subarctic and low-Arctic regions of the Northern Hemisphere. The remaining Histosols occur in temperate lowlands and mountainous regions, whereas only one-tenth are located in tropical regions. Large areas of Histosols occur in the United States and Canada, Western Europe, northern Scandinavia and the West Siberian Plain. Approximately 20 million hectares of forest peat surround the Sunda Shelf in Southeast Asia. Smaller areas of tropical Histosols occur in deltas, such as the Orinoco and Mekong deltas, as well as in depressions (Buol et al., 2003; IUSS Working Group WRB, 2015; Soares et al., 2016).

Histosols perform several environmental and ecological functions because most occur in wetlands. They generally support wetland functions, including wildlife habitat provision, flood control, groundwater recharge, nutrient and biogeochemical cycling, ion sorption, purification of surface water and shallow groundwater, and they also serve as important terrestrial carbon sinks (Weissert & Disney, 2013; Cooper et al., 2015). Carbon storage in Histosols is often higher than that in mineral soils (Rabenhorst, 1995).

However, their agricultural use presents specific challenges related to fertility management, drainage and the rapid mineralisation of organic matter. In many parts of the world, including the United States, Japan and Europe, these soils are used to grow rice, vegetables and sugarcane, but they require careful management practices to prevent degradation (Soil Survey Staff, 2022; De Bélair et al., 2005).

Peat used for arable farming decomposes rapidly because it must be drained, limed and fertilised to support crop production. Under these conditions, drains should be kept as close to the surface as possible, and liming and fertilisation should be applied with caution (Soil Survey Staff, 2010; IUSS Working Group WRB, 2015). While most of the world's soils consist primarily of mineral matter, a small but significant group of soils is formed from organic matter derived from plants or, less commonly, animals (Soil Survey Staff, 2010). In general, soils in which at least 40 cm of the topsoil consists of organic matter, known as peat, are classified as Histosols. In Histosols, decomposition rates are slow, and organic matter and other materials accumulate to a considerable depth. As decomposition proceeds, organic matter is transformed into a homogeneous, dark-coloured mass (Finney et al., 1974; Soil Survey Staff, 2010).

In West Africa, and particularly in Côte d'Ivoire, wetlands and organic soils are under increasing pressure from urbanisation, intensive agriculture and climate change (Food and Agriculture Organization of the United Nations [FAO], 2016). In Songon Municipality, located in the Abidjan District, urban expansion and agricultural activities threaten the ecological balance of organic soils. However, few local studies have provided an in-depth characterisation of these soils, which limits understanding of their agricultural potential and ecological role. This knowledge gap justifies a morphological, pedological and physicochemical characterisation of Histosols in Songon to support sustainable management strategies adapted to the Ivorian context. Specifically, this study aimed to describe the morphological and pedological characteristics of Histosols in Songon, analyse their physicochemical properties, assess their agricultural potential, identify their ecological functions and propose recommendations for sustainable management.

2. Material and Methods

2.1 Geographic Location of the Study Site

The experimental site is located in Songon (5°18'53" N, 40°15'29" W), a municipality in southern Côte d'Ivoire, west of the city of Abidjan. It is bordered to the north by the municipality of Yopougon, to the east by the municipality of Anyama and to the south by the departments of Jacqueville and Dabou. It covers an area of 536 km² (Japan International Cooperation Agency & Ministry of Construction, Housing, Sanitation and Urban Development, 2015; Bakayoko et al., 2026). The study site is a floodplain (Fig. 1).

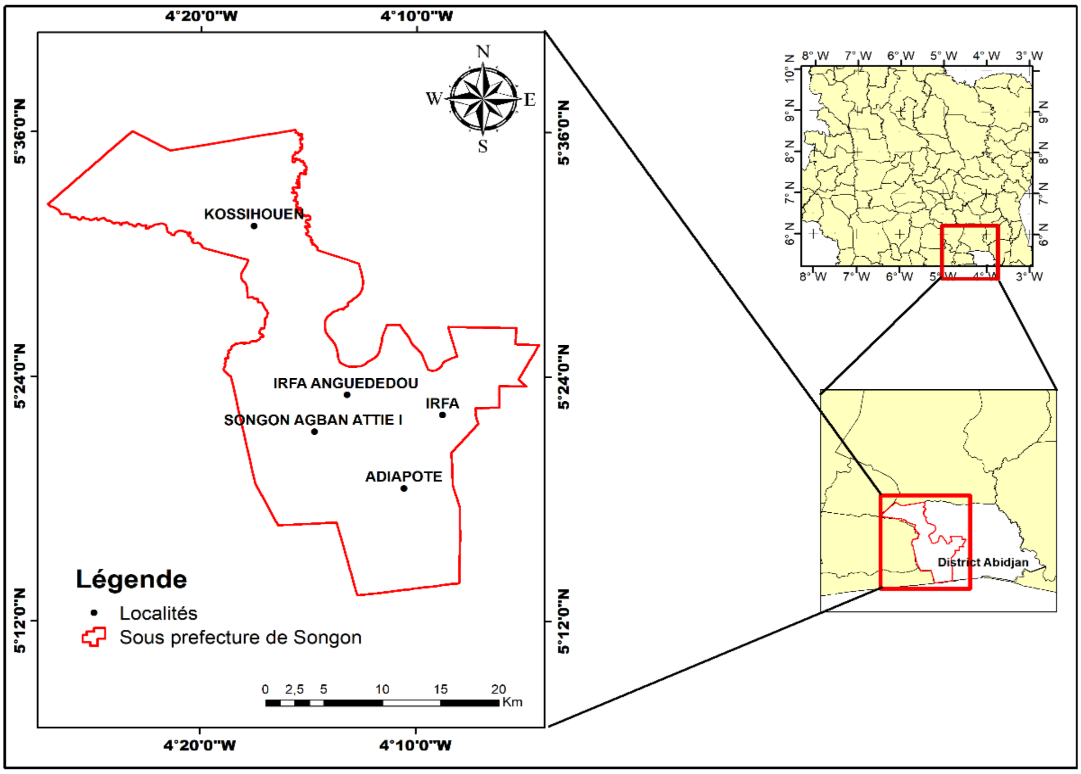

Fig. 1. Location of the site

2.2 Soil Characterisation

A soil pit measuring 100 cm in length and 80 cm in width, with a variable depth of 60–120 cm, was dug in the low-lying area where the experiment was conducted. The soil profile was described according to the variables defined in the French classification of the Commission de Pédologie et de Cartographie des Sols (1967). The description considered the characteristic features of the soil, including the thickness of each horizon, structure and cohesion, texture, porosity, root density and the proportion of coarse particles, based on morphological heterogeneity. Soil colour was determined using the Munsell system by comparing a moist soil sample with standard colours defined by hue, value and chroma. This description allowed the soil to be classified according to the World Reference Base (IUSS Working Group WRB, 2015). At the experimental site, soil samples were collected using an auger at depths ranging from 0 to 20 cm at each corner and in the centre of the plot. These samples were dried, ground and mixed to form a 1 kg composite sample for laboratory analysis (Bakayoko et al., 2026).

2.3 Parameters Measured in the Laboratory

The laboratory analysis was conducted after the composite sample had been dried. It followed conventional, internationally recognised laboratory methods and included the determination of the soil's physical and chemical properties, pH, total organic carbon (C), organic matter (OM), total nitrogen, total phosphorus, available phosphorus and cation exchange capacity (Bakayoko et al., 2026).

3. Results and Discussion

3.1 Soil Characterisation of the Songon Floodplain

The hydromorphic zone and the shallow water area underwent morphological and pedological characterisation. A pit was excavated in the hydromorphic zone, and a core sample was taken from the shallow water area:

Hydromorphic zone (Fig. 2): The soil profile consists of two horizons. The boundary between horizons 1 and 2 is irregular and ranges from 20 to 30 cm in depth.

- Horizon 1 ranges from 0 to 20 cm in depth. It is a dark, blackish-coloured horizon (2.5Y 2.5/1). It is sandy, contains organic matter and has subhorizontal roots. This is an A1 horizon.
- The underlying layer, at a depth of 20–40 cm, is primarily sandy and greyish in colour (5YR 3/1), with a granular structure and loose texture. The perched water table appears at a depth of about 40 cm. This is an Ag horizon.

Shallow water zone (Fig. 2b): The soil profile consists of two horizons.

- From 0 to 15 cm, the soil has an O horizon, black in colour (7.5 YR 3/1), composed of organic matter, with a lumpy texture, low porosity, cohesive consistency and a diffuse boundary.
- At a depth of 15–35 cm, the soil has an H horizon (histic), dark brown in colour (7.5 YR4/4), highly humic and porous, with partially decomposed roots visible to the naked eye.

Fig. 2a. Soil profile in a hydromorphic zone

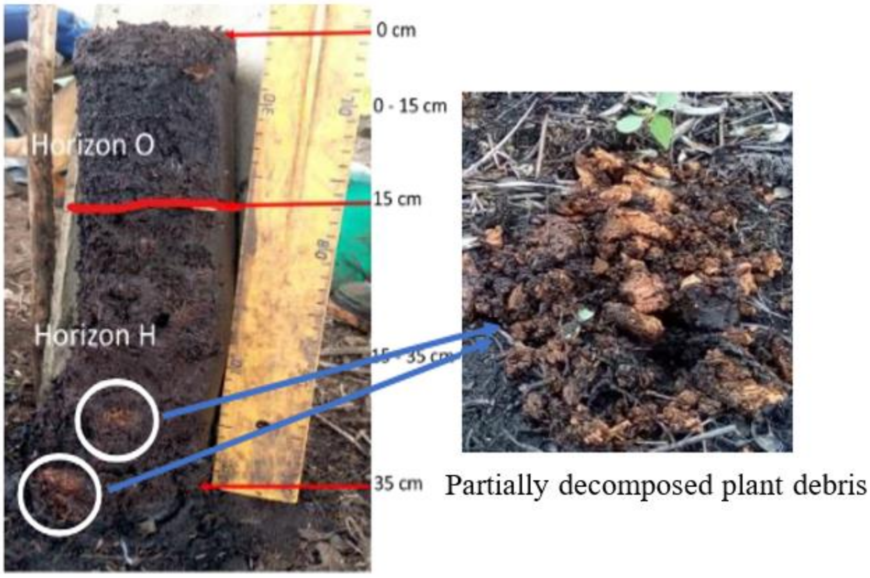

Fig. 2b. Vertic Histosol in the shallow water zone

Fig. 2. Arenosol Stagnic in the hydromorphic zone (a: soil profile in the hydromorphic zone; b: Vertic Histosol in the shallow water zone). Physicochemical characteristics of the soil in the hydromorphic zone within the 0–20 cm horizon.

Table 1 shows that the soil contains no clay, silt or sand. The data indicate that it consists exclusively of organic matter. This soil has a very high organic matter content (78.25%) and organic carbon content (45.39%), and a relatively low cation exchange capacity (CEC) of 3.42 cmol kg-1. The chemical analysis also shows that this soil is low in nitrogen, with an N content of 2.18%. The carbon-to-nitrogen ratio is 20.79, and the redox potential is 133.9 mV. Iron, potassium, zinc, calcium, aluminium and phosphorus are present in low quantities. The soil can therefore be described as a haptic soil with peaty characteristics.

Table 1. Physicochemical Characterisation of Soil in the 0–20 cm Horizon

Chemical properties of the soil	Concentrations in the topsoil (0–20 cm)
Clay	.
Limon (%)	.
Sand (%)	.
pH (eau)	4,72
C (gkg^{-1})	45,39
MO (gkg^{-1})	78,25
N (gkg^{-1})	2,18
C/N	20,79
Zn (ppm)	0,35
Fe (ppm)	0,71
K^+ (cmolkg^{-1})	0,42
Ca^{2+} (cmolkg^{-1})	0,03
Mg^{2+} (cmolkg^{-1})	1,47
Al (cmolkg^{-1})	0,06
Potentiel redox (mV)	133,9
P (ppm)	0.65
CEC (cmol.kg-1)	3,42

3.2 Morphological and Pedological Characteristics

The morphological and pedological characterisation of the Songon floodplain reveals a peaty Histosol typical of water-saturated hydromorphic environments. These soils consist mainly of organic matter and water, which promotes the formation of peatlands. The resulting anoxic conditions interrupt biogeochemical cycles and slow the decomposition of plant biomass, leading to the gradual accumulation of organic matter (Osorio-Leon, 2023; Abbott et al., 2019; Wang-Erlandsson et al., 2022; Schumacher et al., 2022).

From a pedological perspective, peat is classified as a hydromorphic soil (Duchaufour, 1977) and is characterised by a succession of histic horizons. The presence of a peat layer thicker than 30 cm, with an organic matter content exceeding 20%, confirms its classification as a Histosol. Field observations show that the water balance plays a decisive role in the formation and maintenance of these soils, together with climatic and topographic factors (Abbott et al., 2019; Wang-Erlandsson et al., 2022; Schumacher et al., 2022; Thiam, 2023).

3.3 Physical and Chemical Properties

Physicochemical analyses reveal high organic matter (78.25%) and organic carbon (45.39%) contents, together with a high C/N ratio (20.79). This result reflects the slow decomposition of organic matter, which is exacerbated by soil acidity (pH = 4.72). These conditions limit mineralisation and explain the low levels of essential nutrients such as calcium, magnesium and potassium (Sahrawat et al., 1995; Konan, 2013). The cation exchange capacity (CEC) is low, reflecting limited availability of exchangeable bases. This finding is consistent with the observations of Brady and Weil (2002), who highlighted the association between organic carbon and CEC. The accumulation of organic matter with a high C/N ratio leads to reduced biological activity and low mineral content (Vidal et al., 1996). Finally, nutrient deficiency and low CEC can lead to iron toxicity issues, which are common in tropical hydromorphic soils (Zro Bi et al., 2012). These constraints limit soil fertility and pose challenges for irrigated rice farming in low-lying areas.

3.4 Agronomic and Ecological Implications

The results show that the Histosol in Songon has a high organic matter content but limited mineral fertility. From an agronomic perspective, appropriate practices are therefore necessary, including drainage management, judicious fertiliser application and soil pH adjustment. From an ecological perspective, these soils play a major role in carbon sequestration and water regulation, but they remain vulnerable to human-induced disturbances such as urbanisation and intensive agriculture.

4. Conclusion

The study of the Songon floodplain confirmed the presence of a peat-rich Histosol associated with hydromorphic and shallow water conditions. Field observations showed organic horizons, dark colours and visible partially decomposed plant residues, reflecting the influence of prolonged water saturation on soil formation. The physicochemical results further supported this interpretation, with high organic matter and organic carbon contents of 78.25% and 45.39%, respectively. The soil also showed acidity, low cation exchange capacity, a high C/N ratio and low quantities of several mineral elements, indicating restricted nutrient availability in the 0–20 cm horizon. These characteristics suggest that the soil has ecological importance through organic matter accumulation, carbon storage and water regulation, while also presenting constraints for agricultural use. Any use of this floodplain for production should therefore be based on cautious management of drainage, fertilisation and acidity, so that the organic soil is not rapidly degraded. In the context of increasing urban and agricultural pressure in Songon, conserving the hydrological conditions that maintain these soils is essential. The findings provide a local basis for understanding Histosols in southern Côte d’Ivoire and for guiding sustainable wetland management that recognises both their ecological functions and their limited agronomic fertility.

5. Limitations of the Study

This study was limited to a single floodplain site in Songon and therefore provides a local characterisation of Histosols in Côte d’Ivoire. The physicochemical analysis was based on one composite sample from the 0–20 cm horizon, which may not fully capture spatial variability within the floodplain or changes with depth. The morphological description distinguished the hydromorphic and shallow water zones, but the study did not include seasonal monitoring of the water table, redox conditions or organic matter dynamics. As a result, temporal variations related to rainfall, drainage and land-use pressure could not be evaluated. The assessment of agronomic potential was also inferred from measured soil properties and field observations, rather than from crop trials conducted on the site. These limitations should be considered when applying the findings to wetland management. Further studies using replicated sampling, deeper profiles and seasonal observations would help refine management recommendations for similar organic soils.

Declaration of AI Use

This manuscript was prepared through the combined contributions of all author(s), including contributions to the study design, data, content development, results, interpretation, and related scholarly work. The author(s) acknowledge the use of Grammarly and ChatGPT to assist with grammar checking, language refinement, reference formatting. These AI-assisted tools were not used as authors and did not replace the intellectual contributions or scholarly judgment of the author(s). All AI-assisted outputs, including content, references, and interpretations, were carefully reviewed, revised, verified, and approved by the author(s). The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

Competing Interests

Authors have declared that no competing interests exist.

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