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Artículo de investigación

Evaluation of physico-chemical characteristics of soils from the María Lucía Metropolitan Park, Villavicencio, Meta

Evaluación de características fisicoquímicas de suelos del Parque Metropolitano María Lucía, Villavicencio, Meta

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ABSTRACT

Physical and chemical characteristics of soil samples taken from the María Lucía Metropolitan Park, located in the Llanerita Trail of the municipality of Villavicencio, Meta Department, Colombia. In this sense, four calicatas were opened, identified with symbols composed of four capital letters and a consecutive number, up to three figures. Thus, the type of sampling was non-probabilistic, intentional or opinionated, which is a selection procedure in which the probability that population elements have to integrate the sample is unknown; and the elements are chosen on the basis of criteria or judgements set by the investigator, in these samples were determined: texture, wet colour, presence of spots, thick fragments, consistency, structure, root presence, biological activity, surface features, resistance to penetration, moisture, pH. The soils identified and described were found in the livestock area of the park, where they presented textural classes ranging from sandy clay, silty clay and loamy clay, with dark color nuances, in addition, little presence of mottled, thick fragments and roots, low resistance to penetration and moisture. These were categorized as not very compact, with little presence of sand or silt cutaneous and low biological activity especially in subsurface horizons. The pH of these soils was extremely to slightly acidic. According to these physical and chemical characteristics, these soils could still be used for livestock farming; however, it is suggested that other soil characteristics such as real density, apparent density, organic matter, soil phosphates, to identify other uses.

Keywords: texture, pH, biological activity, eastern plains.

RESUMEN

Se evaluaron características físicas y químicas en muestras de suelos extraídas de calicatas del Parque Metropolitano María Lucía, ubicado en la vereda la llanerita del municipio de Villavicencio, departamento del Meta, Colombia. En este sentido, se aperturaron cuatro calicatas, identificadas con símbolos integrados por cuatro letras mayúsculas y un consecutivo numérico, hasta de tres cifras. Así, el tipo de muestreo fue no probabilístico, intencional u opinático, lo cual es un procedimiento de selección en el que se desconoce la probabilidad que tienen los elementos de la población para integrar la muestra; y a su vez los elementos son escogidos con base en criterios o juicios preestablecidos por el investigador, en dichas muestras se determinó: textura, color húmedo, presencia de moteados, fragmentos gruesos, consistencia, estructura, presencia de raíces, actividad biológica, rasgos superficiales, resistencia a la penetración, humedad, pH. Los suelos identificados y descritos se encontraron en su gran mayoría en la zona ganadera del parque, donde presentaron clases texturales que van desde arcilloso arenoso, arcillo limoso y franco arcillo limoso, con matices de color oscuro, además, poca presencia de moteados, fragmentos gruesos y raíces, de baja resistencia a la penetración y humedad. Estos se categorizaron poco compactos, con escasa presencia de cutanes de arena o limo, y actividad biológica baja en especial en horizontes subsuperficiales. El pH de estos suelos fue de extremadamente a ligeramente ácidos. De acuerdo con estas características fisicoquímicas, en estos suelos podrían seguir siendo usados para ganadería, no obstante, se sugiere seguir determinando otras características del suelo como densidad real, densidad aparente, materia orgánica, fosfatos, para identificar otras posibilidades de uso.

Palabras clave: textura, pH, actividad biológica, llanos orientales.

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Introduction

Soil is a critical resource to meet the needs of an ever-growing population, especially in the Latin America and the Caribbean (LAC) region. It is estimated that between 2022 and 2050 plant productivity will decline persistently, affecting between 12% and 14% of agricultural land, grasslands, grazing areas and natural areas. Globally, the most affected region will be Sub-Saharan Africa (Collins & Wischnewski, 2022).

In South America, there has also been a progressive degradation of approximately 16 million square kilometres, of which 4 million are natural areas currently under restoration and protection efforts (Collins & Wischnewski, 2022).

To a considerable extent, this degradation has been driven by the implementation of unsuitable production systems and strategic decisions that favor agricultural expansion at the expense of ecosystem services, thereby compromising the long-term sustainability of soils and natural resources (Food and Agriculture Organization of the United Nations [FAO], 2012).

When management practices are not adequately adapted to local ecological conditions, they can contribute to soil degradation. Even events that are often considered natural phenomena, such as floods, landslides and droughts, may be a consequence, in whole or in part, of human activity (FAO, 2012).

In addition, the implementation of high-cost techniques and inputs, including intensive use of agrochemicals on commercial crop plantations in Latin America and the Caribbean (LAC), has contributed to a significant decline in production over the last decade. This phenomenon is due to the accelerated deterioration of physical, chemical and biological characteristics of the soil (González-Pedraza et al., 2023).

The interaction between these factors has been little studied, although it is now recognized as a key issue in addressing soil degradation and reduced productivity of plantations (Rosales et al., 2006).

There is evidence that soil characteristics have a decisive influence on the yield and production of any crop (González-García et al., 2021a; Castellanos et al., 2021). The application of inappropriate management techniques such as: inefficient use and even lack of appropriate maintenance techniques, poor pest and disease control, prolonged summer periods without the alternative of irrigation, frequent flooding combined with flat topography and insufficient drainage systems, contribute to the accelerated deterioration of physical, chemical and biological characteristics of soils and decrease in their productive capacity (González-García et al., 2021b; González-Pedraza et al., 2022).

Since soil is one of the central resources for agro-food production and safety, its properties must be preserved to ensure its quality and the productive potential of plants. Therefore, the knowledge and evaluation of different physical and chemical characteristics of soils, allows to know what are the uses that can have the soils in the Metropolitan Park Maria Lucía? in order to provide a useful tool for guiding land use planning decisions in the geographic context with park-like conditions.

Materials and methods

Study location

The research was carried out in the María Lucía Metropolitan Park, which is located on the La Llanerita path, 18 kilometers southeast of the city of Villavicencio, on the road leading to Puerto López, at 4°5 19.78 N and 73°30 15,07 O. It is a site with an approximate area of 120 hectares of land belonging to the University Corporation of Meta (Obando-Moncayo, 2020).

Sampling design

The sampling design was carried out by means of calicatas, in this sense four calicatas were opened identified with symbols composed of four capital letters and a consecutive numerical number, up to three figures, located at the following coordinates: 1. Point PMML 001 (W 73°30’33.5’’ and N 04°05’27,9’’), 2. Point PMML 002 (W 73° 30’38.3’’ and N 04°05’41.9’’), 3. Point PMML 003 (W 73° 30’23.7’’ and N 04°05’39.7’’), 4. Point PMML 004 (W 73° 30.488’ and N 04°05.308) (Figure 1). Therefore, the sampling method used was non-probabilistic, intentional, or judgmental. This approach involves a selection procedure in which the probability of each population element being included in the sample is unknown. Instead, elements are chosen based on predefined criteria or judgments established by the researcher (Arias, 2012).

Description of the soil profile and characterisation of its horizons

A description of the soil profile was made at each observation calicata or trunk, and genetic horizons were separated whose thickness depended on color differences and how the factors and processes of soil formation have acted. In each horizon, the following physico-chemical characteristics were determined: texture, wet colour, presence of mottling, thick fragments, consistency, structure, root presence, biological activity, surface features, resistance to penetration, humidity and pH following the methodology used by the US Department of Agriculture (USDA) (Soil Survey Staff, 2014) and by the Agronomy Sub-Directorate of the Instituto Geográfico Agustín Codazzi (IGAC, 2007; Ospina et al., 2010).

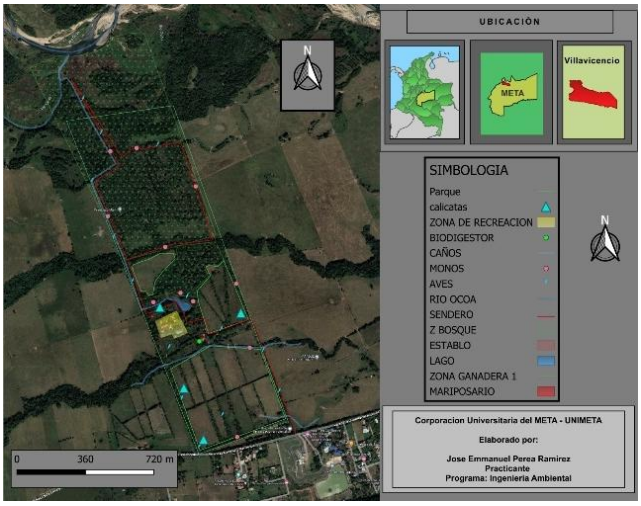

Figure 1. Calicatas location in the María Lucía Metropolitan Park. Source: Perea (2024). Blue triangles correspond to the openings of the calicatas located in the livestock area.

Results and discussion

Table 1 then records the results of the According to what is observed in the observation trunk PMML001, with coordinates W 73°30'33.5'' y N 04°05'27.9'', No differentiation was observed in the soil profile, which was described up to a depth of 50 cm. A sandy-clay-textured horizon was identified, wet colour 2.5YR 5/4, 9% humidity and acidic pH (4) (Figure 2).

No mottled (spots of different colour to the soil matrix) were observed, and the presence of coarse fragments was minimal (1%), with subangular and spherical roundness, and a moderate degree of alteration. The structure presented a subangular block arrangement, with fine-sized aggregates and weak degree of development.

It was also determined a moderately compact consistency, hard and very firm in friability, with light adhesion and moderate plasticity. Low number of very fine roots, moderate biological activity and low calcium carbonate presence were identified (Figure 2).

The calicata or observation trunk PMML 002, located at the coordinates W 73°30'38.3'' and N 04°05'41.9'', It reached a depth of 70 cm and had a humidity of 20.3%. Three horizons were identified: 0 to 20 cm, 21 to 40 cm and 41 to 70 cm. In the first horizon, the soil texture was classified as free clay-silt, with a wet colour 10YR 3/3 and a slightly acidic pH (6). Few fine and weak spots were observed, as well as a low amount (1 %) of gravel-like chunks, with sub-angular roundness, spherical shape and a strong degree of alteration. The structure corresponded to a subangular block, with a weak degree of development and very fine-sized aggregates (Figure 3).

Figure 2. Calicata or observation trunk PMML001, coordinates: W 73°30'33.5'' and N 04°05'27,9'. Source: Authors.

Figure 3. Observation trunk or calicata PMML002, coordinates: W 73° 30'38.3'' and N 04°05'41.9''. Source: Authors.

The consistency of PMML 002 soil on this horizon was not very compact, with soft hardness, very friable, slightly adhesive and moderately plastic. There was a low presence of zonal surface features, with weak appreciability and distribution on all faces. In addition, a frequent number of fine roots and moderate biological activity were recorded. No calcium carbonate was.

From 21 cm to 40 cm depth, significant changes were observed in the physico-chemical characteristics of this profile. The texture on this horizon was classified as clay-loam, with a wet color 7.5YR 5/8 and a moderately acidic pH (5). Common spots, 2 to 5 mm in size, thin and faint were identified. The presence of gravel-like thick fragments was moderate, with subangular roundness, spherical shape and a strong degree of alteration.

The soil structure corresponded to subangular blocks, with a weak degree of development and very fine-sized aggregates. The consistency was characterized as being moderately compact, with light hardness, friable, slightly adhesive and moderately plastic. There was also a low presence of zonal surface features, with weak appreciability and distribution on all sides. A low number of fine roots and moderate biological activity were observed. No calcium carbonates.

In the third horizon of the soil, the texture remained clayey silty loam, with a color of 5YR 5/8 in the wet state and a moderately acidic pH (5). Common spots, 2 to 5 mm in size, thin and visible were identified. Similarly, a low amount (1%) of gravel-like chunks was recorded, with sub-angular roundness, spherical shape and a strong degree of alteration. The structure was classified as a subangular block, with weak development and fine-sized aggregates. The consistency was moderately compact, with a slightly elevated and firm hardness, as well as slightly adhesive and moderately plastic characteristics. There was a low presence of zonal surface features, with weak appreciability and distribution on all faces.

At the same time, a low number of medium-sized roots (diameter between 2 and 5 mm) and little biological activity were observed. In this horizon, unlike the previous ones, there was a reduced presence of calcium carbonates (Figure 3).

At the point PMML 003 a calicata with four horizons was identified in its profile, located at the coordinates W 73°30’23.7’’ y N 04°05’39.7’’, with a humidity of 25.2 % (Figure 4). In the first horizon, ranging from surface to 20 cm depth, the soil texture was classified as sandy loam, with a wet color 10YR 3/2 and a strongly acidic pH (4). A low presence of calcium carbonates was found, with no traces of spots and a reduced number of coarse fragments. These fragments presented a subangular roundness, spherical shape and a slight degree of alteration.

The soil structure in this horizon was granular, with weak development and very fine-sized aggregates. The compactness was characterized by being non-coherent, with a soft hardness, very friable texture and without adhesive or plastic properties.

It was also identified a very low presence of zonal surface features, with weak appreciability and distribution on all sides of the aggregates. In addition, a frequent number of fine roots and moderate biological activity were recorded.

From 21 cm to 47 cm deep in this calicata, a clay-sandy texture was identified, with a color in the wet state 10YR 4/4 and a moderately acidic pH. No evidence of calcium carbonates and few speckled, fine size and faint hue.

It was also estimated that the thick fragments represented 1% of the horizon, with subangular morphology, spherical shape and a slight degree of alteration. The soil structure on this horizon corresponded to fine angular blocks, with moderate development.

The consistency was characterized by being slightly compact, with soft hardness, friable texture, slightly adhesive and moderately plastic. For surface features, a similar trend to the previous horizon was observed, with very few zonal surface features. In addition, a low number of very fine roots and reduced biological activity were recorded.

The third horizon of this point is between 48 cm and 77 cm deep. The soil texture in this layer was classified as loamy-sandy, with a wet color 7.5YR 4/4 and a moderately acidic pH. No evidence of calcium carbonates and few speckled, fine size and faint hue.

In addition, 1% of thick fragments were identified with subangular morphology, spherical shape and a moderate degree of alteration. The soil structure on this horizon corresponded to fine angular blocks, with moderate development.

The consistency was thin, slightly hard, firm, slightly adhesive and moderately plastic. Few superficial features were evident, which were discontinuous, of clear tonality and present in all faces of the aggregates. In addition, a low number of very fine roots and reduced biological activity were recorded.

The fourth and last horizon described, ranging from 78 cm to 120 cm deep, presented a loamy-clayey texture, with a wet color 5YR 5/8 and a moderately acidic pH. No evidence of calcium carbonates, and a common amount of mottled, medium-sized (5 to 15 mm) and visible hue was identified.

There was also a low proportion of thick fragments (1%), with subangular morphology, spherical shape and a moderate degree of alteration. The soil structure was subangular blocks with moderate development. Regarding consistency, the five evaluated aspects exhibited characteristics similar to those of the previous horizon: Hardness, friability, adhesion, plasticity and compactness. In addition, surface features were identified in 25 to 50% of the horizon, which were common, continuous, clear tonality and distributed on all sides of the aggregates. Finally, a low number of very fine roots and reduced biological activity were recorded (Figure 4).

Figure 4. Calicata or observation trunk PMML 003, coordinates: W 73° 30’23.7’’ and N 04°05’39.7’’. Source: Authors.

In the PMML004 observation trunk, located at coordinates W 73°30.488' and N 04°05.308', a relationship was identified between the textural classes of the soil, which vary from sandy loam to Clay loam-silty, and the pH of the different horizons.

The high sand content in the first horizon (0–50 cm) promotes the leaching of bases, resulting in a strongly acidic pH (4). This chemical condition improves in the second horizon (51–70 cm), where a moderately acidic pH (5) was recorded. Additionally, no calcium carbonates were detected in either horizon.

In addition, reduced biological activity and 17.1% humidity were observed.

In the first 50 cm of depth of this calicata, the color in wet state was identified as 5Y 2/1. The transition between horizons presented a diffuse sharpness (>12 cm) and a flat shape, with little or no irregularity. Few fine-sized spots were observed.

Additionally, 1% of the chunks exhibited a subangular morphology and subdiscoid sphericity, with a strong degree of alteration, indicating that they can be easily crumbled by hand. The soil structure in this horizon displayed a subangular arrangement with large-sized aggregates.

As for consistency, the soil was classified as non-coherent, since the knife penetrated effortlessly to the handle. The hardness of this horizon was soft, its friability was described as loose, and it did not present adhesive or plastic characteristics.

There was a low presence of zonal surface features, of weak appreciability and located on all sides of the aggregates. In addition, there was an abundance of very fine roots, without the presence of calcium carbonates and with reduced biological activity.

At a depth of 51 to 70 cm, the wet color was identified as 5Y 5/1. The transition between horizons presented a clear sharpness (2 - 5 cm) and an irregular shape. There was a greater number of spots compared to the first horizon, fine size and faint tonality.

As for the coarse fragments, the same proportion in volume was observed as in the previous horizon, with subangular morphology, spherical shape and a strong degree of alteration. The soil structure exhibited a subangular arrangement with large-sized aggregates. The compactness of the horizon was moderate, since the knife penetrated only partially, even applying a great effort. The soil hardness in this layer was high, its friability was described as firm, and it presented slightly adhesive and plastic characteristics.

Between 25 % and 50 % of the surface showed superficial features, covering small areas and with weak appreciability. Low number of fine roots, no calcium carbonates and reduced biological activity were observed (Figure 5).

Figure 5. Calicata or observation trunk PMML004, coordinates: W 73° 30.488’ and N 04°05.308. Source: Authors.

In the following figure it is observed that the calicatas described probably present a soil baseline (Figure 6).

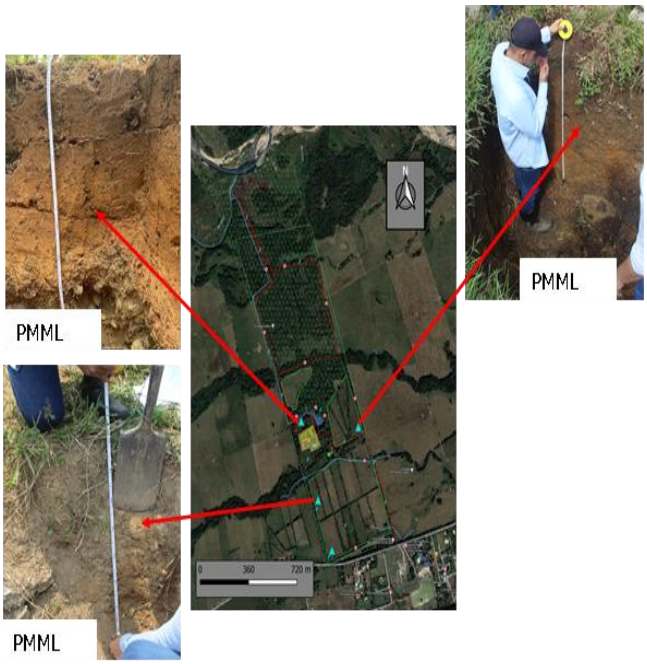

Figure 6. Location points for livestock-use fitness shoes in the María Lucía Metropolitan Park.

All the soil pits were located in areas designated for livestock use, where *Brachiaria decumbens* grass is established. In this regard, Mena et al. (2015) notes that this species is well adapted to low fertility soils and tolerates a pH range between 3.8 and 7.5. Also, Dübbern de Souza (2000) stands out its resistance to trampling and intense grazing.

Considering the suitability qualities of the soils of the Venezuelan plains described by Comerma & Chacón (2002), the soils evaluated in this study are classified with an a2 suitability, due to the presence of six wet months in the study area and moderate oxygen availability.

Depending on the availability of nutrients, these soils may present the following orders: Vertisols, Ultisols and Oxisoles, which are associated with an a3 aptitude. In addition, they have a moderate erosion potential, which classifies them with an aptitude a2 (IGAC, 2007).

The textural classes identified in this study are consistent with Owen (1995), who describes that soils in his study area originate from sedimentary material, are well drained, shallow and of low fertility.

According to Serrato (2013), it has been observed that "the intense precipitation of the region strengthens and intensifies the damage to the physical structure of the soil, which leads to the sealing of the surface layer and the consequent drastic reduction in infiltration rates, air flow and water (p. 77). This highlights the lack of knowledge about the factors and processes of soil formation in different geographical areas, placing as the first cause the inadequate use of tools and the implementation of unsustainable practices (Rivera & Amézquita, 2013).

The pH values obtained in this study are comparable to those reported by Delgado et al. (2018), who documented variations between 3.9 and 5.10. Similarly, they align with the findings of Rivera & Amézquita (2013), who recorded pH values ranging from 4.0 to 4.4, with higher values observed in native savanna soils at a depth of 20 cm

Conclusions

Most of the soils described are found in areas of livestock use, where the grass Brachiaria decumbens predominates, a species that seems to be adequately adapted to the conditions of the study area.

Soils have textural classes ranging from clay-sandy, clay-silt and loam-silt. In addition, the pH values indicate that these are soils with an acidity ranging from extremely acidic to slightly acidic.

According to these physico-chemical characteristics, these soils could continue to be used for livestock. However, additional studies are recommended to determine other soil properties such as actual density, bulk density, organic matter content and availability of phosphates in order to assess possible alternatives for use.

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