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Scientific Article

Organic Matter Fractions and Carbon Stocks in Soils Managed with Swine Manure

Frações da matéria orgânica e estoques de carbono em solos manejados com dejetos de suínos

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ABSTRACT - This study evaluated the impact of liquid swine manure (LSM) application on soil organic matter fractions and carbon stocks in soils of the Mato Grosso Cerrado under *Urochloa brizantha* pasture. The study was conducted on two Arenosols (Quartzipsamments) with sandy textures, classified as NEOSSOLOS QUARTZARÊNICOS Órticos in the municipalities of Diamantino and Nova Mutum (RQo-1 and RQo-2, respectively), and one Ferralsol (Oxisol) with a medium-sandy texture, classified as LATOSSOLO VERMELHO-AMARELO Distrófico (LVAd) in Lucas do Rio Verde, Mato Grosso, Brazil, comparing areas managed under LSM with adjacent areas of native vegetation. Total organic carbon and its physical and chemical fractions were determined by particle-size fractionation and potassium permanganate oxidation, respectively, in addition to carbon stocks and carbon management indices. In the RQo, LSM application increased carbon stocks and the non-labile fraction, indicating strong potential for carbon accumulation and stabilization in sandy soils, despite reduced lability and a lower Carbon Management Index. In the LVAd, carbon stocks and fractions showed no significant changes; however, the Carbon Management Index increased, suggesting improved soil organic matter quality. The results show that LSM application alters soil carbon compartments by soil class, highlighting the need for management strategies tailored to edaphoclimatic conditions to balance agricultural productivity and soil conservation in the Cerrado.

Keywords: Carbon management index. Nutrient cycling. Savanna ecosystem. Swine effluent. Tropical soils.

RESUMO - Este estudo avaliou o impacto da aplicação de dejeto líquido de suínos (DLS) nas frações da matéria orgânica do solo e nos estoques de carbono em solos do Cerrado de Mato Grosso sob pastagem de *Urochloa brizantha*. O estudo foi conduzido em dois Arenossolos (Quartzipsamments) de textura arenosa, classificados como NEOSSOLOS QUARTZARÊNICOS Órticos, nos municípios de Diamantino e Nova Mutum (RQo-1 e RQo-2, respectivamente), e em um Ferralsol (Oxisol) de textura média-arenosa, classificado como LATOSSOLO VERMELHO-AMARELO Distrófico (LVAd), no município de Lucas do Rio Verde, Mato Grosso, Brasil, comparando áreas manejadas com DLS e vegetação nativa adjacente. O carbono orgânico total e suas frações físicas e químicas foram determinados por fracionamento granulométrico e oxidação com permanganato de potássio, respectivamente, além da determinação dos estoques de carbono e dos índices de manejo do carbono. Nos RQo, a aplicação de DLS aumentou os estoques de carbono e a fração não lábil, indicando elevado potencial de acúmulo e estabilização de carbono em solos arenosos, apesar da redução da labilidade e do Índice de Manejo do Carbono. No LVAd, os estoques e as frações de carbono não apresentaram alterações significativas; entretanto, o Índice de Manejo do Carbono aumentou, sugerindo uma melhoria na qualidade da matéria orgânica do solo. Os resultados demonstram que a aplicação de DLS altera os compartimentos de carbono do solo de acordo com a classe de solo, destacando a necessidade de estratégias de manejo adaptadas às condições edafoclimáticas para equilibrar a produtividade agrícola e a conservação do solo no Cerrado.

Palavras-chave: Ciclagem de nutrientes. Ecossistema de savana. Efluentes suínos. Índice de manejo de carbono. Solos tropicais.

Conflict of interest: The authors declare no conflict of interest related to the publication of this manuscript.

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INTRODUCTION

Mato Grosso is consolidating as the nation's largest grain producer, supplying essential inputs for intensive livestock farming (SOGABE; MOORI; MORAIS, 2023). In this scenario, pig farming has expanded significantly, with an estimated herd of 3.16 million animals and an annual generation of approximately 9.9 million m³ of residues (ARRUDA-OLIVEIRA et al., 2024).

Liquid swine manure (LSM) is widely used as an organic fertilizer to transport nutrients and improve soil chemical, physical, and biological attributes (SILVA et al., 2018). However, improper application can lead to surface accumulation of elements such as P, Cu, and Zn, increasing the risk of environmental contamination (SCHERER; NESI; MASSOTTI, 2010; SILVA et al., 2025; CICHELERO et al., 2023).

In addition to nutrient supply, LSM influences the dynamics of soil organic matter (SOM), whose changes in subsurface are often slow (BRAGA; BRAGA; VENTURIN, 2022). Evaluating total organic carbon (TOC) in

isolation may be insensitive to short- and medium-term changes, making physical and chemical fractionation essential to distinguish compartments with different degrees of protection and susceptibility to decomposition (CAMBARDELLA; ELLIOTT, 1992; BLAIR; LEFROY; LISLE, 1995).

Labile fractions, such as particulate organic carbon (POC) and labile carbon (LC), cycle rapidly and are sensitive to management. In contrast, mineral-associated organic carbon (MOC) and non-labile carbon (NLC) represent recalcitrant fractions that contribute to structural stability and long-term carbon storage (NANZER et al., 2019; RIBEIRO et al., 2023; OLIVEIRA et al., 2023). Maintaining these stocks is fundamental for ecosystem functionality and greenhouse gas mitigation, with their dynamics modulated by edaphoclimatic factors and management practices (DIONIZIO et al., 2020; TÓTH et al., 2022).

Although the agronomic application of LSM replenishes nutrients and enhances soil fertility, its continuous disposal raises significant environmental concerns, particularly the potential accumulation of trace elements such as copper (Cu) and zinc (Zn) in the topsoil (SILVA, 2023; CICHELERO et al., 2023). Most previous studies have focused strictly on the absolute accumulation of total organic carbon (TOC) or macronutrients, leaving a critical knowledge gap regarding how different physical and chemical soil organic matter fractions, as well as soil quality indices like the Carbon Management Index (CMI), respond under contrasting soil textures and mineralogy. Therefore, comparing extremely sandy soils (Neossolos Quartzarênicos) with medium-textured soils (Latossolos) under real, long-term farm conditions is a key scientific step toward establishing edaphoclimatic management boundaries that reconcile organic recycling with soil conservation in the tropical Cerrado.

Considering the significant concentration of pig farming in the south-central and north-central regions of Mato Grosso and the need for sustainable management systems, and given the scientific gap regarding how contrasting soil textures under tropical conditions modulate carbon lability and stabilization under continuous waste application, this study is justified by the importance of monitoring the impact of organic residues on soils of different textures. This research advances scientific understanding by demonstrating how soil texture controls carbon protection mechanisms, fractions, and stocks in Cerrado pasture soils subjected to continuous LSM applications. Therefore, the objective was to evaluate whether continuous LSM application alters carbon content in the physical and chemical fractions of organic matter and carbon stocks in pasture soils in these regions.

MATERIALS AND METHODS

Sampling and characterization of the area and soil

The experimental areas were set up on contrasting soil classes under different management durations of liquid swine manure (LSM) application in Mato Grosso, Brazil. In the municipality of Diamantino, the study was conducted on a sandy-textured Arenosol (Quartzipsamment), classified under the Brazilian Soil Classification System (SiBCS) as a NEOSSOLO QUARTZARÊNICO Órtico (RQo-1), which received LSM application for 20 years. In Lucas do Rio Verde, the evaluation was performed on a medium-sandy Ferralsol (Oxisol), corresponding to a LATOSSOLO VERMELHO-AMARELO Distrófico (LVAd), with 10 years of LSM application. In Nova Mutum, a sandy-textured Arenosol (Quartzipsamment), corresponding to a NEOSSOLO QUARTZARÊNICO Órtico (designated as RQo-2), was managed with LSM for 5 years. At all experimental sites, the soil was under pasture cultivation with *Urochloa brizantha* cv. Marandu. Table 1 summarizes detailed soil classifications and textural characteristics.

Table 1. Taxonomic classification and textural class of the studied Cerrado soils under liquid swine manure management in the State of Mato Grosso, Brazil.

Area	SiBCS	WRB/FAO	Soil Taxonomy	Textural class
RQo-1	NEOSSOLO QUARTZARÊNICO Órtico	Arenosol	Quartzipsamment	Sandy
LVAd	LATOSSOLO VERMELHO-AMARELO Distrófico	Ferralsol	Oxisol	Medium-sandy
RQo-2	NEOSSOLO QUARTZARÊNICO Órtico	Arenosol	Quartzipsamment	Sandy

RQo-1 = NEOSSOLO QUARTZARÊNICO Órtico (Arenosol [WRB] / Quartzipsamment [Soil Taxonomy]) located in Diamantino, State of Mato Grosso, Brazil, with 20 years of continuous liquid swine manure (LSM) application; LVAd = LATOSSOLO VERMELHO-AMARELO Distrófico (Ferralsol [WRB] / Oxisol [Soil Taxonomy]) located in Lucas do Rio Verde, State of Mato Grosso, Brazil, with 10 years of continuous LSM application; RQo-2 = NEOSSOLO QUARTZARÊNICO Órtico (Arenosol [WRB] / Quartzipsamment [Soil Taxonomy]) located in Nova Mutum, State of Mato Grosso, Brazil, with 5 years of continuous LSM application. SiBCS = Brazilian Soil Classification System; WRB = World Reference Base for Soil Resources.

The study areas are located within the Cerrado biome and have a tropical climate with a dry winter season (Aw), according to the Köppen–Geiger classification (ALVARES et al., 2013). Average annual rainfall ranges from 1,750 to 2,300 mm, with average annual temperatures from 24.0 to 27.7 °C.

Soil sampling was carried out between November 2019 and February 2020, following the procedure described by Silva (2023). At each of the three study locations, 60-ha areas under the application of liquid swine manure (AUA) and their respective native vegetation areas (NV) were divided into four 15-ha plots. Each 15-ha plot was considered an independent experimental unit. Within each plot, five soil subsamples were collected at points following a zigzag sampling pattern at three soil depths: 0.00–0.05, 0.05–0.10, and 0.10–0.20 m. For

each plot and soil depth, the five subsamples were homogenized to form a composite soil sample representative of the respective experimental unit. Thus, four independent composite samples were obtained for each condition (AUA and NV) at each study site. To evaluate the overall 0.00–0.20 m layer, we mathematically integrated the values from the three depth intervals (weighted average based on layer thickness and soil bulk density) for each of the four plots, providing four independent replicates (n = 4) per treatment.

After collection, samples were dried in a forced-air oven at 65 °C, then disaggregated and sieved through a 2.0 mm mesh. We then performed chemical analyses (pH, H+Al, sum of bases, cation exchange capacity at pH 7.0, base saturation, and soil organic matter) and granulometric analysis (clay, silt, and sand content) according to the methodological procedures described by Teixeira et al. (2017), which are presented in Table 2.

Table 2. Initial chemical properties and particle-size distribution (0.00–0.20 m depth) of Cerrado soils under long-term liquid swine manure (LSM) application and adjacent native vegetation (NV) in the State of Mato Grosso, Brazil.

Soil	Area	pH	pH	H+Al	SB	T	V	SOM	Clay	Silt	Sand
		H_2O	$CaCl_2$	-------- $cmol_c\ dm^{-3}$ --------			--------- % ---------		---------- $g\ kg^{-1}$----------		
RQo-1	AUA	6.21	5.79	1.35	4.47	5.81	76.33	2.93	122.00	68.00	810.00
	NV	4.50	4.65	4.68	0.49	5.17	9.67	1.83	99.33	65.33	835.33
LVAd	AUA	6.02	5.24	2.99	3.02	6.01	50.33	2.87	273.33	91.33	635.33
	NV	4.97	4.42	4.96	1.57	6.53	24.00	2.60	285.00	96.00	619.00
RQo-2	AUA	6.04	5.70	1.27	3.59	4.86	73.33	2.83	100.33	68.67	831.00
	NV	4.33	4.36	5.29	0.38	5.67	6.67	1.57	90.67	71.00	838.33

RQo-1 = NEOSSOLO QUARTZARÊNICO Órtico (sandy texture, 20 years of LSM); LVAd = LATOSSOLO VERMELHO-AMARELO Distrófico (medium-sandy texture, 10 years of LSM); RQo-2 = NEOSSOLO QUARTZARÊNICO Órtico (sandy texture, 5 years of LSM). AUA = area under liquid swine manure application; NV = adjacent native vegetation (control). H+Al = potential acidity; SB = sum of bases; T = cation exchange capacity at pH 7.0; V = base saturation; SOM = soil organic matter. Soil properties were determined according to the official methodologies of Teixeira et al. (2017). Units: $cmol_c\ dm^{-3}$ (for H+Al, SB, and T), % (for V), and $g\ kg^{-1}$ (for SOM, Clay, Silt, and Sand). Data represent mean values of four composite samples per treatment (n = 4).

Physical and oxidizable fractions of organic matter

We quantified TOC by wet oxidation of organic matter with potassium dichromate ($K_2Cr_2O_7$) in an acidic medium, following the procedure described by Yeomans and Bremner (1988). We calculated TOC levels using the method described by Castro, Vieira and Weber (2018).

We physically fractionated SOM following Cambardella and Elliott (1992), separating it into particulate organic carbon (POC) and MOC. For this, we chemically and physically dispersed the air-dried fine earth (ADFE) fraction with sodium hexametaphosphate (5 g L^{-1}) and agitated horizontally for 15 hours. We determined MOC content using the procedure described by Yeomans and Bremner (1988), and calculated POC as the difference between TOC and MOC.

We carried out chemical fractionation of SOM by oxidation with potassium permanganate ($KMnO_4$) following Blair, Lefroy and Lisle (1995) and modified by Shang and Tiessen (1997). The soil sample was sieved, weighed (1 g), placed in centrifuge tubes, and treated with 25 mL of $KMnO_4$ (333 mmol L^{-1}). After agitation and centrifugation, 1.0 mL of the supernatant was transferred to a volumetric flask and diluted with deionized water. To determine LC, absorbance was measured at a wavelength of 565 nm using a spectrophotometer. NLC and the other indices (Lability (L), Lability Index (LI), Carbon Pool Index (CPI), and Carbon Management Index (CMI)) were calculated according to Müller, Weber, and Scaramuzza (2012).

Soil organic carbon stocks

We determined bulk density using the graduated cylinder method, as described by Teixeira et al. (2017), and calculated total organic carbon stocks (TOCS) according to Magalhaes, Ramos and Weber (2016) (based on the data presented in Table 3).

Table 3. Soil total organic carbon (TOC) and bulk density (BD) at 0.00–0.20 m depth in contrasting Cerrado soils under liquid swine manure (LSM) application and native vegetation (NV) in the State of Mato Grosso, Brazil.

Identification	Area	TOC	BD
		g kg^{-1}	g cm^{-3}
RQo-1	NV	7.58	1.25
	AUA	17.72	1.17
LVAd	NV	33.47	1.23
	AUA	36.73	1.21
RQo-2	NV	6.33	1.47
	AUA	13.05	1.47

RQo-1 = NEOSSOLO QUARTZARÊNICO Órtico (sandy texture, 20 years of LSM); LVAd = LATOSSOLO VERMELHO-AMARELO Distrófico (medium-sandy texture, 10 years of LSM); RQo-2 = NEOSSOLO QUARTZARÊNICO Órtico (sandy texture, 5 years of LSM). AUA = area under liquid swine manure application; NV = adjacent native vegetation (control). TOC = soil total organic carbon, determined by wet oxidation (Yeomans and Bremner, 1988); BD = soil bulk density, determined by the graduated cylinder method (TEIXEIRA et al., 2017). Units: g kg^{-1} (for TOC) and g cm^{-3} (for BD). Data represent mean values of four independent replicates (n = 4).

Data analysis

Initially, the data were subjected to the Shapiro-Wilk test ($p \leq 0.05$) to assess normality. Upon confirming the absence of a normal distribution, the non-parametric Mann-Whitney test ($p \leq 0.05$) was used to compare the variables POC, MOC, LC, NLC, L, LI, CPI, CMI, and TOCS between the native vegetation areas (NV) and the areas under LSM application (AUA) in the 0.00–0.20 m layer. Comparisons were performed separately for each of the three soil locations, with four independent experimental units per group (n= 4 for NV and n= 4 for AUA) in each location. All statistical analyses were performed using RStudio software (version 2026.08.2-200).

RESULTS AND DISCUSSION

POC did not differ significantly between native vegetation (NV) and areas under application (AUA) of LSM in soils RQo-1 and LVAd ($p > 0.05$), but was significantly higher under LSM (AUA) in RQo-2. LSM application increased MOC values for RQo-1, but not for RQo-2; in contrast, LVAd showed a reduction relative to NV (Figure 1).

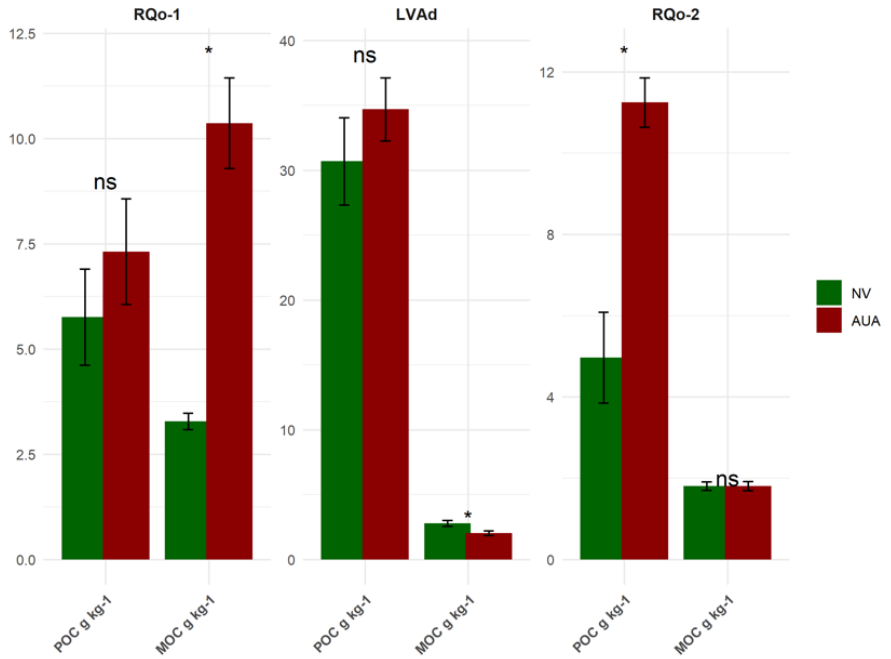


Figure 1. Particulate organic carbon (POC, g kg^{-1}) and mineral-associated organic carbon (MOC, g kg^{-1}) in the 0.00–0.20 m soil layer under liquid swine manure (LSM) application (AUA) and adjacent native vegetation (NV) in the State of Mato Grosso, Brazil. Soils: LVAd = LATOSSOLO VERMELHO-AMARELO Distrófico (Ferralsol / Oxisol); RQo-1 and RQo-2 = NEOSSOLO QUARTZARÊNICO Órtico (Arenosols / Quartzipsamments). ns = not significant; * = significant at $p \leq 0.05$ according to the Mann-Whitney test. Vertical bars represent the standard error of the mean (n = 4).

The differentiated response of the physical fractions reflects the combined effect of soil texture and the duration of LSM management. In sandy soils, such as Neossolos Quartzarênicos, the lower physical protection of organic matter favors rapid POC responses to the recent inputs of organic residues (RAMOS et al., 2023), as observed in RQo-2, with only five years of application. The progressive increase in MOC in RQo-1 (20 years of application) under LSM (AUA) indicates that, over the long term, sandy soils can stabilize organic compounds. This is driven by the significant input of multivalent cations (such as Ca^{2+}) and trace metals from liquid swine manure, which promote cation bridging between kaolinite surfaces and dissolved organic matter. Furthermore, low-C/N swine manure stimulates microbial biosynthesis, producing extracellular polymers that bind sand particles into stable microaggregates, and physically protect carbon.

Conversely, the higher MOC in NV of LVAd reflects the greater organo-mineral protection capacity typical of Latossolos under natural conditions (YE et al., 2017). In this medium-sandy soil, the minerals are already near their carbon saturation threshold under native vegetation due to strong ligand exchange complexes with Fe/Al oxides. Consequently, additional organic carbon from LSM finds few vacant reactive sites, remains chemically unprotected, and is rapidly mineralized by microbes under the tropical Aw climate, preventing further MOC accumulation.

LC showed no significant differences between NV and AUA in any of the soils evaluated. NLC did not differ between treatments in LVAd and was highest under LSM (AUA) in RQo-1 and RQo-2 (Figure 2).

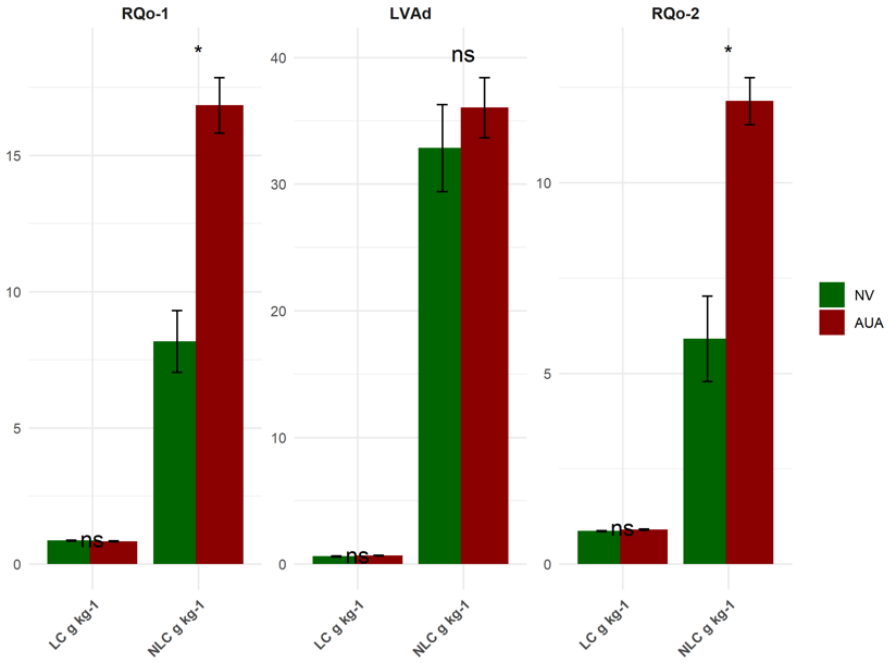


Figure 2. Labile carbon (LC, g kg^{-1}) and non-labile carbon (NLC, g kg^{-1}) in the 0.00–0.20 m soil layer under liquid swine manure (LSM) application (AUA) and adjacent native vegetation (NV) in the State of Mato Grosso, Brazil. Soils: LVAd = LATOSSOLO VERMELHO-AMARELO Distrófico (Ferralsol / Oxisol); RQo-1 and RQo-2 = NEOSSOLO QUARTZARÊNICO Órtico (Arenosols / Quartzipsamments). ns = not significant; * = significant at $p \leq 0.05$ according to the Mann-Whitney test. Vertical bars represent the standard error of the mean (n = 4).

The lack of differences in LC suggests a balance between carbon input via LSM and the rapid mineralization favored by the Cerrado's tropical Aw climate. On the other hand, the increase in NLC under LSM (AUA) in RQo-1 and RQo-2 indicates a process of carbon stabilization in sandy soils under LSM management. In these strictly sandy soils, the accumulated carbon shifts into more humified, recalcitrant forms (NLC) because the soil is far below its carbon saturation capacity, allowing the incoming manure residues to undergo biochemical transformation into stable humic substances. In LVAd, the high mineralogical protection of SOM, mediated by Fe and Al oxides, stabilizes the baseline organic matter and buffers the system, preventing detectable changes in this fraction in medium-sandy soils.

L and LI showed higher values in NV in soils RQo-1 and RQo-2, while CPI showed higher values under LSM (AUA) in these same soils. In LVAd, treatments did not differ significantly for these indices (Figure 3).

These results indicate that, although LSM increases the total carbon compartment size in Neossolos, NV maintains a higher proportion of LC, reflecting greater biological dynamism. The increase in CPI under LSM (AUA) in both RQo-1 and RQo-2 is a recurring pattern in comparisons between agricultural areas and native vegetation, associated with higher total carbon stock, though with less relative lability (BEHERA; SAHOO; MOHANTY, 2025). The lack of differences in LVAd ($p > 0.05$), in contrast to RQo, reinforces the role of soil texture and mineralogy in organic matter quality. Scherer, Nesi and Massotti (2010) reported that successive applications of swine manure did not alter organic matter levels in clayey soils, which is consistent with the high baseline stability and buffer capacity of clay-rich matrices. In

our study, this mineral buffering also explains the lower responsiveness of the medium-sandy Latossolo (LVAd) compared to the highly responsive, strictly sandy Neossolos (RQo).

CMI was higher in NV soils RQo-1 and RQo-2, whereas in LVAd, it was significantly higher under LSM (AUA) (Figure 4).

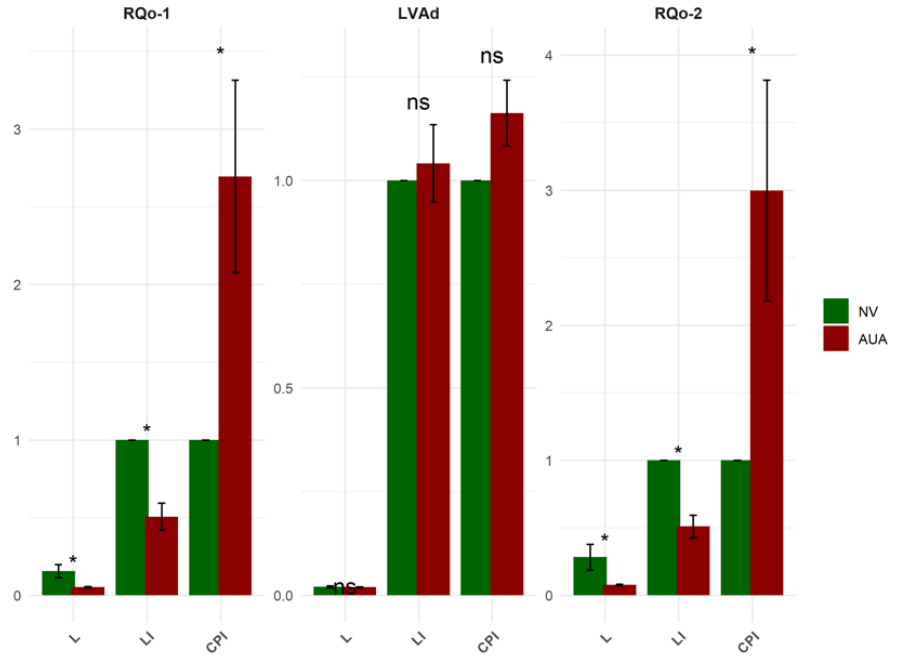


Figure 3. Soil carbon lability (L), lability index (LI), and carbon pool index (CPI) in the 0.00–0.20 m soil layer under liquid swine manure (LSM) application (AUA) and adjacent native vegetation (NV) in the State of Mato Grosso, Brazil. Soils: LVAd = LATOSSOLO VERMELHO -AMARELO Distrófico (Ferralsol / Oxisol); RQo-1 and RQo-2 = NEOSSOLO QUARTZARÊNICO Órtico (Arenosols / Quartzipsamments). ns = not significant; * = significant at $p \leq 0.05$ according to the Mann-Whitney test. Vertical bars represent the standard error of the mean (n = 4).

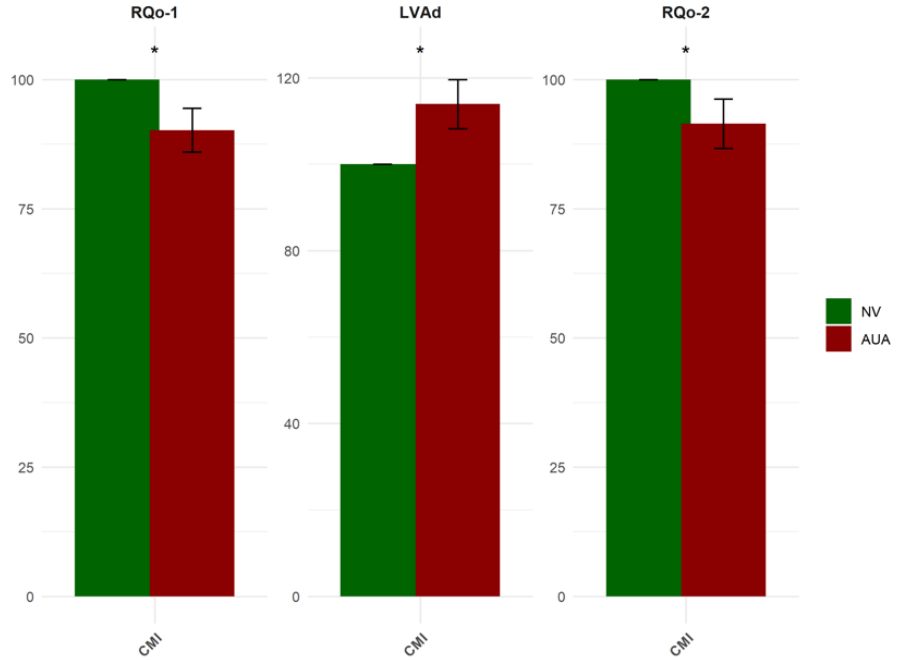


Figure 4. Carbon Management Index (CMI) in the 0.00–0.20 m soil layer under liquid swine manure (LSM) application (AUA) and adjacent native vegetation (NV) in the State of Mato Grosso, Brazil. Soils: LVAd = LATOSSOLO VERMELHO-AMARELO Distrófico (Ferralsol / Oxisol); RQo-1 and RQo-2 = NEOSSOLO QUARTZARÊNICO Órtico (Arenosols / Quartzipsamments). ns = not significant; * = significant at $p \leq 0.05$ according to the Mann-Whitney test. Vertical bars represent the standard error of the mean (n = 4).

In Neossolos, the higher CMI in NV indicates a better balance between the quantity and quality of carbon, reflecting greater lability and better organization of soil C fractions, in agreement with studies that relate high CMI to greater inputs and a higher proportion of labile fractions of organic matter in natural systems or to a greater input of organic residues (MIR et al., 2023). In LVAd, the increase in CMI under LSM (AUA) suggests a relative improvement in the quality of soil organic carbon in response to management. This improvement, even without absolute increases in TOCS, is explained by the fertilizing effect of LSM. The nutrient supply from the manure stimulates the root system of *Urochloa brizantha* cv. Marandu, promoting a continuous flux of root exudates and fine root decay into the soil matrix. This rhizosphere-driven process increases biological dynamism and lability, which helps explain why pastures managed with organic residues improve soil quality in weathered, medium-textured soils.

TOCS showed significantly higher values under LSM (AUA) in soils RQo-1 and RQo-2, while in LVAd there were no significant differences between NV and AUA (Figure 5).

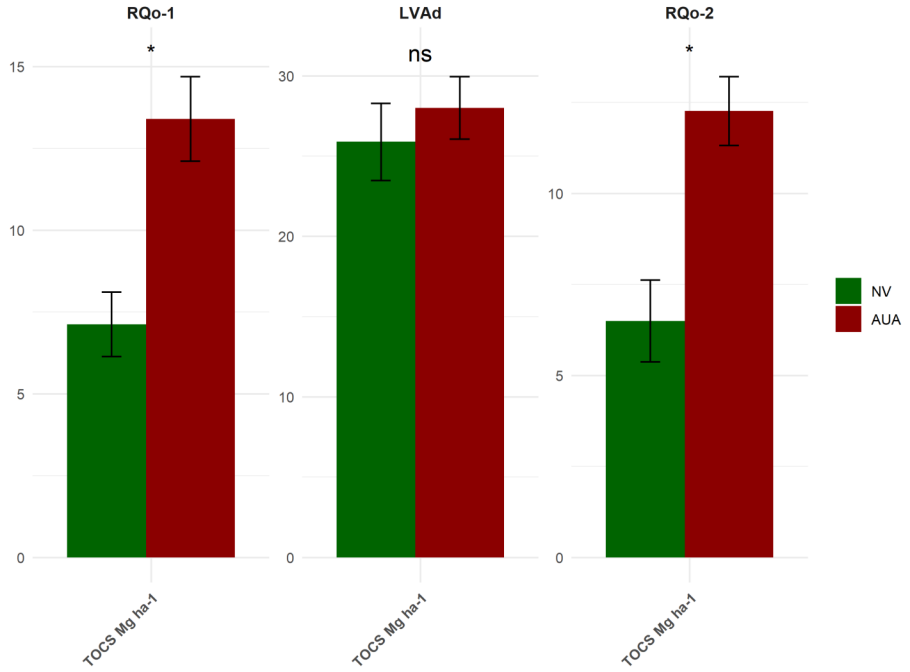


Figure 5. Soil organic carbon stock (TOCS, Mg ha^{-1}) in the 0.00–0.20 m soil layer under liquid swine manure (LSM) application (AUA) and adjacent native vegetation (NV) in the State of Mato Grosso, Brazil. Soils: LVAd = LATOSSOLO VERMELHO-AMARELO Distrófico (Ferralsol / Oxisol); RQo-1 and RQo-2 = NEOSSOLO QUARTZARÊNICO Órtico (Arenosols / Quartzipsamments). ns = not significant; * = significant at $p \leq 0.05$ according to the Mann-Whitney test. Vertical bars represent the standard error of the mean (n = 4).

The increase in TOCS in Neossolos highlights the high capacity for carbon accumulation and storage promoted by LSM in sandy soils, especially those with lower initial organic matter stock. However, this increase should not be directly equated with net carbon sequestration. True carbon sequestration implies a net removal of atmospheric CO_2 over time (DIONIZIO et al., 2020). Because this study did not perform a complete carbon input-output balance or directly measure soil greenhouse gas emissions (such as CO_2 and N_2O) associated with the agricultural system, these results should be interpreted strictly as soil carbon accumulation and storage rather than net carbon sequestration.

Additionally, this pattern reinforces that sandy soils, because of their low natural carbon levels, behave as open thermodynamic systems with a high capacity to accumulate carbon when organic matter is added. Conversely, medium-sandy Latossolos, buffered by organomineral complexes, are already near their carbon saturation capacity under native conditions and require management strategies focused on maintaining existing soil organic matter rather than expecting further storage.

CONCLUSIONS

Liquid swine manure application increased total organic carbon stocks and the non-labile carbon fraction in the NEOSSOLOS QUARTZARÊNICOS Órtico (RQo), indicating a greater potential for carbon accumulation and stabilization in these sandy soils. However, the higher lability and Carbon Management Index observed under native vegetation in the RQo soils indicate that LSM application increased carbon stocks while reducing the relative lability of soil organic matter in these sandy soils.

In the LATOSSOLO VERMELHO-AMARELO Distrófico (LVAd), LSM application did not significantly alter total organic carbon stocks or the evaluated carbon fractions but increased the Carbon Management Index, suggesting improved relative quality of soil organic carbon under manure management.

Overall, the effects of long-term LSM application on soil organic carbon depend strongly on soil class and its inherent capacity to stabilize organic matter. Therefore, LSM management should consider soil-specific characteristics to

maximize carbon accumulation while maintaining the quality and lability of soil organic matter.

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