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Physicochemical characterization of cow dung from Lomé (Togo) for agricultural valorization

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Abstract: Soil degradation in agricultural lands represents a major global environmental challenge of the 21st century. It constitutes a silent crisis threatening global food security, particularly in sub-Saharan Africa. Meanwhile, Togo produces over 650,000 tons of cow dung annually, with less than 20% being valorized. In most cases, this dung is either burned, contributing to greenhouse gas emissions and climate change or discarded, leading to public space clutter. To address this dual issue, this study characterizes Togolese cow dung to assess its potential as an organic soil amendment in agriculture. Physicochemical characterization (e.g., nutrients, trace metals) was combined with FTIR analysis to evaluate manure quality. Results reveal an average organic matter content of 50.65% and 29.11% for organic carbon. The mean pH is alkaline at 8.83, with electrical conductivity of the water at 4.23 dS m^{-1}. NPK fertilizer elements averaged 4406.96 mg kg^{-1} N, 1121.87 mg kg^{-1} P, and 1681.97 mg kg^{-1} K. Exchangeable bases were also notable: Ca (1534.37 mg kg^{-1}), Mg (1548.28 mg kg^{-1}), and Na (1328.13 mg kg^{-1}). FTIR spectra indicate advanced humification, with polysaccharides at 1027 cm^{-1} and stable proteins at 1631 cm^{-1}. Trace elements were present at low levels, including Cd (0.26 mg kg^{-1}) and Pb (7.35 mg kg^{-1}). These trace metal contents are well below thresholds. Overall, the analytical results suggest promising potential for agricultural use, provided appropriate management of stability and application methods is ensured.

1. Introduction

Soil degradation is a global challenge threatening the sustainability of agricultural systems in many regions, particularly in sub-Saharan Africa. It is a silent crisis that undermines global food security, especially in sub-Saharan Africa (Soundron, 2019), (Abalo-Esso *et al.*, 2021). According to FAO (2024), the equivalent of a football field is eroded every five seconds. If no action is taken, more than 90% of the world's soils could be degraded by 2050, while 75% are already affected to varying degrees (FAO, 2025). In West Africa, CGIAR (2023) reports that 67% of agricultural lands are degraded, including soils in Togo. In Togo, soils long considered fertile and agriculturally productive are increasingly degraded, thereby compromising agricultural productivity, especially vegetable production, and food security. According to the (ORSTOM/IRD report (1996), confirmed by (Abalo-Esso *et al.* (2021), 85% of arable soils in Togo are degraded, 68% of cultivated soils exhibit high acidity (pH < 5.5), and 84% have low organic matter contents (OM < 2%). This degradation, mainly physico-chemical in origin, results from several interacting factors, including erosion, salinization, acidification, and the loss of soil organic matter. These changes impair ecosystem functioning and consequently reduce crop yields. Agriculture nevertheless plays an important role in the economy of many countries, particularly in Africa. In Togo, agriculture employs 54.1% of the population, contributes about 42% to the Gross Domestic Product (GDP), and accounts for 20% of export earnings(FAO, 2015). In this context, promoting sustainable agriculture is a key development objective, aligned with the United Nations Sustainable Development Goals, particularly poverty eradication, hunger reduction, and the promotion of sustainable agriculture. To achieve these goals in sub-Saharan Africa, developing the agricultural sector would be highly relevant, as these regions have substantial potential. Togo has, on average, 59% agricultural land across its territory. Lixisols, Vertisols, and Leptosols dominate in the northern and central parts of the country, whereas the south is mainly ferrallitic. These soils are acidic and very poor in organic matter, available phosphorus, nitrogen, potassium, and exchangeable bases (Fiadjoe, 2021). Such deficiencies limit plant production in tropical areas. To overcome these constraints, countries whose economies rely on agriculture often depend on imported superphosphate fertilizers and chemical inputs. However, this dependence on mineral inputs compromises the sustainability and autonomy of Togolese agriculture. In parallel with this challenge, Togo produces about 650,000 tons of cattle manure per year, of which less than 20% is valorized, according to ITRA (2020). In most cases, this manure is either burned, contributing to greenhouse gas emissions and climate change, or simply abandoned, which obstructs public spaces. However, several studies, including that of Gbénou *et al.* (2021), have shown that cattle manure could constitute a sustainable alternative for restoring agricultural soils by supplying organic matter and nutrients while helping to correct soil acidity. In this context, and despite the local availability of this raw material, scientific studies on the physico-chemical characterization of cattle manure in Togo, with a view to its valorization in agriculture and its contribution to improving soil quality, remain limited. Accordingly, the present article aims to characterize Togolese cattle manure in order to assess its potential use as an organic amendment for agricultural soils in Togo.

2. Methodology

2.1 Sampling, pre-treatment and study area

This study was carried out in the Laboratory of Waste Management, Treatment, and Valorization (GTVD), Faculty of Sciences, University of Lomé, Togo, located at 6°10′25″ N and 1°12′57″ E. Cow manure was collected from a livestock farm in Lomé. Five samples, each weighing 4 kg, were collected, packaged in plastic sampling bags, and transported to the laboratory for pre-treatment. The samples were air-dried on a concrete slab under sunlight for two weeks and then manually ground to obtain a homogeneous powder. They were subsequently stored in plastic containers until analysis. To ensure result reliability, all measurements were performed in duplicate. The manure samples were subjected to characterization tests to determine several physico-chemical parameters that could be used to assess their suitability or rejection as an organic amendment. For this purpose, the samples were oven-dried for 24 h at 105°C and manually ground in a laboratory mortar to obtain a fine powder of a few micrometers for analysis. **Figure 1** illustrates the cow dung used.

Figure 1: Cow mannure used

2.2-Physico-chemical parameters of cow manure

2.2.1-Moisture content

Moisture content was determined using the standardized method NF EN 13040 for organic amendments. Five manure samples were oven-dried for 24 h at 105°C. Moisture content was then calculated using the following equation 1:

$$TH = \frac{M_i - M_f}{M_i} \times 100 \quad (1)$$

Variables: TH: moisture content (%); Mi: initial mass (g); Mf: final mass (g).

2.2.2-Determination of pH and electrical conductivity

The pH and electrical conductivity (EC) of the cow manure were determined using the method described by (Bodjona *et al* (2024)). Briefly, 20 g of the dried manure sample, previously ground and sieved at 2 mm, were mixed with 100 mL of distilled water at a 1:5 ratio. The mixture was magnetically stirred for 1 h. The suspension was then allowed to settle for 2 h and filtered. The pH and EC of the resulting aqueous extract were measured using a HANNA pH meter and conductivity meter. The measured values were considered representative of the cow manure.

2.2.3-Determination of organic matter

Organic matter in the manure was determined using the standardized method NF ISO 10694, as described by (Aziablé *et al.* (2016)). Using an electronic balance, 20 g of the pre-dried manure sample were weighed into a crucibleand placed in a furnace set at 450°C for 16 h. The weight loss after calcination corresponded to the organic matter content. During combustion, organic matter is oxidized and converted into carbon dioxide and water vapour, leaving only the mineral fraction in the crucible. The organic matter content was calculated using the following Equation 2:

$$MO = \frac{Mi - Mf}{Mi} X100 \quad (2)$$

The total organic carbon (TOC) content was then derived using the Van Bemmelen factor (Benejar *et al.*, 2018) (equation 3).

$$COT = \frac{MO}{1{,}724} \quad (3)$$

2.2.4-FTIR analysis

The finely ground and sieved samples (<50 µm) were dried at 40–60°C for 24 h. The instrument was switched on and allowed to auto-align for 5–10 min until the green LED signal appeared. OMNIC Paradigm software was opened, and the soil/biochar method was selected (400–4000 cm^{-1}, 32–64 scans, 4 cm^{-1} resolution). The ZnSe HATR crystal was cleaned with isopropanol. A background scan was performed on the empty platform for 1–2 min. The sample was then applied uniformly, compressed at 50–100 psi in ATR mode or placed in a DRIFT cup, and "Collect Sample" was started for 30–60 s with 3–5 replicates. Baseline correction and automatic normalization were applied using the O–H peak at approximately 3400 cm^{-1}, and functional groups such as Si–O at 1000 cm^{-1} and C=O at 1700 cm^{-1} were identified before export.

2.2.5-Determination of fertilizing elements and trace metals

Mineralization and solubilization of samples

Mineralization and solubilisation was done using the method decrit by (Abukari et Cobbinah.; (2025). Solubilization was carried out by nitric acid (HNO_3) digestion. The procedure was performed in a closed system under heat at 150°C. For 1 g of dried and finely ground manure sample, 4 mL of nitric acid were added. In addition, 10 mL of 9% hydrogen peroxide (H_2O_2) were added to each sample and left to react for 24 h before acid digestion. After acid treatment and heating, the samples were filtered through filter paper. The resulting filtrate contained the chemical elements. The concentrations of Ca, Mg, Na, K, Cd, Pb, and Cr were determined using an atomic absorption spectrophotometer (iCE 3000 Series, Thermo Fisher). The table1 summarizes the methods and instruments used for the determination of elements in cow manure**.**

Table 1 : The table below summarizes the methods used for the determination of the analytical parameters

Analytical parameter	Method	Equipment used
Calcium	Flame atomic absorption spectrometry (NF EN ISO 7980)	SAA iCE 3000 Series, Thermo Fisher
Sodium, Potassium	Flame atomic absorption spectrometry (NF T 90-020)	SAA iCE 3000 Series, Thermo Fisher
Magnesium	Flame atomic absorption spectrometry (NF EN ISO 7980)	SAA iCE 3000 Series, Thermo Fisher
Cadmium	Flame atomic absorption spectrometry (NF EN ISO 5961)	SAA iCE 3000 Series, Thermo Fisher
Lead	Flame atomic absorption spectrometry (FD T 90-112)	SAA iCE 3000 Series, Thermo Fisher
Arsenic	Hydride generation atomic absorption spectrometry (NF EN ISO 11969)	SAA iCE 3000 + VP100
Nitrogen and phosphorus	Colorimetry (Method 10071, DR 3800 procedure) / Colorimetry (NFT 90-023	HACH DR 3800

2-2-6 Mineral fraction and total NPK

The mineral fraction or ash content in cow manure was estimated using the **equation 4** given below (Wystalska *et al.*, 2023):

$$\%fraction\ min\acute{e}rale = \frac{Matiere\ s\acute{e}che - Mati\acute{e}re\ organique}{Matiere\ s\acute{e}che} X100 \qquad (4)$$

Total NPK was determined in our manure samples using the following **equation 5** (Adande et Fiogbe, 2015).

$$NPK\ total = N + P + K \qquad (5)$$

2-2-7 Sum of major cations (SMC)

The sum of major cations was determined using the **equation 6** (Lare *et al.*, 2022)

$$SMC = Ca + Mg + K + Na \qquad (6)$$

2-2-8 The relative contribution of each element to the sum of macronutrients was calculated using the equation 7 below (Agriculture (IITA), 2024).

$$\%X = \frac{X}{N+P+K+Mg+Ca+Na} X100 \qquad (7)$$

3. Results and Discussion

3.1-Organic carbon and organic matter contents of cow manure

Table 2 presents the organic matter (OM), total organic carbon (TOC), dry matter (DM), and mineral fraction contents of cow manure.

Table 2. OM, TOC, DM, and mineral fraction contents of cow manure

Parameter	Ours values				References values for the interpretation (IRDA et al., 2008; COMIFER, 2019)		
CM (n=5)	Min	Max	mean	SD	Low reference	Optimal reference	High reference
OM	46.17	52.30	50.65	0.51	<20	20-40	>40
TOC	26.78	30.34	29.34	0.34	<10	10-20	>20
DM	90.56	92.24	91.76	2.84	<70	70-90	>90
MF	43.33	49.02	41.11	8.20	>30	10-30	<10

All parameters are expressed in %. OM: organic matter; TOC: total organic carbon; DM: dry matter, MF : Mineral fraction**.**

The results show an average organic carbon content of 50.65% in cow manure, with values ranging from 46.17% to 52.30%, and an average total organic carbon content of 29.34%, varying from 26.78% to 30.34%. These parameters reflect the carbon richness of the manure. The values obtained are much higher than those reported in the literature for fresh manure. For example, studies conducted by (Guei et al., (2020)) in Daloa, central-western Côte d'Ivoire, on fresh cattle manure reported average organic matter and organic carbon contents of 15.03% and 8.75%, respectively. Similarly, (Cherenfant, (2021) reported organic matter and organic carbon contents of 0.98% and 0.57%, respectively, in manure from Ouanaminthe in northeastern Haiti. Comparatively, these contents vary from one site to another. Such differences may be explained by variations in feed, ration composition, decomposition stage, and storage conditions.These parameters remain highly relevant when considering manure as an organic amendment (He *et al*., 2022). Our results are relatively high and place the manure in the "high organic potential" category, corresponding to the 40-60% range according to the classification of the Institut de Recherche et de Développement en Agroenvironnement (IRDA) (N'Dayegamiye *et al*., 2008). Due to their high organic carbon content, these manures could contribute to carbon storage in soil rather than its release into the atmosphere, thereby helping improve the environment (Huang *et al*., 2020).By using them as organic amendments, their incorporation into soil could help increase organic matter content, water-holding capacity, nutrient availability, and cation exchange capacity, notably through the formation of stable complexes with humus and soil clay particles. This would contribute to soil structural stabilization (Wystalska *et al*., 2023). Moreover, in the context of soil remediation from trace metallic elements, the addition of these manures could promote their immobilization through the formation of organometallic complexes and adsorbates on the humic fraction (Roy et Kashem, 2014). This reduces the mobility and bioavailability of trace metal elements to plants. However, the persistence and stabilization of organic matter, as well as mineralogical conditions, should be verified to ensure that the progressive release of the organic fraction does not instead lead to remobilization of trace metals (Diatta., 2019), (Cissé et Tech, 2024). The use of these manures as organic amendments could help improve the status of Togolese agricultural soils, which are generally poor in organic matter (<2%) and sandy in 87% of cases. This could positively affect crop yields and the quality of agricultural products.

3.2 pH, electrical conductivity, and moisture content of cow manure

The determination of the physical parameters, namely pH, EC, and moisture content of cow manure, yielded the results presented in Table 3. The reference framework proposed by (COMIFER (2019) was used to interpret the analytical parameters of the manure samples.

Table 3. pH in water, electrical conductivity, and moisture content of cow manure

Parameter	**Ours values**				**References values for the interpretation (COMIFER, 2019)**		
CM (n=5)	**Min**	**Max**	**mean**	**SD**	**Low reference**	**Optimal reference**	**High reference**
pH in water	8.32	9.10	8.83	0.04	<6	6.0-7.5	>7.5
EC	2.90	5.00	4.23	1.09	<2	2-4	>4
MC	7.76	9.44	8.24	3.84	<10	10-30	>30

pH : no unit; EC: electrical conductivity, expressed in dS m^{-1}; MC: moisture content, expressed in %.

The cow manure samples showed a water pH ranging from 8.32 to 9.10, with a mean value of 8.83 (Table 3). This indicates an alkaline material, according to the (IRDA (2008) classification for organic manures. These results are slightly different from those reported by many researchers, who generally describe cow manure as being closer to neutrality (pH 6.5–7.0). However, our findings are consistent with those of several authors, including (Gbénou *et al*. (2021) and (Nartey *et al*. (2023), who reported alkaline pH values in cow manure, although with slight variations from one site to another. For instance, (Nartey *et al*. (2023) reported a pH of 8.9 for Ghanaian cow manure. In contrast, (Makumbi *et al*., (2026) reported a pH of 6.54 for poultry manure in Uganda, while Walker *et al*., (2004) found a pH of 7.80 in cattle manure from Maragua, Kenya. These differences may be explained by variations in animal feed, ration composition, forage origin, mineral composition, site management, and the manure's stage of decomposition (He *et al*., 2022). The mainly alkaline character of these manures is agronomically relevant, particularly for use as organic amendments on acidic soils. Indeed, they may help mitigate soil acidity. In remediation contexts, they could also stabilize trace metal elements in soils, thereby reducing their mobility and bioavailability to plants (Benejar *et al*., 2018). This occurs through precipitation, sorption, and complexation mechanisms in soils. In addition, such alkaline pH may help inhibit sulfide dissolution (Liu *et al*., 2025). Using these manures as amendments would help reduce the acidity of Togolese soils, which are generally acidic. Excessive soil acidity promotes aluminum solubilization, which is highly toxic to plant roots, causing root apex necrosis and reducing the retention of nutrients and water, thereby affecting soil health and ultimately crop yields.

Moreover, the manure samples had a mean electrical conductivity of 4.230 dS/m, with values ranging from 2.90 to 5.00 dS/m. This parameter indicates the presence of soluble salts. This value means of electric conductivity are greater than 4 dS m^{-1} range and is considered high according to the classification of the French Committee for the Study and Development of Rational Fertilization (*COMIFER_RAPPORT_fertilisation_15102019*, 2019). However, the value obtained is consistent with previous studies showing that the EC of cow manure varies from one site to another. For example, manure samples from Burundi had an EC of 4.36 dS/m. In contrast, fresh manures have been reported to range from 8 to 15 dS/m. The observed value reflects the presence of soluble salts in the manure. When applied at appropriate doses, these cow manures should not pose a salinization risk because of their moderate electrical conductivity. Their amendment could enrich soils with exchangeable bases and improve cation exchange capacity (Zakariah et al., 2023). The determination of moisture content in our manure samples revealed an average value of 8.24%, corresponding to a dry matter content of 91.76% (Table 3). According to (IRDA *et al.* (2008), these cow manure samples are completely dry. This low moisture content can be explained by prolonged sun drying, which causes dehydration and the volatilization of water molecules under solar heat. Such low water content is an advantage, as it would facilitate transport, storage, and field application for agricultural valorization (Gaillardon *et al*., 1983).

3.3 Nutrient contents in cow manure

Chemical analyses of cow manure produced the results presented in Table 4. The reference framework proposed by (IRDA (2008) and (COMIFER (2019) was used to interpret the analytical parameters of the manure samples. The manure samples contained appreciable amounts of macronutrients, with concentrations ranging from 3,446.35 to 5,055.91 mg/kg for N, 1,015.00 to 1,162.50 mg/kg for P, and 1,602.50 to 1,681.97 mg/kg for K. The mean concentrations were 4,406.96 mg/kg for N, 1,121.87 mg/kg for P, and 1,681.97 mg/kg for K. According to (IRDA (2008), these values indicate a manure of moderate to good agronomic quality, with high nitrogen content and a moderate P/K balance. These nutrient levels suggest that the manure could serve as a relevant organic amendment for West African soils, which are often nutrient-depleted. Its application may help alleviate nutrient deficiencies in tropical agricultural soils.

Table 4. Nutrient contents in cow manure

Parameter	**Ours values**				**References values for the interpretation**		
CM (n=5)	**Min**	**Max**	**mean**	**SD**	**Low**	**Optimal**	**High**
Ntot[b]	3446.35	5055.91	4406.96	905.13	<4000	5000-10000	>15000
P	1015.00	1162.50	1121.87	71.40	<1000	1500-3000	>5000
K	1602.00	1775.13	1681.97	77.21	<1000	1500-5000	>10000
Mg	1095.72	1985.22	1548.28	365.73	<8000	1000-3000	>5000
Ca[b]	1275.00	2015.63	1534.38	345.82	<500	1000-2000	>4000
Na	927.50	1720.00	1328.13	444.08	<500	500-3000	>5000
C/N	60.00	77.70	66.05	3.31	< 15	15–20	> 20

[b] is expressed in mg/kg, and [a]is unitless.

However, as emphasized by (Hamza and Khan., (2025), manure cannot be considered a substitute for complete mineral NPK fertilizers because of its lower nutrient concentration and slower release pattern. Its chemical composition is also known to vary widely depending on feed composition, animal age, decomposition stage, collection practices, and storage conditions. In comparison, (Cherenfant, (2021) reported much lower values in fresh manure from Ouanaminthe, Haiti, whereas (Abile *et al*., (2025) reported substantially higher concentrations in manure from the ILRI Debre Zeit station in Ethiopia. Such differences highlight the strong influence of husbandry conditions and environmental context on manure composition. Beyond its fertilizing value, the relatively high organic matter and phosphorus contents may also contribute to the immobilization of certain trace metals in soil through organometallic complexation, thereby reducing their bioavailability (Peiris *et al*., 2023).

The chemical analyses also revealed appreciable concentrations of exchangeable bases, with mean values of 1,534 mg/kg for Ca, ranging from 1,275.00 to 2,015.63 mg/kg; 1,548 mg/kg for Mg, ranging from 1,095.72 to 1,985.22 mg/kg; and 1,328 mg/kg for Na, ranging from 927.50 to 1,720.00 mg/kg. These results confirm that the cow manure samples constitute a non-negligible source of major cations and may therefore contribute to correcting the acidity of ferrallitic tropical soils. According to the (COMIFER (2019) classification, calcium and sodium contents may be considered good, whereas magnesium content is very high. These findings are consistent with the literature, which shows that cow manure can be regarded as an organic amendment rich in exchangeable bases, although its composition is highly variable. For example, (Abukari and Cobbinah (2025) reported much lower values in the Guinea savanna zone of Ghana, namely 368 mg/kg for Na, 890 mg/kg for Ca, and 430 mg/kg for Mg. The values obtained in the present study are markedly higher, suggesting a strong potential for acid soil amendment through the supply of basic cations capable of buffering soil acidity.In addition, manure application may favor the formation of aggregates with humus and clay particles, thereby improving nutrient retention, water-holding capacity, and cation exchange capacity (Gbénou *et al*., 2021). The C/N ratio is also an informative indicator of carbon content and material stability. The value obtained in this study was 66.05, indicating a high organic carbon content(Guei et al., 2020), (Makumbi et al., 2026). Although this parameter is of interest, such a high C/N ratio may limit immediate agronomic efficiency, as it can slow mineralization and induce temporary nitrogen immobilization when the material is applied directly to soil(Beusch., 2021); (Dick *et al.*, 2003). From a valorization perspective, these manures therefore have good organic potential, but co-composting or additional maturation would likely improve their agronomic performance.

3-4 Major cations, total NPK, and relative contribution of each element

Table 5 summarizes the sum of major cations, total NPK, and the relative contribution of each element to the total macronutrient pool in cow manure.

Table 5. Sum of major cations, total NPK, and relative contribution of each element to the total macronutrient pool in cow manure. [a] expressed in mg/kg; [b] in %.

	SCM[a]	NPK[a]	N[b]	P[b]	K[b]	Ca[b]	Mg[b]	Na[b]
Min	4900.22	6063.35	36.81	8.47	17.11	13.62	11.70	9.91
Max	7495.98	7993.54	38.87	10.84	12.94	14.70	14.47	12.54
Mean	6092.76	7210.80	37.92	9.65	14.47	13.32	13.20	11.43
SD	308.21	351.25	40.97	3.33	3.49	15.65	16.55	20.10

The sum of major cations reached a mean value of 6,092.76 mg/kg, while the total macronutrient pool averaged 7,210.80 mg/kg. These values indicate a high mineral richness, suggesting strong potential for improving soil fertility. According to the reference classification for organic fertilizers, the mean values fall within the high range. This confirms that the manure could contribute to mineral nutrition when incorporated into soil (Gaillardon *et al.*, 1983). The results also indicate a substantial abundance of major cations, which may enhance soil cation exchange capacity and support the chemical fertility of tropical soils. Regarding the relative contribution of each element to the total macronutrient pool, nitrogen was the dominant element, with a mean proportion of 37.92% and values ranging from 36.81% to 38.87%. It was followed by potassium, magnesium, calcium, and sodium, whereas phosphorus showed the lowest proportion, with a mean of 9.65% and values ranging from 8.47% to 10.84% (Table 5). This pattern suggests a fairly complete nutrient profile, but with a stronger emphasis on nitrogen. Such a distribution is favorable for agronomic use, particularly to compensate for nutrient deficiencies commonly observed in tropical soils (Cissé et Tech., 2024) ; (Fiadjoe., 2021).

3.5 FTIR of cow manure

Fourier transform infrared analysis of the cow manure samples produced the spectrum shown in Figure 2. This spectrum provides information on the functional groups present in the organic matter of the manure. It exhibits several characteristic absorption bands, although the overall absorbance remains low. The spectrum shows several peaks corresponding to the typical profile of a complex organic compound (Volkov *et al.*, 2021). In the high-frequency region (3400–3200 cm^{-1}), a strong peak appears at 3273 cm^{-1}. This band is attributable to O–H stretching vibrations and its broad shape is often associated with extensive hydrogen bonding, characteristic of alcohols, phenols, or residual moisture.

In the 2950–2850 cm⁻¹ region, two very intense peaks are observed at 2917 and 2849 cm⁻¹. These peaks are assigned to the symmetric and asymmetric C–H stretching vibrations of CH2 and CH3 groups, confirming the presence of aliphatic chains from lipids or polymers**.**

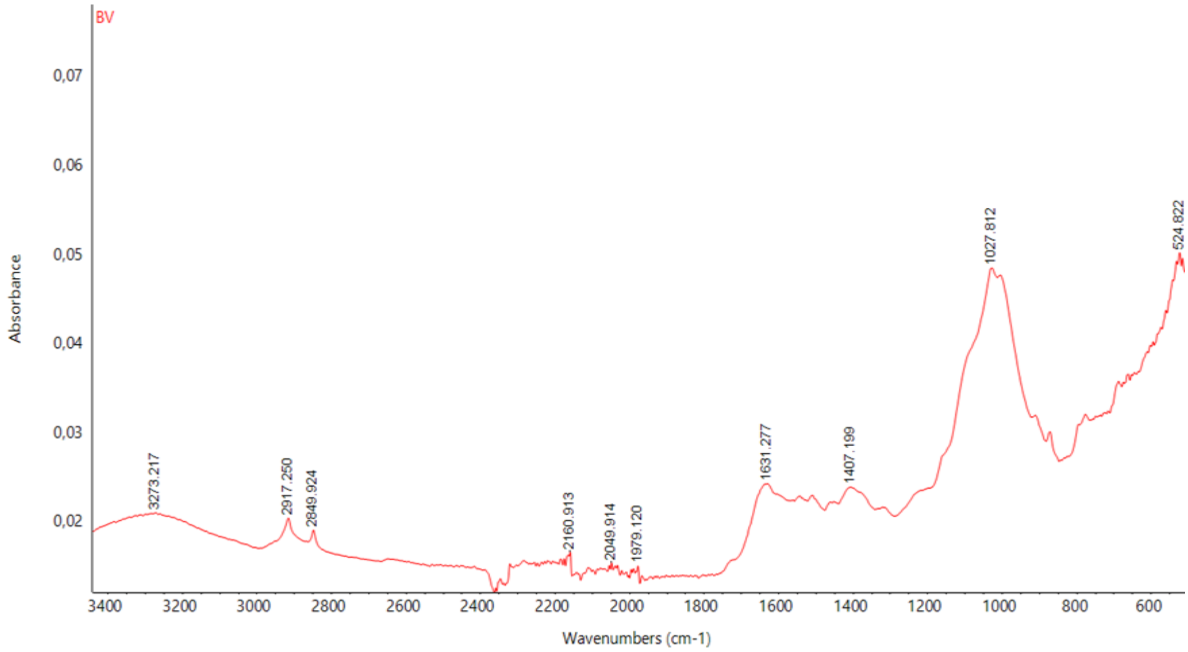

Figure 2. FTIR spectrum of cow manure.

An intense band is also observed in the 1700–1600 cm⁻¹ region, specifically at 1631 cm⁻¹. This band is commonly associated with C=O stretching in Amide I or with C=C double bonds in aromatic structures or alkenes (Volkov *et al*., 2021). The intense peak at 1027 cm⁻¹, observed in the 1100–1000 cm⁻¹ region, is a dominant feature characteristic of C–O–C or C–O stretching vibrations in polysaccharides such as cellulose, hemicellulose, and starch. The predominance of the 1027 cm⁻¹ peak, together with the C–H peaks at 2917 and 2849 cm⁻¹ and the O–H band at 3273 cm⁻¹, strongly suggests that the manure is rich in cellulosic or carbohydrate-like material (Lin-Vien *et al*., 1991). This spectrum is dominated by the signature of polysaccharides and aliphatic components (Dick *et al*., 2003). The band in the 1400–1370 cm⁻¹ region, specifically at 1380 cm⁻¹, is of medium intensity and may be assigned to C–H bending vibrations arising from methyl (CH3) group deformation or from carboxylate salts.

3.6. Trace metal contents

Table 6 presents the concentrations of selected trace metals in cow manure**.** The trace metal analysis of cow manure revealed the presence of Cd and Pb at concentrations of 0.260 mg/kg and 7.350 mg/kg, respectively. In contrast, As and Cr were not detected. These results indicate a low level of trace metal contamination relative to the threshold values recommended by AFNOR NF U44-051 for organic fertilizers. They are also consistent with the literature, which reports trace metals in animal manures, although their occurrence and concentrations vary widely. Such variability may be explained by factors such as site management and animal diet (Chew *et al*., 2020) ; (Hamza et Khan, 2025). For example, (Guei *et al*., 2020), working on fresh cattle manure from Daloa in central-western Côte d'Ivoire, reported Fe at 329 mg/kg and Zn at 66 mg/kg, while Pb and Cd were not detected. This suggests that the trace metal composition of manure is closely related to livestock and environmental conditions. Nevertheless, the trace metal concentrations measured in the present study were well below the maximum allowable levels set by Europeans and French norms for organic amendments (Table 6). Accordingly, these manures may be safely used as organic amendments from an environmental perspective, provided that application rates are controlled to prevent long-term accumulation risks in soils.

Table 6. Trace metal contents in cow manure

Element	Ourvalues (mg/kg)				European norm (mg/kg)	AFNORNFU44 -051 (mg/kg)
	Min	max	mean	SD		
Cd	0.213	0.335	0.260	0.050	<3	<3
Pb	2.550	12.380	7.350	4.040	<120	<180
As	Nd	Nd	Nd	Nd	Nd	Nd
Cr	Nd	Nd	Nd	Nd	Nd	Nd

Nd: not detected.

Conclusion

This study enabled the physico-chemical characterization of cow manure collected in Lomé, Togo. The analysed samples contained appreciable mean levels of major fertilizer elements (NPK) and acceptable exchangeable bases (Ca, Mg, and Na). The water pH was alkaline, with a mean value of 8.83, and the mean electrical conductivity was 4.230 dS/m. Organic matter content was high at 50.65%, corresponding to a total organic carbon content of 29.11%. These results suggest that the studied manure could improve the physico-chemical properties of soils, particularly acidic tropical soils that are poor in organic matter. Its incorporation may help increase soil pH, improve structure, enhance water-holding capacity, and increase nutrient availability. The presence of mineral elements and trace nutrients may also support crop development. Trace metal analysis revealed the presence of cadmium and lead, whereas arsenic and chromium were not detected. These trace metal concentrations were well below the current limits set by AFNOR NF U44-051 and EU Regulation 2019/1009 for organic amendments. The studied cow manure therefore appears suitable for valorization as an organic amendment, provided that application rates are respected. In the context of climate change, soil degradation, and the need to reduce dependence on chemical fertilizers, the valorization of these manures as organic amendments represents a promising alternative. It could contribute to soil fertility restoration and improved crop yields. Further studies are nevertheless needed to evaluate, under field conditions, the effects of these manures on soil properties, contaminant mobility, and crop performance according to different manure types and application rates.

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