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Environment

Influence of fibrous material on the composting, with the inclusion of different biocatalysts

Influência do material fibrioso na compostagem, com a inclusão de diferentes biocatalisadores

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ABSTRACT

The manuscript demonstrate which percentage indexes of fibrous and organic material are necessary in composting windrows, the replacement of the biocatalyst (feces) by organic sludge, with the purpose of forming an alternative quality fertilizer. Individual windrows were designed with different compositions based on 10 calculations of different proportions. The three different materials used in the composting process for each treatment (T1, T2, T3, T4 and T5 with animal feces as biocatalyst, and T6, T7, T8, T9 and T10, with sludge as biocatalyst). Each treatment consisted of 1kg of material with the following proportions: T1 - 70% of fibrous material and 30% of organic material; T2 - 50% fibrous material and 50% organic material; T3 - 30% fibrous material and 70% organic material; T4 - 10% fibrous material and 90% organic material; T5 - 0% of fibrous material and 100% of organic material, where the following parameters of the organic fertilizers generated were analyzed: physical - granulometry; density and porosity, chemical – Organic Matter; pH; P; K; Ca; Mg; At; SB; Al; H and CTC. All treatments are within the classification range of soil with weak acidity, since the pH and OM content were between 7.01 and 10.8% respectively. Thus, even with the variation of the organic biocatalysts used, the indices and required levels of the physicochemical parameters analyzed, of all treatments, regardless of the fiber content, were above the references expressed in the literature, demonstrating a high quality in the fertilizers produced.

Keywords: Organic fertilizer; Biological catalyst; Fiber

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RESUMO

O manuscrito demonstra quais índices percentuais de material fibroso e orgânico são necessários em leiras de compostagem e na substituição do biocatalisador (fezes) por lodo orgânico, com a finalidade de formar um adubo alternativo de qualidade. Leiras individuais foram projetadas com diferentes composições, com base em 10 cálculos de diferentes proporções. Os três diferentes materiais utilizados no processo de compostagem para cada tratamento, T1, T2, T3, T4 e T5 foram com fezes de animais como biocatalisador, e T6, T7, T8, T9 e T10 foram com lodo como biocatalisador. Cada tratamento consistiu de 1kg de material com as seguintes proporções: T1 - 70% de material fibroso e 30% de material orgânico; T2 - 50% de material fibroso e 50% de material orgânico; T3 - 30% de material fibroso e 70% de material orgânico; T4 - 10% de material fibroso e 90% de material orgânico; T5 - 0% de material fibroso e 100% de material orgânico, onde foram analisados os seguintes parâmetros dos adubos orgânicos gerados: físico - granulometria; densidade e porosidade química – Matéria Orgânica; pH; P; K; Ca; mg; No; SB; Al; H e CTC. Todos os tratamentos estão dentro da faixa de classificação de solo com acidez fraca, pois o pH e o teor de MO ficaram entre 7,01 e 10,8%, respectivamente. Assim, mesmo com a variação dos biocatalisadores orgânicos utilizados, os índices e níveis exigidos dos parâmetros físico-químicos analisados, de todos os tratamentos, independente do teor de fibra, ficaram acima das referências expressas na literatura, demonstrando uma alta qualidade nos fertilizantes produzidos.

Palavras-chave: Fertilizante orgânico; Catalisador biológico; Fibra

1 INTRODUCTION

Population growth linked to industrial expansion brought an increase waste generation. In the face of this fact, it is necessary to take actions that may mitigate the impacts caused by their inappropriate disposition (Schott Filho, 2017). In this context, about 79.9 million tons of urban solid waste were generated in Brazil in 2015. In the state of Maranhão, about 2,663,040 tons were produced in that year, of which about 34% were destined in the form of incorrect landfills (Abrelpe, 2015).

Composting is a form of treatment for organic waste to transform waste into reusable products, characterized by a process in which putrescible organic matter is degraded biologically, allowing its reuse, which constitute a significant part of domestic waste (Inácio; Miller, 2009, Morais *et al.*, 2022). This procedure, which can be carried out in the houses, giving the correct destination of these residues, through the segregation and separation of organic and inorganic materials, as well as can be implemented by the institutions that propose environmental education, as a method to maximize the recycling of this minimizing waste and environmental impacts (Souza *et al*. 2019).

Another known form of composting is the one made through organic sludge, obtained through the sewage treatment system and other organic load effluents, giving rise to this final product (Pereira; Fiore, 2022). For Andreoli (1998), if this material has a predominantly organic composition, these residues should be called biosolids.

In this way all sectors of the Brazilian economy, with rise of the lower classes of the last years have generated employment and income for the population, because with the demand of the market the population tended their professional qualification, with that the large companies have increased their staffing and consequently their organic waste productions (Lacerda *et al*. 2020). With this reality, it becomes necessary within the organizations, actions that aim at the rational consumption and the awareness of its employees, as the reuse of produced waste can minimize the costs of the most varied forms (Branco, 2012; Ressetti; Campos, 2020).

For all that is presented here, the present work aims to demonstrate what percentage indexes of fibrous material and organic matter are necessary in the assembly of the composting windrows, as well as the replacement of the traditional biocatalyst (feces) with organic sludge, with the purpose of form an alternative quality fertilizer.

2 MATERIAL AND METHODS

2.1. Characterization of the City

The experiment was carried out in the city of the São Luís-MA classified as tropical, with average temperature of 27.0 ° C and average annual rainfall of 1896 mm, has a population of about 1 million inhabitants in its territory with an extension of 827.1 km² (IBGE, 2017). The experiment was carried out from March 7, 2018 to May 22, 2018, at the Laboratory of Environmental Practices of the Environmental Engineering Department of the CEUMA University.

2.2. Collection of Material

Materials for assembling the experiment were collected in two locations. Both were used in the municipality of São Luís. Organic residues (food residues) were used; residues of grass pruning and organic sludge extracted from septic tanks, these residues were selected for their availability at the CEUMA University, and animal excrement from the corral of the Department of Animal Science of the State University of Maranhão - UEMA.

2.3. Lining and treatment

The experiment was carried out at the Laboratory of Environmental Practices of the Ceuma University, Campus Turu. 10 individual windrows were made, making a proportionality calculation between the three different materials used in the composting process for each treatment. They were divided into two groups, the first with five treatments named T1; T2; T3; T4 and T5, with animal feces as a biocatalyst and the second with five more treatments named T6; T7; T8; T9 and T10, differentiated only by replacing the animal feces bioctalizer with organic sludge, totaling 1kg each treatment. The treatments from T1 to T5 (Table 01) and from T6 to T10 (Table 02), had a gradual decrease in the percentage of fiber in the windrows, until zeroing this component, to check if the presence of the fibrous material is really necessary for the formation of a quality organic fertilizer through composting (Tables 1 and 2).

Table 1 – Treatments with feces biocatalyst

Treatment	Fibrous Material		Animal Feces		Organic MAtter	
	(g)	(%)	(g)	(%)	(g)	(%)
T1	700	70	150	15	150	15
T2	500	50	250	25	250	25
T3	300	30	350	35	350	35
T4	100	10	450	45	450	45
T5	0	0	500	50	500	50

Source: Authorship (2022)

Table 2 – Treatments with organic sludge biocatalyst

Treatment	Fibrous Material		organic sludge		Organic MAtter	
	(g)	(%)	(g)	(%)	(g)	(%)
T6	700	70	150	15	150	15
T7	500	50	250	25	250	25
T8	300	30	350	35	350	35
T9	100	10	450	45	450	45
T10	0	0	500	50	500	50

Source: Authorship (2022)

2.4. Statistical Analyzes

Statistical analysis was performed using Origin. Multivariate analysis techniques were also used as an additional tool, specifically Principal Component Analysis (PCA) using the Minitab statistical software program for Windows (Version 17.3.1).

For the analyses physical and chemical the results were expressed as means and standard deviations (±SD). The data were assessed by analysis of variance (ANOVA) with nested design considering the treatments (10 treatments) and the biocatalyst (organic sludge or manure) as factors and physical and chemical parameters as dependent variables. Post-hoc pairwise testing among all treatments was performed using Tukey test (with a $p < 0.05$). For each set of analyses (physical and chemical), a principal component analysis (PCA) was applied to the mean values of three replicates to identify correlations among the sets of analyses (physical and chemical) and to group the treatments accordingly.

3 RESULTS

3.1. Lining and treatment

From this information, and correlating with the final compost from composting, it can be observed through the physical analysis of the samples, that the final compost presented characteristics similar to the behavior of sandy loam soils, having divergent proportions, with the fraction of sand with a higher percentage in relation to the other fractions, however, characteristics of the silt and clay fractions can still be observed, classifying it as sandy loam compost.

Directly linked to the granulometric composition are the factors of porosity and density. Although the compounds are classified as sandy franc, their density has remained low, this is due to the fact that the particles are more uniform, corresponding to percentages lower than 52%, a reference value to the density of sandy franc soils that serve as a standard comparison in this study.

Therefore, taking into consideration both factors, granulometry and density, it could be noted that the porosity values remained very close, with characteristics of macropores and micropores, due to their variation in composition. Such characteristics allow evidence that the moisture and aeration factors remain at satisfactory levels, since the macropores present in the samples confirm a good aeration together with the good water retention conferred by the micropores.

Relating to chemical factors, the three aspects mentioned above directly influence the way in which ions will be present in the compound, since they infiltrate between the pores of the same, and may be in greater or lesser quantity according to the amount of space present, that is, the level of porosity.

In the case of the samples, the porosity above 50% allows that the capacity of cation exchange (CTC) in the soil is satisfactory, since the high content of organic matter in the samples are able to retain them, thus leading to a greater capacity of retention of nutrients and moisture as can be seen when considering the result of base saturation (SB), which provides us with the amount of negative charge in the compound, thus allowing us to know the amount of exchangeable bases available, i.e., dependent on pH in the samples. This last factor is also related to the saturation level of aluminum and the saturation per base, which reflects the actual amount of bases occupied by interchangeable aluminum ions and other interchangeable cations, such as Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Potassium (K^{+}) and Sodium (Na^{+}). As we can see in Table 3.

Table 3 – Physical evaluation of 10 treatments applied considering the biocatalyst (manure and organic sludge)

Tr.*	CS (%)	TS (%)	Silt (%)	CY (%)	Silt/CY (%)	D (g cm^{-3})	RPY	PY (%)
Manure biocatalyst								
T1	48.0±1.0^{a}	25.6±0.5^{a}	19.0±1.0^{a}	8.0±1.0^{a}	2.4±0.05^{a}	0.5±0.01^{a}	1.5±0.01^{a}	63.0±1.0^{a}
T2	36.0±1.0^{b}	34.3±0.5^{b}	24.0±1.0^{b}	6.0±1.0^{ab}	3.7±0.11^{b}	0.4±0.01^{b}	1.5±0.01^{b}	69.0±1.0^{b}
T3	31.0±1.0^{c}	39.3±0.5^{c}	25.0±1.0^{b}	6.0±1.0^{ab}	4.1±0.01^{c}	0.4±0.01^{c}	1.4±0.01^{c}	69.0±1.0^{b}
T4	30.0±0.5^{c}	38.3±0.5^{c}	25.0±1.0^{b}	6.0±1.0^{ab}	4.1±0.01^{c}	0.4±0.01^{c}	1.4±0.01^{c}	69.0±1.0^{b}
T5	42.0±0.5^{d}	25.6±0.5^{a}	28.0±1.0^{c}	4.0±1.0^{b}	7.9±0.01^{d}	0.4±0.01^{b}	1.4±0.01^{d}	67.0±1.0^{b}
Organic sludge biocatalyst								
T6	36.±0.5^{a}	17.3±0.5^{a}	40.0±1.0^{a}	6.0±1.0^{a}	6.66±0.15^{a}	0.48±0.01^{a}	1.5±0.01^{a}	70.0±1.0^{a}
T7	44.±0.5^{b}	26.0±1.0^{b}	28.0±1.0^{b}	2.0±1.0^{b}	13.9±0.05^{b}	0.35±0.01^{b}	1.4±0.01^{b}	76.0±1.0^{b}
T8	29.±0.5^{c}	33.0±1.0^{c}	32.0±1.0^{c}	6.0±1.0^{a}	5.76±0.04^{c}	0.45±0.01^{c}	1.5±0.01^{a}	71.0±1.0^{a}
T9	35.±0.5^{a}	37.0±1.0^{d}	21.0±1.0^{d}	5.6±0.57^{a}	3.72±0.02^{d}	0.65±0.01^{d}	1.6±0.01^{a}	60.0±1.0^{c}
T10	24.6±0.5^{d}	39.0±1.0^{d}	30.0±1.0^{bc}	7.0±1.0^{a}	3.82±0.02^{d}	0.86±0.01^{e}	1.9±0.01^{c}	56.0±1.0^{d}

*Tr = Treatments. Values are means ± standard deviation (n = 3). Different superscript letters indicate means that significantly differ among treatments at $P < 0.05$ (Tukey test). Coarse sand (CS), thin sand (TS), Clay (CY), cation exchange capacity (CEC), organic matter (OM), porosity (PY), density (D), real porosity (RPY)

Source: Authors (2022)

Along with the physical factors described above and pH, organic matter contributes to the retention of colloids, due to the amount of negative charges in it that attract exchangeable cations to its surface, as well as attributes to the compound greater capacity of water retention.

Taking into consideration the standards adopted in the literature, the treatments in general present corresponding values above 60 g/dm^3, meaning accumulation of organic matter. All treatments have a significant amount of organic matter above 6%, which is considered ideal in the literature. Enabling the fertilizers produced with different biocatalysts, as good alternatives for recovery of degraded soils.

It is important to note that the greater the amount of organic matter, the greater the resistance to loss of nutrients through leaching. Therefore, it can be said that the amount of organic material in compounds is satisfactory.

The amount of cations increases, in series preference of exchange, we have in first place the aluminum cation (Al^{3+}) which is closely linked to exchangeable acidity, this presents effect on a great number of cultures, being harmful in high levels, making the compound toxic and unfit for use when in levels of 10 mmol/dm³. In this context the treatments varied in values between 1.0 - 5.0 mmol/dm³, which leaves them in the low and medium content ranges, qualifying them as suitable for use.

According to Embrapa (2018) in clay soils the content of Phosphorus (P) tends to be lower, since the extractor Melich is sensitive to clay in contrast to sandy soils tend to have a high degree (P). Taking into account that in general the treatments have been qualified as sandy soil, it is confirmed through the analysis that the phosphorus contents are characteristic of sandy soils, remaining above 120 mg/dm³, parameter number for high phosphorus index.

The high levels of potassium (K^+) indicate little weathering, while low indices indicate more weathered soils, having as ideal reference values to be considered satisfactory up to 6.0 mmol/dm³, so unanimously all experimentation is within the standard values.

Regarding the values of the macronutrient Sodium (Na), the main responsible for salinization and corrective component of acidity, it is considered ideal for a soil nourished proportions that can vary up to 10 mmol/dm³, so according to the analyses made it can also be affirmed that in its totality the compounds are within the acceptable parameters.

For calcium (Ca^{+2}) and magnesium (Mg), the minimum desirable values for good crop performance are between 4.0 - 7.0 mmol/dm³ and 5.0 - 8.0 mmol/dm³ respectively, classifying the treatments as a whole within the high content range, ranging from 91.0 - 121 mmol/dm³.

The analysis of the main components and which variables influence the process can be visualized in Figure 1A and B.

Table 4 – Chemical evaluation of 10 treatments applied considering the biocatalyst (manure and organic sludge)

Tr.*	OM[1]	pH	P[2]	K[3]	Ca[3]	Mg[3]	Na[3]
Manure biocatalyst							
T1	92.00±1.00[a]	6.90±0.01[a]	205.00±1.00[a]	3.80±0.01[a]	102.00±1.00[a]	28.00±1.00[a]	7.50±0.10[a]
T2	120.00±1.00[b]	7.20±0.01[b]	613.00±1.00[b]	4.50±0.01[b]	111.00±1.00[b]	33.00±1.00[b]	8.30±0.10[b]
T3	139.00±1.00[c]	7.20±0.01[b]	613.00±1.00[b]	4.10±0.01[c]	121.00±1.00[c]	54.00±1.00[c]	7.40±0.10[a]
T4	131.00±1.00[d]	7.20±0.01[b]	335.00±1.00[c]	5.20±0.01[d]	91.00±1.00[d]	49.00±1.00[d]	8.90±0.10[c]
T5	135.00±1.00[e]	7.20±0.01[b]	219.00±1.00[d]	5.20±0.01[d]	108.00±1.00[e]	50.00±1.00[d]	9.00±0.10[c]
Organic sludge biocatalyst							
T6	101.00±1.00[a]	7.20±0.01[a]	120.00±1.00[a]	2.70±0.01[a]	101.00±1.00[ac]	18.00±1.00[a]	6.00±1.00[a]
T7	107.00±1.00[b]	6.40±0.01[b]	129.00±1.00[b]	2.40±0.01[b]	97.00±1.00[b]	24.00±1.00[b]	5.40±0.10[a]
T8	93.00±1.00[c]	7.00±0.01[ac]	212.00±1.00[c]	2.60±0.01[ab]	101.00±1.00[a]	21.00±1.00[c]	6.30±0.10[a]
T9	80.00±1.00[d]	6.90±0.01[cd]	150.00±1.00[d]	2.80±0.01[a]	99.00±1.00[ab]	17.00±1.00[a]	6.30±0.10[a]
T10	73.00±1.00[e]	6.90±0.01[c]	193.00±1.00[e]	3.40±0.01[c]	102.00±1.00[ac]	14.00±1.00[d]	6.00±0.10[a]

Tr.*	SB[3]	Al[3]	H[3]	CEC[3]	Na/CEC[4]	Al/Al+SB[4]	V[d]
Manure biocatalyst							
T1	141.36±0.20[a]	1.33±0.57[a]	8.00±1.00[a]	150.60±0.36[a]	5.06±0.11[a]	0.70±0.10[a]	94.16±0.15[ac]
T2	156.90±0.10[b]	2.00±1.00[a]	8.00±1.00[a]	166.80±0.20[b]	5.03±0.05[a]	1.30±0.10[b]	94.13±0.15[ac]
T3	186.53±0.25[c]	3.00±1.00[a]	9.00±1.00[a]	198.70±0.26[c]	3.70±0.10[b]	1.60±0.10[c]	94.10±0.10[ac]
T4	154.30±0.26[d]	2.00±1.00[a]	8.00±1.00[a]	164.46±0.35[d]	5.40±0.10[c]	1.30±0.10[b]	93.86±0.15[ab]
T5	172.13±0.15[e]	1.34±0.57[a]	9.00±1.00[a]	182.50±0.40[e]	4.90±0.10[a]	0.60±0.10[a]	94.53±0.25[c]
Organic sludge biocatalyst							
T6	127.66±0.15[a]	1.33±0.57[a]	8.00±1.00[a]	136.73±0.25[a]	4.40±0.10[a]	0.80±0.10[a]	93.63±0.20[a]
T7	128.90±0.10[b]	1.33±0.57[ab]	8.00±1.00[a]	137.76±0.25[b]	3.90±0.10[b]	0.80±0.10[a]	93.56±0.20[a]
T8	130.90±0.10[c]	3.00±1.00[acd]	7.00±1.00[a]	140.86±0.15[c]	4.50±0.10[ac]	2.20±0.10[b]	92.90±0.10[b]
T9	125.30±0.20[d]	4.00±1.00[cd]	6.00±1.00[a]	135.26±0.28[d]	4.70±0.10[c]	3.10±0.10[c]	92.73±0.15[b]
T10	125.53±0.15[d]	5.00±1.00[d]	8.00±1.00[a]	138.63±0.32[e]	4.30±0.10[ad]	3.80±0.10[d]	90.70±0.10[c]

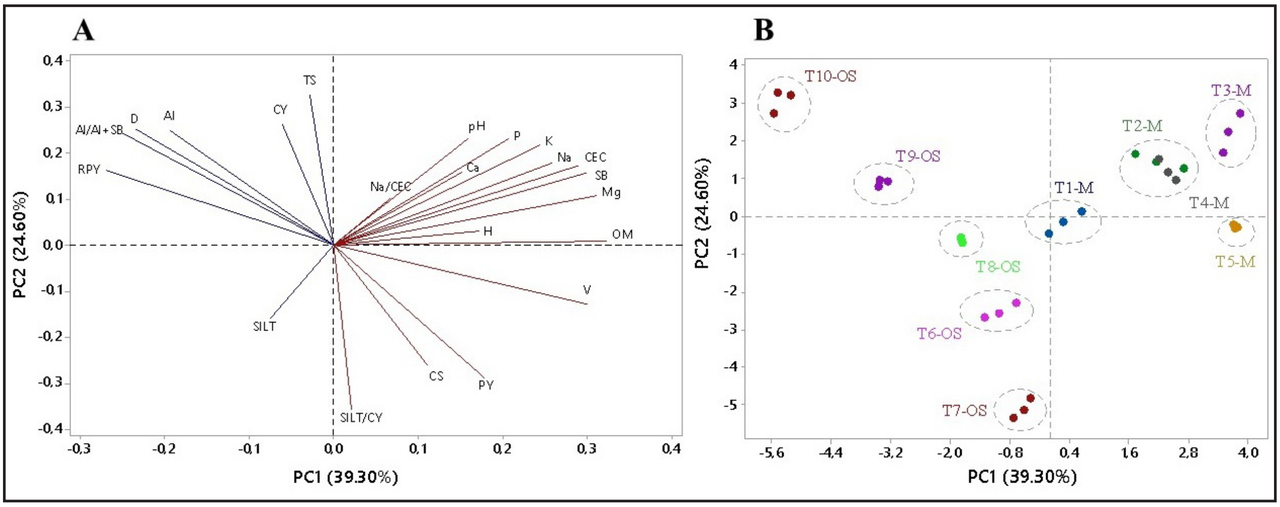
*Tr = Treatments. [1]Values expressed in g dm^{-3}. [2]Values expressed in mg dm^{-3}. [3]Values expressed in mmol dm^{-3}. [4]Values expressed in %. Values are means ± standard deviation (n = 3). Different superscript letters indicate means that significantly differ among treatments at $p < 0.05$ (Tukey test). Organic matter (OM), Cation exchange capacity (CEC)

Source: Authors (2022)

As shown in Fig. 1A, the two first dimensions of the PCA of all characteristics studied explained 60.60% of the variance. Two clusters of biocatalyst appeared (Fig. 1B): cluster #1 comprised five treatments (T10-OS, T9-OS, T8-OS, T6-OS and T7-OS) related with organic sludge biocatalyst, that presented high values for the physical parameters real porosity, Al/Al+SB and density, but presented low values in the chemical parameters SB, Mg, OM and V;

cluster #2 contains others five treatments (T1-M, T2-M, T3-M, T4-M and T5-M) related with manure biocatalyst, that presented high values for the chemical parameters CEC, SB, Mg and OM and have a low real porosity, Al/Al+SB and density (Fig. 1A).

Figure 1 – Principal component analysis (PCA) for dimension 1 and 2: A, chemical and physical composition analysis; B, Treatments: T1, T2, T3, T4, T5 – using manure (M) as biocatalyst and treatments: T6, T7, T8, T9, T10 using organic sludge (OS) as biocatyst. Clay (CY), thin sand (TS), coarse sand (CS), cation exchange capacity (CEC), organic matter (OM), porosity (PY), density (D), real porosity (RPY)



Source: Authors (2022)

In order to investigate possible correlations between all the variables studied, and to evaluate hypothetical models for the classification of samples, PCA technique was employed. Initially an evaluation of the relationships among the twenty-two variables relating to the two sets of treatments was conducted by PCA on the basis of a correlation data matrix in which the variables were standardized and attributed equal weight. The score plot so obtained (Figure 1B) revealed a discrimination of the samples into two diferent classes. The first principal component (PC1) was the most significant for describing the model, accounting for 39.3% of the overall variance. The loading plot (Figure 1A), however, showed that the chemical variables were significant in describing variation in the data set to treatments using manure as biocatalyst. The same way, the physical variables were significant to the data set to treatments using organic sludge as biocatalyst. The loading plot also revealed that the chemical variables OM, Mg, SB and V were the most significant variables, among some variables observed to the biocatalyst manure.

Table 5 – Principal component analysis of physical and chemical variables

Variable	PC1	PC2	PC3	PC4
TS	0.111	-0.261	-0.270	0.155
CS	-0.028	0.327	0.164	0.398
Silt	-0.075	-0.159	0.218	-0.619
CY	-0.062	0.264	-0.220	-0.229
Silt/CY	0.021	-0.358	0.224	0.093
D	-0.235	0.254	-0.078	-0.071
RPY	-0.269	0.162	0.045	-0.204
PY	0.178	-0.289	0.179	-0.010
OM	0.324	0.008	0.121	-0.010
pH	0.159	0.232	-0.067	-0.455
P	0.207	0.230	0.196	0.091
K	0.243	0.218	-0.170	-0.030
Ca	0.152	0.159	0.327	-0.103
Mg	0.311	0.108	0.059	0.080
Na	0.258	0.180	-0.245	-0.019
SB	0.300	0.157	0.143	0.024
Al	-0.194	0.250	0.212	0.117
H	0.172	0.031	0.164	-0.244
CEC	0.290	0.174	0.159	0.021
Na/CEC	0.067	0.101	-0.549	-0.021
Al/Al+SB	-0.252	0.244	0.140	-0.132
V	0.301	-0.130	-0.139	0.025
Total variance (%)	39.3	24.6	11.6	6.9
Cumulate variance (%)	39.3	63.9	75.5	82.3

*Bold numbers indicate significant factors. Clay (CY), thin sand (TS), coarse sand (CS), cation exchange capacity (CEC), organic matter (OM), porosity (PY), density (D), real porosity (RPY)

Source: Authors (2022)

In order to evaluate correlations between all variables. PCA analyses were conducted. From the PCA analyses it may be seen that the first four principal components (PCs 1-4) are the most significant in describing the model and, together, account for 82.3% of the overall variance (Table 4). Indeed, most of the information concerning the system (i.e. 72.4% of the overall variance) is conveyed by PC1 (39.e% of the variance) and PC2 (24.6% of the variance).

4 DISCUSSION

According to Weil *et al*. (2016) sandy soils can be defined as a patchwork of properties, derived from equal proportions of sand, silt and clay particles. It is noteworthy that despite this definition, this does not mean that all three fractions are present in equal quantities, since a small percentage of clay particles is sufficient to attribute the properties to that fraction to the soil (Souza *et al*. 2019).

The result of the physical characterization of the soils after the treatment shows that the soils maintained the sandy to silty to clayey structure. This texture is found in the soil of the State of Maranhão, located in the Legal Amazon region and is suitable for use in agriculture. Contrary to this study, Costa *et al*. (2018) and Silva *et al*. (2020) physically characterized an agricultural soil contaminated with pesticides to sandy to silty. The authors point out that this type of soil contributes more to the adsorption of the contaminant to the soil, leaving more toxicity available. Our work corroborates that of Muscolo *et al*. (2018) that characterized the soil after composting treatment and observed a sandy to silty to clayey texture in the evaluated soil. The authors reinforce the importance of assessing soil texture, as it determines the ability of water and pollutants to be retained in the soil.

As for the chemical parameters of the soil, the pH of the soil in the ten treatments was around neutrality, which is favorable for agriculture, since the pH between 6.2 and 7.5 favors the activity of microorganisms responsible for the fertility of the soil. ground. Contrary to the results obtained in this work, Muscolo *et al*. (2018) and Sena *et al* (2019) showns soils with much higher pHs around 8.0, which can be harmful to the soil.

The pH and organic matter available in the soil contribute to the colloid retention. Due to the amount of negative charges, they attract exchangeable cations to their surface, thus improving the water's holding capacity of the compound (Tavares Filho, 2016; Sena *et al*. 2019). In the present study, all treatments have a significant amount of organic matter above 6% available for plant and soil, which is considered ideal by Teixeira; Donagemma; Fontana (2017). Thus, the fertilizers produced, regardless of the amount of fiber or the biocatalyst used, present themselves as a possible alternative for the recovery of degraded soils.

The availability of aluminum in the soil is directly linked to its exchangeable acidity. Thus, the greater the accumulation of this medium, the more toxic it is for cultures in general. The increase in the amount of cations (Al^{3+}) prevents fertilization of the compound, being considered inappropriate for use when the aluminum contents are above 10 mmol/dm³ (Raij, *et al*., 2001; Pereira; Fiore, 2022). In this context, all treatments varied in values between 1.0 - 5.0 mmol / dm³, which leaves them at low and medium levels, qualifying them as suitable for fertilization.

According to Crusciol *et al*. (2020), there are different categories to classify exchangeable P and K in the soil. For phosphorus, classes of cultures called: silviculture; perennials; annuals and plants, with soil and plant availability rates determined as follows: 0 to 10 mmol / dm³ very low; 3 to 25 mmol / dm³ low; 26 to 60 mmol / dm³ on average; 61 to 120mmol / dm³ in height and above 120mmol / dm³ very high. For potassium, the ranges are: 0.0 to 0.7 mmol / dm³ very low; 0.8 to 1.5 mmol / dm³ low; 1.6 to 3.0 mmol / dm³ on average; 3.1 to 6.0 mmol / dm³ high and above 6.0 mmol / dm³ very high. In the present work, all treatments with or without fiber and regardless of the biological catalyst were in the low to medium range for the availability of K in the soil, and from low to medium for P, demonstrating that the fertilizers formed have potential for fertilization.

Regarding the values of the macronutrient Sodium (Na), the main responsible for salinization and corrective component of acidity, it is considered ideal for a proportion of soil nutrition that can vary up to 10 mmol / dm³. For the parameters of Ca and Mg, the minimum desirable values are: 4.0 - 7.0 mmol / dm³ and 5.0 - 8.0 mmol / dm³ respectively. It can be said that these nutrients are well above the desirable in the literature for fertile fertilizers. More importantly, it is important to note that the material produced has a high CTC, which can mitigate the toxic effect of the high concentration of these micronutrients.

In the present study, the average ratio between Ca and Mg was 2.7: 1 for the feces biocatalyst and 5.4: 1 for the sludge biocatalyst, which is below the ideal for the literature, which is 6: 1, but it is important note that the compounds formed in all treatments have high levels of organic matter, which is characterized as one of the sources of Mg replacement for soils, thus being able to guarantee good levels of this macronutrient in the compound. The results described above corroborate those of Rodrigues *et al*. (2015) and Souza *et al* (2020) who evaluated the influence of organic residues from households, agriculture and agro-industry (organic sludge) on the efficiency of the composting process and on the final quality of the compost produced, replacing the fiber sources and varying the biocatalysts, they also showed proportions of proportions between this macronutrient below those listed in the literature, recommending a correction of the C/N disposition ratio for the compounds.

It is important to point out that by decreasing the amount of fibrous material in the windrows, it is directly influencing the C/N ratio of the compounds to be formed, and even so the results for Ca with the addition of the stool biocatalyst and decrease of the fibrous material showed an improvement in the disposition of this element in the formed organic fertilizer. As for the organic catalyst organic sludge, the ratio of this macronutrient remained practically without difference in all treatments (Table 4), which may indicate that the chemical composition of the biocatalyst may influence the disposition of nutrients in the formed compound.

5 CONCLUSION

The gradual decrease in fiber in the composting process, for the two tested biocatalysts (bovine feces and organic sludge) demonstrates that the best rate of mixtures between the fibrous part and organic waste is 50% for each material.

In addition, the total removal of fiber in the two processes studied, presented itself as a viable alternative for the production of organic fertilizers, thus facilitating the use of this recycling technique in all urban or rural realities, which helps to avoid accumulation and destination inadequate use of this waste in dumps and landfills across cities.

In this way, the inclusion of the organic sludge biocatalyst to replace the traditional one (animal feces), and the reduction of the fibrous material content in the composting process, can be presented as viable alternatives for the formation of quality organic fertilizers, in addition to an alternative effective treatment of this waste.

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