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Evaluation of organic and chemical fertilizer in the recovery of degraded areas arising from the mineral exploration

Higor Almeida da Silva[1], Jandecy Cabral Leite[2], Simonny C. S. Deus[3], Ricardo J. A. Deus[4]

[1,4] Postgraduate Science and Environment, Federal University of the Pará, 66075-110 Pará, Brazil.
[2] Galileo Institute of Technology and Education of the Amazon (ITEGAM). Av. Joaquim Nabuco Nº 1950. Center, 69005-080, Manaus - AM. Brazil.
[3] Environment and Conservation Research Laboratory, Federal University of Pará, 66075-110, Brazil.

Email: higor_sial@hotmail.com, dedeus@ufpa.br

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ABSTRACT

Mining activities have environmental impacts; independent of the mineral is being extracted. The recovery of degraded areas arising geological research is characterized by the Agroforestry System between paricá specie (*Schizolobium amazonicum*) and braquiarão (*Urochloa brizantha*), which with the help of organic and chemical fertilizers promote the enrichment of phytosociological parameters and the restructuring of chemical and physical properties of the soil. The objective of the study was to evaluate the effects of organic and chemical fertilizer on the performance of biometric attributes of forest specie paricá: Circumference at Breast Height (CBH); Diameter at Breast Height (DBH); Dry Mass of Leaves (DML); Aerial Part Dry Mass (APDM) and Plant Height; and the physical properties (density and porosity) and chemical (NPK, Ca, Mg, and H^+ e Al) soil. The study was conducted in an area of 15 ha selected randomly in mining company of Godofredo Viana municipality, MA. The treatments were: No Fertilizer; Organic Fertilizer and Chemical Fertilizer with five repetitions and submitted to analysis of variance ($p < 0.05$) by Tukey test for 6 months of research. The organic fertilization promoted increments high in relation to chemical fertilizer and without fertilizer in all biometric attributes of the plant, as well as the physical and chemical properties of the soil. This study provides parameters for the companies of mining adopt the composting as mechanisms beneficial for recovery environmental characterized in techniques particular of each location, assisting the succession ecological and restructuring the resources natural.

Keywords: Analysis of variance; Biometric attributes; Composting; Agroforestry System.

I INTRODUCTION

Mining activities have environmental impacts; independent of the mineral is being extracted. This activity involves removal of vegetation or impediment of regeneration, removal of the fertile soil layer, soil exposure to erosion that may cause silting of water bodies surrounding and compromising water quality of rivers and reservoirs same watershed [1]. Other impacts that may have harmful effects on the balance of ecosystems are reducing or habitat destruction, scare of the fauna, the death of fauna species and terrestrial and aquatic flora, including any endangered species, interruption corridors of gene flow and removal of biota [1].

In this sense, the recovery of degraded areas for mineral exploration projects can be defined as the set of actions necessary for the area to be able to return to a productive process in environmental equilibrium conditions, as it is necessary that the same to presents conditions physical stability (erosion, land movements) and chemical stability (the area should not be submitted to chemical reactions that may generate harmful compounds to human health and the ecosystem) [2].

According to [3], fertilization is one of the most complex stages in the production of seedlings for the recovery of degraded areas due to the difficulty in finding information about the best doses for native species. The NPK mineral fertilizer is essential for the growth and development of plants, as well as other factors such as sunlight stored in the form of compounds of energy such as Adenosine Triphosphate (ATP) and Nicotinamide-adenine-dinucleotide-phosphate (NADPH), water, carbon dioxide (CO_2) and a continuous flow of mineral salts [4].

The organic fertilizer through composting of organic waste generates a benefit as a final product, the organic compost for use agricultural, constituting a process that enables fulfillment with the items considered fundamental in concept of sustainable development for the efficient treatment and disposal of solid waste: (a) the minimization of environmental impacts; (b) the minimization of waste; (c) Maximize recycling [5].

In this study, the areas recovered by mineral exploration activities are characterized by paricá specie (*Schizolobium amazonicum*) and braquiarão (*Urochloa brizantha*) which assist in the enrichment of biodiversity based in parameters phytosociological existent. This methodology of enrichment of recovery of areas research assist significantly in the growth of cover vegetation, this case harmonize the vegetation type local [6].

II. MATERIALS AND METHODS

II.1 STUDY AREA

The field research project is located in Godofredo Viana municipality, state of Maranhão (Figure 1), specifically in mining company areas. The municipality has an area of 675.168 km^2 and coordinates 1°24'10" S; 45°46'47" W; located in the mesoregion west of Maranhão and microregion of Gurupi [7].

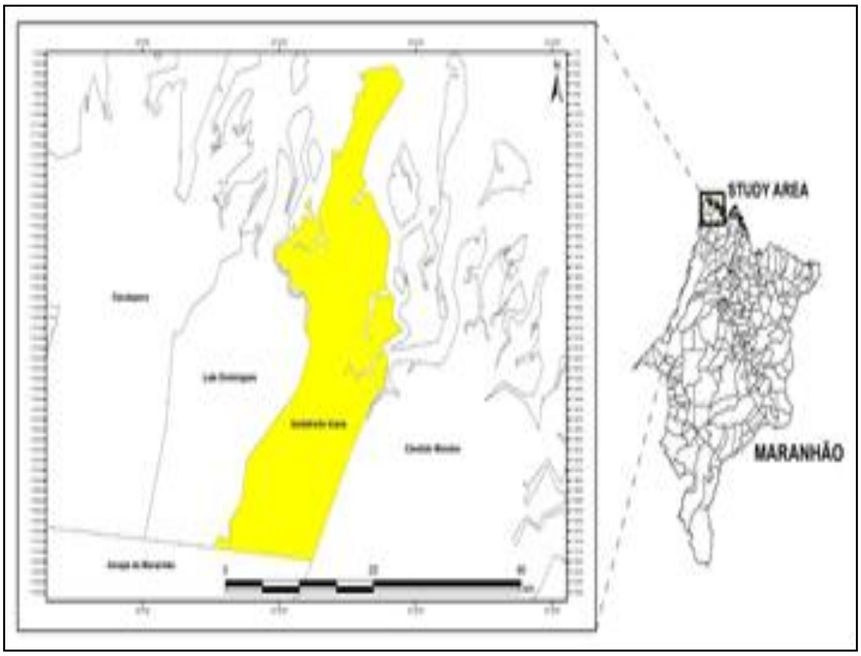

Figure 1: Location of the study area in Godofredo Viana, Maranhão state, Brazil.
Source: Authors, (2018).

In this study, we selected randomly 15 ha for the recovery of degraded areas in the areas of research. This selection was based on recovery techniques based in survey of the structure and composition floristic of communities plant, especially of fragments forest [8]. Information obtained in these activities are the basis for the protection and recovery of formations ecological formed by the seed bank which have tendency to increase according to the intensity of the disturbance [9].

II.2 EXPERIMENTAL DESIGN

The experimental design consisted of randomized blocks with three treatments in five repetitions. The treatments were: T1 (No fertilization); T2 (Organic Fertilizer) and T3 (Chemical Fertilizer). The field research period was six months evaluated in 15 Experimental Units (EU) each corresponding to 1 ha, or 10.000 m^2; evaluating the following variables: Circumference at Breast Height (CBH) in meters (m); Diameter at Breast Height (DBH) in meters; Dry Mass of Leaves (DML) in grams per plant (g/plant); Aerial Part Dry Mass (APDM) in grams per plant; Plant Height in meters; as well as the physical and chemical characteristics of the soil by Porosity and Soil Density and nutrient content, such as: Nitrogen + Phosphorus + Potassium (NPK) in milligrams per cubic decimeter (mg dm^{-3}); Calcium (Ca); Magnesium (Mg); Hydrogen + Aluminum (H+Al) centimol load per cubic decimeter (cmol$_c$ dm^{-3}).

The samples were collected in the 0 to 20 cm, analyzed by the Laboratory of the Department of Soil Science of the University Federal Rural of Amazonia (UFRA) located in the city of Belém-PA. The physical attributes analyzed were: total porosity and soil density, determined by the method of volumetric rings 100 cm^{-3} [10]. The chemical analyses were realized in triplicates [11]. The pH in water, calcium, exchangeable magnesium, sum of bases, cation exchange capacity, base saturation and exchangeable aluminum were realized according to the methodology of [5] (Table 1).

Table 1: Characteristics chemical of soil (average of 15 samples).

	pH	P	K	H+Al	Al^{3+}	Ca^{2+}	Mg^{2+}	SB	CTC	V	MO	C
	(H_2O)	cmol$_c$/dm^3								%	mg/dm^3	
Média	5,28	0,05	0,07	2,59	0,78	1,04	0,61	1,75	4,35	40,2	30,8	16,9

Potential Hydrogen (pH) in water - relation 1:2.5; Phosphorus (P) and potassium (K) - in Mehlich; Acidity Potential (H+Al) - in acetate calcium; Aluminium (Al^{3+}), calcium (Ca^{2+}) and magnesium (Mg^{2+}) - in KCl 1N; Sum of bases (SB), Cation Exchange Capacity (CEC) and saturation base of soil (V%) in calculations; Organic Matter (OM) and Carbon (C) with dichromate potassium in medium sulfuric (method titrimetric of Walkley-Black).

The seedlings of native species Paricá been grown in nurseries **(**Figure 2**).** Before to sowing the seed in bags of polyethylene was conducted the break of dormancy to method thermal, which consists in immersing the seeds in water at a temperature of 100 °C and posterior permanence to four hours until the cooling, which accelerates and standardizes the germination seeds and the emergence of seedlings *Schizolobium amazonicum*. Thus, after 45 to 60 days the seedlings were fully able to planting permanent, with average of 53 cm of height and 7 mm of diameter. Another factor very important for the production of seedlings quality in the nursery, the cleaning of weeds next to the seedlings that may prejudice biological and aesthetically seedlings existent, the removal of seeds that did not germinate with posterior planting new seeds, as well as verification of associations pathogens [12].

Figure 2: Seedlings of paricá high quality with 35 days of sowing
Source: [13].

II.3 TECHNIQUES OF RECOVERY DEGRADED AREAS

The techniques of recovery degraded areas began with the plow tractor doing unzipping and aeration of soil impacted, moreover were performed the procedures of measurement and marking of spacing suitable in the area destined for the rehabilitation environmental; opening of furrows in the soil manually, based in dimension of 30 cm x 30 cm x 30 cm [14]; application of organic fertilizer (composting) at the proportion of 1.5 kg furrow^{-1} [15] analyzed in the study and planting of the species forest paricá and of the species agricultural braquiarão used in methodology (Figure 3).

Figure 3: (a) Team contributors Environmental doing the measurement and the piqueteamento the area to be recovered; (b) Employee performing the rutting later manually to piqueteamento; (c) Exemplification dimensioning of the grooves made in the recovered area; (d) Application of organic fertilizer in scaled groove; (e) Planting of native species paricá (*Schizolobium amazonicum*); (f) Braquiarão seeds (Urochloa brizantha) used in the recovery of impacted areas, establishing the SAF type agrosilvicultural.
Source: [13].

Composting is an important process biological of transforming organic waste in products and inputs for agriculture, occurring through this process, a reduction of waste generated not availed and an optimization in the production of new inputs and natural fertilizers, inside of the cycle of development sustainable, used in the production of agriculture organic [16].

During the period 30 to 40 days, occurred the formation of 300 compost heaps, with average of 1.000 kg weight. The materials used in forming of piles corresponded to the following proportion: 300 kg of black earth; 200 kg of cattle manure; 300 kg sawdust; 150 kg of residues vegetable and 50 kg of food residues (Figure 4). All materials used in the preparation of the organic compound was collected manually with the aid of three shovels, two wheelbarrows and one pickup model L200 outdoor for the transport of materials of the areas most distant until to the final destination.

Figure 4: (a) First layer of organic material being prepared (black soil + manure + sawdust); (b) Second layer of material used for the preparation of compost (food waste); (c) Third layer of the material used for the preparation of organic compound (plant residues); (d) Fourth and final layer of material composting, again adding black earth.
Source: [13].

The planting of seedlings of species *Schizolobium amazonicum* on the field were deposited in the furrows of 30 cm x 30 cm x 30 cm [14], 1.5 kg of organic fertilizer arising of composting with the spacing of 4 m x 4 m between the seedlings of species forest inserted in lines parallel [17]. The *Urochloa brizantha* was sown by broadcasting, fertilized in the same way and with density of planting of 60 kg ha^{-1} of seeds [18].

The mineral fertilizer in terms of N, P_2O_5 and K_2O were supplied on the soil dose of 213, 255 and 268 grams per plant, respectively, and the same applied in the furrows, using the formulated NPK 14-17-18, and characterized the N with 98.6 kg ha^{-1} of urea; P_2O_5 with 118.04 kg ha^{-1} using the superphosphate triple (TSP) and K_2O with 93.05 kg ha^{-1} using potassium chloride (KCl). At the time of transplanting of the seedlings in the field during the season rainy, the doses P_2O_5 were applied in full in furrow while that fertilization NK was parceled to achieve greater efficiency of use of the fertilizers [19].

III. RESULTS

III.1 CHARACTERIZATION OF THE VARIABLES ANALYZED IN THE VEGETATION

The plants of paricá after 6 months planting showed average 2 to 3 meters tall and Circumference at Breast Height (CBH) of average 0.0239 meters with assist of grasses defined regeneration natural vigorous based in the growth of both tree species as of herbaceous species (Figure 5) [20].

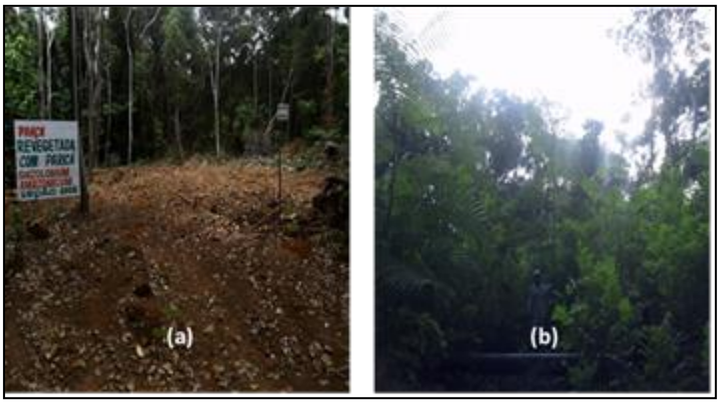

Figure 5: (a) Impacted area due to the geological survey, after the 1st day of planting the consortium paricá and braquiarão; (b) Search area recovered after 6 months of planting restored the phytosociology.
Source: [13].

This rehabilitation environmental characterized by System Agroforestry of type agrossivilcultural, defines an indicator of diversity of species able to achieve stability physical of local degraded [21]. Table 2 shows the results of analyzes for the Circumference at Breast Height (CBH); Diameter at Breast Height (DBH); Dry Mass of Leaves (DML); Aerial Part Dry Mass (APDM) and Plant Height. The data were analyzed and interpreted from the analysis of variance (Test F) and by comparison of average of test TUKEY, according to [22]. Accomplished also the test of Kruskal-Wallis between treatments and variables analyzed used to test if a set of samples derive of the same distribution [23].

Table 2: Comparison between the means of the variables obtained in the sixth month of planting for the circumference at breast height (CBH), diameter at breast height (DBH), dry mass of leaves (DML), aerial part dry mass (APDM) and height of plant of specie *Schizolobium amazonicum* in the three treatments analyzed.

TREATMENTS	CBH (m)	DBH (m)	DML (g/plant)	APDM (g/plant)	Plant Height (m)
No Fertilizer	0,02014c*	0,00641c	31,134B	32,064B	1,593B
Organic Fertilizer	0,02318a	0,00737a	36,118A	37,042A	2,957A
Chemical Fertilizer	0,02214b	0,00704b	35,044AB	35,904AB	2,864A

*Averages followed by the same letter in the columns do not differ statistically by the test Tukey at 5%. Lowercase letters indicate the difference by test Tukey 5% significance and capital letters indicate the difference by the Kruskal-Wallis test at 5% significance.

The organic fertilization showed development lightly superior in relation the chemical fertilizer and significant in relation the no fertilizer in the parameters evaluated. The five variables analyzed showed growth linear (Figure 6), during the six months of analysis with elevated adjustment of equation (R^2 = 0.98 and 0.97) for APDM and DML, respectively, in relation the organic fertilizer.

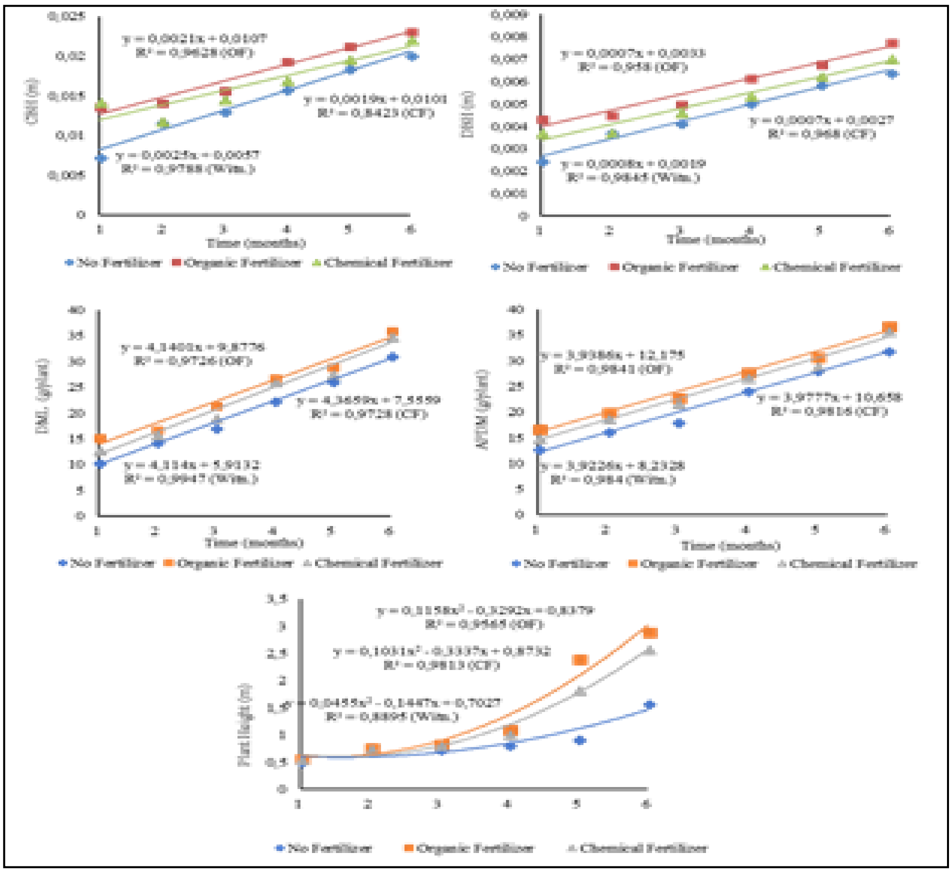

Figure 6: Circumference at Breast Height (CBH); Diameter at Breast Height (DBH); Dry Mass of Leaves (DML); Aerial Part Dry Mass (APDM) and Plant Height in the function of the three treatments applied.
Source: Authors, (2018).

Observed that the maximum growth in CBH = 0.024 m; DBH = 0.012 m; DML = 35.1 g; APDM = 36.2 g and Plant Height = 2.91 m was reached with a percentage of 100% of chemical fertilizer (Figure 6), which corresponds to the dose of 213 g N; 255 g P_2O_5 and 268 g K_2O per plant calculated for 1 ha, showing that chemical fertilizer is fundamental in the growth initial of various species in substrates resultant of mining [24].

The Aerial Part Dry Mass (APDM) showed similar results to those reported by [25] related to specie caroba-do-campo (*Jacaranda cuspidifolia*) with an average of 31.9 g plant^{-1}, this represent higher capacity of adaptation in the period after planting, once the leaves are a the main sources of nutrients and photoassimilates (sugars, amino acids, hormones, etc.) that will supply water and nutrients for roots in the months of planting.

III.2 CHARACTERIZATION OF THE VARIABLES ANALYZED IN THE SOIL

There were no significant differences in granulometry of soil after six months of application of the treatments between organic fertilizer and chemical fertilizer; however, both treatments had obtained behavior superior in relation to the treatment no fertilizer. The organic fertilizer showed in soil density value estimated of 1.08 kg dm^{-3}, the chemical fertilizer characterized in soil density value of 1.16 kg dm^{-3} and no fertilizer the value of 1.33 kg dm^{-3}. In respect the total porosity for organic fertilizer, chemical fertilizer and no fertilizer, the values of average were respectively, 3.76 cm^{-3}; 2.64 cm^{-3} e 1.84 cm^{-3} (Table 3).

Table 3: Density and porosity of the soil after application of three treatments analyzed during the six months of research.

TREATMENTS	Soil Density (kg dm^{-3})	Total Porosity (cm^{-3})
No Fertilizer	1,33c*	1,84c
Organic Fertilizer	1,078a	3,76a
Chemical Fertilizer	1,152b	2,64b

*Averages followed by the same letter in the columns do not differ statistically by Tukey test at 5%.

These results were similar to those reported in [26] who observed influence of the treatments organic compound, chemical fertilizer and no fertilizer in the quantity of macro, micro and total porosity of soil, being the values superiors in treatments that received organic fertilizer.

It is emphasized that raising the total porosity and consequent reduction in soil density by introducing organic compound (Figure 7) accompanied by the sowing of grass *Urochloa brizantha* and other species plants that cover the soil, assist the mechanisms of flocculation of clay and stabilization of aggregates [27].

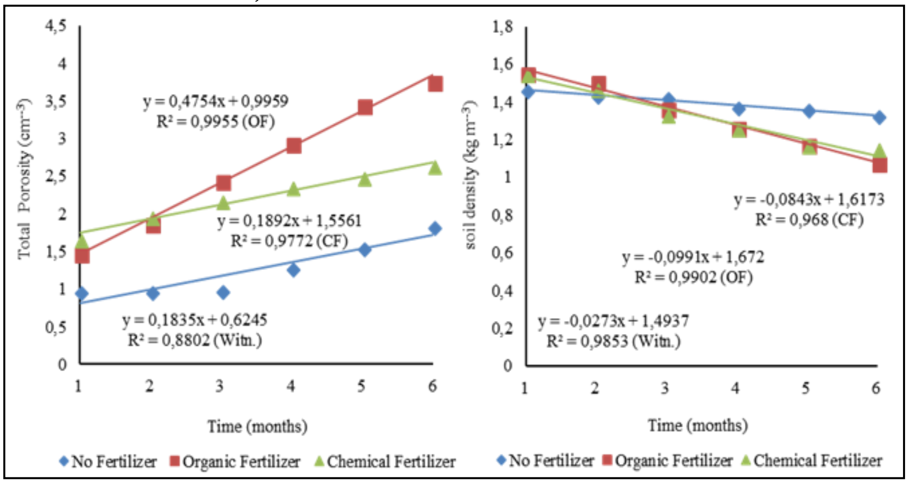

Figure 8: Total porosity and density soil in function of doses of compound organic (1.25 kg ha^{-1}), chemical fertilizers (98.6 kg ha^{-1} of urea, 118.04 kg ha^{-1} of TSP and 93.05 kg ha^{-1} KCl) and no fertilizer during the six months of research.
Source: Authors, (2018).

The organic and chemical fertilizers afforded the increase linear of the total porosity, characterizing also the increase of the humidity and consequently the decrease in soil density (Figure 7), because if the pore spaces stay in their majority occupied by water, due to is related the micropores, there is smaller space filled by air [28]. The organic fertilization showed in the sixth month of study, average of growth similar to (2.734 cmol$_c$ dm^{-3}) of P in the soil; K (0.946 cmol$_c$ dm^{-3}); Ca^{2+} (1.562 cmol$_c$ dm^{-3}); Mg^{2+} (1.442 cmol$_c$ dm^{-3}) and average of reduction in the potential acidity of 1.726 cmolc dm^{-3}. The chemical fertilization afforded average growth similar to 2.468 cmol$_c$ dm^{-3} of P; K (0.918 cmol$_c$ dm^{-3}); Ca^{2+} (1.348 cmol$_c$ dm^{-3}); Mg^{2+} (1.132 cmol$_c$ dm^{-3}) and reduction in the potential acidity of 1.974 cmol$_c$ dm^{-3}. Both treatments were superiors compared to no fertilizer (Table 4).

Table 4: Comparison between the means of the variables obtained in the sixth month of planting for Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg) and Potential Acidity (H + Al) on the soil in the application of the three treatments studied.

TREATMENTS	P (cmol$_c$ dm^{-3})	K (cmol$_c$ dm^{-3})	Ca (cmol$_c$ dm^{-3})	Mg (cmol$_c$ dm^{-3})	H+Al (cmol$_c$ dm^{-3}
No Fertilizer	0,078B	0,076B	1,068B	0,678B	2,58c
Organic Fertilizer	2,734A	0,946A	1,562AB	1,442AB	1,726a
Chemical Fertilizer	2,468AB	0,918AB	1,348A	1,132A	1,974b

*Averages followed by the same letter in the columns do not differ statistically by the test Tukey at 5%. Lowercase letters indicate the difference by test Tukey 5% significance and capital letters indicate the difference by the Kruskal-Wallis test at 5% significance.

The teor P available showed the highest value for treatment with organic fertilizer and during the six months of analysis, exhibited increased growing of the values, even as in the chemical fertilizer; the no fertilizer remained stable during this period (Figure 8). The availability of P in the soil increases with enhance of teor organic matter characterized in the organic fertilization, with the teor of clay and the humidity, interfering consequently in the absorption by plants [29].

As observed by [30], about 81% of the potassium contained in the organic compound (produced with sawdust and manure) was available after applied 22 days in the soil which reinforces the question displacement of magnesium and also suggests that part of the own potassium may have been leached.

For calcium, there was increase linear in the teors of soil in function addition of the of the organic compound and chemical fertilizers (Figure 8), being that the lower levels were found in the no fertilizer, average of 1.562 $cmol_c$ dm^{-3} achieved in the sixth month of analysis with organic fertilizer allied the effect of plants cover, for example, the *Urochloa brizantha*, influence significantly in the mobilization of Ca^{2+} in the soil. In relation the exchangeable magnesium (Mg^{2+}), [31] considered level deficient, for this element, levels below 0.8 $cmol_c$ dm^{-3},characteristic of treatment no fertilizer which showed an average of 0.678 $cmol_c$ dm^{-3} after six months of study. The average of 1.442 $cmol_c$ dm^{-3} (Organic Fertilizer) and 1.132 $cmol_c$ dm^{-3} (Chemical Fertilizer), afforded an increase in the levels of Ca^{2+} and Mg^{2+} in the soil, in agreement with results verified by [32].

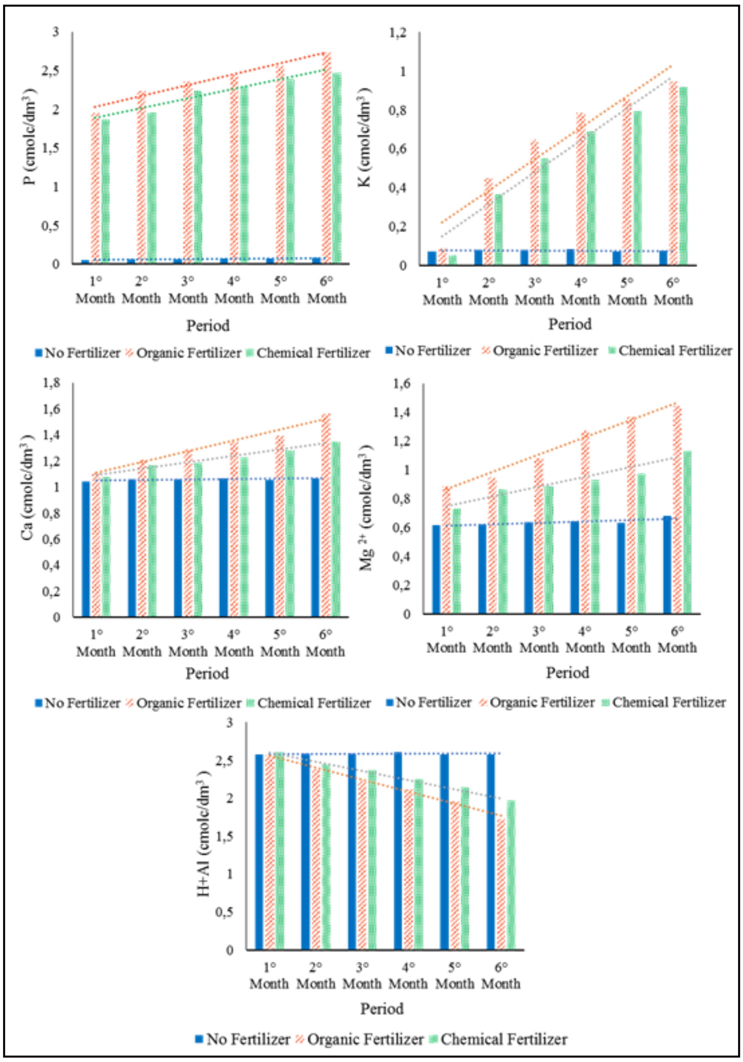

Figure 8: Representation graphical for the teors of phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and potential acidity (H+Al) in function of the three treatments applied in the six-month study.
Source: Authors, (2018).

The organic fertilization afforded reduction linear for H+Al with average 1.726 $cmol_c$ dm^{-3} while the chemical fertilization also promoted reduction linear in potential acidity, average 1.974 $cmol_c$ dm^{-3}, however this development was inferior in relation the organic fertilizer and superior compared to no fertilizer (Figure 8). For [33] also found the reduction potential acidity (H+Al) in soil with the use of tanning sludge in seedlings paricá (*Schizolobium amazonicum*), providing neutralization total of the exchangeable aluminum (Al^{3+}).

IV. DISCUSSION

The organic fertilizer characterized in dose of 6.0 g plant of compound organic for specie paricá [33], even as the utilization of doses of chemical fertilizer already mentioned have improved the maximum productivity of plants in the five variables studied during the six months of evaluation. The organic fertilization promoted growth of 44.96% of the circumference at breast height; 45.68% of diameter at breast height; 43.89% dry mass of leaves; 45.98% aerial part dry mass and 46.54% of plant height in relation to the no fertilizer and chemical fertilization. Sabonaro and [34] , in cultivation in areas of revegetation found highest growth of seedlings *Schizolobium parahyba* (average height and diameter at breast height of 1.26 and 0.018 meters respectively) when used different organic substrates under influence of irrigation, orienting the utilization of organic compounds in the production of various agricultural and forest species. Observed a growth above of 50% of total porosity with the application of organic fertilizer and 47.76% with chemical fertilization, characterizing the point of view physical a soil ideal for development plant [35]. In a study comparing the total porosity in soils destined for different uses, [36] bfound in layers the 0 to 20 cm, Macro and Micro respectively, 31% and 14% in the native cerrado, 23% and 15% for pasture, 24% and 15% for integration agriculture-livestock and 24% and 14% for seeding direct. Organic matter is fundamental importance for the process recovery, since promotes improvements in attributes physical, chemical and biological of soil providing sustainability to the system to be recovered [18]. Therefore, the organic fertilizers arising composting act like a source for the improvement in physical, chemical and biological soil, favoring the processes recovery which in areas of mining suffering constant degradation, require intense demands of organic matter. This study provides parameters for the companies of mining adopt the composting as mechanisms beneficial for recovery environmental characterized in techniques particular of each location, facilitating the succession ecological and restructuring the resources natural.

V. ACKNOWLEDGMENTS

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VI. REFERENCES

[1] Mechi, A.; Sanches, D.L. 2010. **Environmental impacts of mining in the State of Sao Paulo**. *Estudos Avançados*. 24, 209-220. (in portuguese).

[2] Brum, I.A.S. 2000. **Recovery of Degraded Areas by Mining. Monograph Specialization in Management and Environmental Technology Industry**, Polytechnic School, Department of Hydraulics and Sanitation, Salvador, Bahia, 22p. (in portuguese).

[3] Vieira, C.R.; Weber, O.L.S. 2013. **Organic compounds on the growth of paricá seedlings**. IBEAS - Brazilian Institute for Environmental Studies. IV Brazilian Congress of Environmental Management, Salvador, Bahia.

[4] Malta, A.O. 2012. **Production and physicochemical characterization of fruits of guava 'Paluma' as a function of organic and mineral fertilizer**. Work Course Conclusion/ Agronomy Course Coordination of Agricultural Sciences Center of the Federal University of Paraíba, Areia, Paraíba. 66p. (in portuguese).

[5] Embrapa. 2009. Composting - **Science and Practice for the management of organic waste**. 1.ed. Embrapa Solos. 1.ed. Embrapa Solos, Rio de Janeiro.

[6] Locatelli, M.; Vieira, A.H.; Marcolan, A.L.; Pequeno, P.L.L.; Martins, E.P.; Pimentel, C.A.; Gonçalves, E.L. 2012. **Soil Chemistry Characterization and Growth *Schyzolobium parahyba var. amazonicum* (Huber ex. Ducke) Agroforestry Agroecological systems in the state of Rondônia**. FERTBIO. (in portuguese).

[7] IBGE, 2010. **Censo demográfico**. (in portuguese).

[8] Freitas, W.K.; Magalhães, L.M.S. 2012. **Methods and parameters for the vegetation study with emphasis Stratum Arboreal**. *Floresta e Ambiente*. 19, 520-540. (in portuguese).

[9] ALVAREZ-AQUINO, C.; WILLIAMS-LINERA, G.; NEWTON, A.C. 2005. **Disturbance effects on the seed bank of Mexican Cloud Forest Fragments**. *Biotropica*. 37, 337-342.

[10] Embrapa. 1997. **National Center for Soil Research. Soil Analysis Methods Manual**. 2.ed. Rio de Janeiro, 212p. (in portuguese).

[11] Passari, L.M.Z.G.; Soares, P.K.; Bruns, R.E. 2011. **Statistics applied to Chemistry:** Ten common questions. *Química Nova*. 34, 888-892. (in portuguese).

[12] Costa, C.A.; Silva, L.R.; Imbiriba, I.V.F.; Baia, A.D.B.; Silva, I.L.S.S. 2011. **Incidence and control alternative of pathogens in seeds of paricá (*Schizolobium amazonicum* Huber ex. Ducke)**. Annals of the 9º Seminar Annual of Initiation Scientific, 19 to 21 October. (in portuguese).

[13] Luna Gold Corporation. 2014.

[14] Souza, C.R.; Rossi, L.M.B.; Azevedo, C.P.; Vieira, A.H. 2003. ***Paricá:** Schizolobium parahyba var. amazonicum (Huber ex. Ducke) Barneby*. *Circular Técnica*. Embrapa, Manaus, Amazonas.

[15] Rayol, F.O.A.; Rosa, L.S .; Rayol, B.P. 2011. **Effect of spacing and of leguminous crops of cover in management of plants invasive in reforestation of Schizolobium amazonicum Huber ex**. Ducke (paricá). *Revista Árvore*. 35, 391-399. (in portuguese).

[16] Rodrigues, A.C.; França, J.R.; Silveira, R.B.; Graepin, C.; Neuhaus, F.; Amaral, G.M. 2014. **Environmental awareness actions in the exploitation and processing of waste in state school**. 31 SEURS - Seminar University of Southern Region Extension Federal University of Santa Catarina, Florianópolis, Santa Catarina. (in portuguese).

[17] Santos, E.M. 2012. **Growth and paricá plantations production (*Schizolobium amazonicum Huber ex. Ducke*) under different spacing**. Dissertation in Forest Science / Department of Agricultural Sciences, Federal University of Espírito Santo, Jerome, Holy Spirit. 75p.

[18] Longo, R.M.; Ribeiro, A.I.; Melo, W.J. 2011. **Use of green manure in the recovery of degraded by mining in the Amazon rainforest. *Bragantia***. 70, 139-146. (in portuguese).

[19] Costa, M.C.G.; Tonini, H.; Schwengber, J.A.M.; Cantarella, H. 2008. **Initial growth of Schizolobium amazonicum depending on NPK fertilization**. FERTBIO. (in portuguese).

[20] Araújo, M.M.; Chami, L.; Longhi, S.J.; Avila, A.L.; Brena, D.A. 2010. **Cluster analysis at remnant of Araucaria forest**. *Ciência Florestal*. 20, 1-18. (in portuguese).

[21] ALMEIDA, R.P.O.; SÁNCHEZ, L.E. 2005. **Revegetation of mining areas: monitoring and performance evaluation criteria**. *Revista Árvore*. 29, 47-54. (in portuguese).

[22] Ferreira, D.F. 2007. **Sisvar Versão 5.0**. Lavras: UFLA.

[23] Devore, J.L. 2000. **Probability and Statistics for Engineering and the Sciences**. Duxbury, Australia.

[24] AMARAL, C.S.; SILVA, E.B.; PEREIRA, I.M.; NARDIS, B.O.; GONÇALVES, N.H. 2013. **Dalbergia growth miscolobium in substrate reject mining of quartzite fertilized**, *Pesquisa Florestal Brasileira*. 33, 179-187. (in portuguese).

[25] Matos, P.S.; Dutra, T.R.; Massad, M.D.; Sarmento, M.F.Q.; Oliveira, J.C. 2013. **Seedlings of caviúna-do-cerrado (*Dalbergia miscolobium*) and carobinha-of-field (*Jacaranda cuspidifolia*) in response to increasing levels of nitrogen.** 2nd Scientific Seminar and 2nd Exhibition of the Scientific IFNMG work. (in portuguese).

[26] Sampaio, T.F.; Guerrini, I.A.; Backes, C.; Heliodoro, J.C.A.; Ronchi, H.S.; Tanganelli, K.M.; Carvalho, N.C.; Oliveira, F.C. 2012. **Sewage sludge in the recovery of degraded areas: effects on soil physical properties**. *Revista Brasileira de Ciência do Solo*. 36, 1637-1645. (in portuguese).

[27] Neto, A.L.; Albuquerque, J.A.; Almeida, J.A.; Mafra, A.L.; Medeiros, J.C.; Alberton, A. 2008. **Soil physical properties of a coal mining site influenced by liming, organic fertilization and revegetation**. *Revista Brasileira de Ciência do Solo*. 32, 1379-1388. (in portuguese).

[28] Monteiro, M.M. 2014. **Hydrogel effect in plantations of native cerrado seedlings to area recovery degraded by mining in the Federal District**. Dissertation in Forest Science / Department of Forestry, University of Brasilia, Distrito Federal. 90p. (in portuguese).

[29] Santos, D.H.; Silva, M.A.; Tiritan, C.S.; Foloni, J.S.S.; Echer, F.R. 2011. **Quality technological of cane sugar under fertilization with filter cake enriched with phosphate soluble**. *Revista Brasileira de Engenharia Agrícola e Ambiental*. 15, 443-449. (in portuguese).

[30] Damatto Junior, E.R.; Villas Bôas, R.L.; Leonel, S.; Fernandes, D.M. 2006. **Changes in soil properties fertilized with organic compost doses under banana cultivation**. *Revista Brasileira de Fruticultura*. 28, 546-549. (in portuguese).

[31] Sousa, D.M.G.; Miranda, L.N.; Oliveira, S.A. 2007. **Soil acidity and its correction**. In: Novais, R.F.; Alvarez V.V.H.; Barros, N.F.; Fontes, R.L.F.; Cantarutti, R.B.; Neves, J.C.L. (Ed.). Soil fertility. Brazilian Society of Soil Science, Viçosa, Minas Gerais, p.205-274.

[32] Kitamura, A.E.; Alves, M.C.; Suzuki, L.G.A.S.; Gonzalez, A.P. 2008. **Recovery of degraded soil with green manure and sewage sludge**. *Revista Brasileira de Ciência do Solo*. 32, 405-416. (in portuguese).

[33] Tavares, L.S.; Scaramuzza, W.L.M.P.; Weber, O.L.S.; Valadão, F.C.A.; Maas, K.D.B. 2013**. Tanning sludge and its influence on production paricá seedlings (*amazonicum Schizolobium*) and chemical properties of the soil**. *Ciência Florestal*. 23, 357-368.

[34] Sabonaro, D.Z.; Galbiatti, J.A. 2011. **Seedling growth of *Schizolobium parahyba* on different substrates and irrigation levels**. *Rodriguésia*. 62, 467-475.

[35] Novais, R.F.; Mello, J.W.V. 2007. Relação Solo-Planta. In: Novais, R.F.; Alvarez V.V.H.; Barros, N.F.; Fontes, R.L.F.; Cantarutti, R.B.; Neves, J.C.L. (Ed.). **Soil Fertility. Brazilian Society of Soil Science**, Viçosa, Minas Gerais, p.133-204. lization and revegetation. *Revista Brasileira de Ciência do Solo*. 32, 1379-1388. (in portuguese).

[36] Sales, L.E.O.; Carneiro, M.A.C.; Severiano, E.C.; Oliveira, G.C.; Ferreira, M.M. 2010. **Physical quality of Typic Quartzipisamment under different agricultural use systems**. *Ciência e Agrotecnologia*. 34, 667-674. (in portuguese).