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Influence of different tree species on autotrophic and heterotrophic soil respiration in a mined area under reclamation

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Abstract

Planting trees is one of the most effective activities in recovering soil organic carbon (SOC) stocks of degraded areas, but we still lack information on how different tree species can influence soil respiration, one of the main sources of dioxide carbon (CO2) to the atmosphere. This study aimed to explore the influence of different forest species on the autotrophic and heterotrophic components of the total soil respiration in a bauxite mining area under reclamation. We analysed the soil CO2 efflux under five treatments: i) monoculture of clonal Eucalyptus; ii) monoculture of Anadenanthera peregrina (L.); iii) a mixed plantation of 16 native forest species (Nat); iv) a mined area without vegetation cover; and v) a natural forest cover. This design allowed exploring the soil CO2 dynamics in a gradient of recovery, from a degraded area to natural vegetation. Additionally, we measured soil temperature, moisture and soil characteristics. Soil CO2 efflux increased with increasing forest species cover in the rainy months. There was no significant change in CO2 efflux among the tree species. Heterotrophic soil respiration contributed to 64% of total soil CO2 efflux and was associated with litter decomposition. Amongst the abiotic variables, increases in soil moisture had the most influence on CO2 efflux. Therefore, these results help to understand the factors that underpin the loss of SOC and can orient management practices to improve soil organic matter and restore soil quality in degraded areas.

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Abstract

Planting trees is one of the most effective activities in recovering soil organic carbon (SOC) stocks of degraded areas, but we still lack information on how different tree species can influence soil respiration, one of the main sources of dioxide carbon (CO_2) to the atmosphere. This study aimed to explore the influence of different forest species on the autotrophic and heterotrophic components of the total soil respiration in a bauxite mining area under reclamation. We analysed the soil CO_2efflux under five treatments: i) monoculture of clonal Eucalyptus; ii) monoculture of *Anadenanthera peregrina* (L.); iii) a mixed plantation of 16 native

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forest species (Nat); iv) a mined area without vegetation cover; and v) a natural forest cover. This design allowed exploring the soil CO_2 dynamics in a gradient of recovery, from a degraded area to natural vegetation. Additionally, we measured soil temperature, moisture and soil characteristics. Soil CO_2 efflux increased with increasing forest species cover in the rainy months. There was no significant change in CO_2 efflux among the tree species. Heterotrophic soil respiration contributed to 64% of total soil CO_2 efflux and was associated with litter decomposition. Amongst the abiotic variables, increases in soil moisture had the most influence on CO_2 efflux. Therefore, these results help to understand the factors that underpin the loss of SOC and can orient management practices to improve soil organic matter and restore soil quality in degraded areas.

Keywords: Land reclamation; bauxite, CO_2 flux, soil organic matter, Atlantic rainforest

Introduction

Soil respiration is one of the main sources of terrestrial dioxide carbon (CO_2), which increase in the atmosphere has been associated with global warming (Köchy *et al* ., 2015; Shrestha & Lal, 2006). Soil is the largest C reservoir in terrestrial ecosystems, containing about twice as much C as the atmosphere (Kuzyakov & Cheng, 2001) and three times as much as the vegetation (Granier *et al* ., 2000). Soil respiration is a combination of root respiration, root associated microbes and mycorrhizal association (autotrophic respiration) and the respiration of microorganisms during the decomposition process of both soil organic matter and litter (heterotrophic respiration) (Fontaine *et al.* , 2003; Hanson*et al* ., 2000; Millard *et al* ., 2010; Bujalský *et al.* , 2014). However, the magnitude of the temporal variations and the biotic and abiotic factors that influence the efflux of CO_2 from the Reclamaid Mine Degraded Land (RMDL) in process of recovery are still not well understood. Understanding the factors that underline soil CO_2 flux can orient management practices to improve soil organic matter (SOM) and restore soil quality in degraded areas. Mining activities promote drastic changes in the landscape, where the total removal of vegetation cover and topsoil results in intense soil disturbances, which can lead to a decrease of SOM due to the increase in CO_2 efflux (Lorenz & Lal, 2007; Shrestha & Lal, 2006). The recovery process for these soils aims to restore the organic matter content with the restitution of vegetation cover that can provide carbon assimilation through photosynthesis (Shrestha & Lal, 2006). The carbon stored in the shoots and roots is important in reactivating nutrient cycling, increasing soil carbon stocks.

Soil CO_2 efflux is a sensitive indicator of soil metabolic activity and an important tool to investigate the SOM dynamics (Kuzyakov & Cheng, 2001; Haney et al. 2008). Increase SOM and nutrient cycling are major objectives to recovery soil in degraded areas and the analysis of soil CO_2 efflux can give important insights about the rehabilitation process (Subke & Bahm, 2010). The rates of soil CO_2 efflux in mining areas under recovery are associated with the soil organic carbon contents, nutrient availability and environmental variables (Ahirwal et al., 2017, Ahirwal & Maite, 2018). Mukhopadhyay &Maite (2014) compared a mined area in recovery with grassland and natural forest and found that the highest values of soil CO_2 in the grassland were associated with the higher levels of organic matter, microbiological activity and root biomass. Temperature is an important driver of soil CO_2efflux, and Bujalský *et al.* (2014) found that soil respiration was associated with temperature and higher contents of organic carbon and root biomass comparing recovered mined area and natural regeneration. Although few studies report the influence of tree species on soil respiration (Yohannes et al., 2010), there is a lack of studies that explore the influence of tree species on the components of soil respiration in mined areas under reclamation.

The study of CO_2 efflux under field conditions can generate important information about changes in land use and management, however, there is a large gap in such studies for forest ecosystems in tropical regions (Wei *et al.* , 2010), especially in mining areas in the process of recovery. The main hypothesis of this study was that soil respiration in recovering mined areas is not influenced by the composition and density of the tree species used, but they present a strong relation with soil moisture and temperature. Therefore, this study aimed to determine (i) the CO_2 efflux during the dry and rainy months in an area of bauxite mining revegetated with different forest species, (ii) the contribution of heterotrophic and autotrophic respiration to total soil respiration, and (iii) the influence of biotic and abiotic variables on soil CO_2efflux.

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Material and Methods

Study area and experimental design

The study was carried on a bauxite mined area at 780 m altitude in São Sebastião da Vargem Alegre (21°1'58" S and 42°35'8" W), Minas Gerais state, Brazil. The climate predominant is Cwa (Köppen), with hot and rainy summers and a well-defined dry season. The annual precipitation is 1,287 mm and temperature average of 20.3ºC (INMET, 2016). The domain soils are Oxisols, which is depth weathered and present low nutrients availability (Santos et al., 2013; Soil Survey Staff, 2014). Before started the mining, the soil surface layer (0.00-0.20 m) was removed and stored next to the area for one year. During the topographic reconfiguration of the mined area, the soil stored was used to cover the areas followed by a decompaction process using a subsoiler at a depth of 0.60 m.

The experiment was installed in March 2011 using a randomized block design with split plots and three replicates. The plots (40 × 18 m) comprised the following forest cover:*Anadenanthera peregrina* (L.) Speg (Ap); clonal *Eucalyptus*(a hybrid from a cross between *Eucalyptus urophylla* and*Eucalyptus grandis* - clone AEC144®) (Euc) and a mixed plantation (Nat) consisting of 16 native forest species from the region. In addition, we installed plots in a native forest at the second stage of regeneration (Woodland) and in an post-mined area kept without vegetation (Ncov).

Table 1 – Trees species and phenological groups of the mixed plantation treatment.

Species	Phenological group
Anadenanthera peregrina	Pioneer
Ficus insipida Willd	Pioneer
Inga edulis Mart.	Pioneer
Piptadenia gonoacantha (Mart.) JF Macbr.	Pioneer
Enterolobium contortisiliquum (Vell.) Morong.	Pioneer
Ceiba speciosa (A. St.-Hil.) Ravenna	Pioneer
Sapindus saponaria L.	Pioneer
Pera glabrata (Schott) Poepp. Ex Baill	Pioneer
Trichilia sp -	Non pioneer
Cupania oblongifolia Mart. -	Non pioneer
Apuleia leiocarpa (Vogel) JF Macbr	Non pioneer
Handroanthus chrysotrichus (Mart. Ex A. DC.) Mattos	Non pioneer
Hymenaea courbaril var. *stilbocarpa* (Hayne) YT Lee and Langenh	Non pioneer
Lecythis sp	Non pioneer
Paubrasilia echinata Lam.	Non pioneer
Annona squamosa L	Non pioneer

These native species were planted in Quincunx (4 pioneers, with one climax in the center) at a spacing of 2.0 × 1.5 m, using seedlings produced from seeds collected in fragments of Atlantic Forest (Woodland). For Euc and Ap, the adopted spacing was 3 × 2 m.

Evaluation of soil CO_2 efflux

To evaluate the soil CO_2 efflux we installed chloro-polyvinyl chambers (0.20 m x 0.30 m) in triplicate 42 months after planting the Eu, Ap and Nat, as well as in the Woodland and NCov. We installed chambers beneath and outside the litter collectors, allowing to evaluate the soil CO_2 efflux with and without the input of litter from the aerial part of Euc, Ap and Nat. We collected the CO_2 using syringes in the periods of 0, 10, 20 and 40 minutes after closing the chambers. We collected soil CO_2 every two months between September 2014 and July 2015 and we analysed it in a cavity resonance spectrometer (CRDS - cavity ring-down spectroscopy, G2131-i, Picarro, Sunnyvale, CA). During the soil CO_2 efflux measurements, we also

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assessed soil temperature with a digital thermometer inserted at a depth of 5 cm, and soil moisture by the gravimetric method. The CO_2 efflux was calculated using the equation:

$$Flux = \frac{(Q}{T)} \times M \times \frac{(PV}{TR)} \times \frac{1}{A}$$

where Flux: CO_2 (mg $m^{-2}h^{-1}$); $\Delta Q/\Delta T$: the angular coefficient of the adjusted straight line (ppm/s) obtained by readjustment of the gas concentrations during the time (T) of collection; M: the molar mass of CO_2 (g mol^{-1}); P: internal pressure of the chamber, assumed to be 1 atmosphere (atm); V: volume of the chamber (L); R: universal gas constant (0.08205 L atm $K^{-1}mol^{-1}$); T: soil temperature (K); A: base area of the chamber (m^2).

Soil CO_2 efflux partitioning

Aiming to identify the contribution of autotrophic (AR) and heterotrophic respiration (HR) to the total soil respiration (TR), we used the partitioning method that was carried in areas with Euc, Ap and Nat. We also analysed the relative contribution of soil microbiota respiration under the influence of litter (HR_{litter}) and SOM (HR_{SOM}).

$$TR = AR + HR$$

$$AR = \mathrm{TR}_{\mathrm{nolitter}} - \mathrm{TR}_{\mathrm{Ncover}}$$

$$HR = TR - AR$$

$$\mathrm{HR}_{\mathrm{litter}} = \mathrm{TR}_{\mathrm{whithlitter}} - \mathrm{TR}_{\mathrm{nolitter}}$$

$$\mathrm{HR}_{\mathrm{SOM}} = \mathrm{HR}_{\mathrm{total}} - \mathrm{HR}_{\mathrm{litter}}$$

$$HR = \mathrm{HR}_{\mathrm{litter}} - \mathrm{HR}_{\mathrm{SOM}}$$

Where, $TR_{nolitter}$ and $TR_{withlitter}$: total soil CO_2 efflux in the treatment with the absence and presence of litter, respectively; TR_{Ncover}: total soil respiration in the minded area without cover

Soil analysis and root density

Aiming to identify other variables that may influence the soil CO_2 efflux, we determined the main soil soil properties and roots density. Soil samples from the 0-10 layer of each plot, ground in a mortar and passed through a 60-mesh sieve (0.250 mm), were used to determine total organic carbon (TC) and total nitrogen (TN). Total organic carbon was quantified by wet oxidation (YEOMANS; BREMNER, 1988) and TN was determined by the Kjeldahl method, modified by Tedesco (1985). In addition, we analysed the soil bulk density (Ds), by the volumetric ring method; soil particle density (Dp) by the volumetric balloon method and total porosity (Pr). The microbial biomass carbon (CMB) and nitrogen (NMB) of the soil were determined in the 0-10 cm layer only. Samples (<2 mm) were placed in lidded plastic flasks, incubated for 10 days at 25°C, with moisture corresponding to 80% of the moisture equivalent, in order to re-establish the microbial community. After incubation, the CMB and NMB content were determined by irradiation-extraction (ISLAM; WEIL, 1998).

To deternine the roots density, we collected blocks of soil with dimensions of 20 x 20 x 20 cm in triplicate in all plots. After collection, the roots were manually separated from the soil, washed and divided into two classes, with a diameter smaller or larger than 2 mm. After determining the wet weight, the roots were

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placed in plastic pots with 25% alcohol and stored in a refrigerator for later evaluation. An Epson XL 10000 scanner, equipped with an additional light unit (TPU), together the WinRHIZO Pro 2009 software, was used to determine the following morphological characteristics: the biomass of roots smaller than 2 mm (BioRSm2), length of roots smaller than 2 mm (LengRSm2), specific root length (SRL), sectional area of roots smaller than 2 mm (SARSm2), mean root diameter and volume of roots smaller than 2 mm (VRSm2). Following these evaluations, the roots were placed in paper bags and dried in an oven at 60°C to obtain the dry weight. All results of soil properties and roots area presented in the Appendix 1.

Statistical analysis

The data for soil CO_2 efflux were submitted to analysis of variance (ANOVA) and the mean values compared by Tukey's (10%). The influence of biotic and abiotic variables on the CO_2efflux was evaluated using multivariate regression analysis.

Results

Variations in soil moisture and temperature

The soil presented the highest moisture content during November 2014, March and May 2015 for most of the types of cover, while the highest soil temperatures occurred in September 2014, and January and March 2015 (Fig. 1). Woodland showed the highest soil moisture and NCov the highest soil temperature for the studied period.

3.2. Soil CO_2efflux

The five treatments showed significant differences in CO_2 efflux ($p < 0.1$) (Fig. 2), with NCov presenting the lowest soil CO_2 values. Woodland had the highest values for CO_2 efflux during January and March 2015, while the soil CO_2 efflux in Euc, Ap and Nat did not vary during the study period. Euc and Nat had a similar soil CO_2 efflux pattern, with a tendency for higher CO_2 efflux during November, March and May. The increase of CO_2 efflux in Euc, Ap and Nat showed high percentage values compared to Woodland for all measurements, except in May 2015, when the soil CO_2 efflux presented the lowest percentages (< 33%) (Fig. 2a). In November, the three forest covers showed the same soil CO_2 efflux compared to the Woodland.

Temporal variation in CO_2 efflux

The highest CO_2 effluxes were recorded in the months of higher soil moisture (Fig. 3), i.e. November 2014, March and May 2015, with Woodland presenting the highest and NCov the lowest values. Although Euc showed a tendency with higher soil CO_2efflux during the months of higher soil moisture when compared to Ap and Nat, there were no significant differences between the three types of cover ($p>0,1$). In the driest months (September 2014, January and July 2015) Woodland, Euc, Ap and Nat showed no differences for CO_2 efflux, differing only from NCov.

All covers types showed similar soil moisture in the drier months (September 2014, January and July 2015), except Woodland, which had higher soil moisture (Fig. 4). In the rainy months (November 2014, March and May 2015), the lowest soil moisture was found for Euc and the highest for Woodland. Soil temperature was similar for Euc, Ap and Nat in the months of lowest soil moisture, while the lowest and the highest soil temperature were measured for Woodland and NCov respectively. In the rainy season, the highest soil temperature was recorded for NCov.

Soil CO_2 efflux partitioning

The contributions of AR and HR to soil TR were statically significant over the months ($p < 0.1$), with HR presenting the highest values (Fig. 5), These differences can be seen in November 2014, and March and May of 2015, when HR contributed more to TR than AR. In September 2014, and January and July 2015, there

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was no difference between the contributions of AR and HR to soil TR. AR and HR did not differ in the areas of Euc, Ap or Nat.

Grouping the values for AR and HR during the months of highest and lowest soil moisture, (i.e. in the months of the highest and lowest precipitation) for the moments before gas collection it was seen that during the drier months there was no difference between the contributions of AR and HR to TR, with HR accounting for around 55% of TR. However, during the wettest months, HR contributed more to TR (71%). The forest plantations did not differ during the dry months concerning AR and HR, and during the rainy months, differences were only seen between Ap and Nat for AR (Fig. 6).

Contribution of litter to heterotrophic soil respiration

The litter contributed significantly more than the SOM to HR for the cover's types ($p < 0.1$; Fig. 7). The greatest contribution to HR by the litter was recorded in November 2014 for the three types of forest cover. The contribution of litter to HR does not differ between Euc, Ap and Nat, except for November 2015, when the HR was higher in Euc than Nat.

Principal component analysis

The multivariate model with two principal components (PCA) explained 70.7% of the variation of the data set: PC1 (60.3%) and PC2 (10.1%) (Fig. 8). The variables TC, CMB and LC together contributed 43.4%, TN and NMB 25.9%, and DRsm and DRgr 19.7%. From the PCA analysis, we identified three groups, with NCov and Woodland at the two extremes of the scatter plot and the other forest types are allocated between in the middle. In general, soil CO_2 efflux (TR) was positively correlated with soil moisture (Ms), total TC, TN and CMB.

Discussion

4.1. Effect of plant cover on soil CO_2 efflux

Plant cover can highly influence soil CO_2 efflux (Raich & Tufekciogul, 2000) and removal of native forests and land use changes during mining activities accelerate the TC losses by increasing CO_2 efflux (Lorenz & Lal, 2007; Polglase *et al* ., 2000;). Planting trees is one of the most effective activities in recovering TC stocks of degraded areas (Moghiseh *et al.,* 2013). The present study identified that CO_2 efflux tends to increase with the planting of forest cover. Higher diversity in plant species, together with favorable climate conditions, may result in abundance and diversity of soil microbiological community (Lange*et al* ., 2015). Higher microbial activity may affect the decomposition of tree's residues and SOM, and consequently, the production of soil CO_2.

Planting different types of forest cover led to an increase in CO_2 efflux due to the benefits of increasing SOM. Forest species favor soil microbiological activity by contributing organic material from the shoots and roots that contribute to nutrient cycling, speeding up the ecosystem recovery (Shrestha & Lal, 2006), and which may reflect in the increase in soil CO_2 efflux. While the treatment with no plant covers presented the lower values of CO_2 efflux, the Woodland showed higher values (Fig. 2). Soils of mining areas pose a limitation on plant growth, but our results show that planting forest species is the right way to achieve similar soil CO_2 efflux compared with the unmined Woodland.

The forest types Euc, Ap and Nat showed higher values for CO_2 efflux compared to NCov. Different forest covers can influence the soil chemical and biological properties by the input and composition of organic material from the trees (litter and roots), resulting in an increase of TC and soil biological activity. Different tree species contribute with organic material of different characteristics (Craine & Gelderman, 2011; Martin *et al* ., 2009), which may also affect the soil microbiological activity (Barreto*et al* ., 2008) and the increase of TC. Therefore, differences in root biomass, soil organic matter content, and the spatial arrangement of the trees may contribute to soil CO_2 efflux variations (Katayama *et al* ., 2009; Gomes *et al* ., 2016).

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Optimum soil moisture and temperature conditions combined with higher values for TC, TN, LC, C-MB, N-MB and root density (Table 1), may explain the greater values for CO_2 efflux in Woodland (Figure 3). With favourable conditions of temperature and moisture, soil microorganisms act more intensely and produce more CO_2. In addition, the higher root density in Woodland is associated with the higher soil CO_2 efflux for the same climate conditions. Tree roots are responsible for a large flow of C and nutrients in soil, with respiration accounting for a third or more of the total soil CO_2 efflux in tropical forests (Högberg & Read, 2006). In addition, the amount and quality of available C and photosynthetic activity also influence soil CO_2 concentrations and consequently the efflux (Kuzyakov & Cheng, 2001). Therefore, increasing the diversity of forest species, promotes in time the development of soil microorganisms and roots, resulting in higher rates of CO_2 efflux.

4.2. Autotrophic and heterotrophic respiration

The contribution of soil heterotrophic respiration to total respiration in the forest species was on average 55% during the driest period, and 72% during the wettest period (Figure 3). The relative contributions of heterotrophic and autotrophic respiration are specific context-dependent, since are influenced by local soil temperature and moisture conditions (Liu *et al.* , 2009; Hanson *et al* ., 2000), and by intrinsic plant factors, such as the photoassimilates allocation to roots (Epron *et al* ., 2011; Högberg & Read, 2006). The Ap forest cover showed the highest values for the relative contribution of HR (77.4%) during the rainy season. This result may be related to the high decomposition rate of the leaflets from this type of forest cover compared to the others (Gama-Rodrigues *et al.* , 1997) (Figure 4). Wei *et al* . (2010) analysed a global data of forest ecosystems and also found increases in HR in rainy seasons. Soil microbiota is sensitive to soil moisture and may explain the higher HR contribution of HR to total soil respiration during the rainy season (Carbone *et al* ., 2011). Variations in AR are more dependent on plant photosynthetic activity (Gomes *et al* ., 2016), responding slowly to variations in soil temperature and soil moisture when compared to HR (Bond-Lamberty *et al* ., 2004; Högberg *et al* ., 2008, 2009).

The specific partitioning of heterotrophic respiration showed that the soil CO_2 produced originates mainly from the mineralization of plant residues (Figure 7). Plant residues are relatively easier to be degraded by microorganisms compared to the SOM, which is protected by clay-mineral associations and has been passed by biological degradation. In areas in an initial process of recovery, the microorganisms have a preference to use the most recent added forms of C (Novara *et al* ., 2014).

4.3. Influence of biotic and abiotic factors on CO_2flux

The principal component analysis shows that the planted forests are placed between NCov and Woodland, and follow the same pattern of soil CO_2 efflux (Figure 2). This indicates that the planted forests are improving the soil properties comparing with the treatment with no ground cover and are on the way to the soil quality presented in the native forest.

Soil CO_2 efflux is a complex process and is influenced by biotic and abiotic factors. Soil temperature and moisture are the main abiotic factors that influence these processes (Fenn *et al.* , 2010; Wu *et al* ., 2010), affecting directly the biotic factors, such as microorganisms activity and plant cover. An increase in soil temperature leads to an increase in microorganisms activity (Atkin*et al.* , 2000) and root respiration (Schindlbacher *et al* ., 2011), leading to increases in soil CO_2 efflux. Plant cover with tree species creates a microclimate beneath the canopy that reduces variations in soil temperature, and therefore their influence on soil CO_2 efflux (Gomes *et al* ., 2016). However, in the present study, soil temperature did not vary much during the measurements (Figure 1) and a significative response was not found (Figures 9 and 10). Soil moisture is a very important factor in the maintenance and development of microbial activity (Liu *et al* ., 2009). Our results demonstrated that soil moisture was the most important variable and associated positively with soil CO_2 efflux. While low values of soil moisture at the end of the dry season leading to low values of soil CO_2efflux (Figure 2), the increase of precipitation in the rainy season promoted the increase of soil CO2 efflux values. These fluctuations of soil CO2 efflux are directly linked with microbial activity during the dry and rainy seasons.

Conclusions

In this study, we found that afforestation increases total CO_2 efflux in RMDL compared to those with no vegetation cover.

In afforested RMDL, heterotrophic respiration contributes more to total soil respiration and litter decomposition is responsible for the highest CO_2 efflux.

The variation in moisture is the main factor responsible for the soil CO_2 efflux changes in the types of forest cover studied.

The plantations of Euc, Ap and Nat forest cover were efficient in recovering the mined soils, with similar CO_2 efflux values found under the Atlantic Forest remnant.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix 1. Physical, chemical and biological properties of the soil in an area of bauxite mining in process of recovery with eucalyptus (Euc), angico (Ang) and a mixed plantation of native species (Nat), native forest in the second stage of regeneration (Woodland), and a post-mined area with no ground cover (NCov). Mean values are followed by the standard deviation (n = 6).

Ground cover	Soil layer (cm)	TC	TN	LC	CMB	NMB	Ds	Dp
		dag kg^{-1}	dag kg^{-1}	g kg^{-1}	µg g^{-1}	µg g^{-1}	g cm^{-3}	g cm^{-3}
NCov	0-10	1.44±0.05	0.11±0.00	1.16±0.17	62.16±1.75	18.20±3.17	1.13±0.19	2.73±0.0
Euc	0-10	2.37±0.32	0.17±0.04	1.75±0.64	174.69±46.63	25.84±14.18	1.32±0.14	2.70±0.0
Ang	0-10	2.45±0.61	0.18±0.05	2.08±0.56	153.33±59.62	28.58±8.81	1.26±0.10	2.68±0.0
Nat	0-10	2.10±0.31	0.14±0.02	1.82±0.24	157.98±55.08	23.70±12.32	1.21±0.10	2.70±0.0
Woodland	0-10	5.03±0.51	0.36±0.04	4.54±0.20	705.77±28.26	68.65±6.82	0.97±0.09	2.54±0.0

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