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Comparison of physical-chemical attributes in different areas with gullies from Brazil Novo municipality – PA, Brazilian Amazon

Comparação de atributos físico-químicos em diferentes áreas de voçorocas do município de Brasil Novo – PA, Amazônia Brasileira

Comparación de atributos físicoquímicos en diferentes áreas con cárcavas del municipio Brasil Novo - PA, Amazonia Brasileña

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Abstract
With the agricultural activities occurrence developed in Brazil Novo municipality, Pará, in the Brazilian Amazon, the soils show degradation and compaction, deriving from the inappropriate management of this natural resource. The objective of this research was to evaluate through the data systematization of physical and chemical atributes from studies carried out, involving Permanent Preservation Areas, Pasture and Natural Regenaration, in areas with gullies presence in the Brazil Novo county – PA. Deformed and undeformed samples were collected in all the studied areas to determine the physical and chemical properties of the soil in Pasture (A – high area), Permanent Preservation Area (B – low area) and Natural Regeneration (C – intermediate area), in all points (A, B and C) land's topography (slope) and vegetation cover was considered. In the statistical analysis it was observed that there is no significant difference for

the studied layers (0-20 and 20-40 cm), when evaluated the two studied gullies for the three areas, accepting in this way the nullity hypothesis (H0). The soils were classified as halics with low content of organic matter in Natural Regeneration areas. It is noteworthy that the isolation action of Gully 1(V1) contributed to the natural regeneration, while in Gully 2 (V2) it is necessary anthropic intervention, since it was not made any mitigation procedure from the environmental impacts promoted to the soil natural resource.
Keywords: Erosion; Pasture; Permanent preservation area; Soil degradation.

Resumo
Com a ocorrência de atividades agropecuárias desenvolvidas no município de Brasil Novo, Pará, na Amazônia Brasileira, os solos apresentam degradação e compactação, oriundos do manejo inadequado deste recurso natural. O objetivo desta pesquisa é avaliar através da sistematização dos dados de atributos físicos e químicos de estudos realizados, envolvendo Áreas de Preservação Permanentes, Pastagem e Regeneração Natural, em áreas com presenças de voçorocas no município de Brasil Novo - PA. Em todas as áreas estudadas foram realizados coletas de amostras deformadas e indeformadas para determinação de propriedades físicas e químicas do solo em Pastagem (A – área alta), Área de Preservação Permanente (B – área baixa) e Regeneração Natural (C – área média), em todos os pontos (A, B e C) foram levados em consideração à topografia do terreno (declive) e a cobertura vegetal. Na análise estatística quando avaliadas as duas voçorocas estudadas para as três áreas observou-se que não há diferença significativa para as camadas estudas (0-20 e 20-40 cm), aceitando-se assim a hipótese de nulidade (H_0). Os solos foram classificados como álicos e com baixos teores de matéria orgânica em áreas de Regeneração Natural. Ressalta-se que a ação do isolamento da Voçoroca 1 (V_1) contribuiu para a regeneração natural, enquanto na Voçoroca 2 (V_2) faz-se necessário uma intervenção antrópica, haja vista que não foi realizado nenhum procedimento de mitigação dos impactos ambientais promovidos ao recurso natural solo.
Palavras-chave: Erosão, Pastagem, Área de preservação permanente, Degradação do solo.

Resumen
Debido a la incidencia de las actividades agropecuarias desarrolladas en el municipio de Brasil Novo, Pará, en la Amazonia Brasileña, los suelos presentan degradación y compactación derivadas del manejo inapropiado de este recurso natural. El objetivo de esta investigación fue evaluar, mediante la sistematización de datos de atributos fisicoquímicos del suelo en estudios realizados involucrando Áreas de Conservación Permanente, Pastizales y Zonas de Regeneración Natural en áreas con presencia de cárcavas en el municipio de Brasil Novo, Pará. En todas las áreas estudiadas se recolectaron muestras deformadas y no deformadas para determinar las propiedades físicas y químicas del suelo en Pastos (A – área alta), Áreas de Protección Permanente (B – área baja) y Zonas de Regeneración Natural (C – área intermedia). En todos los puntos (A, B y C) se tomó en cuenta la topografía del terreno (pendiente) y la cobertura vegetal. En el análisis estadístico se observó que no hay diferencia significativa para las capas evaluadas (0-20 cm y 20-40 cm), cuando se evaluaron las dos cárcavas estudiadas para las tres áreas, aceptándose así la hipótesis nula (H0). Los suelos fueron clasificados como hálicos con bajo contenido de materia orgánica en Áreas de Regeneración Natural. Se destaca que la acción de aislamiento de la Cárcava 1 (V1) contribuyó en la regeneración natural, mientras que en la Cárcava 2 (V2) es necesaria una intervención antrópica, dado que no fue realizado ningún procedimiento de mitigación de los impactos ambientales provocados al recurso natural suelo.
Palabras clave: Erosión; Pastos; Área de conservación permanente, Degradación del suelo.

1. Introduction

The water erosion is one of the major causes of superficial soil layer loss (ABDO, et al., 2008). According to Lopes and Guerra (2001), ‘gully’ can be understood as an excavation or soil tearing or decomposed rock, which allows the groundwater table exposure. Among the most different categories of water erosion, the gully is considered the most advanced stage of this erosion type (Ferreira, et al., 2011), causing the soil degradation and compromising large areas (Gomide, et al., 2011).

Nowadays, the deforestation for charcoal manufacture, the soil incorrect use for agriculture, livestock and civil engineering works are the main responsible for the environmental damages that form the gullies (Lepsch, 2010). Anthropic factors, such as fires, deforestation and inadequate management of plantations; passive and active geological factors, pedological factors, active and passive climate factors and geomorphological factors are also pointed out by Bacellar (2006).

Vegetation is a determining factor in the erosion processes dynamics (Bonini, et al. 2013). According to Loschi et al. (2011), studies that seek to know the soil attributes, its floristic composition and the species ecological characteristics occurring in altered environments by gully processes have a lot to contribute with programs that aim the conservation, preservation and the recovery of these ecosystems.

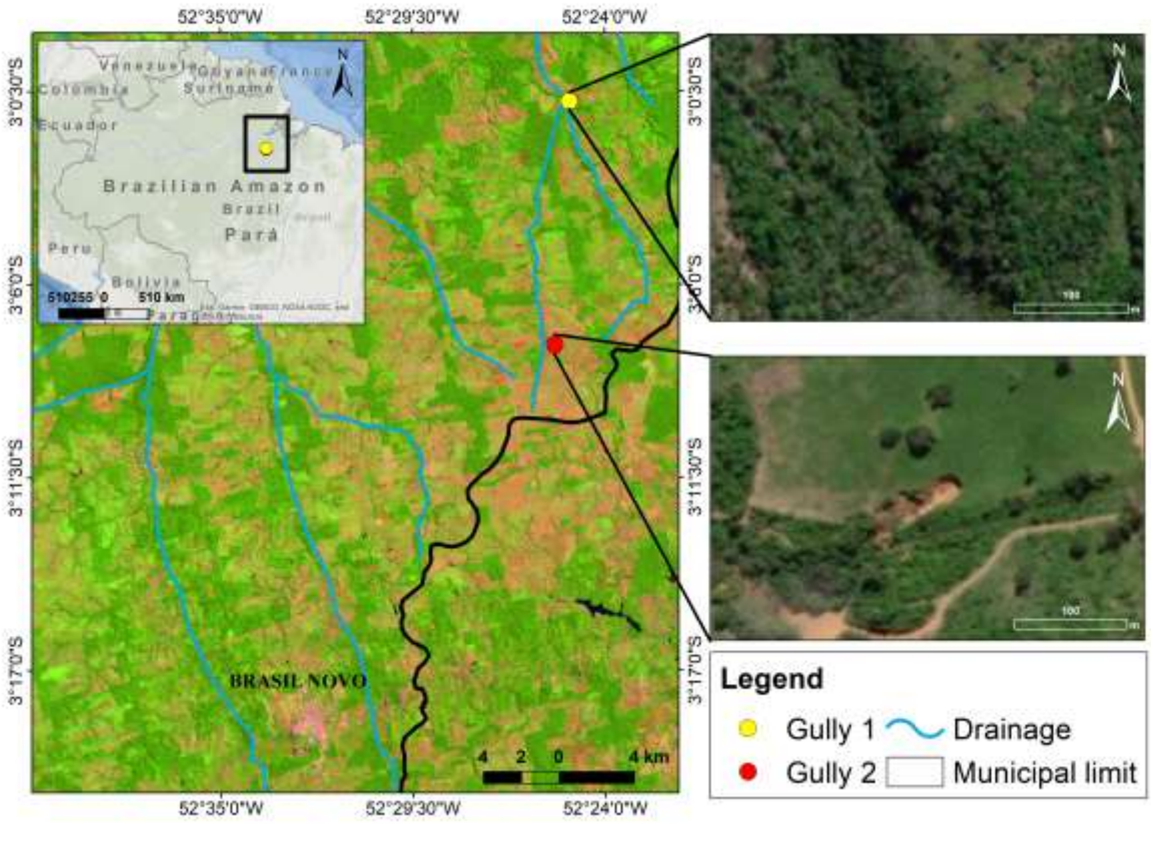
Prevetion must always be considered, since, once installed this erosion form, it becomes almost always unfeasible its elimination, remaining as an alternative its stabilization to avoid the problem intensity (Goulart, 2006). It is worth of mentioning that places where the slope is high, the soil surface was degraded, flood concentration, or due to water runoff influence (Lepsch, 2010), and where there is longer ramp length on lands are more likely to gullies opening, that's why they require a special attention to the management technique use and conservation of soil and water to erosion prevention, and consequently the gullies appearance.

Therefore, the work objective is to realize a diagnosis through data systematization obtained from research with gullies presence in Brazil Novo municipality – PA, under different soil covering, being them, Permanent Preservation Areas, Pasture and Natural Regeneration studied.

2. Methodology

The studies were carried out in Brazil Novo county, in Pará state, in different rural properties. According to the data from Brazil Novo's Environment Municipal Plan (SEMMA, 2019), the annual average temperature from the region is 27,2ºC and the annual average precipitation of 1.680 mm, figures defined by the annual averages of the analyzed stations, in Porto de Moz and Altamira, since there aren't any observation stations in Brazil Novo, having the rainiest months from December through May, and the driest months from June to November. The city vegetation is heterogeneous, formed by fields, scrub and secondary forest. The region soil characteristic is the Yellow Latosol. Below, Figure 1 with the study area location.

Figure 1. Study area location – Gully 1 (Souza, 2018); Gully 2 (Oliveira, 2018).



Source: Authors (2021).

The properties of this study are areas with wavy relief, with approximately 14% slope, equivalent to 6,3º (EMBRAPA, 1979). The areas have approximately nine years old of gully incidence, where their degradation occurred due to inappropriate cutting management and secondary vegetation burning and pasture installation. In the following years, the pasture management was done with soil revolving usage, liming and fertilization. With the water resources proximity, animal trampling, lack of rotated grazing, agricultural implements use, combined with the land's physical and geological properties, it was observed that along from 8 to 12 years the studied pasture areas have been causing severe erosion processes, reaching 23 meters deep and 76 meters wide. Thus, few are the owners who have adopted area isolation for vegetation natural regeneration and APP's recovery or some intervention to the environmental impacts mitigation.

The soil samples were collected in the years 2017 and 2018, in the rainy, between january and february and using the methodology proposed by Santos et. al. (2013), which consists on the gully division into homogeneous units, taking into consideration the land topography and the soil superficial characteristics. Being projected a linear transect on each side of the gully, along each line the collection points were selected, varying between Pasture (high area) APP (low area), besides the point where occurs the highest incidence of vegetation natural regeneration (average area).

The studied depths were 0-20 and 20-40cm. For the soils physical property determination, for density data, it was used undeformed samples on the soil superficial layer, collected with Uhland auger. And the deformed composite samples were collected with a Dutch auger assistance for purposes of soil fertility analysis.

The deformed samples were submitted to the Bulk Soil preparation (BS), in the soil laboratory of Pará's Federal University, Altamira Campus, subsequently sent for chemical analysis at the Rural Federal Universty's laboratory (UFRA), in Belém.

In the chemical analysis, it was determined the Phosphorus contents (P) Potassium (K+), Calcium (Ca2+), Magnesium (Mg2+), Organic Matter (OM), Hydrogenionic Potential (pH), Aluminum (Al3+), Potential Acidity (H+Al), Sum of exchangeable Bases (SB), percentage of Saturation by Bases (V%), percentage of Saturation by Aluminum (m%) and the Cation Exchange Capacity (CEC). The used methodology was proposed by Embrapa (2017), and the results interpretation were based on their reference values.

The undeformed samples were sent to UFPA's soil laboratory/Altamira Campus, for physical analysis, of soil density, and textural classification according to the proposed methodologies respectively by Santos et al. (2013) and Nortcliff (1994).

The statistical analysis was performed through Wilcoxon non-parametric test ($P < 0.05$), considering the values arithmetic average of the nutrients contents obtained from soil samples repetitions into two depths, considering three different areas of two studied gullies.

3. Results and Discussion

The present study shows that the soil density (Ds) of Pastures (high area), APP (low area) and Natural Regeneration (average area) from gully 01, presented averages of 1,20 g.cm^{-3}, 1,37 g.cm^{-3} and 1,34 g.cm^{-3}, respectively. And for gully 02 the Ds presented Pastures averages (high area), APP (low area) and Natural Regeneration (average area), with values ranging from 1,60 g/cm^3, 1,22 g/cm^3 and 1,50 g/cm^3. According to Embrapa for clay soils, the ideal range for density varies from 0,90 a 1,25 g/cm3, where the higher values of soil density, the greater the susceptibility to compaction will be, degraded structure and lowe its total porosity.

For gully 1, it was gotten a lower soil density value, in Pasture Area with 1,20 g/cm^3 in comparison to the other areas. This result is due to adopted management of area isolation, in relation to bovine animals and very close to the natural regeneration area, being essentially constituted by a large well-dense pasture presence, providing in this way the greatest organic matter accumulation to the soils.

For Santos and Salcedo (2010) and Brady and Weil (2013), affirm that the organic matter when present in greater quantities, promotes the soil physical, chemical and biological properties maintenance, mainly in superficial horizons.

Observing the gully 1, the APP's areas and Natural Regeneration were the ones that showed higher density values, being 1,37 g/cm³ and 1,34 g/cm³, respectively. These data show in field, the most degraded soil and with low vegetation biomass production on the soi, the area use historic before the gully was constantly occupied by cattle, being the largest grazing on these areas in previous periods. In accordance with studies by Guareschi et al. (2014) on soils with pastures at the Middle Valley region from Paraíba do Sul, in Pinheiros, the highest density values found in these areas were the animals trampling results, as well as other pressure modalities that promoted the soil compaction, being that the density values obtained by the authors in this study ranged from 1,41 to 1,67 g/cm³.

For the average results attained for gully 2, it was possible to compare with the average parameters proposed by Brady and Weil (2013) indicating that sandy soils with density amplitude varying between 1,25 to 1,75 g/cm-3 with moisture presence can inhibit the penetration and root growth. The presented values in this research show that the soil density is high in Pasture and Natural Regeneration Areas. The soil density in APP area was lower among the studied areas due to the greater quantity of organic residue present.

Similar results were obtained by Sales et al. (2018) when studying four areas with forestry experiments in Paragominas county – PA, it was observed that the secondary forest soil presented density value of 1,02 g/cm³ on the 0-20 cm layer. These data corroborate with the values found in this research in Natural Regeneration Area. For Alves et al. (2015) DS values of 1,40 g/cm³ are restrictive to the roots development.

Natural Regeneration Areas and Pasture showed values of 1,50 and 1,60 g/cm³, respectively. This higher amount at the pasture area represents the soil compaction process, promoting the vegetation natural reestablishment difficulty.

The soil density (Ds) reflects the particles arrangements which, in turn, defines the porous system characteristics. Therefore, higher soil densities reflect lower values for total porosity (LISBOA & MIRANDA, 2014). Thus, it is necessary the techniques usage that provide organic material incorporation.

The obtained results for chemical variables evaluated in the researches are described in Table 1 and Table 2.

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Table 1. Average contents of soil chemical attributes in different gully areas 01 (Souza, W. R, 2018) from the realized study on rural property in Brazil Novo municipality – PA.

Areas (A); (B);

Area	Depth	O.M	V	pH	Al3+	H+Al	m	P	K	Ca	Mg	SB	CEC
	cm	g kg^{-1}	%	H2O	cmolc dm^{-3}	cmolc dm^{-3}	%	mg dm^{-3}	cmolc dm^{-3}	cmolc dm^{-3}	cmolc dm^{-3}	cmolc dm^{-3}	cmolc dm^{-3}
A	0-20	1,35	15,2	4,95	0,55	2,85	52,5	1,5	0,035	0,35	0,1	0,55	3,4
	20-40	0,85	13,8	4,85	0,65	2,80	60,5	1,5	0,02	0,30	0,1	0,45	3,25
B	0-20	0,65	22,2	4,85	0,70	1,55	62,5	1	0,025	0,30	0,1	0,45	2
	20-40	0,75	19,3	4,85	0,65	1,85	61	1	0,02	0,30	0,1	0,40	2,25
C	0-20	1,05	11,1	4,65	0,85	3,55	66	1	0,025	0,30	0,1	0,45	4
	20-40	0,95	12,4	4,75	0,8	3,05	65,5	1,5	0,02	0,30	0,1	0,40	3,45

- High Low

Average (C). Source: Authors (2021).

Table 2. Average contents of soil chemical attributes in different gully areas 02 (Oliveira, W. S, 2018) from the realized study on rural property in Brazil Novo municipality – PA.

Area	Depth	O.M	V	pH	Al3+	H+Al	m	P	K	Ca	Mg	SB	CEC
	cm	g kg^{-1}	%	H2O	cmolc dm^{-3}	cmolc dm^{-3}	%	mg dm^{-3}	cmolc dm^{-3}	cmolc dm^{-3}	cmolc dm^{-3}	cmolc dm^{-3}	cmolc dm^{-3}
A	0-20	15,73	25,96	4,81	0,39	3,6	32,25	1,19	0,03	0,75	0,5	1,28	4,87
	20-40	10,01	30,35	4,8	0,54	3,16	40,07	1,2	0,18	0,65	0,55	1,38	4,54
B	0-20	22,02	33,17	4,44	0,79	4,36	37,81	0,19	0,02	1,3	0,85	2,17	6,53
	20-40	8,58	26,86	4,6	0,44	3,76	33,83	0,79	0,03	0,55	0,8	1,38	5,14
C	0-20	7,44	23,25	4,64	0,49	3,92	46,13	1,45	0,04	0,55	0,6	1,19	5,11
	20-40	5,44	21,3	4,14	0,78	3,76	77,63	0,59	0,02	0,45	0,55	1,02	4,77

Areas - High (A); Low (B); Average (C). Source: Authors (2021).

The results presented in Table 01 show the data from Gully 1, where the organic matter contents are considered low, varying between 0,65 and 1,35 g/kg, the highest values obtained in this research were pasture areas. Santos et al. (2010), points out that in areas with pastures the OM levels were higher only on the most superficial soil layer, giving a better OM distribution in this profile and resulting in a soil with better structure and capacity in water retention and nutrients.

For gully 2 only the Natural Regeneration Areas and APP's showed average levels of soil organic matter on the superficial layer. For Dernadin et al. (2014), the vegetation cover maintenance inn forest areas ensures a greater residues contribution both on the superficial layer and soil sublayer. Salton e Tomazi (2014) report that that the vigorous growth of species root systems, mainly brachiaria, helps in the structures formation in aggregates form on the soil and in the organic matter increase. Thus being able to attribute the land's slope as a determining factor at the OM content of the surface regeneration environment that removes organic residues from the soil surface.

The V% values were low for gullies 1 and 2. For the Gully 1 the values varied from 11,1% and 22,2% and for Gully 2 the amount ranging between 21,3% and 33,17%, i.e., both with figures that characterize as dystrophic soil, of low fertility.

The pH showed high acidity for both studied gullies, being the Gully 1 varying from 4,60 to 4,95 and Gully 2 from 4,14 and 4,81. Similar results were obtained by Oliveira et al. (2017) in soils of São Domingos do Araguaia -PA with values from 4,8 to 4,5. These data allow us to affirm that they are areas with limited nutrient absorption by vegetables, i.e., with reduced nutritional potential. In addition, Michelon et al., (2019) found high pH results in a carried out study evaluating the soil chemical attributes in a no-tillage system with corn for degraded area recovery.

In general the macronutrients values (P, K, Ca, Mg), Base Saturation (SB) and Ion Cation Exchange Capacity (CEC) showed low values for all analyzed areas in both gullies. Centeno et al. (2017), affirm that generally soils with sandy texture have greater deficiencies in organic matter and phosphorus. Dotta et al. (2014) and Oliveira et al. (2017) also obtained low levels of P, K, Ca, Mg in pasture areas at the Amazon region.

In both studies, the Organic Matter input (O.M) on the soil was low, being a limiting factor in the nutrients cycling, which according to Ramos et al., (2018) in tropical soils good OM levels provide a good ion cation exchange capacity, biological activity, aggregates formation, water availability and porous space increase. Assis et al., (2021) in a realized research in Pacajá municipality -PA in a dry and rainy period, also identified organic matter low levels.

Likewise, studies of Silva Junior et al. (2012) on soils in Concordia's municipality-PA presented P levels varying from 1 to 1,8mg.dm^{-3}, also in pasture and natural regeneration areas. Thus, the P low contents found in this research, may be related to the pH that was quite high in all evaluated areas, since the P availability decreases with acidity due to its absorption range required by the cultures, and by the leaching processes of this nutrient.

When the value of Al3+ content is greater than 0,3 cmolc.dm^{-3} and the m% value is higher than 50%, the soil is considered alic. In Gully 1 and 2 the Aluminum contents varied from 0,55 to 0,95 cmolc.dm^{-3} and from 0,39 to 0,85 cmolc.dm^{-3}, respectively.

According to the Wilcoxon test ($P<0,05$) shown in Table 3, it is possible to observe the gullies comparison in both samples (A – high area, B – low area and C – average area) with depths that vary from 0-20 and 20-40 cm, and the comparison within each treatment considering their respective depths.

Table 3. Chemical attributes comparison of soil samples between gully sampling units through Wilcoxon t test application (P<0,05).

Area/Depth	Comparison	Statistics	P-value	Result
0-20 (A)	V1xV2	34	0,6048	= Accept H_0
20-40 (A)	V1xV2	30	0,3865	= Accept H_0
0-20 (B)	V1xV2	29	0,3401	= Accept H_0
20-40 (B)	V1xV2	28	0,2973	= Accept H_0
0-20 (C)	V1xV2	28	0,2973	= Accept H_0
20-40 (C)	V1xV2	31,5	0,4527	= Accept H_0
0-20 (average)	V1xV2	30	0,3865	= Accept H_0
20-40 (average)	V1xV2	30,5	0,4013	= Accept H_0
A (average)	V1xV2	30	0,3865	= Accept H_0
B (average)	V1xV2	28	0,2973	= Accept H_0
C (average)	V1xV2	30	0,3865	= Accept H_0
V1xV2 (average)	V1xV2	30	0,3865	= Accept H_0

A = High Area; B = Low Area; C = Natural Regeneration Area;
V1 = Gully 01 (SOUZA, W. R, 2018); V2 = Gully 02 (OLIVEIRA, W. S, 2018). Source: Authors (2021).

In the statistical analysis when evaluating the two studied gullies for the three studied areas, it was observed that there is no significant difference neither for the superficial layer of (0-20), nor for the depths of (20-40), accepting in this way the nullity hypothesis (H_0). This result is justified by the alic soil characteristic for natural regeneration and the lower OM content observed in this environment. The same also occurred when compared the soil chemical attributes between the depths of each sampling unit, presenting no significant difference, resulting in the alternative hypothesis rejection (Ha) and accepting (Ho).

For gully 01, it was observed that the Natural Regeneration and Pasture didn't obtain significant diferences in the minerals nutrients content on the soil profile. As for natural regeneration, the most superficial layer soil presents better results for chemical attributes when compared to the deeper layer. It can be attributed to the surface runoff process, due to the land's slope and soil particles removal on account of rain action.

Whereas for gully 02, the degradation level was high in all evaluated areas around of this gully, determining that there isn't a smaller or higher aggravating, since it presents similar degradation characteristics in practically all its extension, even where there is the presence of pastures or where natural regeneration is appearing. When it observes the analyzed areas comparisons, they don't present differences. Soil fertility is similar throughout all the gully area, showing with no statistical difference.

In this way, immediate anthropic interventions are necessary in order to guarantee and speed up the recovering process from the soil quality improvement in Gully 2. For Dias-Filho (2015), in areas with pasture presence under under steep relief or where the soil presents with sandy characteristics, care with soil fertility management should be expanded, mainly due to the greater susceptibility of these locals to nutrient losses caused by erosive and leaching processes.

4. Final Considerations

Thereby, the study allows us to conclude that the Gully 1 isolation provided the natural regeneration advantage, while the Gully 2, it makes necessary the intervention implementation to favor the best vegetal recomposition efficiency on the soil, since the area with natural regeneration beginning with nine years old is shown to be fragile within the studied ecosystems. Thus, the erosion control and soil management are the most important aspects to maintain the ecosystems environmental quality.

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