Environmental Diagnosis of Degraded Pasture Areas and Soil Chemical Quality

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Authors' contributions

This work was carried out in collaboration among all authors. Author SFM performed data collection in the field, statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MB and TASLB managed the study analysis, data analysis and helped in the execution of the project. Author BAB managed searches in the literature, translation of the manuscript, all revisions and general corrections together with author EAR. Authors RRS and GAF guided the students during the work. All authors read and approved the final manuscript.

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ABSTRACT

The extensive grazing system is predominant in Brazilian livestock. The lack of adequate management in these areas hinders the performance of the activity and can bring problems related to the environmental degradation of pastures. Therefore, our objective was to perform environmental diagnosis in pasture areas on the Belo Horizonte farm, in the municipality of Dueré-Tocantins in northern Brazil. The environmental diagnosis was made in three pastures composed of *Urochloa brizantha* cv. Marandu (pasture 1, pasture 2 and pasture 3) in the rural property of Belo Horizonte, municipality of Dueré -Tocantins. Degradation was evaluated by the following methods: (a) structured interview of questionnaire to evaluate pasture formation, degradation, recovery and

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maintenance; (b) soil sampling of 0-20 cm layer and (c) visual assessment of the level of environmental degradation. Regarding the first method, the owner reported that the greatest difficulty in adopting conservation pasture practices was the high cost of implementation, which caused only a few practices to be performed. The soil analysis demonstrated that nutritional parameters were lower than the reference values adopted. In the third method, the five parameters: vigor and pasture quality; invasive plant population; soil cover; erosion were evaluated. In the use of these five parameters for evaluation, the individual results were established for each parameter, which ranges from 1 to 4. Only pastures 1 and 3 are in a state of degradation at different levels, 'strong' and 'light/mild', respectively. Reduced soil fertility was found to be one of the causal agents of pasture degradation. Pasture degradation is related to the reduction of soil chemical attributes, such as phosphorus (P), nitrogen (N) and high aluminum (Al) saturation.

1. INTRODUCTION

Brazil holds the second largest cattle herd in the world, with 214.69 million heads and the first commercial herd, second only to India. Still, the income of cattle in the herd has low rates, because it is basically developed in the pasture system, restricting food supplementation. Pasture degradation is of great importance in Brazil, because it directly affects the sustainability of the productive system, considering that the country is one of the largest meat producers in the world [1].

Pasture areas, native and cultivated, are part of the most important components of beef production in the country [2]. The extensive grazing system is a defined and integrated combination of animal, plant, and soil, with grazing as the sole source of protein-energy and food. In addition to pasture being the basis for feeding cattle for meat production, it is possible to explore more productive and economically stable production systems [3].

Among the various genera of fodder planted in the country, the genus *Urochloa* is the most used in Cerrado soils, because it is considered rustic capable of vegetating in poor soils and acids. Despite its rusticity and easy adaptation to various soil types, pastures of *Urochloa* are continuously being degraded, mainly due to low soil fertility, lack of maintenance and inadequate management [4].

Pasture degradation is a worrisome factor, since it is present in all states and biomes of Brazil, at different levels of degradation, proportional to the extent of grazing [5]. The degradation of the areas has compromised the sustainability of livestock production and income in livestock.

Pasture degradation can be explained as a dynamic process of degeneration or relative drop in productivity. It is estimated that 80% of pastures grown in Central Brazil, responsible for more than 55% of national meat production, are degraded. There are several causes that can lead to degradation of pastures in the region; some of these causes include incorrect choice of forage species, lack of fertilization maintenance and inadequate pasture management [6].

Diagnosis of degradation of pastures is important for proper pasture management that will lead to high quality and productive pastures that can supply excellent nutrition for cattle herds.

Some elements are easy to identify in degraded pastures, such as invasive plants, soil erosion, changes in botanical composition and physiological disorders of the dominant plant [7].

Therefore, pastures that have inadequate management can be found in a state of degradation, soil in- stability and changes in vegetation, with a decrease in the pasture area. Therefore, the aim of this study was to perform environmental diagnosis of the pasture areas occupied by *Urochloa brizantha* cv. Marandu in the municipality of Dueré – Tocantins, Brazil.

2. MATERIALS AND METHODS

The study was carried out at the Belo Horizonte rural estate, in the municipality of Dueré, southeast of the State of Tocantins, Brazil. The area is located at coordinates 11º19'27.00"S and 49º19'40.59"W. The regional climate is humid type B1wA'a', with moderate water deficiency, with an average annual rainfall of 1,685 mm and an average annual temperature of 26.9ºC [8]. The soil type is Plinthosol, medium texture

Table 1. Aspects analyzed in the form of visual evaluation for observation of pasture degradation in loco

Parameters evaluated in pasture degradation	Pasture degradation stage	Degree of degradation	Level of pasture degradation
Vigor and quality of pastures	0 %	Grade 0: Absence of pasture degradation (vigorous and good quality, good soil cover by pasture, absence of weeds and no indications of the erosive process).	Absent
Population of forage plants	< 25%	Grade 1 (0+1 sum: Small reduction in forage production, quality, height, and volume, even in times favorable to growth	Slight
Incidence of weeds	25 a 50%	Grade 2 (sum 1+2): Decrease in the area covered by vegetation and small number of plants from natural reseeding, presence of termites.	Moderate
Soil cover by pasture	50 a 75%	Grade 3 (sum 1+2+3): Appearance of invasive species of wide leaves and the beginning of erosive processes by the action of the rains.	Strong
Level of erosion of areas	75 a 100%	Grade 4 (sum 1+2+3+4): Presence of invasive plants in large proportions, colonization of pasture by native grasses and accelerated erosive processes.	Very Strong

Source: Nascimento Jr, et al. [9]

(27.5% to 32.5% clay). Three regions of the species *Urochloa brizantha* cv. Marandu were selected and defined as, pasture 1 (12.1 ha), pasture 2 (9.68 ha) and pasture 3 (8.71 ha).

To perform the environmental diagnosis in the pastures, the following evaluation methods were used: (a) Structured interview for the evaluation of the formation, degradation, recovery and maintenance of pastures was carried out. The owner of the Belo Horizonte property was the only person interviewed. During the application of the questionnaire, care was taken to allow total freedom for the interviewee, so as not to exert any influence on the answers. (b) Analysis of soil chemical properties in the 0-20 cm layer. (c) The visual evaluation of the level of degradation of pastures on site, for which it was used.

The form of visual evaluation considered five parameters of pasture degradation. The parameters were classified according to the stages of pasture degradation studied, for which scores of one to four were established, according to the parameters described. The grades were individually assigned to each parameter, taking into account the degree of pasture degradation (Table 1), and the higher the grade, the lower the degradation, except for erosion and weeds.

According to the characteristics for Cerrado soil conditions on the pasture degradation process, a degradation degree scale ranging from 0 to 4 was established, where the absence of degradation was assigned 0 degree, and the other degrees created with the sum characteristics (0 + 1 = Degree 1; 1+2 = Degree 2; 1 + 2+ 3 = Degree 3; 1 + 2 + 3 + 4 = Degree 4) shown in Table 1 [9].

Subsequently, degradation levels were evaluated and classified using the degrees obtained (degree 0- 4).

3. RESULTS AND DISCUSSION

Parameters evaluated as pasture formation, degradation, recovery, and maintenance, through the questionnaire, showed that the Belo Horizonte farm owner has partial knowledge of the necessary practices for the conservation of pasture areas due to how was his pasture and soil (Table 2).

The owner is aware of most of the questionnaire; however, some activities are put into practice. The greatest difficulty in adopting conservation pasture practices is the high cost of implementation, although the property has already carried out some activities aimed at maintaining pastures, such as weed control, this activity is conducted without specialized technical assistance.

Regarding the characterization of soil chemical properties in the three pastures, virtually all nutritional parameters are lower than the reference value established as good for soil (Table 3). Among the nutrients, P presented the lowest values, with 1.8 mg dm^{-3} for pasture 1, 1.4 mg dm^{-3} for pasture 2 and 1.9 mg dm^{-3} for pasture 3. The reference value for P is 20.1 mg dm^{-3}. However, this is not a point-in-time problem of the studied property; there is a generalized P deficiency in Cerrado soils. Low availability of P, N and high aluminum saturation are the factors that limit the production of forage [10]. The efficiency of the P source is related to the characteristics of soil, forage species and source itself [11].

Urochloas plants are considered capable of vegetating in soils with low available P levels, i.e. they are more efficient in the use of P available in the soil, which requires no more than 45 kg of P_2O_5 ha^{-1} [2]. The fact is that even the *Urochloas,* species cited as less demanding in P, require a minimum of fertilization with this element for an adequate establishment of their pastures.

Phosphorus is of great importance in the establishment of pasture, besides playing a role in plant respiration, it influences storage, transportation, and energy use in the process of photosynthesis, acting in protein synthesis and metabolism of enzymes and, for weeds, it is the most important element after N [2]. P is crucial for the development of root systems, tillering, stolon formation, and besides being fundamental for cell division, due to its role in the structure of nucleic acids [12].

With regard to Al^{3+}, all pastures had values above the reference value, with 0.20 $cmol_c$ dm^{-3}; 0.10 $cmol_c$ dm^{-3}; 0.30 $cmol_c$ dm^{-3} for pastures from 1 to 3, respectively, this requires corrective intervention through limestone. Calcium is important for the development of roots, necessary in the translocation and storage of carbohydrates and proteins, in addition to acting in the formation and integrity of cell wall membranes. Magnesium, on the other hand, makes up the chlorophyll molecule, which gives green color to plants [13].

However, for Saturation Percent by Aluminum (m%) values, with pasture 1 (m% = 8), pasture 2

(m = 4%) and pasture 3 (m = 12%), the values were considered very low, however, the ideal Al in the soil for any type of cultivar is m = 0.0%. With regard to K content, pasture 1 was considered very good with 0.32 $cmol_c$ dm^{-3}, when compared with pastures 2 and 3 (0.14 $cmol_c.dm^{-3}$) and the reference value of 0.20 $cmol_c$ dm^{-3}. Potassium participates in many essential processes in grass, such as photosynthesis, opening and closing of stomata, soil water absorption, enzymatic activities, starch formation and protein synthesis [13]. Potassium deficient grass as a function of plant development leads to thin, fragile stems and no tipping resistance, poorly developed leaves, with uneven coloration, necrotic spots and drying of the tip to the base of the leaf [14]. However, even in pastures 2 and 3, both with 0.14 $cmol_c.dm^{-3}$ there was no disability. It is important to highlight that in pasture 2 the of good quality (Table 5), without nutritional deficiencies in plants.

For base saturation (V %), the values for pasture 1 (31%), pasture 2 (26%) and pasture 3 (24%) were lower than the appropriate reference value for soil contents (60.1%). Base saturation is an excellent indication of the general conditions of chemical soil fertility and can be divided into eutrophic (fertile) soils = V% ≥50%; dystrophic (unfertile) soils = V% <50% [15]. The soils of the three areas were considered as dystrophic (unfertile). This means that there is a small amount of cations, such as Ca^{2+} and Mg^{2+} and K^+ occupying the negative sites of the soil colloids with the remaining sites being occupied by H^+ and Al^{3+} (Table 3).

The soils of the three areas have equal textural classes (Table 4). Pastures 1 and 2 have a clay content of 32.5% and pasture 3 has 27.5%, characterized as the medium texture. The texture presents a certain balance between the contents of sand, silt and clay. Typically, they have a good drainage, good water retention capacity and medium erodibility index. Clay is one of the main colloids responsible for the exchange capacity of cations, for the three pastures both clay and the capacity of cationic exchange have medium values, indicating that, there Silt loam Silt loam are reasonable number of cations of Ca^{2+}, Mg^{2+} and K^+ occupying the negative loads of colloids in addition to H^+ and Al^{3+} (Table 3).

The ability to exchange soil cations represents, therefore, the ability to release several nutrients, favoring the maintenance of fertility for a prolonged period and reducing or avoiding the

occurrence of toxic effects of the fertilizer application [15].

Regarding the determination of the level of degradation of pastures, different types of degradation levels were observed (Table 5). The degradation of Pasture 1 was classified as 'strong' (grade 3), which means that there was a reduction in forage production, quality, height and volume, even at favorable times for the growth and, presence of termites. Soil cover by pasture decreased, however, the number of plants from natural reseeding was not strictly affected. Weed parameters and soil erosion had a medium and low influence on the results, ranging from 25-50% to 0-25%, respectively.

Although weed parameters and soil erosion were medium and low, pasture 1 presented a strong degree of degradation, probably due to other parameters, especially the vigor parameter and quality that presented low values of 0-25%. From the point of view of the chemical analysis, strong degradation (grade 3) can be explained, by very low P values (1.8 g/dm^3), low Ca value (0.9 $cmol_c$ dm^{-3}) and average Mg value (0.5 $cmol_c.dm^{-3}$). The deficiency of these nutrients is harmful to the plant. The typical symptom of P deficiency in grasses is the appearance of grass as if damaged by fire. Calcium deficiency in the plant produces an irregular growth of leaves, resulting in leaves with restricted margins. For Mg, the first evident symptom is chlorosis that appears as light green [13].

In addition to the chemical deficiencies found in pasture 1, the practice of overgrazing was observed in the area, where its support capacity was exceeded. The support capacity of a pasture is expressed in terms of the maximum number of animals supported by the pasture, without causing degradation to it [16]. It is important to highlight that in this area the last recovery activity through pasture reform was carried out six years ago.

All these facts demonstrate the annual need for pasture management to minimize the degradation process. Exceeding the support capacity of a pasture and lack of nutrient replacement are major causes of pasture degradation in Brazil [5]. It is important to emphasize that the support capacity of pastures is very variable due to soil, climate, season and forage species or cultivar. By adopting

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management and maintenance practices in this pasture, the producer could avoid future recovery or renewal practices, which are more costly.

Pasture 2 was classified as having no degradation (Table 5), it presented a vigorous and good quality pasture, good soil cover by pasture and absence of invasive plants and there were no indications of soil erosion. From the perspective of soil chemical analysis, we can

observe that associated with very low Al value and Ca and Mg values of Ca^{2+} 0.5 $cmol_c.dm^{-3}$ and Mg^{2+} 0.4 $cmol_c.dm^{-3}$ respectively. These Ca and Mg values indicate why there was absence (degree 0) of degradation in pasture 2 (Table 5).

The absence of degradation in this area is due to the management practices adopted by the rural owner. In this area, the strategy of recovery of

Table 2. Summary of questionnaire on the formation, degradation, recovery and maintenance of pastures in the rural property of Belo Horizonte, municipality of Dueré – Tocantins

Variables	Farm Belo Horizonte
Soil sampling	-*
Correction	-
Aeration	-
Harrowing	x
Planting fertilization	-
Fertilization in coverage	-
Orientation in pasture formation	-
Meaning of overgrazing	x
Soil erosion	x
Soil compaction	x
Pasture degradation	x
Conservation practices	-
Fire use	-

(-) means that the person is not aware or does not perform the variable; (x) means that the person has knowledge or performs the variable

Table 3. Chemical characterization of the soil of Belo Horizonte farm municipality of Dueré– Tocantins

Soil property/ Pasture	pHCaCl$_2$	P mg dm^{-3}	Ca^{2+}	Mg^{2+}	K$^+$	Al^{3+}	H +Al	CTC	SB	V%
			------------------cmol$_c$ dm^{-3} ------------------							
Reference value.	6.0	20.1	2.41	0.91	0.2	0.0	1.0	8.61	3.61	60.1
Pasture 1	4.4	1.8	0.9	0.5	0.1	0.2	3.4	4.9	1.5	31
Pasture 2	4.3	1.4	0.5	0.4	0.2	0.1	3.1	4.2	1.1	26
Pasture 3	4.3	1.9	0.6	0.3	0.1	0.3	3.1	4.1	1.0	24

Table 4. Textural soil classes of farm Belo Horizonte, municipality of Dueré-Tocantins

Soil Saparates/ Pasture	Clay	Silt	Sand	Textural class
	----------- % -----------			
Pasture 1	22.5	5.0	72.5	Medium
Pasture 2	22.5	5.0	72.5	Medium
Pasture 3	17.5	2.5	80.0	Medium

Table 5. Degradation levels in pasture areas, in the rural property Belo Horizonte, municipality of Dueré-TO

Farm Belo Horizonte	Evaluated parameters						
	VQP	PP	W	PSC	ER	DG	DL
Pasture 1	1	3	2	3	1	3	Strong
Pasture 2	4	4	1	4	1	0	Absent
Pasture 3	3	3	1	3	1	1	Slight

Legend: VQP: Vigor and pasture quality; PP: Plant populations (pastures), W: Weeds; PSC: Soil cover by pasture; ER: Erosion; DG: Degree of degradation; DL: Degradation level

pasture or "pasture reform" was adopted six months ago, the method used was direct recovery with total destruction of vegetation. It is indicated when pasture is in the most advanced stage of degradation there is low forage yield, uncovered soil, high occurrence of invasive species, large amount of termites and ants, low soil fertility and high acidity, high soil compaction and/or soil erosion [5].

This direct recovery option has the highest costs because it requires machinery operations for total soil and conservation preparation. Despite the absence of degradation, the results could have been better, with the performance of soil chemical analysis followed by recommended fertilization and liming. These practices would raise the quality and sustainability of pastures for a longer period.

Pasture 3 presented a mild degradation level (Table 5). This result is mainly due to the low influence of degenerative parameters such as the presence of weeds and erosion, which ranged from 0-25%. With regard to vigor and quality, the population of forage plants and soil cover by pasture, a variation of 50-75 was obtained, which means that there was a small reduction of each of these parameters. Analyzing the chemical attributes of the soil, it can be observed that the values of K, Ca, and Mg (0.1; 0.6; and 0.3 $cmol_c.dm^{-3}$) were considered mean.

Regarding base saturation (V% = 24) when compared to the other areas were considered low. Low V% bases means that there are small amounts of cations, such as Ca^{2+}, Mg^{2+}, and K^+, saturation of the negative loads of colloids and that most of them are being neutralized by H^+ and Al^{3+}. This is, probably, one of the main reasons for the degradation in pasture 3. It should be noted that this pasture has seven years of deployment and the last recovery strategy for pasture reform was carried harrowing and planting grass, out four years ago.

We can observe that soil cover rates by pasture and forage plant population do not vary greatly, remaining on the scale of 3-4 (50-75%, 75-100%) for all pastures. The weed index was in scale from 1 to 2 (0-25%, 25-50%), also for the three pastures. In any case, the vigor and quality parameter varies widely between pasture 1 and pasture 2, with scales of notes 1 and 4 (0- 25%, 75-100%), respectively. Pasture 3 took an intermediate position. There was no scale variation between pastures for the parameter -

soil erosion, the same remained with a score of 1 (0- 25%).

Working with the environmental diagnosis of degraded pasture areas of three properties in Gurupi - Tocantins, [3]. Found different levels of degradation, from a moderate level to a very strong level. Also, according to the same authors, the degradation of the properties was caused not only by the lack of information on the management, but by the absence of the same and suggested a correlation between the chemical composition of the soil and the level of degradation of pasture in all aggravated by the low level of education of the owner on the formation, management and recovery of pastures.

The index of invasive plants observed in pasture 1 may have occurred due to the absence of some management practices, as shown in Table 2. Also, overgrazing affects the support capacity of the pasture and, consequently, results in the fall in vigor and quality. The quality and quantity of forage decrease simultaneously, leaving the soil exposed and without fodder, which leads to the occurrence of invasive plants, because cultivated pastures begin to lose their natural recovery capacity, mainly due to competition from native species [5]. Therefore, the lack of nutrient replacement and the high rate of stocking of this pasture led to high weed indexes, damage of plant vigor and quality resulting in high levels of degradation, which are responsible for the definition of pasture 1 at the level of strong degradation.

Another contributing factor to the deterioration of pastures in the region is climate stress, caused by the concentrated rainy season, which runs from December to March and the prolonged dry season, which can go from May to November according to the station data at the Federal University of Tocantins [17]. Therefore, it is important to adapt the rate of stocking of each growing season and make food supplementation during the dry season, during which period the pressure on pastures increases.

In pastures 2 and 3, the classification of the degradation level (Absent and Mild, respectively), is due to practices of recovery and sealing of pastures adopted by the producer. The sealing of pastures is a way to save "food". It is at the beginning of the rainy season, where pasture sprout vigorously, because of the higher humidity and increased intensity of sunlight, that pasture stems to ensure bulky pasture. The sealing

method alone does not consist of the recovery of degraded pastures; however, it can help in recovery if associated with other practices.

For pasture 1, an alternative would be pasture reform, requiring soil preparation due to low fertility. For soil fertility, soil analysis should be carefully followed, and nutrient replenishment should be done by adding fertilizer. The soil must be upturned over for the installation of a new forage and then sub-soiling to promote unpacking of the soil and leveling harrowing. Although the soil has good drainage and water retention, the practice of level terracing used as a physical barrier to water runoff, would be an excellent alternative for the conservation of pastures in dry periods, allowing the accumulate at the base of the terrace and increasing water infiltration into the soil.

Considering the farmer's knowledge regarding pasture, it is observed that practices of training, management, maintenance, recovery, degradation and low return of livestock activity in Brazil indicate the need for greater technical performance in rural properties [18]. Soil fertility maintenance is fundamental for the persistence of pastures and consequent guarantee of animal production. The degradation of pastures is linked to loss of soil fertility, by factors such as erosion or overgrazing of pasture. To restore soil fertility, all these factors should be corrected and, along with this it is necessary to compensate for nutritional deficiencies, with the use of fertilizers.

4. CONCLUSION

All pastures except pasture 2 are under different degradation levels, ranging from mild level (grade 2) to the strong degradation level (degree 3). Degradation in the property was caused by the absence of management and the practice of overgrazing, especially in pasture 1. This demonstrates a correlation between soil chemical composition and pasture degradation level, where soils with low nutritional availability have a high degree of degradation, and this occurs mainly due to the difficulties encountered by producers in implementing their actions related to pasture formation, management and recovery, a result of the high cost of implementation of these activities.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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