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Analysis of the potential for financial gain through carbon credits with the implementation of biodigesters in the Urban Solid Waste disposal system in Campo Grande – MS

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SUMMARY
The increasing consumption of natural resources in recent years has resulted in the problem of thinking about "what to do with waste". With the population increase, the number of landfills that are created to dispose of waste is progressive, leaving society with these environmental liabilities. This research sought to analyze, continuing other work already carried out, an alternative form of financial gain in the process of implementing a biodigester system in the municipality of Campo Grande – MS. In this way, in addition to reducing the impact on the environment, through the treatment of part of the waste that would be dumped in the landfill, we sought to identify the potential for gain through the generation and sale of carbon credits. Considering two scenarios, one optimistic and one pessimistic, it was possible to identify that in both cases it is advantageous to adopt the carbon credit generation system in the biogas utilization system through biodigesters in the municipality analyzed, with these gains being alternative forms, non-main, of the urban solid waste treatment process.

KEYWORDS: Urban Solid Waste. Biodigestion. Carbon Credit.

INTRODUCTION

In view of the process of anthropization of the environment, one of the visible results is the accumulation of solid waste through "dumps" and landfills. With each passing year, the accumulation increases, with the aggravating factor that we are producing and discarding more waste (ABRELPE, 2020), demanding more and more public resources for its disposal and environmental recovery. Furthermore, the risk of damage to the environment through contamination in the soil and groundwater is constant, even in landfills built with geomembranes to prevent such an incident.

Another environmental impact that results from this disposal process in these locations is the generation of Greenhouse Gases (GHG), which are produced according to the process of decomposition of organic matter that makes up the total mass of Municipal Solid Waste (MSW) that are dumped in these spaces. These GHG come from the anaerobic digestion process, which occurs in the stabilization of organic matter, where microorganisms, in the absence of oxygen and through stages of diverse interactions, consume organic substrates and convert them into methane (CH_4), carbon dioxide. (CO_2), hydrogen sulfide gas (H_2S), ammonia (NH_3) and water (H_2O) (CASSINI, 2003).

The National Solid Waste Policy includes, in its objectives, the recycling and treatment of waste, when possible, as a priority before final disposal (BRASIL, 2010). Therefore, whenever possible, means should be adopted to treat waste, according to its characteristics, seeking not only to comply with the law, but to minimize impacts on the environment.

One of the solid waste treatment processes is through anaerobic digestion, using biodigesters. This process consists of separating the putrescible organic matter that constitutes the MSW mass and sending it to the anaerobic digestion process in facilities that carry out the biodigestion process of the matter. As a result of this process, there is the generation of biogas, largely made up of methane and carbon dioxide, biofertilizer, with high nutritional content for the soil, and generation of inoculum sludge (TENÓRIO, 2015; ALCÂNTARA, ZANG, ZANG, 2022).

These biodigesters make it possible to use this biogas to produce heat energy, through burning. In this process, GHG that would be dispersed by nature, in an anaerobic digestion process in an open location, such as landfills and dumps, are no longer released into the

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atmosphere, mitigating environmental impacts (CASSINI, 2003; EPE, 2008; TENÓRIO, 2015; MARTINS, SILVA, CARNEIRO, 2017; MÜLLER et al 2021). In addition to the heat energy produced in this process, it is possible to account for carbon credits, since carbon and methane are no longer emitted into the atmosphere. To do this, however, it is necessary to have your project duly approved and validated for the issuance of these credits (BRASIL, 2022).

The Kyoto Protocol was an international environmental treaty with the objective of reducing GHG emissions by signatory countries. In this way, each country had its own target for reducing GHG emissions. However, there are countries that have a negative carbon balance (relationship between carbon emissions and carbon capture), that is, they capture more carbon than they emit. In this way, these carbon capture systems can generate "carbon credit", by offsetting the carbon that is generated by another. These credits can be sold between the parties, making several projects economically viable (SOUZA, 2019).

This work aimed to identify the potential for financial gain through the issuance and sale of carbon credits with the implementation of biodigesters in the MSW disposal system in Campo Grande – MS. To do this, it used data from previous research that sought to identify the potential for energy generation through MSW in Campo Grande. The work of Tenório (2015) sought to identify the potential for energy production through the capture of biogas in the municipality's landfill. The second work is a Technical Note developed by EPE – Empresa Brasileira de Energia (2008), which sought to evaluate the entire potential for energy use of MSW, through the capture of biogas in the landfill, through the implementation of an exclusive system of generation of biogas with a biodigester, in addition to evaluating the potential for energy generation through incineration.

In none of the previous works, which are being adopted as the basis for this research, was the potential for financial gain through the creation of carbon credits analyzed. Therefore, the main data were used, in relation to the volume of MSW and gravimetric composition, with updates in relation to the volume according to the population increase in the region. In this way, the aim was to achieve the basic calculations of this project.

METHODOLOGY

To carry out this research, basic data on MSW volume and gravimetric composition from EPE (2008) and Tenório (2015) were used. In this way, it was identified that the volume produced in Campo Grande is 0.7 kg/per capita/day. The composition of putrescible organic matter is 45% (EPE, 2008; TENÓRIO, 2015). This proportion is very close to the national average which, according to ABRELPE (2020) is 45.3%.

The quantity and composition of biogas varies from one study to another, as this depends on the characteristics of the mass of MSW that is generating this gas. Therefore, to measure the amount of biogas, the amount of 75 m³ per ton of putrescible organic matter was considered (EPE, 2008), in accordance with a previous study carried out already considering the characteristics of the site studied. For the composition, the values of 50% methane and 50% carbon dioxide were adopted (EPE, 2008; TENÓRIO, 2015), with a rounding down of the percentage of methane as it is the gas with the greatest environmental impact and, consequently, , greater credit generation capacity.

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Regarding the density of methane gas, Tenório (2015) points to 0.0007168 ton/m³, equivalent to 0.7168 kg/m³. Alcântara, Zang and Zang (2022) point to a lower density, of 0.000656 ton/m³ or 0.656 kg/m³. In another work, Müller et al (2021) advocates a density of 0.0008 ton/m³, equivalent to 0.8 kg/m³. Therefore, it was decided to use the density worked by Tenório (2015) as it is an intermediate value, defining the density of methane at 0.0007168 ton/m³.

Considering that biogas is composed partly of methane and partly of carbon dioxide, it is necessary to use a parameter that weighs the potential impact on the environment according to each gas. The fifth assessment report (AR5 Synthesis Report) from the IPCC (Intergovernmental Panel on Climate Change) uses the "carbon equivalent" as a standardization index, CO_2 e. Therefore, it is necessary to equalize the global warming power of methane to that of carbon dioxide. Using the Global Warming Potential of the Assessment Report Fifth (GWP AR5) presented by the IPCC (2015), we have the value of 1-ton CH_4 equivalent to 28-ton CO_2. In the carbon credit market, each ton of CO_2e. corresponds to a carbon credit, according to the logic that each ton that is no longer emitted allows this quantity to compensate for emissions elsewhere (MARTINS, SILVA, CARNEIRO, 2017; SOUZA, 2019).

According to this information, we have the following data that will serve as a basis for calculations and projections:

Table 1: Information summary table

Daily per capita production of MSW: 0.7 kg/day or 0.0007 ton /day
Putrescible organic matter (45%): 0.315 kg/day/per capita or 0.000315 ton /day/per capita
Biogas volume: 0.075 m³/kg or 75 m³/ton
Methane composition in biogas: 50%
Methane density: 0.0007168 ton/m³
GWP AR5: 1-ton CH4 = 28-ton CO2e

Source: Own authorship.

In this way, the following calculations are obtained:

Table 2: Summary table of the calculations for the quantification of Ton. CO_2 eq./year/per capita.

$Volume\ biogas/day\ (m^3)/per\ capita = (0{,}0007 \times 0{,}45) \times 75$
$Volume\ biogas/day\ (m^3)/per\ capita = 0{,}023625$
$Volume\ methano/day\ (m^3)/per\ capita = 0{,}023625\ \times 0{,}5$
$Volume\ methano/day\ (m^3)/per\ capita = 0{,}0118125$
$Ton\ CH4/day/per\ capita = 0{,}0118125\ \times 0{,}0007168$
$Ton\ CH4/day/per\ capita = 0{,}0000084672$
$Ton\ CH4/year/per\ capita = 0{,}0000084672\ \times 365$
$Ton\ CH4/year/per\ capita = 0{,}003090528$
$Ton\ CO2e/year/per\ capita = 0{,}003090528\ \times 28$
$Ton\ CO2e/year/per\ capita = 0{,}086534784$

Source: Own authorship.

This means that, according to data obtained in previous research, each inhabitant of the municipality of Campo Grande emits 0.086534784-ton CO_2e per year. To be able to calculate the municipality's total emissions, simply multiply by the number of inhabitants. The estimated population, for the year 2021, was 961,001 inhabitants (IBGE, 2021), with a total emission of 79,266-ton CO_2e in the year 2021. To carry out the calculations, the annual growth rate projection was used, which for the municipality is 0.66% per year (IBGE, 2021).

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RESULTS AND DISCUSSION

To quantify the total potential for generating carbon credits through the anaerobic digestion process using biodigesters, it was necessary to project the population increase, according to the information collected, considering the information on the production of CO_2 eq. /year per inhabitant, considering the latest information recorded by IBGE (2021) projecting until the year 2045.

Table 1: Projection of population growth and emission CO_2e/year.

Year	Population*	Ton CO2e/year
2021	916,001	79,266
2022	922,047	79,789
2023	928,132	80,316
2024	934,258	80,846
2025	940,424	81,379
2026	946,631	81,916
2027	952,878	82,457
2028	959,167	83,001
2029	965,498	83,549
2030	971,870	84,101
2031	978,285	84,656
2032	984,741	85,214
2033	991,241	85,777
2034	997,783	86,343
2035	1,004,368	86,913
2036	1,010,997	87,486
2037	1,017,670	88,064
2038	1,024,386	88,645
2039	1,031,147	89,230
2040	1,037,953	89,819
2041	1,044,803	90,412
2042	1,051,699	91,009
2043	1,058,640	91,609
2044	1,065,627	92,214
2045	1,072,660	92,822

Source: Own authorship.
*Projection according to the annual population growth rate (IBGE, 2021).

It is important to highlight that, when we talk about carbon credits, there are numerous types of titles according to the origin of the capture carried out. There are credits that refer to domestic consumption, industrial production, renewable energy, land use and occupation, agricultural production, waste disposal and energy efficiency. The Ecosystem Marketplace[1] is a non-governmental, non-profit platform that aims to gather information regarding the carbon market around the world. To carry out the calculations relating to carbon credit values, data from the Ecosystem Marketplace database relating to carbon credit values relating to renewable energy were used, which includes the production and use of biogas.

Within the renewable energy category, there are credits referring to the production of biogas, hydroelectric, solar, biomass, wind and geothermal. Each one has a different value, with

[1] https://www.ecosystemmarketplace.com/

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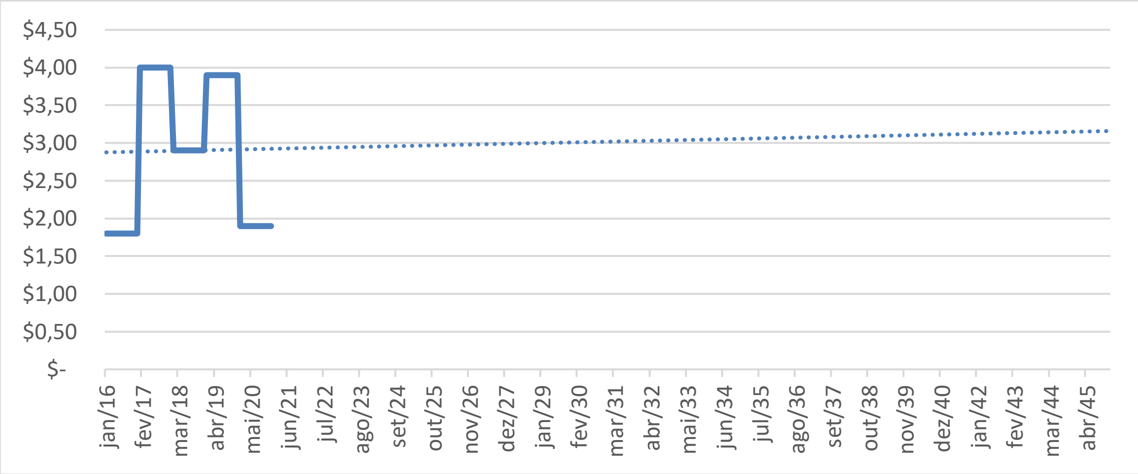
biogas being the most expensive within this category. The values available on the Ecosytem Marketplace platform refer to an average across all types of credit within each category. Therefore, the values that will be used here are still below the real market values, since on average, the price of the biogas credit (most expensive in the category) is pushed down due to other credits that have lower prices.

On the platform, values from 2016 to 2020 are available, based on the annual average. Therefore, it was necessary to perform a linear regression calculation to identify the projected values for future years.

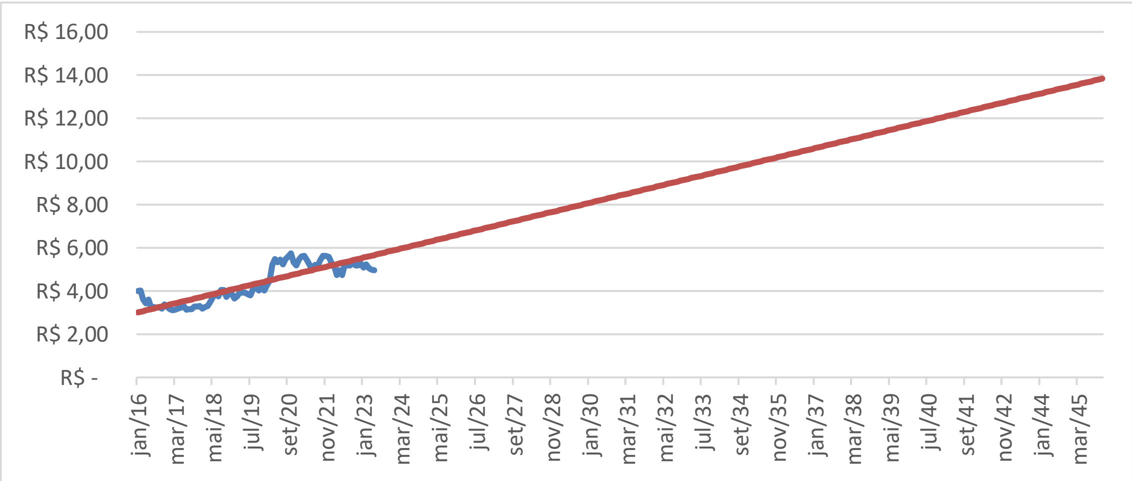
Graph 1: Projection, through linear regression, of biogas carbon credit prices.



Source: Own authorship.

Prices on the carbon credit market are expressed in dollars. As the official Brazilian currency is the real, a linear regression calculation was also carried out to project dollar exchange rates for future moments. The difference is that in this exchange rate history, the period with information collected to calculate the regression is longer, covering from January 2016 to April 2023.

Graph 2: Projection, through linear regression, of dollar exchange prices.



Source: Own authorship.

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Having made these calculations, it was possible to make a projection, through linear regression, of the values of carbon credits, in dollars, and the exchange rate from 2016 to 2045. As the information regarding the population quantity starts in 2021, as shown in table 1, projection values from 2021 to 2045 were used.

Table 2: Projection of carbon credit prices and exchange rate.

Year	Carbon Credit Price	Exchange rate US$	Credit Price in BRL
2021	$2.93	BRL 4.82	BRL 14.14
2022	$2.94	BRL 5.51	BRL 16.23
2023	$2.95	BRL 5.88	BRL 17.35
2024	$2.96	BRL 6.21	BRL 18.39
2025	$2.97	BRL 6.57	BRL 19.52
2026	$2.98	BRL 6.93	BRL 20.66
2027	$2.99	BRL 7.32	BRL 21.90
2028	$3.00	BRL 7.66	BRL 22.97
2029	$3.01	BRL 8.02	BRL 24.13
2030	$3.02	BRL 8.38	BRL 25.30
2031	$3.03	BRL 8.74	BRL 26.48
2032	$3.04	BRL 9.10	BRL 27.66
2033	$3.05	BRL 9.46	BRL 28.85
2034	$3.06	BRL 9.83	BRL 30.05
2035	$3.07	BRL 10.19	BRL 31.26
2036	$3.08	BRL 10.55	BRL 32.47
2037	$3.09	BRL 10.91	BRL 33.69
2038	$3.10	BRL 11.27	BRL 34.91
2039	$3.11	BRL 11.64	BRL 36.14
2040	$3.12	BRL 12.00	BRL 37.38
2041	$3.13	BRL 12.36	BRL 38.63
2042	$3.13	BRL 12.72	BRL 39.88
2043	$3.14	BRL 13.08	BRL 41.14
2044	$3.15	BRL 13.45	BRL 42.41
2045	$3.16	BRL 13.81	BRL 43.68

Source: Own authorship.

Considering that in the carbon credit market, each ton of CO_2e corresponds to a carbon credit, with the logic that each ton that is no longer emitted allows this quantity to offset the emission elsewhere (MARTINS, SILVA, CARNEIRO, 2017; SOUZA, 2019), and, considering the previous calculations presented in table 1, with the projection of population growth with the emission of CO_2e/year, it was possible to calculate the values with the sale of possible captured carbon credits (through the process of using biogas produced in biodigesters in the digestion system anaerobic).

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Table 3: Projected earnings/year, considering the variation in credit quotation and exchange rate variation.

Year	Population	Ton CO2e/year	Price in BRL	Earnings projection/year
2021	916,001	79,266	BRL 14.14	-
2022	922,047	79,789	BRL 16.23	-
2023	928,132	80,316	BRL 17.35	-
2024	934,258	80,846	BRL 18.39	-
2025	940,424	81,379	BRL 19.52	-
2026	946,631	81,916	BRL 20.66	BRL 1,692,732.52
2027	952,878	82,457	BRL 21.90	BRL 1,806,082.47
2028	959,167	83,001	BRL 22.97	BRL 1,906,458.31
2029	965,498	83,549	BRL 24.13	BRL 2,016,197.32
2030	971,870	84,101	BRL 25.30	BRL 2,127,886.38
2031	978,285	84,656	BRL 26.48	BRL 2,241,550.32
2032	984,741	85,214	BRL 27.66	BRL 2,357,214.22
2033	991,241	85,777	BRL 28.85	BRL 2,474,903.44
2034	997,783	86,343	BRL 30.05	BRL 2,594,643.61
2035	1,004,368	86,913	BRL 31.26	BRL 2,716,460.63
2036	1,010,997	87,486	BRL 32.47	BRL 2,840,380.70
2037	1,017,670	88,064	BRL 33.69	BRL 2,966,430.28
2038	1,024,386	88,645	BRL 34.91	BRL 3,094,636.11
2039	1,031,147	89,230	BRL 36.14	BRL 3,225,025.25
2040	1,037,953	89,819	BRL 37.38	BRL 3,357,625.01
2041	1,044,803	90,412	BRL 38.63	BRL 3,492,463.02
2042	1,051,699	91,009	BRL 39.88	BRL 3,629,567.19
2043	1,058,640	91,609	BRL 41.14	BRL 3,768,965.74
2044	1,065,627	92,214	BRL 42.41	BRL 3,910,687.19
2045	1,072,660	92,822	BRL 43.68	BRL 4,054,760.35
				∑ BRL 56,274,670.07

Source: Own authorship.

Gains in the years 2021 to 2025 were not considered, considering that 2021 to 2023 are periods already realized, and past gains are not possible. And for the years 2024 and 2025 they were not accounted for, due to a lack of time necessary for the possible adoption of such technology and adaptation to the project for the effective generation of credit via a biogas capture project through anaerobic digestion in biodigesters. According to the calculations carried out, it was possible to identify a total earning potential, for a period of 20 years, between 2026 and 2045, of BRL 56,274,670.07 (fifty-six million, two hundred and seventy-four thousand, six hundred and seventy reais and seven cents), only with the sale of carbon credits from the system.

Still, it is possible to consider an even more pessimistic scenario, considering the lower carbon credit price and a static exchange rate scenario. Therefore, when considering the lowest value recorded so far, of US$ 1.80, and considering an exchange rate of BRL 4.95 (average exchange rate during the period of the research), we have the following values.

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Table 4: Projected earnings/year, considering credit quotation and fixed exchange rate variation.

Year	Population	Ton CO2e/year	Fixed price ($ 1.80 credit and exchange rate BRL 4.95)
2021	916,001	79,266	-
2022	922,047	79,789	-
2023	928,132	80,316	-
2024	934,258	80,846	-
2025	940,424	81,379	-
2026	946,631	81,916	BRL 729,875.85
2027	952,878	82,457	BRL 734,693.03
2028	959,167	83,001	BRL 739,542.01
2029	965,498	83,549	BRL 744,422.99
2030	971,870	84,101	BRL 749,336.18
2031	978,285	84,656	BRL 754,281.80
2032	984,741	85,214	BRL 759,260.06
2033	991,241	85,777	BRL 764,271.17
2034	997,783	86,343	BRL 769,315.36
2035	1,004,368	86,913	BRL 774,392.84
2036	1,010,997	87,486	BRL 779,503.84
2037	1,017,670	88,064	BRL 784,648.56
2038	1,024,386	88,645	BRL 789,827.24
2039	1,031,147	89,230	BRL 795,040.10
2040	1,037,953	89,819	BRL 800,287.37
2041	1,044,803	90,412	BRL 805,569.26
2042	1,051,699	91,009	BRL 810,886.02
2043	1,058,640	91,609	BRL 816,237.87
2044	1,065,627	92,214	BRL 821,625.04
2045	1,072,660	92,822	BRL 827,047.76
			∑ BRL 15,550,064.35

Source: Own authorship.

Considering the fixed price, at the lowest carbon credit quotation, until then, with a fixed exchange rate of BRL 4.95, we have a total result of BRL 15,550,064.35 (fifteen million, five hundred and fifty thousand, sixty-four reais and thirty-five cents) of revenue from the sale of carbon credits by biogas capture project through anaerobic digestion in biodigesters. As in table 3, the values for the years 2021 to 2025 were suppressed, for the reasons already explained.

Through table 5 we can make a comparison between the two calculations, with the projections according to linear regression of prices and exchange rates and between the fixed value already described.

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Table 5: Projection of earnings/year, considering fixed credit quotation and exchange rate variation and considering the variation in credit quotation and exchange rate variation.

Year	Population	Ton CO2e/year	Fixed projection/year	Variable projection/year	Fixed per capita/year	Per capita/year variable
2021	916,001	79,266			BRL -	BRL -
2022	922,047	79,789			BRL -	BRL -
2023	928,132	80,316			BRL -	BRL -
2024	934,258	80,846			BRL -	BRL -
2025	940,424	81,379			BRL -	BRL -
2026	946,631	81,916	BRL 729,875.85	BRL 1,692,732.52	BRL 0.77	BRL 1.79
2027	952,878	82,457	BRL 734,693.03	BRL 1,806,082.47	BRL 0.77	BRL 1.90
2028	959,167	83,001	BRL 739,542.01	BRL 1,906,458.31	BRL 0.77	BRL 1.99
2029	965,498	83,549	BRL 744,422.99	BRL 2,016,197.32	BRL 0.77	BRL 2.09
2030	971,870	84,101	BRL 749,336.18	BRL 2,127,886.38	BRL 0.77	BRL 2.19
2031	978,285	84,656	BRL 754,281.80	BRL 2,241,550.32	BRL 0.77	BRL 2.29
2032	984,741	85,214	BRL 759,260.06	BRL 2,357,214.22	BRL 0.77	BRL 2.39
2033	991,241	85,777	BRL 764,271.17	BRL 2,474,903.44	BRL 0.77	BRL 2.50
2034	997,783	86,343	BRL 769,315.36	BRL 2,594,643.61	BRL 0.77	BRL 2.60
2035	1,004,368	86,913	BRL 774,392.84	BRL 2,716,460.63	BRL 0.77	BRL 2.70
2036	1,010,997	87,486	BRL 779,503.84	BRL 2,840,380.70	BRL 0.77	BRL 2.81
2037	1,017,670	88,064	BRL 784,648.56	BRL 2,966,430.28	BRL 0.77	BRL 2.91
2038	1,024,386	88,645	BRL 789,827.24	BRL 3,094,636.11	BRL 0.77	BRL 3.02
2039	1,031,147	89,230	BRL 795,040.10	BRL 3,225,025.25	BRL 0.77	BRL 3.13
2040	1,037,953	89,819	BRL 800,287.37	BRL 3,357,625.01	BRL 0.77	BRL 3.23
2041	1,044,803	90,412	BRL 805,569.26	BRL 3,492,463.02	BRL 0.77	BRL 3.34
2042	1,051,699	91,009	BRL 810,886.02	BRL 3,629,567.19	BRL 0.77	BRL 3.45
2043	1,058,640	91,609	BRL 816,237.87	BRL 3,768,965.74	BRL 0.77	BRL 3.56
2044	1,065,627	92,214	BRL 821,625.04	BRL 3,910,687.19	BRL 0.77	BRL 3.67
2045	1,072,660	92,822	BRL 827,047.76	BRL 4,054,760.35	BRL 0.77	BRL 3.78

Source: Own authorship.

In this last table it is possible to make a comparison using the two projections, one more optimistic, considering the projections of quotations and exchange rates according to a certain historical series and another more pessimistic, considering the gains based on these frozen values, credit at the lowest level already achieved and the dollar at a fixed rate.

It is important to highlight that, especially in the projection with variable values, even though it appears to be the closest to reality according to the known history, there is a risk that the values will not materialize, given that the market changes according to supply and demand. The more credit enters the market, the greater the supply, which can push prices down if it is not accompanied by an increase in demand. Likewise, it is possible that there will be an increase in the number of future buyers, pushing demand and, consequently, prices upwards. In this way, it is possible that the real values that will be achieved in future years will be higher than those projected, as well as there is a risk of being lower.

CONCLUSIONS

The results presented meet the proposed objectives of analyzing the potential for financial gain through carbon credits, once implementing biodigester systems in the MSW disposal system in Campo Grande – MS. As previously described, the objective was not to analyze the economic viability through the implementation of this technology, as this had

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already been done in previous works that served as the basis for the formulation of this research. Considering that EPE (2008) identified the economic viability for the implementation of energy use systems, via biodigestors and incineration, and Tenório (2015) via capture of biogas from the landfill, the objective was, then, to take the data already collected to calculate how much it would be possible to benefit from, in addition to energy use, through the sale of carbon credits emitted in the capture process.

Assuming that the biodigester system is implemented in the Campo Grande MSW collection and disposal system, the potential for biogas generation was identified, according to the volume of mass emitted and its gravimetric characteristics. With this, it was possible to calculate the amount of CO_2e which would be prevented from being released into the atmosphere, through the energy use of biogas. Thus, two scenarios were calculated: a more optimistic one and a more pessimistic one.

In the optimistic scenario, the amount of BRL 56,274,670.07 (fifty-six million, two hundred and seventy-four thousand, six hundred and seventy reais and seven cents) generated from the commercialization of carbon credits over twenty years was calculated, from 2026 to 2045. However, as it is a volatile market, these prices can fluctuate up and down, depending on current supply and demand movements.

In the pessimistic scenario, considering the lowest carbon credit price used and considering the dollar price fixed at the average at the time of the research, the amount of BRL 15,550,064.35 (fifteen million, five hundred and fifty thousand, sixty-eight four reais and thirty-five cents) over the same twenty-year period. Likewise, this price can change up or down, depending on fluctuations. However, within what was calculated, it is unlikely that the actual result will be lower than predicted, tending to present greater gains.

In this way, this research managed to achieve the proposed objective, demonstrating that it is possible to obtain revenue from the commercialization of carbon credits, once the biodigestor system for the treatment of urban solid waste in Campo Grande is adopted and implemented. In this scenario, the real gains obtained from the MSW capture and disposal system would come through recycling, the sale of energy generated through biogas and through the commercialization of carbon credits, thus managing to carry out the treatment of a large part of the mass of MSW generated (by recycling and biodigestion), resulting in a decrease in the volume of mass that would actually be discarded in the landfill.

Such measures, in addition to extending the useful life of the landfill, would serve as a practical example for environmental education in the municipality, and could help in the formation of more conscious future generations.

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