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Assessment of per Capita Contribution to Fecal Sewage in Rural Residences of *Quilombola* Communities

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Abstract: The universalization of basic sanitation remains a challenge. For the development of sanitation infrastructure projects, it is essential to use water consumption data that accurately reflect reality, ensuring greater precision. This study aimed to determine the per capita contribution to fecal sewage (Cp) in six *quilombola* residences in Goiás (Brazil). The research was conducted in two phases: (a) a literature review on Cp in similar communities (CpL) and (b) the determination of Cp in six residences from different rural communities (CpP), varying in the number of inhabitants (8, 8, 5, 2, 1, and 1 persons in households R1 to R6, respectively). Flow measurements were obtained using a volumetric flowmeter (nominal flow rate of 1.5 m^3/h) installed in the water pipeline supplying the toilet(s) of each household. A dearth of Cp data was observed in the literature, particularly for rural areas. Research on this topic remains in its infancy, as evidenced by the small number of publications (nine papers) published between 2006 and 2022, of which 44.4% reported on-site measurements. In the present study, the CpP ranged from 12.10 L/cap.day to 21.79 L/cap.day, with a mean of 16.22 L/cap.day (CV = 0.239). These calculated values lie within the lower (9.9 L/cap.day) and upper (51.5 L/cap.day) ranges reported in the literature. Generally, estimated data are higher than values calculated from flowrate measurements, highlighting the importance of direct measurements—which can also help reduce construction costs. Therefore, it is recommended that flowrate measurements and Cp calculations be expanded to residences with diverse demographic and geographic characteristics, also incorporating meteorological data, to obtain more accurate results.

Keywords: flowrate measurement; fecal sewage; sewage per capita; design parameter; rural community; rural households

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1. Introduction

Worldwide, approximately 2.3 billion people lack access to basic sanitation infrastructure [1], and about 1.8 billion consume water without protection against fecal pathogens [2]. Furthermore, 80% of untreated wastewater is returned to the ecosystem [3], potentially compromising human and environmental health. In developing countries such as Brazil, providing basic sanitation services is a significant challenge, with universal access goals set for 2033 [4]. Isolated or remote areas, particularly rural communities, often lack access to potable water and adequate sanitation systems, resulting in a significant deficit [5]. In these areas, the population frequently lacks technical guidance for the environmentally appropriate disposal of wastewater, posing public health concerns and increasing social vulnerability. The absence or inadequacy of basic sanitation contributes to the spread of waterborne diseases, including those transmitted by insects [6]. Therefore, sustainable and low-cost solutions are essential to achieve Sustainable Development Goal 6 (SDG 6) regarding clean water and sanitation.

This study aimed to accurately determine the per capita contribution to fecal sewage (Cp) in rural households, focusing on water consumption associated with toilet flushing—a major component of household wastewater. The accurate estimation of Cp is crucial for designing decentralized sanitation systems that are both efficient and environmentally sound. The objective is to generate reliable, context-specific data that can refine wastewater volume estimates, thereby minimizing contamination risks due to overflows or leaks in treatment systems such as septic tanks [7–9].

The novelty of this research lies in its focus on rural settings, where most available Cp data are based on urban populations. Relying solely on urban data risks underestimating or overestimating design parameters for rural sanitation projects, even when including safety factors. By being one of the first studies to obtain and report Cp values specifically in rural contexts, this work fills an important gap in the literature and provides essential parameters that can guide future projects. This innovative approach not only supports the development of sustainable, low-cost sanitation systems but also contributes significantly to achieving SDG 6 (water and sanitation for all) [10–12].

Accurate water consumption data are indispensable for designing sanitation projects—such as sizing wastewater collection and treatment systems—and for selecting appropriate solutions [7]. Reliable data can help prevent contamination issues that arise from system failures, such as overflows or leaks in septic tanks, which can contaminate groundwater and watercourses [8,9]. The literature reports a wide range of Cp values based on flowrate measurements or estimates, ranging from 9.9 L/cap.day [13] to 51.5 L/cap.day [14]. However, most of this information pertains to urban areas rather than rural settings. The use of urban-based data in rural contexts can lead to inaccurate design parameters that do not reflect reality. Hence, this study addresses a critical need for context-specific data on rural wastewater generation, providing valuable insights for the design of decentralized sanitation systems.

By integrating these findings into the design process, planners and engineers can develop sanitation solutions that more accurately meet the needs of rural communities. This research not only aims to improve public health and environmental protection but also contributes to the broader goal of reducing social vulnerability in under-served regions.

2. Materials and Methods

2.1. Study Area

This study investigated the per capita contribution to fecal sewage (Cp) in residences in six rural *quilombola* communities in the state of Goiás, located in the Midwest region of Brazil (Figure 1). The region has a tropical climate with a dry season from May to September and a rainy season from October to April, with an average annual rainfall of 1529 mm [15]. It is entirely located within the Cerrado biome, where the average annual temperature ranges between 20 °C and 24 °C [16].

The selected communities are certified by the Fundação Cultural Palmares [17] and consist of ethnic–racial groups with a unique historical trajectory, characterized by specific territorial ties and black ancestry associated with resistance to historical oppression [18]. These *quilombola* communities, which vary in the number of inhabitants (Table 1), are among the 29 types of traditional peoples and communities recognized in Brazil [19]. They consist of communities ranging from 10 to 42 families, with 3 to 5 persons per household (Table 1). The criteria for selecting the six communities were the following:

(i) Residences with an indoor bathroom;

(ii) Bathrooms equipped with a toilet featuring a coupled or elevated flush tank;
(iii) Not having other sources of fecal sewage such as urinals or toilets without flushing;
(iv) Willingness to record readings at least weekly;
(v) Feasibility of installing a water meter;
(vi) Uninterrupted water supply.

The households located in the studied rural area typically separate fecal sewage (from the toilet), which is directed to rudimentary septic tanks, from gray water (originating from showers, sinks, and basins), which is disposed of directly on the ground surface [5]. This separation helps prolong the lifespan of the rudimentary septic tank, which receives the fecal sewage, the component with the highest contamination potential. Thus, it was part of the scope of the present study to determine the per capita contribution of fecal sewage exclusively (blackwater—feces and yellow water—urine), without accounting for greywater, as the fecal content can be disregarded since the hydraulic and sanitary equipment (kitchen sink, washbasin, shower) are not fecal deposits.

The water supply is provided either by a collective system or by an individual alternative solution, derived from deep tubular wells or springs (Table 1).

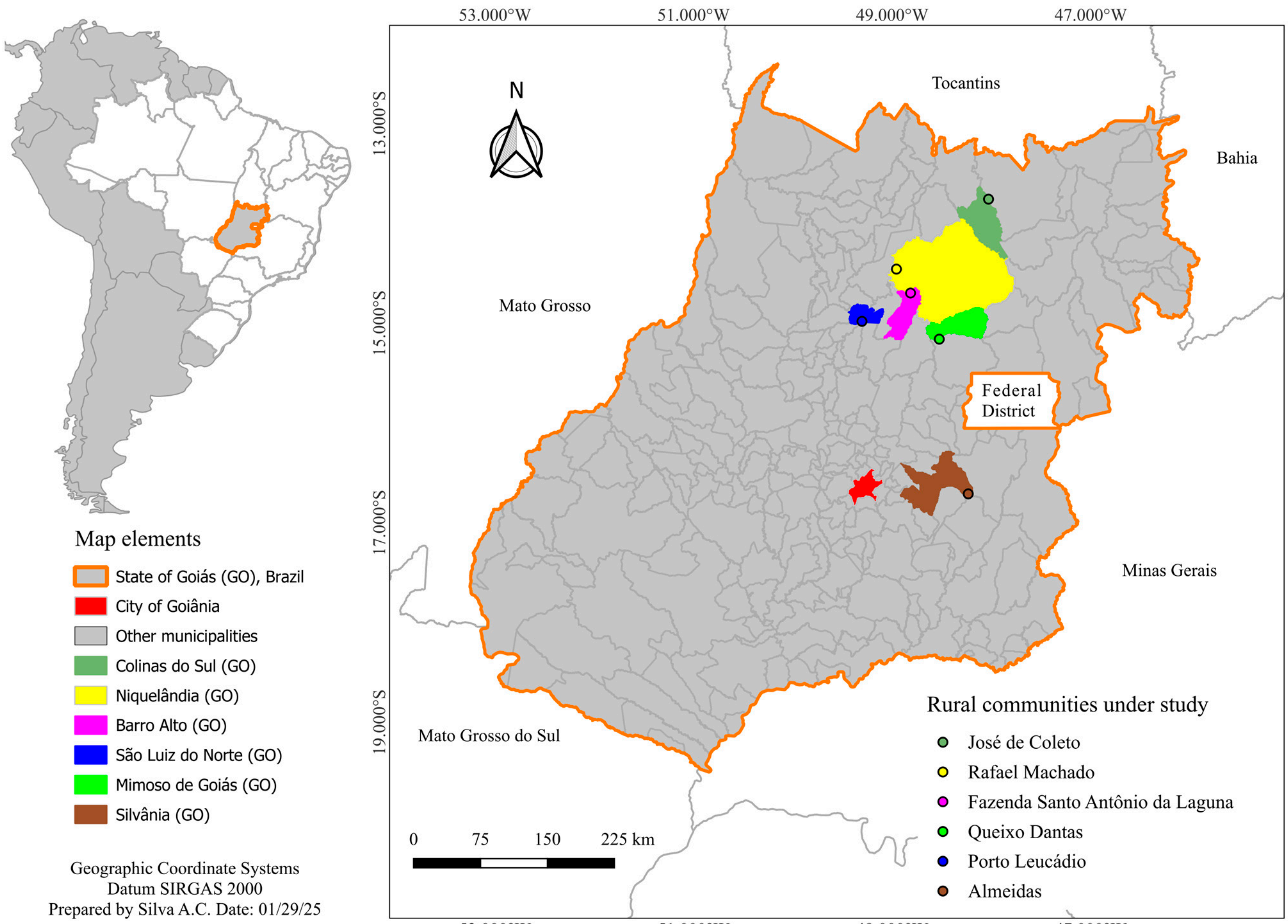

Figure 1. Map of Brazil showing the location of the state of Goiás and the geographical distribution of the communities under study (the capital of the State, Goiânia, is marked in red).

Table 1. Description of the *quilombola* communities under study.

Code	Name of Quilombola Community	Water Source	Municipality	Number of Residents Per Household	Total Households and Estimated Population (cap/HH)	Distance from Goiânia * (km)
R1	Almeidas	WSS (a)	Silvânia	8	42 (3 cap/HH [20]	83
R2	Queixo Dantas	WSS (a)	Mimoso de Goiás	8	17 (5 cap/HH [21]	267
R3	Porto Leucádio	WSS (b)	São Luíz do Norte	5	10 (4 cap/HH) [22]	246
R4	Fazenda Santo Antônio da Laguna	IAS (b)	Barro Alto	2	18 (3 cap/HH) [23]	249
R5	José de Coleto	WSS (b)	Colinas do Sul	1	11 (3 cap/HH) [24]	393
R6	Rafael Machado	IAS (b)	Niquelândia	1	18 (4 cap/HH) [25]	377
Total	6 communities				132 households	

Notes: * capital of the Goiás State; WSS: water supply system (collective); IAS: individual alternative solution; HH: household; (a): deep tubular well; (b): spring.

The research was conducted from September 2023 to November 2024. The methodology was developed in two stages: (a) a bibliometric analysis and (b) the on-site measurement of flowrate and calculation of Cp in six households located in distinct *quilombola* communities in Goiás, as described below.

2.2. Bibliometric Analysisdr

A literature review on studies related to Cp was conducted using the Scopus, Web of Science, and Google Scholar databases. These platforms were chosen because of their ability to access a wide range of sources—including articles and conference papers—especially given the limited availability of journal publications on the topic. Relevant keywords such as "water supply", "sanitary sewage", "faecal wastewater", and "water meter" were used in the search.

The survey was not restricted by timeframe, country, or language and included articles, theses, dissertations, and undergraduate research projects. The works were tabulated and analyzed both qualitatively and quantitatively for their relevance, based on the following inclusion criteria: (i) Does the work provide a value for Cp referring to exclusively fecal sewage? If yes, (ii) were the data estimated or based on measurements? And (iii) does the work pertain to rural or urban populations? Descriptive statistics were then used to determine the number of studies available in the literature on this subject. The Cp of urban and rural areas was compared, given that, exclusively, fecal sewage (feces, urine, and water) has the same composition in terms of fecal content.

2.3. On-Site Measurement and Calculation of per Capita Contribution to Fecal Sewage

To determine Cp, a volumetric water meter with a nominal flowrate (Q_n) of 1.5 m^3/h, manufactured by the German brand Zenner (model RTK-S, Germany), was installed in each residence. Prior to installation, the water meters underwent performance verification testing by Companhia Saneamento de Goiás S.A. (Saneago), which confirmed an error of less than 5%. The selected installation site was the water pipeline supplying the toilet(s) of each residence. This required a bypass in the plumbing system of the existing bathroom facilities, as illustrated in Figure 2.

Figure 2. Bypass in the pipeline with the installation of a volumetric water meter before the toilet to record the volume of water used for flushing. Note: R1: Almeidas—Silvânia; R2: Queixo Dantas—Mimoso de Goiás; R3: Porto Leucádio—São Luíz do Norte; R4: Fazenda Santo Antônio da Laguna—Barro Alto; R5: José de Coleto—Colinas do Sul; R6: Rafael Machado—Niquelândia.

Data collection was carried out at least weekly through water meter recordings, for a period necessary to contemplate the two seasons (dry and rainy). Residents received training to photograph water meters and sent the photographic records via mobile devices with internet access, so that researchers could remotely read the meters. Periodic on-site visits were conducted to ensure the accuracy of the readings by comparing photographic records with the actual volume of water dispensed during flushes. Additionally, these visits allowed for the identification and replacement of malfunctioning meters due to excessive water impurities.

As each photographic record was received, the data were tabulated and analyzed to identify potential errors or failures in meter operation. The Cp for each household was determined based on the total volume of water consumed throughout the monitoring period. To assess statistical var1iability, additional analyses were performed using intermediate readings (e.g., one-day intervals).

3. Results

The Cp values reported in the literature ranged from 9.9 to 51.5 L/cap.day (Table 2), with three studies (33.3%) pertaining to rural areas. In total, four studies (44.4%) presented Cp values based on on-site measurements. The estimated Cp values (5/9) are among the highest, with a lower limit of 13.1 and an upper limit of 36.0 L/cap.day, resulting in data that may differ from those used in basic sanitation infrastructure projects.

Table 2. Cp values found in the literature.

Cp (L/cap.day)	Authorship	Type of Work	Area of Study
9.9 (*)	[13]	Dissertation	Rural
11.6 (*)	[26]	Dissertation	Urban
13.1 (**)	[27]	Article	Rural
14.0 (*)	[28]	Article	Urban
21.2 (**)	[29]	Article	Urban
25.3 (**)	[30]	Article	Urban
33.0 (**)	[31]	Thesis	Rural
36.0 (**)	[32]	Article	Urban
51.5 (*)	[14]	FCW	Urban

Notes: (*): values based on local measurements; (**): estimated values; FCW: final course work.

The per capita contribution values from the literature (CpL) were plotted alongside the values obtained in this study (CpP) and combined (CpL + CpP) (Figure 3). When considering all values, the CpL of 51.5 L/cap.day appears as an outlier, indicating that it is not representative of a typical household, which may be due to the use of a non-conventional toilet combined with the residents' habits of flushing. When considering only literature values from rural households, the CpL of 33.0 L/cap.day is atypical, with an average of 17.0 L/cap.day—slightly higher than the average CpP of 16.2 L/cap.day.

The determination of CpP was carried out during both the dry and rainy seasons over periods ranging from 49 to 327 days (Table 3), with an overall average of 16.22 L/cap.day (CV = 0.239), a minimum value of 12.10 L/cap.day, and a maximum of 21.79 L/cap.day (see Figure 3 and Table 3). During the rainy season, households do not reuse rainwater for toilet flushing due to the consistent water supply.

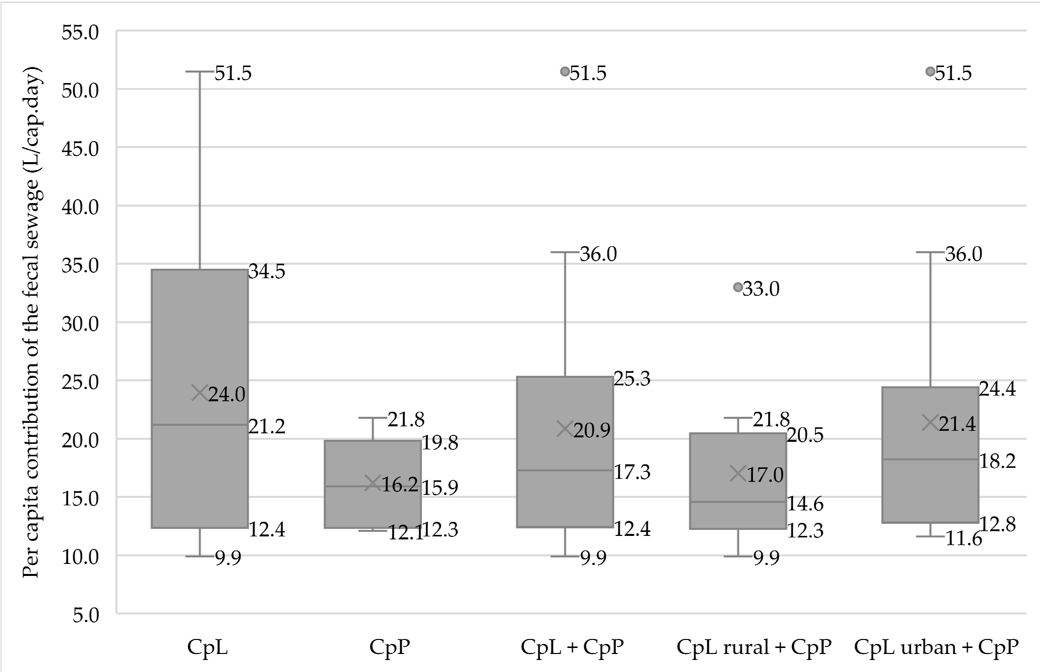

Figure 3. Per capita contribution to fecal sewage from the literature (CpL) and the averages determined in this study (CpP).

Table 3. Flowrate and Cp values determined in rural residences in Goiás (Brazil).

Area of Study	Demography (cap/HH)	Period	Interval (days)	Va (L/day)	Average Volume (L/day)	Cp (L/cap.day)
R1	8 (4 adults, 4 children)	8 April 2024 to 8 November 2024	214	29.583	138.24	17.28
R2	8 (4 adults, 2 teenagers, 2 children)	19 September 2024 to 7 September 2024	49	4.744	96.81	12.10
R3	5 (3 adults, 1 teenager, 1 children)	30 September 2023 to 13 June 2024 and 7 July 2024 to 25 August 2024	306	22.285	72.83	14.57
R4	2 (adults)	13 February 2024 to 8 November 2024	269	11.725	43.59	21.79
R5	1 (adult)	29 February 2024 to 18 October 2024	232	2.878	12.41	12.41
R6	1 (elderly)	16 December 2023 to 7 November 2024	327	6.259	19.14	19.14
Average					16.22	Average
CV					0.239	CV

Notes: Va = average volume in the interval between readings; Cp = per capita contribution to fecal sewage; CV = coefficient of variation; R1 = Almeidas; R2 = Queixo Dantas; R3 = Porto Leucádio; R4 = Fazenda Santo Antônio da Laguna; R5 = José de Coleto; R6 = Rafael Machado. (Children: ≤12 years; teenagers: >12 and <18 years; adults: 18–64 years; elderly: >64 years.)

Considering reading intervals ranging from 1 to 145 days (Table S1, Supplementary Materials), the average Cp values per period varied from 10.8 L/cap.day (R5) to 20.6 L/cap.day (R4), with Cp in R6 ranging from 7.0 to 32.3 L/cap.day—yielding the highest range and a coefficient of variation (CV) of 0.445, much higher than in the other households. In contrast, R2 showed the smallest range (9.9 to 15.0 L/cap.day; CV = 0.131). The other CV values were 0.091 (R1), 0.115 (R4), 0.147 (R3), and 0.188 (R5) (see Table S1, Supplementary Materials).

When comparing Figures 4 and 5 with the average Cp values obtained in each household (Table 3), it can be observed that Cp does not vary substantially with the number of inhabitants. For example, the households with the highest and lowest data variation—R6 (eight inhabitants, average = 19.14 L/cap.day, CV = 0.445) and R1 (one inhabitant, average = 17.28 L/cap.day, CV = 0.091), respectively—differ by only 1.86 L/cap.day. Overall, the results suggest that the number of inhabitants in a household may not exert a significant influence on Cp; however, further studies with larger samples are needed to confirm these findings.

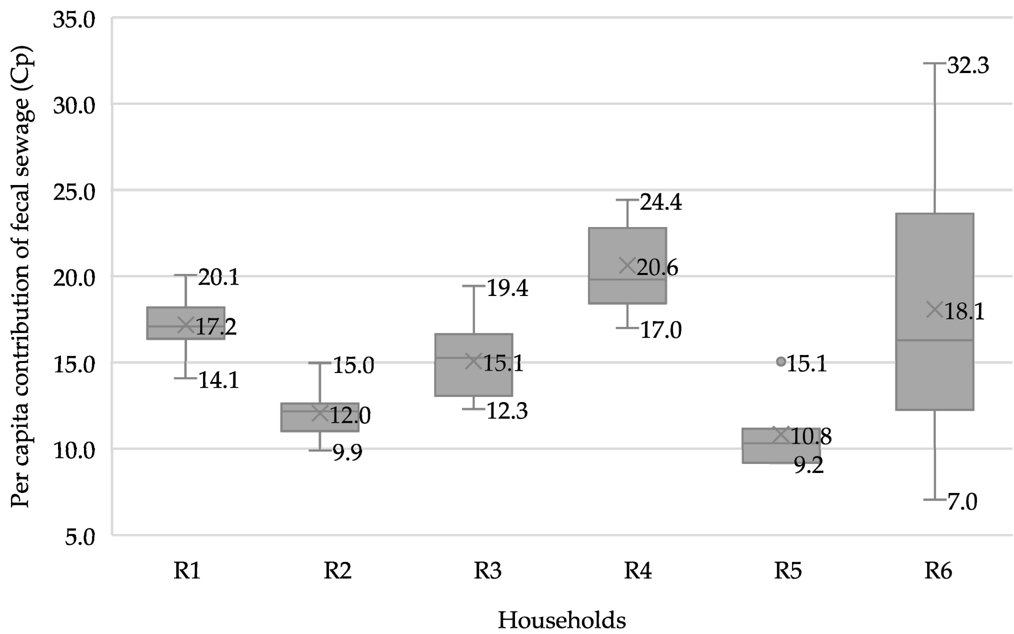

Figure 4. Distribution of Cp for each analyzed period in rural households in Goiás.

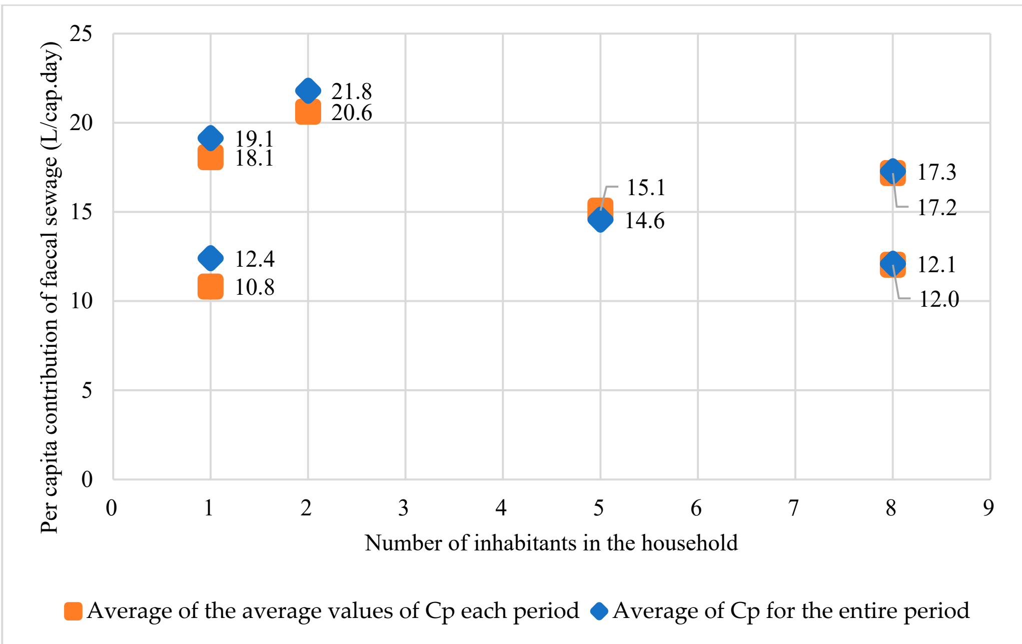

Figure 5. Variation in Cp according to the number of inhabitants in the household.

4. Discussion

The lowest Cp value, as identified both in the literature and in this study, was 7.0 L·cap^{-1}·day^{-1} (Figure 4). It is worth noting that lower values may be found depending on the method used for fecal sewage disposal—for instance, when using a water bucket for flushing, CpL was estimated at 1.2 L/cap.day [27]—and may be higher if additional volumes (e.g., from feces and urine) are considered (estimated at 1.53 L/cap.day [14]). Cp values can also vary according to the volume of water used per flush. Conventional toilets typically use between 6 and 12 L per flush [33]; however, adjustments to the flush mechanism may result in variations. In this context, assuming a toilet capacity of 6.0 L, the CpP values obtained suggest that each person flushes at least twice daily.

It is evident from Table 3 that each household exhibited a distinct CpP. The lowest values were observed in households with eight inhabitants (12.10 L·cap^{-1}·day^{-1} in R2) and one inhabitant (12.41 L/cap.day in R5). These values are very similar to each other and are slightly above the 9.9 L/cap.day reported in [13]. They also fall between the CpL of 11.6 L/cap.day measured in the Ratones neighborhood in Florianópolis, Brazil [26], and the CpL of 13.1 L/cap.day estimated from 50.3 L/cap.day (using a return coefficient of 26%) for households served by the water supply network of the '25 de Maio' Land Reform Settlement community in Ceará, Brazil [27]. If these values were used in project design, systems could be undersized for households with higher Cp values, potentially leading to overflows, hence the importance of using real data.

Households R1 and R6, with one and eight inhabitants, respectively, exhibited average CpP values of 17.28 L/cap.day and 19.14 L/cap.day. These values lie between 14.0 L/cap.day [28] and 21.2 L/cap.day [29]. The first CpL value was obtained by measuring 100 urban households in São Paulo over seven consecutive days [28], whereas the second CpL (21.2 L/cap.day) was estimated for residential households in Australia [29].

Household R3, with five inhabitants, had an average CpP of 14.57 L/cap.day over the entire period and 15.1 L/cap.day when averaging values for each period (Table 3 and Figure 4). These results are close to the 14.0 L/cap.day reported in [28]. Finally, R4 exhibited an average CpP of 21.8 L/cap.day, nearly identical to the 21.2 L/cap.day reported in [29] for the urban area.

When analyzing the Cp values referring to the urban zone (CpL urban, Figure 3), 50% (3/6) are within the range of values found in the present research. It is worth noting that although the quantity of analyzed locations was not considered statistically, the results obtained demonstrate that in rural areas, the per capita contribution of fecal sewage is lower than in urban areas. Furthermore, 66.7% (2/3) of the CpL values referring to the rural zone are also within the CpP range determined in the six investigated rural communities.

When considering only rural households and excluding the outlier CpL value of 33.0 L/cap.day [31], the highest value is 21.8 L/cap.day (Figure 3). This value could be used in design projects to avoid undersizing; however, oversizing may occur for households with lower Cp values. The inadequate sizing of domestic wastewater treatment infrastructure can affect the frequency of sludge removals from systems (e.g., septic tanks) [34]. Moreover, overestimation can result in insufficient wastewater volume for nature-based systems, such as an evapotranspiration basin—a zero-discharge solution for fecal wastewater disposal [35–37]—which may require additional irrigation if plants experience water shortages. Similarly, wetlands [38] could suffer from water scarcity due to the high water demands of the plants they contain [39]. Other ways of disposing of fecal sewage, whether separated or together with greywater, can alter the volume of sanitary sewage generated, thus changing the per capita contribution to be considered in projects for sewage disposal and treatment solutions in rural households.

It is noteworthy that the Cp values obtained in this study are lower than those reported in 55.6% (5/9) of the studies in the literature, including urban and rural Cp. Among these, 60.0% (3/5) used estimated values, which may explain why estimated data are generally higher than measured data.

When considering average CpP values determined from reading intervals of 1 to 145 days (Table S1, Supplementary Materials), the lowest observed value was 7.0 L/cap.day—below the 9.9 L/cap.day reported in [13]—and the highest was 32.4 L/cap.day, slightly below the estimated values of 33.0 and 36.0 L/cap.day reported in [31,32], respectively. The family reported that the resident of R6 receives prolonged visits from relatives, in addition to frequently being absent from home for a few days, which may justify the change in Cp.

A short monitoring period may yield average Cp values that deviate from reality, potentially leading to under- or overestimation. Short reading intervals may not capture adverse conditions (such as seasonality or fluctuations in household occupancy) that occur over time. For example, variations may result from celebrations, holidays, work, or school vacations, trips, or extended visits from relatives.

A longer analysis period more accurately reflects daily routines, yielding more consistent data, whereas shorter periods may capture uncharacteristic behavior, thereby introducing bias. The Cp derived from a longer monitoring period may be influenced by long-term changes in water usage behavior. This was observed in R3, where the monitoring period covered 306 days (wet and dry seasons). During this period, sanitary equipment was replaced and there was a change in the amount of time a resident spent at home during the day due to employment.

Other factors—such as intermittent water supply, defects in toilet installations (which may cause leaks), malfunctioning meters due to compromised water quality, or the absence of residents—can hinder accurate flowrate measurements. For instance, the CpP of 7.0 L/cap.day observed in household R6 represents only 43.4% of the overall average (16.22 L/cap.day).

Seasonality also influences Cp values due to variations in water availability. During the dry season, water supply tends to be lower, and in some *quilombola* communities, water scarcity is common, leading to reduced consumption and the use of alternative storage (e.g., water drums). In such cases, flushes may be performed using buckets, potentially resulting in infrequent urine flushes. Conversely, during the rainy season, increased water consumption may lead to higher Cp values. On rainy days, people tend to stay inside their homes more, instead of performing outdoor work on the rural property, which can increase water consumption. This trend was particularly evident in households R2 and R3, where intermediate readings showed that 75% (R2) and 88% (R3) of CpP values were above the long-term average, with R3 exhibiting a 33.3% increase (average = 14.57 L/cap.day; maximum = 19.42 L/cap.day). However, not all households demonstrated the same trend in the rainy season; intermediate readings showed that 100% (R4 and R5) and 67% (R6) were below the long-term Cp average, demonstrating that the flushing frequency was reduced. Finally, in household R1, 50% of the intermediate readings were below the long-term Cp in both the rainy and dry seasons.

Thus, when monitoring Cp in rural contexts, it is essential to consider these factors. Additionally, knowledge of the water quality provided by the community supply can guide the selection of an appropriate meter. For example, an ultrasonic meter may be more suitable than a velocity or volumetric meter due to its higher resistance to adverse conditions (e.g., water containing particles).

When determining Cp based on water consumption, it is also necessary to account for the volume generated by urine and feces. A healthy individual excretes an average of 128 g of feces and approximately 1.5 L of urine per day [40], which represents about 9% of the total daily fecal wastewater volume produced by an adult—resulting in an average CpP of 17.48 L/cap.day.

5. Conclusions

The main conclusions regarding the results of the local determination of per capita contribution to fecal sewage (Cp) are as follows:

- There is a scarcity of studies based on local flowrate measurements in both urban and, particularly, rural areas.
- Estimated values tend to be higher than those calculated from direct measurements.
- The results obtained in this study are consistent with the lower range of values found in the literature based on flowrate measurements.
- Precise determination of Cp is crucial for the planning of decentralized basic sanitation systems.
- On-site measurements confirm that relying solely on estimated values can lead to under- or overestimation in projects, thereby compromising the effectiveness and sustainability of the proposed solutions.
- Cp can be influenced by seasonal variations.
- The use of appropriate meters, along with consideration of cultural factors, is essential to ensure the collection of consistent data.

In this context, the present study helps to fill data gaps in rural areas and contributes to the formulation of more realistic parameters, which are essential for the success of future basic sanitation projects—particularly in regions with a historical deficit in this public policy. This study is one of the few worldwide to obtain Cp based on flowrate measurements in these communities—and the first to analyze the per capita contribution of, exclusively, fecal sewage from the six *quilombola* communities investigated, providing valuable parameters for the design of decentralized sanitation systems.

It is recommended that measurements be conducted in a larger number of households with diverse demographic and geographic characteristics, and that meteorological data (e.g., temperature, relative humidity, precipitation) be incorporated to obtain values that more closely reflect reality. During the rainy season, if residents reuse rainwater to flush the toilet, then this should be monitored. Future work could also explore correlations between Cp and other factors (e.g., household socio-economic status, age distribution, water quality, or differences in toilet technology). In this regard, future studies could further add to the scope of work analyses of specific socioeconomic values that may be reduced when using calculated, rather than estimated, Cp in the execution of sanitation infrastructure projects.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/w17091350/s1: Table S1. Per capita contribution to fecal sewage (Cp) in the monitoring period for the analyzed residences (R1 to R6) in quilombola communities in Goiás, Brazil.

Author Contributions: Conceptualization, A.C.d.S., A.A. and P.S.S.; methodology, A.C.d.S., A.A. and P.S.S.; software, A.C.d.S. and P.S.S.; validation, A.C.d.S., P.S.S. and A.A.; formal analysis, A.C.d.S., A.A. and P.S.S.; investigation, A.C.d.S., P.S.S. and A.A.; resources, A.C.d.S.; data curation, A.C.d.S. and P.S.S.; writing—original draft preparation, A.C.d.S.; writing—review and editing, A.C.d.S., P.S.S. and A.A.; visualization, A.C.d.S.; supervision, P.S.S.; project administration, P.S.S.; funding acquisition, P.S.S. and A.A. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: The original contributions presented in this study are included in the article/Supplementary Materials. Further inquiries can be directed to the corresponding author.

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Conflicts of Interest: The authors declare no conflicts of interest.

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