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Technical Article

# Service and precariousness of sanitary sewage in rural communities in the state of Goiás, Brazil

*Atendimento e precariedade no esgotamento sanitário em comunidades rurais do estado de Goiás, Brasil*

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## ABSTRACT

The rate of attendance to sanitary sewage services is low in rural communities, representing precarious sanitation conditions with dumping in rudimentary cesspools or in the open. Knowledge of the fractions of effluents generated and the places where they are released is important, since inadequate disposal generates public health problems and negatively impacts the environment. In this way, the objective of this work was to identify the amounts of effluent fractions generated and the deficit of sanitary sewage in rural communities in the state of Goiás. The study area included 97 rural communities, from which data were collected regarding the existence of bathrooms, alternatives and disposal sites for domestic sewage fractions, such as feces separated from urine. The results indicated an absence of a bathroom in 6.6% of the analyzed rural households, being in 2.5 and 18.2% in the households of the settlements and quilombolas, respectively, highlighting in the latter the occurrence of disposal in the open or stream in 13.7%. There was a predominant use of rudimentary cesspools to receive sewage and fecal water, while gray water from the kitchen sink and washing tanks are mainly disposed in the backyard, representing the greatest deficit in the communities. Thus, in most of the studied households there is a deficit due to lack of service, due to the release of untreated effluents into ditches/open air, mainly for gray water, and precarious service due to the unsafe disposal of treated effluents or the use of rudimentary cesspools. Few alternative technologies were found for the treatment of effluents, with ecological pit, biodigester and Tapiocanga stone pit being identified. It was concluded that the deficit of sewage in the households of the studied communities is high, due to the release of effluents without treatment and the use of rudimentary cesspools, characterized as lack of service and precarious service, respectively, observed in 84.6% of households.

**Keywords:** sewage; cesspool; deficit; quilombola; rural settlement; riparian.

## RESUMO

Em comunidades rurais, o índice de atendimento aos serviços de esgotamento sanitário é baixo, representando condições precárias de saneamento, com lançamento de efluentes em fossas rudimentares ou a céu aberto. O conhecimento das frações de efluentes geradas e os locais de seu lançamento são importantes, uma vez que a destinação inadequada gera problemas de saúde pública e impacta negativamente o meio ambiente. Desta forma, o objetivo do trabalho foi identificar as quantidades de frações de efluentes geradas e o déficit do esgotamento sanitário em comunidades rurais do estado de Goiás. A área de estudo contemplou 97 comunidades rurais, das quais coletou-se dados quanto à existência de banheiro e às alternativas e locais de disposição das frações do esgoto doméstico, como fezes separado da urina. Os resultados apontaram para ausência de banheiro em 6,6% dos domicílios rurais analisados, sendo 2,5 e 18,2% nos domicílios dos assentamentos e quilombolas respectivamente, destacando neste último a ocorrência de disposição a céu aberto ou ribeirão em 13,7%. Observou-se uso predominante de fossas rudimentares para recebimento de esgotos e águas fecais, enquanto a água cinza produzida por pias de cozinha e tanques de lavar roupas é disposta principalmente no quintal, representando o maior déficit nas comunidades. Assim, a maioria dos domicílios apresenta déficit de esgotamento sanitário por ausência de atendimento, devido ao lançamento de efluentes sem tratamento em valas/céu aberto, principalmente as águas cinza, e precariedade de atendimento devido à disposição não segura de efluentes tratados ou uso de fossas rudimentares. Foram constatadas poucas tecnologias alternativas para tratamento de efluentes, sendo identificadas fossas ecológicas, biodigestor e fossa de pedra Tapiocanga. Concluiu-se que o déficit do esgotamento nos domicílios das comunidades visitadas é elevado, devido ao lançamento de efluentes sem tratamento e ao uso de fossas rudimentares, caracterizado como ausência e precariedade de atendimento, respectivamente, constatado em 84,6% dos domicílios.

**Palavras-chave:** esgoto; fossa; déficit; quilombola; assentamento rural; ribeirinho.

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## INTRODUCTION

Difficulty in accessing basic sanitation services is a problem that affects billions of people worldwide, with an aggravating situation mainly in peri-urban and rural areas (SINGH; KAZMI; STARKL, 2015). Although this figure has decreased globally, the situation still deserves attention, as in 2015 there were 4.5 billion people without access to safe sanitation services, there remains 2.3 billion who still do not have basic services. This total includes 600 million people who share a toilet or latrine with other households and 892 million (mostly in rural areas) who defecate in the open, as reported by the World Health Organization (WHO) and the United Nations International Emergency Fund (WHO; UNICEF, 2017).

Sanitation deficit is a reality in rural communities of Brazil (SILVA, 2017). Between 1991 and 2010, there was a reduction in the percentage of households with septic pits, making it evident, according to the National Rural Sanitation Program (*Programa Nacional de Saneamento Rural* — PNSR), that this change was related to an increase in households with domestic effluents disposed in ditches or surface waters (BRASIL, 2019), which may include the practice of open defecation. The existing precarious situations contribute to the spread of diseases of fecal-oral transmission, the presence of helminths in soil or water bodies, and taeniasis and diseases transmitted by insects (BRASIL, 2010).

The rudimentary cesspool is the most adopted alternative in rural areas of the world (WHO; UNICEF, 2017) and in the Center-West Region of Brazil (BRASIL, 2013), with variable aspects of construction and the absence of technical criteria in its implementation, as characterized by the WHO (WHO; UNICEF, 2017). Other solutions can be adopted, as presented by several authors in the specific literature (SILVA, 2014; TILLEY *et al.*, 2014; BRASIL, 2018; 2019; SPERLING; SEZERINO, 2018; TONETTI *et al.*, 2018; VON SPERLING, 2018), however, their efficiency may be compromised due to factors such as effluent quality, technology selection, and facility management (YANG *et al.*, 2021).

The inappropriate use of solutions or technologies, including the form of disposal of effluents, can be classified as precarious service and be configured as a deficit. The choice of decentralized and appropriate technologies, in the rural context, is a challenge in several locations (MASSOUD; TARHINI; NASR, 2009), and may involve cost-benefit analysis (MARTIN; JOHNSON, 2019) and decision analysis tools (ULLAH *et al.*, 2020). These techniques need to evolve technical, environmental, and social criteria (RAUT, 2019). In addition, knowledge of the deficit becomes necessary in a given location, as it is through its identification that the type of technology to be implemented is configured. For Roland, Heller and Rezende (2020), the deficit in rural areas is characterized from the point of view of the inhabitants' access to sanitation services.

The separation of effluents is often done so as not to overload existing solutions, allowing for greater durability of the system, with gray water being led to the backyard without any treatment. In this context, the separation of effluents generated in rural communities can be an advantage to reduce the costs of implementing technologies for their treatment, as well as the better use of nutrients (CHENG *et al.*, 2021). In this sense, according to Vidal *et al.* (2019), overall separation of gray water from fecal water resulted as the most sustainable option.

Lehtoranta *et al.* (2022) concluded that the potential for nutrient recovery is several times higher in systems with separation of fractions when compared to a conventional system that receives all wastewater, and which can present a more viable operation and maintenance cost.

The choice to use individual or collective systems must be evaluated on a case-by-case basis, since implementation, maintenance, and operation costs vary, being mainly influenced by the number of inhabitants served (MCCONVILLE *et al.*, 2019; MURUNGI; DIJK, 2019), in addition to the distance between households and to the place of final effluent disposal.

Thus, knowledge about the collection and disposal of effluents in rural communities is an important factor for proposing intervention measures and assisting in the development of public policies. Given the above, this work aimed to identify the amounts of effluent fractions generated and the sewage deficit in rural communities in the state of Goiás, Brazil.

## MATERIALS AND METHODS

The study area included 97 rural communities present in the state of Goiás, Brazil, comprising 28 *quilombola* communities, 62 agrarian reform settlements and seven riverine communities (Figure 1).

Each typology has its own characteristics according to its origin and formation. Thus, an agrarian reform settlement is a set of agricultural units, installed by *Instituto de Colonização e Reforma Agrária* (INCRA) in a rural property, where one of these units, called parcels or lots, is destined for a family of a farmer or rural worker without economic conditions to acquire a rural property (INCRA, 2020). On the other hand, *quilombola* communities, according to Article 2 of Decree No. 4,887 (BRASIL, 2003), are ethnic-racial groups considered to be remnants of *quilombo* communities, according to self-attribution criteria, with their own historical trajectory, endowed with specific territorial relations, with presumption of black ancestry related to resistance to suffered historical oppression. Finally, riverine populations or communities correspond to families who live on the banks of rivers and who carry out activities related to what exists in the vicinity of the places where they live and focused mainly on plant extractivism, fishing, and hunting (GUARIM, 2000).

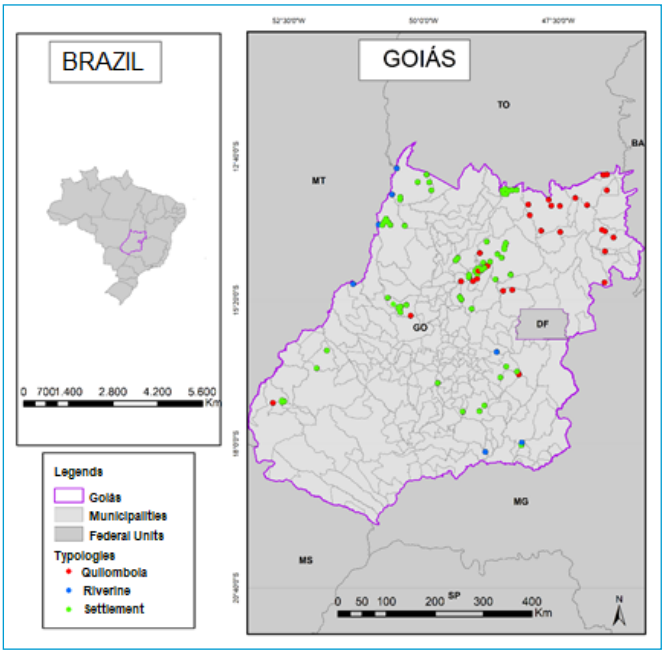


**Figure 1** – Geographical distribution of the studied quilombola and riverine communities and agrarian reform settlements.

The criteria for choosing the communities were based on the selection of municipalities that had one or more rural *quilombola* communities certified by *Fundação Palmares* and/or riverine communities obtained in the Municipal Basic Information Survey (*Pesquisa de Informações Básicas Municipais* — Munic) (IBGE, 2013). Agrarian reform settlements managed by *Instituto Nacional de Colonização e Reforma Agrária Superintendência* (INCRA SR-04) were selected in these municipalities, depending on the number of existing settlements in the state of Goiás, available resources and the time to carry out the activities.

Through the application of questionnaires and checklists, approved by the Research Ethics Committee of Universidade Federal de Goiás (UFG) (Protocol No. 2.886.174/2018), information was collected from 2,088 households, between 2018 and 2019, about the existence of a bathroom and the practices of collection, removal, and disposal of effluents generated in households, which allowed the characterization of sanitary sewage service and its deficit in rural communities in the state of Goiás. The survey was carried out from house to house, according to the sampling plan, and directed to the respondent (person over 18 years of age), being a member of the family and considered responsible for the household. In this case, statistical inferences of individual characteristics are restricted to the group of people responsible for the families.

The design considered families whose members were residents with a (fixed) residence in a parcel (lot or area) of the community who, during the period of *in loco* activities, were present or temporarily absent. The selection of households was carried out in one stage using the systematic random sampling method.

Sampling was calculated from interval estimates of proportions with a confidence level of 95%, and the maximum error varying according to the different levels of geographic coverage. Thus, the lowest level of coverage with the considered precision control of the estimates was per community, with a maximum error margin of 10% and, for all communities of the same type, with a maximum error of 2% (1).

$$n = \frac{N z_{\gamma}^2 p(1-p)}{(N-1)e^2 + z_{\gamma}^2 p(1-p)} \quad (1)$$

Where:

N: population size;

$z_{\gamma}$: the standard normal distribution *score* referring to the confidence level $\gamma$;

p: the population proportion to be estimated;

e: the maximum error of the estimate. In the calculations, the maximum variability was considered to estimate the proportion (p = 0.5).

Percentages were calculated over the universe of diagnosed households minus data considered lost (DL), which varied for each situation and referred to diagnosed households in which some data were not collected, and therefore, disregarded. Thus, as an example, for the items of characterizing service and separation of fractions and gray water deficit, any household without information about one of the sewage fractions was considered missing data.

## Characterization of service in the communities

Sanitary sewage service was characterized in two situations — with and without the existence of a bathroom at home, either inside or outside the property. The research considered the following terms and definitions:

- gray water: liquid effluent generated by the use of shower, bathroom and kitchen sinks, and clothes washing;
- fecal water: liquid effluent generated by toilet flushing water;
- feces and urine (without the use of water): composed exclusively of feces and urine, disposed in a dry pit or in the open;
- sewage: formed by the mixture of fecal water and gray water.

The ways of separating the sewage fractions were classified according to the place where they were disposed, as follows:

- total separation, when gray and fecal water fractions were disposed of in different places;
- partial separation, in which a portion of gray water was segregated from sewage and disposed of in different places;
- without separation, where all fractions had the same destination. In the absence of a toilet, the disposal of feces and urine (without water) was considered directly on the ground (open defecation) or in a dry pit, separated from gray water.

## Identification of deficit in households of rural communities

Adequate service was considered when the rural area is served by collection (sewage network) followed by final disposal; or use of a septic tank, followed by post-treatment or final disposal unit, as defined by PNSR, adapted from Brasil (2013), highlighting that treatment is essential in these situations. In cases where there is no bathroom, the use of a dry pit was considered an adequate technological solution (BRASIL, 2019). The use of alternative technologies suitable for rural areas, such as green pits and biodigesters, which are those described in technology manuals specific to rural areas (BRASIL, 2018; TONETTI *et al.*, 2018), were also considered to be adequate service, generating social and environmental benefits. Thus, deficit was characterized by the absence of service, considering the disposal of effluent or feces in the open, in bodies of water, or lack of bathroom; and precariousness, due to the use of rudimentary cesspools to receive effluents generated in households. The classification and definitions regarding deficit and adequate service followed the provisions of Table 1.

**Table 1 –** Classification adopted regarding deficit and adequate service of sewage, fecal water, gray water, and feces and urine in rural areas.

| Classification | | Description |
|---|---|---|
| Adequate service | | Collection (sewage network) followed by treatment; or use of a septic tank, followed by post-treatment or final disposal unit; use of dry pit. |
| Deficit | Precarious service | Disposal of sewage or its fractions in rudimentary cesspools or its collection, followed by removal and disposal without adequate treatment. |
| | Without service | Single release without sewage treatment or both fractions in rivers, lakes or soil. |
| | | Absence of dry pit and bathroom or toilet at home or around the home. |

Source: adapted from Brasil (2013; 2019).

## RESULTS AND DISCUSSION

### Characterization regarding the existence of a bathroom and disposal of feces and urine

Characterization of the service performed in 97 rural communities in the state of Goiás indicated an absence of a bathroom in 6.6% of the total number of households and its presence in 81.8, 97.5, and 100% of *quilombola* settlements and riverine households, respectively. In the absence of a bathroom, feces and urine were disposed of in a dry pit in 0.4% of settlement households and 4.5% of *quilombola* households, values well below the 82.3% reported by Silva (2007), who studied a *quilombola* community in the state of Paraíba. Disposal in the open or stream was detected in 2.1% of settlement households and 13.7% of *quilombola* households. This last value is above the 8.2% found by Magalhães Filho and Paulo (2017) for *quilombola* communities in the state of Mato Grosso do Sul.

The absence of a bathroom in 18.2% of the households in *quilombola* communities is close to the value of 21.1%, disclosed for the Cerrado Biome by PNSR (BRASIL, 2019). There may be several reasons for this absence, among which, as pointed out by Silva (2017) and Brasil (2019), is the lack of water. Cultural aspects also have an influence, and the practice of open defecation may be seen as natural, being the preference of the population and field workers, and in some cases, the bathroom may not correspond to the hygiene perceptions of traditional populations (BRASIL, 2019). As a consequence, defecation in the open or in a river/stream may contribute to increased health risks for these populations.

### Disposal of sewage and fecal water

Table 2 provides the alternatives for disposal of sewage and fecal water, for both the general total and by typology, in households with a bathroom. Despite the direct discharge to the backyard from the bathroom in a small portion of the households in the communities (1%), the rudimentary cesspool is the main destination for sewage and fecal water, representing, respectively, 52.9 and 25.6% of households in *quilombola* communities, 60.8 and 31.9% of households in settlements, and 78.2 and 13.4% of households in riverine communities. For all households in general, 88.9% of those that have a bathroom release the effluent into a rudimentary cesspool, with 29.6% in the form of fecal water and 59.3% as sewage. The percentages found here for *quilombola* communities are within the range of rudimentary cesspool use found by PNSR for the state of Goiás of between 60 and 80% of diagnosed households (BRASIL, 2019), and also identified by Silveira (2013) in 81% of the rural population.

These percentages occur in Brazil (BRASIL, 2019) and worldwide (WHO; UNICEF, 2017). A study in a rural area of Holambra (São Paulo), found that of the 3,135 inhabitants, 60% used a rudimentary cesspool, and 31% did not know the type of cesspool used (SUPREMA, 2013). In Campinas (São Paulo), the use of a rudimentary cesspool was reported in 81% of the diagnosed locations (FIGUEIREDO, 2019). The values of the sum of effluents of sewage and fecal water found in this work for the settlements and riverine communities exceeded those in the literature, reaching values above 90%.

The wide distribution of rudimentary cesspool use found here can be related to its constructive simplicity (BRASIL, 2015), since they are often excavations in the ground, with or without shoring or waterproofing, and may or may not have precarious closure, in addition to being built from empirical knowledge, without evaluating local conditions (BRASIL, 2015; 2019; FIGUEIREDO *et al.*, 2019), considered an inadequate solution according to the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística* — IBGE) classification (IBGE, 2010). Despite this classification, references such as Brasil (2015), WHO and UNICEF (2017), and Brasil (2019) consider it as an alternative for the destination of sanitary effluents, highlighting that its precariousness arises from aspects related to its location on the property, the local environment and construction characteristics, which can lead to groundwater contamination (pathogens or nitrate), rainwater ingress, surface sewage runoff, and proliferation of vectors (FIGUEIREDO *et al.*, 2019). Thus, in the diagnosed communities, rudimentary cesspools, despite being a solution for sewage disposal, can contribute to health and environmental risks, impairing the population's quality of life, as already observed in research related to the topic (TIMOSHKIN *et al.*, 2018; BAEZ; VILLALBA; NOGUES, 2019; CORRÊA, VENTURA, 2021; OKUHATA *et al.*, 2022).

The second most frequent alternative was the release of effluent from toilets into a septic tank, with or without a drain, receiving sewage in 16, 2, and 4% of households in *quilombola* communities, settlements, and riverine communities, respectively (Table 2). This technology is a waterproofed tank, which allows the sedimentation of suspended solids, but not satisfactorily removing nitrogen and pathogenic organisms (VON SPERLING, 2018). However, to achieve good efficiency within environmental standards, a later technology is needed, since the septic tank is a sedimentation tank, in which the removal of organic matter is limited, since the main objective is the sedimentation of suspended solids (MOUSSAVI; KAZEMBEIGI; FARZADKIA, 2010; VON SPERLING, 2018; GIZINSKA-GÓRNIA, MARIUSZ, 2020). If installed in a place with inadequate permeability, contamination of the water table and soil is favored

**Table 2 –** Disposal alternatives for sewage and fecal water in communities according to their typology.

| Typology | Effluent type | Directly in backyard (%) | Rudimentary cesspool (%) | Septic tank (%) | Other locations (%) |
|---|---|---|---|---|---|
| *Quilombola* | Fecal water | 0 | 25.6 | 0.7 | 0.2 |
| | Sewage | 1 | 52.9 | 16 | 3.6 |
| Settlement | Fecal water | 0.2 | 31.9 | 1.6 | 0.6 |
| | Sewage | 0.8 | 60.8 | 2 | 2 |
| Riverine | Fecal water | 0.9 | 13.4 | 0 | 0.9 |
| | Sewage | 0 | 78.2 | 4 | 2.6 |
| Total | Fecal water | 0.2 | 29.6 | 1.3 | 0.5 |
| | Sewage | 0.8 | 59.3 | 5.8 | 2.5 |

(USEPA, 2002). In their review article, Bernal, Restrepo and Grueco-Casquete (2021) concluded that the septic tank has high applicability for decentralized systems, with a relative weight of 15.11, followed by UASB reactor (12.91), wetlands (12.91), and lagoon systems (12.24).

Other places were identified for the disposal of effluents from bathrooms, namely Tapiocanga stone pit, biodigester, and ecological pit.

A Tapiocanga stone pit was present in 2 and 3.5% of households of *quilombola* and riverine communities, respectively. It is a suitable technology as a post-treatment unit for effluents from septic tanks, where the soil is impermeable. It is characterized by being filled inside with stones with irregular surfaces (rough and uneven), which favors the formation of bacteria colonies (CARVALHO *et al*., 2017). However, it was used for the direct treatment of fecal water, which can impair the quality of the effluent.

A biodigestor was present in 0.7 and 1.9% of households in *quilombola* and riverine communities, respectively. In general, it was present in less than 1% of households. This small amount may be related to the need for qualified labor for its implementation and maintenance (BRASIL, 2018). A biodigester cesspool can be a viable alternative for rural areas, in addition to reducing deaths from diarrheal diseases (COSTA; GUILHOTO, 2014).

An ecological pit was found only in the settlements, occurring in 2.1% of the households with the presence of a bathroom. It allows the treatment of fecal water by the cycling of nutrients through their consumption by banana trees or fast-growing plants with high water demand such as arrowleaf elephant's ear (*taiobas*), papaya (*mamoeiro*) or swamp lily (*lírio do brejo*), without the need for alternative final disposal. It has easy operation and maintenance, such as cleaning the garden and harvesting the fruits, and can be built from common materials such as bricks, PVC pipes, and tires (LEAL, 2014; OLIVEIRA; LEAL, 2017; BRASIL, 2018; FIGUEIREDO; SANTOS; TONETTI, 2018). With the help of a decision-making tool, this technology was chosen and implemented in a participatory way in a *quilombola* community in Mato Grosso do Sul, where excellent results were observed during monitoring (MAGALHÃES FILHO *et al*., 2019).

Thus, the low frequency by which these three technologies were found may be associated with a limited knowledge of these easy-to-use and adaptable alternatives, which allow sanitary, ecological and social benefits; as well as an understanding of aspects of environmental health and health problems due to the lack of adequate sanitation (BRASIL, 2019). One of the factors that influence the sustainability of technologies and, consequently, their replication, is engagement, acceptance, and social responsibility of the population, which are related to the way the population positions itself in relation to the solution (SUSAN, 2008; ORDOÑEZ-FRÍAS *et al*., 2020).

## Disposition of gray water

Table 3 shows the alternatives used for disposing of gray water, with the backyard being the main place for disposing it from the kitchen sink and clothes washing, occurring, respectively, in 80.3 and 86.2% of households in *quilombola* communities, 89.9 and 93.1% of households in settlements, and 75.7 and 95.6% of households in riverine communities.

Gray water from the bathroom is disposed of in a rudimentary cesspool in 49.9% of households in *quilombola* communities, 59.1% of households in settlements, and 73.9% of households of riverine communities. Its disposition in the backyard was adopted in 28.8% of *quilombola* households, 35.9% of settlement households, and 21.3% of riverine households. The septic tank, with or without a drain, was used to receive gray water mainly by households in *quilombola* communities, with 17.3% (Table 3).

The identified release of gray water from the kitchen and clothes washing, mainly in the backyard, was also observed by Silva (2017), in a work carried out in fifteen communities in the five regions of Brazil, in which disposal took place in open pits, directly on the ground and in the yard. Likewise, it was identified

**Table 3 –** Alternatives for disposal of gray water from clothes washing, kitchen with and without grease trap, and bathroom.

| Typology | Effluent source | Directly in backyard (%) | Rudimentary cesspool (%) | Septic tank (%) | Surface water (%) | Other locations (%) |
|---|---|---|---|---|---|---|
| *Quilombola* | bathroom sink and shower | 28.8 | 49.9 | 17.3 | 0 | 3.9 |
| | kitchen (without GT) | 78.8 | 6.3 | 3.3 | 2.6 | 1.8 |
| | kitchen (with GT) | 1.5 | 3.4 | 2.2 | NA | NA |
| | washing clothes | 86.2 | 1.2 | 2.5 | 9.2 | 0.9 |
| Settlement | bathroom sink and shower | 35.9 | 59.1 | 2.2 | 0.1 | 2.8 |
| | kitchen (without GT) | 88.4 | 5.3 | 0.3 | 0.1 | 3.1 |
| | kitchen (with GT) | 1.5 | 1.1 | 0.2 | NA | NA |
| | washing clothes | 93.1 | 2.4 | 0.6 | 0.2 | 3.8 |
| Riverine | bathroom sink and shower | 21.3 | 73.9 | 1.4 | 0.0 | 3.4 |
| | kitchen (without GT) | 71.1 | 19.2 | 0 | 0 | 1.1 |
| | kitchen (with GT) | 4.6 | 4 | 0 | NA | NA |
| | washing clothes | 95.6 | 3.1 | 0 | 0 | 1.3 |
| Total | bathroom sink and shower | 33.5 | 57.2 | 6.2 | 0 | 3.1 |
| | kitchen (without GT) | 85.2 | 6.1 | 1.1 | 0.7 | 2.7 |
| | kitchen (with GT) | 1.6 | 1.8 | 0.7 | NA | NA |
| | washing clothes | 91.3 | 2.1 | 1.1 | 2.6 | 2.9 |

NA: not applicable; GT: grease trap.

as the main destination of these fractions by PNSR in diagnosed communities (BRASIL, 2019), being a common practice in developing countries (OH *et al.*, 2018). Gray water can have organic matter, chemicals, soap, and hair in its composition (BRASIL, 2018), and can contribute to unhealthy conditions and the spread of vectors when disposed in the backyard.

## Separation of fractions

Classification of the form of separation of the generated sewage fractions according to the community typology, considering the diagnosed households, is shown in Table 4. More than half of the households (55.6%) were classified as having partial separation of fractions, that is, they generate sewage and gray water, occurring in 52.5, 56.9, and 55.1% of *quilombola*, settlement, and riverine households.

The practice of partial separation of fractions was also reported by Figueiredo *et al.* (2019), in a rural area of Campinas (São Paulo), with the segregation of gray water in at least one of the parcels in 88% of the properties. In this same region, Figueiredo *et al.* (2019) identified the segregation of gray water from clothes washing in 91.2% of 125 households, from the kitchen in 83.2%, and to a lesser extent from the bathroom (63.2%), a value that is justified by the ease of connecting the toilet plumbing to that of the bathroom shower and sink.

Thus, the percentage of partial separation can be related to the possibility of joining fecal and gray water from the bathroom through hydrosanitary connections, forming sewage, associated with the predominant release of gray water from the kitchen and clothes washing tank in the backyard.

Total separation of fractions (disposal of gray and fecal water in different locations) occurred in 33.5% of settlement households, 19.4% of *quilombola* households, and 15.2% of riverine households (Table 1). This practice of separation has been indicated in rural communities across Brazil (SILVA, 2017). It produces domestic sewage, which has a varied composition, including water, feces, urine, soaps, chemicals, fats, food waste, fibers and hair, nutrients, solids, sludge and thermotolerant coliforms, to have each component released separately (BRASIL, 2018), favoring the removal of its resources in different systems and reuse (BRASIL, 2019).

The absence of separation was observed in 29.7% of riverine households and, to a lesser extent, in *quilombola* households (9.7%) and settlements (7.1%). The low percentage of households that generate only sewage, classified as without separation, may be associated with cultural issues, as well as the need to increase the useful life of rudimentary cesspools that receive fecal water, leading to a preference for not releasing gray water into its interior.

## Sanitary sewage deficit

Table 5 shows that the deficit of sanitary sewage (without service) in relation to the households occurred mainly for gray water of the kitchen, being in 66.3% of *quilombola* households, 78.9% of settlement households, and 80% of riverine households, as well as clothes washing in 79, 85.4, and 80.9%, respectively. The percentages were lower for gray water from the bathroom, being higher in settlement (29.1% households) and riverine communities (28.8%), and lower in *quilombola* communities (20.9%). However, the last lacks a bathroom or a dry pit in 13.5%, followed by settlements with 2.2%, indicating the practice of open defecation. The total deficit due to the absence of a bathroom was identified in 5.1% of the households, being lower in relation to the percentage found in the characterization of service (6.6%), due to the difference in the analysis of missing data carried out in the study and the representativeness of each community. In this case, there were 143 households with missing data for calculating deficit and 143 for separating fractions.

The situation for *quilombola* communities exceeds what was reported by Silveira (2013), who, based on census data from the IBGE (2010), found that 4% in the Center-West Region did not have access to a bathroom or toilet.

**Table 4 -** Classification of the form of separation of sewage fractions in diagnosed households by community typology.

| Classification | | Total separation (%) | Partial separation (%) | Without separation (%) | Households without bathroom (%) |
|---|---|---|---|---|---|
| Rural | *Quilombola* | 19.4 | 52.5 | 9.9 | 18.2 |
| | Settlement | 33.5 | 56.9 | 7.1 | 2.5 |
| | Riverine | 15.2 | 55.1 | 29.7 | 0 |
| | Total | 29.1 | 55.6 | 8.6 | 6.6 |

Total separation: gray and fecal water; partial separation: gray water and sewage; without separation: sewage; without bathroom: feces and urine (without water) + gray water from the kitchen and the tank.

**Table 5 -** Classification of households of the respective typologies regarding deficit due to the absence or precariousness of service.

| Typology | Classification | Gray water | | | Sewage and fecal water (%) | Absence of bathroom and dry pit (%) |
|---|---|---|---|---|---|---|
| | | Bathroom (%) | Kitchen (%) | Clothes washing (%) | | |
| *Quilombola* | Without service | 20.9 | 66.3 | 79 | 0.6 | 13.5 |
| | Precarious service | 0.2 | 1 | 0 | 68 | 0 |
| Settlement | Without service | 29.1 | 78.9 | 85.4 | 0.8 | 2.2 |
| | Precarious service | 0.9 | 0.8 | 0.4 | 90.4 | 0 |
| Riverine | Without service | 28.8 | 80 | 80.9 | 0.8 | 0 |
| | Precarious service | 0.9 | 1.8 | 0.9 | 95.1 | 0 |
| Total | Without service | 26.9 | 75.6 | 83.5 | 0.7 | 5.1 |
| | Precarious service | 0.7 | 0.9 | 0.3 | 84.6 | 0 |

As raised by PNSR, the absence of solutions prevails in dispersed households due to the lack of bathrooms and releases into bodies of water, as well as the disposal of gray water in the backyard (BRASIL, 2019). The absence of solutions in the studied communities occurs mainly for gray water due to its release in the backyard.

Precarious service was identified mainly for sewage and fecal water disposed in rudimentary cesspools in 68% of *quilombola* households, 90.4% of settlement households, and 95.1% of riverine households (Table 4). According to PNSR, this precariousness of service is attributed to the widespread presence of rudimentary cesspools, with the worst rates being identified in isolated and less-densely populated regions and in places without agglomerations (BRASIL, 2019). Precariousness of sanitary sewage has also been reported in other works, such as the ones by Silva (2007), Amorim *et al.* (2013), and Santos *et al.* (2014).

The solutions to be implemented to reduce the deficit must start from the assumption of the integration of technical and technological aspects with the practices developed in rural areas, with an integral approach: transversal and intersectoral for sanitation and community projects, favoring greater satisfaction and learning (MACHADO; MACIEL; THIOLLENT, 2021). Solutions must also aim to close the cycle between sanitation and agriculture/plantations, making it possible to propose technologies that recover and recycle nutrients, to add their value and generate benefits and conditions of health and well-being for populations (FONSECA, 2008; DEMENIGHI; GÓMEZ; SOUZA, 2017; DIAZ-ELSAYED *et al.*, 2020; STARKL *et al.*, 2022). However, the reuse of generated effluents may not be a reality, as concluded by Khalid (2018) for a community in Pakistan, where the main barriers to sustainable and safe reuse of human excreta were sociocultural and religious aspects of traditional societies. Thus, educational work and awareness, involving public policies, can encourage this practice.

## CONCLUSION

- The absence of a bathroom was found in 6.6% of the households in the 97 studied rural communities in the state of Goiás, highlighting the absence of a bathroom in 18.2% of households in *quilombola* communities, with 13.7% having open-air or stream disposition and 4.5% a dry pit;
- Regarding households that have a bathroom, 88.9% have fecal water and sewage disposed of in a rudimentary cesspool, 7.1% in a septic tank, 1% directly in the backyard, and 3.0% in a Tapiocanga stone pit, biodigester or ecological cesspool;
- Most of gray water is disposed directly in the backyard, 86.8% from the kitchen sink, and 91.3% from clothes washing, thus presenting the largest deficit without service or with precarious service. In the case of the bathroom sink and shower, 33.5% also go to the backyard and 57.2% to a rudimentary cesspool;
- The deficit of sewage at the household level, in the condition of precarious service for sewage and fecal water, occurred in 84.6% of the households, and without service in 0.7%, with no bathroom or dry pit in 5.1% of the households.

## AUTHORS' CONTRIBUTIONS

Vale, G.B.: Investigation, Methodology, Conceptualization, Data curation, Writing – original draft; Ruggeri Junior, H.C.: Conceptualization, Formal Analysis, Validation, Writing – review & editing; Scalize, P.S.: Conceptualization, Formal Analysis, Funding acquisition, Methodology, Project administration, Supervision, Validation, Writing – review & editing.

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