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Financial comparison of sewage treatment and disposal systems in rural áreas

Comparación financiera de los sistemas de tratamiento y eliminación de aguas residuales en zonas rurales

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Abstract: Rural communities suffer from the lack of sanitary sewage, which ends up compromising the quality of life of these populations. Studies show that conventional sanitation technologies, due to their high costs, end up excluding rural populations. Among the options for the treatment and final disposal of sewage in rural areas we can mention septic tanks with sump and biodigester tanks with filtering gardens. In view of the above, the objective of this article is to make a financial comparison of two individual sewage treatment systems: septic tank with floor drain, and biodigester septic tank with filtering garden. To perform the financial analysis in the case of the septic tank with drain, the amounts were calculated based on the dimensions indicated by ASPROESTE (2018). For the biodigester septic tank with filtering garden, the quantities of materials indicated by ASPROESTE (2018) were adopted for the case of a residence with 5 people. Finally, after the quantities raised, taking as a basis the prices contained in the National Research System of Costs and Indexes of Civil Construction (SINAPI) the costs of implementation of these devices were estimated. The results show that the septic tank system with drain presented a cost of R$ 2580.22 and the biodigester tank system a total cost of R$ 8,682.93. It is concluded that the biodigester septic tank system is more expensive, but allows the reuse of the effluent as biofertilizer, and the values found are relatively high for low-income populations, being indicated the creation of government programs, which deliver these devices for the poorest population.
Keywords: *Rural sanitation; Costs; Quality of life.*

Resumen: Las comunidades rurales sufren una falta de saneamiento que compromete su calidad de vida. Los estudios demuestran que las tecnologías convencionales de saneamiento, debido a sus elevados costes, acaban excluyendo a las poblaciones rurales. Entre las opciones para el tratamiento y la disposición final de las aguas residuales en las zonas rurales podemos mencionar la fosa séptica con drenaje y el tanque biodigestor con jardín filtrante. En vista de lo anterior, este artículo tiene como objetivo realizar una comparación financiera de dos sistemas de tratamiento individual de aguas residuales: fosa séptica con drenaje de piso y fosa séptica biodigestora con jardín filtrante. Para realizar el análisis financiero en el caso de la fosa séptica con desagüe, se calcularon los importes en base a las dimensiones indicadas por ASPROESTE (2018). Para la fosa séptica biodigestora con jardín filtrante, se adoptaron las cantidades de materiales indicadas por ASPROESTE (2018) para el caso de una residencia con 5 personas. Finalmente, después de las cantidades planteadas, tomando como base los precios contenidos en el Sistema Nacional de Investigación de Costos e Índices de Construcción Civil (SINAPI),

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se estimaron los costos de implementación de estos dispositivos. Los resultados muestran que el sistema de fosa séptica con desagüe presentó un costo de R$ 2580,22 y el sistema de fosa biodigestora un costo total de R$ 8.682,93. Se concluye que el sistema de fosa séptica con biodigestor es más caro, pero permite la reutilización del efluente como biofertilizante, y los valores encontrados son relativamente altos para poblaciones de baja renta, siendo indicada la creación de programas gubernamentales, que entreguen estos dispositivos para la población más pobre.
Palabras clave: *Saneamiento rural; Costos; Calidad de vida.*

INTRODUCTION

In rural communities, investments in infrastructure, sanitary sewage, solid waste collection and water supply are minimal and these services are mostly very precarious, directly influencing the quality of life of the residents (KOLLING NETO; et al 2018).

For Guimarães et al. (2001), sanitation associates systems consisting of a physical infrastructure and an educational, legal, and institutional structure, which covers the following services: water supply to the populations, collection, treatment of sanitary sewage, and control of vectors such as insects, rodents, mollusks, among others. The lack of basic sanitation is pointed out by academia as one of the current factors that are strongly associated with public health problems and environmental pollution.

> In rural areas of municipalities, household waste is commonly disposed of in dry pits, which consist of irregular excavations of uncertain size in the ground. Raw sewage is received in the dry pits without prior treatment and ends up seeping into the ground, making it quite likely that the groundwater and soil where these pits are installed will be contaminated at some point. In addition, dry pits are sometimes located near water catchment wells, which can also be contaminated with pathogens and unwanted organic matter. This situation puts the population at risk, which can be contaminated by waterborne diseases such as hepatitis, cholera, salmonellosis and others. (SILVEIRA E SOUZA et. al, 2021, p.02).

As stated by Silveira e Souza et. al (2021), without basic sanitation infrastructure and exposed to health problems that can be caused by poor management of household facilities and effluents, isolated communities place themselves in a very vulnerable position with regard to human health. Studies indicate that an improvement in the sanitation services provided to the population will considerably reduce the incidence of waterborne diseases, but on the other hand, conventional sanitation technologies (because they are expensive), in research already conducted have been excluding rural populations (JOÃO, SOUSA, and SILVA, 2015).

So, for rural areas, where there is no basic infrastructure necessary for the treatment of domestic sewage, it is necessary to have knowledge of the elements available and avoid such contamination that interfere with quality of life, and among the options for the treatment and final disposal of sewage we can mention septic tank with drain and biodigester tank with filtering garden. Considering that, in general, rural communities have a low purchasing power, this article aims to make a financial comparison of two individual sewage treatment systems: septic tank and floor drain, and biodigester septic tank and filtering garden.

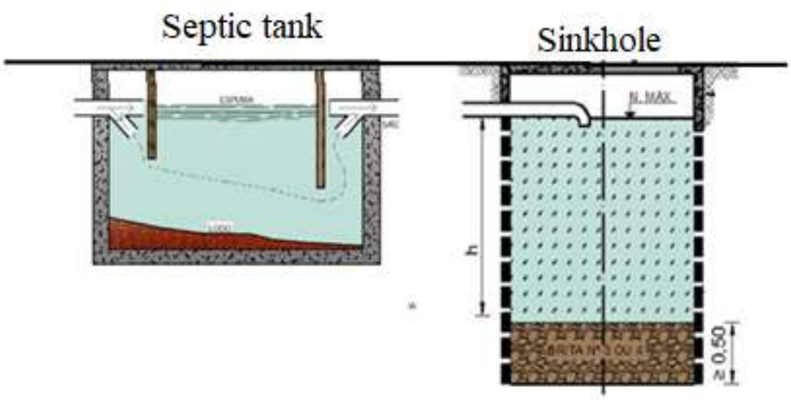
THEORETICAL FOUNDATION

Septic tank and floor drain

The septic tank is the device responsible for the primary treatment of domestic sewage. Its main purpose is to receive and store the sewage for a certain period of time. They are commonly used when there is no option of connecting to the municipal sewage system, usually in rural areas (BRK, 2020). They may be square or circular in shape, made of concrete or masonry, the latter being the most commonly used material. According to Dacach (1979), they have a reinforced concrete bottom and roof slab, and the walls can be made of reinforced concrete or brick masonry internally lined with cement and sand mortar in a 1:3 ratio. One advantage this item offers is its low maintenance cost. Because it is made of an extremely resistant material, such as concrete, it does not require constant maintenance.

The drain is a vertical unit for the purification and final disposal of effluents from septic tanks, built in cylindrical shape, and must ensure a minimum distance of 1.50 m between its bottom and the maximum level of the aquifer (ARAGÃO, 2020). The walls are commonly built in perforated concrete shackles (also known as zimbras), but can also be made with bricks with dry joints - to allow percolation - or perforated ceramic blocks laid in a radial way. It must have a reinforced concrete cover, with a 60 cm inspection cover.

FIGURE 01: Septic tank and floor drain.

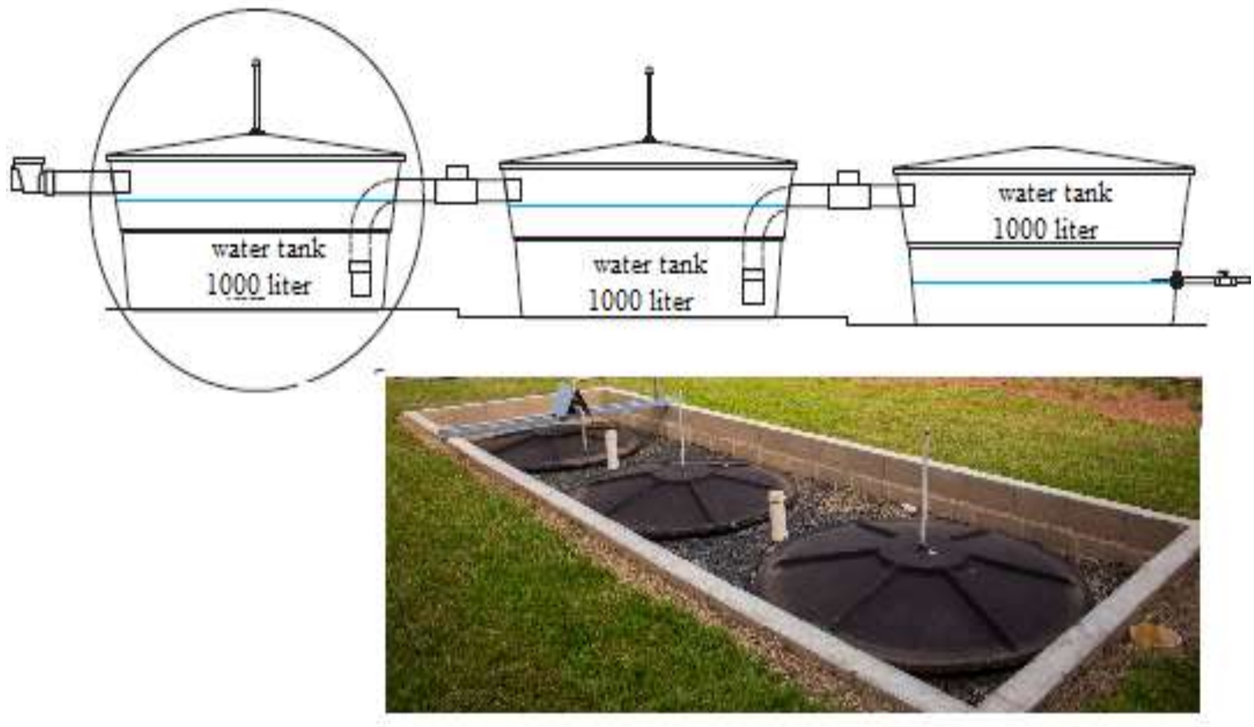


SOURCE: Adapted from CREDER (2006) apud GREEF; HELDT (2020).

Biodigestor septic tank and filtering garden

The Biodigestor Septic Tank (Figure 02) is formed by a set of at least three fiberglass water tanks of 1000 liters - for homes with up to 5 people - connected by pipes, whose purpose is the treatment of sewage from the toilet of rural homes, classified as "black waters" avoiding their disposal in an irregular way that cause environmental impacts and the spread of waterborne diseases (SILVA; MARMO; LEONEL, 2017). According to these same authors the principle of operation of the Biodigestor Septic Tank is the anaerobic fermentation (absence of oxygen) performed by a set of microorganisms present in the sewage itself; being the process performed without the use of electricity, applying at first a mixture of 5 liters of fresh bovine manure and 5 liters of water, once a month.0).

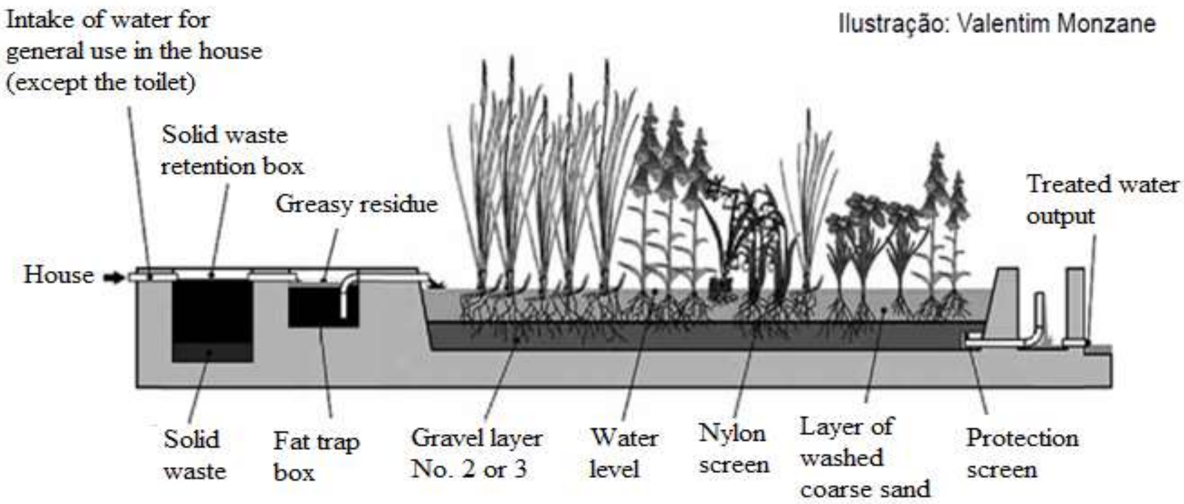
FIGURE 02: Floor plan and front view of the biodigester septic tank system.



SOURCE: SILVA; MARMO; LEONEL (2017).

The filtering garden is a technology adapted to complement the use of the biodigester septic tank, consisting of a small pond with stones, sand and water plants, where the sewage is treated, contributing to the sustainability of the environment, bringing harmony to the landscape, besides presenting a very simple maintenance. After the treatment this effluent has several applications: irrigation of crops, washing floors and windows, use in the toilet, among others; but if there is no interest in reuse, it can be disposed of properly to the environment (SILVA, 2014).

FIGURE 03: Schematic of filter garden assembly.



SOURCE: SILVA (2014).

METHODOLOGY

The methodology consisted of the sizing of the septic tank and the drain, based on the considerations adopted (residence, number of people, characteristic of the soil where it will be located), followed by obtaining the costs of the elements: septic tank, drain, filtering garden and biodigester tank, in order to estimate the costs of each element (SINAPI - Sistema Nacional de Pesquisa de Custos e Índices da Construção Civil) and make a comparison for each set of elements.

Septic tank and floor drain dimensions

For this work we will use a hypothetical residence with 5 people built on sandy soil. For the septic tank and the drain the dimensions according to Table 01, below, will be adopted.

TABLE 01: Pit and drain dimensions for a residence with 5 people.

Dimensions - Rectangular septic tank for 5 people		
Height (H)	Length (L)	Width (B)
1,00 m	1,20 m	0,95 m
Dimensions - Sand floor drain		
Depth (H)	Diameter (D)	Number of Sinkholes
3,00 m	1,30 m	1

SOURCE: Adapted from ASPROESTE (2018).

In the case of the biodigester septic tank, three fiberglass tanks with 1000 liters each will be used; and for the construction of the filtering garden, an area of 10 m² will be adopted (2 m² per resident) as indicated by ASPROESTE (2018).

Quantity of materials

For the financial analysis, it will be necessary to determine the amount of materials for the execution of each device. In the case of the septic tank and the drain, these quantities will be calculated based on the dimensions presented in Table 01. In the case of the biodigester septic tank and the filtering garden, the quantities of materials indicated by ASPROESTE (2018) will be adopted for the case of a residence with 5 people. Finally, after the quantities are determined, the cost of these devices will be estimated based on the prices indicated in SINAPI - Sistema Nacional de Pesquisa de Custos e Índices da Construção Civil.

RESULTS AND DISCUSSIONS

Septic tank cost estimate

A quantitative survey of the services that make up the execution of the cast-in-place septic tank was performed, which are: excavation volume, execution of the lean concrete ballast, execution of the reinforced concrete cover, masonry wall raising, and finally, the wall covering. The results are presented in Table 02.

TABLE 02: Cost to build a septic tank for a residence with 5 people.

Service	Unit	Quantity	Unit Cost	Total Cost
Excavation	m³	3.56	34.29	122.07
Concrete ballast (10 cm)	m³	0.22	494.91	108.88
Reinforced concrete cover (e=5cm)	m²	1.61	139.99	225.38
Masonry Wall (e= 10cm)	m²	6.45	141.76	914.35
Lining mortar	m³	0.1	560.62	56.06
				1,426.75

SOURCE: Research data (2022).

Estimated cost of the drain

A quantitative survey of the services that comprise the execution of the drain was performed, which are: excavation volume, execution of the masonry wall, gravel layer and execution of the reinforced concrete cover. The results are presented in Table 03.

TABLE 03: Cost of executing a drain for a residence with 5 people.

Service	Unit	Quantity	Unit Cost	Total Cost
Excavation	m^3	3.98	34.29	136.47
Masonry wall	m^2	14.9	49.48	737.25
Gravel layer	m^3	0.66	141.76	93.56
Concrete cover	m^2	1.33	139.99	186.19
				1,153.47

SOURCE: Research data (2022).

Estimate of the cost of the biodigester septic tank

A quantitative survey of the materials and services that make up the execution of the biodigester tank was carried out, which are basically the fiberglass water tanks, hydraulic materials (pipes, fittings, valves and records), various materials (glue, paint, sandpaper, etc.). To avoid a very long table, the costs of these materials were added up and inserted in the table as two items. The results are presented in Table 04.

TABLE 04: Cost of executing a drain for a residence with 5 people.

Materials	Unit	Quantity	Unit Cost	Total Cost
Fiberglass water tanks	unit	3	1.051,03	3.153,09
Hydraulic materials	-	-	-	1.412,72
Materials	-	-	-	411.89
Excavation	m^3	6	34.29	205.74
				5,183.44

SOURCE: Research data (2022).

Estimated cost of the filtering garden

A quantitative survey of the materials and services that make up the filtering garden was carried out. The results are presented in Table 5. It is worth noting that this table does not include the purchase of water plants (Taboa, papyrus, yam, etc.).

TABLE 05: Cost of a filter garden for a residence with 5 people.

Materials	**Unit**	**Quantity**	**Unit Cost**	**Total Cost**
EPDM geomembrane (7 m x 4 m)	unit	1	798.00	798.00
Geotextile membranes (Bidim) - 7 m x 4 m	unit	2	382.48	764.96
Flange for 100 mm geomembrane	unit	2	197.00	394.00
Crushed stone no. 2 or 3 (2 m³)	m³	2	139.38	278.76
Nylon screen (1.2 x 10 m)	unit	1	26.98	26.98
Coarse sand	m³	2.5	104.90	262.25
Water tank (50 to 100 l)	unit	1	229.52	229.52
Fat box (DN 100) with cover	unit	1	488.07	488.07
PVC pipe (6 m pipe)	m	6	85.50	85.50
Excavation	m³	5	34.29	171.45
				3,499.49

SOURCE: Research data (2022).

The results show that the septic tank and drain system had a total cost of R$ 2580.22. The most expensive item in both devices is the masonry wall. This cost can be reduced by substituting alternative materials, such as used tires. The system's biodigester septic tank and filtering garden showed a total cost of R$ 8,682.93 being the most expensive item, the fiberglass water tanks.

CONCLUSIONS

However, it can be stated that: (a) the septic tank and drain system presents a lower cost of execution, on the other hand, for the effluent forwarded to the system is not given any utility; b) The biodigester tank and filtering garden system has a higher cost, but allows the reuse of this effluent as biofertilizer; c) The values found for the execution of the systems are relatively high for low-income populations, and an alternative is the implantation of governmental programs that deliver these devices to these populations.

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