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Decentralized Domestic Effluent Treatment System to Attend a Single-Family Residence

Adeilton Antonio Silva Celestino[1], Eduardo Antonio Maia Lins[2], Daniele de Castro Pessoa de Melo[3], Diogo Henrique Fernandes da Paz[4]

[1]Master in Environmental Management, Technological Institute of Pernambuco, Recife, Brazil.
[2]Department of Environmental Engineering, Catholic University of Pernambuco, Recife, Brazil
[3]Coordinator of the master's in environmental management, Technological Institute of Pernambuco, Recife, Brazil.

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***Abstract*— *In Brazil, in semi-urban and rural regions, the absence of basic sanitation becomes more evident, above all, the lack of sanitary sewage, caused by the high cost of implementation and maintenance of centralized systems with collection networks and sewage treatment plants. Given this reality, decentralized systems have been widely used in semi-urban and rural housing centers, providing treatment with efficiency and low cost, besides having an important role in expanding the care of sewage services, especially in areas devoid of sewage collection networks. This research proposes the integration of theoretical models based on the contributions of researchers to the subject, with the equations established by the technical standards ABNT (NBR 7229/1993) and a (NBR 13969/1997) related to effluent treatment, using the theory present in the literature to size an individual system of treatment of domestic effluents, which meets a single-family residence, seeking to generate knowledge for practical application in localities devoid of sewage collection network. For this, it was designed to form an integrated form, a treatment system containing three reservoirs, with the septic touch initiating the purification process, directed to the liquid part for biological treatment in the anaerobic filter, with anaerobic microorganisms stabilizing the organic matter before final disposal of the effluent in the sink. In general, decentralized systems are considered by several researchers as an efficient solution in the treatment of domestic sewage. NBR 13969/1997 defines the likely ranges of removal of pollutants, according to the type of treatment, where the combined septic tank system and anaerobic filter achieved good results in the removal of (BOD), (DQO), (SNF) and sedimentable solids, increasing treatment efficiency and meeting the parameters for effluent disposal in the environment as permitted by CONAMA Resolution No. 430/2011. Regarding the cost of implementation, the budget was obtained by budget spreadsheets, using the unit prices of the National System of Research of Costs and Indexes of Civil Construction, reference, Recife, July 2021. With the treatment system designed in an integrated way, standing out for the lower cost and smaller built area, reducing the costs of implantation by 28% compared to the system with the separate projected reservoirs.*

I. INTRODUCTION

Basic sanitation promotes sanitation and social inclusion, where the human right to water and sanitation declared at the United Nations General Assembly on July 28, 2010, recognizes the right to drinking water and sanitation as an essential right for the full enjoyment of life and all human rights, through Resolution A/RES/64/292 (UN, 2010).

Sanitation did not keep pace with population growth, causing a deficit in the collection and treatment of domestic wastewater, especially in peripheral and rural regions without a collection network and sewage treatment plant. The low population density in these regions becomes financially unfeasible to build collection networks, causing governments to prioritize the implementation of centralized treatment systems in locations with higher concentrations of inhabitants.

According to the publication of the National Water Agency (ANA), in Brazil, 43% of the population has sewage collected and treated, in addition to 12% using septic tank, that is, 55% have treatment considered adequate; 18% have their sewage collected and untreated, which can be considered as a precarious care; and 27% do not have collection or treatment (ATLAS ESGOTOS, 2020).

Currently, reservoirs, lakes and rivers are being overwhelmed by freshwater demand due to rapid industrialization and population explosion. To solve this problem, several decentralized wastewater treatment systems have been built worldwide to reuse wastewater recycling for non-potable uses, such as fire protection, toilet discharge and garden irrigation (BAJPAI; KATOCH; CHATURVEDI, 2019).

The policies and actions of the government of urban and regional development, housing, combating and eradicating poverty, environmental protection, health promotion and other relevant social interest, aimed at improving the quality of life, should consider the essential articulations to promote basic sanitation, including about its financing, according to Federal Law 11.445/2007 (BRASIL, 2007).

The need to advance in the fields of sanitation and water management has resulted in recent reforms of legal frameworks and a significant increase in resources for sanitation. In the academic field, this framework inspires the challenge of better understanding the trajectories of these policies, which motivates this effort to know the historical formative processes and structural factors (MURTHA; HELLER, 2015).

Faced with this reality, decentralized systems are presented as an adequate social technology to serve single-family homes in isolated locations with low cost, shorter execution time and efficiency in the removal of pollutants, acting effectively in the protection of public health and contributing to the preservation of the environment. Social technologies in sanitation are understood as techniques and methodologies developed through interaction with communities and have been shown to be key to the development of sanitation effectively, easily operating and maintaining, in addition to promoting the social inclusion of minority groups through the participation of the population in lectures, training and training on the theme (HORA; RODRIGUES; SACHO, 2019).

The Brazilian Association of Technical Standards, through NBR 7229/1993, design, construction, and operation of septic tank systems, defines the sewage system as being "the set of facilities that brings together collection, treatment and disposal of wastewater". It must be sized and deployed to receive all the evictions.

The mathematics present in the dimensioning of a domestic effluent treatment system, although there is a normative about the minimum volume to be stored in each tank, nothing is about the dimensions about length, width and height. Thus, the purpose of the practice is to discuss the possible changes in these dimensions of the tanks that store and treat effluents (REHFELDT; ERTHAL, 2015).

In this scenario, given the concepts and information contextualized about the treatment of domestic effluents, in isolated regions devoid of a collection network and centralized sewage treatment plant, this research intends to dimension a decentralized system, which is effective in removing pollutants, starting with a primary treatment in the septic tank, followed by secondary treatment in the anaerobic filter and ending with the destination in the sink.

II. METHODOLOGY

STUDY AREA

The project for individual solution of treatment of domestic sewage was elaborated with the purpose of being implemented in a single-family residence with four residents in SítioTreme, located in the rural area of the municipality of São João, at coordinates 8º50'26.0"S and 36º26'12.3"W, 3 km from Mestre Dominguinhos Highway (BR 423,Km 92), in the state of Pernambuco (Figure 1).

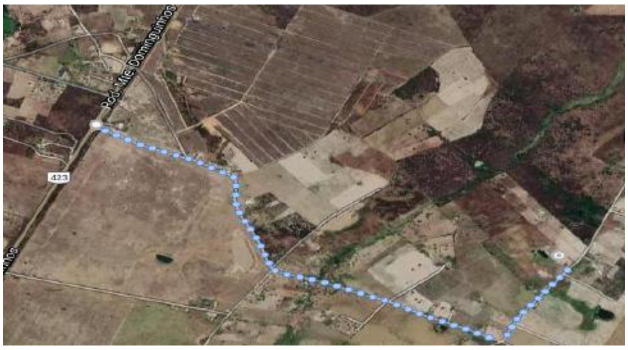

Fig.1: Part of the Map of Countryside–Treme Neighborhood Site.

It can also be replicated in locations with low demographic density devoid of sewage collection networks, such as rural communities and peripheral regions of cities. However, the system is no longer implemented, due to lack of financial incentive to research by the government.

METHODOLOGICAL STEPS

The procedure used in the research is of quantitative approach with descriptive objective, proposing the integration of theoretical models with the equations established by the technical standards NBR 7229/1993 and NBR 13969/1997 related to effluent treatment in Brazil, using the theory present in the literature to size an individual system of treatment of domestic effluents, which meets a single-family residence, seeking to generate knowledge for practice in locations devoid of sewage collection network.

The analyses of the calculations followed the concepts of environmental technology through bibliographic research on the subject contextualized and from data of dimensioning of domestic sewage collected in the technical and scientific literature.

LAYOUT OF A TREATMENT SYSTEM

The project proposes the design of a conventional treatment system model but built in an integrated way sharing the walls of the Septic Tank, Anaerobic Filter and Sinkhole. From fashion to perform a comparison of the cost of deployment of systems with reservoirs built separately and in an integrated way.

The first option is the most widespread, with the reservoirs being constructed separately and interconnected by means of PVC pipes, differentiating from the model under study that predict the execution of the reservoirs in an integrated way, divided into three tanks in masonry structure at once, with walls of 19.0 cm thickness and internal coating with 1.0 cm of chapisco and 2.0 cm of mortar.

The dimensions of the systems under study follow the recommendations of the technical standards NBR 7229/1993 and NBR 13969/1997, in addition to observing concepts of environmental technologist for the construction, operation and maintenance of sewage treatment system, observing the following specifications:

- 1.50 m of buildings, land boundaries, sinks, infiltration ditches and building water extension.
- 3.0 m of trees and any point of public water supply.
- 15.0 m of groundwater wells and bodies of nature water.
- As for the removal of digested sowe, about 10% of its volume should be left inside the tank.

To use the standard, government data are used to obtain the average number of people per dwelling. Among the data collected, ibge corroborates that in the country, in each household live, on average, 2.9 people per residence, with the Northern Region reaching the highest regional average in Brazil, with 3.3 people per dwelling.

According to the National Household Sample Survey (PNAD, 2017), in Brazil almost 70% of households, it is connected to the general sewage network, with the following percentages of connection by region: 27.4% in the North, 47.2% in the Northeast, 60% in the Midwest, 69% in the South and 89% in the Southeast. Among which, 29.9 million people live in rural areas, of this number only 5.7% of the population has sewage connected to the sewage collection network and 23% use septic tank, with the remainder allocating untreated sewage into the environment.

This information is relevant, considering that the number of people per household is the main parameter for sizing the useful volume in liters of each element that makes up the individual treatment system. As the national average is 2.9 people and the most critical region being 3.3 people per residence, we will adopt the worst citation, rounding to 4.0 people, for calculation.

As the system will meet a medium standard residence with four residents, the daily contribution of sewage was adopted to be 130 liters per inhabitant/day, according to Table 1 of NBR 7229/1993. Evaluating that the period of detention of the evictions, by daily sewage contribution range, according to Table 2 of NBR 7229/1993, was used one day. While the slable accumulation rate was used to determine the slable accumulation rate, according to the cleaning interval of one year and the weighted ambient temperature range greater than 20º C, as pointed out in Table 3.

Table 1 - Daily contribution of sewage and fresh sludge by type of occupying building

Building	**Unit**	**Contribution of sewage (C) and fresh sludge (Lf)**	
Permanent occupants			
Residence			
High standard	person	160	1
Medium standard	person	130	1
Low standard	person	100	1
Hotel (except laundry and kitchen)	person	100	1
Temporary accommodation	person	80	1

Table 2 - Period of detention of evictions, by daily contribution range.

Interval between cleaning (years)	**K values per ambient temperature range (t), in °C**		
	T ≤ 10	10 ≤ t ≤ 20	T > 20
1	94	65	57
2	134	105	97
3	174	145	137
4	214	185	177
5	254	225	217

Table 3 - Slable accumulation rate per interval between cleanings and temperature.

Percolation rate min/m	**Maximum daily application rate m³/m².d**	**Percolation rate min/m**	**Maximum daily application rate m³/m².d**
40 or less	0,2	400	0,065
80	0,14	600	0,053
120	0,12	1200	0,037
160	0,1	1400	0,032
200	0,09	2400	0,024

According to NBR 7229/1993, the septic tank system is the set of units for the treatment and disposal of sewage, using septic tank and complementary treatment units and final disposal of effluents and sludge. How much the septic tank is the rectangular cylindrical or prismatic unit of horizontal flow, for sewage treatment by sedimentation, flotation, and digestion processes.

However, to size the anaerobic filter and sink, we will use the technical standard NBR 13969/1997, as it is more specified for the design, construction and operation of complementary treatment units and final disposal of pretreated liquid effluents in the septic tank.

Among the complementary treatments listed, we highlight the parameters related to the anaerobic filter because it is an integral part of this study, with percentage values consisting of 40 to 75% of biochemical oxygen demand, 40 to 70% of chemical oxygen demand, 60 to 90% of non-filterable solids, 70% or more of sedimentable solids and 20 to 50% of phosphate (NBR 13969/1997).

As for the sinkhole, the standard states that it consists of a unit of final disposal of the verticalseptic tank effluent in relation to the infiltration ditch. Due to this characteristic, its use is favorable only in areas where the aquifer is deep, where it can guarantee the minimum distance of 1.50 m between its bottom and aquifer level (NBR 13969/1997).

Because it is a vertical infiltration unit, which crosses a few layers of soil, the site of installation of the sink, needs to undergo a test to estimate the infiltration capacity in the soil and the dimension of the bottom of the pit for testing should be about the same from the bottom of the sink. As far as it is concerned, this quota consists from the minimum distance of the maximum quota of the local aquifer in relation to the output quota of the septic tank pipe (NBR 13969/1997).

SIZING

The dimensioning directly influences the characteristics of the effluent, as well as the desired final efficiency, given this, a system of domestic depletion composed of septic tank, anaerobic filter and sink, sized according to current standards, can achieve an efficiency between 70 and 85% in the removal of biochemical oxygen demand and 80 to 90% in the removal of suspended solids (DA SILVA; MONTEIRO, 2020).

The treatment begins by the septic tank with the collection of effluents from the bathroom from the toilet and the sink and shower drains through direct piping, in addition to the service area and kitchen through the fat box.

Then, the evictions follow by severity for biological treatment in the anaerobic filter, with anaerobic microorganisms act to stabilize organic matter. Finally, the effluent already treated is directed to the sinkhole by taking the layers of the subsoil.

The research provides for the elaboration of a decentralized treatment system with integrated construction system, sharing the walls of septic table, anaerobic filter and sinkhole, with a reduction in implantation costs above 25%, maintaining the effectiveness of treatment with apart apart reservoirs.

However, the dimensioning proposed in this research will serve for both systems, with the calculations performed separately each element that composes the system, diverging only in the design of the project. With both dimensioned to serve a single-family residence with four residents, enabling its implementation in all regions of Brazil. In addition to pay ing the minimum design dimensions, established by technical standards NBR 7229/1993 and NBR 13969/97.

- Daily Contribution of Sewage

In Brazil, the per capita consumption of a medium standard residence is used as a design parameter to size sewage systems. The amount of sewage generated by a population varies according to the existence or not of public supply, the proximity of water from the home, the climate, the habits of the population (FUNASA, 2017).

In 2017, the per capita use of water by families was 116 liters per inhabitant/day, according to IBGE. In view of this information, we will adopt the daily consumption of 130 liters per inhabitant/day, meeting the national average and the parameter of 130 liters of daily sewage taxpayer for medium standard residence established by the technical standard of NBR 7229/1993.

- Taxpayer rate

N = Total contributors

Q = Number of rooms = 2

P = Number of people per room = 2

$$\mathbf{N = Q * P} \quad \textbf{(1)}$$

- Daily Contribution of Sewage

CT = Total contribution

N = Number of contributors = 4 people

C = Daily contribution = 130.0 liters per capture.

$$\mathbf{CT = N * C} \quad \textbf{(2)}$$

- Fat Box

The fat boxes should allow the retention and subsequent removal of the fat, according to NBR 8160/1999, which determines the inner diameter, the submerged part of the septum, the retention capacity and nominal diameter of the outlet pipe.

When sizing the fat box for the collection of only one kitchen, the standard recommends the use of the small fat box (CGP).

As a rule, these boxes are fundamental for the proper functioning of the system and can be prefabricated of fiber cement or reinforced plastic.

- Septic Tank Sizing Equation

TS = Septic tank

N = Number of contributors = 4 people

C = Contribution of dumps = 130 liters

TDH = Hydraulic holding time = 1 day

K = Slable accumulation rate = 57 liters

Lf = Contribution of fresh slable in days = 1 day

$$\mathbf{TS = 1.000 + N * ((C * TDH) + (K * Lf)} \quad \textbf{(3)}$$

- Equation for Anaerobic Filter Sizing

FA = Anaerobic filter

N = Number of contributors = 4 people

C = Contribution of dumps = 130 liters

TDH = Hydraulic holding time = 1 day

K = Slable accumulation rate = 57 liters

Lf = Contribution of fresh slable in days = 1 day

$$\mathbf{FA = 1,6 * N * C * TDH} \quad \textbf{(4)}$$

- Equation for Sink Sizing

The volume of the sink is determined according to the volume of the septic tank and may have equal or higher dimensions. However, it is necessary to determine the rate of soil pergrowth for the proper functioning of the sink (NBR 13969/97).

The bottom dimension of the test pit must be about the same as the sinkhole. As far as it is concerned, that dimension is determined from the minimum distance of the maximum quota of the local aquifer and the output quota of the septic tank pipe. When an assay is done on several layers, the result of each cava is obtained by means of the equation where: Ki and Hi are, respectively, the rates and heights of the layers where the tests were carried out (NBR 13969/1997)

$$\mathbf{K} = \sum(\mathbf{ki} * \mathbf{Hi})/\sum(\mathbf{Hi}) \quad \mathbf{(5)}$$

Table 4 - Conversion of pergrowth rate into surface application rate.

Daily contribution (L)	**Detention time**	
	Days	**Hours**
Up to 1500	1	24
From 1501 to 3000	0,92	22
From 3001 to 4500	0,83	20
From 4501 to 6000	0,75	18
From 6001 to 7500	0,67	16
From 7501 to 9000	0,58	14
More than 9000	0,5	12

S = Sinkhole

C = Length

L = Width

P = Depth

$$\mathbf{S} = \mathbf{C} * \mathbf{L} * \mathbf{P} \qquad \mathbf{(6)}$$

- Pipes and Canecões

The pipes are designed considering the alignment and elevation of the pipes between the tanks, promoting the flow of wastewater during the treatment by gravity, remaining buried desdá exit of the residence until the entry into the septic tank.

Most of the time the pipes used are PVC for building sewage, which must meet the technical specifications placed in the NBR 8160/1999 standard, in addition to the connections necessary to connect, the septic tank with the anaerobic filter and the sink.

- Proposed Model

With the results obtained through the equations established by the technical standards NBR 7229/1993 and NBR 13969/1997, they will define the minimum dimensions for the design of an individual sewage treatment project, designing a model of easy execution and low cost, contextualizing concepts of environmental technology, in addition to socioeconomic and operational aspects.

Socioeconomic aspects include the rapid acceptance by the population, adaptation to the local culture, low installation cost, ease of obtaining materials and skilled workers. It can also generate by-products such as biogas during treatment, or biofertilizers after treatment.

As for the operational part, the individual treatment of domestic sewage offers numerous financial advantages due to the absence of sewage collection network, lifting stations and permanent labor, thus avoiding the collection of monthly fees for maintenance by sanitation companies. Needing only the hiring of the truck clean swosa from time to time, as specified in the project.

The project proposes the construction of a treatment system in masonry at once, with ceramic brick 19 cm thick and internally coated with chapisco and plaster. Dividing into three tanks with distinct functions in the treatment. With the septic tank containing bottom slab, wall coated with mortars and cover slab with sigh for elimination of gases.

The anaerobic filter must contain, in addition to the items already mentioned, a slab with several holes that allows the ascending flow of the sewage seated 50 cm from the bottom slab and the filter bed composed of crushed stone no. 3 or 4. While in the sinkhole the bottom slab is replaced by a layer of crushed stone, allowing the infiltration of the treated effluent underground.

With the system in operation, it is warned to collect samples, after treatment and before percolating underground, for analysis of the main physicochemical parameters such as: biochemical oxygen demand, chemical oxygen demand, non-filterable solids, sedimentable solids and phosphate.

The results obtained in the laboratory should be compared with the parameters found in technical standards such as NBR 7229/1993 and NBR 13969/1997, in addition to the parameters indicated in CONAMA resolution no. 430/11, which refers to this research, related to the decentralized treatment of effluents in Brazil.

BUILDING MATERIALS AND BUDGET

From the dimensioning, the proportions for each treatment unit were reached. Enabling the survey of materials and labor of each element that composes the treatment system in order to pray them, in order to promote the discussion about the economic viability of the proposed systems.

The budget was obtained through budget spreadsheets with unit prices being obtained through consultation with the National System of Research of Costs and Indices of Civil Construction - SINAPI reference, Recife, July 2021 (SINAPI, 2021). This tool was fundamental for the survey of the costs of the system with the apart reservoirs and for the system with the integrated reservoirs.

III. RESULTS AND DISCUSSION

The results of the alvitrate dimensions are described in subsequent items to contribute by expanding the debate by addressing issues related to the decentralized treatment of domestic sewage in peripheral and rural locations devoid of the collection network.

Promoting the use of an individual system of treatment of domestic effluents, containing septic tank, anaerobic filter, and sinkhole, incorporating efficiency, low cost and ease of execution, contributing decisively to public health and the sustainability of the environment.

The research proposes a treatment system designed to form integrated, containing three reservoirs, dividing the walls of septic marquee, anaerobic filter and sinkhole. Separately, each element that makes up the system, based on technical standards NBR 7229/1993 and NBR 13969/1997.

In addition to CONAMA Resolution No. 430/2011, which provides for effluent release conditions and standards. Aiming to attend a single-family residence, occupied by four residents, weighing the generation of 130 liters of daily sewage taxpayer per person for medium standard residence, considering the minimum dimensions established by technical standards.

SIZING CALCULATIONS

- Calculation of the Taxpayer rate

N = Total contributors

Q = Number of rooms = 02

P = Number of people per room = 02

$$\mathbf{N = Q * P (7)}$$

$$N = 2{,}0 * 2{,}0$$

$$N = 4{,}0 \text{ Pessoas}$$

- Daily Contribution of Sewage

CT = Total contribution

N = Number of contributors

C = Daily contribution = 130.0 liters per capture.

$$\mathbf{CT = N * C} \qquad \textbf{(8)}$$

$$CT = N * C$$

$$CT = 4{,}0 * 130{,}0$$

$$\text{Contribuição Total} = 520 \text{ litros por dia}$$

- Fat Box Volume Calculation

Item 5.1.5.13 of NBR 8160/1999

Inner diameter = 0.30 m

Submerged part of the septum = 0.20m

Retention Capacity = 18L

- Septic Tank Sizing

TS = Septic tank

N = Number of contributors = 4 people

C = Contribution of dumps = 130.0 liters

TDH = Hydraulic holding time = 1 days

K = Slable accumulation rate = 57 liters per person per day

Lf = Contribution of fresh slable in days = 1 day

$$\mathbf{TS = 1.000 + N * ((C * TDH) + (K * Lf))} \qquad \textbf{(9)}$$

$$TS = 1.000 + 4 * ((130 * 1) + (57 * 1))$$

$$TS = 1.000 + 4 * (130 + 57)$$

$$TS = 1.000 + 748 = 1.748 \text{ litros}$$

- Dimensions adopted for septic tank:

A septic tank was adopted, in masonry structure at once in ceramic bricks, with walls 19 cm thick and internal and external coating of 3.0 cm, as well as bottom slab and cover slab in reinforced concrete, obeying the minimum dimensions established by NBR 7229/1993.

Length......................... 1.0 m

Width.................................. 1.0 m

Height.................................... 2.0 m

$$TS = 1{,}0 * 1{,}0 * 2{,}0 = 2.000 \text{ litros}$$

- Anaerobic Filter Sizing

FA = Anaerobic filter

N = Number of contributors = 4 people

C = Contribution of dumps = 130.0 liters

TDH = Hydraulic holding time = 1 days

K = Slable accumulation rate = 57 liters per person per day

Lf = Contribution of fresh slable in days = 1 day

To discuss the subject matter of this research, it is important to highlight Law No. 11,419/2006, which provides for the computerization of processes, with this rule to the effective introduction of virtual procedure leading into the judiciary. This norm, presented in the jurisdictional activity, a transformation relative to the understanding before the judiciary of the necessary look at paradigm changes for the benefit of the jurisdiction and, also, of the environment.

$$\mathbf{FA = 1,6 * N * C * TDH} \quad \mathbf{(10)}$$

$$FA = 1{,}6 * 4{,}0 * 130 * 1$$

$$FA = 832 \text{ litros}$$

Dimensions adopted for anaerobic filter:

An anaerobic filter was adopted, in a masonry structure at once in ceramic bricks, with walls of 19 cm thickness and internal and external coating of 3.0 cm, as well as of bottom slab and reinforced concrete cover slab according to the minimum dimensions established by NBR 13969/1997.

Length.......................... 1.0 m

Width.................................. 1.0 m

Height..................................... 1.4 m

$FA = 1{,}0 * 1{,}0 * 1{,}4 = 1.400$ litros

- Sink Scale

Based on the calculations of the capacity of the septic tank, similar dimensions and materials can be adopted, replacing the bottom slab with a layer of crushed stone. However, it is necessary to determine the rate of soil pergrowth for the proper functioning of the sink, according to the NBR 13969/1997 standard.

Length.......................... 1.0 m

Width.................................... 1.0 m

Height..................................... 2.0 m

$$\mathbf{S = C * L * P} \quad \mathbf{(11)}$$

$S = 1{,}0 * 1{,}0 * 2{,}0 = 2.000$ litros

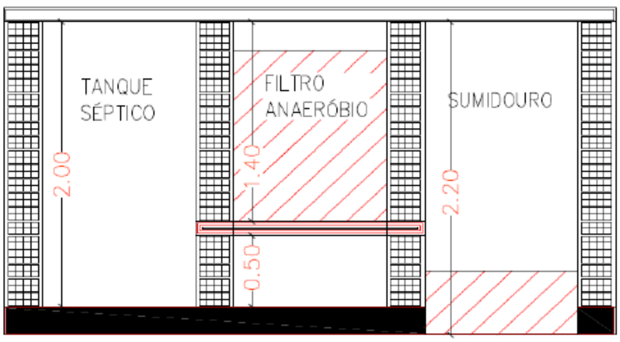

Fig. 3: Cutting of the Domestic Effluent Treatment System

TECHNICAL SPECIFICATIONS

The main parameters and criteria recommended for the implementation of the constituent parts of an engineering project, related to sewage treatment systems, are available in brazilian technical standards (NBR) published by the Brazilian Association of Technical Standards (ABNT) and in the guidelines described in the Funasa Sanitation Manual (FUNASA, 2017).

- Sewage systems

The basic functions of the sewage system are to collect and conduct evictions from the proper use of sanitary appliances to an appropriate destination in accordance with current legislation.

The final disposal of the effluent from the building collector of a sanitary sewage system must be carried out in a particular treatment system when there is no public sewage collection network (NBR 8160/1999).

- Individual Treatment System

Individual systems are designed to safely collect, treat and dispose of domestic effluents generated by a single-family home, composed mostly of: septic tank, anaerobic filter and sink. It must satisfy the characteristics and functionalities established by technical standards NBR 7229/1993 and NBR 13969/1997.

- Construction Lease

The rental of the treatment system must comply with the limits of the land of the residence, in a topographic quota equal to or less than that of the sanitary system, obeying the minimum clearance of 4 m of tanks and 30 m of groundwater or surface water capitation systems. In addition to keep 1.50 m distance between your sinkhole bottom and the aquifer level.

- Earth Drive

The excavation can be carried out manually or mechanically, added to the dimensions of the reservoir with a spacing of 50 cm for each side. This spacing had been used to facilitate the execution of the work and should be regrounded after completion. This backfill must be medically compacted in 20 cm layers using the excavated material itself.

- Bottom Slab

The bottom slab of the system was designed to be executed as baldrame slab, with hollow bottom in the sinkhole and slabs at the bottom, in the septic tank anaerobic filter. Built in reinforced concrete, with wood shape, ribbed steel reinforcement CA-50 10 mm and concrete with compression resistance of 30 MPa.

- False Background of the Anaerobic Filter

The false bottom slab has been designed with 10 cm thickness and holes that allows the upward flow of effluents into the anaerobic filter. Being executed in reinforced concrete, ribbed steel reinforcement CA-50 10 mm and concrete with compressive strength equal to or greater than 30 MPa (NBR 6118/2014).

- Cover Slab

The cover slab was designed with 15 cm thickness, three lids for inspection and sigh pipe in septic tank, anaerobic filter and sink. Being executed in reinforced concrete, with wood shape and shimmage, ribbed steel reinforcement CA-50 10 mm and concrete with compressive strength equal to or greater than 30 MPa (NBR 6118/2014).

- Arrangement of Armor

The arrangement of the reinforcements of the bottom slabs, cover slab and false bottom, was designed to be executed in ribbed steel reinforcement CA-50 10 mm in diameter and 15 cm in spacing.

- Masonry

The masonry designed, provide the construction of walls using massive ceramic bricks with nominal dimensions of 19x9x9 cm seated folded in joints of 1.0 cm of mortar, according to the project. Mortars should be well dosed, in the proportion 1:2:8 (cement, lime and sand) and the bricks have all the flat faces of material (NBR 7170/1983).

- Coating

The coating is composed of the chapisco and the single mass, on the internal and external walls. With the chapisco in the trace of 1:3 (cement and sand), having the purpose of providing greater adhesion between the masonry and the coating. And the unique mass in the traces of 1:2:8 (cement, lime and sand), where the use of hydrated lime, is exencial, because it promotes a greater power of accommodation in the variations of the walls, besides minimizing the risks of cracks.

- Sanitary Facilities

The pipes and canecões will be seated according to alignment and leveling, with full coverage in order to protect the pipe from the requests caused by the transit of people and animals on site. The tubes must be placed with their lower geratriz coinciding with the cradle shaft, so that the bags are in the previously prepared excavations, ensuring a continuous support of the tube body (NBR 7367/1988).

- Cleaning the Work

The work must be delivered without any trace of leftover building materials, nor with waste. The executed pits will need to be completely closed at the end of the execution and the hydrosanitary facilities should be in perfect operation in the delivery of the work.

- Effluent release conditions

The indirect release of effluents into the receiving body shall comply with the provisions of CONAMA Resolution 430/11 that determines the conditions for the release of effluents from any polluting source:

- pH between 5 and 9;
- Temperature: below 40°C;
- Sedimentable materials: up to 1 mL/L in 1-hour inmhoff cone test;
- Biochemical Oxygen-BOD demand 5 days, 20°C: maximum of 120 mg/L;
- Hexane soluble substances (oils and greases): up to 100 mg/L;
- Absence of floating materials: minimum removal efficiency of 20%.

- Maintenance

Maintenance should be carried out by removing 90% of the activated sludge resulting from the sewage treatment process. This stake is responsible for the extermination of biodegradable organic pollutants present in domestic effluents.

In the absence of a collecting net, the use of septic tank presupposes that its effluent was: sent to the drainage network, when available, removed by a cleaning truck or preferably, for reasons of lower cost, infiltrated into the soil through sinks (TOLEDO et al., 2021).

The waste should be removed by a suction hose inserted into the whole of the system prepared to receive the effluents and remove the excess stake, usually the trucks of the clean fossa type.

This material must be removed and transported by specialized companies interested in receiving the proper final destination. The ideal is to leave about 10% of the activated sludge at the bottom of the system, for the continuity of biological treatment of effluents.

SYSTEM EFFICIENCY

The systems under study are heamuch used for their efficiency in removing waste from thewastegiftisstico. Becoming a viable technology, with simplified constructive and operational methods. Differentiating in the layout of the project, with the first being executed separately and occupying a larger deployment area and the second being built in an integrated way, requiring less space on the ground. Due to the lack of government incentive, research cannot execute the proposed system for the analysis of physical-chemical parameters, providing results of efficiency tests in scientific publications and technical standards.

The results found in publications regarding the efficiency of systems that use the septic tank as primary treatment and the anaerobic filter as secondary treatment are very promising, there was a removal of the main pollutants contained in effluents, in the order of 67% for ST, 100% (SST), 62.9% (BOD), 96.7% (WFD), 70.2% (NT), 46.5% (PT) and 80% (K), and the population levels of E. Coli in the treated effluent were below 1000 NMP 100 mL-1 (PITORO, 2019).

The Brazilian Association of Technical Standards, through NBR 13969/1997, Septic Tanks - Complementary treatment units and final disposal of liquid effluents - Design, construction, and operation, defines the probable ranges of removal of pollutants, according to the type of treatment, considered in conjunction with the septic tank (.

Table 5 - Probable pollutant removal ranges.

Process Parameter	Submerged anaerobic filter	Aerobic filter	Sand filter
DBO	40 to 75	60 to 95	50 to 85
COD	40 to 70	50 to 80	40 to 75
SNF	60 to 90	80 to 95	70 to 95
Sedimentable solids	70 or more	90 or more	100
Ammoniacal nitrogen	–	30 to 80	50 to 80
Nitrate	–	30 to 70	30 to 70
Phosphate	20 to 50	30 to 70	30 to 70
Fecal coliforms	–	–	99 or more

With the anaerobic filter obtaining good results in the removal of pollutants, evidenced in the enalises of parameters such as: the biochemical demand of oxygen, the chemical demand of oxygen, the solids in supenção and the sedimentable solids.

In view of these results, it is observed that the primary treatment used only the septic tank is partially efficient, while the combined system using the septic tank as primary treatment and the anaerobic filter as secondary treatment can increase the treatment efficiency, meeting the parameters for disposal of effluents in the environment allowed by CONAMA Resolution No. 430/2011.

ECONOMIC VIABILITY

To evaluate the costs of implementing the treatment systems exposed in this study, the economic feasibility analysis was performed by surveying the costs, using the values obtained in the SINAPI table, shown in Tables 6, 7, 8 and 9, respectively.

Through the tables presented, it was verified that the total cost of the system designed separately was R$ 15,218.99, with the septic tank costing R$ 4,504.56, the anaerobic filter R$ 4,966.88 and the sink r$ 5,747.55. Meanwhile, the cost for tour of the integrated system was R $ 10,940.02, reducing execution costs by 28% compared to the first, making it more viable due to the lower cost.

Table 6 - Comparative Cost Sheet.

SUMMARY WORKSHEET		
Item	**Discrimination**	**Total Value**
1	System with separate reservoirs	
1.1	Septic Tank	R$4,504.56
1.2	Anaerobic Filter	R$4,966.88
1.3	Sink	R$5,747.55
	Sum 1.1+1.2+1.3	R$15,218.99
2	System with integrated reservoirs	R$10,940.02
3	Deployment cost difference	**R$4,278.97**

Thus, the treatment system designed in an integrated way stands out for the lower cost and smaller built area, with economic viability and implementation, achieving the same efficiency of the separate system in the removal of pollutants..

IV. CONCLUSION

Decentralized sewage treatment systems are considered by several researchers as an efficient solution in the treatment of domestic sewage. Performing the primary treatment by means of the septic tank, the secondary treatment biologically with the use of the anaerobic filter and the final destination of the effluents treated in the sink.

This research proposes the layout of a decentralized domestic sewage treatment system, capable of treating waste generated by a single-family residence composed of four residents, built in an integrated way, with a minimum capacity of 2,000 liters in the septic tank, 1,400 liters in the anaerobic filter and 2,000 liters in the sink.

For this, the dimensioning and technical specifications of an individual treatment system divided into three reservoirs were presented, following the recommendations of technical standards NBR 7229/1993 and NBR 13969/1997, with the object of developing an efficient project in the removal of pollutants with low cost of implantation and maintenance.

In view of this, the disposal of effluents in the soil, even treated, is not subject to the parameters and release standards set out in CONAMA Resolution 430/11, but may not cause pollution or contamination of surface and groundwater.

The proposed system is, then, a treatment that can be replicated in isolated communities, obeying technical standards in order to meet the main parameters related to sewage treatment in Brazil, mitigating the aggressive effects on the environment and opening opportunities to improve the living and health conditions of the inhabitants of peripheral and rural localities.

About the cost of implementation, the treatment system designed in an integrated way, stands out for the lower cost and smaller built area, reducing the implementation costs by 28% compared to the system with the separate projected reservoirs.

Based on scientific literature and technical analyses, we can affirm that in order to achieve the universalization of basic sanitation in Brazil, it is necessary to make efforts to expand sewage services, especially in peripheral and rural regions without collection networks and sewage treatment plants.

Therefore, the growing need to develop technologies aimed at the decentralized treatment of sewage, opens space for further studies, referring to the patterns of effluent releases in the receiving bodies, aiming to meet the legal requirements and the preservation of the environment.

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