Feasibility study of the implementation of an evapotranspiration basin with the aid of an ash box as preliminary treatment

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ABSTRACT
The present work aimed at providing knowledge in new sanitation techniques for rural populations and all those who wish to live in a more sustainable way, developing an adequate treatment for their effluents generated in their daily lives. A large part of the Brazilian population does not have basic sanitation or has inadequate forms, such as septic tanks that contaminate the soil and subsequently the water resources of the entire region, with pathogens. Thinking about this idea, an ecologically sustainable way was developed for the treatment of black waters, the Evapotranspiration Basin (BET) with the innovation of the ash box. The sewage coming from the toilet is directed to the ash box built of waterproofed masonry, where it receives preliminary treatment, a gridded basket inside the box retaining coarse solids. In this same box wood ash is added that acts as a flocculant and PH regulator, optimizing the anaerobic digestion process inside the chamber formed by tires in the Evapotranspiration Basin, an impermeable masonry tank submerged in the soil where bacteria remineralize all organic matter. The water contained in the sewage passes through an ascending granulometric filter until it reaches the roots of the plants, where it goes through a natural process of Evapotranspiration, returning a large part of this purified water to the environment. The objective was to compare the budgets of other works and show the economic viability of a BET with the innovation of the ash box.

Keywords: Sanitation, Sustainable, Innovation, Anaerobic bacteria, Evapotranspiration

1 INTRODUCTION

The standard of living of the population is directly associated with the quality and accessibility to water. The availability of water resources has been increasingly compromised as surface and groundwater are contaminated with domestic and industrial effluents. In rural areas, as in most developing countries, access to sanitation services is still considered precarious (VICQ & LEITE, 2014). According to the Brazilian Association of Sanitary and Environmental Engineering (ABES), the lack of adequate sanitation has contributed negatively to the population's health. The United Nations Children's Fund (UNICEF, 2019) points out that the lack of service, can account for approximately 88% of child deaths from diarrhea, in addition, it can cause typhoid fever, cholera, bacterial intestinal infections and hepatitis (TOKARNIA, 2019). One of the most common forms of primary domestic sewage treatment are septic tanks, as they are seen as an effective treatment, especially in rural areas, regions that suffer most from the lack of conventional treatment. Due to the simplicity of implementation and maintenance, septic tanks become positive alternatives (VICQ & LEITE, 2014).

Green Pits or Evapotranspiration Pits are considered alternatives for the treatment of sanitary waters, where anaerobic bacteria, which live and multiply there, treat the sewage as it lodges in the system, dispensing with periodic cleaning by pit cleaning trucks and eliminating extra costs (FIGUEIREDO et al., 1981). Three main groups of microorganisms that participate in anaerobic digestion are used: fermentative, acetogenic and methanogenic bacteria (GOMES, 2006). Anaerobic digestion represents a delicately balanced ecological system, where each microorganism has its main function (CHERNICHARO, 1997). Anaerobic treatment processes have the capacity to reduce only 60% and 80% of the organic matter concentrations, considering the low detention times. Because of this, it is necessary to add another treatment process for greater efficiency (SPERLING, 1995). In the current study the use of the ash box was chosen as the primary treatment, which consists of a pre-treatment for black sewage. The ashes present are capable of absorbing and neutralizing the odors coming from the effluent.

The evapotranspiration basin, besides avoiding the incorrect disposal of the effluent into the environment, also serves as a growing bed, so that people can have fruit trees in their backyard that produce all year round and can be a source of income for families (VIEIRA, 2010). Species of plants do evapotranspiration, especially those with broad leaves, such as Musas (banana trees), Carica papaya (papaya trees), Heliconia velloziana (caetés), Xanthosoma sagittifolium (taioba), etc. which, in addition, consume nutrients in their growth process, allowing the basin to never fill up. Therefore, with this system, the water comes out in vapor form, without any type of contaminant (COELHO et al., 2018).

The present work is justified by the interest in presenting other methods for sewage treatment for areas that do not have conventional treatment and use septic tanks. The objective is to study, based on the available literature, the sizing of an Evapotranspiration Basin (BET), calculating its economic viability along with the help of the ash box, enabling an adequate and sustainable treatment for black sewage, in addition to applying and copying the data from an environmental perception questionnaire for individuals who do not have conventional treatment and use septic tanks.

2 METHODOLOGY PREPARATION OF A BET

The BET should be approximately 1m deep, with areas of 2 m² per user, in homes (PAULO & BERNARDES, 2009). For the implementation, it is necessary to have an available area, and garden areas that are already present can be used. The size of each basin can vary by the leveling of the base, size of the structure, preparation and selection of its materials. Besides not consuming energy, not using chemicals and contributing to the preservation of water availability, the maintenance time required of the system in question presents a low demand, being necessary to remove the sludge from the central chamber every five years and three months on average (COELHO et al., 2018).

For the installation of the BET a 100mm PVC pipe is used in the sanitary network, connected directly to the ash box, with dimensions of 80cm3 , containing in the upper part a fine grating (30 cm x 30 cm), with the objective of retaining the solid particles of difficult degradation by the anaerobic bacteria, such as condoms, absorbents, among others. At the bottom are used ashes, produced by burning wood, as in domestic fireplaces and wood stoves. According to Silvério (2013), the calcium (CaO) generated from burning, gradually turns into calcium carbonate (CaCO3), being used as a flocculant agent, thus the ash forms larger particles from the organic load, facilitating the degradation by anaerobic bacteria.

The anaerobic bacteria inserted in the ash box are transported by gravity to the Evapotranspiration Basin. The process involves microorganisms capable of degrading organic compounds, being transformed into byproducts in liquid form, increasing the volume of water, with nutrients, in the system (PESTANA & GANGHIS, 2010). In the internal part of the ash box is the simple siphon system of the pit, with the function of preventing the gases generated and the resulting stench from returning into the house. For this to occur in a correct way, it is necessary that the entire installation happens in an appropriate way, always requiring the accumulation of water in the curvature of the siphon.

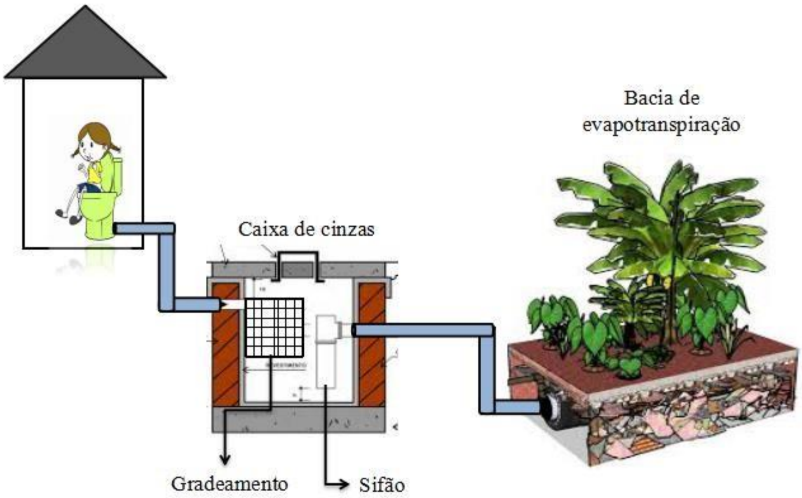
After the ash box, the effluent through another 100mm PVC Tube, is destined to the Evapotranspiration Basin. It is necessary to perform the waterproofing of the system with ferro cement or tarpaulin for waterproofing, after ensuring the waterproofing of the BET, the construction of the anaerobic chamber takes place, which is facilitated with the use of tires, with their own dimensions, used in the form of tunnel to receive the effluent (VIEIRA, 2010). Then it is filled, up to the height of the tire and laterally, with gravel of varied granulometry, providing the coarse filtration in the first layer. With this, an environment is created inside the basin, with free space for water, benefiting the proliferation of bacteria that will help degrade the coarse solids into micronutrients. The next layers are composed of gravel, sand and soil, respectively.

The gravel and sand, approximately 10 cm high, will filter the water that will reach the soil, the last layer of the system, approximately 25 cm high, where species capable of absorbing large amounts of water and occupying little space will be planted, such as Musa (banana trees),

Cucurbita moschata (pumpkin stems), Xanthosoma sagittifolium (taiobas), among others. Due to the high daily water consumption of the species, the liquid part of the effluent will be consumed and what is left will suffer a process known as evapotranspiration, returning to the atmosphere. The solid part of the sewage will be degraded by microorganisms.

According to Vieira (2010), although the BET does not have a cover, as a way to avoid flooding, in case of rain, it should be covered with the leaves that fall from the plants, forming a layer where the rainwater will drain out of the system, so preference is given to species with broad leaves and if necessary, the vegetation cover should be completed with other plants from the garden and grass clippings. Figure 1 exemplifies the Evapotranspiration System described above.

Figure 1. Evapotranspiration system



Source: Authors, 2021.

BUDGET

A budget table was made for the Evapotranspiration System in conjunction with the ash box, including materials and services provided, estimating a residence with three people. The unit costs of inputs and compositions available in SINAP (2019) were considered, basing the budget according to the sizing of the area. It is important to emphasize that the materials that do not make up the table will be used from reuse. The present table price may change, with updates referring to the inputs and labor, if necessary.

APPLICATION OF THE ENVIRONMENTAL PERCEPTION QUESTIONNAIRE

The focal point of the questionnaire was to identify the perceptions of different individuals who have incorrect disposal of their effluents and traditional septic tanks. Contributing to the expansion of the knowledge about the population, as well as their expectations, helping in the definition of strategies and the economic feasibility for the implementation of the evapotranspiration system.

During the period from September 12, 2019 to October 17, 2019, the online questionnaires were applied through Google Form with different social classes and with individuals who do not have a sewer connection. The study aimed to raise data in order to subsidize reflections, knowledge, and decisions, contributing to a better study of the system and minimizing environmental impacts. With the environmental perception questionnaire it was possible to tabulate and compile the data, forming a database whose results subsidized the analysis and writing of this work. The script incorporated aspects related to the participant's profile, specific topics on sanitation, the possible interferences of the incorrect destination of effluents, and the economic feasibility of BET.

3 RESULTS AND DISCUSSIONS

ECONOMIC FEASIBILITY

A budget survey was carried out and BET implementations were researched in the literature, to support the analysis on the implementation costs of this type of project. Additional information such as location of implementation, and number of people served was also collected, when available. To determine the financial cost of a BET, the available information about the projects analyzed in this paper was arranged in Table 1, where it is possible to see the total cost of each project and the number of people served by each one. The column named, cost per person, shows the cost of the project for each person served, calculated by dividing the values in the column, total project cost, by the value of the column of people served.

Table 1. Analysis of the implementation costs of the researched projects

Analyzed Projects	Municipality	Year	Total project cost	People served	Cost per person
Project 1	-	2019	1.403,51	3	467,84
Project 2	Rio Verde - GO	2016	700,00	2	350,00
Project 3	Planaltina - DF	2012	2.619,68	6	436,61
Project 4	Itabira - MG	2014	2.000,00	4	500,00
Project 5	Iranduba - AM	2018	1.056,00	4	264,00

Source: Authors, 2019.

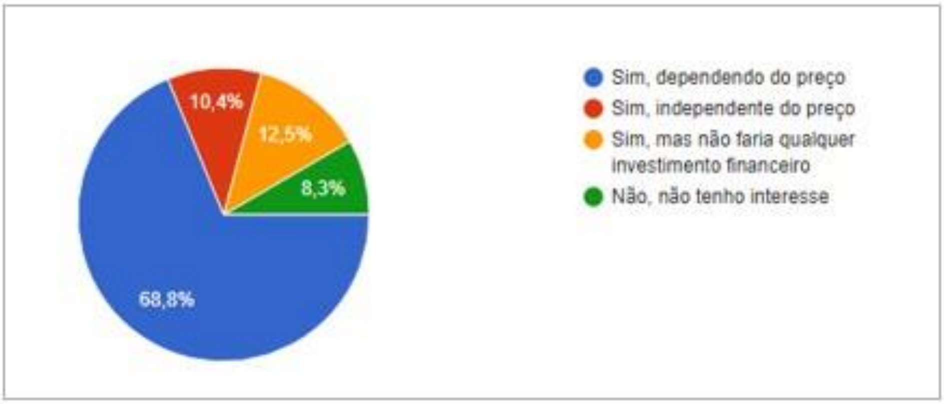
Analyzing the total cost of the projects, it can be observed that Project 2, dimensioned for two people, is tabulated as having the lowest value (R$ 700.00). The possible explanation for this fact would be the budget values of the local materials were different for each state. Project 3, on the other hand, considered to have the highest price (R$ 2,619.68), was planned for six residents, but with no specialized labor in its execution, and was done by a rural community collective effort. The high value can occur as already mentioned, due to the values of the materials varying according to each region.

Project 1 (R$ 1,403.51), of the described work, was dimensioned for a residence with three residents. Comparing with the previously mentioned projects, Project 1 has as its main difference the use of an ash box in its operation, being a pre-treatment, helping in the degradation of the organic matter present in the effluent, in order to guarantee a better quality in the generated fruits. Comparing Project 1 with Project 3 it is observed that the higher value is approximately twice as high as the project under study. It is noteworthy that the labor force of Project 1, initially, is the authors' own, in addition to selected professionals to assist in the implementation of BET, thus, the action contributes to the low cost, being a limiting factor in the choice of the system. Moreover, the difference of people served in each project and the ash pit, is also considered a feasibility factor.

ENVIRONMENTAL PERCEPTION SURVEY

In a survey conducted by the group, using Google Form, 77.8% of the public interviewed said they were willing to invest financial resources in changing the sewage treatment system of their residence, if they were degrading the soil and water resources, as shown in Chart 1. As the BET treatment system releases water into the atmosphere, and not into the soil, it would also fit the requirements of this public. This shows the environmental appeal of the system, which can be used to replace the septic tank system, which releases effluents into the soil.

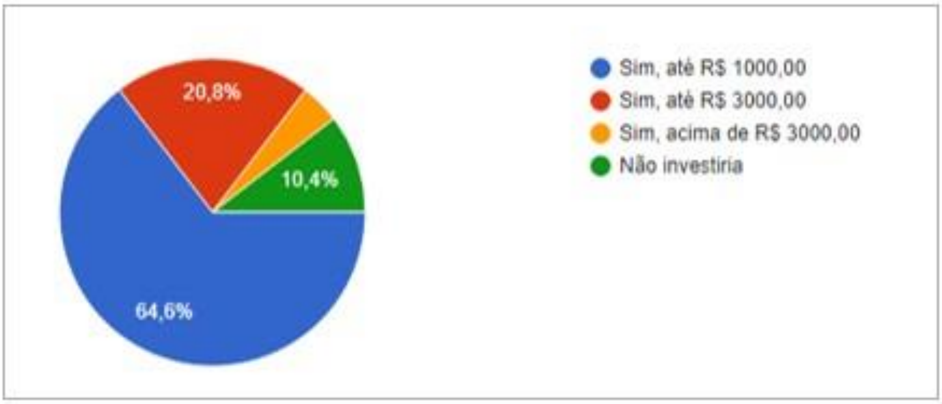
Graph 1. Knowing that the use of septic tanks inadequately designed and managed can cause contamination of water and soil resources, would you be willing to change this system for a more sustainable one?



Source: Authors, 2019.

Graph 2 shows that 85.4% of the interviewees reported that if there was no sewage collection in their residence they would be willing to spend up to R$ 3,000.00 on a sustainable individual treatment system. This information shows that the cost of BET projects is in an adequate range for the significant majority of the interviewed people, because with the maximum amount of R$ 3,000.00 established by the survey, it would be possible to serve a residence with about seven residents (using the average value of the projects per person served).

Graph 2. If you did not have sewage collection in your residence, would you be willing to invest in an individual system for sustainable sewage treatment?



Source: Authors, 2019.

Aiming to define a satisfactory sample design, this research adopted quantitative methods for information gathering, enabling the knowledge of relevant aspects of the relationship between the population and basic sanitation.

4 CONCLUSION

It is possible to observe that BET's can vary greatly in cost depending on the constructive choices and unpaid labor. With the present work, it was possible to estimate an average for the financial projection for companies interested in promoting the installation of the system, and the cost per person served varied from R$ 264.00 to R$ 500.00. Importantly, the perception of the population interviewed by the authors, in estimating the cost of a more sustainable treatment system was consistent with the values of the BET system raised in the work.

Depending on the construction methodology used, BET can have low implementation and operation costs, and may even be lower than the septic tank system. In addition, it has the advantage of being an impermeable system, thus avoiding the contamination of soil and water resources. Thus, it improves the quality of life of the residents and the environment, avoiding environmental degradation through sanitation.

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