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(RESEARCH ARTICLE)

Performance evaluation of the sewage treatment system SANEBOX

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Abstract

Sewage treatment processes have been increasingly the target of research aimed at developing solutions that meet environmental standards at lower costs for society. The generation of sanitary sewage and its final release, without treatment or with inefficient treatment in sewage networks, lakes, rivers or oceans have aggravated the quality of water resources and put at risk the health of the population given water-delivery diseases. This article aimed to evaluate the results obtained by the Treatment System called SANEBOX, for the treatment of sanitary sewage, considering a period of two years of monitoring campaigns in it. Additionally, a comparison is made in terms of achieving environmental goals of this System with other conventional technologies that have usually been implemented in Brazil. The guiding parameters for this evaluation were Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Sedimentable Materials (SM), Total Suspension Solids (TSS), Vegetable or Animal Oils and Greases (OGv/a), Tensoactive Substances That React to Methylene Blue (MBAS), Ammoniacal Nitrogen (N-NH4+) and Phosphorus (P). The results obtained show that the SANEBOX System has similar performance and, in some parameters, much higher than the conventional Sewage Treatment System, either in terms of removal of pollutants, or in terms of occupied area, energy consumption and nuisance to neighborhoods by bad odors.

Keywords: Water pollution; Technological innovation; Environment; Water resources.

1. Introduction

The new Legal Framework for basic sanitation in Brazil - Law No. 14,026, of July 15, 2020, opened positive expectations regarding the improvement of the quality of the country's inland waters, in addition to the consequent improvement of the quality of life of the population due to the inherent reduction of risks of contamination and damage to people's health. In this context, Sewage Treatment Systems become even more important because, according to Gebicki, Byliński and Namieśnik (2016), it is not enough just to have a system for reducing pollutants from sanitary sewage, but primarily to implement a system that is capable of presenting the efficiency of removal of pollutants necessary for lower socio-environmental costs. Kaetzl et al. (2018) confirm that with the increase of environmental degradation in the world it is essential to develop engineering techniques and technologies capable of performing this task, emphasizing that the volume of construction and even the energy expenditure of a Sewage Treatment System needs to be considered because they imply a greater or lower consumption of natural resources of the planet.

Zhang et al. (2019), addressing types of domestic sewage treatment, state that conventional treatment systems for organic loads greater than 100 $kg.d^{-1}$ are expensive both in the implementation and in the operation and maintenance phase of them. The same authors report in their research that in addition to the private costs of these conventional

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systems there are also external costs related, for example, to discomfort to the neighborhood by generation of bad odors and visual pollution.

In view of this panorama, this article has the general objective of showing the results of a detailed evaluation of the performance of the SANEBOX Sewage Treatment System, developed by a group of Brazilian engineers from VWAServiços e Consultoria Ambiental based in Volta Redonda/RJ and in full phase of operation on a full scale for the reduction of pollutants present in sanitary sewage activities of both residential and industrial, commercial and service activities. The relevance of this article is to provide the dissemination of knowledge about the treatment process used in SANEBOX, in terms of efficiency of removal of pollutants such as: Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Sedimentable Materials (SM), Total Suspension Solids (TSS), Vegetable or Animal Oils and Greases (OGv/a), Tensoactive Substances That React to Methylene Blue (MBAS), Ammoniacal Nitrogen (N-NH4) and Phosphorus (P).

Finally, it is concluded that the SANEBOX System has competitive advantages much higher than those presented by conventional systems, whether they are built in concrete, masonry, fiberglass, polycarbonate or other materials, especially: smaller occupied area, lower cost of implantation, operation and maintenance, lower energy consumption by treated sewage volume, bad odors practically non-existent and similar pollutant removal efficiencies and in some parameters Superior.

This article is organized as follows. In the second section there is a description of the operation of the SANEBOX System, general technical data in terms of process requirements, as well as a sample of some details in terms of materials used and applicability. In the third section, the methodological approach used in the performance evaluation of SANEBOX is presented. In the fourth section we have the results obtained by this system over 2 years of monitoring campaigns carried out in eight SANEBOX units installed and operating to treat sewage in two hospitals, one University, two Industries, one Marina and one residential condominium. In the fifth section, the conclusions of the work are presented, following the last section containing the bibliographic references.

2. Material and methods

2.1. SANEBOX: descriptive and general aspects

The SANEBOX System, according to its developers, aims to treat sanitary sewage from allotments, multifamily residential buildings, groups of multifamily residential buildings, shopping centers, small and large support structures and small and medium-sized vessels, public buildings, health service establishments, schools, hotels and the like, restaurants, markets, hypermarkets, convention center, ports, airports, racetracks, agricultural activities, industries, service sites, in addition to being able to complement (when necessary), existing sewage treatment systems.

It is important to note that such a system needs to be preceded by fat boxes (when cooking/cafeteria effluent generation occurs) and a pre-treatment in order to avoid early saturation of SANEBOX. Therefore, the sanitary sewage generated in the activity (after fat box and those from bathrooms and changing rooms) are initially taken to a coarse solids retention system (railing) and proceed to preliminary decanting unit and scum retention. Still by severity the sewers should go to an anaerobic reactor of reduced dimensions (on average the volume reduction is 30%) for the preliminary removal of organic matter. This is followed by the accumulation of this sewage in a base pit from which, through pumping, the transfer to a sequence of hyperbaric units consisting basically of oxygen saturation, prefiltration, adsorption by media composed of natural decarbonating fibers, flow meter and chemical disinfection by chlorination occurs. Due to the process being developed at high pressure, the residence times are reduced which provides the achievement of environmental goals to lower costs of electricity, in addition to occupying reduced area, which is supported by Abma (2010) as fundamental factors in the design of projects and operation of sewage treatment systems. It is noteworthy that the final stage of disinfection of the treated sewage in SANEBOX can also be performed by the addition of hydrogen peroxide or UV radiation, without significant changes in extermination of pathogens present in the treated sewage (CHUANG et al., 2019). After disinfection, the treated sewage sits to the public or private collection network, or to the nearest water body, emphasizing it is necessary to request the legal release permissions, previously, to the competent agencies, as in any such installation. Figure 1 shows the flowchart of the SANEBOX process more specifically.

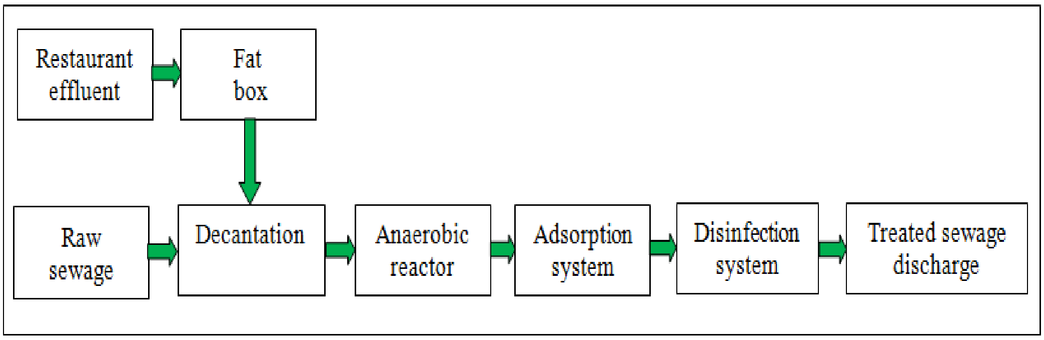

Figure 1 Sequence of SANEBOX process abatement units

It is important to note that the SANEBOX System is a compact unit normally installed on the coarse solids retention units, decanting, anaerobic and elevating, respecting the necessary accesses for the maintenance that is necessary. The system is typically mounted inside restored and conditioned marine containers to receive the hyperbaric system. With the closure of the treatment system, as observed by Sarbu (2021), and also because the screen treatment system is not biological but by adsorption, there is no emanation of bad odors, regardless of adverse climatic factors or even in cases of accidental discharges of effluents that can cause toxicity in microorganisms with consequent inactivation or death of them. A comparison in terms of proportion can be observed in Figure 2 where a SANEBOX unit installed in residential condominium can be compared to a conventional fiberglass system. It is emphasized that the treatment flow rate in both cases is 6 $m^3.h^{-1}$.

Figure 2 Comparison of SANEBOX and Conventional System proportions for the same number of people. A- SANEBOX system with pretreatment below the floor; B- Conventional treatment system

2.2. Methodology

The methodology used in the present work regarding nature, is applied because it aims to generate knowledge for projects and selection of type of sewage treatment process that minimize bad odors, meet the environmental standards of release and quality of water resources at lower at social costs. As for the objectives, this work is descriptive, because it uses a series of results obtained with the operation of SANEBOX units to perform its performance evaluation under different work regimes. As for the approach, this is a combined research (qualitative and quantitative), because it generates the opportunity to identify a technology that meets environmental goals at lower costs for society, which certainly contributes to accelerate the solution of problems related to the lack of basic sanitation in several locations and even in several countries. As for the method, the proposed research involves a case study, as shown in Figure 3.

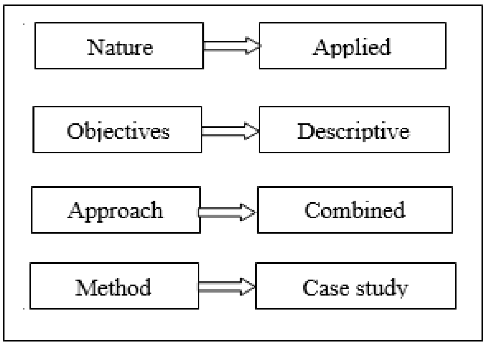

Figure 3 Classification of the survey performed

3. Results and discussion

The results obtained in the two years of studies involved five different types of activities that generate sanitary sewage, that is: two hospitals, one University, two Industries, one Marina and one residential condominium. The parameters analyzed and the results obtained are shown in table 1a (for BOD, COD, SM and TSS) and table 1b (for OG, MBAS, N-NH4$^+$ and P). It is emphasized that the government launching standards used here are those contained in Brazilian federal legislation (RESOLUTION CONAMA 430/2011) and state legislation of Rio de Janeiro (CONEMA Resolution 90/2021).

Table 1a Average results and removal of pollutants from sanitary sewage by the SANEBOX System

Activity	**BOD. mg.l^{-1} inlet**	**BOD. mg.l^{-1} outlet**	**BOD. %**	**COD. mg.l^{-1} inlet**	**COD. mg.l^{-1} outlet**	**COD. %**	**SM. ml.l^{-1} inlet**	**SM. ml.l^{-1} outlet**	**TSS. mg.l^{-1} inlet**	**TSS. mg.l^{-1} outlet**	**TSS. %**
Hospitals	742	36.3	95.1	1509.6	77.0	94.9	8.5	< 0.1	809	37.2	95.4
Condominium	654	32.6	95.0	1334.9	76.1	94.3	9.0	< 0.1	713	33.7	95.3
Industries	560	30.2	94.6	1156.7	69.4	94.0	6.7	< 0.1	611	32.6	94.7
University	482	30.7	93.6	998.2	68.9	93.1	4.6	0.14	538	31.2	94.2
Harbor	388	28.3	92.7	807.5	64.6	92.0	2.3	0.17	296	28.7	90.3
Government Standard	-	<40.0	>85%	-	-	-	-	< 1.0	< 40.0	>85%	>85%

Table 1b Average results and removal of pollutants from sanitary sewage by the SANEBOX System

Activity	**OG. mg.l^{-1} inlet**	**OG. mg.l^{-1} outlet**	**MBAS. mg.l^{-1} inlet**	**MBAS. mg.l^{-1} outlet**	**N-NH4$^+$. mg.l^{-1} inlet**	**N-NH4$^+$. mg.l^{-1} outlet**	**P. mg.l^{-1} inlet**	**P. mg.l^{-1} outlet**
Hospitals	138	15.7	4.8	0.85	42.4	4.1	8.0	0.85
Condominium	146	15.1	3.7	0.77	33.6	3.7	6.4	0.58
Industries	172	16.1	3.2	0.63	45.2	4.6	9.2	0.88
University	106	12.4	2.8	0.54	31.8	3.6	6.1	0.56
Harbor	77	10.3	2.9	0.59	26.7	3.0	5.5	0.50
Government Standard	-	<30.0	-	<2.0	-	<20.0	-	< 1.0

As can be seen, the SANEBOX System fully met the sewage treatment requirements of the activities evaluated both in terms of Brazilian federal legislation for the release of liquid effluents, as well as in terms of state legislation, which is more restrictive considering that the release of sanitary sewage in the region where the study was developed takes place in the Paraiba do Sul River that supplies almost 17 million people. It is also observed that the SANEBOX System has an efficiency curve that slowly decays as the raw sewage becomes "weaker", remaining but in compliance with current legislation.

4. Conclusion

From the data collected and presented in this article, it is concluded that the SANEBOX System meets Brazilian environmental standards regarding Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Sedimentable Materials (SM), Total Suspension Solids (TSS), Vegetable or Animal Oils and Greases (OGv/a), Tensoactive Substances That React to Methylene Blue (MBAS), Ammoniacal Nitrogen (N-NH4+) and Phosphorus (P).

Additionally it is possible to lower that it has competitive advantages much higher than those presented by conventional systems, whether they are built in concrete, masonry, fiberglass, polycarbonate or other materials, especially: smaller occupied area, lower cost of implantation, operation and maintenance, lower energy consumption by treated sewage volume and practically non-existent bad odors.

Compliance with ethical standards

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Disclosure of conflict of interest

The author declares no conflict of interest.

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