End-of-life tire reuse in the construction of an individual domestic sewage treatment system

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Introduction: The automobile industry has developed rapidly, accompanied by the obvious increase in tire waste production (Chen et al., 2017). After the end of its intended useful life, it is classified as an end-of-life tire (ELT). It is estimated that the annual global tire production was 1.5 billion units in 2015, while that of used tires approached 17 million tons per year (Escobar-Arnanz et al., 2018). The management of ELTs is a worldwide concern. Their disposal is not advisable because they are not biodegradable and their storage is unsafe because they are considered flammable, in addition to creating environments suitable for diseases (Mohajerani et al., 2020). There are recycling alternatives that include the recovery of material by crushing, civil engineering applications, high temperature pyrolysis or the recovery of energy by combustion (ETRMA, 2016). However, they are laborious and highly expensive processes (Hejna et al., 2020). Another solution is reverse logistics (RL), which returns end-of-life waste to the supply chain, with environmental and economic benefits for companies. There are laws that require tire manufacturers and importers to properly dispose of ELTs. These laws influence the current situation, especially when RL is not practiced in accordance with the laws in force. In developed countries, the management of any solid waste (SW) is a common practice, the result of adequate public policies, strict laws and programs for the population (Lino & Ismail, 2014). On the other hand, in developing countries, most of the generated SWs are sent to landfills or open areas (Dacewicz, 2019), including PFVs. In this sense, as tire production is expected to continue, due to the growing demand from automobile fleets, it is of interest to explore new applications for ELTs, even if small compared to the number of tires generated each year. This work presents an alternative to reuse ELTs for the treatment of domestic sewage, with the construction of a septic tank system followed by an anaerobic filter (ST+ANF), replacing the traditional masonry structure.

Methodology: The system was implemented in a residence located in the North of Brazil, in a municipality that does not have sewage collection and treatment. The implementation of the system involved the collection of ELTs in local tire shops, totaling 35 tires type 1000x20 (1,051 m in diameter and 0.241 m in width). Then, the system was dimensioned, according to specific norms (ABNT, 1993, 1997), assembled, fixed and waterproofed for the correct operation. The design took place as a conventional system, however, with adaptations due to the fixed structure of the ELTs, and to identify the number of tires for each unit. The construction started with the excavation of the area to store the system. Asphalt mass was used, it was obtained from the mixture of asphalt emulsion type RL-1C and sand (ABNT, 2006), and used in the fixation and waterproofing of the units, in addition to the civil construction materials necessary to avoid soil pollution, and in the connection between the units and the system seal to maintain anaerobic treatment conditions. Finally, the financial and environmental feasibility were analyzed, comparing the budgets of the proposed and conventional systems dimensioned for the same residence, and the estimated number of s removed from the environment and used in the construction of the system, respectively.

Results and discussion: The municipality does not have ELT collection points. Generally, these residues are available in tire stores for collection. The burning of ELTs in a dump area was found. The nearest official collection point to the municipality is 76 km away (Reciclanip, 2021). It is essential that the public authorities and tire dealers, carry out effective and regular collections and continue the neglected RL chain in the municipality. The ST volume was 1.7 m³ and the ANF was 1.04 m³. It was decided to divide the ST into two chambers in series, ST-I and ST-II, avoiding greater heights of the units. The volume of each tire is 0.20 m³. Thus, the ST-I required 5 and the ST-II required 4 tires. The ANF needed 7 ELTs. After excavating the area, in the construction of the bottom slab, another ELT was fixed to the concrete, to reduce infiltration or leakage at the base of the units. Thus, the system was assembled with 19 ELTs. The units were assembled, fixed and waterproofed, and then drilled and interconnected with polyvinyl chloride (PVC) pipes. The watertightness tests were positive and the land regularized with the backfill, finalizing the implantation of the system. The ANF effluent was directed to the soil, with an acceptable estimate of reduction of organic matter. The system was designed for cleaning every year. The proposed system budget was $ 100.53 and the conventional budget was $ 120.78. The difference does not draw attention, however, the significant environmental advantage of reusing ELTs stands out, which, in the municipality, would have inadequate final destination, in addition to the sewage treatment, since this system is absent in the municipality. The precipitation rates of the Amazonian winter in northern Brazil are high (Hilker et al., 2014). In such cases, it is recommended to use sewage treatment units made of waterproofing material (BRASIL, 2015). As the tightness of the system was tested and confirmed, its implementation is justified. However, ABNT and Brazilian environmental legislation do not regulate this type of structure and its construction. Therefore, this is a good opportunity to analyze the structural efficiency and domestic sewage treatment of the system. Finally, 71,980 ELTs that would be reused and removed from the environment, if all residences in the neighborhood where the residence is located adopted the proposed system. Although it is an estimate, the number is relevant and attractive for the conservation of the environment and public health, in addition to giving visibility to the reduction of ELTs. As the reuse of ELTs is an expensive process, the proposed system is an extremely economical solution. The study proposes an alternative of reusing ELTs for the treatment of domestic sewage, without diminishing the importance of RL in the treatment of ELTs.

Conclusions: In this work, individual domestic sewage treatment units (ST+ANF) were dimensioned and built, using ELTs to replace masonry structures. The units were adapted according to the structure of the tires and presented good tightness and reliability. The system proved to be an alternative for small and medium-sized municipalities where reverse logistics is neglected. Although the proposed system is only 16.6% cheaper than the traditional one, the reuse of ELT in sewage treatment represents a double environmental advantage and the conservation of public health. The number of ELTs estimated to benefit the neighborhood with the proposed system is significant and constitutes the strategy for reducing or removing ELTs from clandestine areas. The results obtained have been satisfactory so far. The monitoring of the effluent and the structural analysis of the units will confirm its complete functionality.

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