Evaluation Of The Efficiency Of A Septic Tank Combined With Anaerobic Filter, Filled With Plastic Residue, Including A Root Zone

Vivian Silva Lira[1]
Alice Gabriela Freire[2]
Renata Fracácio[3]
Leandro Cardoso Morais[4]

ABSTRACT

Considering the damage resulting from in natura disposal of waste in soil or water bodies, we installed an alternative system of domestic effluent treatment consisting of a septic tank combined with an anaerobic filter, including a root zone. System efficiency was evaluated based on physical, chemical, and biological analyses, in addition to ecotoxicological tests (toxicity tests with Ceriodaphnia dubia). Conductivity values decreased from 3380 to 561 μS cm-1 (83.4%) after treatment. Average organic matter removal efficiency was 88.75% and there was a significant decrease in BOD. Phosphorus removal percentage was 97.68%, while nitrogen removal percentage was 94.7%. Toxicity tests determined an LC50 = 1.70% for the raw effluent and an LC50 = 16.63% for the treated effluent. The system achieved good efficiency in reducing all analyzed parameters. The use of a plastic residue as a filter element in the anaerobic filter proved to be feasible.

Keywords: septic tank; anaerobic filter; conduits; root zone.

[1]Mestre em Ciências Ambientais. Doutoranda do Programa de Ciências Ambientais da UNESP. Instituto de Ciência e Tecnologia, Sorocaba, Brasil. vivianslira@gmail.com

[2]Graduado em Engenharia Ambiental. Secretaria Municipal de Meio Ambiente de Ubatuba. Alice.smma@gmail.com

[3]Doutora em Ecologia e Recursos Naturais. Docente do Departamento de Engenharia Ambiental UNESP. Instituto de Ciência e Tecnologia, Sorocaba, Brasil renata.fracacio@ unesp.br

[4]Doutor em Engenharia Química. Docente do Departamento de Engenharia Ambiental UNESP. Instituto de Ciência e Tecnologia, Sorocaba, Brasil. Leandro.cardoso@ unesp.br

Lack of sewage collection and treatment is still a reality in many developing countries, including Brazil. Considering the damage resulting from the disposal of fresh manure in soil or water bodies to both public health and the environment, it is essential to ratify the need to treat the generated effluents (ITB 2017).

The septic tank is a household effluent treatment device that can treat effluents with simplicity and low cost. Septic tanks can have a single chamber, serial chambers, or overlapping chambers simultaneously developing various functions, biochemically transforming substances and compounds into chemically inert or stable structures (US EPA 2002a; Jordão & Pessoa 2005).

According to Andrade Neto (2006), an anaerobic filter can be used to complement the treatment due to its capacity to retain solids and to recover from qualitative and quantitative overloads. It gives high operational safety to the system and greater stability to the effluent, maintaining the advantages of anaerobic treatment, producing little sludge, not consuming energy, making the operation simple and economical. Among the main advantages of these filters are the greater operational simplicity and the remarkable robustness to load biomass shocks and toxicity, which is a typical characteristic of systems with biofilms (Almeida et al. 2011).

According to the literature, corrugated PVC conduits as support medium in an anaerobic filter are similar to or more efficient than other materials used, such as gravel, bamboo, Luffa cylindrica, Luffa acutangula (Jordão & Pessoa 2005; Chanakya & Khuntia 2014; Fernandes et al. 2015). The main advantage of anaerobic biofilm filters filled with synthetic carrier materials compared to organic materials is the degradation time, in view of the durability of plastic materials (Nabizadeh et al. 2008; Lee et al. 2007; Chanakya & Khuntia 2014).

However, effluents from an anaerobic filter may still contain nitrogen and phosphorus in quantity, concentration, and forms that can cause problems in the recipient body. Effluents from any source of pollution may only be released directly or indirectly into water bodies, since they do not cause or have the potential to cause toxic effects to aquatic organisms in the recipient body (US EPA 2002a; Brasil 2005; 2011).

Thus, root zones can be used as advanced wastewater treatment since, according to Vymazal (2007), surface-flow constructed wetlands consist of basins or channels in which the effluent follows through a gravel or sand medium; there, plants are rooted, imitating transitional ecosystems between terrestrial and aquatic environments. This creates a favorable environment for the growth of several rhizosphere bacteria, which decompose the various inorganic pollutants present in the effluent into elementary forms (Saumya et al. 2015). The use of the genus Typha in wetlands or roots is reported in the literature (Brasil et al. 2007; Bastos et al. 2010; Vera et al. 2013; Fia et al. 2015; Pelissari et al. 2014; Costa et al. 2015; Von Sperling 2015).

In view of the above, this paper verifies the feasibility of an alternative system for effluent treatment in places without basic sanitation. We used a septic tank combined with anaerobic filter (with plastic PVC waste), including a root zone (to improve the limnological conditions so that the discharge of these effluents into the receiving body does not compromise the present biota).

METHODOLOGY

SYSTEM CONSTRUCTION

The system was built and tested in a residence located in the countryside, in Iperó city, São Paulo State, Brazil (23°26'19.219" S and 47°32'53.549" W). The residence had 09 inhabitants and the system received only black water from the toilet in the only bathroom in the house. The system consisted of three water tanks, two of which were made of unsaturated polyester reinforced with glass fiber, while the last was made of polyethylene (root zone), with dimensions shown in Table 01. The sizing of the system was estimated to contribute with 100 L inh^{-1} day^{-1}L (ABNT NBR 7229 1993; ABNT NBR 13969 1997).

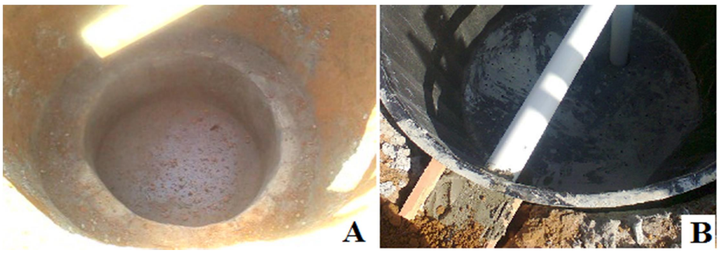
Table 01: Dimensions of the tanks used to compose the septic tank system with an anaerobic filter including a root zone.

Dimensions	Septic Tank	Anaerobic Filter	Root Zone
Height (m)	1.4	1.12	0.94
Diameter (m)	1.38	1.36	1.52
Volume (L)	2000	1500	1000

Source: The Authors

According to the standard NBR 13969 (ABNT 1997), a false bottom was made in concrete for the anaerobic filter (Figure 01A). The trench was deepened approximately 80 cm where a waterproof concrete structure was made (Figure A). Figure 1B shows the water tank with the previously drilled bottom (holes approximately 02 cm in diameter).

Figure 01. Development of the anaerobic filter with false bottom made in concrete and water tank with the previously drilled bottom. Notes: (A) false bottom of waterproofed concrete. (B) water tank with holes in the bottom for the effluent to rise



Source: The Authors

The material chosen to compose the media was plastic in the form of conduits (corrugated polypropylene and PVC elements - Figure 02A), which are abundant construction waste. The filter medium was placed in the form of a module; conduits were disposed within a bag made of vinyl screen sewn for this purpose, aiming to facilitate the removal and cleaning of the filter when necessary, as shown in Figure 02B.

A third polyethylene box comprised the root zone (Figure 02D). The gravel substrate was approximately 40 cm high from the bottom of the box, and plants with approximately 60 days of age were arranged (*Typha domingensis).* The third box started to receive the effluent coming from the anaerobic filter about 02 months after the system began to receive the effluent, and the system was analyzed after 70 days (dry season). The anaerobic filter effluent passes through the substrate and root zone exiting the opposite side, being taken to the sump by a 100-mm drainage pipe in hollow PVC with holes of 01 to 02 cm, allocated in a 01-m long trench filled with gravel to avoid possible clogging.

Figure 02. System under construction. Notes: (A) plastic waste (conduits - corrugated polypropylene elements), (B) anaerobic filter, (C) developing system, and (D) root zone.

Source: The Authors

Physical and chemical analyses

Collection was performed using disposable water sampling bailers with a capacity of 01 liter. The initial effluent from the septic tank and the treated effluent from the last box were collected for comparison purposes. Some analyses were performed on site: pH (Digimed DM-22 pH meter), conductivity (Digimed DM-32 conductivity meter), dissolved oxygen and temperature (Digimed DM-4P oximeter), in which the method of potentiometry was used, as described in Table 02.

Moreover, $BOD_{5,20}$ was obtained by means of dilutions: 50, 10, and 5% for the initial effluent. For the treated effluent, a sample was taken without dilution, following a sample with 50% dilution and another with 25% dilution. The dilution water was previously prepared by aerating deionized water and adding 01 mL of the phosphate buffer solution, 01 mL of magnesium sulfate solution, 01 mL of calcium chloride solution, and 01 mL of ferric chloride solution to each liter of aerated deionized water. This ensured that the only limiting factor in the test was the concentration of organic matter present in the sample, according to APHA (2012). The values were obtained through a portable oximeter (Digimed DM-4P).

Drying, calcination, and filtration were used to define total solids (TS) and total (TDS), fixed (FDS), and volatile dissolved solids (VDS), as well as total (TSS), fixed (FSS), and volatile sedimentable solids (VSS), which were determined after one hour of sedimentation in the Imhoff Cone (Figure 03), following the recommendations of APHA (2012).

Table 02 - Methodologies adopted for physical, chemical, and biological analyses

Variables	Units	Methodology	References
pH	-	Potentiometry	-

Electrical conductivity	μS cm^{-1}		
Dissolved oxygen	mg L^{-1}		
Temperature	°C		
Total Organic Nitrogen (TON)	mg L^{-1}	Spectrophotometry	APHA (2012)
Total phosphorus (TP)	μg L^{-1}	Spectrophotometry	APHA (2012)
Biochemical oxygen demand (BOD)	mg L^{-1}	Potentiometry	APHA (2012)
Total and Thermotolerant coliforms	NMP	Colorimetry (Collilert ®)	APHA (2012)

Source: The Authors

TOXICITY TESTS WITH *C. DUBIA*

Ceriodaphnia dubia is a freshwater microcrustacean of the order Cladocera, which is commonly used in ecotoxicological tests due to its sensitivity, short life cycle, and wide ecological distribution in freshwater (US EPA 2002b). The organisms were obtained from the same place where ecotoxicological tests were carried out: LATHIS (Laboratory of Toxicology of Environmental Pollutants and Histology) - Institute of Science and Technology of Sorocaba (ICTS), UNESP - São Paulo State, Brazil. Acute toxicity tests were performed with the raw and treated samples. Six test concentrations were established, with 50; 25; 12.5; 6.2; 3.1; and 0% of the samples diluted in culture water, the latter (0%) being only culture water. The culture water was prepared with deionized water by adjusting the pH between 7.2 and 7.6, and hardness between 40 and 48 mg $CaCO_3$ L^{-1}.

The experiment was performed with 10 replicates, each having 01 test organism. It was maintained for 04 days, where the parameters hardness, pH, and dissolved oxygen were monitored at each test solution renewal, following the recommendations of US EPA (2002b). The biological effect observed was mortality. Median lethal concentration (LC_{50}) was calculated after 48 hours of exposure through linear interpolation, available in the statistical program ICPIN (Norberg-King 1993).

Figure 03. Sedimentation of the samples in the Imhoff cone, allowing comparison between raw and treated samples.

Source: The Authors

RESULTS AND DISCUSSION

The first tank was filled in about 08 days. It should be noted that the system received only black water from the toilet. With this data, it was possible to calculate the actual daily effluent flow, which was 0.25 m³ day^{-1}, resulting in 28 L inh^{-1} day^{-1}, according to NBR 7229 (ABNT 1993) and NBR 13969 (ABNT 1997). This is a very reasonable value considering that each person uses the toilet on average about 04 times a day, with a volume of 07 liters per discharge. The second tank took about 45 days to fill, with a minimum daily flow of 0.038 m³ day^{-1}, resulting in 4.47 L inh^{-1} day^{-1}. Such a difference can be justified by the end of school holidays and therefore fewer contributors. In addition, the false bottom built led to an increase of more than 200 L in the volume of the anaerobic filter.

Conductivity values had a marked reduction after treatment (83.4%), from 3380 μS cm^{-1} to 561 μS cm^{-1} (Table 03). The result found in the quantification of nitrogen in the raw effluent, 333.10 mg L^{-1} (Table 03), was consistent with that found by Paulo et al. (2013) when analyzing the treatment of black water by an evapotranspiration basin, 335.40 mg L^{-1}. For phosphorus, the concentration was higher than that reported in the literature for black water (Palmquist & Hanæus 2005; Murat Hocaoglu et al. 2010; Gallagher & Sharvelle 2011; Sharma et al. 2016), which shows that the effluent is very rich in nutrients and therefore with great potential to cause damage if released *in natura* in the environment.

High concentrations of nutrients and high electrical conductivity lead to believe that the effluent evaluated is predominantly formed of urine, since it is the fraction that contains the majority of nutrients of the sanitary effluent, approximately 80% nitrogen, 55% phosphorus, and 60% potassium (Johansson et al. 2002; Otterpohl et al. 2004; Beler-Baykal 2015).

The overall mean value of the biochemical oxygen demand ($BOD_{5,20}$) of the effluent was 74.6 ± 1.3 mg L^{-1}, as can be seen in Table 03. This value is lower than that reported in the literature for black water (Gajurel et al. 2003; Oldenburg et al. 2008; Gallagher & Sharvelle 2011; Paulo et al. 2013; Sharma et al. 2016). According to the São Paulo State Decree No. 8468, five-day BOD is the standard for effluent emission directly into water bodies for a minimum overall efficiency of the treatment process equal to 80% (São Paulo 1976). Therefore, the treatment proved to be satisfactory, aligning the effluent with the legislation (Table 03).

Table 03. Comparison of variables before and after treatment.

Variables	Raw	Treated	Efficiency (%)
pH	7.60	7.50	-
Temperature (°C)	25.30	21.60	-
Electrical conductivity (μS cm^{-1})	3380.00	561.00	-
OD (mg L^{-1})	0.67 ± 0.08	3.94 ± 0.63	83.00

$BOD_{5,20}$ (mg L^{-1})	74.60 ± 1.30	8.39 ± 0.98	88.75
TON (mg L^{-1})	333.10	21.00	93.69
TP (mg L^{-1})	115.90	2.80	97.68
Total coliforms (NMP)	2.41×10^6	1.43×10^5	94.05
Thermotolerant coliforms (NMP)	1.2×10^6	1.4×10^4	98.86

Source: The Authors

Organic matter removal efficiency in the system was 88.75%. The filter element used domestically, whose primary applicability is the covering and protection of electrical wiring, has a high specific surface area, 220 m² m^{-3} (Almeida et al. 2011). This may have contributed to high efficiency. Couto et al. (2015) used the same material in an anaerobic filter for ash treatment, observing that the removal of organic matter and solids by the anaerobic filter may have been favored by the high specific area and porosity of the support medium. That situation allowed biofilm establishment both internally and externally, increasing the contact of the effluent with the anaerobic biomass. In addition to being a low cost material, an efficient support medium is used to treat both domestic and copper-contaminated effluents (Qureshi et al. 2001; Tembhurkar & Mhaisalkar 2006).

Dissolved oxygen (DO) increased by 3.27 mg L^{-1}, probably due to the oxygenation provided by the roots of the plants (Brix 1997; Faulwetter et al. 2009). Oxygen release from the root varies among plant species (Brix 1997; Stottmeister et al. 2003). Wiessner et al. (2002), evaluating the potential of oxygen release in four species of halophytes, observed that species *Typha latifolia* had the highest rates, reaching 1.41 mg h^{-1} $plant^{-1}$, a fact that reinforces the species used in this study belonging to the same genus.

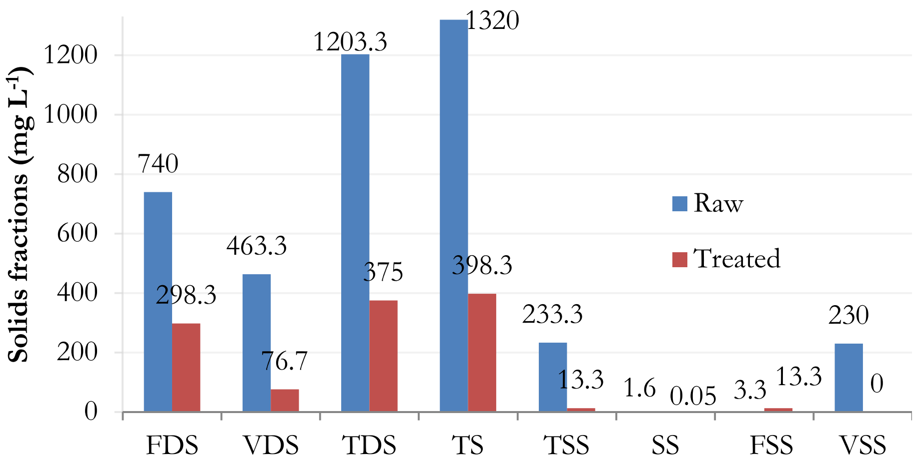
Nitrogen removal efficiency in the system was 94.7%, probably due to nitrification in the anaerobic filter. The low concentration of organic matter verified by $BOD_{5,20}$ in the effluent may have been a determining factor for the high efficiency of the treatment in reducing nitrogen. According to Missagia (2010), who evaluated microorganisms in different biofilms, high concentrations of organic matter decrease nitrification, since the heterotrophic biomass competes successfully for oxygen and space, expelling nitrifying microorganisms from the biofilm.

The system achieved the expected efficiency in the removal of suspended and sedimented solids, as shown in Figure 04. The final concentration of sedimented materials was 0.05 mg L^{-1} (Figure 04), below the limit established by CONAMA 430/2011 for water bodies, which is 1 mg L^{-1}.

Dissolved solids were shown to be very frequent in the initial effluent. In contrast, suspended solids had a lower than expected frequency. This is due to this fraction containing sedimentable solids;

as the sample was already withdrawn from the septic tank, some of these solids were already sedimented therein.

Figure 04. Solids fractions quantification in raw and treated effluents.



Source: The Authors

TS and TSS were consistent with the values reported by Paulo et al. (2013) for black water, and lower than those reported by other studies, in which TSS ranged from 625 to 1053 mg L^{-1} and VSS ranged from 401 to 683 mg L^{-1} (Murat Hocaoglu et al. 2010; Gallagher & Sharvelle 2011; Sharma et al. 2016).

The VSS/TSS ratio for the raw effluent was 0.98 , showing that most of the suspended solids in the raw effluent are volatile, and hence of organic origin. For the treated effluent, the same ratio was 0, demonstrating that the biochemical digestion process probably oxidized all organic fractions, as can be seen in Figure 04. Sharma & Kazmi (2015) consider that TSS can be used as substitutes for microbial parameters (total and thermotolerant coliforms) in monitoring the efficiency of black water treatment.

Regarding microorganisms, system efficiency reached 94 and 98.8% in the removal of total and thermotolerant coliforms, respectively (Table 03). Toxicity tests determined an LC_{50} = 1.70% for the raw effluent and an LC_{50} = 16.63% for the treated effluent. These results demonstrated that the system reduced the acute toxicity of the raw effluent by approximately 10 times. When evaluating the efficiency of a wetland in the treatment of municipal effluents, using chronic bioassays, Hemming et al. (2002) found that C. dubia was more sensitive to effluent toxicity than *Vibrio fischeri* and *Pimephales promelas*. Thus, the reduction of acute toxicity for C. dubia shows that the system in question contributes to the protection of aquatic communities, which are directly affected by the release of in natura effluents.

CONCLUSION

The system achieved good efficiency in reducing all analyzed parameters. The use of a plastic residue as a filter element in the anaerobic filter proved to be feasible. The use of species *Typha domingensis* in the root zone may have contributed to improve the limnological conditions of the effluent, since the planted seedlings remained alive and developed. The treated effluent reduced the likelihood of ecotoxicity for the biota present in the receiving waters.

REFERENCES

Associação Brasileira de Normas Técnicas, 1993. NBR 7229: Design, construction and operation of septic tank systems**.** Rio de Janeiro, 15 pp.

Associação Brasileira de Normas Técnicas, 1997. NBR 13969: Septic Tanks - Complementary Treatment Units and Final Disposal of Liquid Effluents - Design, Construction and Operation. Rio de Janeiro, 60 pp.

Almeida PGS, Oliveira SC, Chernicharo CAL 2011. Operation of trickling filters post-UASB reactors without the secondary sedimentation stage. *Eng Sanit Ambient* 16(3):271-280. http://www.scielo.br/pdf/esa/v16n3/v16n3a10.pdf

Andrade Neto CO 2006. The use of the anaerobic filter for sanitary sewage treatment. [cited 2017 April 6]. Available from: http://www.meiofiltrante.com.br/edicoes.asp?link=ultima&fase=C&id=207

APHA - American Public Health Association, 2012. Standard methods for the examination of water and wastewater**.** 22th ed. Washington: APHA. 1360 pp.

Bastos RKX, Calijuri ML, Bevilacqua PD, Rios EN, Dias EHO, Capelete BC, Magalhães TB 2010. Post-treatment of UASB reactor effluent in waste stabilization ponds and in horizontal flow constructed wetlands: a comparative study in pilot scale in Southeast Brazil. *Water Science Technology* 61(4):995-1002. http://dx.doi.org/10.2166/wst.2010.960.

Beler-Baykal B 2015. Stream segregation in household use: a review of grey water as an alternative source of water and yellow water as an alternative source of fertilizers. *Water Qual Expo Health* 7:27–37. https://doi-org.ez87.periodicos.capes.gov.br/10.1007/s12403-013-0105-3

Brasil 2005 - Conselho Nacional do Meio Ambiente. Resolução CONAMA nº 357, de 17 de março de 2005. It deals with the classification of water bodies and environmental guidelines for its classification, as well as establishes the conditions and standards for the discharge of effluents, and provides other measures [cited 2017 April 29]. Available from: http://www.mma.gov.br/port/conama/res/res05/res35705.pdf

Brasil 2011 - Conselho Nacional do Meio Ambiente. Resolução CONAMA nº 430, de 13 de maio de 2011. Provides for the conditions and standards for the discharge of effluents, complements and modifies Resolution No. 357/2005 [cited 2017 April 29]. Available from: http://www.mma.gov.br/port/conama/legiabre.cfm?codlegi=646

Brasil MS, Mato AT, Soares AA 2007. Planting and fenological performance of *Typha sp*. used in the domestic wastewater treatment under constructed wetland system. *Associação Brasileira de Engenharia Sanitária e Ambiental – ABES* 12(3). http://dx.doi.org/10.1590/S1413-41522007000300006

Brix H 1997. Do macrophytes play a role in constructed treatment wetlands? *Water Science Technology* 35(5):11–17. https://doi.org/10.1016/S0273-1223(97)00047-4

Chanakya HN, Khuntia HK 2014. Treatment of gray water using anaerobic biofilms created on synthetic and natural fibers. *Process Safety and Environmental Protection* 92(2):186-192. https://doi.org/10.1016/j.psep.2012.12.004

Costa JF, Martins WLP, Seidl M, Von Sperling M 2015. Role of vegetation (*Typha latifolia*) on nutrient removal in a horizontal subsurface-flow constructed wetland treating UASB reactor trickling filter effluent. *Water Science Technology* 71(5):1004-1010. DOI: 10.2166/wst.2015.055

Couto EA, Calijuri ML, Assemany PP, Santiago AF, Lopes LS 2015. Greywater treatment in airports using anaerobic filter followed by UV disinfection: an efficient and low cost alternative. *Journal of Cleaner Production* 106:372-379. http://dx.doi.org/10.1016/j.jclepro.2014.07.065

Faulwetter JL, Gagnon V, Sundberg C, Chazarenc F, Burr MD, Brisson J, Camper AK, Stein OR 2009. Microbial processes influencing performance of treatment wetlands: a review. *Ecological Engineering* 35(6):987-1004. doi:10.1016/j.ecoleng.2008.12.030

Fernandes WV, Barbosa G, Júnior A, Batista MM, Anjos Júnior RH 2015. Evaluation of the organic matter removal of septic tank effluent using anaerobic filter filled with *Luffa cylindrica* as support medium. *Revista Eletrônica de Gestão e Tecnologias Ambientais* 3(1):1-13. doi:http://dx.doi.org/10.17565/gesta.v3i1.12995.

Fia FRL, Matos AT, Fia R, Borges AC, Abreu EC 2015. Influence of nutrient loading and species cultivated on the removal of K, Na, Cu and Zn from swine wastewater treated in constructed wetlands. *Revista Ambiente Água* 10:542-553. http://dx.doi.org/10.4136/ambi-agua.1216.

Gajurel DR, Li Z, Otterpohl R 2003. Investigation of the effectiveness of source control sanitation concepts including pre-treatment with Rottebehaelter. *Water science and technology* 48(1):111-118.

Gallagher N, Sharvelle S 2011. Demonstration of anaerobic digestion of black water for methane capture and use in an office building, *Water Pract Technol* 6. DOI: 10.2166/wpt.2011.008

Hemming JM, Turner PK, Brooks BW, Waller WT, La Point TW 2002. Assessment of Toxicity Reduction in Wastewater Effluent Flowing Through a Treatment Wetland Using *Pimephales promelas*, *Ceriodaphnia dubia*, and *Vibrio fischeri*. *Arch Environ Contam Toxicol* 42(9). doi:10.1007/s002440010285

ITB - Instituto Trata Brasil 2017. Situation Sanitation in Brazil. [cited 2017 October 10]. Available from: http://www.tratabrasil.org.br/saneamento-no-brasil

Johansson M, Jönsson H, Höglund C, Stintzing A, Rodhe L 2002. Final Report for Source-Separated Human Urine: A Future Source of Fertilizer for Agriculture in the Stockholm Region? Prepared for the Stockholm Water Company, Stockholm. [cited 2017 October 17] Available from: http://www.sswm.info/sites/default/files/reference_attachments/JOHANSSON%202000%20Urine%20Separation%20-%20Closing%20the%20Nutrient%20Cycle_0.pdf

Jordão EP, Pessoa CA 2005 Tratamento de esgotos domésticos. 4. ed. Rio de Janeiro: ABES, 932 pp.

Lee S, Lee H, Lee S, Chitapornpan S, Chiemchaisri C, Polprasert C, Ahn K 2007. Media configuration and recirculation of up flow anaerobic floating filter for piggery wastewater treatment. *Korean Journal of Chemical Engineering* 24(6):980-988.

Missagia B 2010. Study of bacterial communities in biological filters Percolators used for post-treatment of effluents from a UASB reactor, PhD Thesis, Escola de Engenharia da UFMG, Belo Horizonte, 113 pp.

Murat Hocaoglu S, Insel G, Ubay Cokgor E, Baban A, Orhon D 2010. COD fractionation and biodegradation kinetics of segregated domestic wastewater: black and grey water fractions. *J Chem Technol Biotechnol* 85:1241–1249. doi:10.1002/jctb.2423

Nabizadeh R, Naddafi K, Mesdaghinia A, Nafez AH 2008. Feasibility study of organic matter and ammonium removal using loofa sponge as a supporting medium in an aerated submerged fixed film reactor (ASFFR). *Electronic Journal of Biotechnology* 11(4).

Norberg-King T 1993. A linear interpolation method for sublethal toxicity: the inhibition concentration (ICp) approach (Version 2.0). US Environmental Protection Agency, Environ. Res. Lab.-Duluth, Duluth, MN, Technical Report 03-93 of National Effluent Toxicity Assessment Center.

Oldenburg M, Meinzinger F, Nisipeanu P, Schneider C 2008. Begrifflichkeiten und Kennzahlen zur Zusammensetzung von Teilstromen neuartiger Sanitarsysteme. *KA Abwasser Abfall* 55(10):1113. DOI: 10.3242/kae2008.10.006

Otterpohl R, Braun U, Oldenburg M 2004. Innovative technologies for decentralised water-, wastewater and biowaste management in urban and peri-urban areas. *Water Sci Technol* 48(11-12):23–32. doi: https://doi.org/10.2166/wst.2004.0795

Palmquist H, Hanæus J 2005. Hazardous substances in separately collected grey- and blackwater from ordinary Swedish households, *Sci Total Environ* 348:151–163. https://doi.org/10.1016/j.scitotenv.2004.12.052

Paulo PL, Azevedo C, Begosso L, Galbiati AF, Boncz MA 2013. Natural systems treating greywater and blackwater on-site: integrating treatment, reuse and landscaping. *Ecol Eng* 50:95–100. http://dx.doi.org/10.1016/j.ecoleng.2012.03.022

Pelissari C, Sezerino PH, Decezaro ST, Wolff DB, Bento AP, Junior OC, Philippi LS 2014. Nitrogen transformation in horizontal and vertical flow constructed wetlands applied for dairy cattle wastewater treatment in southern Brazil. *Ecol Eng* 73:307-310. http://dx.doi.org/10.1016/j.ecoleng.2014.09.085.

Qureshi FM, Badar U, Ahmed N 2001. Biosorption of Copper by a Bacterial Biofilm on a Flexible Polyvinyl Chloride Conduit. *Applied and Environmental Microbiology* 67(9):4349–4352. doi: 10.1128/AEM.67.9.4349–4352.2001

São Paulo 1976 - Decreto nº 8.468, de 31 de maio de 1976. Approves the regulation of Law Nº. 997/1976, which provides for the Prevention and Control of Environmental Pollution. [cited 2017 April 26]. Available from: https://www.al.sp.gov.br/repositorio/legislacao/decreto/1976/decreto-8468-08.09.1976.htmlSaumya S, Akansha S, Rinaldo J, Jayasri MA, Suthindhiran K 2015. Construction and evaluation of prototype subsurface flow wetland planted with Heliconia angusta for the treatment of synthetic greywater. *J Clean Prod* 91:235–240. http://dx.doi.org/10.1016/j.jclepro.2014.12.019

Sharma MK, Kazmi AA 2015. Anaerobic onsite treatment of black water using filter-based packaged system as an alternative of conventional septic tank. *Ecol Eng* 75:457–461. http://dx.doi.org/10.1016/j.ecoleng.2014.12.014

Sharma MK, Tyagi VK, Saini G, Kazmi AA 2016. On-site treatment of source separated domestic wastewater employing anaerobic package system. *Journal of Environmental Chemical Engineering* 4(1):1209–1216. https://doi.org/10.1016/j.jece.2016.01.024

Stottmeister U, Wiessner A, Kuschk P, Kappelmeyer U, Kastner M, Bederski O, Muller RA, Moormann H 2003. Effects of plants and microorganisms in constructed wetlands for wastewater treatment. Biotechnol Adv 22:93–117.

Tembhurkar AR, Mhaisalkar VA 2006. Study of Hydrodynamic Behavior of a Laboratory Scale Upflow Anaerobic Fixed Film Fixed Bed Reactor. Journal of Environ Science & Engg 48(2):75-80.US EPA 2002a - United States Environmental Protection Agency. Onsite Wastewater Treatment and Disposal Systems, EPA 625-R-00-008.

US EPA 2002b - United States Environmental Protection Agency. Method 1002: short-term methods for estimating the chronic toxicity of effluents and receiving waters to freshwater organism. United States Environmental Protection Agency, Washington, DC.

Vera L, Martel G, Márquez M 2013. Two years monitoring of the natural system for wastewater reclamation in Santa Lucía, Gran Canaria Island. *Ecol Eng* 50:21–30. http://doi.org/10.1016/j.ecoleng.2012.08.001

Von Sperling M 2015. Comparison of simple, small, full-scale sewage treatment systems in Brazil: UASB–maturation ponds–coarse filter; UASB–horizontal subsurface-flow wetland; vertical-flow wetland (first stage of French system). *Water Sci Technol* 71(3):329. http://dx.doi.org/10.2166/wst.2014.496.

Vymazal Jan 2007. Removal of nutrients in various types of constructed wetlands. *Science of The Total Environment* 380(1–3):48-65. https://doi.org/10.1016/j.scitotenv.2006.09.014.

Wiessner A, Kuschk P, Kastner M, Stottmeister U 2002. Abilities of helophyte species to release oxygen into rhizospheres with varying redox conditions in laboratory-scale hydroponic systems. *Int J Phytoremediation* 4:1–15. doi: 10.1080/15226510208500069

Evaluation Of The Efficiency Of A Septic Tank Combined With Anaerobic Filter, Filled With Plastic Residue, Including A Root Zone

Vivian Silva Lira, Alice Gabriela Freire, Renata Fracácio, Leandro Cardoso Morais

Avaliação Da Eficiência De Um Sistema De Tanque Séptico, Filtro Anaeróbio Preenchido Com Resíduo Plástico Aliados À Zona De Raízes

RESUMO

Considerando os danos decorrentes do despejo de dejetos *in natura* nos corpos d'água ou no solo, foi instalado um sistema alternativo de tratamento de efluentes domésticos com tanque séptico e filtro anaeróbio seguido de zona de raízes. A avaliação da eficiência do sistema se deu através de análises das variáveis físicas, químicas, biológicas e ecotoxicológicas (testes de toxicidade com *Ceriodaphnia dubia*). Os valores de condutividade reduziram após o tratamento (83,4%), passando de 3380 a 561 $\mu S.cm^{-1}$. A eficiência média de remoção de matéria orgânica foi de 88,75% e houve uma acentuada diminuição da DBO. A remoção do fósforo foi de 97,68% e do Nitrogênio ficou em 94,7%. Os ensaios de toxicidade determinaram uma CL_{50}= 1,70% para o efluente bruto e no tratado, uma CL_{50}= 16,63%. O sistema alcançou boa eficiência na redução de todos os parâmetros analisados. A utilização de um resíduo plástico com o elemento filtrante demonstrou-se viável.

Palavras-chave: tanque séptico; filtro anaeróbico; conduítes; zona de raízes.

Submissão: 27/08/2018
Aceite: 02/05/2020