IWA 17th SWWS AND 9th ROS
10th–14th November, 2024
Curitiba-Brazil

Evaluation of *Escherichia coli* and Helminths Decay in Vertical Wetlands Applied to Sewage Sludge Treatment

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Highlights:

- The treatment of anaerobic sludge for agricultural reuse.
- Sludge dewatering and stabilization in vertical wetlands with a view to environmental sustainability.
- Removal of pathogenic organisms in the treatment of sludge in vertical wetlands under different loading rates.

Keywords: Constructed wetlands, sewage sludge, pathogens, biosolids, microbiological standards.

INTRODUCTION

The law n.14.026/2020, which updates the sanitation framework in Brazil, aims to increase sewerage and treatment from 52% to 90% of the Brazilian population until 2033 (BRASIL, 2020). If on the one hand, this measure will reduce the release of untreated sewage into the environment, on the other hand it will result in an increase in sludge production - the main byproduct from sewage treatment.

Although the amount of sludge represents only 1% to 2% of the volume of treated sewage, its management is quite complex, corresponding to 20 to 60% of the operating costs of a Sewage Treatment Plant (STP) (CANZIANI, 1999; VON SPERLING e ANDREOLI, 2014). Currently, the most common route to dispose of sewage sludge in Brazil is landfilling, whereas agricultural use and thermal methods play a second role. Although still environmentally accepted, there's is a soaring tendency to restrict sending of wastes like sewage sludge to landfills, particularly due to the high contents of nutrients and organic matter. In the Brazilian context, these resources are of great interest to agricultural, livestock and forestry, a widespread sector ranging from the local to regional level. Despite the potential to use sludge derived products in soil, it is of utmost importance to assure its sanitary and environmental safety, which reflects in quality standards established by specific regulations - in Brazil there is the Resolution n. 498/2020 (BRAZIL, 2020).

Among the alternatives to treat sewage sludge, there is the Vertical Wetlands, a relatively recent technology usually applied to small sanitation systems. The main advantages of this technology comprise good stabilization and dehydration, long term application and buildup (up to 10 years) and

simplification of operational procedures. Besides these advantages these units could comply with quality standards for use in soils, although this potential are still under investigated.

Therefore, this work aimed to assess the decay of *Escherichia coli* in 12 pilot scale units of vertical wetlands, varying the types of vegetation and sludge loads. The performance of each unit was compared with the Brazilian resolution 498/2020 (BRASIL, 2020), in order to check if besides sludge treatment these units were able to achieve biosolids standards.

METHODOLOGY

This work was carried out in the Sanitation Research and Training Center (CePTS - UFMG/COPASA), located inside Arrudas STP, in Belo Horizonte - MG. In this center, a minor part of the influent sewage is derived to research units, among them an Upflow Anaerobic Sludge Blanket (UASB) reactor. The sludge from this reactor was applied in 12 vertical wetlands, each one with 0,9 m^3 and filled with different layers of crushed stone. A layer of 0,4 m was reserved above the media for application and buildup of sludge, that was applied once a week from november 2022 to february 2024.

Different configurations were used: four units planted with tifton-85 grass (*Cynodon spp.*), four with elephant grass (*Cenchrus purpureus*) and four control units without the presence of vegetation; in each group four sludge loading rates were tested: 75, 100, 150 and 200 kg ST/m^2/year.

After stopping application of sludge, analyses of E.coli were carried out in two depths (varying according to each unit) in each unit. The analysis was done using the Colilert method described by EPA 2003. Additionally, we intend to investigate helminth eggs in the sludge/biosolids accumulated in each wetland according to the method of Meyer et al. 1978.

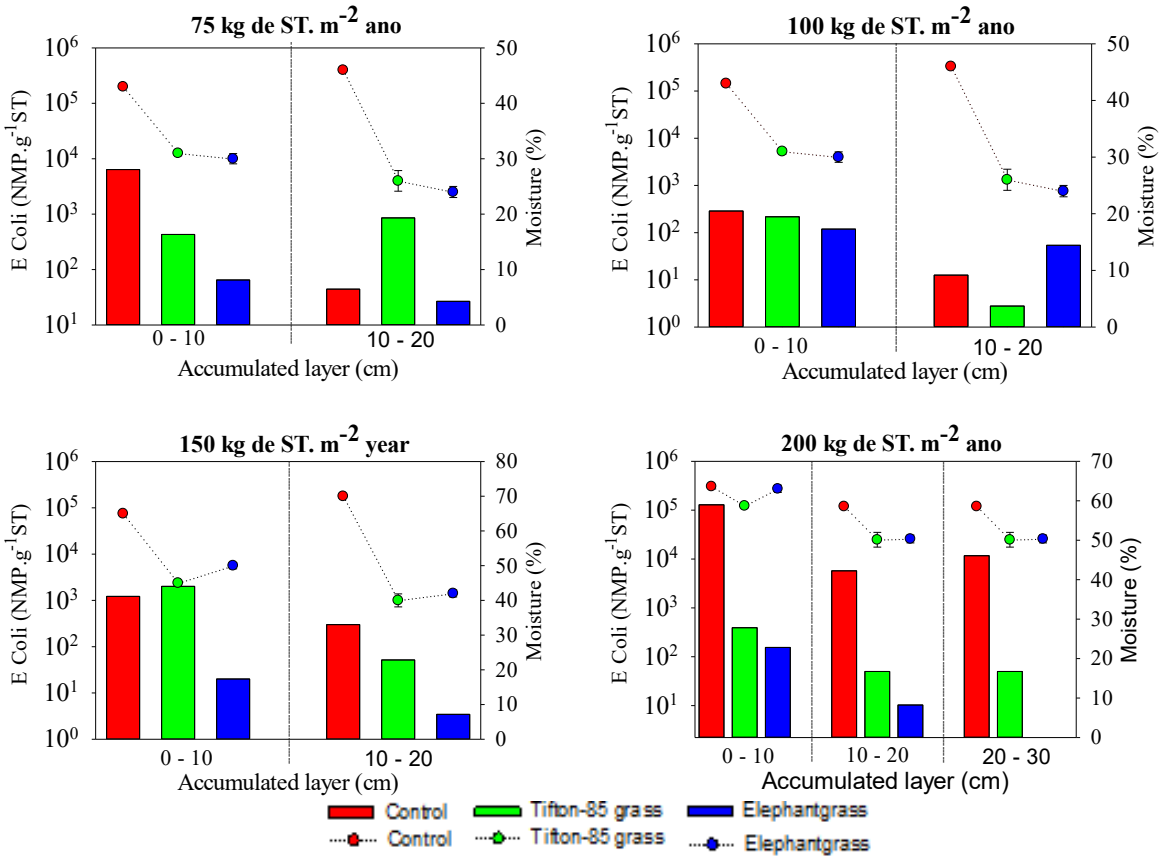
RESULTS AND CONCLUSIONS

Figure 1 shows the concentrations of E. coli and the moisture content present in the residue accumulated in the two layers of each unit. The concentration of E. coli was lower in the planted units compared to the unplanted, as well as in the deepest layer. According to Wu et al. (2012) rapid variations in humidity in planted units caused mainly by the evapotranspiration process result in a significant reduction of pathogenic microorganisms in vertical wetlands. Additionally, there is the possibility that plants may release root exudates to the media, contributing to mobility and metabolization of contaminants and pathogenic organisms (El-Gendy e Ahmed, 2020).

The microbiological standards for agricultural use of biosolids, established by Resolution n.498/2020, was achieved predominantly in the deepest layer and by the planted units. It is also worth noting that in general, the vertical wetland promoted a decay of 2 to 3 logarithmic units of E. coli, considering an E. coli average concentration of 2.86E+ 04 NMP.g-1ST in the raw sludge (from the UASB reactor).

Tanoh et al. (2022) suggest that the hydration and dehydration process of the sludge being treated is one of the factors responsible for the reduction of pathogenic organisms present. KIM & SMITH (1997) highlight that the influence of moisture and aeration in the environment may be responsible for the reduction of Escherichia coli present.

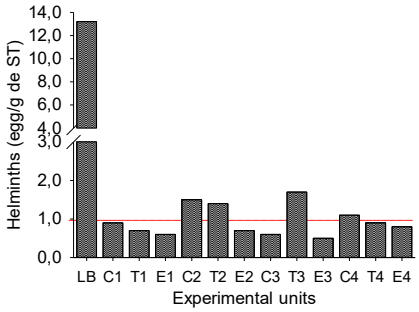
Figure 1: E.coli concentration (NMP.g-1 ST) and moisture content in the layers of accumulated sludge in 12 vertical wetlands used to treat sludge from UASB reactor.



As presented in Figure 2, the incoming raw sludge (LB) has a high concentration of helminth eggs, with a value of 13 eggs per gram of TS. In general, almost all units met the limit established by legislation of one egg/g of TS, and the units planted with elephant grass stand out for complying with the legal requirements even with higher loading rates. Although studies report a higher concentration of eggs in the sludge accumulated in WV due to its high sedimentation rates (NELSON et al., 2004), some studies (SANGUINETTI et al., 2005; KONÉ et al., 2007) indicate that, in addition to natural deaths, the elimination of helminth eggs in sludge accumulated in WV results from biological processes occurring on the surface of the beds, such as dehydration, mineralization, secretion of root exudates, and predation.

Regarding the sludge accumulated on the surface of the treatment units, compliance with the criteria established by Brazilian environmental legislation for agricultural use was achieved for the deeper layers of the accumulated material and consequently in the units with the presence of plants. However, a "rest" phase for the units is necessary for the complete stabilization of the sludge. The units planted with elephant grass met the limits established by Brazilian legislation of one egg/g of TS for biosolids suitable for disposal in agricultural areas.

Figure 2. Concentration of Helminths (eggs/g of TS) in the incoming sludge and experimental units.



LB: incoming raw sludge; control units (C), units planted with Tifton-85 grass (T), and units planted with elephant grass (E) for loading rates of 75 (1), 100 (2), 150 (3), and 200 (4) kg of TS/m²/year, respectively.

REFERENCES

Andrade, L. C.; Andreazza, R.; Camargo, F. A. O. Soil microbial activity under wastewater treatment plant sludge doses from an industrial landfill. Ciência Rural, v. 46, p. 267-272, 2016. https://doi.org/10.1590/0103-8478cr20140871.

BRASIL. Lei nº 14.026. Atualiza o marco legal do saneamento básico. 2020. Disponível em: http://www.planalto.gov.br/ccivil_03/_Ato2019-2022/2020/Lei/L14026.htm#art7. Acesso em: 23 mar. 2024.

BRASIL. Ministério do Meio Ambiente. Conselho Nacional do Meio Ambiente. (2020) Resolução nº 498, de 19 de agosto de 2020. Define critérios e procedimentos para produção e aplicação de biossólido em solos, e dá outras providências. Diário Oficial da União, Brasília.

Canziani, J. R. F. Análise Econômica para a reciclagem agrícola do lodo de esgoto da ETE-Belém. Sanare Revista Técnica da Sanepar. Curitiba/PR, v. 11, n. 11, 1999.

El-Gendy AS, Ahmed AG (2020) Pilot-scale water hyacinth bed for dewatering of sewage sludge (Cama de jacinto de água em escala piloto para desidratação de lodo de esgoto). Desalin Water Treat 194:450-458. https://doi.org/10.1007/s11356-021-12982-y.

Environmental Agency. Part 3: Methods for the isolation and enumeration of Escherichia coli, including verocytotoxigenic Escherichia coli. In: Environmental Agency, The Microbiology of Sewage Sludge, UK, 2003.

Kim, B. J.; Smith, E. D. Evaluation of sludge dewatering reed beds: a niche for small systems. Water Science and Technology, v. 35, n. 6, p. 21–28. 1997.

Koné, D., Cofie, O., Zurbrügg, C., Gallizzi, K., Moser, D., Drescher, S. & Strauss, M. 2007 Helminth eggs inactivation efficiency by faecal sludge dewatering and co-composting in tropical climates. Water Res. 41, 4397–4402.

Meyer, K. B. ;Miller K. D. e Kaneshiro, E. S. Recovery of Ascaris Eggs from Sludge The Journal of Parasitology Vol. 64, No. 2 , pp. 380-383. 1978.

Nelson, K. L., Cisneros, B. J., Tchobanoglous, G. & Darby, J. L. 2004 Sludge accumulation, characteristics, and pathogen inactivation in four primary waste stabilization ponds in central Mexico. Water Res. 38, 111–127.

Peruzzi, E.; Nielsen, S.; Macci, C.; Doni, S.; Jannelli, R.; Chiarugi, M.; Masciandaro, G. Organic matter stabilization in reed bed systems: Danish and Italian examples. Water Science and Technology, v. 68, n. 8, p. 1888-1894, 2013.

Sanguinetti, G. S., Tortul, C., Garcia, M. C., Ferrer, V., Montangero, A. & Strauss, M. 2005 Investigating helminth eggs and Salmonella sp. In stabilization ponds treating septage. Water Science & Technology 51, 239–247.
Sharma, M.; Yadac, A.; Mandal, M. K.; Pandey, S.; Pal, S.; Chaudhuri, H.; Chakrabarti, S.; Dubey, K. K. Wastewater treatement and sludge management strategies for environmental sustainability. Environmental Engineering, v. 2, p. 97-112, 2022.
SISTEMA NACIONAL DE INFORMAÇÕES SOBRE SANEAMENTO – SNIS. Diagnóstico dos serviços de água e esgotos. Site institutional, 2022. Disponível em: <http://www. snis.gov.br/>.
Stefanakis, A. I.; Tsihrintzis, V. A. Dewatering mechanisms in pilot-scale Sludge Drying Reed Beds: Effect of design and operational parameters. Chemical Engineering Journal, v. 172, Issue 1, p. 430-443, 2011. DOI https://doi.org/10.1016/j.cej.2011.05.111. Disponível em: https://www.sciencedirect.com/science/article/abs/pii/S1385894711006929. Acesso em: 14 mar. 2024.
Suntti, C.; Magri, M. E.; Philippi, L. S. Filtros plantados com macrófitas de fluxo vertical aplicados na mineralização e desaguamento de lodo de tanque séptico. Engenharia Sanitária e Ambiental, v.16, n.1, p. 63-72, 2011.
Tanoh,R., Nikiema, J.,Asiedu,Z.,Yathilake, N. & Cofie, O. 2022 The contribution of tipping fees to the operation, maintenance, and management of fecal sludge treatment plants: the case of Ghana. J. Environ. Manage. 303, 114125. https://doi.org/10.1016/j.jenvman.2021.114125.
Tsutiya, M. T. Características de biossólidos gerados em estações de tratamento de esgotos. In: Tsutiya, M. T.; Comparini, J. B.; Sobrinho, A. P.; Hespanhol, I.; Carvalho, P. C. T.; Melfi, A. J. (Ed.). Biossólidos na agricultura. São Paulo: Sabesp, 2001, cap. 4, p. 89-131.
Von Sperling, M.; Andreoli, C. V. Introdução. In: Andreoli, C. V.; Sperling, M. V.; Fernandes, F. Lodos de esgotos: tratamento e disposição final. 2ª edição, Belo Horizonte: Editora UFMG, 2014. cap. 1, p. 11 - 14.
Wu, Y.; Li, T.; Yang, L. Mechanisms of removing pollutants from aqueous solutions by microorganisms and their aggregates: a review. Bioresource Technology. v. 107, p. 10–18, 2012.

ACKNOWLEDGMENT

The authors would like to acknowledge the support obtained from the Research, Development and Innovation Regulatory Program from the Water Supply and Sanitation Services Regulatory Agency of the State of Minas Gerais – ARSAE-MG and the Sanitation Company of the State of Minas Gerais – COPASA.