Use of Bioelectrochemical Systems for the Domestic Wastewater Treatment and Reuse

Author: Gustavo Holz Bracher Supervision: ChrissaLee Butler; Meindert Montenegro; Michelle Sands

Abstract

The goal of this study was to evaluate the potential of bioelectrochemical systems (BES) for domestic wastewater treatment and reuse.

BES are systems capable of using microorganisms as catalyst on electrodes for power generation from water contaminants removal.

The BES are a promising sustainable technology that could be used for sewage treatment to allow its reuse, since studies verified the capacity of BES to produce energy, remove organic matter, nutrients and pathogens from sewage, and produce low waste quantities.

Introduction

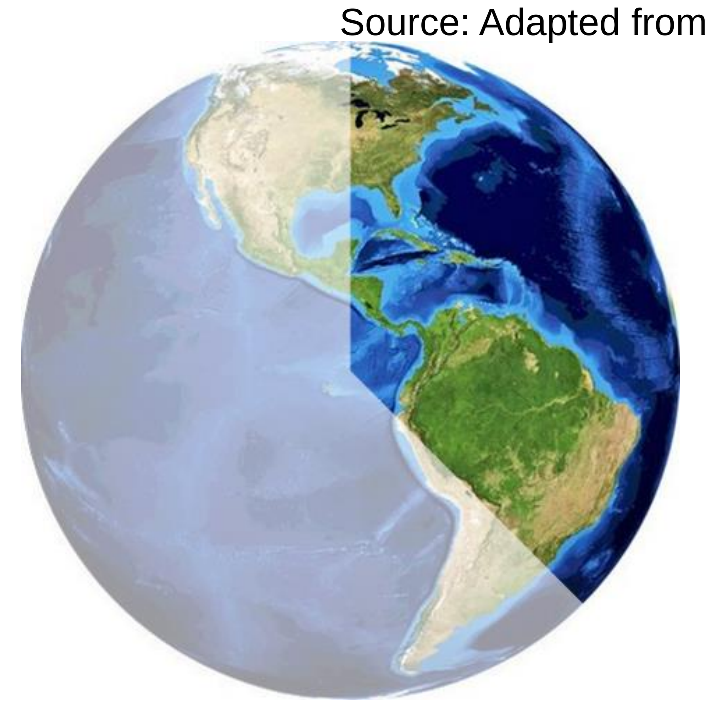
Domestic wastewater — *Liquid discharges from non-industrial anthropic sources (e.g. residences, commercial establishments, institutions)*

Sanitation — *Collection and treatment of domestic wastewater*

Human right — *Sanitation as an essential human right to an adequate standard of living for all and to the realization of all human rights (UN, 2010).*

Source: Adapted from Polistore (n.d.).

2.3 billion *without basic sanitation (WHO, 2017)*



2/3 *face water scarcity at least one month per year (UN-WWAP, 2017)*

Source: Adapted from Abreu (2020); Alves (2020); ECAS (n.d.); Fenatema (2020); RSL (2018); Sergipe (2016); Schons (n.d.).

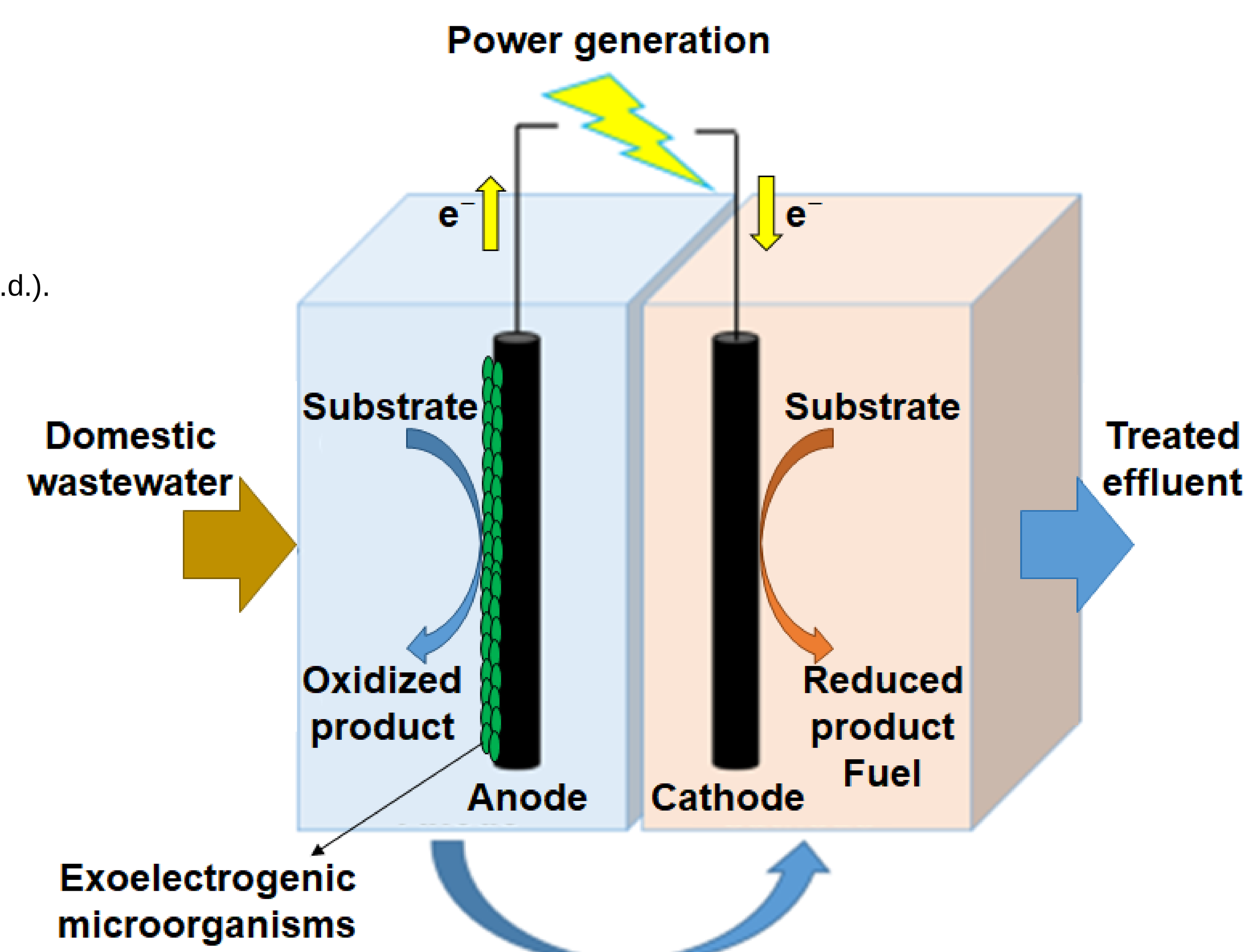
Domestic wastewater treatment for water reuse

Source: UN (n.d.).

BES

- may be a sustainable alternative to treat domestic wastewater
- reducing demand for fossil fuel
- reducing CO2 emission

Bioelectrochemical Systems



Source: Adapted from Jain and He (2018).

Findings

Gajaraj and Hu (2014):
- Integration of a BES into a conventional wastewater treatment
- Reduction of 11% of sludge production

Lu, Abu-Reesh and He (2016):
- Synthetic wastewater treatment by a BES
- Removal of >90% of the organic matter, 75% of ammoniacal nitrogen and 52% of salinity

Chen et al. (2017):
- Domestic wastewater treatment by a BES
- Removal of >95% of organic matter, nitrogen and phosphorous

Liang et al. (2018):
- Domestic wastewater treatment by a pilot scale BES
- Removal rate of 70-90% of organic matter
- Power generation of 0.033 kW/m³

Pérez-Rodríguez et al. (2018):
- Municipal wastewater treatment in a pilot scale BES
- Removal of 92% of organic matter, 96% of helminth eggs and 99% of fecal coliforms

Kumar and Singh (2020):
- Municipal wastewater by a BES integrated with constructed wetland
- Removal of 64-96% of nitrogen, 50-91% of phosphate, 58-88% of sulphate, 73-85% of organic matter
- Power production higher than the consumption in the BES.

Conclusion

The BES are a promising sustainable technology that could be used for domestic wastewater treatment to allow its reuse.

References

Abreu, N. (2020). *Primary settler.* Autossustentável. https://autossustentavel.com/2020/08/como-o-esgoto-e-tratado-conheca-como-funciona-uma-ete.html
Alves, E. (2020). *Lack of tap water*. Edenevaldo Alves. https://www.edenevaldoalves.com.br/petrolina-residencias-estao-ha-mais-de-2-dias-sem-agua-no-bairro-antonio-cassimiro-compesa-responde/
Chen, X., Zhou, H., Zuo, K., Zhou, Y., Wang, Q., Sun, D., Gao, Y., Liang, P., Zhang, X., Ren, Z.J. & Huang, X. (2017). Self-sustaining advanced wastewater purification and simultaneous in situ nutrient recovery in a novel bioelectrochemical system. *Chemical Engineering Journal*, 330, 692-697. doi: 10.1016/j.cej.2017.07.130
ECAS (n.d.). *Treated wastewater outlet*. ECAS. http://ecas.digitalcannes.com/mark-tester/
Fenatema (2020). *Population without sewage collection*. Fenatema. https://www.fenatema.org.br/noticia/falta-de-saneamento-basico-prejudica-o-rendimento-escolar/5623
Gajaraj, S., & Hu, Z. (2014). Integration of microbial fuel cell techniques into activated sludge wastewater treatment processes to improve nitrogen removal and reduce sludge production. Chemosphere, 117, 151-157. doi: 10.1016/j.chemosphere.2014.06.013
Jain, A., & He, Z. (2018). Cathode-enhanced wastewater treatment in bioelectrochemical systems. *Npj Clean Water*, 1(1), 1-5. doi: 10.1038/s41545-018-0022-x
Kumar, M., & Singh, R. (2020). Sewage water treatment with energy recovery using constructed wetlands integrated with a bioelectrochemical system. *Environmental Science: Water Research & Technology*, 6(3), 795-808. doi: 10.1039/C9EW00867E
Liang, P., Duan, R., Jiang, Y., Zhang, X., Qiu, Y., & Huang, X. (2018). One-year operation of 1000-L modularized microbial fuel cell for municipal wastewater treatment. *Water research*, 141, 1-8. doi: 10.1016/j.watres.2018.04.066
Lu, Y., Abu-Reesh, I. M., & He, Z. (2016). Treatment and desalination of domestic wastewater for water reuse in a four-chamber microbial desalination cell. *Environmental Science and Pollution Research*, 23(17), 17236-17245. doi: 10.1007/s11356-016-6910-z
Pérez-Rodríguez, P., Martínez-Amador, S.Y., Valdez-Aguilar, L.A., Benavides-Mendoza, A., Rodríguez-de la Garza, J.A., & Ovando-Medina, V.M. (2018). Diseño y evaluación de un sistema secuencial bioelectroquímicio para el tratamiento de agua residual municipal y generación de voltaje. *Revista Mexicana de Ingeniería Química*, 17(1), 145-154. doi: 10.24275/uam/izt/dcbi/revmexingquim/2018v17n1/Perez
Polistore (n.d.). *Earth*. Polistore. https://www.polispumastore.com.br/mouse-pad-planeta-terra
Redação Síndico Legal (RSL) (2018). *Sewage discharge*. SíndicoLegal.com. https://sindicolegal.com/condominio-localizado-em-mangabeiras-e-autuado-por-lancamento-de-esgoto/
Schons, E. (n.d.). *Eutrophication*. UFG. https://files.cercomp.ufg.br/weby/up/596/o/trat_eflu_3.pdf
Sergipe (2016). *Installation of sewage collection network.* Governo do Estado de Sergipe. https://www.se.gov.br/noticias/Governo/governo-ja-executou-70-do-esgotamento-sanitario-de-nossa-senhora-das-dores
United Nations (UN) (n,d,). Sustainable development goals. United Nations. https://www.un.org/sustainabledevelopment/news/communications-material/
United Nations (UN) (2011). *Resolution adopted by the Human Rights Council 18/1 - The human right to safe drinking water and sanitation*. Geneva: United Nations.
United Nations World Water Assessment Programme (UN-WWAP) (2017). *The United Nations world water development report 2017 - wastewater: the untapped resource*. Paris: UNESCO.
World Health Organization (WHO) (2017). *Progress on sanitation and drinking water: 2017 update and SDG assessment*. Geneva: World Health Organization.