Abstract

[Research Title]

Exhaustive Analysis of Reduction Effect of Environmental Burdens in Collection, Transportation and Treatment of Johkasou Sludge by Using Sludge Thickening Vehicles and Proposal of the Optimal Method for Utilization

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[Abstract]

Due to the centralization and regional expansion of sludge treatment facilities, concerns have been raised about increased costs and energy consumption associated with the collection and transportation of Johkasou sludge. Therefore, further sophistication and efficiency in collection and transportation are required. Sludge thickening vehicles, which concentrate Johkasou sludge at the site of generation, can reduce the volume and amount of sludge handled by one-third to one-quarter, thus contributing to more advanced and efficient collection and transportation. However, the extent to which the introduction of thickening vehicles improves the efficiency of sludge collection and transportation, and how concentrated sludge affects processing and energy recovery at treatment facilities, is not well understood. The objective of this study is to propose optimal utilization methods for sludge thickening vehicles by comprehensively assessing the environmental impact related to the collection, transportation, processing, and resource recovery of Johkasou sludge.

An exhaustive analysis system has been developed that allows for the evaluation of the environmental impacts of the entire process of collection, transportation, processing, and resource recovery using vacuum trucks and sludge thickening vehicles. This was achieved by establishing work unit costs for sludge collection and transportation, knowledge about sludge processing and resource recovery, and route analysis methods.

Based on the exhaustive analysis system, total $CO_2$ emissions were analyzed using a combination of vacuum trucks and sludge thickening vehicles for collection and transportation, and standard denitrification treatment methods, high-load denitrification with membrane separation, and a newly developed combination of anaerobic membrane separation with the Partial Nitritation and Anammox (PNA) process for processing and resource recovery. It was found that combining a sludge thickening vehicle with anaerobic membrane separation and the PNA process could achieve zero total $CO_2$ emissions. This combination has been shown to be the optimal condition for the utilization of sludge thickening vehicles, and it also suggests

that such integration could serve as a measure toward building a low-carbon society, reducing environmental impacts, and establishing a circular and ecological economy.

Qian, Y., Chen, F., Shen, J., Guo, Y., Wang, S., Qiang, H., Qin, Y., Li, Y. Y. (2022). Control Strategy and Performance of Simultaneous Removal of Nitrogen and Organic Matter in Treating Swine Manure Digestate Using One Reactor with Airlift and Micro-granule . Bioresource Technology, 355 , 127199. https://doi.org/10.1016/j.biortech.2022.127199

Guo, G., Li, Y., Zhou, S., Chen, Y., Urasaki, K., Qin, Y., Kubota, K., Li, Y. Y. (2022). Long Term Operation Performance and Membrane Fouling Mechanisms of Anaerobic Membrane Bioreactor Treating Waste Activated Sludge at High Solid Concentration and High Flux. Science of the Total Environment, 846, 157435.
https://doi.org/10.1016/j.scitotenv.2022.157435

Chen, Y., Guo, Y., Feng, G., Urasaki, K., Guo, G., Qin, Y., Kubota, K., Li, Y. Y. (2023). Key Factors for Improvement of Nitrogen Removal in a HAP-enhanced One-stage Partial Nitritation/Anammox Process. Chemical Engineering Journal, 452, 139589.
https://doi.org/10.1016/j.cej.2022.139589

Guo, G., Zhou, S., Chen, Y., Wang, W., Qin, Y., Li, Y. Y. (2023). Evaluation of Bioenergy Production and Material Flow in Treating Japanese Concentrated Johkasou Sludge Using High-solid Anaerobic Membrane Bioreactor Based on One-year Operation. Chemical Engineering Journal, 469, 143918.
https://doi.org/10.1016/j.cej.2023.143918

Chen, Y., Feng, G., Guo, G., Urasaki, K., Kubota, K. Li, Y.Y. (2023). Improved Properties and Enhancement Strategies of Hydroxyapatite-Based Functional Granular Sludge for a High-Rate Partial Nitritation/Anammox System. Environmental science & technology, 57(19), 7624–7633.
https://doi.org/10.1021/acs.est.3c00491

Guo, G., Zhou, S., Chen, Y., Qin, Y., Huang, X. Li, Y.-Y. (2024). Enhanced methanogenic degradation and membrane fouling associated with protein-EPS by extending sludge retention time in a high-solid anaerobic membrane bioreactor treating concentrated organic sludge. Water research, 248, pp.120879–120879. https://doi.org/10.1016/j.watres.2023.120879

Guo, G., Zhou, S., Chen, Y. Li, Y.-Y. (2024). Phosphorus recovery coupling with one-stage partial nitritation/anammox process for the treatment of high-nutrient permeate from anaerobic membrane bioreactor treating concentrated organic sludge. Chemical engineering journal, 484, pp.149474–149474. https://doi.org/10.1016/j.cej.2024.149474

Mishima, I., Yoshikawa, N., Asakawa, S., Noguchi, Y., Amano, K. (2023). Life-cycle Analysis of Environmental Loads from Household Septic Systems in Japan Focusing on Effluent Water Discharge. Science & Technology, 88(11), 2719.
DOI: 10.2166/wst.2023.370

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