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A Bioaugmentation Approach for Efficient Total Nitrogen Reduction in Landfill Leachate

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ABSTRACT

In this study, the focus was on assessing the efficacy of Bioaugmentation in addressing Total Nitrogen (TN) levels in leachate from one of South Korea's largest waste landfills. The utilization of proprietary bioaugmentation technology led to a remarkable 89% reduction in Total Nitrogen levels within a mere three weeks of implementation at the site. The significant outcome of this reduction not only ensured compliance with stringent Total Nitrogen discharge standards but also brought about the added advantage of eliminating the need for certain chemicals in the leachate treatment process. This dual benefit highlights the practical and sustainable nature of Bioaugmentation as a solution for Total Nitrogen reduction in Landfill Leachate. The findings from this study contribute valuable insights into the potential of Bioaugmentation as a cost-effective and efficient strategy. The ability to expedite the reduction of Total Nitrogen levels in landfill leachate not only addresses environmental concerns but also holds promise for streamlining waste management practices on a larger scale. As we move forward, such innovative approaches could play a crucial role in shaping more sustainable and eco-friendly solutions for waste treatment in landfills.

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Introduction

Landfilling is one of the most common disposal methods for solid waste in many countries, involving burying the waste in the land. Excess rainwater percolating through the waste layers in a landfill leads to the generation of leachate. One of the primary environmental concerns associated with landfill leachate is the contamination of groundwater and surface water [1]. The leachate from landfills is a type of wastewater that typically contains high concentrations of Total Nitrogen and other organic pollutants. Discharging this leachate directly into water bodies or leaving it untreated can cause serious environmental pollution [2].Various methods are used to treat leachate, each with different effectiveness levels. The primary ones include biological, chemical, membrane separation, and thermal processes. Physico-chemical methods are often costlier and less effective. Biological processes, like the activated sludge method, have proven effective in removing organic carbon and nutrients from leachate, offering a practical solution for environmental concerns linked to landfill waste [3]. Researchers believe biological treatment technologies are a low-cost, less complex approach for the sustainable treatment of landfill leachate compared to physical and chemical treatment techniques [4].

Biological treatment, a process reliant on the inherent capabilities of microorganisms to degrade organic pollutants in wastewater, encounters challenges when faced with complex compounds that resist efficient biodegradation. The persistence of such pollutants in wastewater poses a significant threat to overall water quality. In response to this issue, bioaugmentation strategies emerge as a promising solution. Bioaugmentation involves introducing specialized microorganisms into the polluted environment, specifically chosen for their ability to biodegrade resilient molecules. This strategic addition not only addresses the limitations of conventional biological treatment but also proves to be a cost-effective and environmentally friendly approach. By enhancing the capacity of microorganisms to break down complex compounds, bioaugmentation plays a crucial role in improving the overall efficiency of wastewater treatment processes and ensuring the sustained quality of water resources. This approach aligns with sustainable practices, contributing to a healthier and more robust aquatic ecosystem [5].

A waste processing company oversees the management of this landfill in South Korea, operating one of the country's most extensive waste disposal facilities. Covering a total area of 600,000 m2, the landfill adheres to best management practices and prioritizes top-tier environmental preservation. Bioaugmentation strategies were employed to test the leachate produced at this landfill site, aiming to reduce Total Nitrogen (TN) levels. The primary goal of this study was to test if the bioaugmentation program can help to reduce TN levels in the biological treatment process, achieve discharge levels below 30 mg/L, and minimize the use of various chemicals employed for TN removal following the biological treatment. The bioaugmentation technology used for this study is a proprietary composite biocatalyst that enhances a broad range of hydrolytic, oxidative, and reductive biochemical reactions. It contains a novel consortium of metabolically

cooperative microorganisms with endogenous and exogenous enzymes, and small molecule co-factors which support both biocatalytic and metabolic activity. They are composed of all-natural materials and non-genetically modified.

Treatment Plant Design

The landfill facility produces around 25m3/day of leachate with elevated Total Nitrogen levels. However, the current treatment process design falls short of meeting the necessary Total Nitrogen discharge standards. The treatment plant comprises several stages, including a Deaeration Tower for chemical treatment, a Total Bioreactor Volume of 1200 m3 for biological treatment, additional chemical treatment to enhance Total Nitrogen removal, and filtration. Despite these stages, the existing system faces challenges in achieving the required standards for Total Nitrogen, encouraging the exploration of alternative strategies such as bioaugmentation to enhance the efficiency of the treatment process.

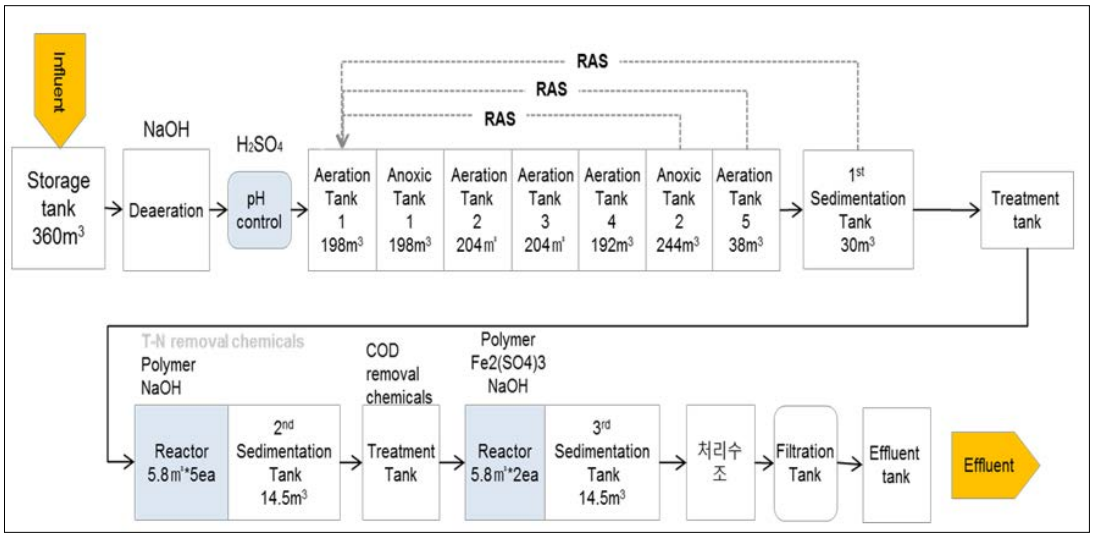

Figure 1: Leachate Treatment Plant PFD

In wastewater, total nitrogen (TN) is mainly expressed through ammonia, nitrite, nitrate, and organically bonded nitrogen [6]. Nitrification-denitrification process is the most common process for nitrogen removal, from wastewaters. Nitrification refers to the biological oxidation of ammonia nitrogen to nitrate, and takes place under oxidative conditions, while denitrification refers to the reduction of nitrate to gaseous nitrogen, under anoxic conditions, in the presence of organic carbon [7]. The biological treatment at this site with hydraulic retention time greater than 30 days showed less than 50% reduction in TN values. This was a clear indication that the biology in the reactors was incapable of achieving effective TN reduction through nitrification/denitrification.

Application Methodology

The bioaugmentation technology used in this study is in powder form and completely soluble in water. A 1000-liter tote was prepared once a week by dissolving the bioaugmentation technology in water. This active solution was continuously dosed into the first aeration basin. Aeration tank 1 was selected as the ideal location for bioaugmentation to maximize the retention time in the biological reactors. The active biology dosed in aeration tank 1 eventually flowed into the next series of biological reactors in the treatment plant, thereby improving the efficiency of all the biological reactors.

Results

The introduction of bioaugmentation successfully reduced TN levels to below 30 mg/L in the first sedimentation tank within three weeks of dosing. From the fourth to the seventh week, the plant management opted to discontinue the use of TN removal chemicals, achieving TN levels consistently below the discharge standards during that period.

Table 1: Results after Bioaugmentation

Date	Total Nitrogen (mg/l)
20-May	215.77
31-May	147.55
8-Jun	29.96
15-Jun	32.33
24-Jun	29.40
29-Jun	22.13

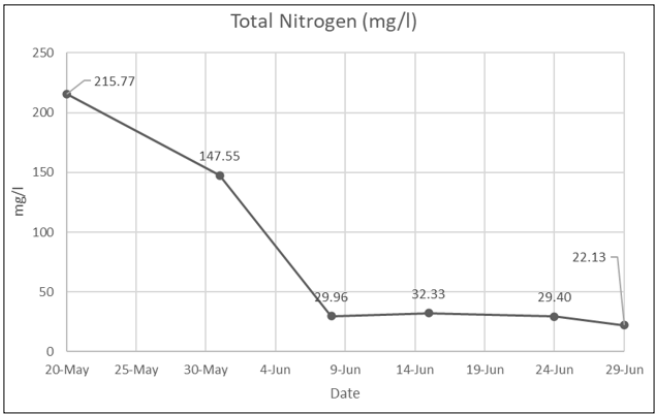

Figure 2: Total Nitrogen Levels after implementing Bioaugmentation Program

Conclusion

Bioaugmentation played a key role in enhancing biological TN removal, successfully achieving Total Nitrogen levels below 30 mg/L. Additionally, it eliminated the necessity of using chemicals to address excess TN after the biological treatment. Within 5 weeks

of implementing the bioaugmentation program at this landfill site for treating the leachate, the site observed 89% reduction in the TN levels. This research highlights the significance of bioaugmentation in mitigating Total Nitrogen (TN) levels within landfill leachate, particularly in situations where the current system falls short of meeting discharge standards. Bioaugmentation emerges as a key player in addressing this challenge, providing a cost-effective solution for landfill operators to enhance the overall efficiency of their treatment plants. By introducing specific microorganisms capable of biodegrading challenging TN components, bioaugmentation acts as a strategic intervention to improve the treatment process and bring TN levels within compliance. This not only contributes to environmental protection by safeguarding water quality but also holds economic benefits for landfill operators, making the adoption of bioaugmentation a practical and sustainable approach in landfill leachate management.

References

1. P Kjeldsen, MA Barlaz, AP Rooker, A Baun, A Ledin, et al. (2002) Present and Long-Term Composition of MSW Landfill Leachate: A Review. Critical Reviews in Environmental Science and Technology 32: 297-336.
2. Zhangbao Wang, Zhensheng Xiong, Liming Yang, Ling Lai, Hongyan Xiao, et al. (2022) Enhancing nitrogen removal in mature landfill leachate by mixed microalgae through elimination of inhibiting factors. Science of The Total Environment 828: 154530.
3. MX Loukidou, AI Zouboulis (2001) Comparison of two biological treatment processes using attached-growth biomass for sanitary landfill leachate treatment. Environmental Pollution 111: 273-281.
4. A Podder, D Reinhart, R Goel (2020) Nitrogen management in landfill leachate using single-stage anammox process-illustrating key nitrogen pathways under an ecogenomics framework. Bioresource Technology 312: 123578.
5. A Nzila, S Razzak, J Zhu (2016) Bioaugmentation: An Emerging Strategy of Industrial Wastewater Treatment for Reuse and Discharge," International Journal of Environmental Research and Public Health 13: 846.
6. F Bagherzadeh, MJ Mehrani, M Basirifard, J Roostaei (2021) Comparative study on total nitrogen prediction in wastewater treatment plant and effect of various feature selection methods on machine learning algorithms performance. Journal of Water Process Engineering 41: 102033.
7. M Farazaki, P Gikas (2019) Nitrification-denitrification of municipal wastewater without recirculation, using encapsulated microorganisms. Journal of Environmental Management 242: 258-265.