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Bioaugmentation in Leachate Treatment: Enhancing Ammonia Nitrogen Elimination in US Landfills

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Abstract

Purpose: This research seeks to assess the quantitative effects of implementing bioaugmentation solutions within existing landfill leachate management systems. The study involves the analysis of different sites to gauge the influence on leachate composition, considering various industry management practices such as lagoons, tanks, sewer discharge, or off-site trucking. The primary objective is to examine changes in microbial communities within the leachate, specifically focusing on their impact on ammonia nitrogen elimination rates. The ultimate goal is to achieve lower levels of ammonia nitrogen before the discharge of leachate to publicly owned treatment works (POTW).

Methodology: The research employs a comprehensive methodology that involves the examination of diverse landfill sites utilizing various industry management practices for leachate treatment. The analysis includes assessing leachate composition and the study evaluates effectiveness of bioaugmentation in enhancing ammonia elimination rates, considering different leachate treatment approaches and operating conditions. This involves a systematic comparison of outcomes across sites and management practices.

Findings: The findings of this study indicate that bioaugmentation is an effective strategy for accelerating ammonia elimination rates in landfill leachate. The analysis reveals notable improvements in microbial communities, leading to reduced levels of ammonia nitrogen in the leachate prior to its discharge to POTW. The study highlights the versatility of bioaugmentation across different industry management practices, showcasing its potential benefits under varying operating conditions and treatment setups.

Unique contributor to theory, policy and practice: Based on the study's outcomes, it is recommended that landfill operators and leachate management practitioners consider implementing bioaugmentation solutions to expedite ammonia elimination rates. The findings suggest that bioaugmentation is a cost-effective and fast-to-deploy solution that requires negligible capital expenditure. This approach has the potential to generate significant savings, especially in the face of a more stringent regulatory environment. The recommendations emphasize the adaptability and efficiency of bioaugmentation across a broad range of operating conditions within existing landfill leachate management infrastructure.

Keywords: *Bioaugmentation, Landfill, Leachate, Ammonia Nitrogen*

I. INTRODUCTION

According to the EPA, the overall waste produced in 2018 amounted to 292.4 million tons, with an average daily waste generation of 4.9 pounds per person.[1]Approximately 140 million tons of this waste find their way to landfills.[2] Landfill leachate is a complex blend formed by the infiltration of rainwater through waste, the water produced during waste biodegradation, and the inherent moisture within the waste mass. Within this blend, significant amounts of dissolved organic matter, salts, heavy metal ions, and diverse organic compounds are present. Recognized as a hazardous substance, landfill leachate poses potential threats to the surrounding environment and ecosystems. The diverse composition of leachate highlights the need for careful management and treatment to mitigate the environmental risks associated with its release into surrounding areas.[3]

Due to tightening environmental regulations for landfill leachate across all 50 states in the US, the solid waste industry is facing increasing pressure to find complimentary technologies to treat leachate wastewater. Landfill operators are mandated by the Resource Conservation and Recovery Act (RCRA) regulations to collect and manage the leachate generated within the landfill. USA landfills typically either release their leachate to a nearby publicly owned treatment works (POTW) or discharge it into surface water, as per common disposal practices.[4]

Leachate from US landfills is typically treated offsite at wastewater facilities. However, there's a growing issue as some operators are hesitant due to higher chemical concentrations. This has led landfill owners to consider onsite treatment options.[5] High levels of ammonia nitrogen are a major concern for many landfill operators in the USA. Compliance with discharge permits often requires lowering ammonia nitrogen levels in landfill leachate.[6]

Several technologies have been devised for the treatment of landfill leachate, encompassing diverse approaches such as biological treatments (e.g., activated sludge), chemical treatments (e.g., chemical precipitation), and physical-chemical treatments (e.g., adsorption and membrane processes).[3] Biological treatment relies on the natural biodegradation of organic pollutants by microorganisms within wastewater. However, the effectiveness of microorganisms in breaking down highly complex compounds is often limited. In response to this challenge, bioaugmentation strategies can be employed as a solution. Bioaugmentation involves introducing specific microorganisms with the capability to efficiently biodegrade these complex compounds, thereby enhancing the overall treatment process. This method is not only more cost-effective but also environmentally sustainable when compared to conventional physio-chemical approaches. By leveraging the inherent abilities of specialized microorganisms, bioaugmentation emerges as a promising and eco-friendly alternative for addressing the challenges posed by the inefficient biodegradation of complex organic pollutants like ammonia nitrogen in wastewater.[7]

This study focuses on demonstrating the viability of implementing a bioaugmentation strategy to help maintain low and stable ammonia nitrogen concentrations in leachate wastewater.

II. METHODOLOGY

The application of bioaugmentation technology was tailored to site requirements. In U.S. waste landfills, leachate is typically treated in either leachate tanks or lagoons. For this study, we specifically examined two landfill sites employing leachate tanks for treatment. The methodology involved continuous direct dosing into these tanks using a transfer pump and hose setup. Bioaugmentation technology was applied on a weekly basis at both treatment sites.

Treatment Site 1: The site generates approximately 15,000 - 20,000 gallons per day of leachate, which is collected and pumped into two 134,000-gallon tanks. Maintained at a 50% full mark, the operational volume of each tank is 68,000 gallons, resulting in a calculated retention time of 3.5 to 4.5 days. Tank 1, equipped with active aeration and an overflow into Tank 2, primarily handles leachate. Hanna HI 98194 Multiparameter was used to take pH, Temperature and Dissolved Oxygen (DO) readings on site for samples from top and bottom of the leachate tank 1. Tank 2 serves as an "overflow storage tank," and most leachate is pumped offsite from Tank 1. Each tank has a retention time of approximately 7 to 9 days. Treated leachate from these tanks is transported to a local publicly owned treatment works (POTW) for further treatment. The objective was to showcase the feasibility of implementing a bioaugmentation strategy using bioaugmentation technology to help maintain consistently low ammonia nitrogen concentrations at the discharge point of leachate Tank 1.

Table 1

Hanna HI 98195 Multiparameter Readings – Treatment Site 1

Sample Description	**Date**	**Time**	**Blower**	**pH**	**Temp (˚C)**	**DO (ppm)**
Well Water (Control)	29-Jul	8:45 AM	NA	8.67	28.29	5.77
Leachate tank 1 (Top)	29-Jul	8:45 AM	Active	8.73	33.18	3.51
Leachate tank 1 (Bottom)	29-Jul	9:00 AM	Active	8.72	33.81	3.8
Drinking Water (Control)	29-Jul	11:22 AM	NA	5.63	30.32	5.48
Leachate tank 1 (Top)	29-Jul	11:25 AM	Active	8.77	34.72	2.54
Leachate tank 1 (Bottom)	29-Jul	11:35 AM	Active	8.77	34.67	2.57
Well Water (Control)	30-Jul	8:47 AM	NA	8.69	32.02	5.42
Leachate tank 1 (Bottom T-0)	30-Jul	8:50 AM	OFF (T=0)	8.60	34.43	0.03
Leachate tank 1 (Bottom T-20)	30-Jul	9:10 AM	OFF (T=20)	8.61	34.15	0.46

Treatment Site 2: This landfill receives an average of 1600 tons per day of municipal solid waste (MSW) and operates two cells, generating 26,000 gallons of leachate daily. The leachate is managed using two 260,000-gallon aerated mixed tanks, which discharge directly into a sewer line connected to the city wastewater treatment plant (WWTP). The objective at this treatment site was to exhibit the viability of employing a bioaugmentation approach with Bioaugmentation Technology, ensuring a consistent and stable reduction in ammonia nitrogen concentrations at the discharge point of leachate Tank 2.

Table 2

Hanna HI 98195 Multiparameter Readings – Treatment Site 2

Sample Description	Date	Dissolved Oxygen (mg/l)	pH	Temperature (˚C)	TDS (ppm)
Tank 1 Inlet	19-Mar	ND	7.88	25.34	8793
Tank 2 Discharge	19-Mar	1.08	7.84	25.96	4964

For both identified treatment sites, a $1m^3$ tote was arranged with a pump and hose for convenient dosing of the bioaugmentation product into leachate tank 1. Weekly, the tote was filled with water, and the recommended dose of bioaugmentation technology was dissolved into it. The resulting active biological solution was then directly administered into leachate tank 1, with the pump requiring approximately 15-20 minutes to empty 275 gallons of the active biological solution.

Sampling: At Treatment Site 1, samples were collected from the bottom of Tank 1 at different time intervals: immediately after turning off the blower (T-0) and 20 minutes (T-20). The purpose of this time offset was to assess the impact of aeration and mixing on Ammonia Nitrogen and Total Suspended Solids (TSS) in the samples. The time intervals showed minimal effect on Ammonia Nitrogen values, with a 1% change for bottom samples at T-0 and T-20. At Treatment Site 2, leachate samples from Tank 2 discharge were collected twice a week. All samples from both treatment sites were analyzed at Midwest Laboratories in Omaha, NE.

III. FINDINGS

Bioaugmentation at both treatment sites demonstrated a significant reduction in Ammonia Nitrogen levels. For Treatment Site 1, the effluent ammonia nitrogen from week 0 to 2 did not exhibit considerable improvement. However, instances occurred when the Ammonia Nitrogen levels were in the range of 650-680 mg/l, indicating a 32% reduction from week 0. Starting from week 2, Nitrate+Nitrite N levels increased, signifying improved nitrification activity[8] in the leachate tank, and subsequently, lower Ammonia Nitrogen levels followed. Data validated by third-party labs (Midwest Laboratories) revealed that the bioaugmentation technology contributed to a remarkable 94% reduction in Ammonia Nitrogen levels within 22 days. Ammonia nitrogen readings for Week 3 represent the lowest values in effluent Ammonia Nitrogen observed in the last 3 years during the study period, as verified by reviewing the site's historical data.

Table 3

Reduction in Ammonia Nitrogen Levels (mg/l) before and after Bioaugmentation at both the treatment sites

Treatment Site	**Ammonia N levels before bioaugmentation**	**Ammonia N levels after bioaugmentation**	**% reduction in Ammonia N levels**
Treatment Site 1	723.0 mg/l	348.0 mg/l	52%
Treatment site 2	981.5 mg/l	61.0 mg/l	94%

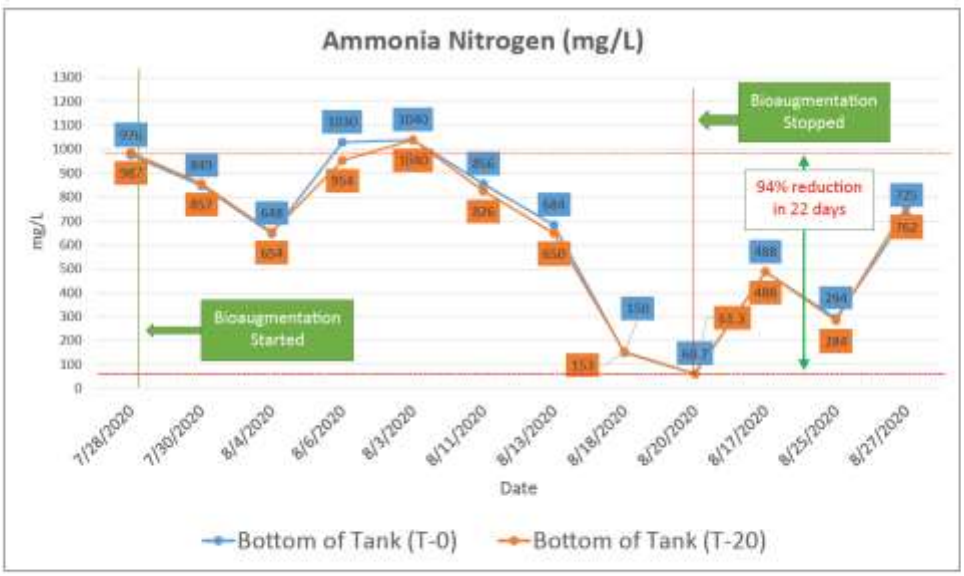

Figure 1: Graph showing reduction in Ammonia Nitrogen levels (mg/l) during the study at Treatment Site 1

In the case of Treatment Site 2, the blower in Tank 2 unexpectedly went offline just as we anticipated seeing steady results, resulting in new instabilities for the tank system. Ammonia levels were monitored twice a week by on-site personnel, and weekly samples were shipped to Midwest Labs by the landfill operator. From both sources, i.e., the on-site lab and Midwest Laboratories, ammonia levels exhibited similar trends throughout the trial period. Effluent ammonia concentrations from week 1 to week 7 did not show significant improvement. During this phase, the blowers for Leachate Tank 2 were not in operation, leading to anoxic conditions in Tank 2. Starting in week 8, the blower for Leachate Tank 2 resumed operation, and as the system went back online, Ammonia Nitrogen levels began to decrease within two weeks.

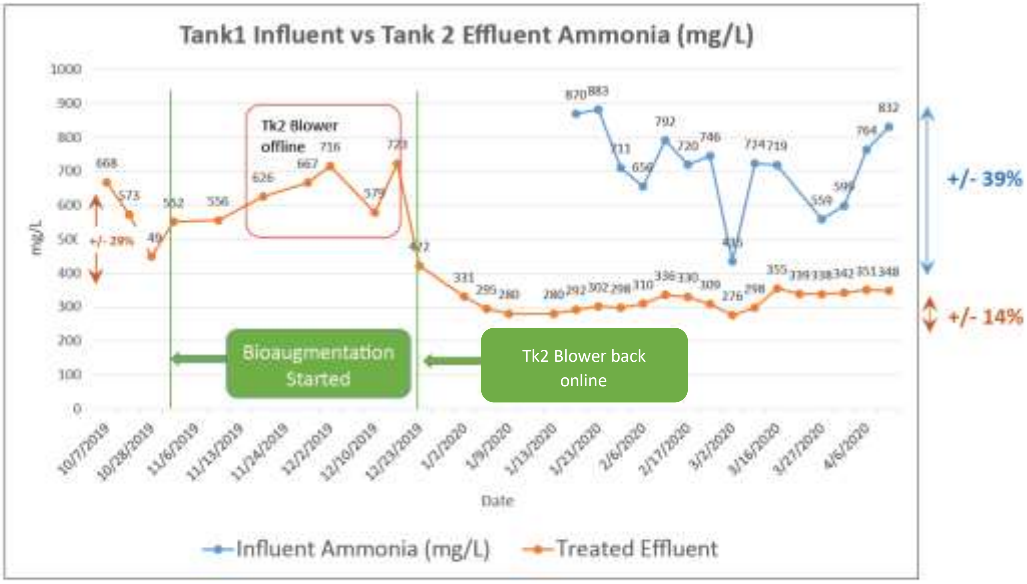

Figure 2: Graph showing reduction in Ammonia Nitrogen levels (mg/l) during the study at Treatment Site 2

IV. CONCLUSION

The Bioaugmentation technology utilized in this study, acting as a robust biological catalyst to enhance the natural capacity of microbial active systems, has demonstrated significant effectiveness in accelerating the biological removal of nutrients from wastewater under diverse operating conditions. The study conducted at both the treatment sites indicates that Bioaugmentation can play a critical role in achieving effluent stability, particularly for landfill leachate. In situations where landfill operators encounter challenges in meeting discharge standards, especially for Ammonia Nitrogen, the study highlights Bioaugmentation as a compelling solution. This technology proves to be cost-effective, free from chemical inputs, and easily implementable.

V. RECOMMENDATIONS

Landfill management operators are advised to incorporate Bioaugmentation into their leachate management strategies. This proactive approach not only enhances efficiency but also proves instrumental in overcoming regulatory compliance challenges. By introducing Bioaugmentation, operators can optimize their leachate management practices, ensuring that they not only meet but exceed regulatory standards. This strategic integration provides an innovative approach, aligning with environmental regulations and contributing to the sustainable and responsible management of landfill facilities.

REFERENCES

[1] United States Environmental Protection Agency, "National Overview: Facts and Figures on Materials, Wastes and Recycling | US EPA," US EPA, Dec. 03, 2022. https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials

[2] J. McDonald, "Think Twice Before You Throw Out Your Plastic Water Bottle," dumpsters.com, 2017. https://www.dumpsters.com/blog/us-trash-production

[3] C. Teng, K. Zhou, C. Peng, and W. Chen, "Characterization and treatment of landfill leachate: A review," Water Research, vol. 203, p. 117525, Sep. 2021, doi: https://doi.org/10.1016/j.watres.2021.117525.

[4] "Landfills Effluent Guidelines | US EPA," US EPA, Nov. 06, 2015. https://www.epa.gov/eg/landfills-effluent-guidelines

[5] O. of R. & Development, "State of the Practice of Onsite Leachate Treatment at Municipal Solid Waste Landfills," cfpub.epa.gov. https://cfpub.epa.gov/si/si_public_record_Report.cfm?dirEntryId=358950&Lab=CESER (accessed Dec. 26, 2023).

[6] Wastetodaymagazine.com, 2023. https://www.wastetodaymagazine.com/article/treating-ammonia-in-landfill-leachate/ (accessed Dec. 26, 2023).

[7] A. Nzila, S. Razzak, and J. Zhu, "Bioaugmentation: An Emerging Strategy of Industrial Wastewater Treatment for Reuse and Discharge," International Journal of Environmental Research and Public Health, vol. 13, no. 9, p. 846, Aug. 2016, doi: https://doi.org/10.3390/ijerph13090846.

[8] S. Hossain, C. W. K. Chow, D. Cook, E. Sawade, and G. A. Hewa, "Review of Nitrification Monitoring and Control Strategies in Drinking Water System," International Journal of Environmental Research and Public Health, vol. 19, no. 7, p. 4003, Jan. 2022, doi: https://doi.org/10.3390/ijerph19074003.