Anammochar Process for One-Step Ammonia Removal from Wastewater

Villanova University Investigators

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Background and Unmet Need

The US Congressional Water Authority reports that nitrogen is the main pollutant in rivers and streams, posing a significant threat to aquatic ecosystems and water quality nationwide.[1] Although federal law currently does not limit nitrogen discharge from wastewater, 24 states have proactively implemented regulations to control nutrient levels and to safeguard sensitive water bodies. As awareness of environmental impacts grows, there is mounting pressure on municipalities to adopt effective nitrogen removal strategies and comply with evolving regulatory standards.

Anammox (anaerobic ammonium oxidation) is an advanced bacterial process used to remove nitrogen from wastewater by oxidizing ammonium using nitrite under anaerobic conditions. This environmentally friendly approach reduces the need for traditional energy-intensive methods, yet it requires precise control of both ammonium and nitrite levels to operate efficiently. Existing anammox systems are typically dependent on prior nitrification steps, which not only elevate operational costs but also limit the applicability of the process to side stream treatment scenarios, preventing its wider adoption in mainstream wastewater treatment.

Dr. Duran and his colleagues have pioneered research into a next generation anammox technology that eliminates dependency on nitrification and functions effectively with minimal ammonium requirements. This innovative solution is designed to be scalable and adaptable, unlocking the potential for mainstream nitrogen removal and expanding the reach of the anammox process well beyond traditional side stream treatment. By overcoming previous technical barriers, this new approach promises to make advanced nitrogen removal accessible to a broader range of municipal wastewater treatment facilities.

Opportunity

The Duran lab has invented a novel Anammochar technology that combines a specially engineered biochar with a unique anammox culture grown using proprietary cultivation techniques. These bacteria are specifically tailored to function efficiently in low ammonium environments, overcoming a major limitation of traditional anammox systems. The hybrid bioreactor leverages both the redox-active and adsorptive properties of biochar and the biological capabilities of the anammox bacteria, enabling direct conversion of ammonium to nitrogen gas in a single step, without the requirement for additional nitrite supplementation through nitrification. This innovative approach not only simplifies the treatment process but also makes it feasible to deploy anammox-based nitrogen removal in mainstream wastewater treatment streams, where ammonium concentrations are typically lower than in side streams. By enabling efficient nitrogen removal at lower substrate concentrations, this technology opens the door to scalable, cost-effective, and widely applicable solutions for municipal and industrial wastewater facilities.

[1] US Environmental Protection Agency. (2025). National Rivers and Streams Assessment 2018–2019: Key Findings.

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By eliminating the need for traditional nitrification steps, the Duran invention offers substantial operational advantages. It can achieve up to an estimated 75% reduction in energy consumption compared to conventional nitrogen removal methods, translating to significant cost savings for treatment facilities. Furthermore, by streamlining the conversion process and minimizing intermediate steps, the system dramatically reduces emissions of nitrous oxide—a potent greenhouse gas, by as much as 90%.

These improvements not only enhance the environmental sustainability of wastewater treatment but also position Anammochar as a transformative solution capable of meeting the increasing regulatory and market demand for greener, more scalable mainstream nitrogen removal technologies.

Applications

This innovative technology offers a more efficient and cost-effective solution for modern wastewater management. The technology leverages a unique Anammox bacteria strain, supported by a proprietary biochar, capable of operating at low ammonia concentrations, making it exceptionally scalable for diverse wastewater treatment applications. By integrating a hybrid biochar anammox system, it eliminates the need for ammonia oxidation to nitrite, streamlining treatment processes with promising operational cost saving benefits.

Unique Attributes

- Anammox Bacteria Strain: Operates efficiently at low ammonia concentrations, allowing for highly scalable deployment in wastewater treatment facilities.
- Hybrid Biochar / anammox bacteria functionality eliminates the necessity to oxidize ammonia to nitrite, resulting in substantial cost savings and supporting the scalability of technology use in mainstream wastewater treatment processes.

Stage of Development

Technology Readiness Level 3: Proof of concept demonstrated in the laboratory.

Intellectual Property

Provisional Patent application filed February 2026,

Licensing and Collaboration Opportunity

Villanova is seeking a licensee or collaborators to support further technology development and / or to commercialize the invention.

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