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Popular Article

Application of Micro and Nano Aeration in Aquaculture

Ravindra Sontakke[1*], Harsha Haridas[2], Sunil Kumar Nayak[2], Dhalongsaih Reang[2], Somu Sunder Lingam[3]

[1] Assistant Professor (C), College of Fishery Science, Muthukuru, Nellore District, Andhra Pradesh

[2] Scientist, Powerkheda Centre, ICAR-CIFE, Madhya Pradesh

[3] Assistant Professor, Tamil Nadu Dr. Jayalalithaa Fisheries University, Nagapttinam, Tamil Nadu

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Abstract

Aquaculture, the culture of aquatic plants and organisms, has become increasingly vital in meeting global demands for fish. However, the industry faces challenges related to water quality management, particularly dissolved oxygen levels crucial for aquatic life and waste water treatment. Micro-nano aeration represents a cutting-edge approach to oxygenation in aquatic environments, combining the advantages of micro and nano-scale aeration technologies. This innovative method utilizes both microscale and nanoscale bubbles to enhance dissolved oxygen levels and improve water quality in a variety of applications, including aquaculture, water treatment, and environmental remediation.

Introduction:

Micro and nano aeration technology focuses on generating and dispersing microscale bubbles (ranging from 10 to 1000 micrometers in diameter) and nanoscale bubbles (typically less than 100 nanometers in diameter) into water bodies. Unlike conventional aeration systems, micro and nanobubbles offer several distinct advantages due to their small size, high surface area-to-volume ratio, and exceptional stability. These nanobubbles, being significantly smaller, possess a much larger interfacial area relative to their volume. As a result, they exhibit enhanced gas solubility and retention, allowing for more efficient oxygen transfer to water and improved oxygenation of aquatic ecosystems.

The generation of nanobubbles can be achieved through various methods, including ultrasonic cavitation, hydrodynamic cavitation, electrolysis, and membrane-based techniques. These methods produce nanobubbles with high purity and stability, ensuring their effectiveness in oxygen delivery and water treatment applications.

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Applications of Micro-Nanoaeration: There are diverse applications of nanoaeration across different sectors, including:

1. **Water Treatment:** Nanoaeration technology by increasing dissolved oxygen concentrations, facilitates the degradation of organic pollutants, suppresses anaerobic conditions, and reduces the formation of harmful algal blooms. This makes nanoaeration an attractive option for improving the ecological balance and resilience of aquatic ecosystems.

2. **Wastewater Treatment:** In wastewater treatment plants, nanoaeration can augment biological processes by providing a sustained oxygen supply to microbial consortia. Nanobubbles enhance the activity of aerobic microorganisms, accelerating the degradation of organic matter, nutrients, and contaminants in wastewater streams. This leads to improved treatment efficiency, reduced energy requirements, and enhanced effluent quality.

3. **Environmental Remediation:** Nanoaeration has potential applications in environmental remediation efforts, particularly in the restoration of polluted water bodies and ecosystems. By promoting oxygenation and microbial activity, nanobubbles facilitate the natural degradation of pollutants, such as petroleum hydrocarbons, heavy metals, and persistent organic compounds. This contributes to the remediation of contaminated sites and the rehabilitation of impacted environments.

4. **Aquaculture:** In aquaculture operations, maintaining adequate dissolved oxygen levels is critical for supporting fish health, growth, and overall productivity. Nanoaeration systems provide an effective solution for oxygen supplementation in aquaculture ponds, tanks, and raceways. By delivering nanobubbles directly to aquatic organisms, nanoaeration promotes optimal oxygenation while minimizing energy consumption and operational costs.

Application of Micro-nano aeration in aquaculture

Aquaculture has emerged as a significant contributor to global food security, providing a diverse range of aquatic products. Nevertheless, the industry faces many environmental and economic hurdles, especially in maintaining optimal water conditions for aquatic organisms and effluent treatment and disposal. Dissolved oxygen (DO) is paramount for aquatic life, and inadequate levels can impair growth, reproduction, and overall health. Traditional aeration techniques, such as diffused aeration and paddlewheel aerators, have been the mainstay in oxygenation systems. However, they have limitations in efficiency, energy consumption, and

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operational costs. In response, researchers are exploring innovative approaches, including nanotechnology and micro aeration, to enhance oxygen transfer and optimize aquaculture operations.

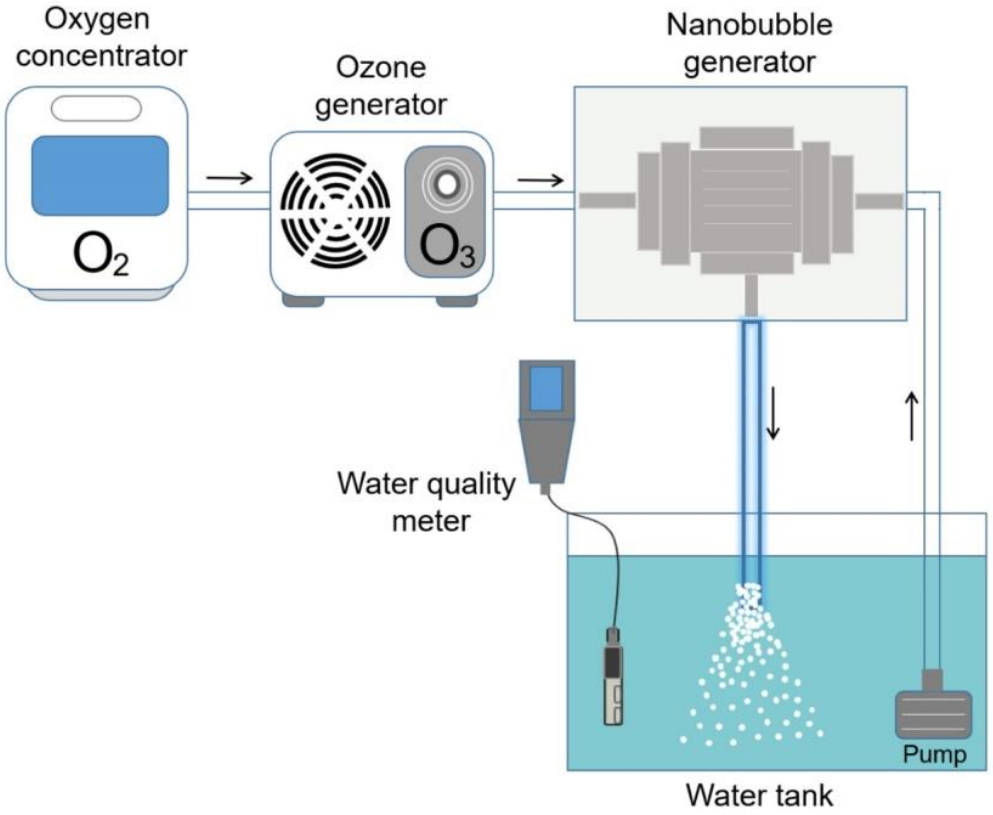

Fig. Laboratory set up of ozone nanobubbles production system

Source- Jhunkeaw et al., 2021

Micro and nano aeration systems can be implemented in various aquaculture settings, including recirculating aquaculture systems (RAS), ponds, and raceways. By delivering oxygen directly to the water column at a microscale, these systems can enhance oxygen solubility and distribution while minimizing energy consumption and operational costs. Additionally, microbubbles have been shown to improve water mixing and circulation, aiding in the dispersion of oxygen and nutrients throughout the aquaculture environment.

Research has demonstrated the efficacy of nanobubble technology in enhancing DO levels and promoting fish health and growth. Studies have shown that nanobubbles remain suspended in water for extended periods, providing a sustained oxygen supply to fish and other aquatic organisms. Furthermore, nanobubbles can penetrate biofilms and improve oxygenation in densely stocked aquaculture systems, mitigating the risk of hypoxia and improving water quality. Similarly, research reports that injection of ozone nanobubbles into water reduces bacterial load and bacteriophages. However, the impact of nano bubble on fish is another concern while adopting this new technology. The study conducted on Nile tilapia with short term and long-term exposure showed no harmful effect such as gas bubble disease or any similar

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effect. The commercial adoption of nanobubble technology in aquaculture is still in its infancy, ongoing research and development efforts hold promise for its widespread application in the future.

Effluent treatment in aquaculture is crucial for maintaining water quality and mitigating environmental impacts. Micro and nano aeration technology can play a significant role in enhancing effluent treatment processes by improving dissolved oxygen levels, promoting aerobic microbial activity, and facilitating the degradation of organic matter and contaminants. The presence of micro and nanobubbles enhances the efficiency of biological degradation processes, leading to accelerated breakdown of organic matter, such as uneaten feed, feces, and metabolic waste, present in the aquaculture effluent. This helps reduce organic load and improve water quality.

Challenges and Considerations

While nanotechnology and micro aeration hold promise for revolutionizing aquaculture, several challenges and considerations must be addressed to ensure their successful implementation. The scalability and cost-effectiveness of nanobubble technology are major areas of concern. Commercial-scale production of nanobubble generators and the associated costs of nanomaterials may pose barriers to widespread adoption in the aquaculture industry. Similarly, the deployment of micro aeration systems necessitates careful design and optimization to achieve maximum efficiency and efficacy. Factors such as bubble size distribution, aeration rate, and system configuration must be tailored to specific aquaculture settings and species requirements. Furthermore, operational challenges, such as maintenance and cleaning of micro aeration equipment, may arise and require specialized expertise and resources.

Conclusion

The application of nanotechnology and micro aeration holds significant promise for advancing the sustainability and productivity of aquaculture systems. These innovative approaches offer novel solutions to address challenges related to oxygenation, water quality management, and resource efficiency in aquaculture operations. While further research and development are needed to overcome technical and regulatory hurdles, the potential benefits of nanobubble technology and micro aeration systems are substantial. By harnessing the power of nanoscience and microengineering, the aquaculture industry can enhance its resilience, reduce environmental impacts, and meet the growing demand for high-quality seafood in a sustainable manner.

References

Jhunkeaw, C., Khongcharoen, N., Rungrueng, N., Sangpo, P., Panphut, W., Thapinta, A.,

Senapin, S., St-Hilaire, S. and Dong, H.T., 2021. Ozone nanobubble treatment in freshwater effectively reduced pathogenic fish bacteria and is safe for Nile tilapia (Oreochromis niloticus). *Aquaculture*, *534*, p.736286.

Linh, N.V., Khongcharoen, N., Nguyen, D.H., Rungrueng, N., Jhunkeaw, C., Sangpo, P., Senapin, S., Uttarotai, T., Panphut, W., St-Hilaire, S. and Van Doan, H., 2023. Effects of hyperoxia during oxygen nanobubble treatment on innate immunity, growth performance, gill histology, and gut microbiome in Nile tilapia, Oreochromis niloticus. *Fish & Shellfish Immunology*, *143*, p.109191.

Linh, N.V., Mai, T.T., Senapin, S., St-Hilaire, S., Rodkhum, C. and Dong, H.T., 2022. Impacts of oxygen and ozone nanobubbles on bacteriophage in aquaculture system. *Aquaculture*, *551*, p.737894.

Sakr, M., Mohamed, M.M., Maraqa, M.A., Hamouda, M.A., Hassan, A.A., Ali, J. and Jung, J., 2022. A critical review of the recent developments in micro–nano bubbles applications for domestic and industrial wastewater treatment. *Alexandria Engineering Journal*, *61*(8), pp.6591-6612.

Xu, Y., Li, L., Lou, S., Tian, J., Sun, S., Li, X. and Li, Y., 2022. Effects of nano-aerators on microbial communities and functions in the water, sediment, and shrimp intestine in Litopenaeus vannamei aquaculture ponds. *Microorganisms*, *10*(7), p.1302.

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