

Nanobubble Technology in wastewater treatment

Enhancing Efficiency Across the Wastewater Treatment Process.

This document outlines nanobubble technology and its application in wastewater treatment. It explains how nanobubbles alter water's **physicochemical properties**, particularly gas-liquid interactions, to improve process efficiency and stability. Nanobubbles are positioned as a process-intensification tool that enhances existing treatment systems without replacing them.

- ✓ Efficient Process Operation
- ✓ Enhanced Process Stability
- ✓ Improved Gas Transfer Efficiency
- ✓ Consistent Performance

Challenges in Conventional Wastewater Treatment

Wastewater treatment processes rely heavily on gas-liquid interactions, particularly for aeration, flotation, and biological treatment. Conventional systems often face limitations such as:

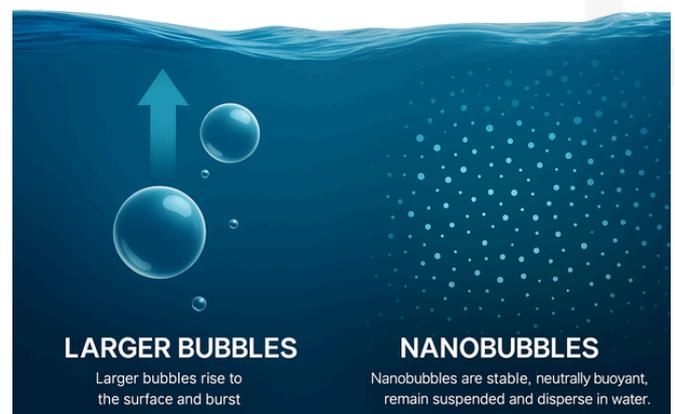
1. Inefficient gas dissolution and rapid bubble escape
2. Non-uniform dissolved oxygen distribution
3. High energy demand for aeration and mixing
4. Formation of anaerobic microzones and process instability

These challenges arise largely from the physical behavior of conventional macro- and microbubbles, which have high buoyancy, short residence times, and limited interaction with the bulk water phase.

Solution: Nanobubble Pretreatment

Nanobubbles are ultra-fine gas bubbles, typically below one micrometer in diameter, that remain stably suspended in water for extended periods. Due to their nanoscale size, they exhibit negligible buoyancy and move through the liquid via Brownian motion.

Nanobubbles possess distinct physicochemical characteristics, including high surface area, surface charge, and long residence time, which differentiate them from conventional bubbles and influence how gases behave in water.

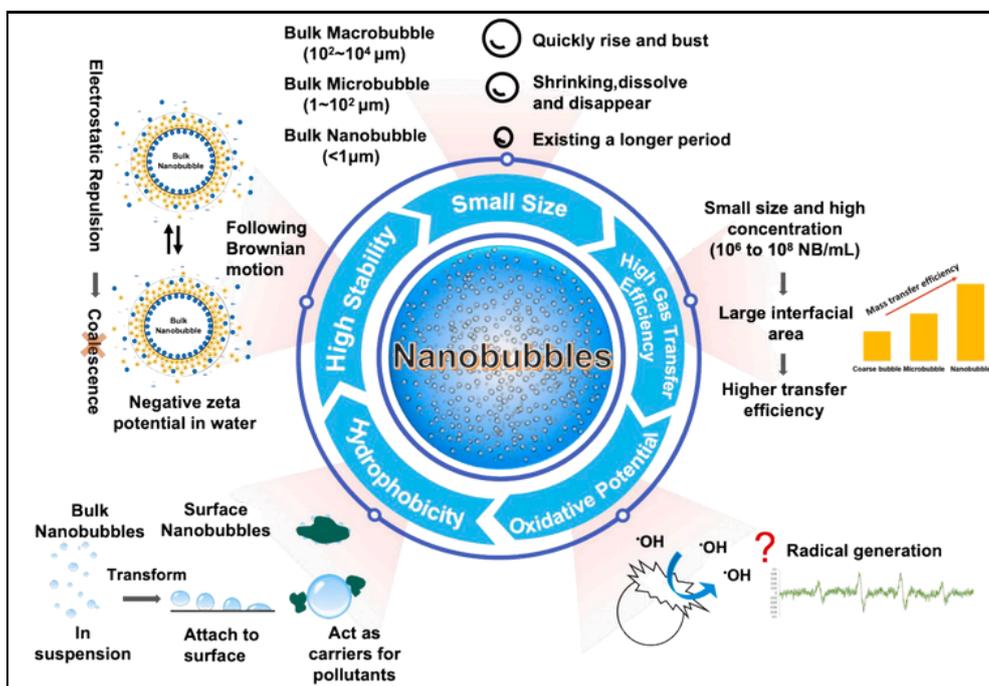


Why Nanobubbles Are Relevant

Nanobubbles influence wastewater treatment not by direct treatment action, but by modifying the physicochemical environment of water. By changing gas solubility, distribution, and interfacial behavior, nanobubbles create conditions that allow existing treatment processes to operate more efficiently and uniformly.

Physicochemical Effects of Nanobubbles in Water

Nanobubbles alter water behavior at a fundamental level, leading to process-wide benefits:



Reference

Enhanced Gas Retention

Due to their low buoyancy and long stability, nanobubbles remain suspended in water for extended durations. This increases the effective residence time of gases such as oxygen, improving gas availability throughout the treatment volume.

Increased Gas-Liquid Interfacial Area

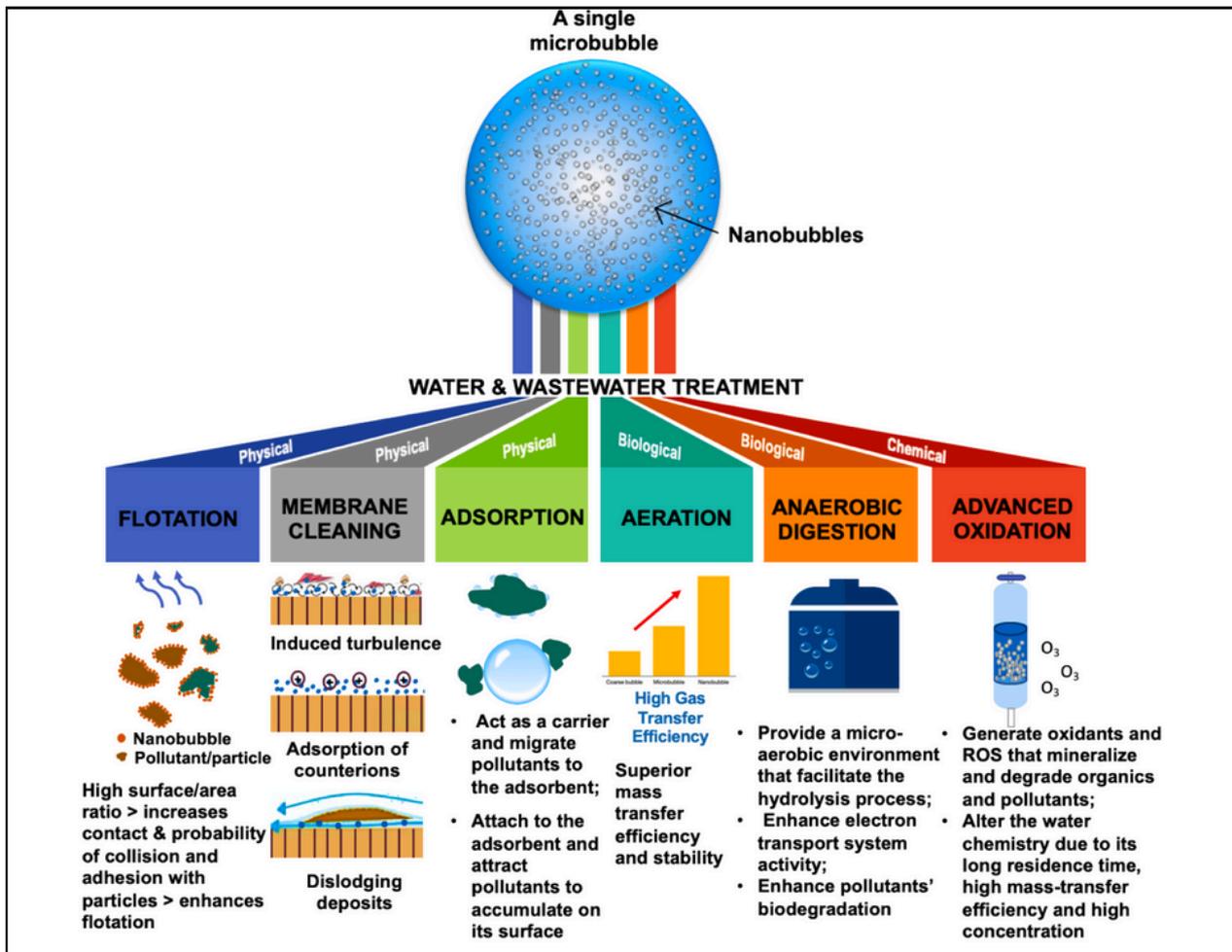
The extremely small size of nanobubbles results in a very large cumulative gas-liquid surface area. This enhances mass transfer interactions between gas and water without increasing airflow or energy input.

Surface Charge and Electrochemical Effects

Nanobubbles typically carry a surface charge, which affects ion distribution and interfacial interactions in water. This surface activity influences how gases, dissolved compounds, and suspended particles interact within the treatment system.

Uniform Gas Distribution

Nanobubbles disperse evenly through the water column via Brownian motion, reducing gradients in dissolved gas concentration and supporting more uniform process conditions.



Reference

Role of Nanobubbles in Improving Process Efficiency

By modifying the physicochemical properties of water, nanobubbles support process efficiency across wastewater treatment systems:

- ▶ *Improved utilization of supplied gases*
- ▶ *More stable dissolved oxygen profiles*
- ▶ *Reduced dependence on excessive aeration or mechanical mixing*
- ▶ *Improved consistency of biological and physicochemical processes*

These effects occur at a system level rather than at a single treatment unit, enabling incremental improvements across the treatment train.

Integration into Wastewater Treatment Systems

Nanobubble systems can be integrated at multiple points within wastewater treatment infrastructure, including:

- ▶ *Equalization and balancing tanks*
- ▶ *Aeration basins and biological reactors*
- ▶ *Flotation and clarification units*
- ▶ *Tertiary polishing and advanced treatment stages*

How Nanobubbles Are Installed

Nanokriti Nanobubble generators are typically installed in inline or sidestream configurations. They can operate alongside existing blowers, diffusers, and pumps without requiring major civil modifications. Strategic placement allows nanobubble-conditioned water to influence downstream processes.

Process-Level Perspective

Nanobubble technology should be viewed as a process intensification tool. By altering how water holds and interacts with gases, nanobubbles improve the operating environment of wastewater treatment systems, enabling conventional processes to operate more efficiently under the same hydraulic and loading conditions.

Rather than focusing on isolated performance metrics, the value of nanobubbles lies in their ability to enhance process stability, efficiency, and robustness by modifying water's physicochemical properties.

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