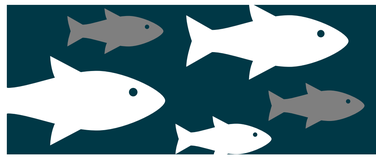
# Cost-Efficient and Sustainable
# Nitrogen Remediation for Aquaculture Production Facilities



Recirculating Aquaculture Systems (RAS) apply a technology-based approach to raise antibiotic- and hormone-free fish on land, a "best choice" by the Monterey Bay Aquarium. The growing demand for sustainable aquaculture has led to increased RAS application but also necessitates new and affordable solutions for RAS wastewater treatment.

## RAS TECHNOLOGY IS VALUED FOR ITS EXCEPTIONAL WATER RECYCLING ABILITIES

Through recirculation, up to 99% of RAS water is reused as biofilters convert harmful ammonia ($NH_3$) into nitrate ($NO_3$), over time accumulating >60 mg $NO_3$-N/L in culture systems.

High $NO_3$ concentrations are relatively benign to adult fish, but detrimental to drinking water supplies and the environment if left untreated before discharge.

Periodic flushing during system maintenance and solid waste removal creates nitrate-laden wastewater; as RAS demand expands nitrogen (N) remediation will need to be addressed.

## NITROGEN MITIGATION CAN BE ACCOMPLISHED THROUGH BIOLOGICAL DENITRIFICATION

Biologically driven denitrification is a simple solution that is both highly effective and cost-efficient for $NO_3$ removal.

Under anoxic (i.e., low oxygen) conditions, naturally occurring bacteria known as denitrifiers can switch from oxygen to nitrate utilization in their respiration process, converting the nitrate into di-nitrogen ($N_2$) gas:

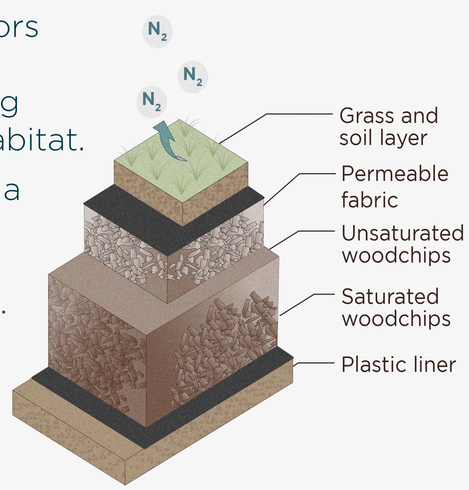
$$5C + 4NO_3^- + 2H_2O \rightarrow 2N_2 + 4HCO_3^- + CO_2$$

### WOODCHIP DENITRIFICATION BIOREACTORS

Engineered systems called bioreactors are designed to harness & regulate biological denitrification by providing denitrifying bacteria with suitable habitat.

Nitrate-rich water is routed through a packed woodchip bed (i.e., the carbon or food source), typically a long and narrow plastic-lined trench.

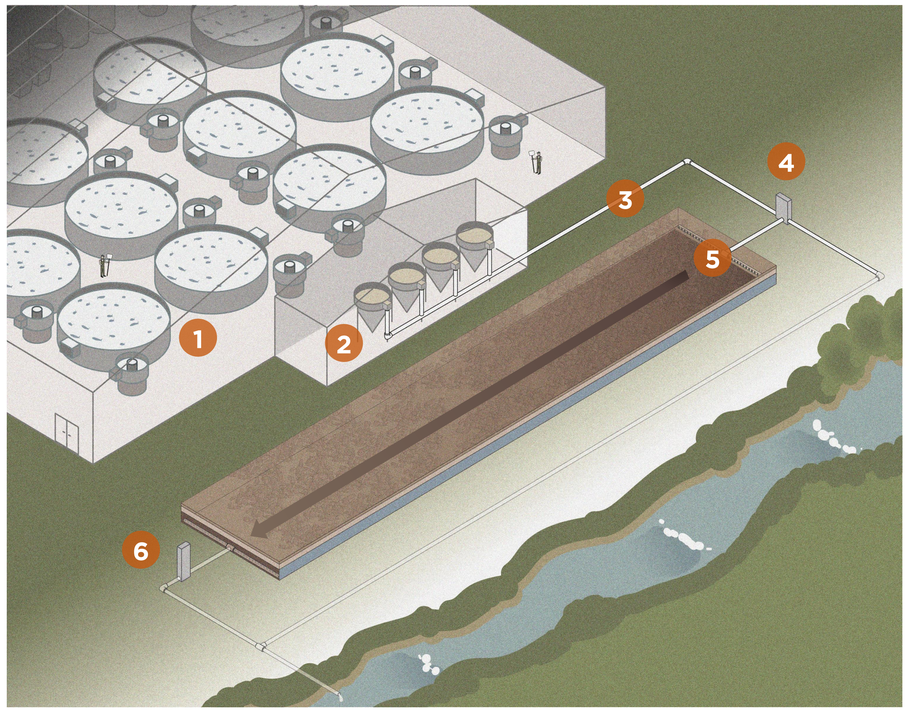
Bioreactors are designed for specific retention times, allowing sufficient contact time between nutrients and bacteria.




## WOODCHIP DENITRIFICATION BIOREACTORS OFFER A NOVEL APPROACH FOR RAS WASTEWATER TREATMENT

Treating non-point source agricultural N runoff bioreactors have proven beyond proof of concept to be a successful low-cost and low-maintenance treatment.

Point-source wastewater offers additional engineering advantages including year-round flow, consistent water temperature, and predictable influent concentrations.




1. A small percentage of culture water high in $NO_3$ leaves daily through system flushing
2. Solids dewatering also creates a $NO_3$ rich solution, captured at the top of settling cones
3. The supernatant and culture water join and are routed outside into the bioreactor
4. An influent control structure feeds water into the system or overflows to the bypass line
5. Water travels through the bed which is designed for specific retention (i.e., holding) time
6. An effluent control structure regulates internal water depth and discharges treated water

## THE CONSERVATION FUND'S FRESHWATER INSTITUTE IS EXPLORING HOW WOODCHIP BIOREACTORS CAN BENEFIT THE RAS INDUSTRY

Four onsite experimental bioreactors (L x W x D; 3.8 m x 0.76 m x 0.61 m, each) are permitting researchers to examine how this technology can be adapted for RAS wastewater (i.e., high nutrient loading) with a focus on extending bioreactor lifespan.

For more information and current publications visit us at: www.conservationfund.org

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