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COOPERATIVE EXTENSION
INFO SHEET

Kentucky State University Cooperative Extension Connections


Mineralization Process

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Turning Fish Waste into Plant Nutrients

Mineralization in Aquaponics

Aquaponics is a hybrid growing system that combines fish and plant production in a recirculating water system (hydroponics). Fish are fed a commercial fish feed, plants use nutrients dissolved in the water for growth, and solid fish waste is removed.

Despite being resource efficient, there is a need to dispose of the concentrated fish effluent (mineralization). These solids contain valuable nutrients, including nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and other micronutrients that can improve plant growth and limit the need for supplemental nutrients.

What is Mineralization?

Mineralization is a simple process that recovers these nutrients by using native beneficial bacteria to convert nutrients bound within the solids into plant-available forms.

Mineralization of fish effluent can be compared to composting in soil. In aquaponics, concentrated fish solids are discharged into an offline holding tank. Nutrients are bound in their organic form and are not readily available to plants. Microbes degrade these organic molecules, releasing nutrients in an inorganic form that plants can use.

Mineralization can occur in two ways:1. aerobic (with oxygen) and 2. anaerobic (without oxygen or low oxygen). In both types, waste sludge is collected from the solids filter and moved to a separate mineralization tank. Under aerobic conditions, the sludge is aerated continuously, promoting the growth of aerobic bacteria essential to the mineralization process. Over time, the microbes digest the solids, greatly increasing levels of essential nutrients like N, P, Mg, and sulfur (S), as well as limiting nutrients like K and Ca.

After 10 to 14 days, the aeration is shut off, the sediments are allowed to settle, and clean water can be transported directly to the sump of an aquaponic system.

Under anaerobic conditions, bacteria decompose organic matter in tanks with little to no oxygen. While this method can be useful for recovery of specific nutrients, if not managed properly, anaerobic digesters can result in toxic levels of ammonia for both fish and plants.

Kentucky State University (KSU) Research Findings:
KSU studies demonstrate that a 14-day aerobic mineralization cycle significantly enhances nutrient availability, with increases of 143% in phosphate, 47% in nitrate, and ≥20% in calcium and potassium concentrations.

Why Mineralization Matters?

- Increases availability of essential and limiting nutrients, especially for fruiting crops (*Figure 1*).
- Enhances overall water quality and system stability.
- Reduces dependence on external nutrient supplements.
- Moves aquaponics toward a zero-discharge system through nutrient recovery.

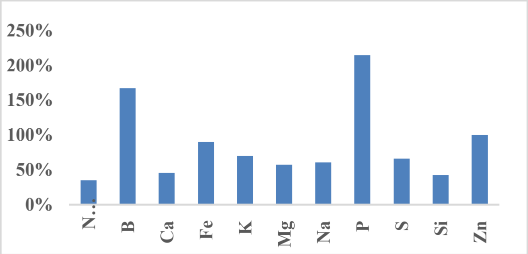


Figure 1. Percent increase in essential nutrient concentrations in aquaponics system water after addition of mineralization water, relative to the control treatment without mineralization water.

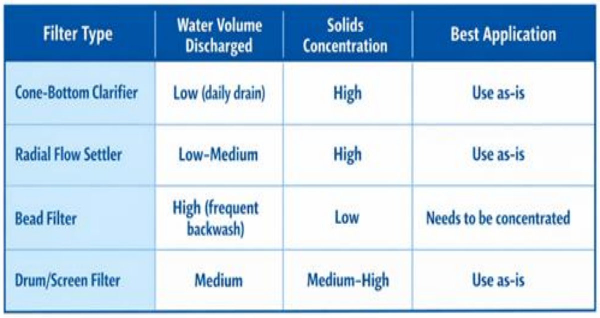
Set-up and Operation

To optimize the mineralization process, there are a few things to keep in mind.

1. *Mineralization requires concentrated solids to function properly.*

The concentration of the solid waste depends on the type of solids filtration in your system. While there is no precise metric for concentration of effluent, think of Goldilocks. If the solid waste is too dilute, there isn't enough organic matter to feed a robust microbial community. If it's too thick, you can't properly aerate/mix the solids. This will create low oxygen zones, increasing the likelihood of harmful gas buildup and loss of essential nutrients. Effluent should appear slightly murky with a yellow/amber to tan "tea-like" tint, with most solids settled to the bottom after aeration is turned off. *Table 1* provides a general guideline based on type of filter.

Table 1: Filter Guide



Filter Type	Water Volume Discharged	Solids Concentration	Best Application
Cone-Bottom Clarifier	Low (daily drain)	High	Use as-is
Radial Flow Settler	Low-Medium	High	Use as-is
Bead Filter	High (frequent backwash)	Low	Needs to be concentrated
Drum/Screen Filter	Medium	Medium-High	Use as-is

2. *How do I manage the mineralization cycle?*

Most aerobic mineralization systems are operated as batch or continuous. Batch system use multiple tanks operating in rotation. While one tank is actively mineralizing, another is being filled with fresh waste, and a third is used as the finished nutrient solution. Continuous systems are constantly being filled and then drained, without concern for complete mineralization. Many producers will opt for a continuous system, as it conserves space, requires less management, and shows comparable nutrient recovery to batch systems.

3. *What size tank do I need?*

A good rule of thumb is to have your mineralization system be 5-10% of your system volume. For a 4,000-gallon system, a continuous mineralization tank will be ~250 gallons. In a batch system, you may have three 300-gallon tanks.

4. *Mineralization tanks should be food grade and food safe.*

For mineralization, almost any tank can be utilized; however, the most important consideration is that the tank is food-grade and UV-resistant. Intermediate Bulk Containers (IBC) are a good option, as they are low cost and food safe.

5. *Target a dissolved oxygen level of 4-6 mg/L*

To accomplish this, at least 1 cubic foot per minute (CFM) of aeration per 100 gallons is recommended. The air pump may need to be upsized to accommodate for the depth of the tank. Multiple air diffusers are preferred.

Direct Application

Mineralized fish waste can also be directly applied to soil to increase nutrient levels for soil-grown plants. Use in moderation due to potential accumulation of salts in soil.

Figure 2 (Image Source: KSU Mineralization System: Janelle Hager)

Best Management Practices

- Maintain dissolved oxygen at 4–6 mg/L.
- Use mechanical filtration to capture solids.
- Stir or aerate mineralization tanks to prevent anaerobic zones.
- Maintain temperature between 70–85°F.
- Return only clarified liquid to the main system.
- Periodically remove sludge buildup.

Potential Challenges

- Low oxygen leading to anaerobic decay.
- Incomplete solids breakdown.
- Sludge accumulation reducing tank capacity.
- Nutrient imbalances affecting crop growth.

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Sources

Cripps, S. J., & Bergheim, A. (2000). Solids management and removal for intensive land-based aquaculture production systems. *Aquacultural Engineering, 22*(1–2), 33–56.

Cripps, S. J., & Kelly, L. A. (1996). Reductions in wastes from aquaculture. In *Aquaculture and water resource management* (pp. 166–201). Blackwell Science.

Davidson, J., & Summerfelt, S. T. (2005). Solids removal from a coldwater recirculating system—Comparison of a swirl separator and a radial-flow settler. *Aquacultural Engineering, 33*(1), 47–61.

Fleckenstein, L. J., Akuak, A. M., Caines, V. C., Ward, J. C., & Hager, J. V. (n.d.). *Sustaining plant productivity under low feed rates in aquaponics by supplementing mineralized aquaculture effluent*. Unpublished manuscript, School of Aquaculture and Aquatic Science, Kentucky State University; EARTH University.

Kentucky State University School of Agriculture, Communities, and the Environment. (2021). *Aquaponics production manual: A practical handbook for growers* (Final 02/24/21) [PDF]. Kentucky State University. https://www.kysu.edu/documents/school-of-agriculture-communities-and-the-environment/aquaponics_handbook_2021_final_022421.pdf

Malone, R. F., Chitta, B. S., & Drennan, D. G. (1993). Optimizing nitrification in bead filters for warmwater recirculating aquaculture systems. In *Techniques for modern aquaculture* (pp. 315–325). American Society of Agricultural Engineers.

Summerfelt, S. T. (1999). Waste-handling systems. In *CIGR handbook of agricultural engineering, Volume II: Animal production and aquacultural engineering* (pp. 309–350). American Society of Agricultural Engineers.

Summerfelt, S. T., Wilton, G., Roberts, D., Rimmer, T., & Fonkalsrud, K. (2004). Developments in recirculating systems for Arctic char culture in North America. *Aquacultural Engineering, 30*(1–2), 31–71.

Timmons, M. B., & Ebeling, J. M. (2013). *Recirculating aquaculture* (3rd ed.). Ithaca Publishing Company.

Veerapen, J. P., Lowry, B. J., & Couturier, M. F. (2005). Performance evaluation of radial/vertical flow clarification applied to recirculating aquaculture systems. *Aquacultural Engineering, 33*(1), 47–61.