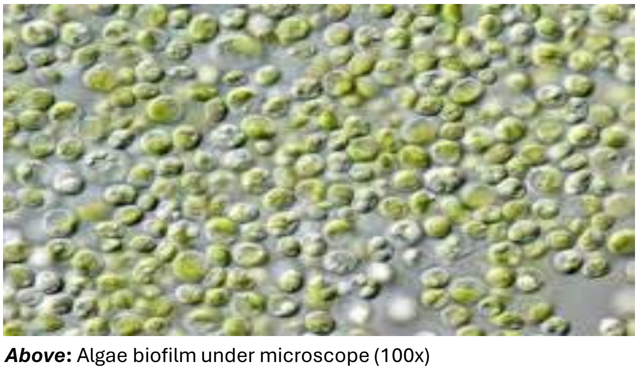
Managing Algae and Biofilm in Tropical Hydroponic Farms

Tropical climates pose unique challenges for hydroponic farmers, as warm, humid conditions accelerate the growth of algae and biofilms. These contaminants can block irrigation lines, reduce essential nutrient availability to crops, and harbor harmful pathogens that compromise both plant health and food safety[1]

Algae and Biofilms in Hydroponics: Hidden Challenges for Crop Growth and Food Safety



***Above*:** Algae biofilm under microscope (100x)

Algae are photosynthetic microorganisms that thrive in water systems exposed to light, especially in tropical hydroponic setups.

In Singapore's climate, high temperatures combined with extended daylight hours accelerate algae growth in nutrient reservoirs, irrigation lines, and grow trays. This leads to clogged systems, destabilized pH levels, and compromised nutrient availability, reducing plant growth efficiency[2].

Biofilms are microbial communities that adhere to surfaces, pipes, and irrigation lines, harboring plant pathogens like *Pythium* and *Fusarium*. These plant pathogens can infect crops and increase susceptibility to secondary microbial contamination with food borne pathogens, raising the risk of foodborne contamination when produce is consumed raw or inadequately washed[1].

Potential Risks of Algae and Biofilms in Hydroponics to Productivity and Food Safety

Algae and biofilms pose significant challenges in hydroponic farming, potentially affecting both farm operational aspects, production and food safety[2]. Key risks include:

- Reduced water flow and clogging, leading to inefficient nutrient delivery.
- Nutrient competition, causing imbalances and deficiencies for plant's optimal growth.
- Algae-induced pH fluctuations, affecting nutrient solution stability.
- Biofilm formation, promoting persistent microbial proliferation that is difficult to remove and increase the risk of plant diseases.
- Biofilms can harbor human pathogens, increasing the risk of contamination and compromising food safety[1].

Regular cleaning of hydroponic systems ensures optimal performance, preventing clogs, algae growth, and equipment failure. This maintenance minimizes downtime and reduces economic losses by keeping crops healthy and yields high.

[1]Tham, C., Zwe, Y. H., Ten, M., Ng, G., Toh, J., Poh, B., Zhou, W., & Li, D. (2024). Sanitization of hydroponic farming facilities in Singapore: What, why, and how. *Applied and Environmental Microbiology, 90*, e00672-24. https://doi.org/10.1128/aem.00672-24

[2] Sela Saldinger, *et al*. (2023). Hydroponic agriculture and microbial safety of vegetables: promises, challenges, and solutions.

Above: Severe algae and biofilm growth in an NFT channel

Balancing Mechanical and Chemical Cleaning for a Healthier Hydroponic System

Maintaining hygiene in hydroponic systems requires a combination of mechanical and chemical cleaning to ensure optimal crop health and efficient system performance. Mechanical cleaning, including scrubbing, high-pressure water, and filtration, helps remove debris, biofilms, and organic matter from surfaces and irrigation lines. This should be followed by chemical disinfection using agents like calcium hypochlorite ($Ca(ClO)_2$), which effectively eliminate remaining algae, biofilms, and pathogens. Integrating both methods—mechanical first, then chemical—enhances overall system cleanliness, supports healthier crop growth, and reduces downtime in hydroponic farming[3].

Step-by-Step Guide: Cleaning and Sanitizing Hydroponic Systems in Tropical Climates

Proper cleaning and disinfection are essential to prevent algae, biofilm buildup, and pathogen contamination that can harm crops and reduce productivity. Follow these steps to keep your hydroponic system clean, safe, and efficient.

Step 1: Perform Weekly Routine Inspection

- Check for signs of algae or biofilm on grow trays, irrigation lines, NFT channels, reservoir tanks, etc.
- Look for clogs, slimy buildup & green discoloration.

Step 2: Mechanical Cleaning

- Drain the system completely.
- Scrub surfaces using brushes & high-pressure water.
- Clean & rinse all parts (irrigation lines, reservoir walls, grow trays, channels & filters) to remove loosened debris.

Step 3: Chemical Disinfection Using Chlorine-Based Sanitizers

Use calcium hypochlorite (preferred due to higher chlorine content, better stability, and longer shelf life than bleach and hydrogen peroxide) as per your cleaning goal. Refer to the table below:

Sanitization Purpose	Calcium Hypochlorite (65-70%)	Final Chlorine Conc. (ppm)	How Long to Run Disinfectant in System	Frequency
Routine system cleaning	0.25 g per 10 liters	25 ppm	30 – 60 min	Monthly to Quarterly
Moderate biofilm & algae removal	2.5 g per 10 liters	250 ppm	1 – 2 Hours	Half yearly
Heavy contamination control	5 g per 10 liters	500 ppm	6 hours	As needed
Equipment & surface sanitation	0.75 g per 10 liters	75 ppm	5-10 min	Monthly/After use

Step 4: Rinse Thoroughly With Clean Water

- Drain the system completely to remove all hypochlorite solution.
- Refill the system with clean tap water and run the circulation pump for at least 10–15 minutes. Drain and repeat the rinse process twice to ensure all chlorine residues are removed.
- Use chlorine test strips to confirm that free chlorine levels are below 1 ppm before moving to the next step.

Step 5: Refill and Restart the System

- Refill with fresh nutrient solution after ensuring all residual disinfectant is flushed.
- Check free chlorine, pH and EC levels before replanting.

[3] Van Os, E. A. (2008). Comparison of some chemical and non-chemical treatments to disinfect a recirculating nutrient solution.

Sanitizer Residues Can Harm Crops — Proper Washing is Essential

While chlorine-based sanitizers like calcium hypochlorite are effective in maintaining hygiene in hydroponic systems, failure to properly rinse treated surfaces or systems can lead to harmful residual chlorine levels that negatively impact crop health and yield.

Proper Handling, Application, and Storage of Chlorine-Based Sanitizers in Hydroponics

Calcium hypochlorite ($Ca(ClO)_2$) must be diluted to safe concentrations for hydroponic use. Proper dilution ensures effective disinfection while minimizing risks to plants, workers, and equipment.

Adding chlorine-based sanitizers directly to a hydroponic nutrient solution is hazardous due to potential reactions with ammonia-based fertilizers, producing toxic chloramines and chlorine gas. To prevent harm, always drain the nutrient solution before sanitization and flush the system thoroughly with clean water afterward.

Incorrect dilution can cause chlorine toxicity, root damage, and equipment corrosion. Always add sanitizer to water, not the reverse, to avoid splashes and reactions. Use non-metallic containers to prevent corrosion and instability[5].

Lettuce plants exposed to higher concentrations of residual chlorine (10 mg/L and 40 mg/L) showed clear signs of stunted growth and leaf damage, compared to healthy plants in the control (no residual chlorine) and 0.2 mg/L treatments. This demonstrates how inadequate rinsing after sanitation can severely damage sensitive crops[4].

Key Takeaways for Farmers

- Tropical climates accelerate algae and biofilm growth, leading to clogged irrigation lines, unstable pH, reduced nutrient flow, and increased pathogen risks.
- Biofilms harbor harmful pathogens like *Pythium* and *Fusarium*, which can cause plant diseases, reduce yields, and increase food safety hazards.
- Combine mechanical and chemical cleaning methods for effective system hygiene. Scrubbing followed by chlorine-based disinfection ensures thorough removal of algae and pathogens.
- Use chlorine-based sanitizers at recommended concentrations and contact times. Improper use or rinsing may leave harmful residues that stunt plant growth.
- Thorough rinsing after disinfection is essential to prevent chlorine toxicity. Always confirm free chlorine is below 1 ppm before replanting.
- Follow a consistent maintenance schedule and apply chlorine-based sanitizers safely using proper dilution, contact time, and rinsing procedures.

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About the Author
Cliff Tham is part of Agri-Technology and Food Innovation Department within Urban Food Solutions Division. His research background focuses on food safety in urban agriculture systems. Currently, his research interests include seed genetics, breeding new varieties of Asian leafy vegetables with superior traits.

[4]Lonigro, A *et al* (2017). *Effects of residual disinfectant on soil and lettuce crop irrigated with chlorinated water*
[5]Aquaclear Technology (n.d.). Storage of Calcium Hypochlorite. Retrieved from https://www.aquaclear.com.cn/fra/Calcium-Hypochlorite-Storage.html