PRODUCE SAFETY IN HYDROPONIC & AQUAPONIC OPERATIONS

Fish Health and Handling

NECAFS
The Northeast Center to Advance Food Safety

The Food Safety Modernization Act's Produce Safety Rule (FSMA PSR) sets mandatory standards for growing, harvesting, packing, and holding produce for human consumption.

Farms that are covered by the FSMA PSR will be held to certain standards designed to reduce the presence of foodborne illness causing organisms that can contaminate produce. This factsheet outlines the requirements for covered farms and uses the word "must" when the practice is required by the FSMA PSR.

For farms that may not be subject to the FSMA PSR, it is important to consider the implementation of these practices to ensure your produce is safe.

Introduction

In an aquaponic operation, the production of fish and produce are interconnected through recirculating water. While the Food Safety Modernization Act Produce Safety Rule (FSMA PSR) does not require practices specific to fish health and handling, it is important for aquaponic growers to understand that these practices impact produce safety. In short, healthy fish and proper handling are critical to produce safety. The objective of this factsheet is to focus on practices that promote an aquatic environment that will support the growth of healthy fish, thereby reducing produce safety risk.

The key points covered in this factsheet include:

- Aquaponic systems combine fish production with produce production which can lead to cross contamination.
- Supporting healthy fish reduces produce safety risk.
- Designing systems to be adequately cleaned and sanitized reduces produce safety risk.
- Standard operating procedures (SOPs) standardize important steps needed to manage a specific system reliably.
- Humans remain a source of contaminants and should follow good health and hygiene practices.

Engineering and System Design

The foundation of fish health and produce safety is system design. It is important to follow sound design principles to 1) meet the needs of the species being grown and 2) inhibit pathogen growth. This includes 1) choosing durable, smooth, and cleanable materials that do not introduce other food safety hazards, 2) calculating solids removal and biofiltration needs, and 3) providing adequate aeration or oxygenation to all system components. These are important because poor system design may promote a habitat for pathogens. Therefore, the physical

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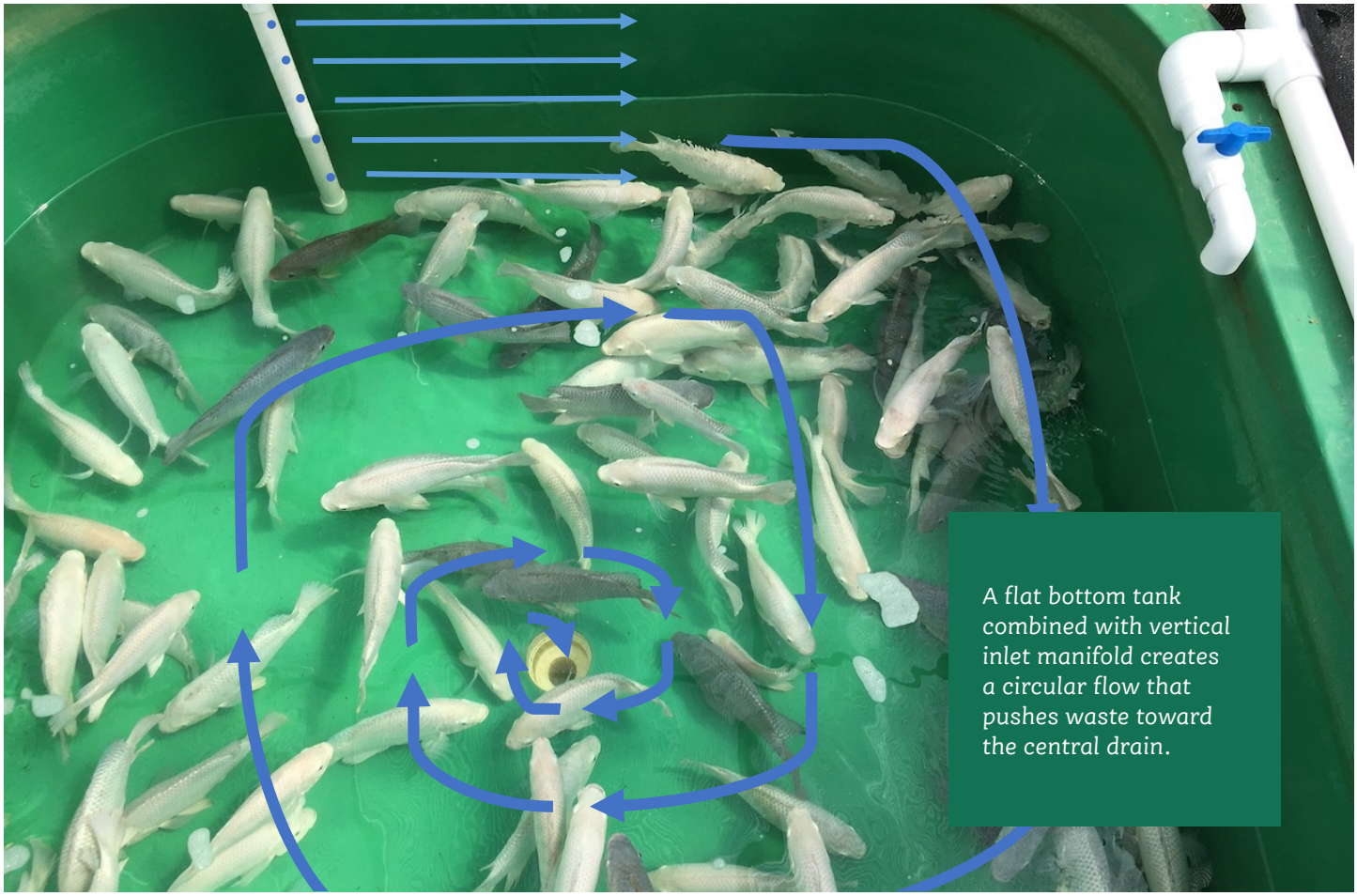
infrastructure of an aquaponic system will determine the ability for growers to maintain optimal water quality conditions, thereby ensuring long-term success and minimizing produce safety risk.

The shape, material, color, and size of the fish tanks are important considerations. These factors can impact both fish health and cleanability of the system.

The shape of a fish tank can affect circulation, so round tanks with a central drain for removal of solids are ideal. With appropriate inlet manifold design and flow rates, rounded square tanks can also rapidly discharge solids through a central bottom drain. Designs should facilitate easy cleaning and sanitizing, and ideally have windows to monitor fish for any abnormal behavior and signs of disease. Tanks should be constructed out of a strong inert plastic or fiberglass because of their durability and life span. White or light-colored tanks allow a grower to see the fish better, check the amount of waste that has settled, check water turbidity, visually inspect to determine the need for cleaning, and to see if cleaning was done well. They also reflect sunlight and keep water cool. Growers should have covers and shading to keep fish in and predators out. Covers also maintain a stable water temperature, and prevent algae growth. It is also good practice to implement a failsafe to keep the tank from draining during emergency situations such as plumbing failures and power outages.

Another important aspect of system design is the solid waste management system, which involves solids filtration. Managing fish waste and other organic detritus in the water is an important component of maintaining fish health. This is especially important in recirculating systems where solids can build up over time and break down into small particles that are difficult to collect. As microbes decompose particles, they consume oxygen and reduce the amount available for fish and plants. High levels of suspended solids can clog fish's gills and increase susceptibility to disease and mortality. In general, solids should be removed from the overall system flow as quickly as possible to reduce the negative water quality impacts of accumulated organic waste.



A flat bottom tank combined with vertical inlet manifold creates a circular flow that pushes waste toward the central drain.

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Human-System Interaction

It is critical for growers to adopt produce safety practices to prevent pathogen introduction through human interaction with the system. This includes practices such as proper use and maintenance of disinfectant foot baths and personal health and hygiene. Growers should also adopt practices to ensure fish health including fish handling, maintaining optimal conditions, and managing solid waste.

Maintaining optimal water quality for the species being raised supports the growth and health of fish, reduces disease and minimizes the transfer of pathogens to workers or produce.

Fish should be fed and handled using practices that support optimal growth and minimize stress, including proper sanitation, minimal handling, and frequent observation. Standard operating procedures (SOPs) need to be operation-specific and describe the day-to-day activities needed to maintain optimal water quality and minimize fish stress. Growers need to train personnel on the SOPs and confirm their proper implementation.

It's a good practice to maintain logs of measured water quality parameters in order to track changes over time.

WATER QUALITY

Growers should monitor water quality daily as changes can cause stress and declines in fish health. The parameters important to fish health include dissolved oxygen, alkalinity, ammonia, nitrate, nitrite, and pH. These must be maintained within concentration ranges appropriate for the species being grown.

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FISH REARING AND HANDLING

When rearing and handling fish, growers should consider several factors to optimize fish health and minimize produce safety risks. There is a possibility that zoonotic diseases can be transferred from fish to humans, so maintaining fish health is good for worker safety, food safety, and the productivity of the system. Fish rearing and handling starts before fish are introduced to the system and happens continuously throughout their lifecycle.

Before introducing fish into the system

SYSTEM SETUP

Setting up appropriate systems for the species being grown is essential to promoting fish health and reducing susceptibility to disease.

Choose Fish

Choosing fish and plants that are better adapted to the region's climate will reduce the costs associated with maintaining optimal environments for growth, such as heating and cooling. An environment that is closer to the fish's natural habitat reduces fish stress and disease pressure and increases welfare.

Clean and Sanitize

If system components–such as troughs, tanks, and plumbing–have been used before, they should be thoroughly cleaned and sanitized before filling and starting up a new system. New components should also be cleaned and sanitized prior to startup. Sanitizers should not be used in the water-circulating components of an aquaponic system when fish are present.

Establish Biofilter

Wait until the initial biofilter establishment process is complete before adding fish to a new aquaponic unit. This means that total ammoniacal nitrogen (TAN) and nitrite concentrations have fallen to a steady state below toxicity thresholds for the fish species being raised.

Quarantine Fish

A quarantine system, including mechanisms for solids removal and biofiltration, should be constructed to house fish upon delivery. Thoroughly clean and sanitize the quarantine system and quarantine the fish for one to two weeks. Growers should follow strict hygiene protocols to prevent pathogens from entering or leaving the system. Contaminated fish can be a source of both fish pathogens and foodborne pathogens. While in quarantine, fish should be treated for any existing parasites and observed for abnormal behavior.

After introducing fish into the system

FEEDING AND NUTRITION

Choosing the type of fish feed and its protein content is important, as these can affect the quality of the water and ultimately becomes the nutrient source for the produce being grown.

Choose Quality Feed

Using high quality feed and properly storing it to prevent against mold and rodent pests will reduce the risk of fish getting sick or transmitting pathogens to the system through their feces.

Choose Feeding Strategy

Using a timed feeder is one way to reduce fish stress, increasing welfare and resistance to disease, and stabilizing water quality parameters.

THIS SYMBOL MEANS YOU CAN FIND ADDITIONAL RESOURCES ON THE TOPIC DISCUSSED ON PAGE 6

HANDLING AND DISEASE PREVENTION

Stressed fish are more susceptible to illness and disease. Along with water quality monitoring and proper nutrition, good management and handling, proper sanitation, and removal of dead or sick fish aid in the prevention of fish diseases. In addition to implementing good hygiene to prevent the spread of pathogens, workers should be trained in a few practices specific to preventing diseases in fish, including:

Manage Fish Stress

Keep fish out of water for as little time as possible and minimize rough handling and transport of the fish to reduce stress. Maintain optimal ranges of the water quality parameters discussed above.

Monitor Fish Health

Recognize the signs of poor fish health. If fish do become ill, treatment options in aquaponics are limited. Remove diseased fish as soon as possible, euthanize, and dispose of them appropriately, away from the healthy fish. Monitor the remaining fish closely for signs of disease.

Practice Good Hygiene

Hygiene of personnel during fish handling and feeding operations is essential to prevent the transfer of disease organisms between humans and fish.

Maintain Clean Production Environment

Cleaning up fish feed or other debris around the fish tanks regularly will reduce the likelihood of attracting pest animals that can carry foodborne disease. Sanitizers and many cleaning chemicals are toxic to fish and should be used and handled with care according to the label and stored properly.

IDENTIFYING SICK FISH

Sick fish can transfer disease to each other, potentially compromising the entire group. Personnel should be trained to identify signs of fish disease. Daily observation of fish is recommended to catch signs of disease early. Sick fish should be removed and euthanized as soon as they are identified, and disposed of in a way that does not contaminate other fish or produce. Some of the indicators include:

- Fish stop eating (usually the first sign of illness)
- Color change
- Change in respiration rate
- Degraded fins and scales
- Excess mucus on the skin or gills
- Emaciation and/or distended abdomen
- Exophthalmia (pop-eye)
- Hemorrhage (an abnormal discharge of blood)
- Lesions (a defined area of diseased tissue such as an ulcer, blister, or canker)
- Pale or swollen gills (often seen with fish "gulping" at the surface of the water for air)

This fish is exhibiting degraded fins and scales, color change, and a change in respiration rate.

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Fish Health and Handling Takeaways

It is critical for growers to consider produce safety when planning and implementing practices primarily intended to support fish health. Because the produce and fish production pieces of an aquaponic operation are interconnected, establishing a system and maintaining practices that support fish health will also promote produce safety. Produce safety implications of system design choices should be considered as components are replaced or an operation is expanded. A holistic approach including system design and human–system interaction can help to ensure both fish health and produce safety by minimizing the growth and distribution of pathogens in aquaponic systems.

Additional Resources

Some of the resource links provided here may be general in nature and can be adapted to hydroponic and aquaponic operations. These links do not represent an exhaustive list of content on this topic and are intended as a starting point to guide the user toward finding additional relevant resources.

A Guide to the Aquaponics Food Safety Plan Development: Green Aquaponics LLC as a Model: https://www.researchgate.net/profile/Reza-Ovissipour/publication/331295437_A_Guide_to_the_Aquaponics_Food_Safety_Plan_Development/links/5c709c2592851c6950391266/A-Guide-to-the-Aquaponics-Food-Safety-Plan-Development.pdf

Aquaponics Produce Manual A Practical Handbook for Growers: http://www.ksuaquaculture.org/PDFs/Aquaponics%20Handbook%202021%20Updated%20.pdf (Suitable Species of Fish for Culture pg. 1, Fish stress and diseases pg. 37)

Biosecurity in Aquaculture, Part 1: An Overview: http://fisheries.tamu.edu/files/2013/09/SRAC-Publication-No.-4707-Biosecurity-in-Aquaculture-Part-1-An-Overview.pdf (Cleaning and sanitizing in aquaculture pg. 3)

Fish Welfare in Aquaponic Systems: Its Relation to Water Quality with an Emphasis on Feed and Faeces–A Review: https://www.mdpi.com/2073-4441/9/1/13

Hygienic and Sanitary Design for Produce Farms: http://go.uvm.edu/hygienicdesign

Recirculating Aquaculture, 4th edition: https://www.worldcat.org/title/recirculating-aquaculture/oclc/1107463793?referer=di&ht=edition

Small-scale aquaponic food production, Integrated fish and plant farming: https://www.fao.org/3/i4021e/i4021e.pdf (Fish health and disease pg. 117)

Water Quality in Aquaponics: https://fisheries.tamu.edu/files/2020/10/Water-Quality-In-Aquaponics-Sink-Masabni.pdf

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