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Bacterial pathogens in biofilms pose health risks in recirculating systems

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Biosecurity measures can deter bacteria, fungi, algae and parasites

Biofilm sloughing in aquaculture facilities can release pathogens into the water, exposing fish and humans to infection. Here, a culture tank is swabbed for testing.

The rapidly growing recirculating aquaculture sector is generally independent of environmental conditions because most facilities are indoors. However, this form of aquaculture presents an increased potential for pathogenic bacteria to become established in the system through the formation of biofilms. Pathogenic bacteria released from biofilms are capable of causing recurring diseases in fish, as well as increasing exposure to humans.

Biofilms

Biofilms form at the water/solid interface of all components of aquaculture systems. They are also present in streams and on medical implants, and cause plaque on teeth. Biofilms have been found on the scales and skin of fish, and are of concern in the food industry, where there is evidence of biofilms on food contact surfaces.

Many different organisms are incorporated into biofilms, including bacteria, fungi, algae and parasites. Fluctuations of the dominant type of organism occur over time.

Bacterial biofilms are used in wastewater treatment plants in some countries to aid in cleaning water. Some bacteria found in aquaculture system biofilms are essential in the removal of ammonia and nitrites, metabolic waste products harmful to fish.

Studies have shown that bacteria in biofilms adapt to adverse environmental conditions by altering their cellular functions. Biofilm bacterial cells have been found resistant to antimicrobials treatments, including antibiotics, surfactants or detergents, heavy metals, phagocytic predators and drying.

Potential risks

The presence of human pathogenic bacteria in a recirculating aquaculture system can make the system a potentially unacceptable public health risk. The periodic sloughing of piscine pathogens can also cause recurring disease in stressed fish. These fish can be asymptomatic and enter the food chain. If any cross-contamination occurs during processing, finished products can be contaminated, leading to the possibility of infection in the consumer.

Another hazard is that symptomatic fish are often given antibiotics in feed or treated with antimicrobials in the water. Bacteria in biofilms can develop resistance to these antimicrobials, and if infection occurs, normal methods of treatment may not be as effective.

Bacterial pathogens

Table 1 lists some bacterial pathogens isolated from biofilms in aquaculture facilities. Most of these organisms are opportunistic pathogens, and all of them are ubiquitous in the environment. Some of the more significant human pathogens are *Bacillus cereus*, *Shigella* spp., and *Vibrio* spp.

King, Pathogenic bacteria associated with biofilms, Table 1

Bacterium	Risk

Acinetobacter spp.	H
Aeromonas hydrophila	F/H
Aeromonas spp.	F/H
Bacillus cereus	H
Bacillus spp.	F/H
Citrobacter freundii	F/H
Enterobacter cloacae	H
Enterococcus spp.	H
Escherichia coli	H
Photobacterium damsela	F/H

Table 1. Pathogenic bacteria associated with biofilms in commercial aquaculture facilities.

Bacillus cereus

Bacillus cereus is becoming more of a concern in the food industry because it is a hardy, spore-forming organism capable of surviving harsh conditions, including high temperatures. *B. cereus* ingestion can lead to vomiting or diarrhea after the spores germinate and produce either emetic toxin or diarrheic toxin. This bacteria can also cause ocular or wound infections, septicemia, and other nonspecific central nervous system or respiratory infections, though presentation of these symptoms is not common.

Regular testing of biofilms can help limit bacterial exposure to both staff and culture animals.

Shigella *spp.*

Shigella spp. cause dysentery and are generally associated with poor sanitation. These bacteria have a low infectious dose, which facilitates rapid transmission, especially in crowded, unsanitary conditions. Fecal matter from infected individuals contaminates food and water.

Vibrio *spp.*

Three major species of *Vibrio* lead to infections in humans: *V. cholerae*, *V. parahemolyticus*, and *V. vulnificus*. Commonly found in water, *Vibrio* cholerae can persist in shellfish and plankton beds that have been contaminated with polluted effluent. This species contains many harmless aquatic strains, as well as the more virulent strains that are responsible for the gastrointestinal illness cholera. Cholera is another disease related to poor sanitary conditions. It is transmitted primarily by contaminated water and food.

Vibrio parahemolyticus can also cause gastrointestinal distress when undercooked or raw seafood has been consumed. *V. parahemolyticus* is widely distributed in coastal waters and associated with every type of seafood. It is more prevalent in warmer seasons, but can be isolated from cold water.

Vibrio vulnificus is associated with wound infections and septicemia in humans, though usually only in immunocompromised patients. Septicemia is primarily associated with consumption of raw oysters. Death rates for septicemic patients can be quite high. The organism is less often associated with gastrointestinal illness, and its role in causing gastroenteritis is not well understood.

Vibriosis

Vibriosis also occurs in fish. It is most common in marine fish, but can also be present in freshwater fish. Disease outbreaks of vibriosis in fish vary with temperature, strain virulence and the amount of environmental stress present.

Conclusion

Many types of microorganisms are incorporated into biofilms in recirculating aquaculture systems. Although these organisms are an essential part of the systems' biofiltration, bacterial pathogens can also be present. Occasional sloughing of the biofilm can release these pathogens into the water, exposing fish and humans to infection.

Some organisms of primary concern to humans include *B. cereus*, *Shigella* species and *Vibrio* species. These pathogenic bacteria can cause gastrointestinal disease, wound infection, and/or septicemia in humans.

Exposure to humans can result from cross-contamination of infected fish with finished products during processing, or direct exposure to water. Because many of the pathogenic bacteria in biofilms are common in the aquatic environment, elimination is an unrealistic goal. Decreasing the number of pathogens present is more attainable. Appropriate biosecurity measures decrease the risk of exposure to both fish and employees.

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