by **Stephen G Newman**

Risk of toxins from blue green algae to aquaculture

Many aquaculturists, whether they are farming fish or shrimp, typically in ponds, understand that high levels of blue green algae are not desirable. Blue green algae are not really algae; it is photosynthetic bacteria called cyanobacteria. It is among the oldest living group of bacteria with evidence of its existence dating back more than 3 billion years. Blue green algae are diverse group of organisms, occupying many different environments and are very successful ecologically. Its preferred niches are those where the nutrient loads are "unbalanced" or eutrophic, that gives them a competitive edge over the myriad algae species, including green, red, brown algae and others that typically occupy marine, estuarine and freshwater environments.

Pond based aquaculture systems that rely on relatively low water exchange rates are at a greater risk for problems with these bacteria than high flow through rate systems where excess nutrients can be carried off into effluent settling ponds or into discharge canals that enter the same water source that is subsequently used for influents. The term eutrophic refers to systems that have high levels of nutrients such as phosphorous and nitrogen that allow these photosynthetic bacteria to readily proliferate at the expense of other more desirable organisms.

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Emergence of cyanobacteria in the area

As human populations increases there has been a concomitant increase in the types and amounts of waste products that enter into estuarine and near shore ecosystems. Vast amounts of nitrogen and phosphorous originating from many different sources enter these environments. Sources include agricultural run-off from feed lots, from the production of row crops fertilised with chemical fertilisers, from inadequately treated sewage from cities and smaller municipalities, as well as, to a much lesser extent, run off from aquaculture operations that do not comply with Best Aquaculture or Best Management Practices. These pollutants have resulted in the development of innumerable dead zones in these ecosystems. Cyanobacteria proliferate in these areas resulting in depleted oxygen levels, which subsequently cause fish, and other marine animal kills. The number of reported dead zones increases each year with more than 500 now reported annually. This is a serious problem that has broad ranging implications for aquaculture, as these are not

environmentally suitable areas to produce fish or shrimp.

Toxins and its risk

Cyanobacteria present in the pond have been found to inhibit the growth and variety of macro and microorganisms and negatively affect profitability. They can ruin the suitability of a pond to produce shrimp or fish. They have also been found to produce a very impressive array of toxins. There are many reported cases of problems from the consumption of water that has been contaminated with cyanobacterial toxins. There are also many instances where toxins have been deposited in animals produced by aquaculture and a leading cause of what is known as off-flavour. This muddy taste can destroy the value of a crop and in extreme cases result in total loss of the crop. Savvy consumers know that seafood that tastes this way is not fit for human consumption. The more responsible producers, typically through the processing plants, taste fish and shrimp before processing and reject product that has off flavour.

Cyanobacteria produce literally dozens of, if not hundreds or more, toxins. These toxins are divided into two broad groups, the odorous metabolites (toxins are usually metabolic by products not compounds produced to assure access to food such as antibiotics) and bioactive metabolites. The most common examples of metabolites that cause foul smelling and foul tasting seafood (odorous) are those that are classically associated with off-flavour, 2-methyl isoborneol (MIB) and geosmin. These toxins are produced by a number of different species and are only released when the cells die. Their toxins are quite common. Geosmin is the odour that often is noted after rain showers. They can be quite toxic in addition to ruining the value of a crop.

Those metabolites that are bioactive include toxins known as hepatotoxins that damage the liver and related organs such as the hepatopancreas (HP). The most common of which are the microcystins and the nodularins. Nodularins can contaminate drinking water and can accumulate in bivalves, fish and even prawns. Microcystins have been shown to accumulate in fish and prawns as well. In fact levels have been reported that are high enough to potentially have an adverse effect on humans consuming them.

Cyanobacteria also produce cytotoxins, neurotoxins, dermatotoxins. The threat posed to humans that eat shrimp and fish obviously varies with the type of toxin and the quantity present in the animal at the time it is

Blue green algae in affected pond.

consumed. Low levels are typically not problematic and World Health Organisation (WHO) has established acceptable threshold levels of these toxins. However, there are serious concerns that some of these toxins may pose short and long-term threats to consumers that eat them. Food poisoning from consuming toxins such as nodularin and microcystin does occur; the more fish and shrimp are produced in the same contaminated environment the risk is certain to increase. Consumption of water containing various toxins has resulted in hospitalisations and even in some cases human deaths. Animal deaths are common.

Also among the toxins produced is Beta-methylamino L alanine or BMAA. This toxin is produced by virtually every group of cyanobacteria. It is an amino acid that is not found in normal protein and is a potent slow acting neurotoxin. The toxin was discovered as a result of a syndrome that was affecting a group of Pacific Islander natives that were consuming fox bats. These are large fruit eating bats that ate cycad seeds that have been contaminated with BMAA producing bacteria. They were found to have a unique neurodegenerative disease, coined amyotrophic lateral sclerosis-parkinsonism/dementia complex that appeared at a frequency that was fifty to one hundred times greater than the global incidence of ALS. These neurological problems have been linked to the presence of the BMAA in their diets. More recently BMAA has been linked to other neurodegenerative diseases including Alzheimer's. While it is likely that these diseases are multifactorial, the presence of BMAA appears to be a potentially important if not critical component. There are many who believe that this may be only one example of a myriad of environmental toxins that we are unwittingly being exposed to that impact human health.

Control and prevention

While there have not been any extensive studies to date on the presence of BMAA toxin in the environment (aside from its likely presence in every type of cyanobacteria), it has been isolated from wild fish, shrimp and crab at what would be characterised as disturbingly high levels in the US. There have been no wide studies of farmed fish or shrimp as of yet although given the wide range of algal species that have been found to produce this toxin, it is likely present in some farmed product as it a common practice for shrimp and fish to be produced in ponds containing heavy levels of blue green algae.

This toxin does not belong in the human food chain at any level. The evidence is strong enough to warrant forced testing for its presence at harvest much as current HACCP guidelines require testing for specific antibiotic residues that are deemed illegal. While some may view this as extreme, the evidence continues to accumulate that these toxins are ubiquitous and that it can have dire consequences from long-term consumption.

Management

Given the nature of these bacteria, it is very unlikely that they can be eliminated entirely from production systems. The goal should however, to be to manage around them and take proactive steps to reduce their numbers through whatever means there are available. Controlling the growth of these

Blue greens on paddle wheels.

bacteria in ponds becomes of paramount importance if one is to control the levels of potentially problematic toxins.

Rather than killing the algae outright the best solutions are those that involve trying to shift the ecosystem away from them. Perhaps the best possible approach is to seed the ponds with bacteria (typically stable Bacillus species) and allow them to compete with the cyanobacteria for nutrients. This can cause a slow displacement of the algae in the ponds and a shift away from the cyanobacteria to more desirable algal species. Another approach is to modify production systems so that they become more heterotrophic based. Through manipulation of the carbon to nitrogen ratios, the pond can be pushed towards biofloc technology.

Conclusion

Aquaculturists have become too blasé about the presence of large numbers of cyanobacteria in their ponds. While the evidence is at this time largely one of circumstance as no broad reaching in-depth studies have been published that show how widely disseminated many of the toxins that these organisms produce are, it is very likely that in some production systems, high levels of some of the more onerous toxins are going to be found to be present. Given the nature of some of them such as BMAA, it makes a lot of sense for aquaculturists to utilise strategies that reduce the presence of these bacteria in their production systems. It is critical for the true sustainability of aquaculture that these issues be addressed and incorporated as a part of Best Management Practices. Screening for BMAA should be required for all lots of farmed shrimp and as well for the fish that are farmed in similar environments before they are sold for export and it would be wise for those who regulate the local sale to consider this requirement as well.

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