Summary from INND/Toxipedia on Potential Impacts of PVC Used in Geoduck Aquaculture on the Aquatic Environment

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Introduction

Based on data provided by the Shellfish Aquaculture Regulatory Commission, there is approximately 1 thousand miles of PVC tubes, comprising 2,000 tons, in use at any given time for geoduck farming in Puget Sound.[1] In a report published in 2009 by members of the School of Aquatic and Fishery Science at the University of Washington, the authors state that "There is no peer-reviewed information available on the ecological impacts of the mesh-covered polyvinyl-chloride (PVC) tubes currently used in geoduck aquaculture."[2]

INND/Toxipedia hired Essco Safety Check to conduct a chemical analysis of typical PVC tubes found on Puget Sound's beaches that had been used in geoduck aquaculture. The analysis found the following chemicals in the PVC samples:

- Arsenic
- Bromine
- Calcium
- Chlorine
- Copper
- Iron
- Lead
- Manganese
- Silver
- Strontium
- Tin
- Titanium
- Zinc

Two samples in particular had elevated levels of lead.

Potential Threats of Chemicals Found in PVC Tubes

Toxic chemicals found in PVC can potentially enter the aquatic ecosystem and food chain by particulate pieces breaking off of the tubes as well as leaching of the chemicals into the water and sediment. A report published by the Healthy Building Network states that "Lead is known to leach into water carried in PVC pipes that contain lead stabilizers."[3] Other toxic metals found in these pipes may pose the same threat of leaching into the environment and contaminating plants, plankton, fish, and more, affecting the entire food chain all the way up to humans. Below are facts from peer-reviewed professional journals about the impacts of these chemicals on aquatic environments.

Arsenic

- Several aquatic plants have been shown to accumulate arsenic at extremely high rates. If these plants are a food source to either humans or other aquatic organisms they could pose a threat to their health.[4]
- When levels of phosphorous are low arsenic is very toxic to algae.[5]
- Water/sand fleas are extremely sensitive to arsenic.[5]

- Juvenile mummichogs, a small fish similar to a minnow, whose parents were exposed to arsenic, experienced an increased rate of curved or stunted tails.[6]
- Researchers found that juvenile mummichogs whose parents were exposed to arsenic had 13 genes with altered expressions. These genes are important in embryo development and could be the cause of structural deformities.[6]
- Arsenic, even at very low concentrations, is toxic to the immune system of fish.[7]
- Arsenic can accumulate most rapidly in aquatic habitats and proceed to move up the food chain, eventually to humans.[8]
- Fish have been found to contain extremely high levels of arsenic.[8]
- Inorganic arsenic is more toxic than its organic form.[8]
- Arsenic is known to inhibit more than 200 enzymes found in fish and interferes with their function.[8]
- In fish, arsenic has been shown to inflame the liver and gall bladder.8
- In fish, arsenic has been shown to disrupt reproductive processes by disrupting ovarian cell cycles, inhibiting ovarian follicle development, impairing spermatogenesis, and changing testicular architecture.[8]
- In birds, arsenic exposure can impact immune responses.[8]

Chlorine

- Larger fish are more susceptible to death from chlorine exposure than smaller fish.[9]
- At certain levels, exposure to residual chlorine can inhibit the growth of phytoplankton. [9]
- Several studies have concluded that salmonoids are the most sensitive fish species to residual chlorine. [9]
- "Chronic toxicity effects on growth and reproduction occur at much lower concentrations than acutely lethal concentrations."[9]
- In experiments, salmon avoided sea water contaminated with chlorine.[10]
- Mussels exposed to chlorine experienced reductions in physiological activities such as filtration rate and foot activity.[11]
- Several species of fish, including coho salmon, have been found to avoid water contaminated with chlorine.[12]

Copper

- Exposure to low levels of copper can negatively affect the olfactory system in Coho salmon.[13]
    - Disruption of the olfactory system inhibits the salmon's natural predator avoidance responses.[13]
    - Copper has been shown to have similar impacts on the olfactory system of Chinook salmon, rainbow trout, brown trout, fathead minnow, and tilapia.[13]
- Copper exposure to larval fish can interfere with behavior such as schooling, maintaining position in currents, and other behaviors that are integral to migration and survival.[14]
- Copper has been shown to cause respiratory stress in spiny dogfish.[15]
- Water fleas fed a diet of algal food contaminated with copper experienced reduced growth and reproduction.[16]

Lead

- "Lead is known to leach into water carried in PVC pipes that contain lead stabilizers."[3]
- Several types of tested were able to survive in water with high concentrations of lead for extended periods of time.[17]
- High concentrations of lead adversely affected survival and reproductive cell production in female sea urchins.[18]
    - Similar concentrations were found to be toxic to early life stages of sea urchins.[18]
- Researchers have found that lead exposure in fish at levels that do not cause death are linked to adverse behavioral effects.[19]
    - These effects last even when fish are placed in lead free water.[19]
- Deposit feeding bivalves have been shown to bio-accumulate lead.[20]
    - While acute and chronic toxicity of lead to bivalves needs further investigation, eating bivalves with high levels of lead can pose threats to human health.[20]

Zinc

- In experiments, water/sand fleas subjected to chronic exposure to zinc experienced a decrease in calcium intake leading to reduced movement and filtration, ending in decreased food uptake.[21]
    - Once exposure ended, fleas were able to return to normal calcium intake and feeding.[21]

Need for further research

The use of PVC in geoduck aquaculture raises many human and ecological health concerns especially since a recent review of geoduck aquaculture found no data on the consequences of the use of PVCs. The burden of responsibility to demonstrate a lack of harm must be assumed by the proponents of this activity as they stand to generate substantial financial benefits. New drugs are not approved for human consumption and released on to the market without careful research and review. The same should be the case for PVC used in the environment. Clearly one of the primary concerns is the volume of PVC material and other equipment used and lost as geoduck aquaculture is expanded. An additional concern is the contaminants generated in the manufacture and disposal of PVCs. A precautionary[22] approach is warranted considering the potential for human and ecological harm.

The following questions require more research to adequately assess the impacts on the ecological and human health:

1. How much PVC material, mesh or rubber bands are lost due to sand or wave action or scouring?
2. What are the effects of UV light on the PVC material?
3. What chemicals are leached into the aquatic environment from the PVC, mesh, or rubber bands?
4. Do chemicals bio-accumulate in the geoduck?
5. Are there other ecological effects on aquatic organisms?
6. Are there alternatives to PVC?

7. Examine the bio-concentration and bioaccumulation of chemicals at all levels of the food chain.

Conclusion

With the large amount of PVC currently in use in Puget Sound for geoduck aquaculture, the aquatic environment in the region is at risk of chronic contamination from the toxic chemicals found in them. Continued use of PVC creates a consistent stream of these chemicals entering the water, aquatic life, and surrounding area. Critical to understanding the impact of chemical contaminants is how they bio-concentrate and bio-accumulate at all levels of the food chain from the smallest organisms to fish and mammals. The longer the exposure to these chemicals, the more dramatic the impacts will be, and the harder it will be to return to a healthy, safe environment for both wildlife and humans. In an industry such as geoduck aquaculture that depends so heavily on a healthy environment to produce high quality products, continuing to use PVC threatens the sustainability of not only Puget Sound but the geoducks as well.

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