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Denitrification Based on Sulfur at the Aquarium of MAAO

by Sebastien Delaporte and Michel Hignette

The utilization of sulfur as a support for the growth of denitrifying bacteria has been the subject of many studies. The possibility of using this method in aquaria has been tested in experimental systems at the Aquarium du Musée national des Arts d'Afrique et d'Océanie (MAAO) in Paris. Later, M. Langouet developed larger systems at the aquarium of St. Malo with satisfactory success. Now we have decided to utilize this method for the 60,000 liter general sea water system at the aquarium at MAAO.

Measurements of physical/chemical parameters of the water were made using a Hach DR 4000 U spectrophotometer. Direct absorbance of UV light at 2 wavelengths permitted very accurate measurement of nitrate concentration. The denitrifying unit consisted of four large PVC pipes, each with a volume of 240 liters, 2 meters high and 40 centimeters in diameter; and 2 small PVC pipes, each with a volume of 25 liters, 1.5 meters high and 15 centimeters in diameter. The four large pipes were filled with 850 kilograms of sulfur beads, equally distributed. The two small pipes were filled with maerl, a gravel made from calcareous algae skeletons. The system was set up so there were two identical units working in parallel, each composed of two large sulfur-filled pipes and one small maerl-filled pipe. A pump at the bottom of each sulfur pipe supplied water.

The denitrifying system was connected to a separate tank with no animals, to prevent nitrite from flowing into the main saltwater system. This 10,000 liter aquarium had a nitrate ion concentration of 320 milligrams per liter (mg/1). From previous models we expected a maximum nitrate elimination of two kilograms of nitrate per day per cubic meter of sulfur. We regulated the flow for each sulfur pipe to 50 liters per hour, or 200 liters per hour total.

During the first eight days we noticed a drop in nitrate concentration, and an increase in nitrite concentration to as high as 69 mg/1 on the eighth day. We believe that the bacteria present on the sulfur developed during eight days to cause this level. After eight days there are enough bacteria in the sulfur pipes to completely break down the nitrate and to utilize the nitrite as an oxygen source. This is when we noticed a rapid drop of both nitrite and nitrate in the tank.

Once the bacteria population stabilized and the nitrite level was very low, we connected the system to the main tank. Then we added another 10,000 liters of water with high nitrate to the tank containing the denitrifying system, and saw a peak of 2 mg/1 nitrite affer one day and a low nitrate level affer three days.

This batch treatment cycle was repeated three times. Each time there was a nitrite peak the first day and a lowered level affer three days. The three repetitions resulted in a decrease in the nitrate concentration of about 100 mg/1. Then the tank with the denitrifying system was connected to the general saltwater circulation system.

At a flow rate of 200 liters per hour, in thirteen days the nitrate concentration dropped from 220 mg/1 to I 10 mg/1 and remained at this level. The flow rate was then increased to 500 liters per hour. The nitrate concentration dropped for fiffeen days to stabilize at 20 mg/1. Finally, the flow rate was set at 1500 liters per hour, and the nitrate concentration stayed between 4 and 10 mg/1, depending on the amount of food that had been added.

During the denitrifying process the pH varied greatly and dropped to about 6 near the output of the sulfur pipes. However, the use of calcareous maerl buffered the pH, so it ranged from 7.2 to 7.5 at the output of the small maerl pipes. There were also two additional maerl pipes that were independent of the denitrifying system. The pH of the system was more stable, with a level near 8 in the 60,000 liter tank. The acidic water dissolved the maerl and caused it to partially break down to small particles, which caused the small pipes to clog quickly, in about fiffeen days. Thus the maintenance of the denitrifying system consisted only of regularly replacing the maerl in the small pipes. The breakdown of this calcareous material resulted in an increase of calcium ions which reached a level higher than 600 mg/1 in the aquarium.

Affer six months in operation, we noticed that the sulfur beads also broke down, restricting the water flow through the sulfur pipes. This decrease in water flow led to anaerobic conditions in various areas, causing very strong odors. Injecting air into the bottom of the pipes at the first appearance of such odors was found to eliminate the problem.

Potential disadvantages of this type of denitrifying system are the drop in pH and the production of sulfate. No increase in sulfate was noted initially. However, affer the maerl pipes clogged, water occasionally passed through the sulfur pipes and returned directly to the aquarium instead of through the maerl pipes. Sulfate concentration was measured as high as 5300 mg/1, the normal level being between 2500 and 3000 mg/l. Even at this level, fish showed no alteration of behavior. The average concentration of sulfate present in one gram of maerl varied with location. In the aquarium it was 220 mg/1. In the denitrifying system it was 431 mg/1. The level in new maerl was 219 mg/1. It appears that during normal operation the sulfate was precipitated by the maerl, preventing an increase in sulfate level in the aquarium water.

This method of denitrification causes a rapid decrease in nitrate level in an aquarium without affecting fish behavior. However, it is necessary when using this method to monitor closely the nitrite peak at the beginning of the process. Monitoring the breakdown of the calcareous maerl is also necessary to prevent excess sulfate production and to maintain adequate pH as the calcium concentration increases.

References may be requested from Aquarium Systems, Inc. by phoning 800-822-1100, or by visiting info@aquariumsystems.com.

8141 Tyler Blvd., Mentor, OH 44060.
Website: http://www.aquariumsystems.com
Email: info@aquariumsystems.com