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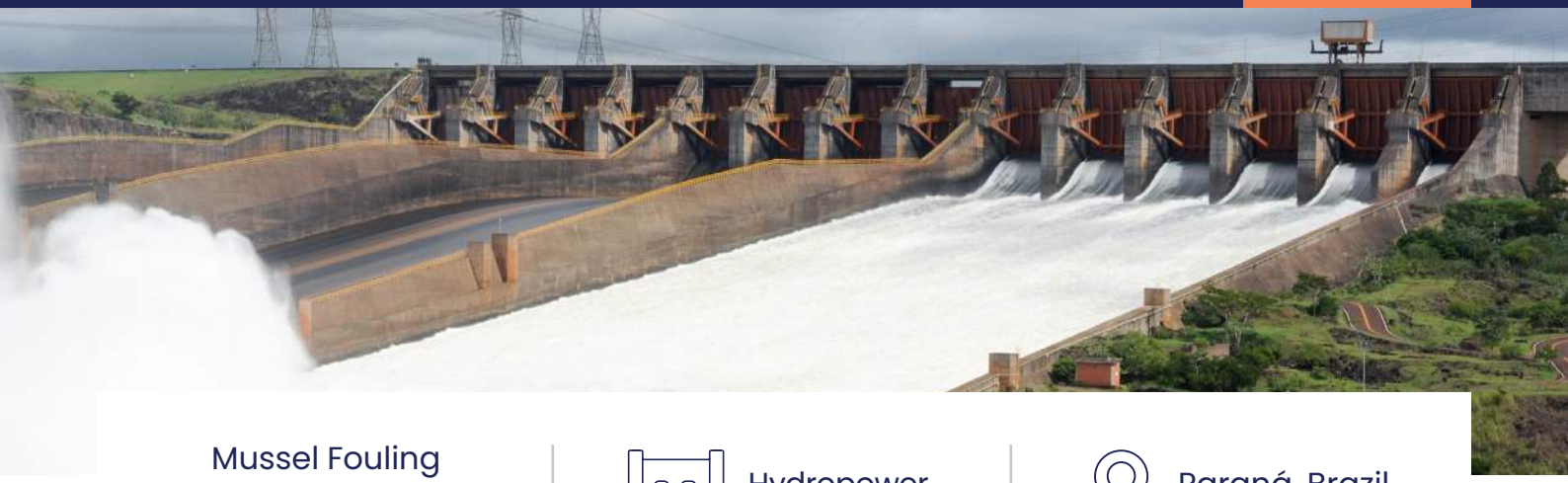
Case Study



Mussel Fouling Prevention | Hydropower | Paraná, Brazil

Controlling Biofouling in Governador José Richa Power Plant, Brazil

Background

An extensive study was carried out between May 2022 and July 2023 to evaluate the ability of the HOD™ (Hydro-Optic Disinfection) HOD UV system to control biofouling in the Governador José Richa Power Plant owned by Companhia Paranaense de Energia (COPEL), located on the Iguaçu River, Paraná, Brazil. The plant has four 310 MW generating units totaling 1240 MW.

UV radiation is widely used to eliminate microorganisms in water and has a history of many studies for its use in water for human consumption, without causing damage to water quality. The HOD UV system has already been reviewed by federal agencies (Oficio MAPA No. 57/2018/CGAA and Oficio IBAMA No. 336/2020/DIQUA) to authorize its use.

The Solution

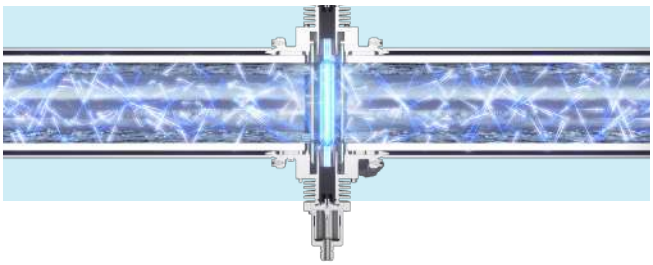
The pilot installation at the Gobernador José Richa Plant featured Atlantium's HOD UV system.

Atlantium's patented Total internal Reflection (TIR), which maximizes the UV light energy, ensures homogeneous UV dose distribution, and offers superior efficiency and power (kW) compared to traditional UV. The HOD UV system's TIR technology, similar to the principles of fiber optics, reflects the energy from UV light into the HOD UV chamber.

A key component of the installation was the HOD UV system's integrated monitoring and control system. This setup includes a dedicated UV sensor for each lamp, a built-in UV transmittance (UVT) sensor, and external feedback from a flow meter. These features work together to maintain the precise UV dosage required for the specific needs of the application. This level of control was crucial for achieving high-quality results, especially given the significant variations in water transmittance during the 12-month trial period.

To optimize performance, the installation also incorporated a 125-micron self-cleaning mesh filter before the HOD UV system. This filter effectively removes large particles and mussel shells from the water, preventing them from reducing the efficiency of the UV radiation by "shading" the microorganisms.

The pilot installation was conducted in generating unit 4 (310 MW), which continued using chemical products to control mussels, hydrozoa, and sludge. These contaminants were present in large quantities in the bearing cooling system's water line, causing maintenance issues. The HOD UV system proved effective in addressing these challenges, demonstrating its advantages in maintaining efficient and reliable operation.



The project was executed in three stages:

1. Over a period of 12 months, monthly samples were collected from 9 BioBoxes. These included 1 raw water sample and 8 samples distributed at the inlet and outlet of the cooling systems of each of the plant's four generating units. These samples were then analyzed at the laboratory of the Federal University of Paraná (UFPR).
2. At the end of the 12-month period, the plant was shut down for scheduled maintenance. During this time, the cooling systems were opened, inspected, and analyzed in situ.
3. Comprehensive analysis of the plant's heat exchanger maintenance data.

HOD UV system consisting of a filter plus the HOD UV system installed in the cooling system of generator unit 4 of Governador José Richa Power Plant

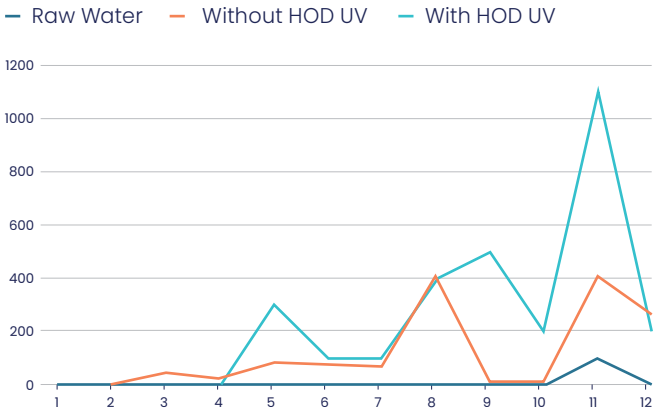
BioBox installed in the cooling system of the Governador José Richa Power Plant

Results

Stage 1: Presence of Mussels on Sample Plates

The plates analyzed monthly in the laboratory showed a variation in the presence of mussels over time.

Variation in the number of mussels over 12 months



As shown in the above graph, the data collected over the 12 months show a monthly variation in the number of mussels. The first data collection was in June 2022. In the third collection (August 2022), the first individuals began to be visualized and a first peak of larval recruitment occurred in collection 5 (October 2022). Recruitment is the time when the species reproduces more intensively and releases larvae into the water in greater numbers.

As of collection 8 (January 2023), a large and prolonged process of larval recruitment began and continued until collection 11 (April 2023). It is common for the species to show two recruitment peaks throughout the year: a smaller one in early spring and a larger one in early summer, which is consistent with the results obtained.

The expected summer peak occurred later and lasted longer, possibly due to heavy rains in the spring that caused changes in water turbidity and in the supply of phytoplankton, which is what the golden mussel mainly feeds on. Even so, it was possible to clearly identify recruitment times.

The 12 plates in BioBox 1 had no control treatment with raw water from the reservoir for 12 months. This accounts for the higher number of mussels in this BioBox. BioBoxes 2, 3, 4, 5, 6, 7 and 8 were not treated with UV radiation and BioBox 9 had water treated with the HOD UV system.

BioBox 2 | BioBox 4 | BioBox 6 | BioBox 8 | BioBox 9 (HOD UV)

Microscopic photographs showing the absence of hydrozoa on the BioBox 9 plate compared to the others

Number of mussels per square meter, per treatment

Months	Raw Water	Without UV	With UV
1	0	0	0
2	0	0	0
3	0	42.8	0
4	0	28.5	0
5	300	85.71	0
6	100	85.71	0
7	100	71.4	0
8	400	414.2	0
9	500	14.28	0
10	200	14.28	0
11	1100	414.2	100
12	20	271.4	0
Total	**226.67**	**120.21**	**8.33**

Biofouling % reduction

Raw Water	0%
Without UV	50.5%
With UV	96.7%

The table shows the difference between these 3 treatments, where it is clear that the golden mussel is better controlled by the HOD UV system: throughout the 12 months of the experiment, BioBox 9, with the HOD UV system, presented only one specimen of golden mussel in collection 11 (April 2023).
This table shows the average number of mussels per square meter in the three treatments. (Note: in this average, the data from the BioBox that presented water circulation problems during the experiment were excluded.)

With respect to BioBox 1, with raw water as the worst-case scenario for the number of mussels on the plates, the table shows the percentage of biofouling reduction of the two control methods tested.

The lower presence of hydrozoa in BioBox plate 9 of collection number 6, which was a common occurrence throughout the experiment is seen in the table showing the reduction in biofouling expressed as a percentage.

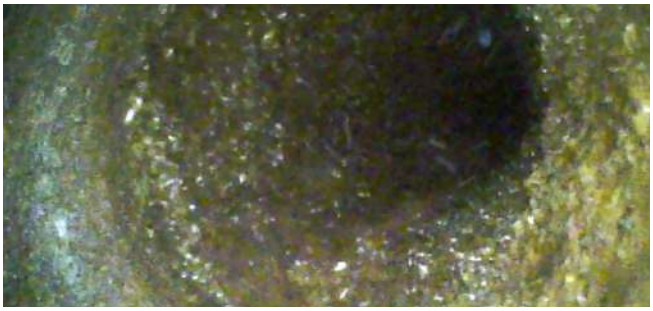
Stage 2: Pipe Scraping

The pipe points located before the HOD UV system showed high densities of adult mussels, slime, and hydrozoa. On the other hand, the points selected after the HOD UV system showed low or no presence of these fouling organisms, which evidenced the positive effect of the HOD UV system for biofouling control.

The pipe scraping before the HOD UV system showed a density of 126,600 mussels/m^2 while the pipe scrapings after the HOD UV system showed an average density of 2,844 mussels/m^2, where several points had no fouling organisms and indicated an estimated biofouling reduction of 97.75%.

Weighing the scraped material was also important in making it possible to count the number of hydrozoa and to establish the amount of ferruginous sludge. The weight of the scraped material corresponded to the total amount of biofouling in the pipeline, considering all organisms: In the pipe before the HOD UV system, this weight was 35.5 g per 100 cm^2, while the pipes after the HOD UV system presented an average weight of 2.35 g per 100 cm^2, with an average mussel reduction of 93.3%.

A borescope was used at strategic points, where it was not possible to perform scraping, showing the same results: the points studied before the HOD UV system showed high densities of mussels, hydrozoa, and sludge, as can be seen in the image captured by the borescope in the cooling pipe of the bearing, before going through the HOD UV system. At this point, in addition to the image, it was possible to collect a layer of organisms adhered to the pipe.



Boroscopic photo showing large amounts of mussels, sludge and hydrozoa in the pipe, before the HOD UV system

Spots inspected after the HOD UV system showed few or no attached organisms.

Borescope photo without mussels, mud, or hydrozoa in the bearing pipe after the HOD UV system. The stains shown in the photo correspond to old corrosion in the piping.

Stage 3: Analysis of the plant cooling system cleanliness data

COPEL monitors all the heat exchangers in the bearing line daily, and the data were analyzed together throughout the experiment. After analyzing all the data, it was found that the increase in the pressure differential of the heat exchangers during the experiment period was slower in generating unit 4, where the HOD UV system was installed.

The data collected showed that the increased rate of the pressure differential (ΔP) of the bearing cooling system between cleaning periods, with a gradual increase in pressure differential (or "fouling rate"), was 70% slower in generating unit 4, where the HOD UV system was installed, thus showing that the other generating units had more fouling organisms and thus increased the pressure differential faster, requiring more frequent cleaning. The strut bearing data show that the gradual pressure rise was 25% slower in generator unit 4 with the HOD UV system.

Analyzing the data for the Unit 4 bearing before the start of the experiment in 2021, we see a significant improvement in the number of cleanings. With the installation of the HOD UV system in Unit 4, the increase in pressure differential (or "fouling rate") was 78% slower All stages were conducted satisfactorily and presented consistent data, which made it possible to draw scientifically supported conclusions.

Throughout the study, it became clear that the HOD UV system had a positive effect on the control of golden mussels, ferruginous sludge, and hydrozoa in the cooling system of the Gobernador José Richa Power Plant.

Lower Biofouling, Less Maintenance

In the 12-month study with the BioBox, the result of the number of mussels and the weight of hydrozoa and sludge was significantly lower in the BioBox 9 plates with the HOD UV system. Opening the cooling system for inspection at the end of the experiment also showed a lower amount of biofouling in the pipes located after the HOD UV system. Lastly, the analysis of the cleaning data of the heat exchangers of the four generating units of the plant showed a lower need for maintenance in unit 4, in which the HOD UV System was installed.

The results of the experiments and analyses carried out during the 13 months led to the same conclusion: the HOD UV system is effective for the purpose tested and can replace the chemical methods used so far, causing less environmental impact and even increasing the efficiency of biofouling control in cooling systems.

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About us

For more than two decades, Atlantium Technologies has helped to ensure water safety with its innovative HOD™ (Hydro-Optic Disinfection) UV technology and novel approach to performance, monitoring, and control. Atlantium's superior, environmentally friendly water treatment solutions ensure stable, efficient, and dependable production.

With thousands of full-scale installations for leading brands in various industries globally, we're committed to consistently meeting our customers' water quality needs, ensuring pure results.

Pure Performance

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