Thank you for your comment, Dennis Bitter.

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Attachment: 2 CASE STUDY RNT Whitepaper AIS control HOD Science.pdf

Comment Submitted:

This note is to bring awareness to an emerging UV science for AIS. The USBR has found and validated a very affective UV technology from a Company named Atlantium Technologies to control invasive mussels. The science is very unique in that it has performance and acceptances not seen by any other UV technology. It has a high efficacy with optimum power usage to deliver a very effective dose. Recently, the USBR has studied the science to control AIS in the lower Colorado river. Attached is a brief white paper from RNT consulting. A full scale trial was conducted this last summer and the final report will be released early 2014.

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# Use of Atlantium UV Technology as Means of Biofouling Control

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## Introduction

Biofouling is the generic term used for the process of deposition of living organisms and inorganic material onto all surfaces submerged in either marine or freshwater environments. The first to attach to most materials immersed in water are bacteria, followed by microscopic plants and animals (algae, protozoa and fungi). This assembly of organisms produces a biofilm, which is the slime layer covering the surfaces of all materials submerged for a period of time. This process is frequently referred to as "*microfouling*". The rate of formation and the composition of the biofilm depends on the season, the ambient water quality and the nature and composition of the material immersed. The sticky "slime layer" also traps particles of sand and clay present in the water, thereby further increasing the thickness of the biofilm.

Once biofilm is present, secondary "*macrofouling*" can proceed. Depending on their presence or absence in the environment, larger plants and animals will settle onto the surface (hydroids, bryozoans and macroscopic algae attach first, followed by sponges, mussels, clams, barnacles and tube building worms). In marine systems the primary macrofoulers of concern are blue mussels, oyster and barnacles. In freshwater systems, dreissenid mussels (zebra and quagga mussel), asian clams and golden mussels are the main macrofoulers.

The impact of biofouling on once-through industrial cooling systems is profound. The biofilm formation on the inner surfaces of cooling systems results in reduction of heat-transfer capability and increased frictional resistance. The presence of macrofoulers such as mussels, clams or barnacles further increases the frictional resistance of flow, sometimes even blocks the flow completely.

In 1980, Thackery estimated that biofouling of heat exchangers cost the electric power plants in U.K. between $750 million and $1.5 billion annually. Chow (1985) estimates the losses due to biofouling at an 1150Mwe electric plant at $2 million annually. During the summer of 1998 several power-generating facilities on the Great Lakes experienced significant power losses due to biofouling of cooling water circuits by dreissenid mussels. One unit of a coal fired station on Lake Erie lost 55,335 MW hours between June and September 1998. Prices for electricity fluctuate between $20 and $100/MW hour, therefore this lost production equals to $1.1 and 5.5 million. Also in 1998, a nuclear plant on the south shore of Lake Ontario recorded losses of power due to biofouling estimated at 70,200 MW hours ($1.48M and $7M.)

Chemical treatment of the raw water is the preferred choice of most industries for the prevention of biofouling. The most frequently used chemical is chlorine, either as chlorine gas or sodium hypochlorite solution. When added to the incoming water at concentration of 0.3 to 0.5 mg/L as Total Residual Chlorine (TRC), it minimizes both microfouling and macrofouling of the systems treated. Chlorine is inexpensive, easy to obtain and easy to use. However, due to the increasing environmental concerns surrounding the use of chlorine (primarily due to, formation of carcinogens such as trihalomethanes (THC), regulators in Canada and in the U.S. have been placing ever more stringent requirements on the use of chlorine in water streams returning to the natural environment, encouraging industrial users to seek alternate means of biofouling control.

In other applications such as reverse osmosis (RO) desalination, the use of biocides, particularly chlorine, is widely practiced despite documented evidence that although biocides may be advantageous in controlling microbial counts in the water, in some cases they can actually exacerbate biofouling of the membranes.

UV is one of the most promising technologies available for control of biofouling. UV has no known deleterious environmental effects and does not require discharge permit for water treated.

**Protection of RO Membranes**

A ground breaking field study on UV based biofouling control was conducted at a brackish water reverse osmosis (BWRO) desalination plant treating groundwater in the northern Israel. Medium pressure UV was applied as a pre-treatment disinfection step prior to RO desalination (Harif et al, 2011). Two double stage desalination trains that operate in parallel were chosen for the study. One train served as control with no treatment applied, while the other train had an Atlantium HOD™ MP-UV system installed prior to the RO membrane. Both trains were run in parallel for a period of four months. At the end of the experiment sacrificial membranes placed in front of the first RO stage on each train were removed and examined. The results of the study suggest that MP-UV pre-treatment prolonged the train performance. The prolonged train perfomance manifested itself in a lower relative normalized permeate flux decline and significantly fewer extracellular polymeric substances were found on the RO membrane which received MP-UV treated water. Further, the UV treated membrane had thinner biofilm with lower species diversity and lower overall cell density counts (cells/cm2) then the untreated membrane. The authors concluded that pre-treatment disinfection using MP-UV may be a promising option for combating biofouling of RO membranes and prolonging operation of the trains between cleaning events.

**Control of Marine Macrofouling**

Another unique experiment testing the effect of medium pressure UV on macrofouling prevention in sea water environment was carried out between July 2011 and May 2012 in Israel. The experiment took place at the Israel Electric Corporation Orot Rabin site in Hedera. Atlantium HOD™ MP-UV RZ163-14 system was installed prior to a heat exchanger prone to severe macrofouling caused by settlement of barnacle and mussel larvae present in the raw seawater (Fig.1). An identical but unprotected heat exchanger in a parallel system was used as control. Both heat exchangers were cleaned manually just prior to the start of the experiment.

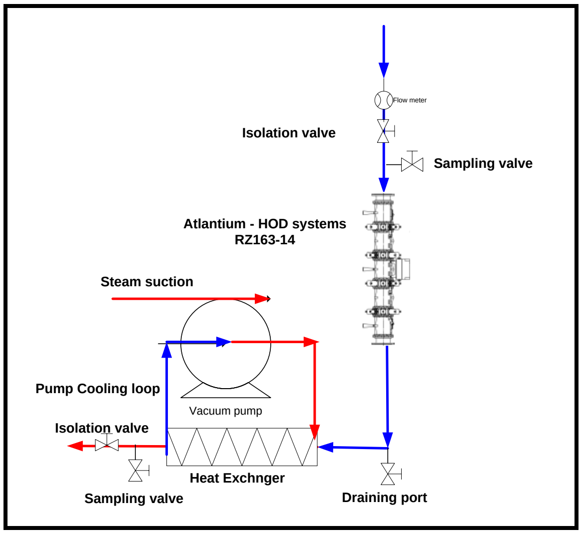


Fig.1 Schematic of the experimental installation

After six month of continuous operation both heat exchangers were inspected. The heat exchanger used as the control had high level of macrofouling (Fig.2), while the heat exchanger protected by Atlantium HOD™ MP-UV RZ163-14 system was almost pristine (Fig.3).

Fig.2 Control Heat Exchanger after six month of operation.

Fig.3 UV protected heat exchanger after six month of operation.

This study concluded that treatment of raw water with Atlantium HOD™ MP-UV prior to heat exchangers can minimize macrofouling, improve heat exchanger performance and substantially increase the time between maintenance cycles.

**Control of Freshwater Macrofouling**

Since the introduction of zebra and quagga mussels into fresh waters of North America, macrofouling in industrial systems carrying raw water has become as much of a problem as macrofouling in salt water systems. Several studies carried out in the 1990's have shown that flow-through UV systems have the ability to prevent attachment of zebra and quagga mussel larvae (veligers) to downstream surfaces. Most of the trials were done on the Great Lakes and involved relatively small volumes of water (Lewis and Whitby 1993, Chalker-Scott et.al 1993, Chalker-Scott et.al 1994, Evans et.al. 1995, Lewis and Whitby 1996, Lewis and Cairns 1998). The available body of evidence suggested that medium pressure lamps with UV wavelengths between 200 and 400nm will inhibit downstream settlement of dreissenids if the veligers are exposed to a radiation dose of approximately 100 mW-s/cm$^2$.

In 2012 Atlantium Technologies sponsored an evaluation of Atlantium HOD™ MP-UV as preventative treatment for the settlement of quagga mussel veligers. This study was carried out by an independent consultant, RNT Consulting Inc. on the Lower Colorado River. Four separate experiments were done between May and September 2012.

Water from the Colorado River containing many quagga mussel veligers was drawn into the flow through field laboratory. Ahead of the UV system was a small settling tank equipped with 12 settling plates (Fig.4). From the settling tank the raw water entered the Atlantium UV system assembly where it was exposed to a pre-set UV dose.


Fig.4 Settling tank and the UV system

After irradiation the water exited the laboratory, travelled through a 2 inch PVC pipe for approximately 75 feet to a set of eight settling drums. The first settling drum contained water approximately 5 minutes after irradiation, drum number 5 was 10 minutes and drum number 8 contained water 18 to 20 minutes after exposure. From drum number 8 the water was discharged back to the river.

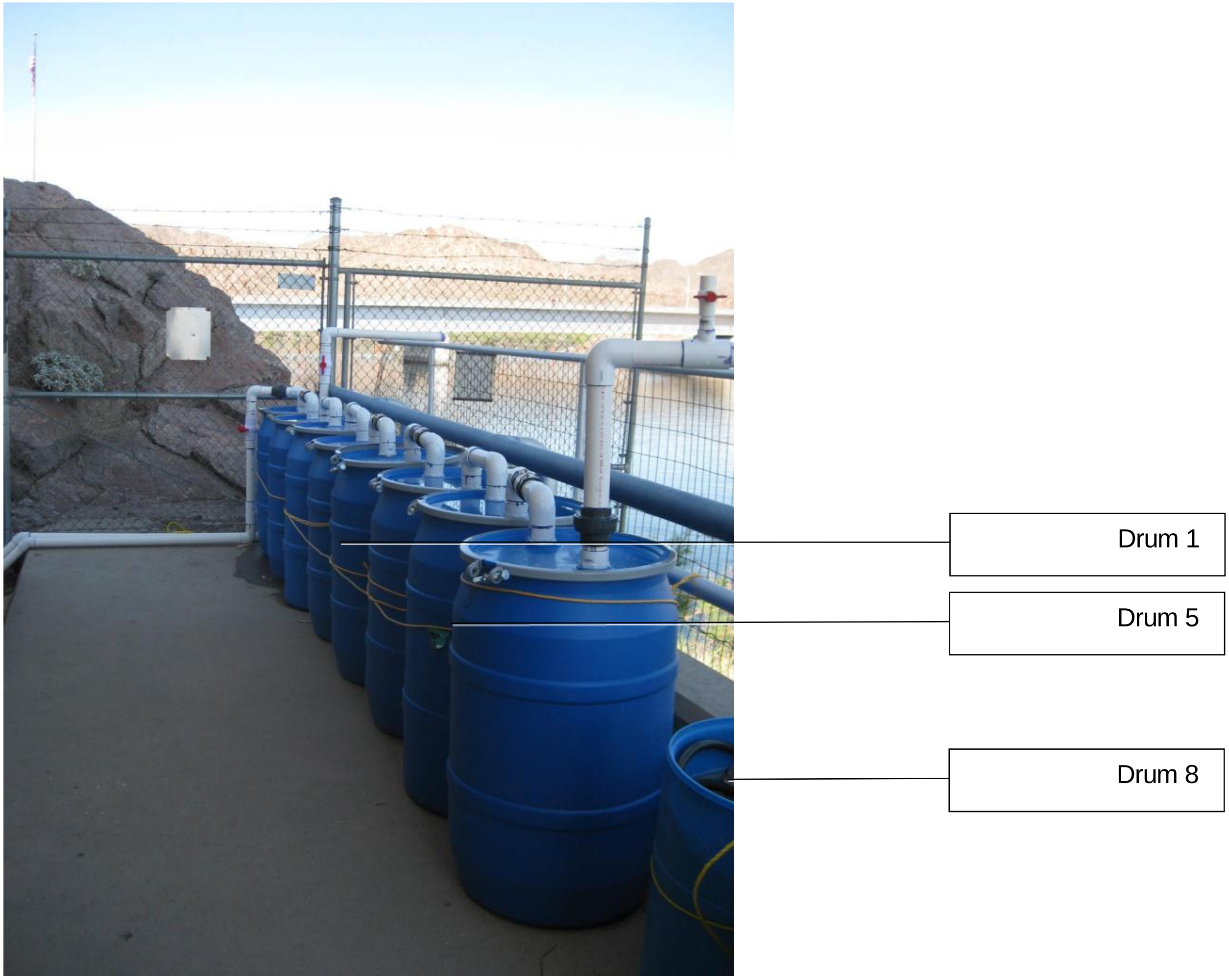


Fig.5 Settling drums

Drums 1,5 and 8 each contained twelve settling plates. The settlement plates were identical to those deployed in the pre-UV settlement chamber.

Four separate experiments using different UV dose were carried out between June and September 2012. Veliger settlement past the UV lights was decreased by 98% to 99% in all four experiments (Fig.6). These results are particularly impressive as the objective of the experiment was to find the lowest possible UV dose capable of preventing majority of settlement and well below the generally accepted prevention dose of 100 $mW\text{-}s/cm^2$.

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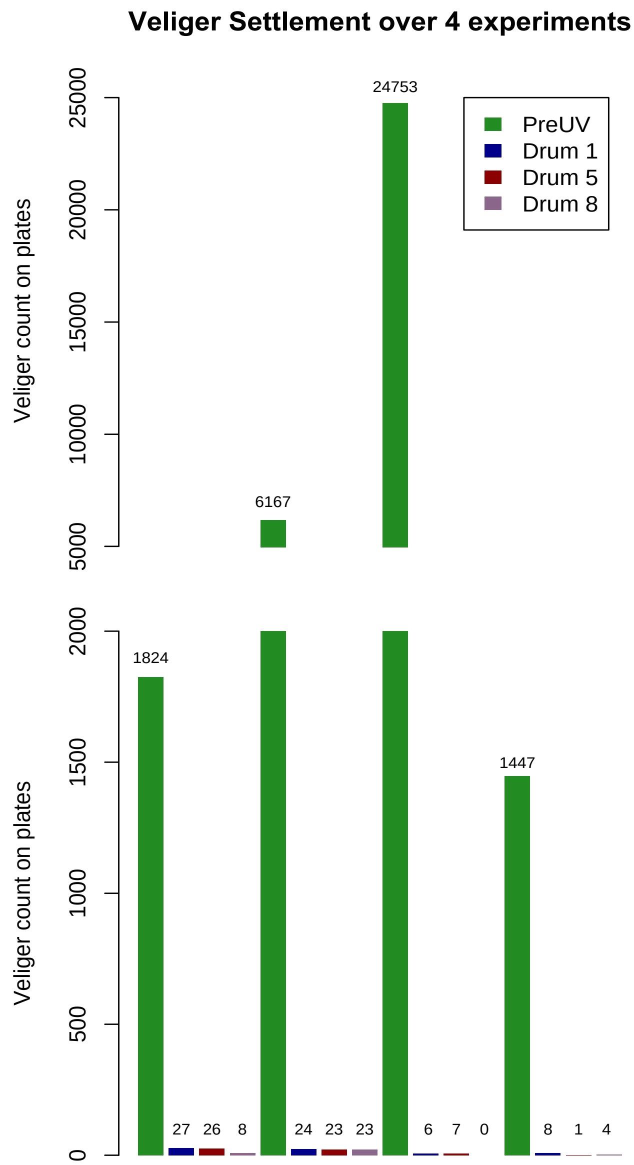


Fig.6 Overview of veliger settlement on plates in each of four settlement tanks, before and after UV treatments of varying strengths (Experiment 1 through 4, left to right).

## Summmary

Medium pressure UV systems can be successfully used to minimize micro and macrofouling in raw water systems.

It is important to note that all the studies discussed in this paper have been obtained using an innovative and proprietary Atlantium HOD™ MP-UV system. The manufacturer claims it is the "sum of the sciences" working together that make the system different based on three unique features;

A patented inner quartz sleeve which recycles the UV energy produced to completely "fill" the reaction chamber delivering the desired UV dose to every particle which may be passing

Medium pressure lamps which can be tuned by software to provide the desired dose under changing conditions of water transmissibility

Patented logic and controls which rely on input from two sensors per each lamp to optimize the specific required dose throughout the chamber.

Other medium pressure UV system may deliver similar results but the results of these experiments can only be guaranteed when using Atlantium HOD™ MP-UV.

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