ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT, ZONE 7
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ORIGINATING SECTION: WATER QUALITY
CONTACT: Gurpal Deol/Brian Keil

AGENDA DATE: October 21, 2015 ITEM NO. 17g

SUBJECT: Removal of Algal Toxins from the South Bay Aqueduct Water - Bench-Scale Study

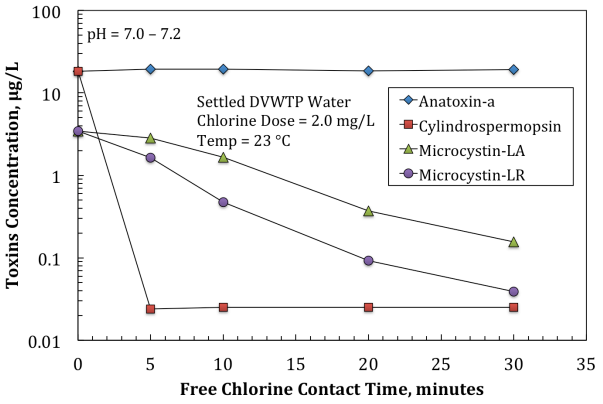
SUMMARY:

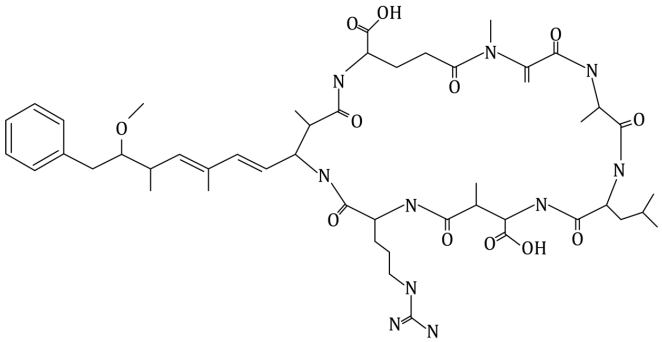
- In response to a recent cyanobacteria bloom in Lake Erie, the USEPA has established health advisories (HAs) for two cyanotoxins: microcystin and cylindrospermopsin. The USEPA developed two 10-day HA levels for each toxin: one for infants younger than 6 years old, and one for individuals 6 years and older. For more information, see: http://www2.epa.gov/nutrient-policy-data/cyanobacteriacyanotoxins
- In response to this new advisory, Zone 7, Alameda County Water District (ACWD), and Santa Clara Valley Water District (SCVWD) jointly funded a comprehensive bench-scale testing effort aimed at evaluating the efficiency of four different treatment technologies for the destruction or removal of cyanotoxins from South Bay Aqueduct (SBA) water.
- Water Quality & Treatment Solutions (WQTS) has completed the Study and the Final Report is available at: http://www.zone7water.com/images/pdf_docs/water_quality/algal-toxin-sba_final-1.pdf
- The Study concluded:
  1) Chlorine was highly effective at destroying cylindrospermopsin and was moderately effective at destroying microcystin to below the HA level under optimal conditions. A third cyanotoxin not addressed in the HA: anatoxin-a, was virtually unaffected by chlorine treatment.
  2) Powdered Activated Carbon (PAC) was found to be moderately effective at adsorption of the three toxins tested, but must be coupled with another treatment technology for effective control.
  3) Chloramine was infective against the three types of toxins tested.
  4) Ozone was found to be highly effective at destroying all three toxins.

FUNDING:
The Study was funded from Fund 100 - Water Enterprise.

RECOMMENDED ACTION:
Information only.

ATTACHMENTS:
Executive Summary - Bench-Scale Evaluation of the Potential Destruction of Cyanotoxins with Treatment Technologies Applied to South Bay Aqueduct Water, October 5, 2015.





Bench-Scale Evaluation of the Potential Destruction of Cyanotoxins with Treatment Technologies Applied to South Bay Aqueduct Water

Executive Summary

Prepared for

Zone 7 Water Agency

Alameda County Water District

Santa Clara Valley Water District

WQTS
Water Quality & Treatment Solutions, Inc.
An environmental engineering and science consulting company

October 5, 2015

BENCH-SCALE EVALUATION OF THE POTENTIAL DESTRUCTION OF CYANOTOXINS WITH TREATMENT TECHNOLOGIES APPLIED TO SOUTH BAY AQUEDUCT WATER

EXECUTIVE SUMMARY

PREPARED FOR:

ZONE 7 WATER AGENCY
LIVERMORE, CALIFORNIA

ALAMEDA COUNTY WATER DISTRICT
FREMONT, CALIFORNIA

SANTA CLARA VALLEY WATER DISTRICT
SAN JOSE, CALIFORNIA

PREPARED BY:

WATER QUALITY & TREATMENT SOLUTIONS, INC.
LOS ANGELES, CALIFORNIA

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OCTOBER 5, 2015

EXECUTIVE SUMMARY

BACKGROUND

Cyanobacteria, formerly known as blue-green algae, are photosynthetic bacteria that are naturally present in lakes, streams, and most fresh water bodies. Under the right combination of environmental and ecological conditions, cyanobacteria can multiply into massive blooms. Many cyanobacteria produce trace chemicals that are toxic at low concentrations. These chemicals are commonly referred to as cyanotoxins, or algal toxins. The World Health Organization (WHO) has a provisional guidance value of 1 µg/L for total microcystin-LR, which is one of the most common types of cyanotoxins.[1] Cyanobacterial blooms have occurred in US water supplies for decades, but their occurrence has largely been limited to recreational waters. However, in 2014, a massive bloom in Lake Erie generated elevated levels of cyanotoxins that resulted in the breakthrough of 2.5 µg/L of microcystins into the City of Toledo's drinking water. Since this level exceeded the WHO's provisional guidance level of 1 µg/L, the City issued a "do not drink or boil" order for the tap water of half a million consumers. This event highlighted the vulnerability of drinking water to cyanotoxins.

Neither the USEPA nor the State of California currently has drinking water limits for cyanotoxins, and water utilities are not required to monitor for them in their water supplies. However, in response to the bloom in Lake Erie and its effect on the City of Toledo's drinking water, and after reviewing the available science, in 2015, the USEPA established health advisories (HAs) for two cyanotoxins: microcystin and cylindrospermopsin. The USEPA developed two 10-day HA levels for each toxin: one for infants younger than 6 years old, and one for individuals 6 years and older. The infant HA for microcystin was set at 0.3 µg/L, while that for cylindrospermopsin was set at 0.7 µg/L. Both levels are lower than the WHO guidance of 1 µg/L.

This study included a comprehensive bench-scale testing effort aimed at evaluating the efficiency of five different treatment technologies for the destruction or removal of cyanotoxins from South Bay Aqueduct (SBA) water. The study was funded jointly by the three SBA water users: Zone 7 Water Agency (Zone 7), Alameda County Water District (ACWD), and Santa Clara Valley Water District (SCVWD).

TESTING DESCRIPTION & RESULTS

Three water samples were collected and used in this study: A raw SBA sample collected from the influent to ACWD's WTP 2, a settled water sample from Zone 7's Del Valle Water Treatment Plant (DVWTP), and a settled water sample from SCVWD's Penitentia WTP. Each sample was spiked with approximately 10 µg/L of each of four cyanotoxins: 1) microcystin-LR, 2) microcystin-LA, 3) cylindrospermopsin, and 4) anatoxin-a. The raw SBA water sample was used for pre-ozonation testing and for PAC adsorption testing. The settled DVWTP water sample was used for chlorine and chloramine testing. The settled Penitentia WTP water sample was used for intermediate ozone

1 World Health Organization. *Guidelines for Drinking-Water Quality. 3rd Ed., Incorporating the first and second addenda, Volume 1, Recommendations*, Geneva (2008)

testing. Ozone, chlorine, chloramine, or PAC was added to each water sample at different doses, and some under different pH conditions. Cyanotoxin samples were then collected and analyzed using the LC/MS-MS method and the ELISA method calibrated to microcystin-LR.

CONCLUSIONS

The following table presents a summary classification of the effectiveness of each treatment technology against each type of cyanotoxin tested. A full circle indicates that the treatment technology is excellent at destroying or removing the toxin to below the HA levels, while an open circle indicates that it is ineffective against the toxin. A ¾-full circle suggests that the technology is could destroy the toxin to below the HA level, but may require a longer contact time or a higher dose than typically used. A half-full circle indicates that the technology is moderately effective, and needs to be supplemented by another technology in order to destroy the toxin to below the HA level.

Summary Classification of the Effectiveness of Each Treatment Technology for the Removal of the Cyanotoxins Evaluated in this Study

Technology	Microcystins	Cylindrospermopsin	Anatoxin-a
Ozone	●	●	●
Free chlorine	◕	●	○
PAC Adsorption	◒	◒	◒
Chloramine	○	○	○

● Excellent ◕ Good ◒ Moderate ○ Ineffective

"Excellent" = the technology can reliably reduce the toxin to below the HA level.
"Very good" = the technology is could destroy the toxin to below the HA level, but may require a longer contact time or a higher dose than typically used.
"Moderate" = the technology is moderately effective, and needs to be supplemented by another technology in order to destroy the toxin to below the HA level.
"Ineffective" = the technology did not reduce the toxins by any measurable amount under the conditions evaluated in this study.

As shown in above, the following is a synopsis of the findings of this study:

1. *Typical ozone doses used at SBA plants, whether on raw water or settled water, are highly effective at destroying all three types of toxins tested in this study.*
2. *Chlorine is highly effective at destroying cylindrospermopsin and virtually ineffective against anatoxin-a. Chlorine can destroy microcystins below the HA level, but requires longer contact time*

and can be assisted by a low(er) water pH compared to its effectiveness against cylindrospermopsin.

3. *Adsorption of the three types of toxins on Hydrodarco B (HDB) PAC was moderate. Effective control of toxins to below the HA levels requires coupling of PAC with another treatment technology.*
4. *Chloramine is ineffective against the types of toxins tested.*

Finally, one remaining challenge to the application of preozonation to SBA water within the context of cyanotoxins treatment is to develop an understanding of the ozone dose required to lyse the cyanobacterial cells that may be present in the raw water before the ozone can destroy the toxins that may be released from the inside of the cells. This study was not able to quantify this dose.