Algae, Cyanotoxins, and Taste & Odor

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ALGAE FORMATION

NATURALLY OCCURRING ORGANISMS THRIVE UNDER CERTAIN CONDITIONS:

- Sunlight (shallow depth)
- Warm temperatures
- Slow Moving Water (i.e. Lakes/Reservoirs)
- Elevated nutrients
  - Nitrogen
  - Phosphorous
  - Potassium

HARMFUL ALGAL BLOOMS (HABS)

Typical season duration = 3 to 5 months

Promote growth of cyanobacteria

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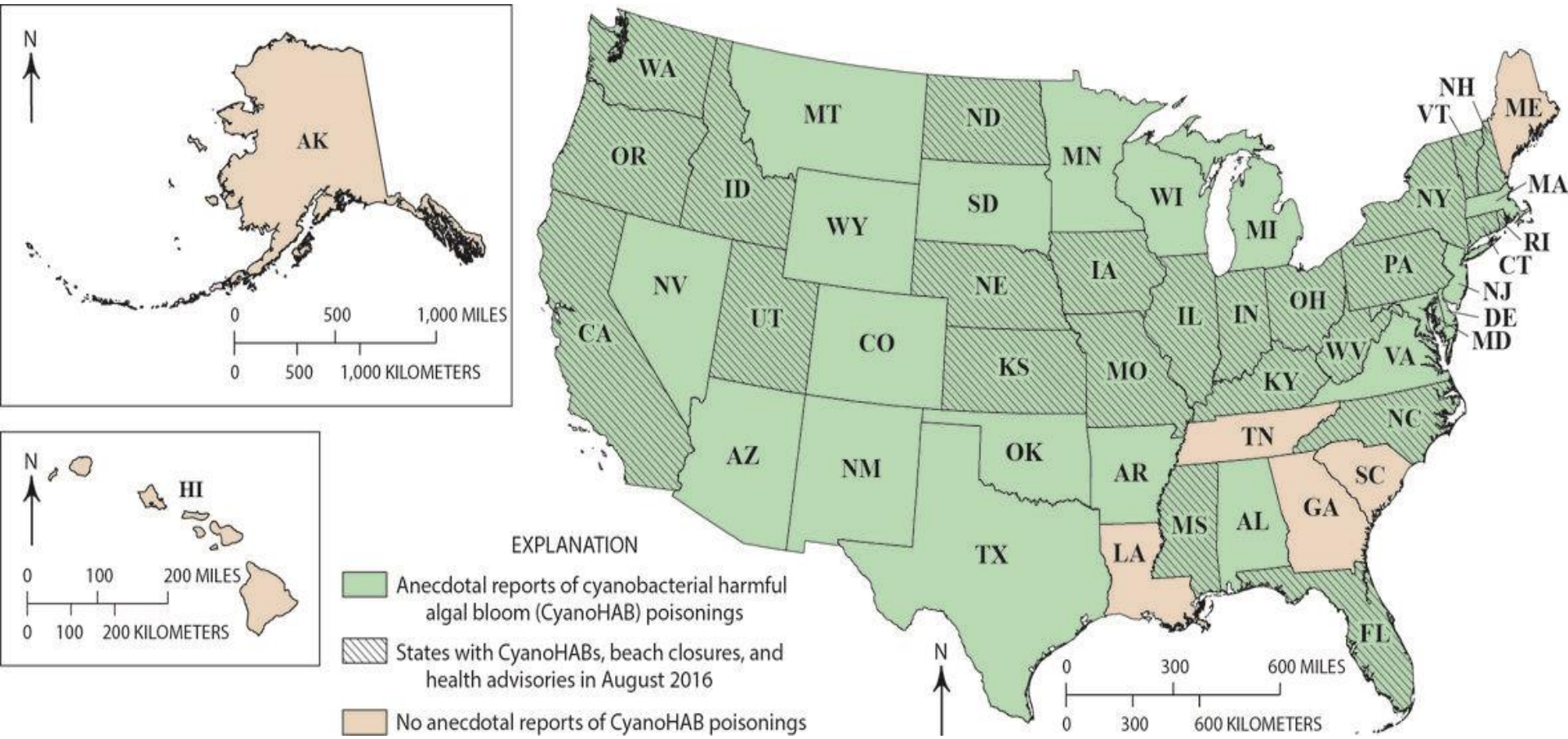
HARMFUL ALGAL BLOOMS IN THE US



https://www.usgs.gov/news/science-harmful-algae-blooms

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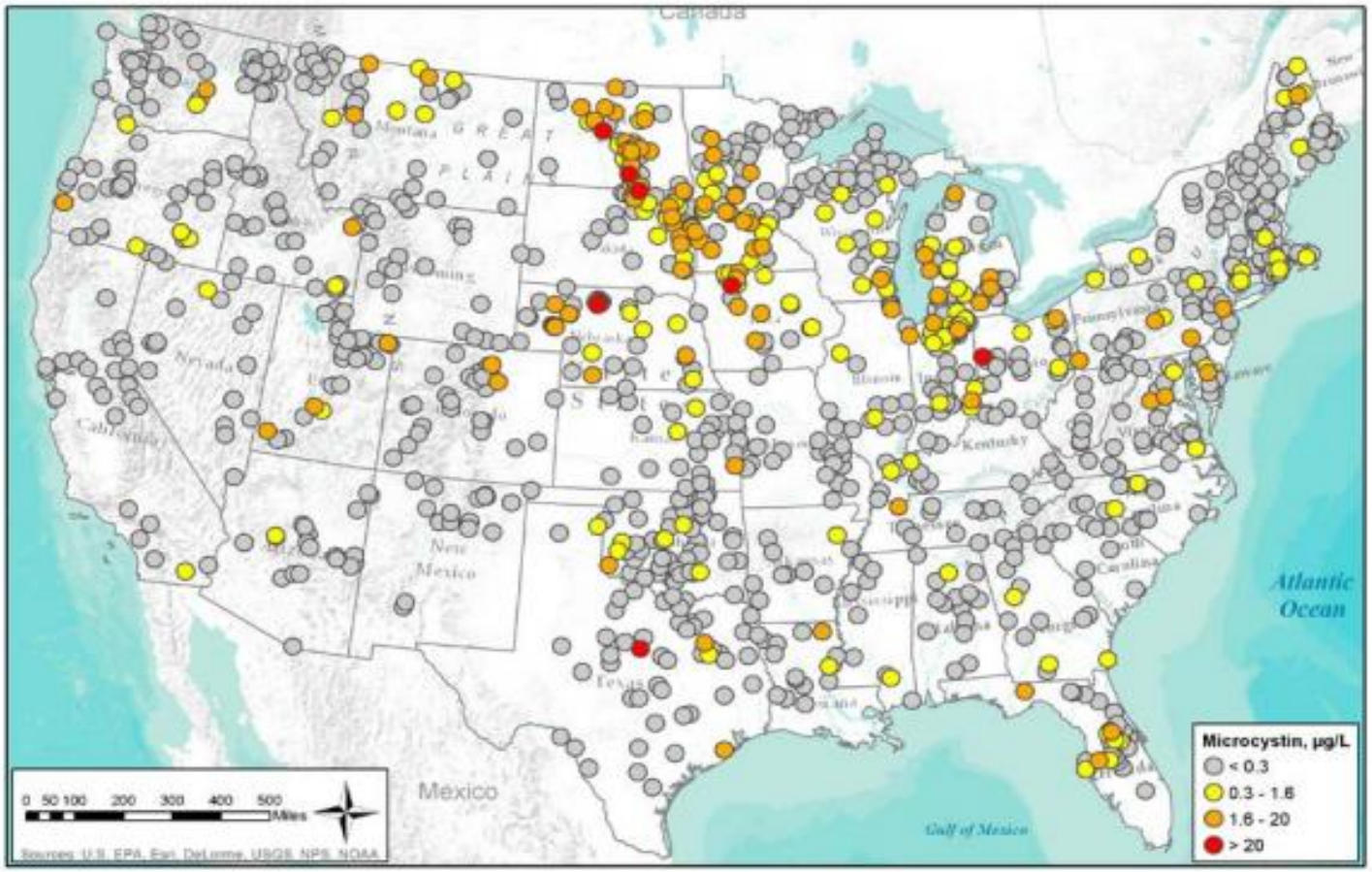
HARMFUL ALGAL BLOOMS IN THE US



https://www.awwa.org/Portals/0/files/resources/water%20knowledge/rc%20cyanotoxins/201609_Cyanotoxin_Occurrence_States_Approach.pdf

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Satellite Image of Blue-Green Algal Outbreak on Lake Erie, 2011

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TASTE & ODOR COMPOUNDS

TRANS-1,10-DIMETHYL-TRANS-9-DECALOL

- “Earthy” or “Dirt” odor
- OTC = 4 ng/L (ppt)

2-METHYLISOBORNEOL

- “Musty” or “Mold” odor
- OTC = 4 to 10 ng/L (ppt)

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CYANOTOXINS

BY-PRODUCT OF CYANOBACTERIA LIFE CYCLE

Over 3,000 known species

2 PRIMARY CLASSES:

- Hepatotoxin – affecting the liver
- Neurotoxin – affecting nerves & nervous system

3 PRIMARY TOXINS EVALUATED:

- Anatoxin-A
- Cylindrospermopsin
- Microcystin-LR

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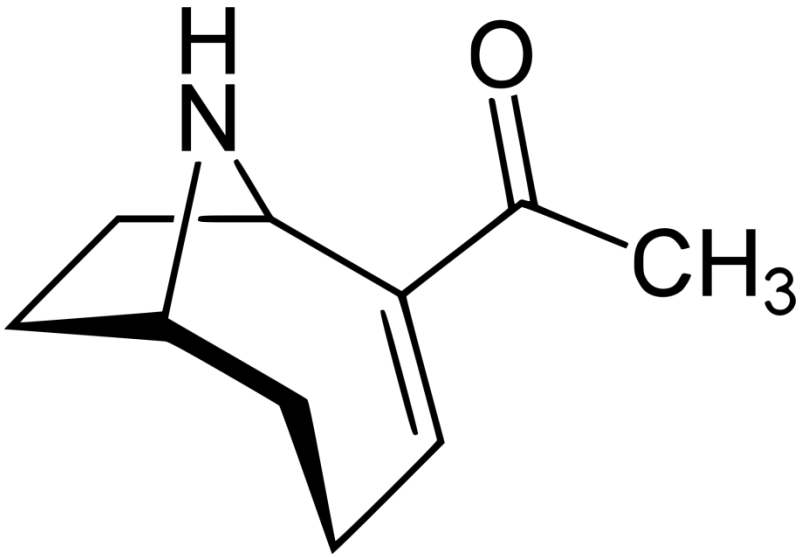
ANATOXIN-A

NEUROTOXIN



SYMPTOMS:

- Coordination loss
- Muscle spasms/convulsions
- Respiratory paralysis

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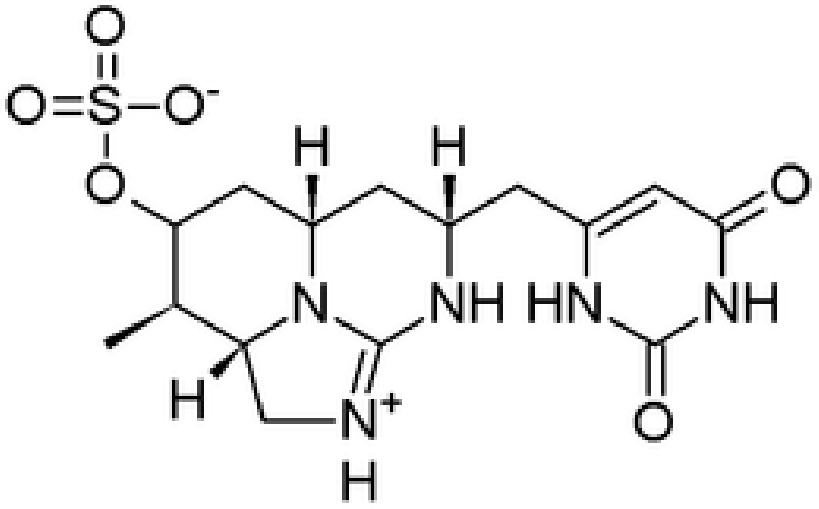
CYLINDROSPERMOPSIN

HEPATOTOXIN



SYMPTOMS:

- Nausea
- Diarrhea
- Liver damage/failure
- Kidney damage/failure

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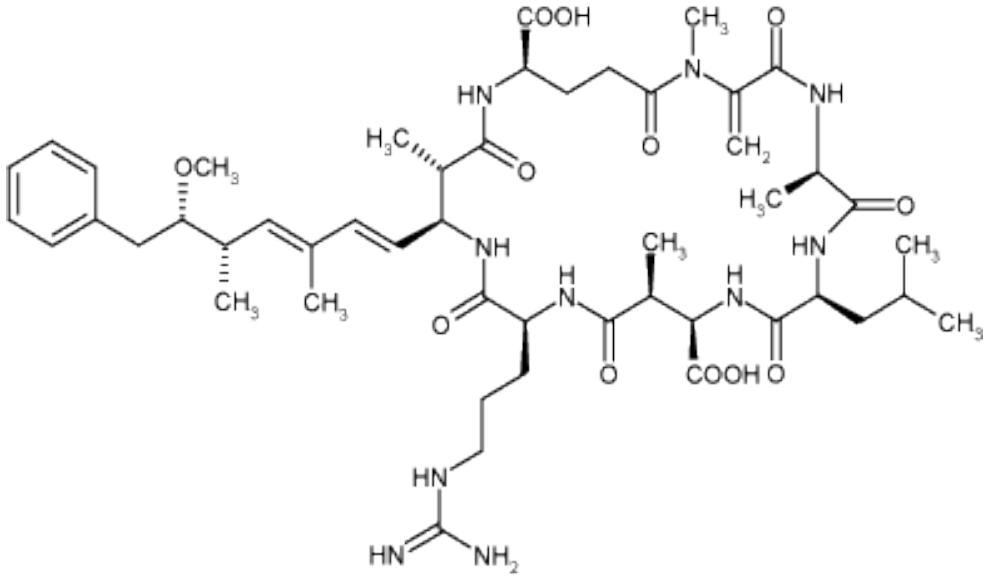
MICROCYSTIN-LR

HEPATOTOXIN



SYMPTOMS:

- Nausea
- Diarrhea
- Liver damage/failure
- Kidney damage/failure

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Control Strategies

Source Water or Reservoir Control

- Nutrient Management
- Reservoir Mixing
- Super-oxygenation

Treatment, Removal, Inactivation

- Chlorine Dioxide
- Ozone
- Advanced Oxidation
- Granular Activated Carbon Adsorption

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REGULATORY STATUS
TASTE & ODOR

NATIONAL SECONDARY DRINKING WATER REGULATIONS (NSDWR) ESTABLISHED BY THE US-EPA

Secondary Maximum Contaminant Levels (SMCLs) for 15 contaminants (nuisance chemicals)

- Cosmetic effects - Skin & Tooth Discoloration
- Aesthetic - Taste, Odor, Color

EPA RECOMMENDS SECONDARY STANDARDS TO WATER SYSTEMS BUT DOES NOT REQUIRE SYSTEMS TO COMPLY

States may enforce more stringently

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REGULATORY STATUS
CYANOTOXINS

Cyanotoxin	Drinking Water Health Advisory (10-day)	
	Bottle-fed infants and pre-school children	School-age children and adults
Cylindrospermopsin	0.7 µg/L	3 µg/L
Microcystins	0.3 µg/L	1.6 µg/L

USEPA HEALTH ADVISORY

Table 2. States guidance for cyanotoxins summary

State	Microcystins (µg/L)	Cylindrospermopsin (µg/L)	Anatoxin-a (µg/L)	Saxitoxin (µg/L)
Minnesota	0.1 [1]	NG[2]	NG	NG
Ohio [3]	0.3	0.7	20	0.2
Ohio [4]	1.6	3.0	20	0.2
Oregon [3, 5]	0.3	0.7	0.7	0.3
Oregon [4]	1.6	3	3	1.6

[1] Microcystin –LR
[2] No guidance
[3] Children under 6 and sensitive populations
[4] Children 6 and older and adults
[5] Oregon previously used WHO recommended levels for Microcystins, switching to USEPA levels due to HAs

STATE GUIDANCE

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T&O
CASE STUDY

CONTEXT

SURFACE WATER | West Palm Beach, FL

TOC/NOM PRESENT – 14 mg/L

TASTE & ODOR ISSUES –

- MIB = 40 ng/L
- GEOSMIN = 85 ng/L

EVALUATED PAC VIA JAR TESTING –

15 minute contact time

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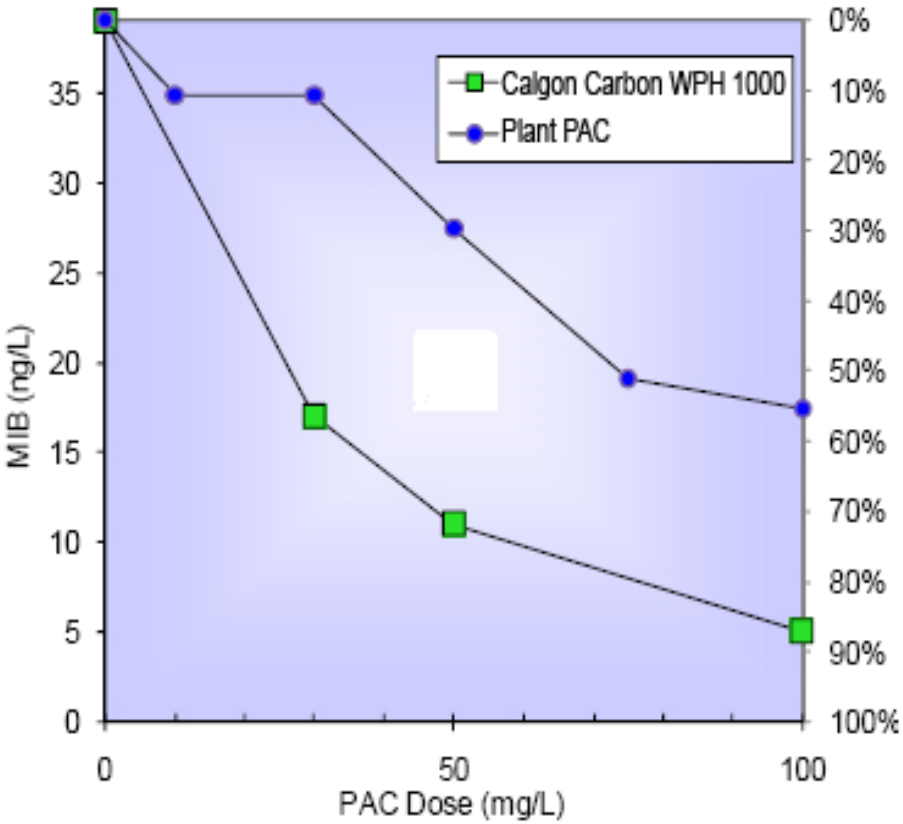
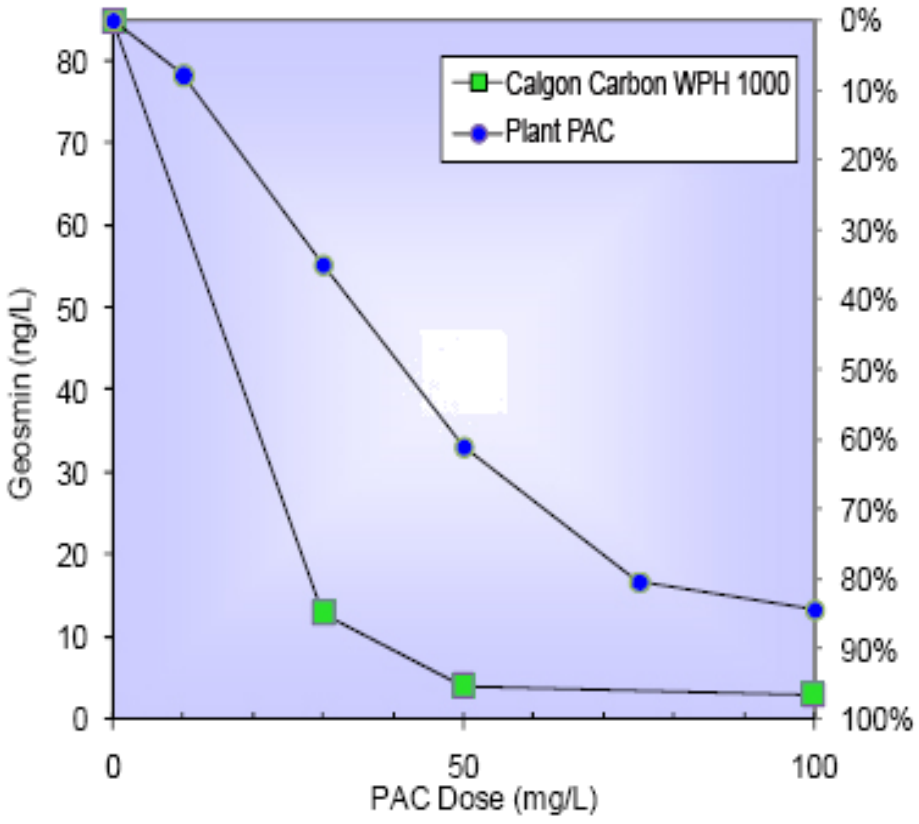
T&O CASE STUDY



MIB removal at varied PAC doses from raw water (low spike)



Geosmin removal at varied PAC doses from raw water (low spike)

City of West Palm Beach, Prepared by MWH June 2009

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CYANOTOXIN
CASE STUDY #1

SURFACE WATER

Upstream of GAC contactors

NOM/TOC PRESENT

Average feed = 2.1 mg/L

SPIKED WITH CYANOTOXINS

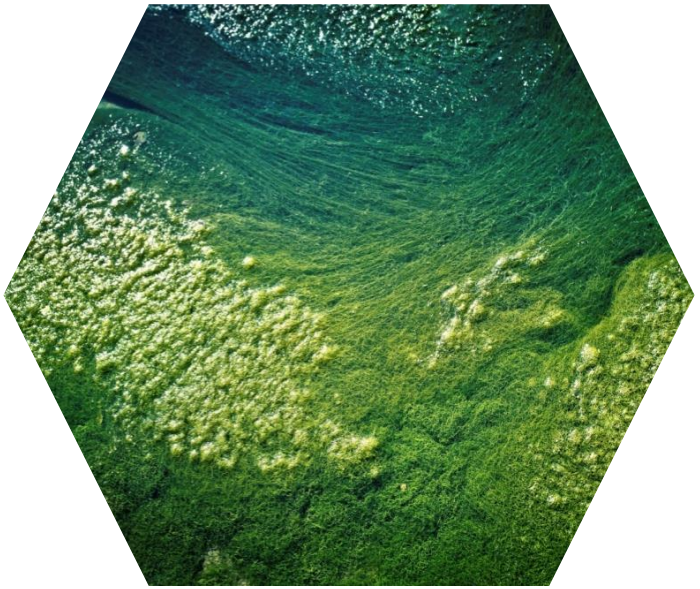
Anatoxin-A feed = 22 µg/L

Cylindrospermopsin feed = 55 µg/L

Microcystin-LR feed = 45 µg/L

CONTACT TIME (EBCT)

7 minutes



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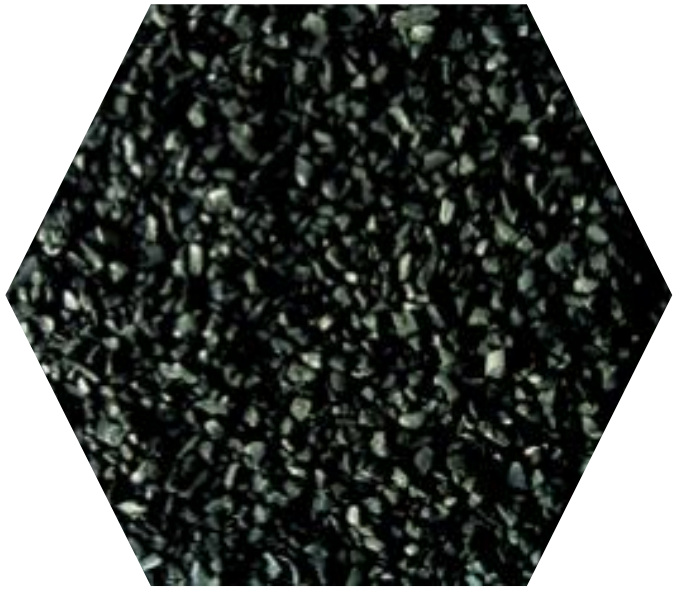
CYANOTOXIN
CASE STUDY #1

FILTRASORB 300

- Re-agglomerated bituminous coal
- 8x30 mesh
- 900 mg/g Iodine Number
- Virgin



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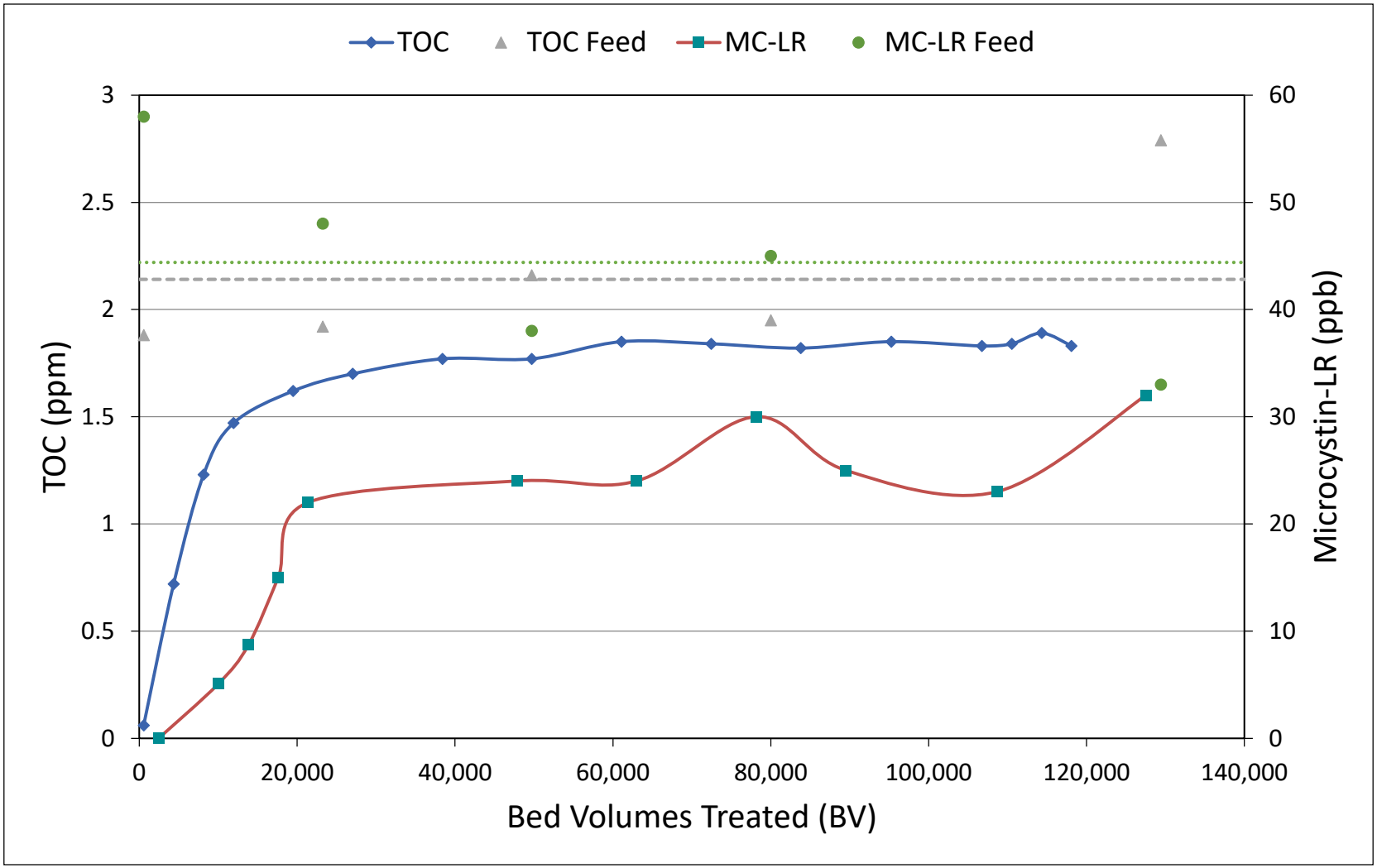
CYANOTOXIN CASE STUDY #1

MICROCYSTIN-LR



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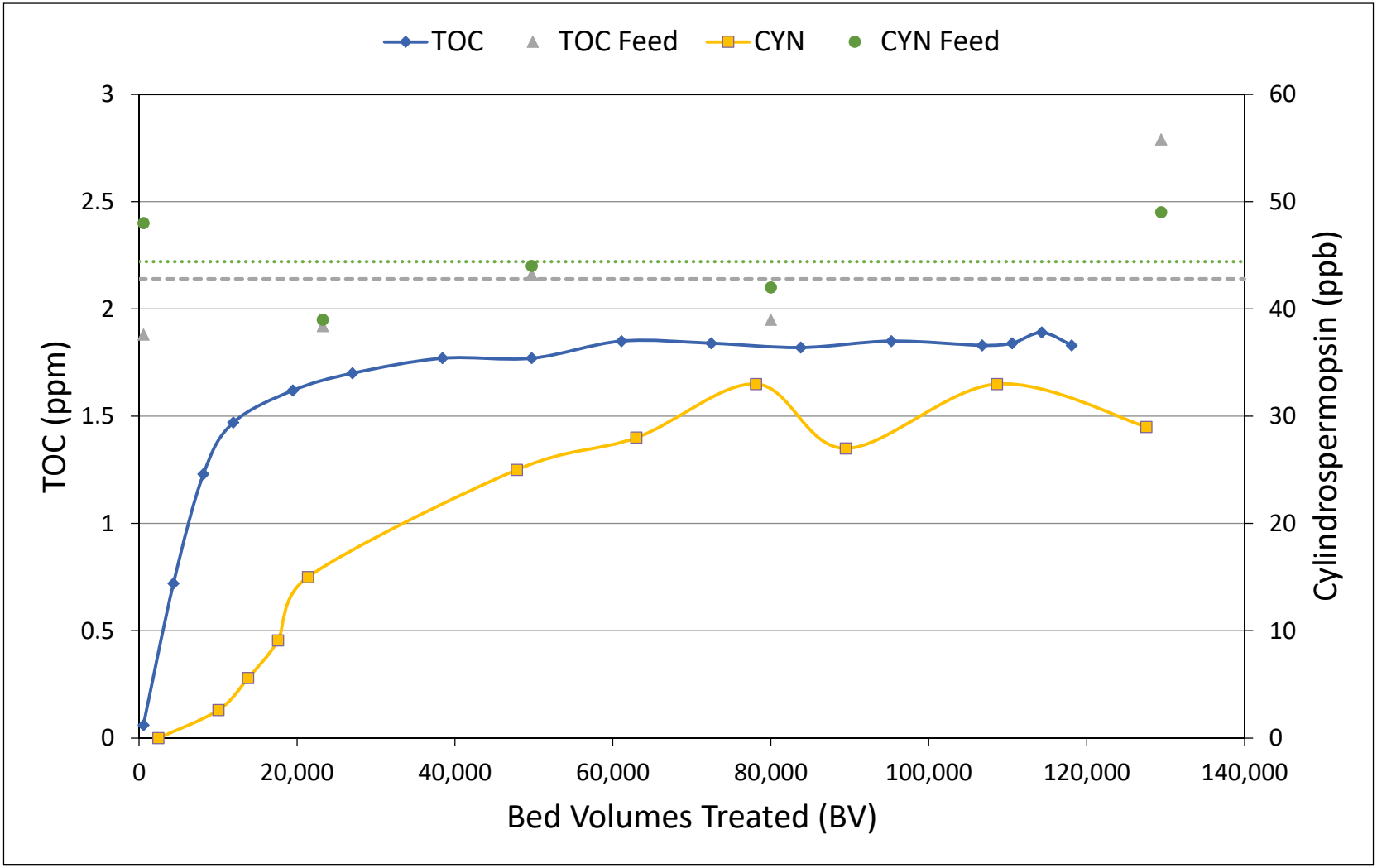
CYANOTOXIN CASE STUDY #1

CYLINDROSPERMOPSIN



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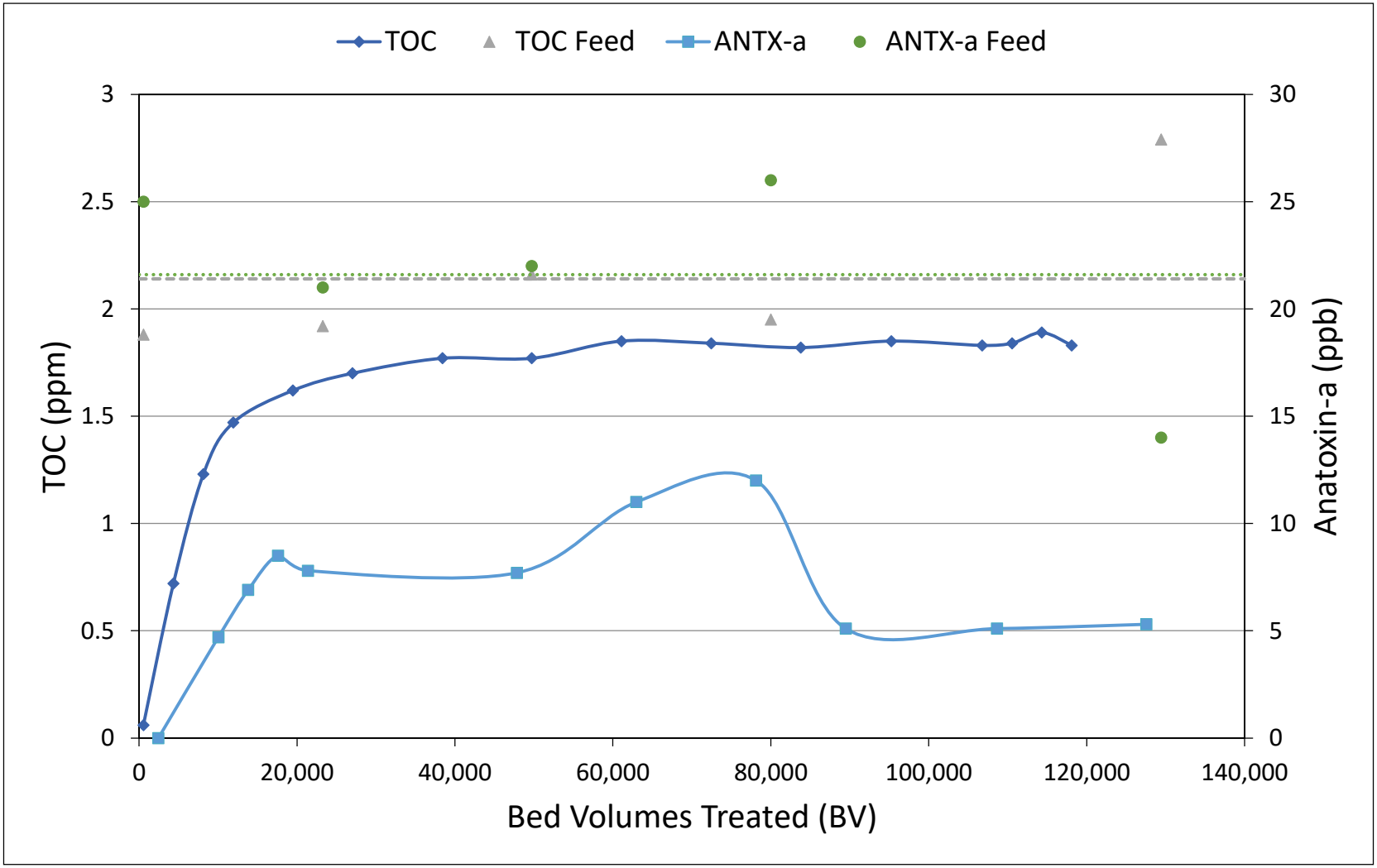
CYANOTOXIN CASE STUDY #1

ANATOXIN-A



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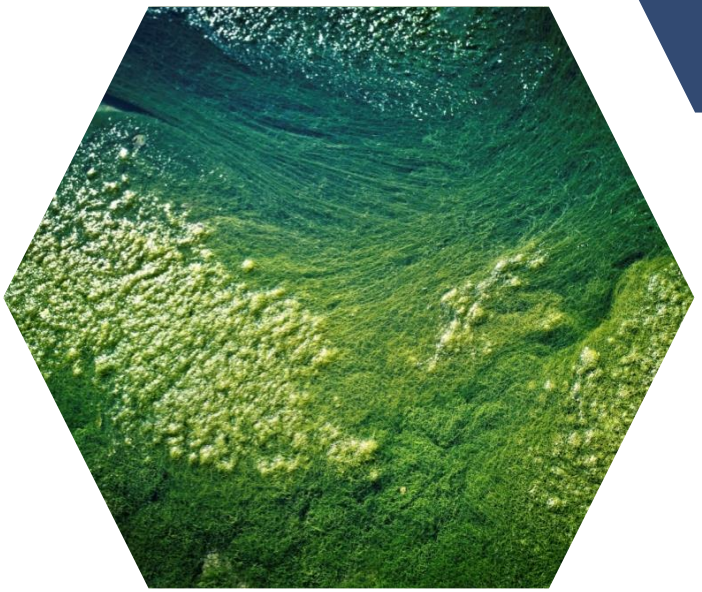
CYANOTOXIN
CASE STUDY #1

676 DAYS SIMULATED

245 million gallons water



CYANOTOXIN BREAKTHROUGH

Initial breakthrough = 52 days

50-70% breakthrough at conclusion

TOC BREAKTHROUGH

60% breakthrough at first cyanotoxin detection

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CYANOTOXIN
CASE STUDY #2

SURFACE WATER

Upstream of GAC contactors

NOM/TOC PRESENT

Average feed = 2.1 mg/L

SPIKED WITH CYANOTOXINS

- Anatoxin-A feed = 86 µg/L
- Cylindrospermopsin feed = 45 µg/L
- Microcystin-LR feed = 55 µg/L

CONTACT TIME (EBCT)

15 minutes

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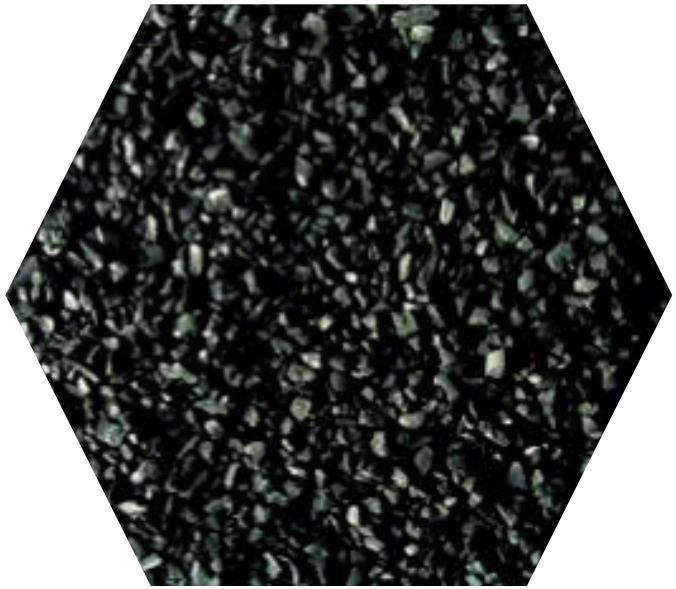
CYANOTOXIN
CASE STUDY #2

FILTRASORB 400

- Re-agglomerated bituminous coal
- 12x40 mesh
- 1000 mg/g Iodine Number
- Virgin and reactivated (CMR) GAC



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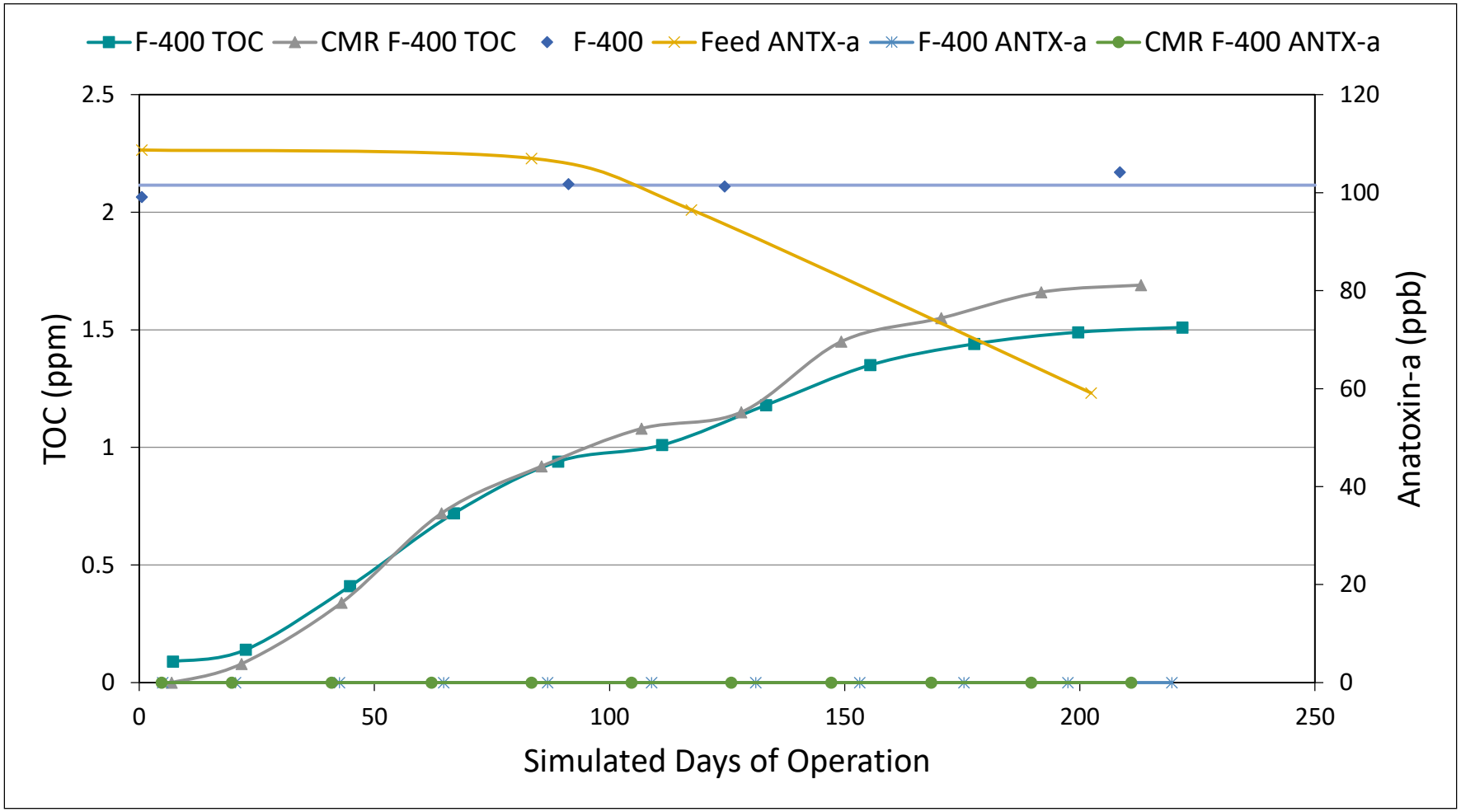
CYANOTOXIN CASE STUDY #2

ANATOXIN-A



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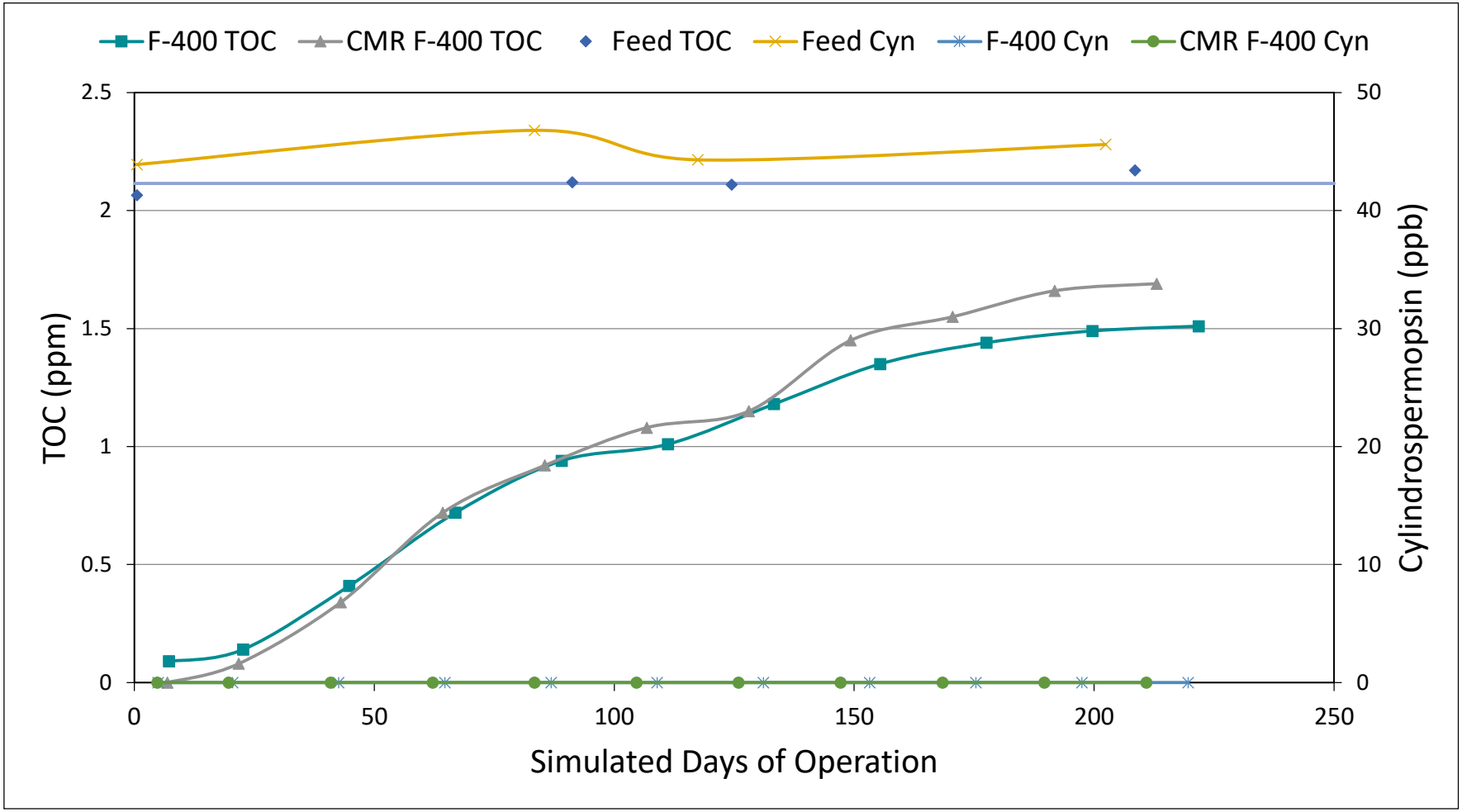
CYANOTOXIN CASE STUDY #2

CYLINDROSPERMOPSIN



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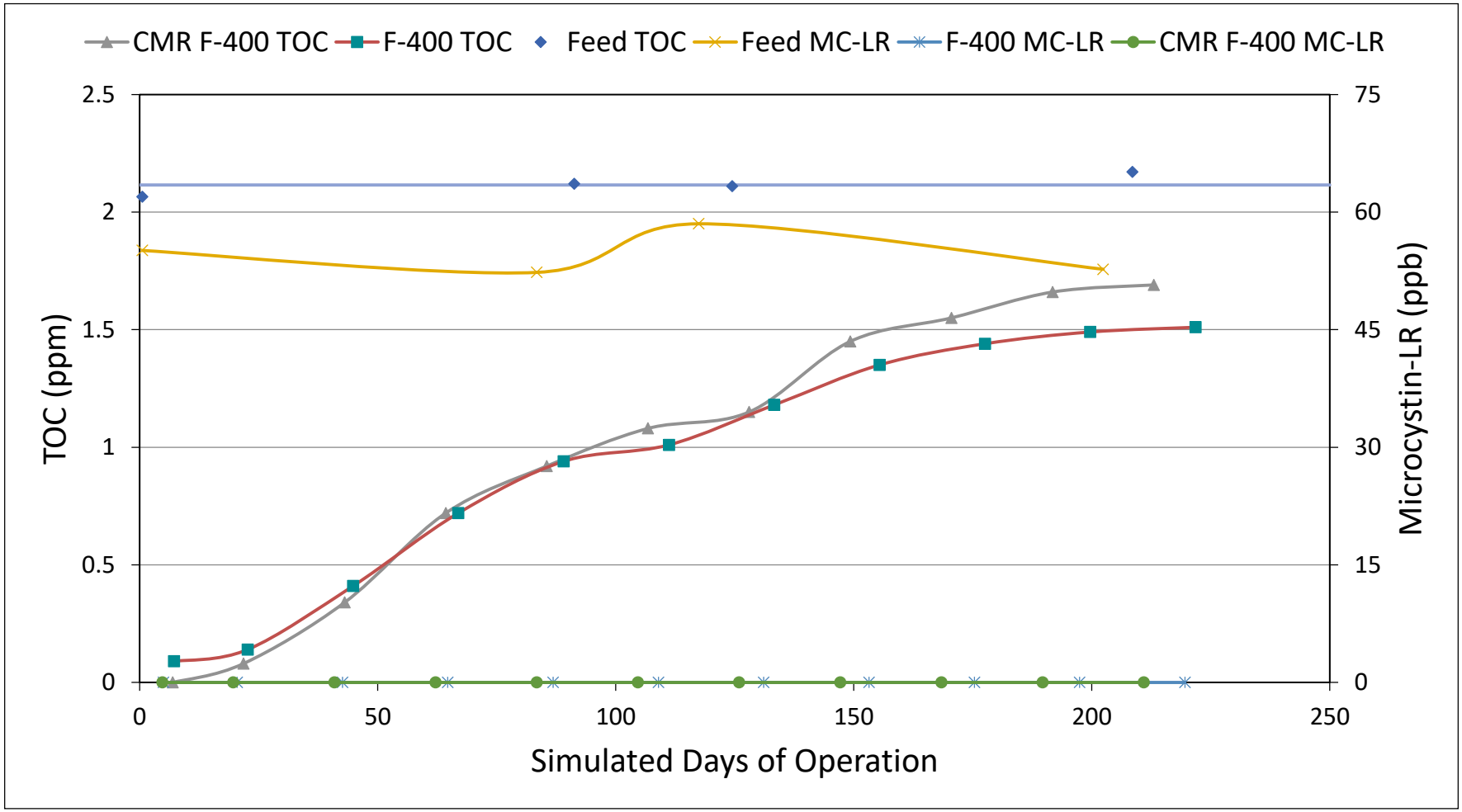
CYANOTOXIN CASE STUDY #2

MICROCYSTIN-LR



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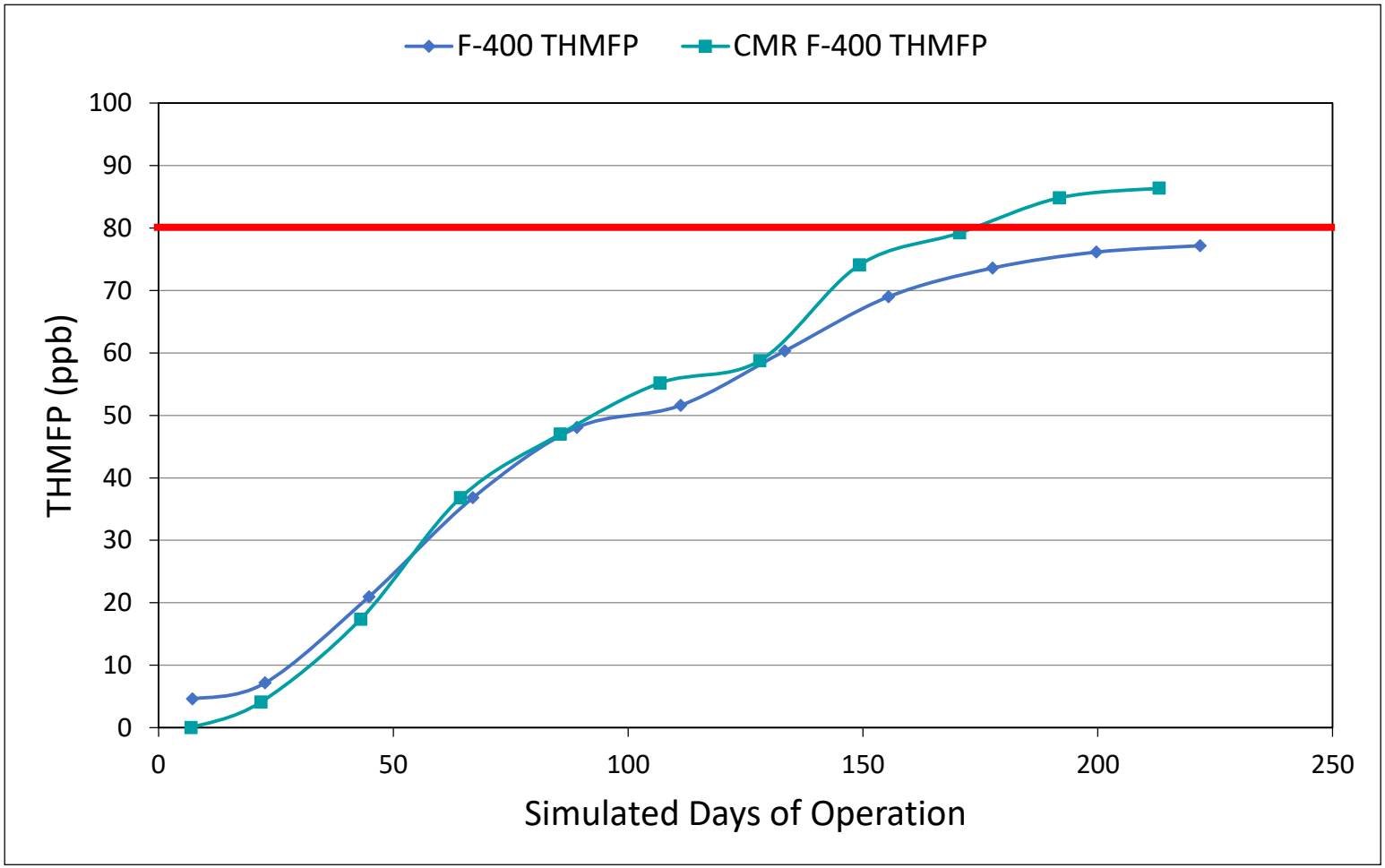
CYANOTOXIN CASE STUDY #2

THM FORMATION



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CYANOTOXIN
CASE STUDY #2

230 DAYS SIMULATED

53 million gallons water

NO CYANOTOXIN BREAKTHROUGH

- Virgin & reactivated GACs
- Anatoxin-A detection limit = 0.6 µg/L
- Cylindrospermopsin detection limit = 0.03 µg/L
- Microcystin-LR detection limit = 0.15 µg/L

TOC BREAKTHROUGH

- Virgin = 74% of influent
- React = 82% of influent

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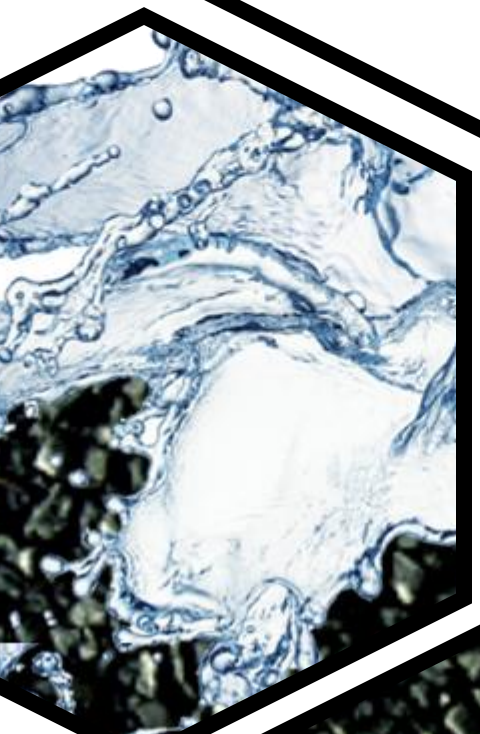
FINAL TAKEAWAYS



- **PAC can be used seasonally** as an additional barrier of defense
- **It's important to properly maintain your GAC filters** to assure that proper treatment can be obtained during a Harmful Algal Bloom
- **Not all Carbons are the same**; there are benefits to pilot testing with your specific water to determine the best carbon for your application

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THANK YOU FOR YOUR TIME.

QUESTIONS?

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