

Cyanobacteria in Sacramento Region Waterways

Sacramento Environmental Commission

Introduction

The Sacramento Environmental Commission (SEC) is a joint County/City commission chartered to advise the Sacramento County Board of Supervisors and the City Councils of Elk Grove, Folsom, Galt, Isleton and Sacramento on environmental issues facing our community. Our mission is to provide environmental leadership, assistance and analysis, and provide advice to the participating governments. Our goal is to promote a vision of environmental quality, conservation, public health and environmental management, environmental justice and sustainability throughout the County. The SEC is also an advisory body to the Sacramento County Environmental Management Department.

The SEC received a presentation from staff of the State Water Resources Control Board (SWRCB) Surface Water Ambient Monitoring Program (SWAMP) on the expanding distribution of Harmful Algal Blooms (HABs) and presence of cyanobacteria at the SEC's September 2016 monthly meeting. The SWAMP presentation highlighted several key points that raised the concern of SEC Commissioners to further consider this topic.

The SEC prepared this analysis to determine if additional efforts are needed to monitor the presence of HABs in Sacramento County and whether further actions may be necessary to avoid or minimize a potential public health threat.

Summary

Based on the data reviewed and information compiled, the SEC developed a series of findings summarized in the following points:

- Cyanotoxins and algal toxins pose risks to the health and safety of people and pets recreating in water bodies, eating fish, and drinking water.
- The SEC conducted a ranking of the sixteen waterways to determine those that pose a lower or higher potential for expose public to HABs.
- Certain Sacramento County waterways pose a higher risk of HAB exposure to the public, including:
 - American River
 - Sacramento River
 - Cosumnes River
 - Morrison Creek Group/East Drainage Canal/Steelhead Creek/Dry Creek/Arcade Group
 - Deer Creek Group
 - North Fork Badger/Laguna Creek/ Deadman/Bear Slough Creek
 - Delta Waterways and Sloughs
 - Folsom Lake
- The waterways with higher risk of HAB exposure warrant a higher level of monitoring during lower flow and higher temperature conditions.

- If HABs are detected which pose an immediate threat to public health through known pathways, action should be taken to inform the public of the hazard, post on-site signage, or take direct action to manage the presence, abundance, and distribution of the HABs.

Background

Consistent with its roles and its continuing education on current environmental issues of concern, the SEC received a presentation from staff of the State Water Resources Control Board (SWRCB) Surface Water Ambient Monitoring Program (SWAMP) at the SEC's September 2016 monthly meeting. The SWAMP presentation highlighted several key points that raised the concern of SEC Commissioners to further consider this topic. These points included:

- Cyanobacteria, formerly known as blue-green algae (Cyanophyceae), are a group of bacteria with chlorophyll-a capable of photosynthesis. Under the right conditions of pH, nutrient availability, light, and temperature, cyanobacteria can reproduce quickly, forming a Harmful Algal Bloom (HAB) (EPA, 2015).
- The occurrence of freshwater HABs are increasing throughout California because of:
 - Increasing surface water temperatures
 - High concentrations of nutrients
 - Occurrence of drought and low flow conditions
- Cyanobacteria and harmful algal blooms (HABs) can have negative impacts on the environment, people, pets, wildlife, or livestock, as well as the economy.
 - Some HABs can produce large amounts of cyanotoxins or algal toxins, which can poison livestock, wildlife, and humans.
 - Certain other types of cyanobacteria are nontoxic but can impart an unpleasant taste to water and fish as well as giving off an unpleasant smell as they die and decay. Cyanotoxins and algal toxins pose risks to the health and safety of people and pets recreating in water bodies, eating fish, and drinking water.
 - They can accumulate in fish and shellfish to levels posing threats to people and wildlife consumers.

Based on this presentation, the SEC decided to further investigate the occurrence of HABs in Sacramento County and what level of effort should be considered to adequately monitor and manage future occurrences that could pose a public health concern.

SEC Information Review

Commissioners researched specific information to determine if a potential public health threat was present because of the contamination of Sacramento County waterways with algae species that may produce toxic compounds leading to HABs. It was quickly determined that regional information addressing this topic was not available. Based on this initial investigation, the SEC

elected to address key elements of this issue using other available information. This other information enabled the SEC to respond to the following inquiries.:

- A. What is the relative toxicity of cyanotoxins including microcystins?
- B. What of the exposure pathways that may cause public exposure to these toxins?
- C. What is the potential exposure from Sacramento County waterways?

SEC Commissioners considered each of these questions and compiled available information to provide further guidance.

A. Relative Toxicity of Cyanobacteria Algal Blooms

It has been estimated that 25 to 75% of cyanobacterial blooms are toxic. Production of cyanobacterial toxins (cyanotoxins) includes human and animal health hazards, which can present risks of illness and mortality at environmentally relevant concentrations (Blaha et al, 2009).

Microcystins have been shown to be acutely (and chronically toxic) to animals and with acute LD₅₀ (lethal dose for 50% of subjects) of the individual microcystin structural variants ranging between 50 and 1000 µg/kg following injection in mice. After injection, severe liver damage is observed followed by circulatory failure, heart failure and death. The oral LD₅₀ in mice (5000µg/kg body weight.) or in rats (>5000µg/kg body weight.) is approximately 100-fold higher than the injected. LD₅₀, may be due to slow gastrointestinal uptake of toxins in mice (Blaha et al, 2009).

A comparison of various data suggests that microcystin is very toxic relative to arsenic and cyanide (see Table 1), but less toxic than another biological toxin, saxitoxin, and the poisons sarin, dioxin, and strychnine (Smith 2013). The LD₅₀ is often expressed as the µg of a toxin per kg of body weight of an animal. The LD₅₀ is telling us that when administered that dosage in µg agent/kg body weight, 50% of the animals exposed would likely die.

Table 1 Relative Toxicity of Various Toxins

Substance	Animal	LD ₅₀ (µg/kg)	Original Data Source
Arsenic	Mouse	26,000-48,000	<u>EPA AEGs 2007</u>
Sodium cyanide	Rat	15,000	<u>EPA AEGs 2010</u>
Microcystin-LR	Mouse	5000	<i>LD₅₀ values for Microcystin-LR, compiled by Beagle Bioproducts</i>
Sarin	Rat	125	<u>Scremin et al., 2003</u>
Dioxin	Mouse	114	<u>National Library of Medicine, for emergency responders</u>
Saxitoxin	Mouse	10	<u>Humpage EPA abstract, Falconer EPA chapter</u>
Strychnine (rat poison)	Rat	5	<u>Government of Queensland factsheet</u>

The U.S. Environmental Protection Agency (U.S. EPA) Candidate List (CCL) is a list of contaminants that are currently not subject to any proposed or promulgated national primary drinking water regulations, but are known or anticipated to occur in public water systems. Contaminants listed on the CCL may require future regulation under the Safe Drinking Water Act (SDWA). EPA announced the Final CCL 4 on November 17, 2016 (EPA, 2016).

The U.S. EPA published national drinking water Health Advisories for the cyanotoxins, microcystins, and cylindrospermopsin (see Table 2). The Health Advisories identify the cyanotoxins levels in drinking water which are less than or equal to those by which adverse human health impacts are unlikely to occur over a 10-day period.

Health Advisories are developed to help states and water systems assess local situations and during emergency situations and spills. They are not a federally enforceable, regulatory limit. Given the health concerns that can occur from cyanotoxins in drinking water, many potable water purveyors are taking actions to manage and reduce the risks from cyanotoxin contamination in drinking water. These actions can include steps for cyanotoxin monitoring, adjusting treatment to address contamination before levels are of concern and notifying the public through a Drinking Water Advisory when tap water toxin levels are a possible public health concern. (EPA, Undated).

Table 2 Cyanotoxin Health Advisories

10-DAY HEALTH ADVISORIES	Advisory Level
Microcystins	
Children pre-school age and younger (under 6 years old)	0.3 µg/L
School-age children (6 years and older)	1.6 µg/L
Cylindrospermopsin	
Children pre-school age and younger (under 6 years old)	0.7 µg/L
School-age children (6 years and older)	3.0 µg/L

Source: U.S. EPA 2016b

B. Potential for Public Exposure

The public can be exposed to cyanobacterial blooms and cyanotoxins by:

- Drinking water that comes from a lake or reservoir with a cyanobacterial bloom
- Drinking untreated water
- Engaging in recreational activities in waters with cyanobacterial blooms
- Inhaling aerosols from water-related activities such as jet-skiing or boating
- Inhaling aerosols when watering lawns, irrigating golf-courses, etc. with pond water
- Using cyanobacteria-based dietary supplements that are contaminated with microcystins
- Receiving dialysis (this has been documented only in Brazil)

Evidence of bioaccumulation and toxicity of cyanotoxins to other aquatic vertebrates (*i.e.*, reptiles and birds) are very scarce, and literature is mainly based on reports of mass mortality of birds and waterfowls, insufficiently linked to the presence of cyanotoxins.

Recently, it was reported the presence of microcystins in domestic ducks *Anas platyrhynchos* and in the black-crowned night heron *Nycticorax nycticorax* in Lake Taihu (China). Among the various organs analyzed, higher amounts of microcystins were found in the intestines, liver and stomach and smaller amounts in the pancreas, gallbladder, kidney, heart, lung, spleen, gonads and muscles. They found also considerable amounts of microcystins in the egg yolk, which indicates a possible risk for bird embryos. No bird mortality was reported in this study (Ferraro-Fielho 2011).

A study was conducted to determine whether bioaccumulation of microcystins occurs in lettuce foliar tissue when sprayed with solutions containing microcystins at concentrations observed in aquatic systems (0.62 to $12.5 \mu\text{g} \cdot \text{L}^{-1}$). Microcystins were found in lettuce foliar tissues (8.31 to $177.8 \mu\text{g}$ per Kg of fresh weight) at all concentrations of crude extracts. Spraying with water containing microcystins and cyanobacteria may contaminate lettuce at levels higher than the daily intake of microcystins recommended by the World Health Organization (Hereman & Bittencourt ,2012)

C. Potential Exposure In Sacramento County Waterways

Sacramento County contains multiple waterbodies that provide water supply, recreation, and food for the community. The SEC has qualitatively ranked these waterways to reflect the potential risk of HABs to the community. The waterways of Sacramento County were identified in Figure 1.

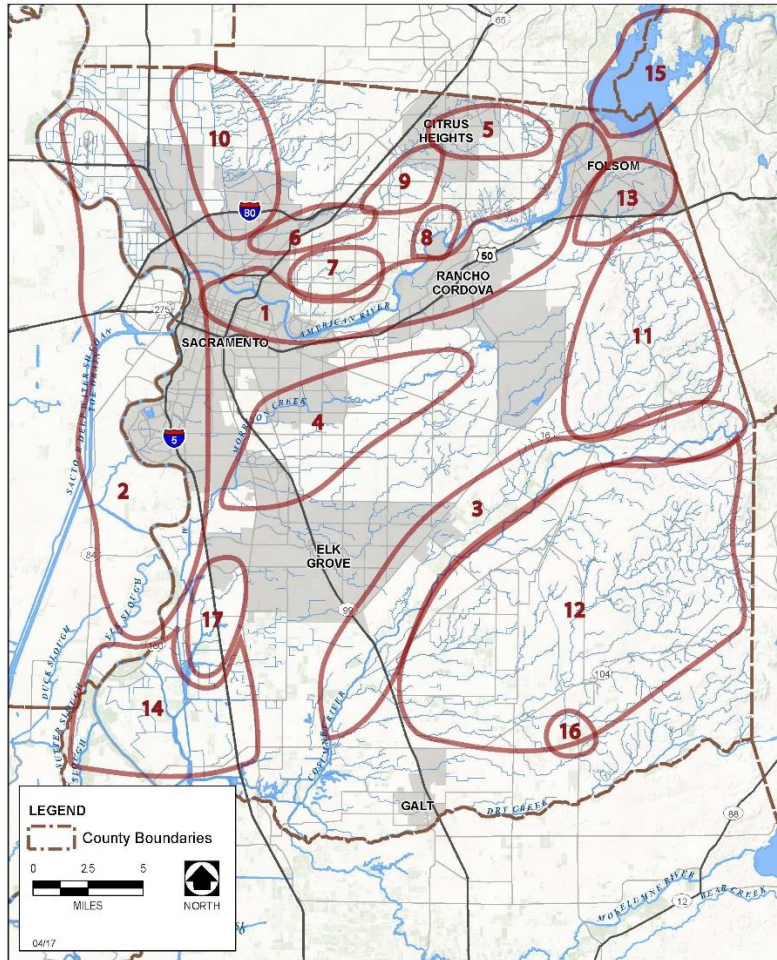


Figure 1 Sacramento County Waterways

Based on this inventory of waterways, the SEC grouped them into sixteen waterways for easier consideration and to reflect common physical traits, location, and waterway type.

The SEC identified several criteria to rank these waterways to reflect their relative potential to expose public to HABs. These criteria include:

- Waterways prone to low flow conditions or stagnation which could induce the occurrence and abundance of HABs
- Waterways that offer contact public recreation opportunities
- Waterways that provide irrigation or public water supply
- Waterways located in an urban area with specific consideration if located in an identified environmental justice community

Based on these criteria, the SEC conducted a ranking of the sixteen waterways to determine those that pose a lower or higher potential for expose public to HABs. Table 3 shows the waterway ranking values and final ranking for lower and higher potential exposure.

The final rank shown in Table 3 reflects the waterway’s relative HAB public exposure risk. Those waterways that best meet the criteria are ranked higher than those waterways that only partially meet or do not meet the criteria.

Table 3 Relative Public Exposure Risk of Sacramento County Waterways

Waterway Number	Waterway Name	Prone to Low Flow	Contact Recreation By Public*	Irrigation or Water Supply	Located in Urban Area (or EIC)	Final Rank
1	American River Group	2	3	3	2	Higher
2	Sacramento River Group	2	3	3	2	Higher
3	Cosumnes River Group	2	3	3	2	Higher
4	Morrison Creek Group	3	2	1	3	Higher
5	Cripple Creek Group	3	2	1	1	Lower
6	Arcade Group	3	2	1	2	Higher
7	Carmichael Group	3	2	1	1	Lower
8	Fair Oaks Group (Carmichael Cr./Minnesota)	3	2	1	1	Lower
9	Arcade/Cripple Creek Group	3	2	1	1	Lower
10	East Drainage Canal/Steelhead/ Dry Creek/Arcade Group	3	2	1	2	Higher
11	Deer Creek Group	3	2	2	1	Higher
12	North Fork Badger/Laguna Creek/ Deadman/Bear Slough Creek	3	1	3	2	Higher
13	Humbug Creek	3	2	1	1	Lower
14	Delta Waterways and Sloughs	3	3	3	1	Higher
15	Folsom Lake	2	3	3	1	Higher
16	Lake Rancho Seco	1	3	1	1	Lower
17	Stone Lake/North Stone Lake	2	2	2	1	Lower

*Designated swimming, fishing, boating

**SB 535 Disadvantaged Communities (OEHA)

Legend	3 = Fully Meets Criteria
	2 = Partially Meets Criteria
	1 = Does not Meet Criteria

Findings

Based on the information considered by SEC, the following findings summarize the SEC's conclusions:

- Cyanobacterial toxins are relatively highly toxic if ingested in drinking water, contaminated vegetable crops, or consumed with contaminated aquatic invertebrates (mussels and oysters). Direct ingestion through water contact recreation is also a mechanism for ingestion.
- Children and pets are more susceptible to exceeding applicable health advisory levels because of smaller body size and weight.
- While Sacramento County HAB public health exposure risk may be less than other regions of California, there is present a risk which may increase with higher temperatures, more frequent low flow conditions, and higher frequency of drought.
- Certain Sacramento County waterways pose a higher risk of HAB exposure, including:
 - American River
 - Sacramento River
 - Cosumnes River
 - Morrison Creek Group
 - East Drainage Canal/Steelhead Creek/Dry Creek/Arcade Group
 - Deer Creek Group
 - North Fork Badger/Laguna Creek/ Deadman/Bear Slough Creek
 - Delta Waterways and Sloughs
 - Folsom Lake
- The waterways with higher risk of HAB exposure warrant a higher level of monitoring during lower flow and higher temperature conditions.
- If HABs are detected which pose an immediate threat to public health through known pathways, action should be taken inform the public of the hazard, post on-site signage, or take direct action to manage the presence, abundance, and distribution of the HABs.

Recommendations

The SEC offers the following recommendations for consideration by its authorizing agencies. It is intended that these recommendations be considered to provide a reasonable level of protection which corresponds to the potential level of risk and threat to public health.

- Continue the ongoing efforts of the Environmental Management Department (EMD) to track and monitor the presence of HABs which may contain toxins, including:
 - Checking electronic monitoring statistics being recorded for the American and Sacramento Rivers, including flow rate and water temperature, to determine the potential conditions present that may promote HABs.

- Responding to public complaints regarding Blue Green Algal reports.
 - Collaborating with State Water Resources Control Board and getting test results when Sacramento sites are sampled.
 - Combining surveying waterways with the stormwater program, utilizing same staff person.
 - Coordinating efforts with Sacramento County Department of Parks and Recreation to respond to HAB events on park waterways.
- Initiate outreach to the Sacramento Yolo Mosquito Vector Control District to hold training on HAB recognition and reporting.
 - Train American River Park and Folsom State Park Rangers to recognize HABs and report to EMD and SWRCB.
 - Create a Cyanobacteria Fact Card for educating community groups that currently volunteer to monitor conditions along public waterways that will promote recognizing HABs and report to EMD.
 - Produce a short (2 minute) education video addressing HABs and their potential hazard, for posting on the EMD website and other online locations.
 - Coordinate with the Sacramento County Public Information Office to assist in production of articles and photos for local newspapers, magazines, or other information sources about HABs and how to report them to EMD.

References

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