EPA's Efforts in Addressing Cyanotoxins in Recreational and Drinking Waters

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Office of Water/Office of Science and Technology
EPA Workshop on Cyanobacteria and Cyanotoxins: Occurrence and Detection Methods
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Outline

- Provide a brief background on the Contaminant Candidate List (CCL) program and the Regulatory Determination process for cyanobacteria and cyanotoxins in drinking water.
- Briefly describe what is a Human Health Ambient Water Quality Criteria.
- Describe the activities at EPA relating to cyanobacteria and cyanotoxins in drinking and recreational waters.

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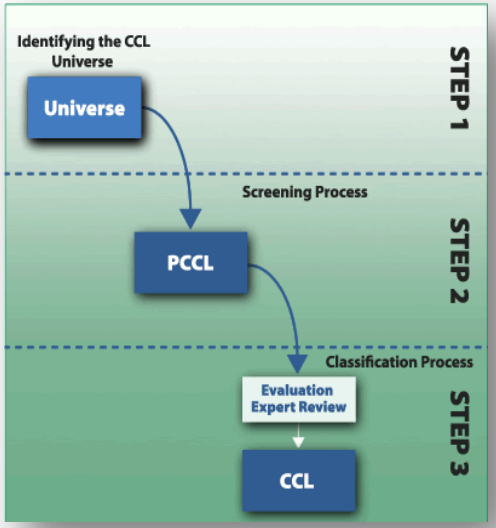
Drinking Water: Safe Drinking Water Act (SDWA) Requirements

SDWA Section 1412(b)(1)

- **Contaminant Candidate List (CCL)**
  - Develop a list of unregulated contaminants that are known or anticipated to occur in public water systems and may require a drinking water regulation.
  - EPA publishes the list every five years.
- **Unregulated Contaminant Monitoring Rule (UCMR)**
  - Collect data to help determine which, if any, of the listed contaminants EPA should regulate, based on their measured levels at selected public water systems and their potential health effects.
- **Regulatory Determination**
  - Determine whether or not to regulate at least five contaminants from the CCL with National Primary Drinking Water Regulation (NPDWR) after evaluating criteria specified under the SDWA; Publish determinations on a five year cycle.
- **Regulation Development**
  - If EPA decides to regulate, the Agency has 24 months to propose and 18 months to finalize the health goal and the NPDWR.

CCL Process for Cyanobacteria/Cyanotoxins



- Universe of potential drinking water contaminants.
- Identifies contaminants that should be further evaluated (the preliminary CCL or PCCL).
- Select contaminants based on more detailed evaluation of:
  - Known or anticipated occurrence in PWS
  - Adverse health effect
- More information at: www.epa.gov/safewater/CCL

- **Cyanobacteria included in CCL**
  - CCL 1 (1998) includes Cyanobacteria (blue-green algae), other freshwater algae, and their toxins
  - CCL 2 (2005) includes Cyanobacteria (blue-green algae), other freshwater algae, and their toxins
  - CCL 3 (2009) includes Cyanotoxins (anatoxin-a, microcystin-LR, and cylindrospermopsin)
  - CCL 4 (due 2014) – EPA started evaluating contaminants for CCL 4

Regulatory Determination for Cyanobacteria/Cyanotoxins

- SDWA requires EPA to promulgate a NPDWR and to publish a Maximum Contaminant Level Goal (MCLG) for a contaminant if:
  - Can cause adverse health effects;
  - Known to occur in public water systems with a frequency and at levels of public health concern; <u>and</u>
  - Regulation presents a meaningful opportunity for health risk reduction.
- Contaminants MUST meet all three criteria for a positive regulatory determination.
- **Regulatory Determination for cyanobacteria and cyanotoxins**
  - RD 1 (2003) – No Regulatory Decision - not sufficient information
  - RD 2 (2008) - No Regulatory Decision - not sufficient information
  - RD 3 (Due 2013)
    - EPA started evaluating all contaminants on CCL 3 for the Regulatory Determination Criteria

Guidelines & Regulations for DW

- No federal regulations or guidelines for cyanotoxins.
- WHO guidelines of 1µg/L for microcystin-LR (MC-LR) in drinking water.
- Guidance values have been adopted by many countries and some states:

- Brazil 1 µg/L MC-LR
  3 µg/L Saxitoxin
  15 µg/L Cylindrospermopsin
  10,000 cells/mL or 1mm^3/L biovolume cyanobacteria
- Australia 1.3 µg/L MC-LR Tox Eq
  3 µg/L Anatoxin-a
  3 µg/L Saxitoxin
  1 µg/L Cylindrospermopsin
- Canada 1.5 µg/L MC-LR Tox Eq
- **Ohio** 1 µg/L MC-LR Tox Eq
  20 µg/L Anatoxin-a
  1 µg/L Cylindrospermopsin
  0.2 µg/L Saxitoxin
- **Oregon** 12 µg/L MC-LR Tox Eq
  3 µg/L Anatoxin
  1 µg/L Cylindrospermopsin
  3 µg/L Saxitoxin

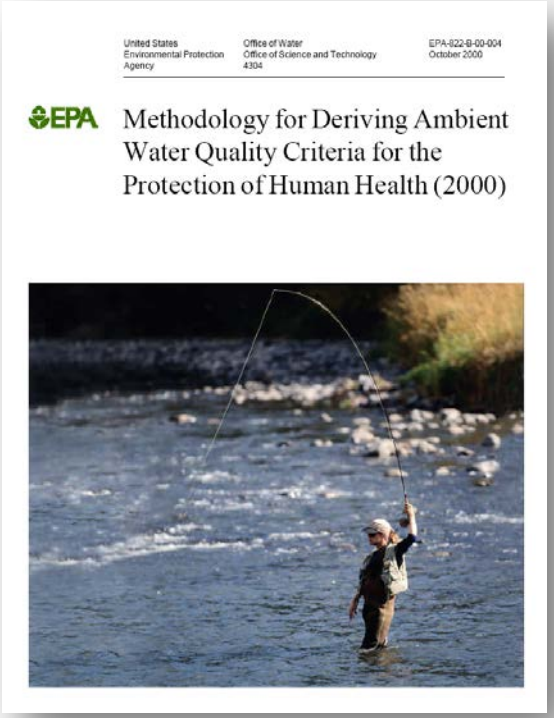
Recreational Water: Clean Water Act (CWA) Requirements

CWA Section 304(a)

- **Water Quality Criteria**
  - Limits on particular chemicals or conditions in a water body
    - Elements of water quality standards
    - Protect designated uses (e.g. aquatic life, recreation, public water supply)
    - Expressed as a *narrative* or *numeric*
    - EPA's recommendation to States and Tribes

- EPA publishes two types of Ambient Water Quality Criteria (AWQC):
  - Aquatic Life Criteria - protection from ingesting aquatic organism only
  - Human Health Criteria - protection from ingesting water and aquatic organism
    - Highest concentration of a pollutant in water that is not expected to pose a significant risk to human health.

Human Health AWQC Development


United States Environmental Protection Agency | Office of Water Office of Science and Technology 4304 | EPA-822-B-00-004 October 2000

EPA

Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000)

- Toxicity
  - Toxic effects and dose-response properties
  - Risk Specific Doses for linear carcinogens
  - Point of Departure (POD)/Uncertainty Factor (UF) for nonlinear carcinogens
  - Reference dose (RfD) for non carcinogens
- Exposure
  - Relative Source Contribution (RSC)
  - Exposure parameters: body weight (BW) drinking water intake (DI) and Fish Intake (FI)
- Bioaccumulation factors (BAFs)
  - Site-specific BAFs or National BAFs
  - Use of site-specific BAFs encouraged
  - Trophic level data on accumulation of chemical in fish or shellfish

Guidance document available at http://www.epa.gov/waterscience/criteria/humanhealth/method/complete.pdf

Technical support documents:

- **Risk Assessment** http://www.epa.gov/waterscience/criteria/humanhealth/method/supportdoc.pdf
- **National Bioaccumulation Factors** http://www.epa.gov/waterscience/criteria/humanhealth/method/tsdvol3.pdf
- **Site-specific Bioaccumulation Factors** http://www.epa.gov/waterscience/criteria/humanhealth/method/tsdvol3.pdf

Guidelines & Regulations for RW

- No federal regulations or guidelines for protecting human health and ecosystem from HABs.
- WHO international guidelines for Recreational Waters are:

Relative Probability of Acute Health Effects	Cyanobacteria (cells/mL)	Microcystin-LR (µg/L)
Low	< 20,000	<10
Moderate	20,000-100,000	10-20
High	100,000-10,000,000	20-2,000
Very High	> 10,000,000	>2,000

- Guidelines for microcystin concentrations and/or equivalent cell densities of cyanobacteria for recreational waters are in place in 6 countries

- Australia — Level 1- 50,000 Cells/L ~ 10 µg/L, Biovolume>4 mm^3/L
  Level 2- Biovolume > 10 mm3/L or Scum
- Canada — 100,000 cells/L ~ 20 µg/L MC (total)
- **California** — MC-LR: Humans: 0.8 µg/L; Fish: 13 ng/g; Livestock: 3 µg/L; Pets: 1µg/L
  Anatoxin-a: Humans: 90 µg/L; Fish: 1,100 ng/g ; Livestock: 100 µg/L; Pets: 40µg/L
  CYL: Humans: 4 µg/L; Fish: 66 ng/g; Livestock: 10µg/L; Pets: 4µg/L
- **Ohio** — MC-LR: Public Health Advisory: 6µg/L; No Contact Advisory: 20µg/L
  Anatoxin-a: Public Health Advisory: 80 µg/L; No Contact Advisory: 300 µg/L
  CYL: Public Health Advisory: 5 µg/L; No Contact Advisory: 20 µg/L
  Saxitoxin: Public Health Advisory: 0.8 µg/L; No Contact Advisory: 3 µg/L
- **Oregon** — **>** 40,000cells/mL of MC or Planktothrix to 100,000 cells/mL of total toxic cyanobacteria
  MC-LR: 8µg/L; Anatoxin-a: 20 µg/L; CYL: 6µg/L; Saxitoxin: 100 µg/L
- **Oklahoma** — > 100,000 cells/mL ~ 20 µg/L MC (total)

EPA activities related to Cyanotoxins in Drinking Water and Recreational Water

EPA activities: ORD/National Health and Environmental Effects Research Laboratory

- **Evaluation of toxicology using animal models**
  - **Toxicity of Cylindrospermopsin (CYN) in gestationally-exposed animals**
    - Effects in utero exposure at birth and during the lifetime of the animal.
    - Based on previous work, we will investigate adverse critical organ effects after dose-related exposures to CYN over the lifetime of the animal. Organ endpoints will include hepatic, pulmonary and reproductive.
    - In progress
  - **Toxicity of freeze dried cyanobacterial cell masses (lyophilates) from blooms**
    - Test lyophilates obtained from algal blooms with multiple toxins using the mouse bioassay. Animals will be initially exposed to lyophilates by the intraperitoneal route. Endpoints will include clinical and serum chemistry parameters as well as histopathology.
    - Collaboration with USGS, NC DENR and Baylor University
    - Submitting the permit to conduct animal studies.

- Contact: Neil Chernoff (919-541-2651)

EPA activities: ORD/National Health and Environmental Effects Research Laboratory (Cont.)

- **Evaluation of toxicology using animal models**
  - **Cyanotoxin mixture toxicity and biomarker evaluation:**
    - Based on the chemical analysis of the lyophilates, the toxicity of relevant mixtures of pure cyanotoxins will be determined in mammals.
    - Blood and various tissue levels of the administered toxins will be determined and related to the observed toxicity.
    - In collaboration with USGS - not started
  - **Potential mammalian toxicity of Golden Algae (Prymnesium parvum) toxins:**
    - Ichthyotoxic lyophilates of P. parvum will be administered to mice and any adverse effects will be determined and evaluated.
    - In collaboration with Baylor University - In progress
- Contact: Neil Chernoff (919-541-2651)

EPA activities in DW: OW/Office of Groundwater and Drinking Water

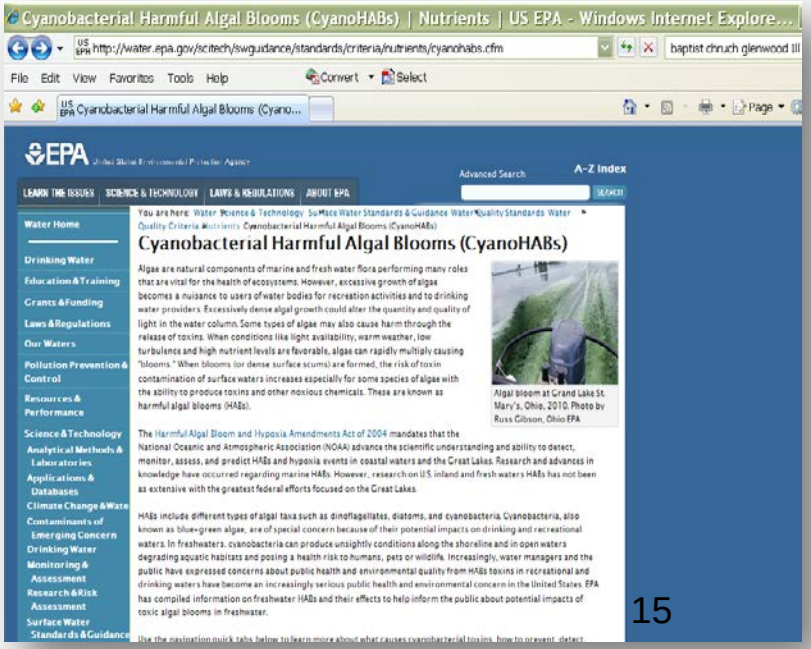
- **Development of Analytical Methods for Cyanotoxins**
  - Description:
    - Liquid chromatography combined with mass spectrometry method (LC/MS/MS) for microcystin.
    - Would potentially include an immunoassay screen (ELISA) for many toxins and possibly protein-phosphate inhibition assay (PPIA) to determine bioactivity. If cyanotoxins are found in the screening, microcystin-LR will be analyzed for.
    - EPA may also develop methods for anatoxin-a and cylindrospermopsin (time and budget permitting).
    - Currently also developing an immunocolumn method for the cleanup (remove OM) and concentration of microcystins from samples.
  - Status:
    - Have preliminary results from testing of spiked microcystin recovery of the immunocolumns with reagent water and with drinking water.
    - Will retest starting in summer and expect to have the method for microcystin ready by Fall 2013.
  - Contacts:
    - Microcystin method: Jody Shoemaker (ORD/NERL, 513-569-7298) and Jim Sinclair (LSSU/immunocolumn project, 513-569-7970)
    - Anatoxin-a and cylindrospermopsin method: Steve Wendelken (513-569-7491)

EPA activities in DW: OW/Office of Science and Technology

- **DW Health Advisories (HA) for Cyanotoxins: Microcystin-LR, Anatoxin-a, and Cylindrospermopsin**
  - Description:
    - Joint collaboration with Health Canada
    - Informal technical guidance for unregulated drinking water contaminants to assist Federal, State and local officials, and managers of public or community water systems in protecting public health as needed.
    - HA are non-regulatory concentrations of cyanotoxins at which noncancer adverse health effects are not anticipated to occur over specific exposure durations - one-day, ten-day, and Lifetime. Cancer Risk is also calculated.
  - Status:
    - OST is collecting information on the toxins properties, exposure and occurrence information for the three toxins and will do the quantification of toxicological effects .
    - Health Canada provided the toxicity profiles, and will provide the analytical methods and treatment technologies sections for the document.
    - The HA are expected to be release by Summer 2013.
  - Contact:
    - Lesley Vázquez-Coriano (202-566-1125)

EPA activities in DW and RW: OW/Office of Science and Technology

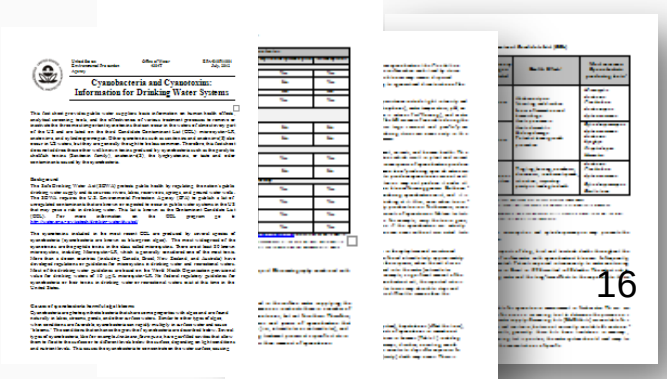
- **Cyanobacteria Harmful Algal Blooms Webpage**
  - Description:
    - Webpage to help inform the public, states, tribal and local governments, and other federal agencies about key issues regarding cyanobacteria blooms in recreational waters and drinking water.
    - Includes information on:
      - Causes, prevention and mitigation
      - Human health and ecological effects
      - Detection methods
      - Available policies and guidelines
      - Past and ongoing research
      - Links to other resources
  - Status:
    - Published on July 18, 2012
    http://www.epa.gov/nandppolicy/links.html
  - Contact:
    - Lesley Vázquez-Coriano (202-566-1125)



EPA activities in DW: OW/Office of Science and Technology

- **Cyanobacteria and Cyanotoxins Fact Sheet for Drinking Water Operators**
  - Description:
    - Information sheet to provide information to public water suppliers on human health effects, analytical screening tools, and the effectiveness of various treatment processes to remove or inactivate the three cyanotoxins listed in CCL: microcystin-LR, anatoxin-a, and cylindrospermopsin.
  - Status:
    - Published on the CyanoHABs Webpage http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/upload/cyanobacteria_factsheet.pdf

  Contact:
    - Lesley Vázquez-Coriano (202-566-1125)



EPA activities in DW: ORD/National Center for Environmental Assessment

- **Toxicological Reviews for Anatoxin-a, Cylindrospermopsin, and Microcystins**
  - Description:
    - Dose-response assessments to support the health assessment of unregulated contaminants on the CCL.
    - The purpose of these documents is to compile and evaluate the available quantitative and qualitative hazard and dose response data regarding the three cyanotoxins listed in CCL.
  - Status:
    - All 3 documents went for public comment and external peer review on 2007 and are available under the letter T at: http://cfpub.epa.gov/ncea/cfm/nceapubtitle.cfm?ActType=PublicationTopics&detype=document&excCol=archive&from=2006&to=2006
    - ORD is expecting to have revised versions by December 2012/January 2013.
  - Contact:
    - Belinda Hawkins (ORD/NCEA, 513-569-7523)

EPA activities in DW:
ORD/National Risk Management and Research Laboratory

- **Oxidation of cyanotoxins and product analysis**
  - Description:
    - To determine the stability of a number of cyanotoxins (microcystins and other algal toxins) when exposed to oxidative water treatment (chlorination, chloramination, ozone).
    - Preliminary findings:
      - Disinfection by-products have been identified after transformation using high-resolution mass spectrometry.
      - All the cyanotoxins/algal toxins are effectively treated in the presence of HOCl with a range of reaction rates which are pH dependant.
  - Status:
    - Expected to continue into 2013
    - Research is to be expanded to measuring concentration in natural waters and their treatment within full-scale water treatment plants.
  - Contact:
    - Heath Mash (513-569-7713)

EPA activities in DW: ORD/National Risk Management and Research Laboratory

- **Enhanced Source Water Monitoring for DW Treatability Translations**
  - Description:
    - To explore whether blooms have an impact on DBPs, and what type of bloom (e.g. green algae, blue-green bacteria, etc) cause more of a problem.
    - Part of a project on the impact of land-use on water quality of the East Fork Lake (Ohio River).
    - For the DW part, samples have been taken at one point in the lake next to the Claremont County water treatment plant intake and at the end of the water treatment plant.
  - Status:
    - Reservoir monitoring from 2010 continuing through June 2012 for:
      - Algal parameters : chl a, fluorescence pigment analysis, algal taxonomy (microscope ID and enumeration)
      - Toxin identification and quantification: ELISA and HPLC/PDA analysis
      - Other: Nutrients , metals and DO.
    - Toxin related samples and samples to differentiate (total versus free toxin concentration) have been collected and preserved but not yet analyzed.
  - Contact:
    - Michael Elovitz (ORD/NRMRL,513-569-7642) and Armah Delacruz (ORD/NERL,513-569-7224) for ELISA testing

EPA activities in RW: OW/Office of Science and Technology

- **Economic Analysis of Nitrogen and Phosphorus Pollution in the U.S.**
  - Description:
    - Compile current, existing data on the economic impacts of nutrient pollution on designated uses or economic sectors (e.g., tourism, fishing industry, aquaculture) to counterbalance the cost estimates from potential treatment upgrades
    - Provide new and/or updated information on the economic impacts of nutrient pollution on certain designated uses or economic sectors that do not yet have information available currently (e.g., some recreation, drinking water, public/private water supply);
    - Summarize existing data on the costs of treatment technologies and other approaches to mitigate nutrient pollution and eutrophication.
  - Status:
    - Selecting contractor
  - Contact:
    - Mario Sengco (202-566-2676)

EPA activities in RW:
OW/Office of Wetlands, Oceans and Watersheds

- **National Lakes Assessment (NLA)**
  - Description
    - National Aquatic Resource Surveys (NARS) are a series of national assessments being conducted by EPA, states, tribes and other partners to study rivers and streams, coastal waters, wetlands, and lakes in a revolving sequence with the purpose to learn what are the condition of the Nation's water resources.
    - As part of the first NLA survey (2007), USGS analyzed microcystin in lakes across the country and was able to analyze for anatoxins and saxitoxins in many of the samples.
    - These data are the first-ever national study of algal toxins.
    - NHERRL is working with USGS to understand occurrence of cyanotoxins (cylindrospermopsin and saxitoxin) and the potential implications for human health.
  - Status:
    - 2012 NLA started and 40% of its sites have been sampled.
    - Analyzing samples for microcystins.
  - Contact:
    - Amina Pollard (202-566-2360)

❖ NLA website**:** http://water.epa.gov/type/lakes/lakessurvey_index.cfm

EPA activities in RW:
OW/Office of Wetlands, Oceans and Watersheds

- **Water Data Project**
  - Description
    - Joint collaboration with OGWDW,OST, EPA Regions, USGS, OEI, Forest Service and NOAA
    - To increase awareness of water quality and will help fill information gaps on the value of clean water to local communities as well as on human health and the economy.
  - Status:
    - Water Data Analysis plus GIS Mapping
      - Algal blooms: overall incidences map and relation to source waters
      - Maps relating drinking water source waters vs. surface water impairments
    - Narratives Relating Surface Water Quality to Human Health and the Economy (case studies, stories)
      - Analysis of media reporting regarding water quality issues to develop case examples and community narratives including relating to potential map products
    - 'How's My Waterway?'
      - multi-platform site including availability as a mobile app: will provide interested users with locally relevant information on the condition of waterbodies
  - Contact:
    - Margarete Heber (202-566-1189)

EPA activities in RW: ORD/National Health and Environmental Effects Research Laboratory

- **Cyanobacteria Assessment Network (CyAN)**
  - Description:
    - Started in 07/2012 to 07/2013
    - Approach to detect and predict the probability of cyanobacterial blooms developing over the next several days and whether the bloom may intensify or diminish using remote satellite technology.
    - The predictive model will then be incorporated into a mobile application to provide publicly accessible information on bloom presence.
  - Status:
    - Data retrieve started.
  - Contact
    - Blake Schaeffer (850-934-9205)

Thank You

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