Monitoring to Determine Geosmin Sources and Concentrations in a Northern Colorado Reservoir

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Overview

- Horsetooth Reservoir & Colorado Big Thompson (CBT) Project
- Geosmin & effects on drinking water quality
- 2008 geosmin episode at Fort Collins Water Treatment Facility
- Monitoring response on Horsetooth Reservoir and CBT Project
- 2008 & 2009 results and major findings to date
Colorado Big Thompson (CBT) Project & Horsetooth Reservoir
Horsetooth Reservoir

- 156,735 acre-feet capacity
- 80 ft. (24m) mean depth; 188 ft (57 m) maximum depth
- 1.0 – 1.5 years hydraulic residence time
Geosmin in Drinking Water Supplies

- Produced by some species of cyanobacteria (blue-green algae) and actinomycetes (filamentous bacteria)

- “Earthy” odor detectable at <5 ng/L (ppt)

- Typically released after cell lysis and death

- Very difficult Taste & Odor (T&O) compound to remove during water treatment

- Does not pose public health risk, but affects public perceptions about aesthetic quality of water
City of Fort Collins 2008 Geosmin Outbreak & Response

Caught by surprise – peak concentration of 25 ng/L

Treatment Response: Fed PAC and adjusted flow blend

Monitoring program initiated on Horsetooth Reservoir to assess spatial distribution of geosmin concentrations
2008 Horsetooth Reservoir Geosmin Sampling & Analysis

- Samples collected at top and bottom of reservoir
- Samples were unfiltered and analyzed for total geosmin concentration
- Analysis conducted on-site using solid phase microextraction (S.M.6040D (2005)) and gas chromatography/mass spectrometry
- Two-day turn around on results
2009 Expanded Geosmin Monitoring Program

Objectives:

1. Better understand the spatial and temporal trends in geosmin

2. Improve early-warning capabilities
   - Sample earlier, more often and at more key sites

3. Evaluate the physical, chemical and biological factors affecting occurrence, transport and fate in Horsetooth Reservoir
Horsetooth Reservoir Results

2008 - 2009 Horsetooth Reservoir
1 meter Geosmin Data

Surface

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Hansen Feeder Canal & East Portal
Adams Tunnel Sample Sites

2009 Geosmin Concentrations in Hansen Feeder Canal & East Portal Adams Tunnel Sample Sites

- C10 Adams Tunnel
- C30 HFC below Flatiron
- C40 HFC at Big Thompson
- C50 HFC at Horsetooth Inlet

- [ ] not sampled

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HFC-Inlet Canal (C50) & Horsetooth Reservoir

- Hansen Feeder Canal
- C50
- Inlet Bay
- R20
- R21
- Spring Canyon Dam
- R30
- Dixon Canyon Dam
- R40
- Soldier Canyon Dam
- FCWTF

2009 Hansen Feeder Canal (@ HT Inlet) & Horsetooth Reservoir (@ 1 m) Geosmin

- Inlet Bay (R20) 1 m
- Spring (R21) 1 m
- HFC @ HT Inlet (C50)
Profiles and reservoir geosmin data from October 5, 2009
Key Findings

- Significant spatial variation in geosmin within the reservoir and upstream water bodies.
- Significant geosmin concentrations can exist at the bottom of the reservoir even when the reservoir is stably stratified.
- Data suggest that geosmin is both transported into the reservoir via the Hansen Feeder Canal and produced within Horsetooth Reservoir.
- No correlation exists between geosmin and chlorophyll-a concentrations or the algal cell density of the potential geosmin producing genera.
- Understanding geosmin transport and fate will require separate analysis of the dissolved and cell-bound fractions.
- Numerical modeling is needed to fully understand flow patterns in Horsetooth Reservoir and the impact of Hansen Feeder Canal interflow on geosmin transport.
Conclusions

- For drinking water utilities, early warning system for geosmin is critical for protecting the aesthetic quality of the water.

- Key elements for geosmin monitoring success were:
  1) high quality data
  2) short turn-around times
  3) scheduling flexibility provided by analytical laboratory

- Control strategies depend on understanding the temporal and spatial variability, concentrations, production sites, transport and fate of geosmin within source watersheds.

- Several years of monitoring will be required to more fully understand the temporal and spatial dynamics of geosmin production and fate in Horsetooth Reservoir.