Taste and Odor from Algae:
A Primary Nuisance for a Secondary Standard

Robert Compton, P.E.
Water Supply Engineering Section
Drinking Water Branch
Alabama Department of Environmental Management

Overview

- Taste and Odor complaints of “musty and dirt”
- What is the source? Geosmin and 2MIB from algae
- What’s the compliance and safety? SMCL and no safety concerns
- How to treat? Additional treatment or algal growth inhibition
  - Treatment types: Carbon, RO, change water source
  - Algal Growth inhibition/operational techniques
- Communication and trust
- Conclusion

What's the problem?

- The Department receives numerous taste and odor complaints of "dirty" or "musty" drinking water, particularly during the warmer months.
- EPA lists "Odor" as a Secondary Containment or "Nuisance Chemical"[A]. The Secondary Maximum Contaminant Limit (SMCL) for odor is 3 Threshold Odor Number (TON) [B].
- The complaints are strongly correlated by the water systems to algal blooms in the source water for the systems.

[A] - Secondary Drinking Water Standards: Guidance for Nuisance Chemicals | US EPA

[B] – ADEM Admin Code r. 335-7-3-.02

Secondary Maximum Contaminant Limit (SMCL)

Secondary standards are established to assist water systems in managing their drinking water for aesthetic considerations, such as taste, color, and odor. These contaminants **are not considered to present a risk to human health** at the SMCL; however, exceeding the SMCLs may cause water to appear cloudy or colored, taste or smell bad, damage equipment, or reduce effectiveness of treatment, or other undesirable effects.

Threshold Odor Number

- Uses EPA Method 2150-B[C] - there are several closely related methods allowed by the EPA with the main difference being the initial concentration mechanism of the drinking water sample.
- The Methods all ultimately rely on a sniff test or a data set of sniff tests.
- The wide range of perceptibility, both from person to person and within the same individual, means that customers may be the first to notice an increase in TON.

[C] - Analytical Methods Recommended for Drinking Water Compliance Monitoring of Secondary Contaminants (epa.gov)

Cause of the Odor

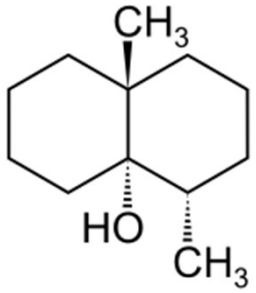
- Geosmin and Mucidone were identified as the two primary contributors to odor in water[D].
- Mucidone was later found to primarily be odorous due to 2-methylisoborneol (2MIB)[E].
- Both are mainly produced by blue-green algae (cyanobacteria) and, secondarily, filamentous bacteria but also can be found in other aquatic life, which can contribute to the muddy smell in some commercial fish.

[D] – Geosmin from Microorganisms, Gerber, 1968.

[E] – Source of musty odor associated with mucidone, Mashni et al., 1982.

Geosmin

- Odor detection threshold is very low, ranging from 6-10 ppt in water.
- No known health impacts
- Petrichor (the smell associated with rainfall on dry soil) is associated with the aerosolized release of geosmin from the ground.
- Some scientists believe the high sensitivity humans have is a mechanism to assist with survival[F].
- Afterall, its what camels do[G].

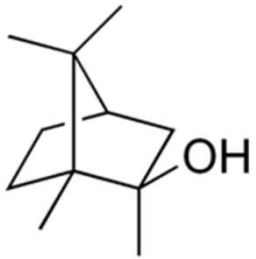


[F] – Why does rain smell good?, Palermo, 2013.

[G] – Sure can smell the rain, Jordán, 2015.

2-Methylisoborneol (2MIB)

- Odor detection threshold is very low, ranging from 2-20 ppt in water.
- No known health impacts.
- Mechanistically like Geosmin, the two have similarities but may or may not be found together[H].



[H] – Biochemical and ecological control of geosmin and 2-methylisoborneol in source waters, Jüttner and Watson, 2007.

Potential Sources of Geosmin and 2-MIB

- Although some reports indicate the potential for other sources, most outbreaks do not isolate the specific organism causing the issue. It is believed that most outbreaks are due to cyanobacteria.
- A common belief that is not corroborated with empirical evidence is that planktonic surface algae (algal blooms) are the main cause of outbreaks[I].
- 30% of known cyanobacterial producers are nonplanktonic (non-floating).
- Many of the remaining known producers are benthic (low water level) or epiphytic (biofilm).
- No known description for geosmin or 2-MIB *production* in anoxic environments.

[I] – Odourous algal cultures in culture collections, Persson, 1988.

Geosmin and 2-MIB at the Cellular Level

- Odorous volatile organic compounds (VOCs) created by microscopic organisms is still thought to be the leading cause of Geosmin and 2-MIB
- Geosmin and 2-MIB are found within the cell as well as a dissolved fraction in the surrounding environment (water).
- The fractional amounts can vary widely and are not well studied but some reports show higher than 80% of the geosmin to be bound to the cell[J].
- This dissolved fraction can be very useful when determining appropriate treatment.

[J] – Effect of environmental factors on geosmin production by Fischerella muscicola, Wu and Jüttner, 1988.

Operational Choices to Consider

Evaluation

- Have you had taste and odor issues in the past?
- Consider source water characteristics
  - Prone to stratification
  - Nutrient inputs from land sources
    - Nitrogen
    - Phosphorus
  - Stagnation (water stops moving)
- Have other systems on same source had problems?

Preparation – Source Determined to be Vulnerable

- Determine conditions that would make the source the most vulnerable (seasons)
- Evaluate treatment options
  - Is current treatment sufficient
  - Mechanical (detention time, sedimentation, filtration, aeration, carbon, membrane)
  - Chemicals (ozone, PAC) (copper sulfate, $KMNO_4$, $NaMNO_4$, chlorine)
- Treatment insufficient
  - Are mechanical changes necessary?
  - Are additional chemicals needed?
    - Will some need to be turned off so as not to lyse the cells?
    - Will some need to be changed?

Observation

- Visual algal growth (blooms or films)
- Change in dissolved oxygen
- pH drop after sunset
- Elevated CO2
- Short filter runs
- Increase in coagulant load
- Increased disinfectant/oxidant demand

Monitoring

- Geosmin or 2-MIB is present or thought to be present
- Conduct monitoring to determine if chemicals are present (~$50-100/sample for each)
- Monitor raw water
- Consider multiple sample locations/time of day
- Consider turn around times (around a day for some labs)
- Start adjusting treatment

The Fallout

- Communication is an important component in creating and fostering a trusting relationship with customers.
- We are built to distrust off smells or colors in our water, it is natural for customers to be concerned!
- Consider continuous outreach and education. Letting customers know of the problem before it may occur can foster trust.

Conclusion

- Geosmin and 2-Methylisoborneol are primary contributors to “dirty” and “musty” taste and odor issues in drinking water.
- Although the EPA does not consider the chemicals unsafe in drinking water concentrations, odor has a Secondary Maximum Contaminant Limit of 3 TON
- Monitor and Treat as appropriate with consideration of mechanical and chemical limitations
- Communicate with your customers to foster a relationship built on trust

Robert J. Compton
robert.compton@adem.alabama.gov
Water Supply Engineering Section
Drinking Water Branch
Alabama Department of Environmental Management
PO Box 301463
Montgomery, AL 36130-1463
(334) 271-7773

Thank you!
Questions?