Management Strategy to Reduce Tastes and Odors In Phoenix's Water Supply

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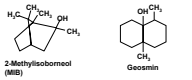
BACKGROUND

Phoenix had a severe problem with "tastes and odors" (T&O) in drinking water. Removing T&Os within a water treatment plant is very expensive.

In 1999, ASU and the City of Phoenix started a three-year project (1999-2002) to reduce the T&O problem

Key aspects of the study were:

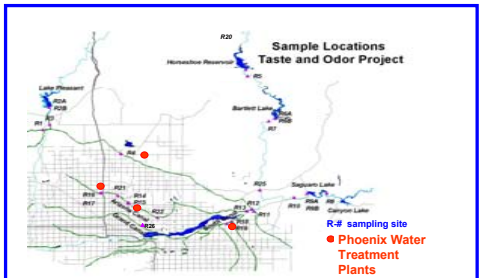
- An intensive monitoring program, a "rapid response" system to allow real-time management,
  and an "open data" policy. Results were shared with all cities in the Valley.
- Research to understand causes of the T&O problem, particularly "culprit" algae, and to develop and analyze management techniques.
- Use of a "multiple barrier" approach.
- Implementation and evaluation of a management strategy within the three-year project, with the intention of measurably reducing the T&O problem.



The two major compounds that cause T&O problems are algal metabolites, produced by a small number of blue-green algae. The T&O threshold for both compounds is ~ 10 ng/L

Tastes and odors in water supplies may be caused by any of several dozen compounds. Among the most common are those caused by two algal metabolites, MIB and geosmin (below). In Phoenix's water supply system, MIB is the most important T&O compound.

MIB is produced by blue-green algae in the large storage reservoirs, in the canals, and even in the water treatment plants. MIB concentrations vary in time and space.



Map of Study Region. Phoenix has four main water treatment plants, shown in red. Sampling was conducted monthly at all sites throughout the year. During the summer, weekly sampling was conducted in the canals. Physical parameters, nutrients, and T&O compounds were measured, and algae were identified.

Management Practices

A "multiple barrier" approach was developed to reduce MIB levels in water delivered to consumers.

"Barriers" (management practices) were implemented in the reservoirs, the canals, and the water treatment plants (WTPs). Among 20+ practices were evaluated, about half a dozen were found to be successful:

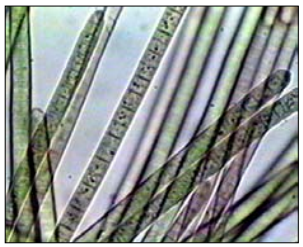
Manage reservoir releases: Water released from the upper outlet of Lake Pleasant had high MIB. Releases are now made from the lower gate (hypolimnion) to avoid high MIB levels (Figure 1).

Blend source waters: When one source (generally SRP) water has high MIB, switch to the other (generally CAP) source.

Treat algae in canals: The monitoring program is used to identify "hotspots" of culprit algae; mechanical or chemical treatments are used to remove them (Figure 2).

Source switching: Switch water production from the Deer Valley WTP (which often received water with high MIB) to other plants with better source water.

Treat with powdered activated carbon (PAC). When MIB levels are high, PAC is added water entering the water treatment plants to adsorb MIB. The PAC is removed by sand filters in the WTPs (Figure 2).



Microphotograph of *Oscillatoria*, a common blue-green algae that produces MIB in the reservoirs and canals. Fewer than a dozen species of algae in the Phoenix area contribute to the T&O problem.

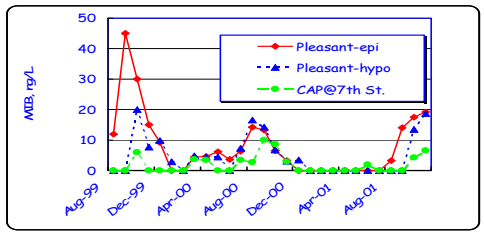


Figure 1. By releasing water from the hypolimnion, rather than the epilimnion, and occasionally using Colorado River water directly (bypassing L. Pleasant), MIB levels in the CAP Canal were consistently kept < 10 ng/L.

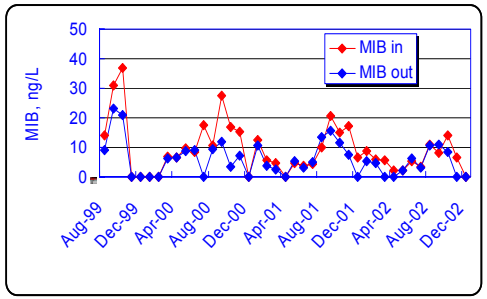
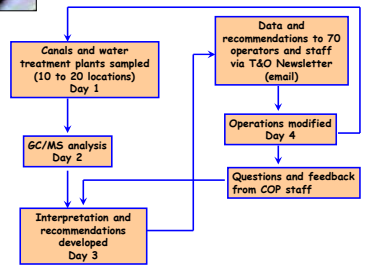


Figure 2. Effectiveness of PAC treatment at Val Vista WTP. MIB concentrations in treated water (MIB out) were generally lower than inlet concentrations, due to the use of PAC to adsorb MIB. Levels of PAC used was based upon MIB levels measured the previous week, communicated via the *T&O Newsletter*.



Communication System

A communication system was crucial for implementation of management concepts. An electronic *T&O Newsletter* distributed to about 80 WTP operators, chemists, and water management personnel provided monitoring results and management recommendations were made weekly during the T&O season. Feedback from WTP operators, chemists, and engineers was incorporated into the *Newsletters*.

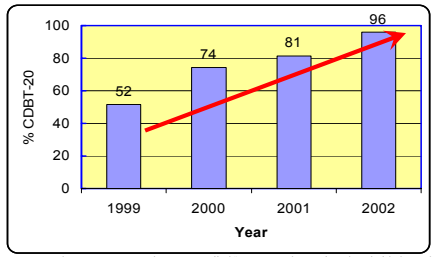


Figure 3. Did it work? We used a metric called "consumer days below threshold" (CDBT) to evaluate success. This metric utilizes monthly water production, average water use, and measured MIB and geosmin to compute the number of days that consumers are drinking water below specific threshold levels (10 or 20 ng/L). During the months of August-November, when the T&O problem is generally worst, the number of "consumer days below 20 ng/L" (CDBT-20) increased from 52% in 1999 to 96% in 2002, a considerable improvement. The project was not as successful at keeping MIB < 10 ng/L.

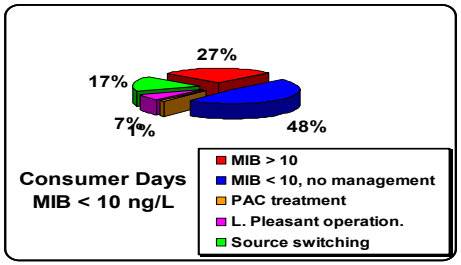


Figure 4. What worked? First, MIB concentrations would have been < 10 ng/L about half the time in 2001 without any management. Source switching (to avoid high MIB water at Deer Valley) and modification of Lake Pleasant releases were the most effective management practices, adding about 25% more consumer days with MIB < 10 ng/L. Finally, MIB was greater than 10 ng/L about 27% of the time.

Intellectual Merit

The project demonstrated the utility of a regional/ecosystem approach to address a practical water quality problem.

The communication system had unintended desirable consequences. Originally, we envisioned the *T&O Newsletter* as a way to deliver monitoring data and recommendations, with little thought regarding feedbacks. However, the *Newsletter* had a "democratization" effect. Empowered with data, Water Services Department staff (WTP operators, chemists, etc.) became very innovative, contributing extensively to the development of management concepts, embarking in their own experiments and providing criticism.

This approach may have utility in other areas of environmental management, replacing the traditional "top-down" approach in which research outcomes are published and then implemented over periods of years or even decades (or worse, go unused). In addition to *speeding implementation of new management practices*, it allows *immediate evaluation of new concepts* and *incorporation of novel ideas from the entire management community* into an evolving management strategy.

Broader Impacts

Phoenix has adequate water supply during normal years, with reasonably good quality. With a projected population of six million by 2030, the quantity and quality of water will barely be adequate, even in "normal" years.

In addition to tastes and odors, water quality issues that confront the region include buildup of salinity, nitrate contamination of aquifers, elevated (natural) arsenic concentrations, and disinfection byproducts.

In this project, we demonstrated the viability of a regional/ecosystem approach for addressing water quality problems. Expansion of the regional management concept to a broad suite of problems will be essential to ensure adequate water quality.

More information on the T&O Project can be found at http://www.public.asu.edu/~westerho/tasteandodor.htm