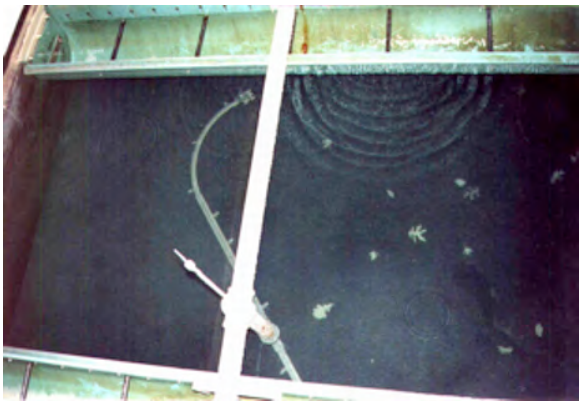
Removal of
Total Organic Carbon

A Technical Review



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Alternatives to TOC Removal Requirements: Direct Measures of DBP Formation

Since public health concerns center around the formation of DBPs, it seems reasonable to employ the most direct known parameters of DBP production during treatment and distribution and use these established measures to establish a more uniform and rational limit for drinking waters to meet independent of source, system size, alkalinity or other externalities.

It is clear that USEPA recognizes that TTHM and HAA5 provide some measure of overall DBP formation. The near-absence of the compounds that constitute these groups should be some indication that unknown DBPs, although varied in composition, have not been formed in large measure.

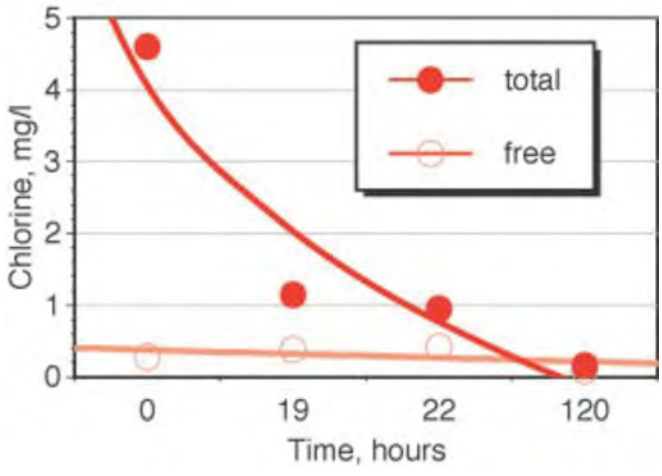
Disinfectant Persistence

Another indicator useful for operation and system monitoring should be the depletion of the disinfectant residual. If a residual remains persistent over a prolonged period (e.g., days and weeks), it may be assumed that DBP formation reactions are not proceeding rapidly. This can be a particularly important water system monitoring procedure because the measurement of disinfectant residual is routinely practiced at utilities that practice disinfection.

Following our recommendation, a number of Midwestern systems are currently following a simple monitoring program to determine the *persistence* of their finished water residual under ideal (clean pipe) and field (dirty pipe) conditions. To assess disinfectant loss in the clean pipe, finished water is stored in darkness in a clean glass bottle. Aliquots are removed over a period of hours to days to weeks to observe disinfectant residual persistence.

An example of a disinfectant residual persistence study for an ammonia-bearing Illinois groundwater supply, shown below, indicates that most of the finished water chloramine residual reacts with dissolved reducing agents in a clean glass bottle within a day. In the absence of reducing agents, this chloramine residual would be expected to persist for days and, possibly, weeks in clean glass bottles.

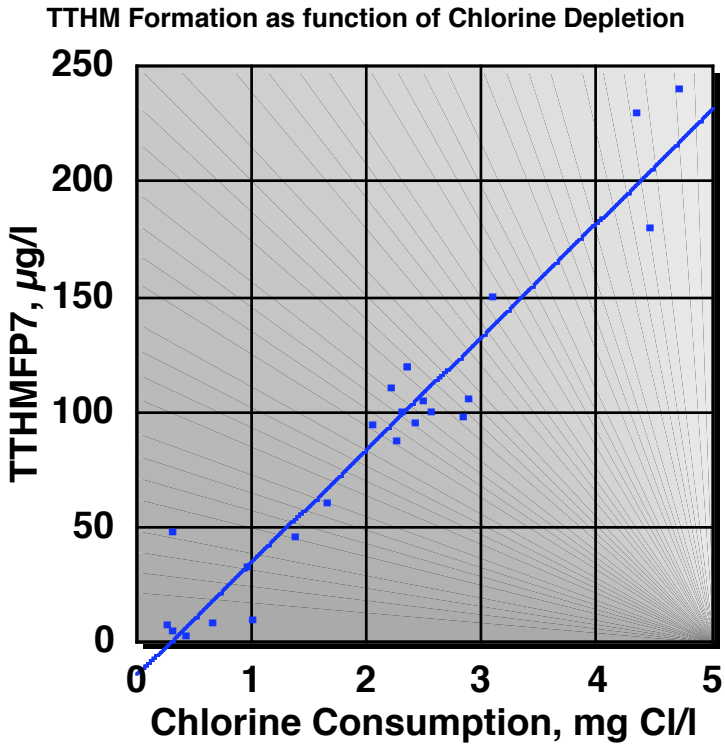
Chlorine Residual Depletion, Illinois Ground Water



Reduction of DBP Formation by Enhanced Coagulation

To assess a water's response to varied coagulant dosages or lowered pH, a more direct measure of the reduction of DBP formation seems appropriate. Standard Methods (APHA) exist for such parameters as *total trihalomethane forming potential* (TTHMFP) and *chlorine demand* (persistence). Particularly the latter test, indicating the progressive loss of disinfectant residual as it is slowly consumed by organic reducing agents in the finished water, is both inexpensive and can be reliably conducted by water plant laboratory personnel.

Data (1994) from Little Rock, Arkansas (plotted below) indicate that approximately 50 *µ*g/l of TTHM were formed for each mg/l of chlorine consumed over a 7-day period (TTHMFP7). These results suggest that, for a specific water and disinfectant residual, it may be possible to establish a relationship where *chlorine consumed* serves as an rapid and inexpensive index of DBP formation.



Health Effects of TOC

TOC has not been shown to lead to disease in humans. Evidence cited by USEPA (1998) for the relationship of known disinfection by-products to disease might be considered tenuous.

> *"… while EPA cannot conclude there is a causal link between exposure to chlorinated surface water and cancer, these studies have suggested an association, albeit small, between bladder, rectal, and colon cancer and exposure to chlorinated surface water."*
>
> *"As with cancer, EPA cannot conclude at this time there is a causal link between exposure to DBPs and reproductive and developmental effects."*
>
> *"While EPA recognizes there are data deficiencies in the information on the health effects from the DBPs and the levels at which they occur, the Agency believes the weight-of-evidence presented by the available epidemiological studies on chlorinated drinking water and toxicological studies on individual DBPs support a potential hazard concern and warrant regulatory action at this time to reduce DBP levels in drinking water."* ***[Federal Register: December 16, 1998 (Volume 263, Number 2410]***

Nationwide DBP Occurrence Study

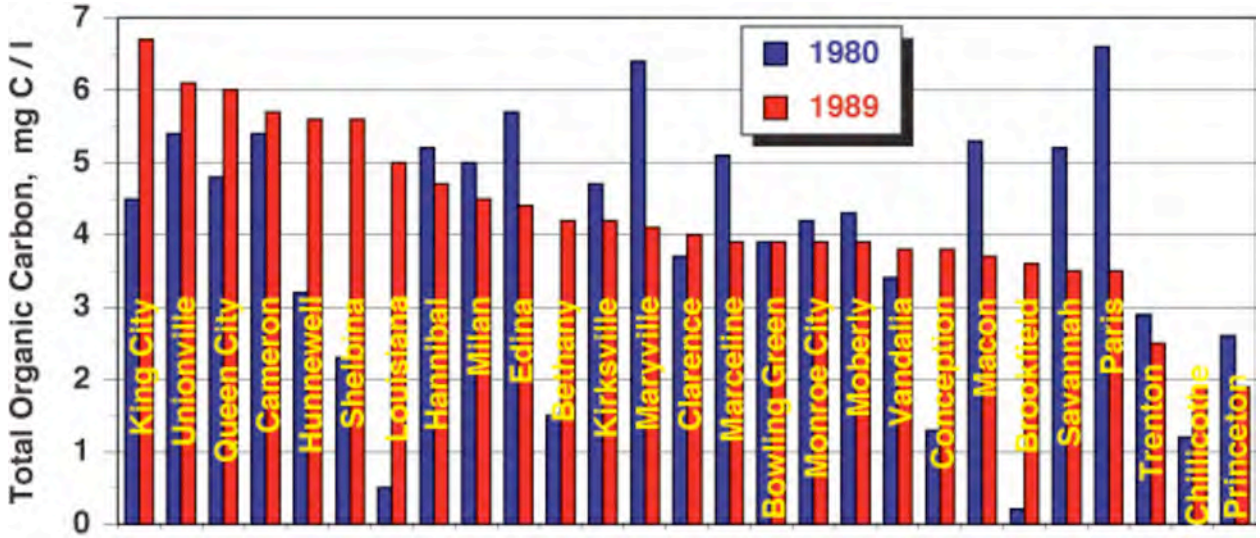
This is not to dismiss the importance of exercising caution with respect to the control of potentially harmful health effects from poorly understood or unknown sources. Instead, it is important to support more scientific approaches to the establishment and implementation of health-based regulations.

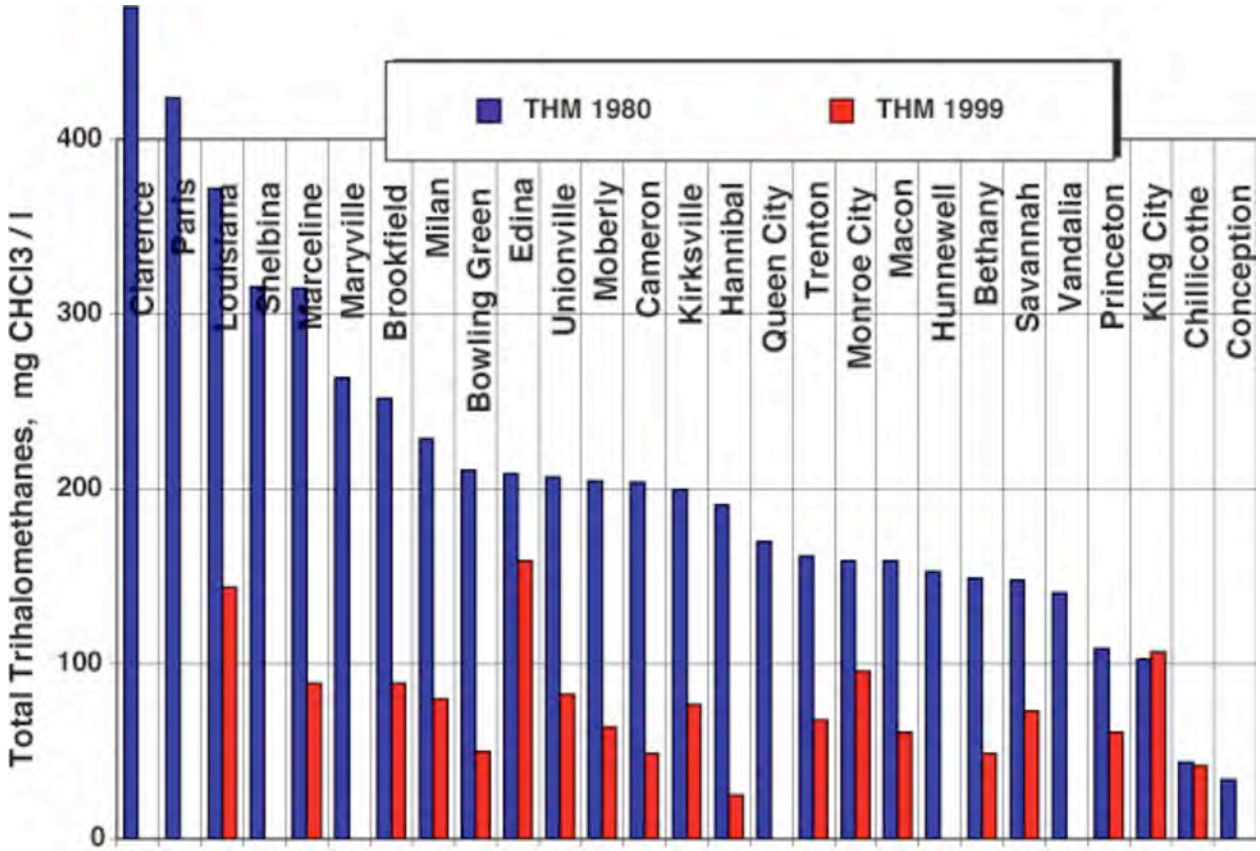
Recently, as part of a *Nationwide DBP Occurrence Study* (2004), USEPA researchers report that they "have quantified the occurrence of more than 200 previously unidentified disinfection by-products". Since the compounds discovered were frequently brominated and iodinated DBPs, it should be noted that there is presently little helpful data available on the bromide and iodide content of most drinking water sources.

Most encouraging about the new studies is that the researchers will attempt to determine how toxicologically significant the newly discovered compounds are; which are more genotoxic and cytotoxic to mammalian cells. They will employ "a battery of in vivo and in vitro toxicity assays, with an emphasis on newer reproductive and developmental health effects". Those who manage water utilities for the benefit of their communities may be encouraged that this approach will lead to regulations that are more clearly focussed on potential health threats than the TOC removal requirement.

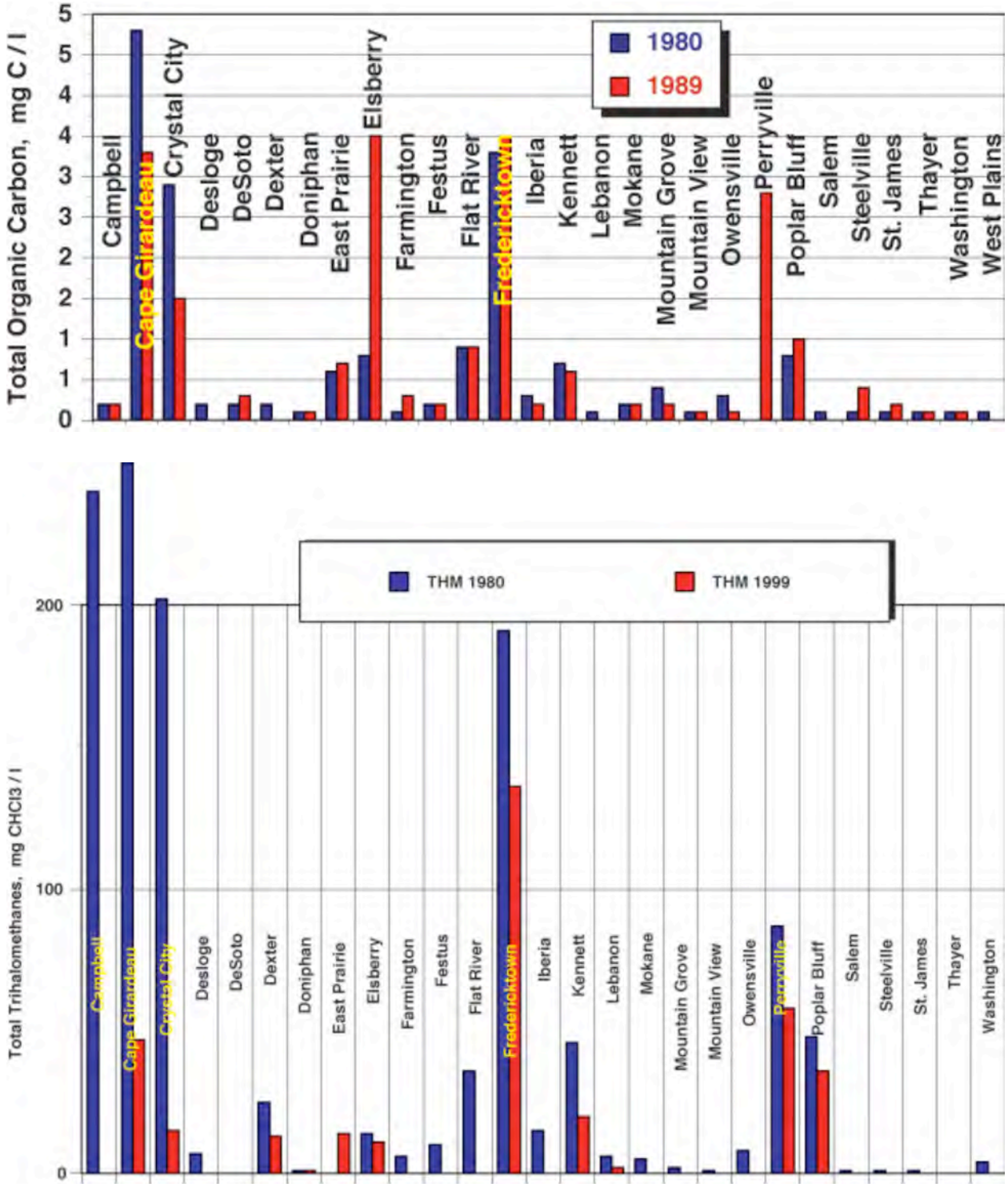
Disinfection by-products of health concern in drinking water: results of a U.S. Nationwide Occurrence Study. S. Richardson , A. Thruston, S. Krasner, H.S. Weinber, R.Chinn, M.J. Sclimenti, S. Pastor, G.D. Onstad. International Mass Spectrometry Conference, Edinburgh , Scotland , August 31 - September 5, 2003 .

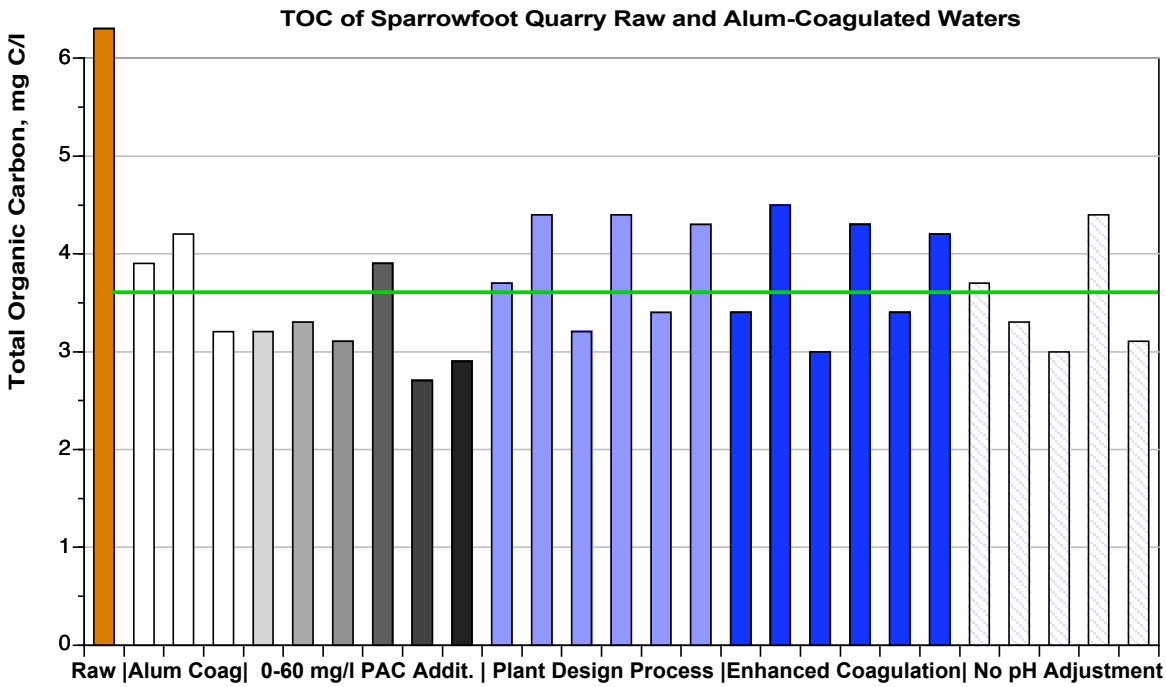
TOC and TTHM in Northern Missouri Drinking Waters





TOC and TTHM in Southern Missouri Drinking Waters





Investigations of Water Treatment Processes for the Removal of Organic Matter from Sparrowfoot Quarry Water, Clinton, Missouri, H_2O'C Engineering, Columbia, MO, January 6-10, 1997.