Drinking Water Quality: Organic Carbon

What is This Indicator, and Why Is It Important?

Total Organic Carbon (TOC) is an indicator of the quality of Delta water as a source of drinking water. Organic carbon and bromide are precursors to the formation of harmful disinfection byproducts (DBPs) in municipal water supplies (see conceptual model in Figure 1). Source water with high DOC and bromide concentrations requires additional treatment steps, increases the cost of treatment, and may lead to increased health risk from exposure to disinfection byproducts. Since 22 million Californians get tap water that originates in the Delta, organic carbon in water exported from the Delta is important to both public health and the cost of drinking water in California. The CALFED Drinking Water Quality Program has the goal of achieving an average TOC concentration of 3 mg/L and bromide concentration of 50 µg/L or equivalent level of public health protection using a cost-effective combination of alternative source waters, source control and treatment technologies.

What Do the Data Show?

The data (Figure 2) show that throughout the period of record the average organic carbon concentration has exceeded the CALFED target. There is a great deal of seasonal variation with concentrations typically dropping below 3 mg/L in the late summer and fall and exceeding the target during the remainder of the year. Organic carbon concentrations usually peak in January or February coinciding with periods of higher river flow.

This data shows the baseline conditions for this parameter as an indicator of the suitability of Delta water as a municipal water supply. This data probably does not reflect any changes due to water quality actions initiated by the CALFED program. Due to the high degree of year to year variability it is also difficult to reach any firm conclusions about long term trends but it appears that drinking water quality in the Delta as measured by organic carbon improved over the ten years shown (1992-2002). However, organic carbon continues to be problematic for municipal users of Delta water and definitive answers about management actions to address this problem may still be a few years away.

Discussion

The basic equation for formation of disinfection byproducts,

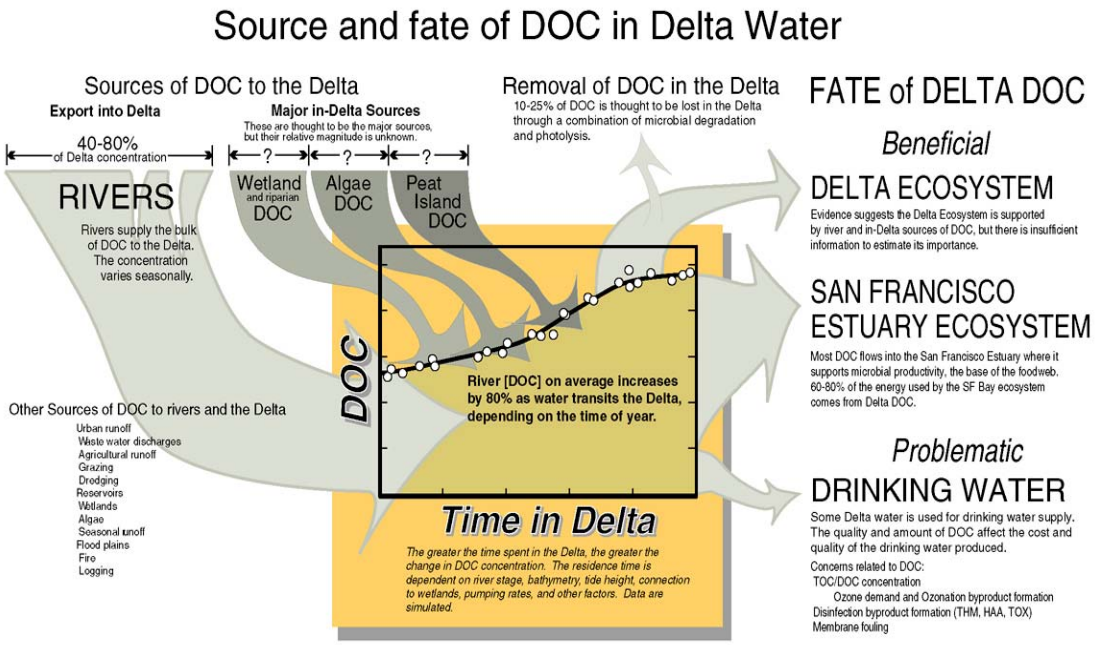
organic carbon + bromide + chlorination = disinfection byproducts,

shows that organic carbon is only one factor leading to the presence of these undesirable chemicals in tap water. Bromide, the other major ingredient is discussed as a separate indicator. The other major factor in the equation is the process of disinfection by chlorination. Changing the disinfection processes at drinking water treatment plants, including switching to other types of disinfection, can also reduce DBP formation. Many treatment plants using Delta water have already switched to ozone disinfection and many more are planning to. This will reduce but not eliminate the use of chlorine. CALFED is supporting several projects aimed at reducing DBP formation through advances in treatment technology. Reducing organic carbon concentrations in source water will also reduce DBP formation and is one of the primary goals of the source control elements of the CALFED Drinking Water Quality Program.

The reasons for the apparent downward trend in TOC shown in Figure 2 are not known. Nearly all land uses and discharges contribute some organic carbon to the system including agriculture, forestry, urban runoff, municipal wastewater, and runoff from natural lands. Upstream discharge management may be affecting riverine loads to the Delta but we do not have enough data to determine if there has been any measurable change in systemic loading. However, there is sufficient information to show that it will take a broad and diverse set of actions addressing multiple sources to achieve any significant reduction in organic carbon at the Delta export pumps.

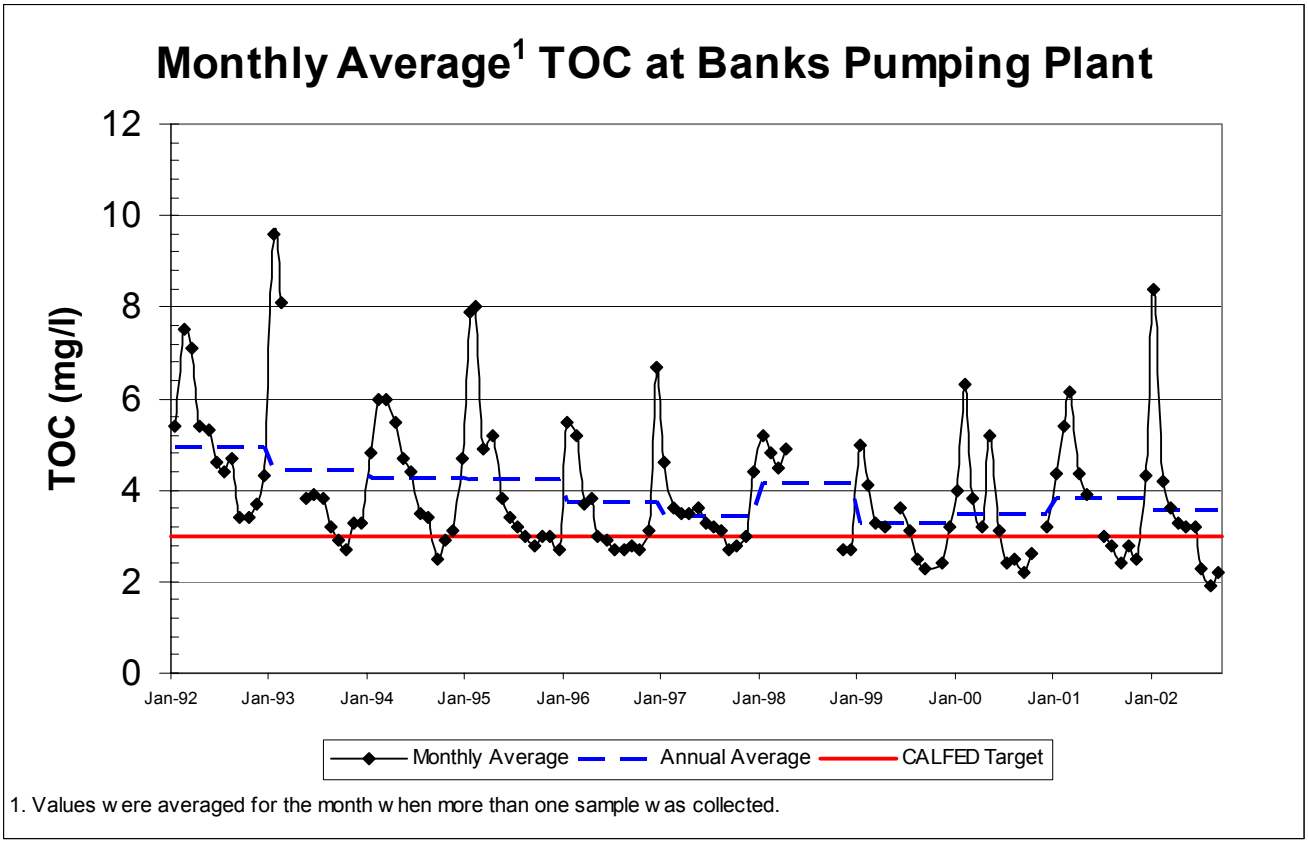
Drainage from islands with peat soils has been identified as a significant source of organic carbon in the Delta although the exact amount is not known. Another potentially important organic carbon source is wetlands. Organic matter produced by the growth and decay of plants in wetlands could be a significant source of TOC in the Delta. There is evidence suggesting that increasing wetland acreage could increase organic carbon concentrations in Delta channels.

Water management can also have an effect on Delta drinking water quality. Since there is a major and somewhat predictable seasonal change in TOC concentrations at the export pumps, timing of Delta water exports is important. Reducing exports during periods of high organic carbon concentration would improve drinking water quality. Other water management actions in the Delta could also have an influence on organic carbon concentrations. Changes in way that water is moved through or stored in the Delta could change TOC concentrations. Installation of permanent barriers in the south Delta will route more San Joaquin River water (higher TOC than other Delta tributaries) into the central Delta. The proposed storage of water on Delta islands would also increase in-channel TOC concentrations. The cumulative impact of all actual and proposed CALFED actions is unknown.



Source: USGS, Brian Bergamaschi

Figure 1. Conceptual model of the sources, transport, fate, and effects of dissolved organic carbon in the Delta. The relative size of the arrows represent their probable relative contributions. Question marks indicate major uncertainties.



1. Values were averaged for the month when more than one sample was collected.

Data source: DWR, O&M, Water Quality Section

Figure 2. Total organic carbon (TOC) at the Harvey O. Banks Delta Pumping Plant, the point where the majority of the water destined for municipal uses leaves the Delta.

Technical Note: Total Organic Carbon at the Delta Pumping Plant

The Indicator

Goal: This indicator responds to the Drinking Water Quality Program's (DWQP) ROD goal of 3 mg/L at the south and central Delta pumps.

The Data

Data Collection: There is a long record of water quality analyses, good data density (frequency), and a long list of drinking water constituents of concern analyzed at the major Delta inflow and export locations. The data set at the Banks Pumping Plant is probably the most complete. The data set shown is from discrete grab samples but there is also data from a continuous on-line organic carbon analyzer at this location.

Data Quality / Limitations: Organic carbon is not a single pollutant but an aggregate measure of a complex mixture of compounds dissolved or suspended in water. For drinking water purposes it is used as a measure of the amount of disinfection byproducts that may be produced when the water is treated and as a basis for treatment plant operational decisions. It is also a trigger for additional regulatory requirements under the Safe Drinking Water Act. There are a number of different methods for measuring both the amount and characteristics of organic carbon in water the most common being total organic carbon (TOC), dissolved organic carbon (DOC), ultraviolet absorbance (UVA), and trihalomethane formation potential (THMFP). Since 3 mg/L TOC is an explicit CALFED water quality target and TOC data is widely available, we are using it as one our primary indicators of drinking water quality, but it is far from perfect for this purpose.

There is ample evidence of the overall poor correlation between TOC and DBP formation particularly in the complex Delta water environment. Other indirect measures of DBP formation potential such as DOC ultraviolet absorbance UVA have similar shortcomings. Direct disinfection byproduct formation potential analysis is expensive and is sensitive to variables such as temperature, pH, contact time, and chlorine concentration. There is no widely accepted standard method for measuring DBP formation potential.

Delta water is not the only source of organic carbon to treatment plants in the system. Organic carbon can also come from local watersheds, storage reservoirs, and other sources between the Banks pumping plant and the point of treatment.

Degree of Development

Total organic carbon analyses on grab samples from the Delta Pumping plant have been collected approximately monthly since 1986. There is an excellent baseline of data to work from to assess changes in this parameter.

Longer-Term Science Needs

There is still a great deal of uncertainty about the sources, transport, and transformation processes affecting organic matter in Delta water. Additional monitoring to better define the spatial and

temporal distribution of aqueous organic matter in the Delta is needed. The role of algae as a source of DBP forming material is poorly understood. The observed increase in concentrations and changes in characteristics of organic matter between Delta inflows and exports has not been adequately explained. There is little information about the sources and processes governing organic matter concentrations in the Sacramento and San Joaquin River watersheds. Development of better analytical tools for characterization of organic matter as a drinking water constituent of concern are needed. Work is needed to improve and standardize current methods (THMFP and TOC for example) and to develop/adapt new methods to characterize organic matter in water. There is little information about the effectiveness of non-point source Best Management Practices in reducing drinking water constituents of concern.