Project Profile Information Form

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Project Title: POLAR NOM: CHARACTERIZATION, DBPS, TREATMENT

Project Number: 451

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Objectives:
(State the relevant objectives of the project; 75 words or less.)

♦ Develop a comprehensive method for isolation and fractionation of natural organic matter (NOM) from a variety of waters, including low-humic waters.

♦ Characterize polar NOM by elemental composition, size, structure, and reactivity (with chlorine, chloramines, and ozone). Evaluate characteristics for relationships between structure and reactivity.

♦ Study the effect of full- and bench-scale treatment processes—coagulation, ozonation-biofiltration, activated carbon (AC), anion exchange resins (AER), and membranes—on polar NOM and disinfection by-product (DBP) formation.

Background:
(Provide background information; 75 words or less.)

NOM in drinking water serves as a precursor for DBPs. Utilities are looking toward precursor removal as a key means of DBP control to meet regulations. The NOM in water supplies is a complex, heterogeneous mixture of hard-to-identify compounds (polar and nonpolar). Nonpolar or humic NOM is hydrophobic, better characterized, and more readily removed by coagulation when compared with polar or nonhumic NOM. A better understanding of polar NOM and DBP formation is clearly needed.

Highlights:
(Provide “at a glance” the main findings of the research [minimum of three]; 100 words or less.)
Polar NOM can now be isolated and characterized as transphilic, hydrophilic acid plus neutral (A+N), hydrophilic base, and colloid fractions. Polar NOM can account for a majority of NOM in low-humic waters or in conventionally treated waters. Transphilic and hydrophilic fractions can have higher trihalomethane (THM) and haloacetic acid (HAA) yields upon chlorination than the hydrophobic fraction. High DBP (especially HAA) yields may be caused by the aliphatic hydroxyl and carboxylic acid structures in those fractions. Conventional water treatment is better at removing nonpolar NOM. Advanced processes such as GAC or AER columns and membranes can provide additional polar NOM removal.

**Approach:**
(Describe the research approach for this project. May use subject subheads; 125 words or less.)

The project focused on understanding the relationships between the types of NOM (nonpolar and polar fractions), DBP formation, and the effects of various treatment processes on NOM and DBPs. Four low humic, conventionally treated waters with a range of raw water qualities were studied in two coordinated, parallel efforts.

♦ Studies of NOM fractions: comprehensive isolation of raw and full-scale treated (including some advanced full-scale treatments) waters into five NOM fractions of differing polarity (nonpolar and four polar fractions); NOM characterization of the solid isolates; and NOM and DBP formation characterization of individually redissolved isolates.

♦ Advanced treatment studies: bench-scale treatment of raw and conventional full-scale treated waters; standard fractionation into three NOM fractions (nonpolar, transphilic, and hydrophilic); NOM characterization; and DBP formation.

**Results/Findings:**
(Describe the results/findings of the research. May use subject subheads; 200 words or less.)

NOM can be isolated into nonpolar (hydrophobic) and four polar fractions: transphilic, hydrophilic A+N, hydrophilic base, and colloid. Differential spectroscopy and methylation pyrolysis–gas chromatography/mass spectrometry are useful polar NOM characterization techniques. In some low-humic and conventionally treated waters, the majority of NOM is polar.

Transphilic and hydrophilic fractions can have higher DBP yields upon chlorination than hydrophobic NOM. The hydrophilic A+N fraction can have high DBP (especially HAA) molar yields, part because of the aliphatic hydroxyl and carboxylic acid structures. Hydrophilic base fractions are small but can have the
highest haloacetonitrile yield and chlorine demand. The colloid fraction was lowest in reactivity and amount.

Traditional and the studied advanced treatment techniques preferentially remove nonpolar NOM DBP precursors. For general NOM removal, ferric chloride coagulation is more efficient than alum; pH depression and activated silica provide additional benefit. Carbon adsorption and AER treatment at high doses remove polar NOM. Ozonation decreases nonpolar NOM and increases polar NOM, probably by transformation; subsequent biotreatment removes polar NOM, producing a modest overall NOM removal. Membrane (ultrafiltration) treatment effectively removes polar NOM (hydrophilic more than transphilic). Significant amounts of polar NOM can be removed by a combination of treatments.

**Impact:**
(Describe the relevant impacts that the research results may have on the water industry. Use general subheads such as recommendations or benefits. Subheads more specific to the project may also be used, such as treatment, analytical development, regulatory implications, and so forth; 100 words or less.)

Polar NOM can produce high yields of DBPs, especially HAAs, upon chlorination. Removal of polar NOM may be needed for chlorine disinfection to remain viable, as DBP limits are lowered. Utilities can benefit from NOM characterization—e.g., using specific ultraviolet absorbance (SUVA) and XAD-8 fractionation—of their water, including clarified water, when optimizing DBP precursor removal.

The first treatment step should be optimization of NOM removal by conventional treatment, which will provide some removal of polar NOM. Adding advanced treatment processes, such as GAC or AER columns or membranes, can provide additional polar NOM removal as needed.

**Participating Utilities** (if applicable; maximum of five):
Contra Costa Water District, Concord, California; City of Martinez, Water Department, Martinez, California; Suez Lyonnaise des Eaux, Le Pecq, France; Metropolitan Water District of Southern California, La Verne, California.