Formation Potential of Disinfection by products of 4 water sources after Nanofiltration (NF) and Advanced Oxidation Processes (AOPs) at optimal and Sub-Optimal Conditions

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Abstract The importance of understanding the impact of different precursor removal treatments on disinfection byproducts (DBP) formation concentrations. This can be elucidated by exploiting the physico-chemical characteristics of NOM in raw water source groups to minimise the formation of DBPs.. Pre-curser technology treatments include coagulation, Ion exchange, Adsorption, membranes biotreatment, ozone and AOPs. Establishing correlations experimentally between different raw water sources, water treatment used and DBP formation, by measuring raw water characteristics at the point before treatment and DBP-FP in the corresponding final water just after treatment using the analytical methods as above and the previously established methods for HAA and THM analysis. Analytical methods for the determination of DBPs from 16 categories are used to determine an extensive range of DBPs, giving a better understanding of the composition of the DBP mixture as a whole. The analytical methods can then be used to determine and compare water treatment technologies under optimal and suboptimal conditions and hence provide operational advice on minimising DBP formation by comparing treatment methods.

Keywords: Disinfection byproducts; Nanofiltration; Advanced Oxidation Processes.

1. Introduction

Chlorine was first used to disinfect drinking water in the US as early as 1908. However it wasn't until the 1970's that Rook discovered a possible link to higher levels of chloroform in drinking water treated with chlorine and inadvertently linked the possibility of precursor material to products of the disinfection process (Rook, 1976). Since then, over 600 disinfection by products have been discovered, some of which may have health implications, prompting regulative legislative controls to be introduced. While the introduction of chlorine to disinfect water has been one of history's great public health advances in eliminating pathogens for safe drinking water, it becomes important to safeguard the public against disinfection by product exposure. This is an ongoing dilemma and balancing act (Richardson, Plewa, Wagner, Schoeny, & DeMarini, 2007a; H S Weinberg, Krasner, Richardson, & Thruston, 2002).

To minimise disinfection byproducts (DBP) formation different treatment technologies are used to reduce the amount of NOM present in raw waters before the disinfection stage. Depending on the type of natural organic matter (NOM) present in the raw waters a combination of coagulation, ion exchange, adsorption, membranes, biotreatment, and advanced oxidation processes (AOPs) treatment technologies can be used to remove the precursor material. The type of treatment depends heavily on the physico-chemical properties of the precursor NOM present, for example, size, hydrophobicity and charge, and these are highly source dependant and highly variable. NOM is a highly complex mixture, its variable and unpredictable nature can make it difficult to predict the formation of DBPs, which DBPs and their concentration. Because of this, the toxicity and exposure to the mixture of DBPs is also difficult to predict.

Approximately 45-50% of the total organic halide concentration, representing the DBP mixture is unidentified. Little is known about components of the mixture, their interaction and hence their toxicity. Therefore, risk assessment of human exposure becomes difficult to assess, especially considering most toxicological studies focus on exposure to one, maybe two chemicals at any one time, when the reality is over 600 DBPs (Barrett, Krasner, & Amy, 2000; Bond, Goslan, Parsons, & Jefferson, 2010; Richardson, Plewa, Wagner, Schoeny, & DeMarini, 2007b; Howard S Weinberg, Richardson, Salvador, Chinn, & Onstad, 2006).

2. Material and Methods

Nanofiltration (NF) and AOPs were performed on four different water sources. Optimal and sub-optimal conditions were used to treat each water type by using a

hydrophilic and hydrophobic membrane. AOPs were performed using hydrogen peroxide at concentrations of 2mM with a UV dose of up to 8000mJ/cm^2. DBP-FP of 35 DBPs was measured.

Results and Conclusions

Nanofiltration, under optimum conditions removed 90% of the Total organic Carbon (TOC), whereas AOPs removed 37%. As nanofiltration is a removal technology, the removal of the DBP precursors is apparent under optimum conditions and can be seen in figure 1.1. Figure 1.2 shows the speciation of the DBPs formed, separating them into their corresponding categories, THMs, HANs, Cl solvents, HK, HNM and HAAs. This shows the removal of the DBP precursors can be different under different treatment operating conditions. AOPs break down molecules to smaller counterparts by reacting with the ·OH hydroxyl radical. The result can be seen in figure 1.3. At 2mM of H_2O_2, in water sample C, as the UV dose increases over time the smaller molecules formed react with the chlorine increasing the DBPs formed. Raw water characteristics of each water type can be seen in table 1. These characteristics can be correlated to the DBPs formed during formation potential with chlorine.

Table 1: Raw water Characteristics of each water type.

Water Type	pH	TOC (mg/L)	NPOC (mg/L)	UV254	TN (mg/L)	Alkalinity (mg/L)	Bromine (µg/L)	Iodine (µg/L)	TOX (ug/ml)	Nitrate (µg/L)	Phosphate (µg/L)
Lowland Reservoir	5.70	9.04	7.09	0.06	16.59	85.00	130.50	3.18	28.44	1.012	33.41
Upland	5.39	21.39	15.08	0.17	12.34	5.00	39.45	1.84	8.03	0.513	27.98
Lowland River	6.80	3.84	3.78	0.11	36.63	232.50	116.50	1.98	45.60	4.13	192.59
Lowland	6.34	6.61	4.33	0.01	17.68	203.75	184.50	3.77	82.29	1.51	295.01

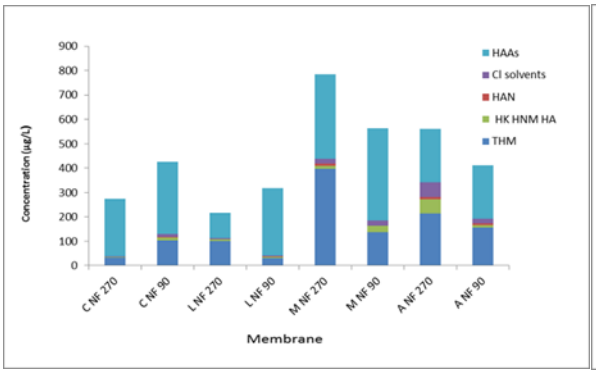

Figure 1.1 DBP-FP total of raw water after NF

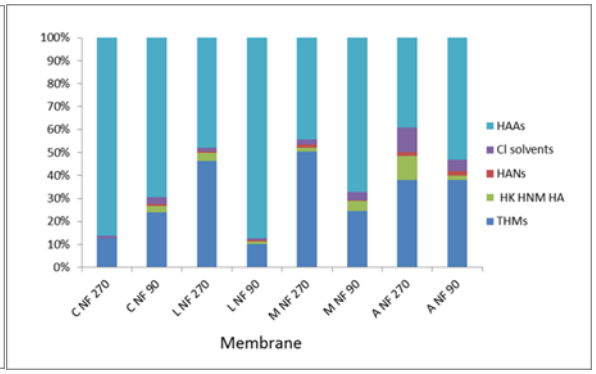

Figure 1.2 DBP speciation of raw water after NF

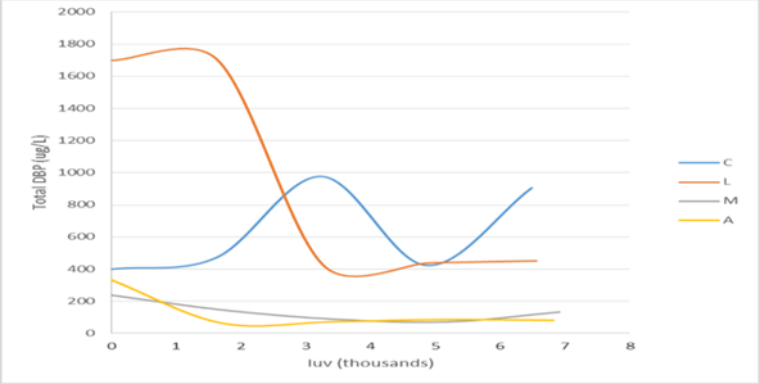

Figure 1.3 DBP-FP total after AOPs with with a UV dose of up to 8000mJ/cm^2

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