Natural Organic Matter In Water Characterization And Treatment Methods Advances In Librarianship Seminar

Samples of raw and treated water after coagulation were collected from drinking treatment systems serving the cities of Akron, Barberton, Newton Falls and Ravenna (OH). Sampling was performed in a weekly basis (e.g., one to three samples each week) during periods comprising from two to three years, leading to the collection of between 600 and 1000 samples at each treatment facility. Water quality parameters (e.g., dissolved organic carbon (DOC), pH, ultraviolet absorbance at 254 nm (UV254)), bromide content, fluorescence excitation-emission matrices (EEM), and disinfection by-product and total organic halogen formation potential (DBPFP and TOX-FP) were determined for the samples before and after coagulation. Parallel factor analysis (PARAFAC) was applied in order to generate independent models on different subsets of each drinking water treatment plant (DWTP) data set: (i) raw water, (ii) treated water, (iii) composite data set (i.e., raw and treated water), and (iv) differential EEM ([delta]EEM)-based model. Three principal fluorophore groups were identified in the Akron,

Barberton and Newton Falls raw and treated water data sets (two components with humic nature and a component with protein-like character), while four moieties (two humic-like and two protein-like components) were retained in the group of samples from Ravenna DWTP. Results of independent PARAFAC modeling were analyzed based on an uncorrected matrix correlation (UMC) approach in order to determine the impact of different coagulants on the structural character of the PARAFAC fluorophore groups. A quantitative analysis intended to study the distribution of the fluorophore moieties before and after treatment, predominant fluorescent structures in the treated water, and PARAFAC components being most affected by the specific coagulant in each DWTP was conducted. Results indicate that NOM in the water sources under monitoring has a highly similar spectral character. Principal conclusions after analysis in a multi-coagulant and multi-plant scenario included: (i) coagulation does not have a significant impact on the structure of the PARAFAC components, (ii) no new fluorescence entities are formed after coagulation, (iii) only physical removal of fluorophores is taking place in the coagulation process, and (iv) irrespective of the coagulant being applied (e.g., aluminum or iron-based salt), the same fluorescence entity (C2-high humic-like component) is the most affected by coagulation in terms of

removal. PARAFAC analysis on [delta]EEM showed to be a valuable tool in order to determine recalcitrant fluorescence groups to coagulation treatment and to establish preferential removal of a specific moiety. Study of the coagulation process in the Akron DWTP, which corresponds to a parallel treatment train involving application of aluminum sulfate (alum) and aluminum chlorohydrate (ACH) on the same water source, confirmed that the fraction of NOM being impacted by these coagulants is identical and variations can only be noticed in the relative reduction attained for the estimated concentration of each fluorophore group in the NOM. Analysis of this particular DWTP demonstrated that a fluorescence-PARAFAC approach can improve the traditional DOC based-criterion used in DWTPs for selection and evaluation of a particular coagulant. Incorporation of PARAFAC components in a previously formulated semi-empirical coagulation model allowed establishing the role of each fluorophore group in the fraction of non-sorbable DOC (fraction of DOC that is not removed by coagulation) at each DWTP, offering improved understanding of the character of this organic material. Results showed that this fraction exhibited significant variation during the period of study at each treatment facility, while the fraction of sorbable DOC being effectively removed by coagulation had a significant non-linear association with the coagulant

dose being applied; suggesting that marginal DOC removal will be attained after a specific concentration of coagulant has been applied. PARAFAC components showed to be suitable predictors of DBPFP and TOX-FP when multiple linear regression analyses were performed. Predictive capability differed for each set of raw and treated water samples and varied in an inter-DWTP basis. Higher association of PARAFAC components with trihalomethane formation potential (THMFP) was observed compared with the degree of fitting when the haloacetic acid formation potential (HAAFP) was analyzed. PARAFAC components with humic-like nature showed to be closely associated with THMFP and HAAFP, while structures with protein-like nature exhibited weak association with DBPFP and TOX-FP. PARAFAC analysis provided insight about the particularities of each water source and the efficiency of the specific treatment process applied in each facility. Results indicate that fluorescence analysis coupled with PARAFAC application may represent a practical tool to be used in the control and optimization of the water treatment operations increasing the efficiency of the processes (e.g., reducing chemical costs) and assuring the desired quality characteristics in the drinking water being supplied.

For the first time, natural organic matter (NOM) in the Red River, MN (RRNOM) and water from the

Moorhead Water Treatment Plant (MWTP) were
separated into six fractions: hydrophobic acid,
hydrophobic base, hydrophobic neutral, hydrophilic
acid, hydrophilic base, and hydrophilic neutral. A
novel NOM fractionation technique using a series of
solid phase extraction cartridges (three Bond Elute®
ENV cartridges, one Strata[TM]-C cartridge, and one
Strata[TM]X-AW cartridge) was used. The technique
requires only 6 hours of fractionation time, which is
much faster than traditional fractionation techniques
(24 hours). Hydrophobic acid and hydrophilic neutral
were the two major fractions accounted for 36% and
25% of RRNOM, respectively. The six NOM fractions
of RRNOM were further characterized using Fourier
transformed infrared spectroscopy and solid state
13C nuclear magnetic resonance spectroscopy. The
hydrophobic acid and hydrophilic neutral fractions
contained mainly carboxylic acids and primary
amines respectively. The fractionation results of
finished water at MWTP revealed that hydrophilic
neutral fraction was the highest (45% of NOM). This
study provides valuable information on NOM
composition in the Red River water and efficiencies
of treatment units at MWTP for removal of different
NOM fractions. With this information, appropriate
operational adjustments on treatment processes can
be made to minimize problematic NOM fractions that
deteriorate drinking water quality.
Characterization and Treatability of Natural Organic

Matter (NOM) for Drinking Water
ProductionCharacterization and Removal of Natural
Organic Matter (NOM) in Drinking Water Treatment
ProcessesFunctions of Natural Organic Matter in
Changing EnvironmentSpringer Science & Business
Media

The use of low-pressure membranes, microfiltration (MF)
and ultrafiltration (UF), has increased dramatically over
the last decade in response to new drinking water
regulations focused on increased control of pathogens
and disinfection byproducts (DBPs), and reduced
membrane costs. The overall goal of this project was to
investigate the specific contributions of the different
types of natural organic matter to MF / UF fouling with
the intent to develop a surrogate test or index that could
be used to predict NOM fouling at low cost through a
combination of source water characterization and rapid
bench-scale testing.

To protect stream organisms in an ephemeral stream at
the Savannah River Site, a proposed National Pollutant
Discharge Elimination System (NPDES) permit reduced
the copper limit from 25 [mu]g/l to 6 [mu]g/l at Outfall
H-12. Efforts to reduce copper in the wastewater and
stormwater draining to this outfall did not succeed in
bringing copper levels below this limit. Numerous
treatment methods were considered, including traditional
methods such as ion exchange and natural treatment
alternatives such as constructed wetlands and peat
beds, all of which act to remove copper. However, the
very low target metal concentration and highly variable

outfall conditions presented a significant challenge for these treatment technologies. In addition, costs and energy use for most of these alternatives were high and secondary wastes would be generated. The Savannah River National Laboratory developed an entirely new 'detoxification' approach to treat the outfall water. This simple, lower-cost detoxification system amends outfall water with natural organic matter to bind up to 25 [mu]g/l copper rather than remove it, thereby mitigating its toxicity and protecting the sensitive species in the ecosystem. The amendments are OMRI (Organic Materials Review Institute) certified commercial products that are naturally rich in humic acids and are commonly used in organic farming.

There are many by-products of water disinfection that are still not fully understood and can be potentially harmful. In this volume all the current research in this area is discussed, along with an examination of the role of NOM (natural organic matter) and its relationship to DBP (disinfection by-product) formation and control in drinking water. Understanding the relationship of NOM to DBP may well lead to new techniques for analyzing and treating water and enable reasonable choices to be made for source-water protection, treatment plant process optimization, and distribution system operation to control DBP's. This volume emphasizes the characterization and reactivity of polar natural organic matter. It examines analytical methods which better characterize NOM and determines some of the polar and nonvolatile DBP forms. It presents innovative new methods, sich as capillary electrophoresis for haloacetic

aceids and LC/MS for the identification of polar dinking
water DBPs.

Functions of Natural Organic Matter in Changing
Environment presents contributions from the 16th
Meeting of the International Humic Substances
Society (IHSS 16) held in Hangzhou, China on
September 9-14, 2012. It provides a comprehensive
and updated research advance in the field of
characterization, function, application of humic
substances (HS) and natural organic matter (NOM)
in environment, agriculture, and industry. A broad
range of topics are covered: i) formation, structure
and characteristics of HS and NOM; ii) HS/NOM and
carbon sequestration; iii) HS/NOM and
biogeochemical cycling of nutrients; iv) HS/NOM and
the environmental processes of toxic elements and
anthropogenic organics; v) HS/NOM, naturally
occurring and engineered nanoparticles; vi)
HS/NOM, biodiversity and ecosystem health; vii)
HS/NOM in water and water treatment; viii)
characterization and function of biochar in the
environment; and ix) industrial products and
application of HS. The book will be an invaluable
reference for chemists, biologists, environmental
scientists, ecologists, soil scientists, water scientists,
agronomists, global change researchers and policy
makers. Jianming Xu is Professor and Director at the
Institute of Soil and Water Resources and
Environmental Science, Zhejiang University,

Hangzhou, China. Jianjun Wu is Professor at the
Institute of Soil and Water Resources and
Environmental Science, Zhejiang University,
Hangzhou, China. Yan He is Associate Professor at
the Institute of Soil and Water Resources and
Environmental Science, Zhejiang University,
Hangzhou, China.

This book is written as a reference on organic
substances in natural waters and as a
supplementary text for graduate students in water
chemistry. The chapters address five topics: amount,
origin, nature, geochemistry, and characterization of
organic carbon. Of these topics, the main themes
are the amount and nature of dissolved organic
carbon in natural waters (mainly fresh water,
although seawater is briefly discussed). It is hoped
that the reader is familiar with organic chemistry, but
it is not necessary. The first part of the book is a
general overview of the amount and general nature
of dissolved organic carbon. Over the past 10 years
there has been an exponential increase in
knowledge on organic substances in water, which is
the result of money directed toward the research of
organic compounds, of new methods of analysis
(such as gas chromatography and mass
spectrometry), and most importantly, the result of
more people working in this field. Because of this
exponential increase in knowledge, there is a need
to pull together and summarize the data that has

accumulated from many disciplines over the last decade.

Water Supply has been the most comprehensive guide to the design, construction and operation of water supply systems for more than 40 years. The combined experience of its authors make it an unparalleled resource for professionals and students alike. This new sixth edition has been fully updated to reflect the latest WHO, European, UK and US standards, including the European Water Framework Directive. The structure of the book has been changed to give increased emphasis to environmental aspects of water supply, in particular the critical issue of waste reduction and conservation of supplies. Written for both the professionals and students, this book is essential reading for anyone working in water engineering. •Comprehensive coverage of all aspects of public water supply and treatment •Details of US, European and WHO standards and practice •Based on decades of practical professional experience

Abstract: Elevated levels of disinfection by-products (DBPs), detected in Cairo residential water supply during the past decade, were the motivation to study the process of DBP formation at the water treatment plant (WTP) stage. It is hoped that an in-depth understanding of natural organic matter (NOM) characteristics and DBP formation/removal in an existing WTP will yield a baseline as well as insights for the development of optimum strategies for cost-effective reduction of potentially harmful drinking water compounds

such as Trihalomethanes (THMs) and Haloacetic acid
(HAAs). The objectives of this research were to: investigate
the degree of removal of the various NOM fractions in
conventional WTPs and identify the factors that may possibly
enhance their removal; and investigate the levels of formed
DBPs within conventional WTPs when pre-chlorination and
post-chlorination are applied. Water samples were collected
from El-Fustat WTP in Cairo from 4 different points along the
treatment process and covering the four different seasons of
a year. NOM was quantified by classical surrogate
parameters such as total organic carbon (TOC), dissolved
organic carbon (DOC), and ultraviolet absorbance (UVA254);
and characterized more precisely according to its
hydrophobic-hydrophilic properties using resin fractionation.
THMs, HAAs and other water quality analyses were
conducted for all collected samples. Measurements of NOM
fractions following each treatment unit indicate that the
hydrophobic fraction is significantly removed by the
coagulation/flocculation/ sedimentation processes (56% to
13% in the various seasons) whereas the transphilic, and
hydrophilic fractions were removed to much lower degree
(51% to 10%) and (15% to 4%), respectively. The
hydrophobic fraction had formed flocs with the added alum
more than the other two fractions. No further removal of NOM
takes place in rapid sand filtration or post-chlorination units.
Although the THMs values recorded for the entire study were
complying with the Egyptian guidelines, it is not guaranteed
that tap concentrations will comply to the guidelines limits.
This is because THM/THMFP does not exceed 39%, leaving
room for 61% to be reacted in pipe lines and storage tanks
until it reaches the customers taps. In addition, HAAs
concentrations at the plant effluent were much higher than
the regulating limits, alarming the WTP to exert more effort to
reduce THMs, and HAAs values. On an attempt to identify the

relative importance of NOM fractions in THMs formation, the measured values of the THMs were regressed to each NOM fraction and the coefficient of determination (R^2) was calculated. Results showed that unlike hydrophobic fraction and transphilic fractions (R^2 = 0.01, 0.14), respectively, hydrophilic NOM fractions are consistently most responsible for THM and HAAs production at the plant effluent (R^2 = 0.77, 0.62. Although, hydrophilic fraction was the main contributor to THMs and HAAs formation in El-Fustat WTP; coagulation/flocculation and sedimentation could not successfully remove it during treatment. Accordingly, the processes of coagulation/flocculation/sedimentation/filtration are not guaranteed to be useful in decreasing the DBPs levels. El-Fustat WTP does not technically implement "Enhanced Coagulation"; however, initial results from this study shows that the hydrophillic DOC fraction is less likely to be removed during Enhanced Coagulation but the major DOC contributor to DBPs formation. Future work should test this hypothesis through a bigger and wider sample size. Free chlorine concentrations are responsible for the high THM levels at the plant effluent, which implies its responsibility on THMs formed in the plant and the formation potential in distribution pipelines. Therefore, reducing the chlorine doses as much as possible to reach zero free chlorine before post-chlorination and the minimum acceptable free chlorine residual for secondary disinfection is going to reduce the THMs and HAAs levels substantially.
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In this project the researchers addressed four maj
The objective of this research was to develop
fluorescence-based tools that are suitable for performing
rapid, accurate and direct characterization of natural
organic matter (NOM) and colloidal/particulate
substances present in natural water. Most available
characterization methods are neither suitable for
characterizing all the major NOM fractions such as
protein-, humic acid-, fulvic acid- and polysaccharide-like
substances as well as colloidal/particulate matter present
in natural water nor are they suitable for rapid analyses.
The individual and combined contributions of these NOM
fractions and colloidal/particulate matter present in
natural water contribute to membrane fouling,
disinfection by-products formation and undesirable
biological growth in drinking water treatment processes
and distribution systems. The novel techniques
developed in this research therefore, provide an avenue
for improved understanding of these negative effects and
proactive implementation of control and/or optimization
strategies. The fluorescence excitation-emission matrix
(EEM) method was used for characterization of NOM
and colloidal/particulate matter present in water. Unlike
most NOM and colloidal/particulate matter
characterization techniques, this method can provide fast
and consistent analyses with high instrumental
sensitivity. The feasibility of using this method for
monitoring NOM at very low concentration levels was
also demonstrated with an emphasis on optimizing the
instrument parameters necessary to obtain reproducible
fluorescence signals. Partial least squares regression

(PLS) was used to develop calibration models by correlating the fluorescence EEM intensities of water samples that contained surrogate NOM fractions with their corresponding dissolved organic carbon (DOC) concentrations. These fluorescence-based calibration models were found to be suitable for identifying/monitoring the extent of the relative changes that occur in different NOM fractions and the interactions between polysaccharide- and protein-like NOM in water treatment processes and distribution systems. Principal component analysis (PCA) of fluorescence EEMs was identified as a viable tool for monitoring the performance of biological filtration as a pre-treatment step, as well as ultrafiltration (UF) and nanofiltration (NF) membrane systems. The principal components (PCs) extracted in this approach were related to the major membrane foulant groups such as humic substances (HS), protein-like and colloidal/particulate matter in natural water. The PC score plots generated using the fluorescence EEMs obtained after just one hour of UF or NF operation could be related to high fouling events likely caused by elevated levels of colloidal/particulate-like material in the biofilter effluents. This fluorescence EEM-based PCA approach was sensitive enough to be used at low organic carbon levels present in NF permeate and has potential as an early detection method to identify high fouling events, allowing appropriate operational countermeasures to be taken. This fluorescence EEM-based PCA approach was also used to extract information relevant to reversible and irreversible membrane fouling behaviour in a bench-scale flat sheet

cross flow UF process consisting of cycles of permeation and back-washing. PC score-based analysis revealed that colloidal/particulate matter mostly contributed to reversible fouling, while HS and protein-like matter were largely responsible for irreversible fouling. This method therefore has potential for monitoring modes of membrane fouling in drinking water treatment applications. The above approach was further improved by utilizing the evolution of the PC scores over the filtration time and relating these to membrane fouling by the use of PC scores' balanced-based differential equations. Using these equations the proposed fluorescence-based modeling approach was capable of forecasting UF fouling behaviours with good accuracy based solely on fluorescence data obtained at time = 15 min from the initiation of the filtration process. In addition, this approach was tested experimentally as a basis for optimization by modifying the UF back-washing times with the objective of minimizing energy consumption and maximizing water production. Preliminary optimization results demonstrated the potential of this approach to reduce power consumption by significant percentages. This approach was also useful for identifying the fouling components of the NOM that were contributing to reversible and irreversible membrane fouling. Grand River water (Southwestern Ontario, Canada) was used as the natural water source for developing the techniques presented in this thesis. Future research focusing on testing these methods for monitoring of membrane fouling and treatment processes in large-scale drinking water treatment facilities that experience

different sources of raw water would be useful for
identifying the limitation of these techniques and areas
for improvements.

Drinking water quality has been a matter of concern for
several decades. Disinfection of drinking water improves
its microbiological quality and prevents disease
outbreaks. However, continuously increasing scientific
research concerns the presence of organic and inorganic
contaminants in water. Many of these compounds,
named haloforms, originate from the procedure of
disinfection, being formed during reactions of
disinfectants with natural organic matter present in water.
Haloforms may possess carcinogenic or mutagenic
properties; therefore minimization of their concentrations
in drinking water is a critical issue. Regulatory measures
are becoming more and more stringent, as new health
effects become known and optimized high-sensitivity
analytical methodologies are being developed. Up-to-
date research findings concerning all these aspects have
been collected, critically reviewed, summarized, and are
presented and discussed in the present book.
Approximately 77 percent of the freshwater used in the
United States comes from surface-water sources and is
subject to natural organic matter contamination
according to the United States Geological Survey. This
presents a distinct challenge to water treatment
engineers. An essential resource to the latest
breakthroughs in the characterization, treatment and
removal of natural organic matter (NOM) from drinking
water, Natural Organic Matter in Waters:
Characterization and Treatment Methods focuses on

advance filtration and treatment options, and processes for reducing disinfection byproducts. Based on the author's years of research and field experience, this book begins with the characterization of NOM including: general parameters, isolation and concentration, fractionation, composition and structural analysis and biological testing. This is followed by removal methods such as inorganic coagulants, polyelectrolytes and composite coagulants. Electrochemical and membranes removal methods such as: electrocoagulation, electrochemical oxidation, microfiltration and ultrafiltration, nanofiltration and membrane fouling. Covers conventional as well as advanced NOM removal methods Includes characterization methods of NOM Explains removal methods such as: removal by coagulation, electrochemical, advanced oxidation, and integrated methods

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