

# SURBHI TAK

**Ph. D. (Environmental Engineering)**

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## Education:

Degree	Field	University	Institute	Year	CGPA/%
Doctorate	Environmental Engineering	IIT Roorkee	IIT Roorkee	2020	83.00
M.Tech	Environmental Management of Rivers & Lakes	IIT Roorkee	IIT Roorkee	2015	8.78
B.Tech	Biotechnology	DCRUST, Murthal, Haryana	DCRUST, Murthal, Haryana	2013	8.55
Intermediate	12 <sup>th</sup>	CBSE	D.A.V. Centenary Public School	2009	88.0
Matriculation	10 <sup>th</sup>	CBSE	D.A.V. Centenary Public School	2007	91.1

## Areas of Interests:

- Environmental science & engineering
- Drinking water and wastewater treatment
- Analytical Environmental chemistry
- Emerging contaminants: Analysis and removal
- Environmental biotechnology.
- Advanced water and wastewater treatment
- Environmental sustainability & management
- Biofiltration

## Work Experience:

- Postdoctoral fellow**, Department of Energy & Environment, Sejong University, Seoul, South Korea (Feb 2021- present)
- Summer Intern**, Department of Biotechnology, PGIMS Rohtak, India (May–Aug 2012)

## PhD Research:

**Title:** Natural and effluent derived organic matter removal using synergy of advanced oxidation and biofiltration processes

**Supervisor:** Dr. Bhanu Prakash Vellanki, Department of Civil Engineering, IIT Roorkee, Uttarakhand, India

### Abstract:

Disinfection of treated effluent water is a critical final step in any drinking water treatment plant. The reaction of the widely used disinfectant, chlorine, with the natural organic matter and effluent organic matter (NefOM), from anthropogenic activities around the catchment, leads to formation of unwanted disinfection byproducts (DBPs). Major fraction of the DBPs are trihalomethanes (THMs), which are regulated in drinking water. Many studies have reported their carcinogenicity. NefOM, which are precursors to DBP formation, can be partially oxidized by advanced oxidation processes (AOPs), followed by degradation of the simpler and more biodegradable compounds by biological activated carbon (BAC) treatment, allowing for economical treatment.

Two drinking water treatment plants, one conventional and one moving bed biofilm reactor, along river Yamuna were monitored over a period of 12 months for quantification of THMs. The total THM concentration was always well above the USEPA limits, while lower than the BIS limits. XAD resin fractionation indicated a preponderance of hydrophobic organic carbon and the inefficiency of both the plants in removing the hydrophobic fraction of NefOM. Kinetic screening experiments were conducted to identify the AOP (UV/H<sub>2</sub>O<sub>2</sub>, O<sub>3</sub> and O<sub>3</sub>/H<sub>2</sub>O<sub>2</sub>) most effective in mineralizing DOC and decreasing UV<sub>254</sub> at various pH, UV intensities, and ozone and hydrogen peroxide concentrations. These experiments identified UV/H<sub>2</sub>O<sub>2</sub> as most effective AOP in decreasing the THM formation potential. Biofilm was allowed to establish on a raw granular activated carbon column with river Yamuna water as influent. Pseudo steady state was established after 90 days of operating the column. BAC columns were fed with AOP treated water and overall decrease in DOC, UV<sub>254</sub>, hydrophobicity and THMF<sub>P</sub> was observed. The AOP-BAC treatment was optimised for each AOP and O<sub>3</sub>/H<sub>2</sub>O<sub>2</sub>-BAC showed the maximum decrease in hydrophobicity and THM formation potential.

## Masters Research:

**Title:** Analysis of disinfection systems for wastewater treatment with special reference to trihalomethanes

**Supervisor:** Prof. Arun Kumar, Department of Hydro and Renewable energy, IIT Roorkee, Uttarakhand, India

### Abstract:

Apart from numerous other well-known drawbacks of chlorination, viz., onsite operational hazards, residual chlorine toxicity,

trihalomethanes (THM) formation is the major factor that came into limelight in the last 40 years, primarily in drinking water treatment industry. Treated effluent from wastewater treatment plants are also chlorinated and then discharged, indirectly coming in human contact, so there is need to consider THM as a potable as well as wastewater parameter. In this study, THMs were identified in seven sewage treatment plants (STPs) in North India. STPs were selected based on treatment technology employed viz. up-flow anaerobic sludge blanket (UASB), activated sludge process (ASP), sequential batch reactor (SBR) and oxidation pond (OP). THM concentrations obtained at all the seven STPs were below BIS standards of drinking water (0-40 $\mu\text{gL}^{-1}$ ). UASB plant shows considerably higher concentration of THM. UV followed by chlorination is suggested as an alternative to chlorination. Per MLD capital and operation & maintenance (O&M) cost of UV Disinfection was analyzed revealing decreasing per MLD capital cost of UV with increasing plant capacity. The comparative annual O&M cost analysis of chlorination, de-chlorination and UV disinfection shows that there is up to 63% reduction of the total annual O&M cost by UV in comparison to chlorination, whereas in the case of chlorination followed by de-chlorination, total reduction is 71%.

### Technical Skills and knowledge

- Environmental science: Potable water and wastewater treatment, characteristics and microbiology of wastewater, unit processes, biological wastewater treatment; advanced oxidation processes
- Environmental Engineering: Wastewater engineering and design; environmental impact assessment; aquatic ecology, water resource engineering and management, environmental planning and management
- Environmental Chemistry: Analytical environmental chemistry, chemical processes occurring in environmental system, emerging contaminant analysis and removal
- Introductory Biology: Basics of biology, microbiology, genetics, cell biology, biochemistry, bioprocess engineering, immunology, molecular biology etc.
- Environmental Biotechnology: Biofiltration for the removal of emerging chemical as well as biological contaminants
- **Instrumental Expertise and Lab development:** Gas chromatography-Mass spectrometry (GC-MS), Ion chromatography (IC), Total organic carbon (TOC) analysis, High pressure liquid chromatography (HPLC), QToF-MS, UV spectrometry, FTIR etc. Apart from that, all the general water quality analysis protocols and establishment of set-ups for laboratory scale studies.

As a teaching assistant during my PhD, I was actively involved in teaching of few courses.

- Wastewater Engineering (CEN 503)
- Introduction to Environmental Studies (CEN 105)

### List of Publications:

#### Publications in SCI-indexed Journals/Book Chapters:

1. **Tak, S., & Vellanki, B. P. (2020), Comparison of O<sub>3</sub>- BAC, UV/H<sub>2</sub>O<sub>2</sub>-BAC, and O<sub>3</sub>/H<sub>2</sub>O<sub>2</sub>-BAC treatments for limiting the formation of disinfection byproducts during drinking water treatment in India, *Journal of Environmental Chemical Engineering*, 104434. (SCI, Q1, IF: 4.3)**
2. **Tak, S., & Vellanki, B. P. (2019). Applicability of advanced oxidation processes in removing anthropogenically influenced chlorination disinfection byproduct precursors in a developing country, 186, *Ecotoxicology and Environmental safety*. (SCI, Q1, IF: 4.87)**
3. **Tak, S., Tiwari, A., & Vellanki, B. P. (2020). Identification of emerging contaminants and their transformation products in a moving bed biofilm reactor (MBBR)-based drinking water treatment plant around River Yamuna in India. *Environmental Monitoring and Assessment*, 192, 1-23 (SCI, Q2, IF:2.27).**
4. **Tak, S., & Vellanki, B. P. (2018). Natural organic matter as precursor to disinfection byproducts and its removal using conventional and advanced processes: state of the art review. *Journal of Water and Health*, 16(5), 681-703. (SCI, Q2, IF: 1.68)**
5. **Tak, S., & Kumar, A. (2017). Chlorination disinfection by-products and comparative cost analysis of chlorination and UV disinfection in sewage treatment plants: Indian scenario. *Environmental Science and Pollution Research*, 24(34), 26269-26278. (SCI, Q1, IF: 3.3)**
6. **Tak, S., & Kumar, A. (2018). Trihalomethanes Occurrence in Chlorinated Treated Effluents at Sewage Treatment Plants of North-Indian Region. In *Advances in Waste Management* (pp. 279-288). Springer, Singapore.**
7. **Tak, S., Vellanki, B.P. & Ahuja, S. (2020). A review on disinfection and disinfection byproducts. In *Contaminants in Our Water: Identification and Remediation Methods*. January 1, 2020 , 105-117**

#### Conference Publications

1. **Tak, S., & Vellanki, B. P. (2019). Reduction of chlorination disinfection byproduct precursors by the synergy of advanced oxidation and biofiltration processes. AGUFM, 2019, H43L-2212.**
2. **Tak, S., & Vellanki, B. P. (2019, March). Identification of disinfection byproducts and its precursors in River Yamuna in India: First case study of the situation. In *Abstracts Of Papers Of The American Chemical Society* (Vol. 257). 1155 16TH ST, NW, Washington, Dc 20036 USA: Amer Chemical Soc.**
3. **Tak, S., & Vellanki, B. P. (2018) Identification of trihalomethanes (THM) in Indian drinking water treatment plants and their relation with NOM characteristics, International Conference on desalination, NIT, Trichy, India.**
4. **Tak, S., & Kumar, A. Trihalomethane occurrence in treated effluents of sewage treatment plants, International conference on waste management, Recycle, 2016, IIT Guwahati, Guwahati**

### Conference Presentations

1. **Tak, S., & Vellanki, B. P.** (2019) Reduction of chlorination disinfection byproduct precursors by the synergy of advanced oxidation and biofiltration processes, *AGU Fall Meet 2019*, 9<sup>th</sup>-13<sup>th</sup> Dec 2019, San Francisco, CA, USA
2. **Tak, S., & Vellanki, B. P.** (2019) Identification of disinfection byproducts and its precursors in River Yamuna in India: First case study of the situation” *ACS National meeting and exposition*, 31 March - 4th April 2019, Orlando, Florida, USA
3. **Tak, S., & Vellanki, B. P.** (2018) Identification of trihalomethanes (THM) in Indian drinking water treatment plants and their relation with NOM characteristics, *International Conference on desalination*, NIT, Trichy, India. (**Best paper award**)
4. **Tak, S., & Vellanki, B. P.** (2018) Trihalomethane identification and NOM characterization in Indian drinking water treatment plant. *ACS on campus*, IIT Roorkee, India.
5. **Tak, S., & Vellanki, B. P.** (2017), Trihalomethane identification in Indian drinking water treatment plants and removal of natural organic matter using UV based advanced oxidation processes, *IUVA Symposium: UV Technology Advancement for Water Environment at NUS*, Singapore.
6. **Tak, S., & Kumar, A** (2016). Trihalomethane occurrence in treated effluents of sewage treatment plants, International conference on waste management, *Recycle, 2016*, IIT Guwahati, Guwahati. (**Best paper award**)
7. **Tak, S., & Kumar, A** (2015). Analysis of disinfection system for wastewater treatment with special reference to trihalomethanes formed during chlorination. *National seminar on Ganga rejuvenation*, NIH, Roorkee (December, 2015).

### Research Projects:

1. **Removal of disinfection byproducts from drinking water treatment plants in India** (Jan 2016-Jun 2018), sponsored by NBCC, India (Research fellow)
2. **Fate and management of emerging contaminants:** Analysis of emerging contaminants (>300) in Agra and Mathura water treatment plants. (Research fellow)
3. **Analysis of trihalomethanes in wastewater treatment plants** supported by National Ganga River Basin Authority (NGRBA), Govt. of India and Central Pollution Control Board (CPCB), Govt. of India. (Jul-Dec 2014) with Prof. Arun Kumar, Department of Hydro and Renewable Energy, IIT Roorkee (Student Research associate)
4. **Conservation of water in Industries** (Aug-October 2014) (Student Research associate)
5. **Water conservation plan for IITR Campus** (May-Aug 2014) (Student Research associate)

### Awards and Achievements:

1. Received **CSIR student travel grant** for attending AGU Fall Meet 2019.
2. Received **AGU student travel grant award** by American Geophysical Union).
3. Received **IITR Dean of Resources and Alumni Affairs (DORA) Travel support** for attending *ACS National Meeting & Exposition 2019*.
4. Won the **Best Paper award 2018**, at InDACon, NIT Trichy.
5. Won the **Best Paper award 2016**, at Recycle, IIT Guwahati
6. GATE: AIR 367
7. **MHRD** Scholarship for MTech and PhD
8. Laureate certificate by DAV college management committee March 2007

### Position of Responsibility and Extra-Curricular Activities

1. Organizing secretary, **Cognizance** (Technical fest), IIT Roorkee
2. Coordinator, Literary Society (**LISOC**), DCRUST, Murthal
3. Coordinator, **Engenesis** (Technical society of Department of Biotechnology, DCRUST, Murthal)

### References:

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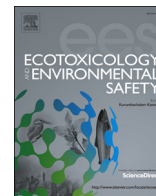
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# Applicability of advanced oxidation processes in removing anthropogenically influenced chlorination disinfection byproduct precursors in a developing country

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## ARTICLE INFO

### Keywords:

Drinking water treatment  
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Advanced oxidation processes  
Effluent derived organic matter

## ABSTRACT

The studies on occurrence of contaminants of emerging concern in drinking water treatment plants or even wastewater treatment plants in developing country like India, are very limited. Trihalomethanes (THMs) is one such contaminant of concern in drinking water treatment sector. THMs are the major disinfection byproducts (DBPs) formed during the widely used chlorination process. Their identification and removal is of utmost importance in developed as well as developing nations. This study is first of its kind to assess the removal of mixture of urban run-off driven organic matter, agricultural run-off driven organic matter, untreated sewage effluent driven organic matter and little natural organic matter (NOM) (altogether NefOM) (major DBP precursors) using advanced oxidation processes (AOPs) in the Indian region. Since, NOM vary geographically, this study will add up to applicability of generally utilized AOPs for removal of site explicit (Indian) NefOM. Trihalomethanes at a conventional water treatment plant at Mathura and a moving bed biofilm based non-conventional water treatment plant at Agra were monitored over a year, demonstrating the inability of the water treatment plants to limit formation of DBPs from Yamuna inlet water at any time of the year. Various AOPs (UV-H<sub>2</sub>O<sub>2</sub>, O<sub>3</sub>-H<sub>2</sub>O<sub>2</sub>, O<sub>3</sub>) and UV (ultraviolet) photolysis were assessed for their ability to decrease the trihalomethane forming potential (THMFP) by degrading the contaminants in the waters of Yamuna. Kinetic studies were conducted to evaluate the selected AOPs based on their ability to mineralize dissolved organic carbon (DOC), and decrease UV<sub>254</sub> at various pH, UV intensities, and ozone and hydrogen peroxide concentrations. UV-L/H<sub>2</sub>O<sub>2</sub> at an intensity of 47 mJ/cm<sup>2</sup>/min, pH = 7, and at hydrogen peroxide concentration of 0.5 mM provided an optimum reduction of DOC (64%) and UV<sub>254</sub> (87%). Fractionation studies indicated that treatment by UV-L/H<sub>2</sub>O<sub>2</sub> leads to the most significant decrease in the hydrophobic fraction of the water, while further study indicated that UV-L/H<sub>2</sub>O<sub>2</sub> also showed maximum attenuation of THMFP.

## 1. Introduction

Trihalomethanes (THMs), a significant group of chlorination disinfection byproduct (CDBP), usually occur in water due to the reaction of natural organic matter (NOM) present in water with the chlorine. NOM is highly versatile in nature and varies with the site and season. Four main compounds of THMs are chloroform (CHCl<sub>3</sub>), bromodichloromethane (BDCM, CHCl<sub>2</sub>Br), dibromochloromethane (DBCM, CHClBr<sub>2</sub>) and bromoform (CHBr<sub>3</sub>). These compounds have been reported as a probable human carcinogen (Group B2 and Group C) by the International Agency of Research on cancer (IARC) (USEPA, 1999). Some animal toxicity studies have indicated that the site of tumour formation in animals was liver, kidney, thyroid, and intestines (Sharma

et al., 2009). Various epidemiological studies have reported a link between long term exposures to CDBP and potential human health effects (WHO, 2011; Zhang et al., 2018). Most carcinogenic effects were in terms of the colon, rectal and bladder cancer (Genisoglu et al., 2019; Villanueva et al., 2004). More than 600 disinfection byproducts (DBPs), which are carcinogenic and mutagenic have been detected in drinking water systems (Abbasnia et al., 2018). Other adverse effects related to THMs consumption includes problem in respiratory functions, asthma as well as reproductive effects (Abbasnia et al., 2018; Hamidin et al., 2008; Lourencetti et al., 2012; Nickmilder and Bernard, 2007). Various bodies across the globe are regulating the occurrence of THMs. United States Environmental Protection Agency (USEPA) has given The Stage 1 Disinfectant and Disinfection Byproducts Rule (DBPR) to reduce the

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# Comparison of $O_3$ -BAC, $UV/H_2O_2$ -BAC, and $O_3/H_2O_2$ -BAC treatments for limiting the formation of disinfection byproducts during drinking water treatment in India

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## ARTICLE INFO

Editor: Zhang Xiwang

### Keywords:

Disinfection byproducts  
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Biofiltration  
River Yamuna

## ABSTRACT

Natural organic matter (NOM) acts as a precursor to toxic disinfection byproducts (DBPs). Recently it has been established that a mixture of natural and effluent derived organic matter (NefOM) leads to very high concentration of DBPs. Both conventional and non-conventional/advanced ways of drinking water treatment do not remove NefOM sufficiently. Advanced oxidation processes (AOPs) have been shown to oxidize dissolved organic carbon (DOC) effectively but entail high energy inputs. Therefore, combining AOP as a pre-oxidation step with an economical system like biological activated carbon (BAC) filtration is a more economical solution. In this study, BAC was developed from virgin granular activated carbon (GAC) with river Yamuna water, which has the highest levels of DOC in the world, as influent water. Two columns were used, with one of them as a control. For the development of BAC from GAC, Empty bed contact time (EBCT) of 12 min was found to be effective. Steady-state was achieved after 90 days of continuous operation of the columns. After the steady-state was achieved, EBCT of 16 min was found to be optimum for the diffusion of organic molecules inside the biofilm and mineralization by the attached biomass on the surface of BAC.

The percentage DO consumption and,  $DOC/UV_{254}$  reduction was found to be constant from  $t = 90$  to  $t = 120$  days, after which the column was assumed to be acting as a BAC column. To optimize the AOP dose for AOP-BAC experiments, biodegradable DOC (BDOC) was measured after various doses of individual AOP treatments. The maximum increase in biodegradability was observed in case of  $O_3/H_2O_2$  with BDOC of 3.43 mg/L at an ozone dose of 5.44 mg/L and 0.5 mM  $H_2O_2$ . All three AOP treated water were passed through BAC columns and change in BDOC, DOC, hydrophobic fraction of DOC and  $UV_{254}$  were observed. The maximum DOC, hydrophobic fraction of DOC and  $UV_{254}$  reduction was observed with  $O_3/H_2O_2$ -BAC, as expected from BDOC results. The primary reason is enhanced biodegradability after optimum  $O_3/H_2O_2$  treatment and thus better utilization of simpler organic molecules by microbes in the BAC column. Maximum trihalomethane formation potential (THMFP) reduction was also observed in the case of  $O_3/H_2O_2$ -BAC treatment.

## 1. Introduction

Natural organic matter (NOM) is ubiquitous in aqueous systems and acts as precursors to carcinogens like trihalomethanes (THMs). The formation of THMs and other disinfection byproducts (DBPs) depends on the characteristics of NOM, which vary with time and geography. Due to increasing anthropogenic, the characteristics of organic matter in surface waters are changing. Surface waters in developing countries now have a significant fraction of organic matter from anthropogenic sources. Such mixed organic matter can be referred to as effluent derived or

anthropogenically influenced organic matter and mixture is called natural and effluent derived organic matter (NefOM) [1]. The source of NefOM can be industrial effluents, treated and untreated sewage, and agricultural and urban-runoffs [1]. The current water treatment systems are not equipped to remove high levels of NefOM. Removal of NefOM is essential due to established adverse consequences like membrane fouling, colour, odour and taste problems and more significantly DBP formation on reaction with a disinfectant like chlorine. DBPs especially THMs have proven carcinogenic nature [2–9]. The conventional processes of water treatment, viz., coagulation, sedimentation, filtration or

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# Identification of emerging contaminants and their transformation products in a moving bed biofilm reactor (MBBR)–based drinking water treatment plant around River Yamuna in India

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**Abstract** The prevalence of emerging contaminants of concern in water regimes is very common these days. High anthropogenic intervention is leading to occurrence of various types of microcontaminants of concern in drinking water systems. Their removal using conventional form of treatment systems employed in water treatment plants is not widely researched upon. Their fate in the conventional as well as advanced water treatment system needs to be focused upon for efficient and safe water disposal. Some compounds may leave the system unchanged or some might transform into much more toxic byproduct. Moreover, understanding level of occurrence of these emerging contaminants in source water bodies is also quintessential for assessing their fate in treatment plant itself as well as in the final treated water. Here in this study, the occurrence and removal of various classes of emerging contaminants were investigated in a moving bed biofilm reactor (MBBR)–based advanced drinking water treatment plant (ADWTP) alongside one conventional drinking water treatment plant, both of which use River Yamuna as the source of water. Non-target analysis utilizing high-performance liquid chromatography combined with time of flight (HPLC-QToF) identified more than

300 compounds. Pharmaceuticals accounted for a major fraction (58%) of the identified compounds, followed by plasticizers and insecticides. Nine parent compound and their transformation products were additionally identified using solid-phase extraction followed by analysis using gas chromatography mass spectrometry and HPLC-QToF. The degradation pathway of the parent compounds in MBBR-based ADWTP was also analyzed in depth. The efficiency of each unit process of MBBR-based drinking water treatment plant was studied in terms of removal of few emerging contaminants. Pharmaceutical compound like diclofenac supposedly was persistent, even, toward the end of the treatment train. Semi-quantitative analysis revealed ineffective removal of pyridine, hydrochlorothiazide, and diethyl phthalate in the outlet of ADWTP. ADWTP was able to remove a few emerging contaminants, but a few were recalcitrant. Likewise, it was established that although some parent compounds were degraded, much more toxic transformation products were formed and were prevalent at the end of the treatment.

**Keywords** Emerging contaminants · Yamuna River · Mass spectrometry · Drinking water treatment plant · Identification · Non target analysis

**Electronic supplementary material** The online version of this article (<https://doi.org/10.1007/s10661-020-08303-4>) contains supplementary material, which is available to authorized users.

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## Introduction

Nowadays, the most crucial challenge for water treatment industries is to supply potable water to consumers, which is biologically as well as chemically risk free.

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# Chlorination disinfection by-products and comparative cost analysis of chlorination and UV disinfection in sewage treatment plants: Indian scenario

Surbhi Tak<sup>1</sup> · Arun Kumar<sup>1</sup>

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**Abstract** Apart from numerous other well-known drawbacks of chlorination, viz. on-site operational hazards and residual chlorine toxicity, trihalomethane (THM) formation is the major factor that came into limelight in the last 40 years, primarily in drinking water treatment industry. Treated effluent from wastewater treatment plants is also chlorinated and then discharged, indirectly coming in human contact, so there is need to consider THM as a potable as well as wastewater parameter. In this study, THMs were identified in seven sewage treatment plants (STPs) in North India. STPs were selected based on treatment technology employed, viz., up-flow anaerobic sludge blanket (UASB), activated sludge process (ASP), sequential batch reactor (SBR), and oxidation pond (OP). THM concentrations obtained at all the seven STPs were below BIS standards of drinking water (0–40  $\mu\text{g L}^{-1}$ ). UASB plant shows considerably higher concentration of THM. UV followed by chlorination is suggested as an alternative to chlorination. Per million liter per day (MLD) capital and operation and maintenance (O&M) costs of UV disinfection were analyzed revealing decreasing per MLD capital cost of UV with increasing plant capacity. The comparative annual O&M cost analysis of chlorination, dechlorination, and UV disinfection shows that there is up to 63% reduction of the total annual O&M cost by UV in comparison to chlorination,

whereas in the case of chlorination followed by dechlorination, total reduction is 71%.

**Keywords** Disinfection · Chlorination · UV disinfection · DBPs · Wastewater · Trihalomethanes · Cost analysis

## Introduction

Disinfection is a significant piece of wastewater treatment framework that inactivates the water-borne microbial pathogens, seed to water-borne infections influencing human wellbeing. Disinfectants apart from focusing on pathogens react with natural organic matter (NOM) present in the water offering ascend to new genera of mixes called disinfection by-products (DBPs) (Rook 1974). The other important source of DBP is wastewater-derived organic matter or effluent-derived organic matter (EfoM). EfoM tends to have completely different properties from NOM (Krasner et al. 2009; Yang et al. 2014; Doederer et al. 2014). The aromatic moieties present in EfoM are of completely different origin than those in NOMs. EfoM especially from biologically treated wastewater consists of biodegradation products and soluble microbial products (SMPs) (Jarusutthirak and Amy 2007). Therefore, the quantity and quality of DBPs expected in wastewater treatment plants will vary differently from potable water treatment plants. The term DBP is not new in India considering drinking water treatment, but rather for wastewater treatment, their implication and comprehension is very restricted. Chlorination is the most winning type of disinfection in India and different nations as a result of its entrenched practices, wide range germicidal effectiveness and minimal effort of chlorine (Yang et al. 2005). As per Central Pollution Control Board (CPCB), New Delhi, India, report, chlorination is as yet not utilized at each sewage treatment plant (STPs) across the

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# Natural organic matter as precursor to disinfection byproducts and its removal using conventional and advanced processes: state of the art review

Surbhi Tak and Bhanu Prakash Vellanki

## ABSTRACT

Natural organic matter (NOM) is ubiquitous in the aquatic environment and if present can cause varied drinking water quality issues, the major one being disinfection byproduct (DBP) formation. Trihalomethanes (THMs) are major classes of DBP that are formed during chlorination of NOM. The best way to remove DBPs is to target the precursors (NOM) directly. The main aim of this review is to study conventional as well as advanced ways of treating NOM, with a broad focus on NOM removal using advanced oxidation processes (AOPs) and biofiltration. The first part of the paper focuses on THM formation and removal using conventional processes and the second part focuses on the studies carried out during the years 2000–2018, specifically on NOM removal using AOPs and AOP-biofiltration. Considering the proven carcinogenic nature of THMs and their diverse health effects, it becomes important for any drinking water treatment industry to ameliorate the current water treatment practices and focus on techniques like AOP or synergy of AOP-biofiltration which showed up to 50–60% NOM reduction. The use of AOP alone provides a cost barrier which can be compensated by the use of biofiltration along with AOP with low energy inputs, making it a technoeconomically feasible option for NOM removal.

**Key words** | AOP, biofiltration, disinfection byproducts, drinking water treatment, trihalomethanes

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## INTRODUCTION

Providing safe drinking water is essential for sustaining human life on earth. With the growing demand for water, it is becoming difficult for drinking water industries to meet the quality needs, both chemically and microbiologically. The chemical aspect refers to chemical contaminants in water sources that are a direct threat to human life. One such contaminant is disinfection byproducts (DBPs) which are formed as a result of disinfection of the water in the treatment process itself. Disinfection is crucial for maintaining the microbiological safety of water, i.e. it aids in inactivating microbial pathogens (bacteria, virus, protozoa etc.) that can cause various water-borne diseases (Gomez-Alvarez *et al.* 2016). One such disinfectant is chlorine and it is the most widely used across the globe. DBPs are generally formed by

the reaction of disinfectants such as chlorine with organic precursors present in source water; these organic precursors are mainly called natural organic matter (NOM) and NOM acts as a forerunner to DBPs. Some of the chlorination disinfection byproducts are shown in Table 1. Trihalomethanes (THMs) are the major class of DBPs formed. Though THMs is not a regular water quality parameter, various studies have reported their occurrence in water systems across the globe and stringent guidelines have been imposed for controlling THM levels in water supply systems (Golfopoulos 2000; Rodriguez *et al.* 2003; Ivahnenko & Zogorski 2006; Wang *et al.* 2007; Kumari *et al.* 2015). THMs constitute four main volatile organic compounds (VOCs): trichloromethane (chloroform), bromodichloromethane (BDCM),

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