Dr. (Mrs.) MINASHREE KUMARI
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📱 7066544200/8102805359
📍 2nd Floor, 2919A, Block-C, Sushant Lok Phase-I, Gurgaon -122002, Haryana, India.

🏃 Carrier objectives

Ambitious and hardworking environmental professional. To pursue a challenging career and be part of a progressive organization that gives scope to enhance my knowledge, skills and to reachthe pinnacle in the teaching and research field with sheer determination, dedication, and hard work.

🔍 Research interests

Drinking water treatment, wastewater treatment, disinfection by-products (trihalomethanes), emerging contaminants in water and wastewater, environmental risk assessment, predictive modeling, fate and transport of pollutants, nanomaterials, environmental analytical chemistry, and environmental biotechnology.

👤 Skills & Expertise

a) Experienced in working with emerging contaminants, disinfection by-products (coagulation-flocculation, disinfection), nanomaterials (adsorption) etc.

b) **Hands-on experience on instruments** such as Gas Chromatography (ECD, TCD and FID), Total Organic Carbon (TOC) analyzer, Atomic Absorption Spectroscopy (AAS), Flame Photometer, Particle Size Analyzer, CHNS analyzer, High Performance Liquid Chromatography (HPLC), Zeta potential analyzer, Bomb calorimeter, Double beam UV-Vis spectrophotometer, ICP-MS, UASB reactors, Microwave digestor etc.

c) **Software handled**: MS office 2010 (Word, PowerPoint, Excel), SPSS 21.0, Statese: Design Expert, @Risk: Risk Analysis software (Monte Carlo Simulation in Excel), Origin,Sigma Plot, ChemDraw, Edraw.

d) **Experienced in handling consultancy projects of organizations like** National Thermal Power Corporation Limited, Bokaro Thermal Power Plant, Chandrapura Thermal Power Plant, Patratu Thermal Power plant, Kaphilla industries etc.

e) Expert in environmental analysis and monitoring of water and wastewater contaminants, environmental health, safety and risk assessment.

f) Proficient in data analysis and interpretation, technical (report/research articles) writing, and possess excellent oral and presentation skills.

g) Highly motivated, adaptable, hardworking, and meticulous researcher having a tremendous zest for knowledge and drive for excellence, team player with leadership skill who believes in integrity and credibility.

🎓 Educational Qualifications

Ph.D.: **Environmental Sciences from** Indian Institute of Technology (Indian School of Mines) Dhanbad, Jharkhand, India, 2017

Thesis Title: **Risk assessment, modeling and control of trihalomethanes (THMs) from drinking water**

Course work during PhD:
- *Water Supply & Treatment*
- *Wastewater engineering*
- *Environmental Ecology & Microbiology*
- *Research Methodology & Statistics*
- *Solid and Hazardous waste Management and Land Reclamation*

Post-Graduation: **M.Sc. (Biotechnology) 2008,** Vinoba Bhave University, Hazaribag, Jharkhand, India, 73.17%

Graduation: **B.Sc. (Zoology) Hons 2004,** Vinoba Bhave University, Hazaribag, Jharkhand, India, 73.875%

XIIth **C.B.S.E Board [2000],** Kendriya Vidyalaya Dhanbad, Jharkhand, India, 67.5 %

Xth **C.B.S.E Board [1998]**, Kendriya Vidyalaya Dhanbad, Jharkhand, India, 66.6%

Work Experiences

- **Post-Doctoral Fellow** at the Department of Civil Engineering, Indian Institute of Technology Delhi, New Delhi (Dec 2018-Dec 2020) - Emerging contaminants (pharmaceutical drugs, antibiotics) in water and wastewater, mixture toxicity risk assessment, model approaches, and nanoparticles.

- Environmental Researcher-Freelancer, IIT (ISM) Dhanbad (April 2017-Dec 2018) Control of trihalomethanes in drinking water supplies/ NCL Pune (Feb 2018-Dec 2018), Women scientist proposal, DST-WOS-A (Hydrodynamic cavitation system for removal of natural organic matter).

- Teaching Assistant (July 2013 to March 2017), Department of Environmental Science & Engineering, IIT (ISM) Dhanbad

- **Junior Research Fellow (JRF),** Indian School of Mines (ISM), Dhanbad in a project funded by the **Ministry of Drinking Water and Sanitation (DW&S),** GoI, New Delhi in a project entitled **"Disinfection by-products formation and their management in drinking water supplies in India".** The project mainly emphasized on monitoring and establishing the concentration range of THMs in drinking water supplies (Sep 2011 to June 2013)

- **Lecturer,** Marwari College, Ranchi, Jharkhand. The work profile included lectures for B.Sc. and M.Sc. Biotechnology along with their practical classes, invigilationduties (IIT_JEE Exam; Bank PO Exam; Semester Exams) (Feb 2011-Sep 2011).

- **Lecture**r, P. K. Roy College, Dhanbad, Jharkhand. The work profile included lectures for B.Sc. Biotechnology along with their practical classes (Aug 2010 - Dec 2010).

- Research Trainee, **BCIL-DBT,** R&D, Molecular Biology lab. at SPAN Diagnostics, Surat, Gujarat. Worked on the project entitled **"RNA isolation and purification from bacterial different sources".** Apart from this, got hands on experience in techniques such as DOT BLOT, Reverse hybridization, ELISA, Multiplex PCR, AFB Staining, Sputum processing and suspension preparation from *M. tuberculosis*, Denaturing

agarosegel protocol optimization (Nov 2009 - May 2010)

- Part-time **Lecture**r (B.Sc. Zoology), SSLNT College, Dhanbad, Jharkhand (July 2008 - Oct 2009).

- M.Sc. Dissertation Trainee at Subhashree Biotech Kolkata, February 2008-April 2008.

Certificate Courses

- **"MATLAB Programming and its applications"** organized by Computer Centre, IIT(ISM) Dhanbad, 07th -11th April 2014
- MHRD- GIAN course on **"Nanomaterials for biomedical applications",** organized by the Centre for Biomedical Engineering, IIT Delhi, 12th-16th March 2019.
- Fundamentals of Life-Cycle Assessment, www.udemy.com (Feb 2021)
- Environmental Impact Assessment for Environmental Health (IGNOU, 2021)

Publications

Book

Minashree Kumari. 2016. Transfer and expression of plasmids from antibiotic resistance bacteria. Lambert Academic Publishing, Germany, 978-3-659-92928-1.

Book Chapters

- **Kumari, Minashree,** Gupta, S.K. (2016). "Multi-pathway risk assessment of trihalomethanes exposure in drinking water supplies" In: *Recent Trends in Asian Water Environment and Technology, Ed. AL. Ramanathan, Absar Kazimi, Futoshi Kurisu and Manish Kumar.* Springer Publication, ISBN: 978-93-81891-28-5.

  https://www.springer.com/gp/book/9783319392578. [Citation: 1]

- Gupta, S.K., **Kumari, Minashree.** (2013). Factors influencing the formation of trihalomethanes in drinking water supplies. Strategic Technologies of Complex Environmental issues: A Sustainable Approach. ISBN: 978-93-83083-85-5, p225-231.www.krishisanskriti.org/vol_image/10Sep201512095436.pdf [Citation: 3]

- **Kumari, Minashree,** Gupta, S.K. "Trihalomethanes (THMs) in Wastewater: Causes and Concerns", In Cost-efficient Wastewater Treatment Technologies**, Accepted, Springer Publications**

- **Kumari, Minashree. "**Risk assessment of nanocellulose exposure" In NANO-BIOSORBENTS FOR DECONTAMINATION OF WATER, AIR, AND SOIL POLLUTIONS. Accepted, Elsevier publications.

Research articles in Peer reviewed SCI listed International Journals (Published)
Total Citations: 169; h-index: 8 (as per google scholar) [Total Impact Factor: 64.01] *Corresponding author*

1. **Kumari, Minashree*.,** Kumar, A. (2021). Can pharmaceutical drugs used to treat Covid-19 infection leads to human health risk? A hypothetical study to identify potential risk. Science of the Total Environment, 778, 146303 **(IF 7.963).** [Citation: 1]

2. Anchal, P., **Kumari, Minashree*.,** Gupta, S.K. (2020). Human health risk estimation and predictive modeling of halogenated disinfection by- products (chloroform) in swimming pool waters: A case study of Dhanbad, Jharkhand, India. Journal of

Environmental Health Science & Engineering, **18**, 1595-1605 (**IF 2.130).** DOI: 10.1007/s40201-020-00578-6. ISSN 2052-336X.

3. **Kumari, Minashree***., Kumar, A. (2020). Identification of component-based approach for prediction of joint chemical mixture toxicity risk assessment with respect to human health: A critical review. *Food and Chemical Toxicology*, 143, 111458. (**IF 6.023)** ISSN: 0278-6915 [Citation: 6]

4. **Kumari, Minashree***., Gupta, S.K. (2020). Water quality assessment, Statistical analysis and kinetics of trihalomethanes (THMs) formation in drinking water supplies - A complete batch study. *Environmental Engineering and Management Journal*, Vol. 19 Issue 3, 427-438. 12p. (**IF 0.19)** ISSN: 1582-9596 [Citation: 1]

5. **Kumari, Minashree***., Kumar, A. (2020). Human Health risk assessment of antibiotics in binary mixtures for finished drinking water. *Chemosphere*, 240, 124864. ISSN: 0045-6535 (**IF 7.086)** [Citation: 16]

6. **Kumari, Minashree***., Gupta, S.K. (2020). A novel process of adsorption cum enhanced coagulation flocculation spiked with magnetic nanoadsorbents for the removal of aromatic and hydrophobic fraction of NOM along with turbidity from drinking water. *Journal of Cleaner Production*, 244, 118899, ISSN: 0959-6526. DOI: 10.1016/j.jclepro.2019.118899 (**IF 9.297)** [Citation: 15]

7. **Kumari, Minashree***., Gupta, S.K. (2019). Response surface methodological (RSM) approach for optimizing the removal of trihalomethanes (THMs) and its precursors by surfactant modified magnetic nanoadsorbents (sMNP) - An endeavor to diminish probable cancer risk. *Scientific Reports (Nature journal)*, 9, 18339 (**IF 4.379)** ISSN 2045-2322 [Citation: 10]

8. **Kumari, Minashree*** & Gupta, S.K. (2018). Removal of aromatic and hydrophobic fractions of natural organic matter (NOM) by surfactant modified magnetic nanoadsorbents (MNPs). *Environmental Science and Pollution Research*, 25(25):25565-25579. DOI: 10.1007/s11356-018-2611-0 (**IF 4.223**). ISSN 0944-1344 [Citation: 10]

9. **Kumari, Minashree*** & Gupta, S.K. (2018). Age dependent adjustment factor (ADAF) for the estimation of cancer risk through trihalomethanes (THMs) for different age groups- A innovative approach. *Ecotoxicology and Environmental Safety*, 148, 960-968. Elsevier, (**IF 6.299**). ISSN: 0147-6513 [Citation: 9]

10. Ali. S., **Kumari, Minashree**., Gupta, S.K., Sinha, A., Mishra, B. K. (2017). Investigation and mapping of fluoride endemic areas and associated health risk - A case study of Agra, Uttar Pradesh, India. *Human and Ecological Risk Assessment*, 23 (3), 590-604. http://dx.doi.org/10.1080/10807039.2016.1255139. ISSN: 1080-7039 (**IF 5.190)** [Citation: 10]

11. **Kumari, Minashree**., Gupta, S.K., & Mishra, B.K. (2015). Multi-exposure cancer and non-cancer risk assessment of trihalomethanes in drinking water supplies - A case study of Eastern region of India. *Ecotoxicology and Environmental Safety*, 113, 433–438. ISSN: 0147-6513. Elsevier (**IF 6.299)** [Citation: 53]

12. **Kumari, Minashree** & Gupta, S.K. (2015). Modelling of trihalomethanes in drinking water supplies - A case study of Eastern region of India. *Environmental Science and Pollution Research*, 22:12615-12623. ISSN: 0944-1344. Springer (**IF 4.223**). [Citation: 34]

✦ *Papers in Non-Refereed Journals (Published)*

(a) International

i. **Kumari Minashree,** Kumar Arun (2020). Human health risk due to exposure of ciprofloxacin in drinking water samples of Yamuna River, India. International Research Journal of Pharmacy and Pharmacology, 8(2), Presented at the 7th World congress and Exhibition on Antibiotics and Antibiotics Resistance, London, UK, March 2020 [Virtual presentation]

ii. **Kumari, Minashree** & Gupta, S.K. (2015). Speciation and kinetics of trihalomethanes formation in drinking water. International conference on Geo-Engineering and climate change technologies for sustainable environmental management, MNNIT Allahabad, October 9-11, 2015. Science &Technology, 1(4), 157-163. ISSN 2394-3750.

(b) National

Gupta, S.K., **Kumari, Minashree**. (2013). Factors influencing the formation of trihalomethanes in water treatment plants in Eastern India. MINENVIS, ISSN: 0972-4648, 78, p1-6.

✦ *Papers in Conference Proceedings (International/National)*

1. **Kumari, Minashree** and Gupta, S.K. (2016). Adsorption of NOM by iron oxide magnetic nanoparticles: Synthesis, kinetics and isotherms. 10th World Aqua Congress, November 24-25, 2016, New Delhi, India. Proceeding, p267-280.

2. **Kumari, Minashree**., Gupta, S.K. (2015). Modelling of trihalomethanes drinking water supplies-a case study of eastern region of India. Annual conference and exposition, American Water Works Association (AWWA), Anaheim, California, United States of America, June 7-10, 2015, *Proceedings.*

3. **Kumari, Minashree**., Gupta, S.K. (2015). Use of nanoparticles for the removal of trihalomethanes in drinking water supplies-a review. National workshop on challenges and opportunities for management of water supplies in rural areas, Department of Environmental Science & Engineering, January 23-24, 2015, IIT (ISM) Dhanbad, *Proceedings*, p164-169.

4. **Kumari, Minashree**., Gupta, S.K. (2015). Seasonal variation and correlations of trihalomethanes in drinking water supplies. 102nd Indian science Congress, University of Mumbai, January 3-7, 2015, *Proceedings*, p196-197.

5. **Kumari, Minashree**., Gupta, S.K. (2013). Multipathway risk assessment of trihalomethnaes in drinking water supplies. 1st International Forum on Asian water technology, JNU Convention Centre, December 18-20, 2013, *Proceedings,* p64-65.

6. **Kumari, Minashree**., Gupta, S.K., & Mishra, B.K. (2012). Chlorination by- products formation and their removals from drinking water. National conference on sustainable development of ground water resources in industrial region (SDGRIR 2012), Department of Environmental Science & Engineering, IIT (ISM) Dhanbad, March 22-23, 2012, *Proceedings*, p120-129.

✦ *Papers presented in Conferences/Seminars/ Workshops but not published*

1. **Kumari, Minashree**., Kumar, A. Health risk assessment of drugs used for the treatment of novel coronavirus, COVID-19: Lopinavir, ritonavir, and azithromycin. Society for Risk Analysis (SRA), Texas, USA, December 13-17, 2020.

2. **Kumari, Minashree**., Gupta, S.K. (2014). Factors influencing the formation of disinfection by-products in Eastern part of India. International conference on Energy Technology, Power Engineering and Environmental Sustainability (ETPEES-2014), JNU New Delhi, June 21-22, 2014. *Souvenir & Abstracts*, p16.

3. **Kumari, Minashree**., Gupta, S.K. (2014). Concentration and correlations of trihalomethanes in drinking water systems from an exposure assessment perspective. National conference on Harmony with Nature in context of environmental issues and challenges of 21st century (HARMONY 2014), Department of Environmental Sciences, Faculty of Earth Sciences, Mohan Lal Sukhadia University, Udaipur, Rajasthan, November 28-30, 2014, *Souvenir & Abstracts*, p59.

4. **Kumari, Minashree**., Gupta, S.K. (2012). Disinfection by-products formation and their removals from drinking water- A review. UGC sponsored National seminar on Biodiversity: Its conservation and sustainable development for human welfare, Department of Zoology, VBU Hazaribag, April 7-9, 2012, *Souvenir & Abstracts*, p74.

5. **Kumari, Minashree**., Gupta, S. K. (2012). Chlorination by-products formation and their removals from drinking water-a review. National conference on environmental problems and their remedial measures (EPRM-2012), Department of Environmental Science, Ch. Charan Singh University, Meerut, March 24-26, 2012, *Souvenir & Abstracts*, p27.

6. **Kumari, Minashree**., Gupta, S.K. (2012). Factors influencing the formation of disinfection by-products in Eastern part of India. International conference on Anthropogenic Impact on Environment and Conservation Strategy, Department of Zoology, Ranchi University, November 2-4, 2012. *Souvenir & Abstracts*, p16.

✓ *Papers submitted/under review in Peer Reviewed International Journals*
1. **Kumari**, **Minashree***., Gupta, S.K. Trihalomethanes in drinking water: factors, risk and associated guidelines-A systematic review. Chemosphere. *Under review*
2. **Kumari, M*., Kumar. A.** Antibiotic nanoparticle risk paper, Environmental Science and Pollution Research, *Under Review*
3. Kumar, A., Mahato, J.D., **Kumari, M*.,** Gupta, S.K. Feasibility analysis of newly developed fly-ash coagulant for the removal of natural organic matter from drinkingwater. Separation and Purification Technology, *Under Review*
4. Kumari, M*., Kumar. A. Ecological-human health risk assessment of pharmaceutical in water. Journal of Environmental Management, *Under review*

Courses taught
✓ **Environmental Sciences/Engineering**
1. Municipal wastewater Treatment (B. Tech, Lab course)
2. Water supply Treatment and Wastewater Engineering (M. Tech, Lab course)
3. Ecology and Environmental Biotechnology (B. Tech, Lab course)
4. Physiochemical Process (M. Tech, Lab course)
5. Environmental Chemistry and Microbiology (M. Tech, Lab course)
6. Environmental Engineering (B. Tech, Theory paper

✓ **Biotechnology**
1. Immunology (M.Sc. Theory paper)
2. Molecular Biology (M.Sc. and B.Sc. Theory paper)

3. Instrumentation (X-ray diffraction, Chromatography, Centrifugation, NMR, etc.) (M.Sc. Theory paper)
4. Microbiology (B.Sc. Theory paper)

Students Guided

1. Puja Anchal (M. Tech Thesis) IIT ISM Dhanbad- Trihalomethanes in swimming pool water, 2016
2. Shreya Guha (M. Sc. Thesis) TERI University- Wastewater reuse, 2019
3. Nikhil (B. Tech, 3rd Year) IIT Delhi- Disinfection, 2019
4. Rohit (B. Tech, 3rd Year) IIT Delhi-Nullah sampling and physicochemical properties, 2019
5. Adane Woldemedhin, Ph.D. Exchange Student, IIT Delhi- Fluoride removal, 2019

Awards & Achievements

1. Peer reviewer of SCI International Journals (Reviewed 20+ manuscripts)
   - Science of The Total Environment 2021(Elsevier)
   - Scientia Iranica, 2021(Elsevier)
   - Arabian Journal for Science and Engineering, 2021 (Springer)
   - Environmental Processes, 2021 (Springer)
   - Biotechnology Reports, 2020 (Elsevier)
   - RSC Advances 2020 (Royal Society of Chemistry)
   - Water and Environment Journal 2019 (Wiley Online Library)
   - Environment Monitoring and Assessment 2019, 2020 (Springer)
   - Environmental Science & Pollution Research 2019 (Springer)
   - Water Research 2016 (Elsevier)

2. **Best Science story award, AWSAR DST 2020** (PDF Category). Prize includes a cash prize of ₹10000 and a certificate of appreciation.

3. **Reviewer book:** Natural Organic Matter in Water: 2nd edition Proposal, Elsevier, 2020 (Received a remuneration fee of $100)

4. **Editorial Board Member**, Environmental Management Journal, Springer, 2019.

5. Awarded **CSIR** International Travel Grant for attending the 7th World congress andExhibition on Antibiotics and Antibiotics Resistance, London, UK, March 2020.

6. Awarded **Science and Engineering Research Board** (SERB) International Travel Grant, Department of Science and Technology, GoI, New Delhi for presenting my work at the 134th Annual conference and exposition organized by the American Water Works Association (AWWA), Anaheim, California, USA, June' 2015.

7. Awarded MHRD, GoI, New Delhi Junior Research Fellowship July' 2013

8. Awarded Department of Biotechnology-Biotech Consortium India Limited scholarship, **GoI** Nov' 2009.

9. **JRF representative,** Department of Environmental Science & Engineering, IIT(ISM) Dhanbad, 2015-2016.

10. Topped the class among PhD research scholars and M. Tech students in **"Wastewater Engineering"** and **"Water Supply and Treatment"** subjects during my Ph.D. Course work, 2013-2014.

11. 1st prize in **quiz competition** at National Environmental Engineers Meet (NEEM- 2015), organized by Department of Environmental Science and Engineering, IIT(ISM) Dhanbad.

12. 1st prize in **online case study** at National Environmental Engineers Meet (NEEM- 2015), organized by Department of Environmental Science and Engineering, IIT(ISM) Dhanbad.

13. 2nd prize in the online **essay writing** competition on International Yoga Day 2016, IIT(ISM) Dhanbad.

14. **Secured 5th position the university in my master's degree** (M.Sc. Biotechnology, Vinoba Bhave University), 2008

15. **Topped my college and secured 2nd in the whole university** in B.Sc. (Zoology Hons.), Vinoba Bhave University, 2004

16. Selected as an Assistant Professor, Department of Environmental Science, M.S Baroda University, Vadodara, Gujarat. August 2017.

17. Proposal selected for final presentation, Women Scientist A scheme, Department of Science and Technology,GoI, Delhi, September 2019.

In Print Media and News

✓ My research work on the analysis of trihalomethanes in five different water treatment plants in the Eastern Region in India was covered and published as front-page news by leading English **"The Telegraph"** and Hindi newspapers **"Dainik Jagran, Dainik Bhaskar"** on the occasion of World Water Day, 2015. Articles on my research were also published by**"Hindustan",** a leading Hindi newspaper in India.

✓ **Kashish News channel** aired a half-hour program on the identification and the harmful adverse effects of trihalomethanes in their prime slot in March 2015.

Laboratory Set-up, Training programs and workshops organized

• Established Instrumentation lab and Wastewater Engineering Lab-2 in the Department of Environmental Science and Engineering, IIT (ISM) Dhanbad.

• Organized one National workshop on **"Challenges and opportunities for management of water supplies in rural areas"**, Department of Environmental Science & Engineering, January 23-24, 2015, IIT (ISM) Dhanbad (Total Strength: 150).

• Two workshops for water resource professionals of the Government of Jharkhand under the **Key Resource Centre (KRC) scheme** at Centre of Mining Environment, Department of Environmental Science & Engineering, IIT (ISM) Dhanbad (Total Strength: 30).

Membership of professional bodies

• American Water Works Association (AWWA), California, USA and AWWA India (**ID: 02905411**)
• **Member** India-UK Water Centre

Worked on Projects

• Revisiting water reuse criteria with regards to emerging contaminants
• Sensor project at IIT Delhi funded by DST and Intel
• nanoSAICM

- Disinfection by-products formation and their management in drinking water supplies in India
- Control of trihalomethanes in drinking water supplies

Personal details

- Date of Birth: 25/01/1983
- Marital Status: Married
- Nationality: Indian
- Hobbies: Reading, Travelling, Drawing
- Skype ID: minashreek@skype.com
- Google Scholar https://scholar.google.co.in/citations?user=iYuIhbAAAAAJ&hl=en
- Research gate https://www.researchgate.net/profile/Minashree_Kumari5
- ORCID https://orcid.org/0000-0002-8908-9691

❖ References

1) Prof. S. K. Gupta, PhD Supervisor
   Professor
   Department of Environmental Science and Engineering
   Indian Institute of Technology (Indian School of Mines) Dhanbad-826004,
   Jharkhand, India
   Email: skgsunil@gmail.com
   Contact No: 09431126495

2) Dr. Arun Kumar, PDF Mentor
   Professor
   Environmental Engineering
   Department of Civil Engineering
   Indian Institute of Technology Delhi, Huaz Khas-110016, India
   Email: arunku@civil.iitd.ac.in
   Contact No: 08527843076

3) Dr. Alok Sinha
   Professor/HOD
   Department of Environmental Science and Engineering/Department of Civil Engineering
   Indian Institute of Technology (Indian School of Mines) Dhanbad-826004,
   Jharkhand, India
   Email: aloksinha11@yahoo.com
   Contact No: 09471518560

I hereby declare that all the information given above is true to the best of my knowledge.

(Minashree Kumari)

Can pharmaceutical drugs used to treat Covid-19 infection leads to human health risk? A hypothetical study to identify potential risk
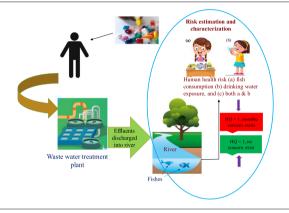
Minashree Kumari *, Arun Kumar

Department of Civil Engineering, Indian Institute of Technology Delhi, Hauz Khas, Delhi 110016, India

HIGHLIGHTS

- First study on risk effects of exposure of pharmaceutical drugs used in Covid-19 infection
- Combined ingestion of contaminated water and fish consumption exposure poses major risks.
- Ritonavir is expected to pose adverse effects on human health.
- Co-existence of pharmaceuticals in water shows risks to human health.
- Regular monitoring of pharmaceuticals (HQ > 1) in water matrices is required to reduce the possible risk.

GRAPHICAL ABSTRACT

ABSTRACT

This is the first study to assess human health risks due to the exposure of 'repurposed' pharmaceutical drugs used to treat Covid-19 infection. The study used a six-step approach to determine health risk estimates. For this, consumption of pharmaceuticals under normal circumstances and in Covid-19 infection was compiled to calculate the predicted environmental concentrations (PECs) in river water and in fishes. Risk estimates of pharmaceutical drugs were evaluated for adults as they are most affected by Covid-19 pandemic. Acceptable daily intakes (ADIs) are estimated using the no-observed-adverse-effect-level (NOAEL) or no observable effect level (NOEL) values in rats. The estimated ADI values are then used to calculate predicted no-effect concentrations (PNECs) for three different exposure routes (i) through the accidental ingestion of contaminated surface water during recreational activities only, (ii) through fish consumption only, and (iii) through combined accidental ingestion of contaminated surface water during recreational activities and fish consumption. Higher risk values (hazard quotient, HQ: 337.68, maximum; 11.83, minimum) were obtained for the combined ingestion of contaminated water during recreational activities and fish consumption exposure under the assumptions used in this study indicating possible effects to human health. Amongst the pharmaceutical drugs, ritonavir emerged as main drug, and is expected to pose adverse effects on r human health through fish consumption. Mixture toxicity analysis showed major risk effects of exposure of pharmaceutical drugs (interaction-based hazard index, HI_{int}: from 295.42 (for lopinavir + ritonavir) to 1.20 for chloroquine + rapamycin) demonstrating possible risks due to the co-existence of pharmaceutical in water. The presence of background contaminants in contaminated water does not show any influence on the observed risk estimates as indicated by low HQ_{add} values (<1). Regular monitoring of pharmaceutical drugs in aquatic environment needs to be carried out to reduce the adverse effects of pharmaceutical drugs on human health.

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RESEARCH ARTICLE

Human health risk estimation and predictive modeling of halogenated disinfection by- products (chloroform) in swimming pool waters: a case study of Dhanbad, Jharkhand, India

Puja Anchal[1] · Minashree Kumari[1] · Sunil Kumar Gupta[1]

Abstract

Disinfection is an important process to make the water free from harmful pathogenic substances, but sometimes it results in the formation of harmful by-products. Development of predictive models is required to define the concentration of THMs in pool water. Majority of studies reported inhalation to be the most significant THMs exposure route which is more likely to be dependent upon the concentration of THMs in pool water and in air. THMs concentration in the analyzed pool water samples and in air was found to be $197.18 \pm 16.31 \ \mu g \ L^{-1}$ and $0.033 \ \mu g \ m^{3-1}$, respectively. Statistical parameters such as high correlation coefficients, high R^2 values, low standard error, and low mean square error of prediction indicated the validity of MLR based linear model over non-linear model. Therefore, linear model can be most suitably used to pre-assess and predict the THMs levels in swimming pool water. Risk estimation studies was conducted by using the united states environmental protection agency (USEPA) Swimmer Exposure Assessment Model (SWIMODEL). The lifetime time cancer risk values related to chloroform exceeded 10^{-6} for both the sub-population. Inhalation exposure leads to maximum risk and contributed up to 99% to total cancer risk. Risk due to other exposure pathways like accidental ingestion and skin contact was found to be negligible and insignificant. Monte Carlo simulation results revealed that the simulated THMs risk values for the studied exposure pathways lies within ±3.1% of the average risk values obtained using SWIMODEL. Hence, the risk estimates obtained using SWIMODEL seemed to be appropriate in determining the potential risk exposure of THMs on human health. Variation in input parameters like body weight (BW) and skin surface area (SA) leads to difference in risk estimates for the studied population. Non cancer risk was found to be insignificant as represented by low hazard quotient (HQ < 1) values. Through monitoring and regulations on control of THMs in swimming pool water is required to minimize the risk associated.

Keywords Swimming pool · Chloroform · Predictive models · Risk exposure · Hazard quotient

Introduction

Disinfection of swimming pool water is essential to maintain hygienic conditions and to avoid the outbreak of waterborne diseases like typhoid and cholera [41]. Several types of disinfectants like chlorine, bleaching powder, chlorine dioxide etc., have been used of which chlorine is the most widely used in swimming pool due to its efficacy, low cost and retentive power [6, 25].

However, during the course of disinfection, chlorinated compound reacts with natural organic matter (NOM) substances of swimmer's origin (sunscreen, mucus, urine, skin particles and hairs), and results in the formation of undesirable harmful halogenated by-products known as disinfection byproducts (DBPs) [38]. Swimming pool water serves as water matrices with high concentrations of DBPs due to constant chlorination and the persistent organic load of swimmer's origin. The occurrence and quantity of DBPs in swimming pools is governed by several factors such as the mode of disinfection, the type and concentration of disinfectant used, the NOM content, the physicochemical characteristics of treated waters etc. [11, 22, 47, 48]. Erratic addition of substances from swimmers, inconsistent interactions of different precursors (natural and swimmers

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[1] Department of Environmental Science and Engineering, Indian Institute of Technology (ISM), Dhanbad, Jharkhand 826004, India

 Springer

Journal Pre-proof

Identification of component-based approach for prediction of joint chemical mixture toxicity risk assessment with respect to human health: A critical review

Minashree Kumari, Arun Kumar

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Identification of component-based approach for prediction of joint chemical mixture toxicity risk assessment with respect to human health: A critical review

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WATER QUALITY ASSESSMENT, STATISTICAL ANALYSIS AND KINETICS OF TRIHALOMETHANES FORMATION IN DRINKING WATER SUPPLIES - A COMPLETE BATCH STUDY

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Abstract

The study attempted to identify the best suited models to determine the kinetics of chlorine decay and trihalomethanes (THMs) formation in drinking water supplies. Batch experiments were conducted on synthetic water samples to simulate the characteristics of raw water collected from Maithon water treatment plant (MWTP), Dhanbad, Jharkhand, India. Influence of various parameters like total organic carbon (TOC), reaction time, pH and chlorine dose on the rate of THMs formation were analysed. The studies revealed that above 50% of THMs were formed within the first 83.65 min. Later on the reaction rate decreases and it takes 7.32-9.26 hours for 99% formation of total THMs. Pearson correlation matrix dictated strong correlation of reaction time followed by pH, dose and TOC with THMs formation. Principal component analysis (PCA) demonstrated that dissolved organic carbon (DOC) is the most influencing parameter for THMs formation. Chlorine decay kinetics followed second order reaction and the rate constant was found to be 0.0131 L/mg.min⁻¹. THMs formation kinetics was analysed by Clark and Kavanaugh model. Validation results indicated lower error of prediction (< 6%) for Clark's model than Kavanaugh model (< 20%). Thus, it was observed that Clark's model more suitably predict the formation of THMs in Indian drinking water supplies.

Key words: chlorine decay, drinking water, kinetics, model, trihalomethanes, validation

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OPEN

Response surface methodological (RSM) approach for optimizing the removal of trihalomethanes (THMs) and its precursor's by surfactant modified magnetic nanoadsorbents (sMNP) - An endeavor to diminish probable cancer risk

Minashree Kumari* & Sunil Kumar Gupta

Response surface methodology (RSM) approach was used for optimization of the process parameters and identifying the optimal conditions for the removal of both trihalomethanes (THMs) and natural organic matter (NOM) in drinking water supplies. Co-precipitation process was employed for the synthesis of magnetic nano-adsorbent (sMNP), and were characterized by field emission scanning electron microscopy (SEM), trans-emission electron microscopy (TEM), BET (Brunauer-Emmett-Teller), energy dispersive X-ray (EDX) and zeta potential. Box-Behnken experimental design combined with response surface and optimization was used to predict THM and NOM in drinking water supplies. Variables were concentration of sMNP (0.1 g to 5 g), pH (4–10) and reaction time (5 min to 90 min). Statistical analysis of variance (ANOVA) was carried out to identify the adequacy of the developed model, and revealed good agreement between the experimental data and proposed model. The experimentally derived RSM model was validated using *t-test* and a range of statistical parameters. The observed R^2 value, adj. R^2, pred. R^2 and "F-values" indicates that the developed THM and NOM models are significant. Risk analysis study revealed that under the RSM optimized conditions, a marked reduction in the cancer risk of THMs was observed for both the groups studied. Therefore, the study observed that the developed process and models can be efficiently applied for the removal of both THM and NOM from drinking water supplies.

Long-term exposure of disinfection by-product (DBPs) especially trihalomethanes (THMs) in drinking water is potentially harmful and is a cause of major health concern. Since 20th century, chlorination has been widely used as a disinfectant to protect water against microbial growth during water treatment process[1]. Over the years, increasing attention has been paid on human health risks of THMs in drinking water supplies. THMs consists of four compounds i.e. chloroform ($CHCl_3$), bromodichloromethane ($CHBrCl_2$), dibromochloromethane ($CHBr_2Cl$) and bromoform ($CHBr_3$). The sum of four THMs is referred to as total THMs (TTHMs). Literature studies revealed that prolonged exposure of THMs leads to increased risk of different types of cancer such as bladder, colon, rectum, blood, stomach and rectal[2–4]. Toxicological and epidemiological studies have reported a direct link between THMs and cancer risk[3,4].

Dissolved organic matter (DOM), mainly humic acids (HAs) and fulvic acids (FAs) are the major precursors for the formation of THMs in drinking water. A number of water quality operational parameters like pH, temperature, residual chlorine concentration, natural organic matter (NOM) etc., influences the formation of THMs.
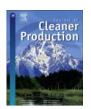
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A novel process of adsorption cum enhanced coagulation-flocculation spiked with magnetic nanoadsorbents for the removal of aromatic and hydrophobic fraction of natural organic matter along with turbidity from drinking water

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ABSTRACT

The present study developed a novel conjugate process for the removal of aromatic, hydrophobic fraction of natural organic matter and turbidity from drinking water supplies. Magnetic nanoadsorbents were synthesized under laboratory conditions and their surface properties were enhanced by surface modifiers followed by their characterization. The synthesized magnetic nanoadsorbents was then used in combination with conventional aluminum and iron coagulants for the removal of both natural organic matter and turbidity from drinking water. Adsorption cum enhanced coagulation-flocculation study was conducted in two different stages i.e. adsorption of natural organic matter by magnetic nanoadsorbents (stage 1) followed by coagulation-flocculation experiments using conventional coagulants like alum and ferric chloride (stage 2). Study indicated that magnetic nanoadsorbents-alum conjugate process is efficient in removing trihalomethane precursors. Significant removal of dissolved organic matter (98.7%), ultra violet absorbance at 254 nm (99.7%) and trihalomethane formation potential (91%) was achieved. The overall study showed that the developed magnetic nanoadsorbents-alum conjugate process is highly efficient in removing the trihalomethane precursors with a marked reduction in the overall cost for its large scale application.

1. Introduction

Availability of potable water is a major issue all across the globe. In order to make the water drinkable, it must be free from natural organic substances and turbidity. Presence of natural organic matter (NOM) due to surface discharge, agricultural runoffs, vegetation decay and release of domestic waste distresses the performance of unit operations of water treatment plants (WTPs) and affects water quality (Golfinopoulos, 2013). These substances interfere with the biological stability of water triggering color, taste and odor problems and also acts as a substrate for bacterial growth in the water distribution system. NOM in aquatic environment can be derived from both the external sources (allochthonous) and internal sources (autochthonous) (Kosobucki and Buszewski, 2014). NOM is chiefly a heterogeneous mixture of hydrophobic and

hydrophilic fraction of organic material and are major precursors of disinfection by-product (DBPs) formed during the disinfection of water (Chaukura et al., 2018). Fractionation studies revealed that hydrophobic portion of NOM primarily leads to the formation of carcinogenic DBPs i.e trihalomethanes (THMs) in chlorinated drinking water (Wang et al., 2013; Matilainen and Sillanpaa, 2010). Variation in NOM concentration is associated with changes in biogeochemical cycles of particular environment (Kumari and Gupta, 2015).

Due to their adverse effects on human health, several treatment technologies/methodologies such as coagulation-flocculation (Bongiovani et al., 2016; Mao et al., 2013), enhanced coagulation (Uyak et al., 2007; Yigit et al., 2009), adsorption (Esmaeili et al., 2012) ozonation (Garcia, 2011; Molnar et al., 2012), ion exchange membranes (Vaudevire et al., 2019), ultra/nano filtration (Ma et al., 2014), and advanced oxidation processes (Matilainen and Sillanpaa, 2010; Nie et al., 2010) have been developed. Some of these technologies are not techno-economically feasible due to high cost, membrane fouling and regeneration, sludge generation and

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Human health risk assessment of antibiotics in binary mixtures for finished drinking water

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HIGHLIGHTS

- First study on antibiotics risk in binary mixture by UESPA weight of evidence.
- Use of pharmacological data for risk assessment of antibiotics in binary mixture.
- Binary mixture of antibiotics under the studied condition do not possess any risk.
- USEPA weight of evidence method can be used for risk assessment of antibiotics.
- Concentration of antibiotic was major contributor to overall variance in risk estimate.

ARTICLE INFO

ABSTRACT

The present study developed a new step-wise approach to estimate the potential human health risk of antibiotics in binary mixture for drinking water samples for two different sub-populations. Monte Carlo simulation based uncertainty analysis was performed to reduce uncertainty in risk assessment. Human health risk assessment studies were carried out using the acceptable daily intake (ADIs) for exposures of individual antibiotics considering point of departure (POD) and uncertainty factors (UFs). The estimated ADI values were used to estimate the predicted no effect concentrations (PNECs), at or below which no adverse human health effects are anticipated. Hazard quotient (HQ) in risk assessment was calculated as a ratio of environmental concentrations (ECs) and PNECs (EC/PNEC). The study showed that the average HQs values of individual antibiotics in adult and children were found below the acceptable limit, demonstrating no possible human health risk for both the subgroups. HI_{interaction} values of antibiotics in binary mixture was calculated using HQ values of antibiotics. The study observed that the estimated HI_{interaction} values of antibiotics in binary mixture was found to be less than 1 for both the sub populations, indicating no potential adverse effects on human health. Concentration of antibiotics was the primary contributor (>65%) to the overall variance in the uncertainty estimates for HQs of individual antibiotics in drinking water for adult and children. The co-occurrence of antibiotics in binary mixture for drinking water samples doesn't possess any possible risk on human health for the studied population.

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1. Introduction

Safe and clean drinking water is the basic necessity for mankind and plays a vital role in health safety. Contamination of water resources possess a serious threat to the global water environment due to the presence of several environmental contaminants, including endocrine disrupters compounds (EDCs), pharmaceuticals and personal care products (PPCP) and other substances, in the water sources that may be used by a water treatment plant (WTP) for the production of water for human consumption (Jones et al., 2001). Antibiotics are the most frequently used drugs by human beings and have been detected in the aquatic environment since the 1970s and in the last twenty years, in all types of surface water, groundwater and the oceanic environment (Klosterhaus et al., 2013; Luo et al., 2014; Veach and Bernot, 2011). In recent decades, antibiotics have emerged as potential environmental contaminants due to their toxicity to non-target organisms and their omnipresent occurrence in the environment due to widespread and incessant release from sources like

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Removal of aromatic and hydrophobic fractions of natural organic matter (NOM) using surfactant modified magnetic nanoadsorbents (MNPs)

Minashree Kumari[1] · Sunil Kumar Gupta[1]

Abstract

The present study investigated the potential of surfactant modified magnetic nanoadsorbents (MNPs) for the removal of aromatic and hydrophobic fractions of natural organic matter (NOM), leading to the formation of trihalomethanes (THMs) in chlorinated drinking water. Co-precipitation method was used for the synthesis of MNPs. However, MNPs have a tendency to form an agglomeration. Therefore, polyethylene glycol (PEG) was used as a surface modifier to reduce the agglomeration. The PEG-coated MNPs were characterized by field emission scanning electron microscopy (FESEM), transmission electron microscopy (TEM), energy-dispersive X-ray analysis (EDX), BET surface area, X-ray diffraction (XRD), Fourier transform spectrometer (FTIR), and zeta (ζ) potential. FESEM observation indicates that PEG-coated MNPs were spherical in shape and 25 nm in size. Zeta potential values ($- 58.35$ to $- 74.9$ mV) indicated excellent stability of PEG-MNPs. FTIR spectra indicated the presence of a $-CH_2$ group, responsible for the chemical interaction between aromatic and humic content. Batch experiments were conducted by studying the effect of pH, contact time, and adsorbent dosage on NOM removal. Excellent removal of DOC (94.49%) and UV_{254} (89.32%) was observed at the optimum dose of adsorbent (0.75 g/L) and at pH 7.0. Adsorption kinetics followed pseudo-second-order reaction (R^2, 0.973) and occurs by multilayer chemisorption which is due to the chemical interaction between aromatic and humic compounds of NOM with MNPs. Thus, MNPs showed great potential as a novel adsorbent for the removal of aromatic and hydrophobic compounds of NOM and can significantly be used to curtail the problem of THMs in drinking water supplies.

Keywords NOM · Nanoadsorbents · Adsorption · Isotherms-kinetics · Drinking water

Introduction

The availability of clean and safe drinking water has become a global hazard. Adequate drinking water is not available and the surface water which is being used as raw water in water treatment plants (WTPs) contains harmful substances like natural organic matter (NOM). NOM is a complex heterogeneous mixture of organic materials. The primary sources of NOM generated by biochemical degradation of vegetation in the watershed area and decomposition of aquatic organisms such as algae and weeds in the water body cause odor, color, and taste problems. Nature of NOM and their concentration vary with source and time regime as well as a number of other environmental factors (Sharp et al. 2006a, b; Fabris et al. 2008). During the disinfection process, NOM reacts with chlorine (disinfectant) via a series of oxidation and substitution reactions forming potentially carcinogenic organic compounds known as trihalomethanes (THMs) (Nikolaou et al. 2004; Iriarte et al. 2003).

Due to the adverse effects of THMs on human health, various treatment techniques and processes have been developed to remove NOM from drinking water supplies. These include coagulation-flocculation, reverse osmosis, ion exchange resins, ultra-filtration, membrane filtration, advanced oxidation processes (O_3/H_2O_2, O_3/UV, UV/H_2O_2, TiO_2/UV, H_2O_2/catalyst), etc. (Kabsch-Korbutowicz 2005; Yan et al. 2009; García

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Age dependent adjustment factor (ADAF) for the estimation of cancer risk through trihalomethanes (THMs) for different age groups- A innovative approach

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ARTICLE INFO

ABSTRACT

Lifetime cancer risk due to trihalomethanes (THMs) in drinking water supplies for different age groups were investigated for the first time using age dependent adjustment factor (ADAF) as per USEPA protocol. Five water treatment plants (WTPs) in Eastern part of India were monitored for establishing the baseline concentrations of THMs and their seasonal variations. The concentration of THMs (231–484 µg/L) in all WTPs exceeded the USEPA guidelines (80 µg/L). Risk analysis of THMs through different pathways revealed that major risk (> 97%) is caused through oral ingestion and is the most vulnerable pathway. Amongst different THMs, chloroform triggered the major risk through oral and dermal routes while BDCM for inhalation. The analysis of lifetime cancer risk for various age group dictated that it was highest (2.37×10^{-4}) for 60–80 yrs age group while it was lowest (4.89×10^{-5}) for 0–1 yr. The cancer slope factors for each THM species were combined with different exposure models and probability of cancer risks for different age groups. Monte Carlo simulations of cancer risk through different exposure routes dictated significant correlation between estimated and simulated risk. The average risk estimated through different exposure models lies well within ± 2.7% of the simulated average risk.

1. Introduction

The provision of safe and clean drinking water is one of the major concerns of developing countries like India. Chlorination is the most accepted disinfectant throughout the world because of its economical availability and effectiveness against the waterborne pathogens. Although chlorine disinfection reduces mortality and morbidity due to water-borne diseases (Calderon, 2000; Golfinopoulos and Nikolaou, 2005) however, it can react with natural organic matter (NOM) and form various types of trihalomethanes (THMs) such as chloroform, bromodichloromethane (BDCM), dibromochloromethane (DBCM) and bromoform, which are probable carcinogens (NCI, 1976; Hrudey, 2009. Based on the toxicological studies, National Cancer Institute (1976) emphasized the probable carcinogenic effect of various THM species. Over the years, a number of toxicological and epidemiological studies have been carried out which indicates a direct relationship between THMs and carcinogenic and non-carcinogenic risk (Boorman et al., 1999; Nieuwenhuijsen, 2005; Richardson et al., 2007; Villanueva et al., 2007). Literature studies have revealed that exposure to these THMs may lead to development of different type of cancers such as bladder, colon–rectum and brain. In addition to this, reproductive disorders, birth defects, cardiac anomalies, still-births, miscarriages, low birth weights, pre-term deliveries and neural tube defects have also been reported (Wright et al., 2004; Richardson, 2005; Ristoiu et al., 2009; Wu et al., 2010; Viana et al., 2009).

US EPA cancer risk paradigm is generally used to estimate the probable risk of THMs on the human population. Human health cancer risk index is the unit risk and represents the probability of an individual developing cancer as a result of contaminant exposure over his (her) lifetime (USEPA 1989, 2005a). The human health risk assessment for THMs in drinking water considers multiple routes of exposure including ingestion, inhalation and skin contact (i.e. dermal absorption). Water is not used only for drinking purposes but also for cooking, showering, bathing, washing, laundering, cleaning and so forth activities. Thus, the exposure and uptake of the contaminants not only occurs by ingestion but also through skin contact i.e. dermal absorption and inhalation. Hence, in all risk assessments studies inhalation and dermal absorption should also be considered along with oral ingestion (Jo et al., 1990; Weisel et al., 1999).

Previous studies on cancer risk assessment were mainly focused on estimating the risk considering explicit values of input parameters i.e. body weight, skin surface area, ingestion rate, exposure duration etc.

Multi-exposure cancer and non-cancer risk assessment of trihalomethanes in drinking water supplies – A case study of Eastern region of India

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ARTICLE INFO

ABSTRACT

The lifetime cancer risk and the hazard index of trihalomethanes (THMs) through oral ingestion, dermal absorption, and inhalation exposure from supply water of five WTPs were analysed. THMs concentration varied from plant to plant and was found to be in the range of 274–511 μg/l, which is much higher than the prescribed USEPA standards of 80 μg/l. Chloroform was the most dominant THM followed by bromodichloromethane (BDCM), and dibromochloromethane (DBCM). Cancer risk analysis through multi-pathways exposure reveals that residents had a higher cancer risk through oral ingestion than other two routes of exposure. The lifetime cancer risks of THMs from supply water were 100 times higher than prescribed USEPA guidelines. The higher cancer risk found for Indian context than those reported for other countries like USA, UK, Japan, Australia, is mainly due to the higher concentration level of THMs, water intake and average body weight. The study also revealed that amongst different THMs, chloroform is the major THMs causing cancer risk through both oral and dermal route of exposure whereas in case of inhalation it was mainly because of BDCM. Average lifetime cancer risk analysis indicated that females are more prone to cancer risk than males. Oral ingestion is a major route indicating the potential impact of non-cancer risk while it was insignificant through dermal exposure. Sensitivity analysis of THMs revealed that chloroform is the predominant parameter followed by body weight and exposure duration influencing cancer risk.

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1. Introduction

Disinfection is the last step in the water treatment processes for the protection of public health. In India, chlorine is used as the primary disinfectant because of its low cost and its convenience for application in water purification. However, the presence of trihalomethanes (THMs) in chlorinated drinking water can pose severe health threat due to its potential carcinogenicity. In recent decades, various epidemiological studies have been conducted to determine the relationship between disinfection by-products (DBPs) and different health outcomes e.g., cancers and reproductive outcomes (Nieuwenhuijsen, 2005; Tardiff et al., 2006; Hrudey, 2009). Many studies suggested that exposure to DBPs increase the risk of bladder, colon, rectum, leukaemia, stomach and rectal cancers (Llopis-González et al., 2011; McGeehin et al., 1993). The results of animal studies have demonstrated that liver, kidney, and intestinal tumorigenesis are associated with chronic

ingestion of THMs (Dodds et al., 1999; Yang et al., 2000). In addition, some experimental studies have also demonstrated that exposure to DBPs in water is related to spontaneous abortion, and other adverse reproductive outcomes (Waller et al., 1998). Since THMs are the most prevalent and well documented DBP compounds in drinking water, they are generally considered as indicators of DBP exposure in epidemiological investigations.

Recent studies have attempted to improve exposure assessment by using individual exposure measures combining routinely collected water system THM measurements with a measure of ingestion, such as number of glasses or water drank per day. However, only a few studies accounted for spatial and temporal fluctuations in THM levels across the distribution system. Furthermore, seeking to improve the exposure assessment, studies have begun to incorporate behavioural determinants of different routes of exposure to DBPs such as dermal absorption and inhalation during bathing and showering, and ingestion of drinking water but the contribution of these was unclear (Hoffman et al., 2008; MacLehose et al., 2008). Lee et al. (2004) calculated cancer risks and hazard index of THMs through different exposure routes

RESEARCH ARTICLE

Modeling of trihalomethanes (THMs) in drinking water supplies: a case study of eastern part of India

Minashree Kumari[1] · S. K. Gupta[1]

Abstract This study aimed at developing a model for predicting the formation of trihalomethanes (THMs) in drinking water supplies. Monitoring of THMs in five major water treatment plants situated in the Eastern part of India revealed high concentration of THMs (231–484 μg l^{-1}). Chloroform was predominant, contributing 87–98.9 % to total THMs. Seasonal variation in THMs levels dictated that the concentration were higher in autumn than other seasons. Linear regression analysis of data indicated that TOC is the major organic precursors for THMs formation followed by DOC and UV$_{254}$. Linear and non-linear predictive models were developed using SPSS software version 16.0. Validation results indicated that there is no significant difference in the predictive and observed values of THMs. Linear model performed better than non-linear one in terms of percentage prediction errors. The model developed were site specific and the predictive capabilities in the distribution systems vary with different environmental conditions.

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Introduction

Disinfection of water is one of the most significant public health advances of the twentieth century. Several methods have been used for disinfection of drinking water (e.g., chloramination, ozonation, chlorine dioxide, and ultraviolet irradiation). However, chlorination is most widely used in the world because it is extremely efficient and cost-effective. Although, chlorination worked well, it was discovered that the use of chlorine posed potential health risks due to the formation of carcinogenic halo-organic compounds, as disinfection by-products (DBPs). At present, more than 600 DBPs have been identified among them the trihalomethanes (THMs), i.e., chloroform [CHCl$_3$], bromodichloromethane [CHCl$_2$Br], dibromochloromethane [CHBr$_2$Cl], and bromoform [CHBr$_3$] have been widely reported in drinking water supply (Richardson 1998). Looking on to potential health risk of these THMs, many countries around the world, i.e., the U.K., the USA, Japan, France, Australia, etc. including U.S. Environmental Protection Agency (USEPA) and World Health Organization (WHO), have regulated these compounds in their drinking water quality standard.

Past studies have established that the levels of THMs in chlorinated waters vary according to the levels of their precursors, i.e., pH, temperature, natural organic matter (NOM), ultra violet absorbance at a wavelength of 254 nm (UV$_{254}$), bromide concentration, dose of chlorine applied and reaction time, etc. The variation in the precursors and their concentrations greatly influence the formation and speciation of these THM compounds in drinking water supply (Rathbun 1996).

Monitoring of THM in drinking water supplies is extremely essential to exercise quality control and ensure the compliance of regulatory guidelines/standards. A more effective approach can be obtained through the use of predictive models. Many mathematical predictive models for THMs formation

Investigation and mapping of fluoride endemic areas and associated health risk – A case study of Agra, Uttar Pradesh, India

Shahjad Ali, Minashree Kumari, Sunil Kumar Gupta, Alok Sinha & Brijesh Kumar Mishra

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Investigation and mapping of fluoride endemic areas and associated health risk – A case study of Agra, Uttar Pradesh, India

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Abstract

The present study aimed at identifying the fluoride endemic areas in five different blocks in Agra district, Uttar Pradesh, India. A total of 365 ground water samples from 73 villages were analysed for establishing the concentration range of fluoride in drinking water. The fluoride level in the study area varied from 0.14-4.88 mg/L. Out of 73, the fluoride levels in 45 villages did not meet the permissible WHO standards. The Baroli Ahir block was found the highly fluoride endemic area followed by Saiyan, Bichpuri, Achnera and Etmadpur. Chronic daily intake of fluoride in adults was 1.25 and 1.5 times higher than those in children and infants, respectively. The probability of dental fluorosis in infants was higher (42%) while adults were more prone to bone and skeletal fluorosis (60%). The hazard quotient analysis revealed that children were found to be at maximum risk followed by infants and adults. Sensitivity analysis revealed that the fluoride concentration is the major influencing parameter responsible for different type of fluorosis in various age groups.

Speciation and kinetics of trihalomethanes formation in drinking water supplies

SPECIATION AND KINETICS OF TRIHALOMETHANES FORMATION IN DRINKING WATER SUPPLIES

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ABSTRACT: Trihalomethanes (THMs) are formed in drinking water supplies as a result of chlorination which are carcinogenic in nature and may cause the diseases like bladder cancer, colon cancer etc. This study aims at establishing the concentration range and speciation, of THMs in the drinking water supplies of eastern part of India. The results delineated significantly higher concentration of THMs (231-484 µg/L) exceeding the maximum allowable limit prescribed by IS 10500 (2012) and USEPA (2011). Speciation of THMs revealed predominance of chloroform followed by $CHBr_2Cl$ and $CHBrCl_2$. However, bromoform was not detected in any of the samples. This may be due to absence of bromide ion below detection limit (< 0.01 mg/L). Effects of contact time, pH and chlorine doses on THMs formation were also investigated. The study indicated increase in THMs with increasing contact time and chlorine dose. The increase in THMs was directly proportional to the applied chlorine dose. The rate of reaction of THMs formation increased as the pH of water was increased from 6 to 9. Meanwhile, THMs were not detected in the pH range below 5 because at this pH chlorine does not react and remains as elemental chlorine. Kinetics of THMs formation and chlorine decay followed first-order reactions. THM formation kinetics were determined using Clark and Kavangauh models. Validation of the models revealed that Clark model (error of prediction, 5.913) predicted THMs formation more accurately than Kavangauh (error of prediction, 19.71). The models may have considerable utility, particularly for evaluating the potential of THM formation in the distribution system following post disinfection with chlorine.

Keywords: trihalomethanes, speciation, kinetics, models, validation

1 INTRODUCTION

In India, water chlorination continues to play an important role because of its potency and wide spectrum of germicidal persistence along with it displays long-lasting residual properties. However, in addition to its role as a disinfectant, chlorine reacts with natural organic matter (NOM) present in raw water, resulting in the formation of various disinfection by-products (DBPs) such as trihalomethanes (THMs) and haloacetic acids (HAAs). The generation of THMs has been shown to be a function of various water quality parameters and chlorination conditions, including total organic carbon (TOC), type of organic precursor, pH, temperature, bromide ion concentration, reaction time and UV_{254} absorbance (Zhang et al., 2009; Lu et al., 2009; Uyak et al., 2007). The formation of THMs can be represented by the classical "haloform reaction" given by March (1992) as mentioned below:

$$2R - CO - CH_3 - 3Cl_2 \xrightarrow{hv} 2R - COCCl_3 + 2H_2 \qquad (1)$$

and a subsequent hydrolysis:

$$2R \quad COCCl_3 \quad 2H_2O \xrightarrow{hv} 2RCO \quad OH \mid 2CHCl_3 \qquad (2)$$

For identifying management strategies in order to respect the quality standards, it is essential to have models able to reproduce THMs formation in water supply systems. To date, few kinetic models have been developed for the formation of THMs in drinking water supplies. The kinetic models are difficult to develop as the reaction of chlorine with the organic constituents in water is complex. Many proposed models are based on empirical relationships among the total THMs concentration and some parameters, which influence their formation, developed using either laboratory or field scale data (Chowdhury et al., 2009). Di Cristo et al. (2014) investigated the applicability of different empirical models on to water supply systems and their ability in reproducing THMs concentrations in real situations. The alternative is to use models based on kinetics involved during chlorine reactions (Kavangauh et al., 1980; Gang et al. 2002), but in this case the kinetic parameters have to be quantified. Therefore, the objective of this work was to study the speciation and formation kinetics of THMs in drinking water for human use and consumption along with the effect of major influencing parameters on the rate of THMs formation.

The ubiquitous nature of antibiotic resistance genes (ARGs) among environmental pathogens from a variety of sources such as air and water suggests that the aquatic environment, and specifically alternative water treatment systems, may act as reservoirs for drug resistant bacteria and ARGs, thereby contributing to the widespread dissemination of antibiotic resistance. Water is considered an important medium for transfer of resistance genes and resistant bacteria to the broader environment. The book describes the isolation of antibiotic resistance bacteria from different natural sources i.e. soil and water and expression of the isolated plasmid DNAs into suitable host. The bacteria isolated were multi drug resistant (MDR) to three antibiotics i.e. chloramphenicol, erythromycin and tetracycline. The ubiquitous nature of MDR in soil and water, the presence of diverse ARGs of human health significance, as well as the transfer of resistance determinants through conjugative plasmids to recipient bacteria, suggests that environmental exposure through contact or consumption with contaminated water is probable.

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Transfer and expression of plasmid from antibiotic resistance bacteria

Minashree Kumari

Transfer and expression of plasmid from antibiotic resistance bacteria

Futoshi Kurisu

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Trends in Asian Water Environmental Science and Technology

Book Chapter

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Multi-pathway Risk Assessment of Trihalomethanes Exposure in Drinking Water Supplies

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1. Introduction

Disinfection is the last step in the water treatment processes for the protection of public health. In India, chlorine is used as the primary disinfectant because of its low cost and convenience for application in water purification. However, chlorination results in formation of trihalomethanes (THMs) in drinking water which can pose severe health threat due to their potential carcinogenicity. In recent decades, various epidemiological studies have been conducted to determine the relationship between THMs and different health outcomes e.g., cancers and reproductive outcomes (Hrudey, 2009). Llopis-González et al. (2011) suggested that exposure to THMs increase the risk of bladder, colon, rectum, leukemia, stomach and rectal cancers. The results of animal studies have demonstrated that liver, kidney and intestinal tumorigenesis are associated with chronic ingestion of THMs (Yang et al., 2000). Since THMs are the most prevalent and well documented disinfection by product (DBP) compounds in drinking water, they are generally considered as indicators of DBP exposure in epidemiological investigations.

Recent studies have attempted to improve exposure assessment by considering individual exposure durations, concentration levels and water intake per day. However, only a few studies accounted for spatial and temporal

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Factors Influencing the Formation of Trihalomethanes in Drinking Water Supplies

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***Abstract** Presence of Trihalomethanes (THMs) in drinking water has become a major concern worldwide because of their adverse health impacts. These THMs are formed due to reaction of chlorine with natural organic matter and other precursors found in water. This study aims at establishing the concentration range of THMs in drinking water supplies. The concentrations of THMs (274-511 µg/l) found to be much higher than the prescribed USEPA standards and WHO guidelines. The study also revealed that amongst various THMs, contribution of chloroform was highest (93.07-98.9%) followed by other THMs. Correlation study delineated that TOC, DOC and UV_{254} are the main organic precursors responsible for the formation of THMs in drinking water. Bromoform was not detected in the water which can be attributed to the absence of bromide in raw water. Pearson correlation matrix revealed that pH and temperature have also significant and definite correlation (r = 0.767 and 0.945, respectively) with the THMs.*

Keywords: Drinking water, Chloroform, Trihalomethanes, UV_{254}, SUVA, NOM

1. INTRODUCTION

The disinfection of water using chlorine is most commonly used practice all over the world because of its low cost, easy to use, efficient against a broad spectrum of microorganisms and enables the maintenance of a residual protection. Disinfection of water using chlorine has a strong drawback, which is the generation of several Disinfection By-products (DBPs) as reported by researchers long back in 1970's (1; 2; 3). During chlorination, chlorine reacts with the residual natural organic compounds in water to form DBPs, which have been reported to be potent carcinogens (4; 5). The most common form of DBPs is the trihalomethanes (THMs) which include trichloromethane ($CHCl_3$), bromodichloromethane ($CHBrCl_2$), dibromochloromethane ($CHBr_2Cl$) and tribromomethane ($CHBr_3$). Amongst the various DBPs, THMs are of major concern today because of their presence in greatest concentration in the drinking water and are sometime used as indicators of total disinfection by-product formation (6).

The formation of DBPs depends primarily on source water quality characteristics and on the location in the treatment process where disinfectants are added. The most important water quality parameters that influence the formation of DBPs include the nature and concentration of organic