BIOGRAPHICAL SKETCH

NAME: Shankar G. Aggarwal

CURRENT POSITION TITLE: Principal Scientist

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EDUCATION/TRAINING:

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Pt Ravishankar Shukla University, Raipur, India	B.Sc.	June 1990	Physics, Chemistry, Maths
Pt Ravishankar Shukla University, Raipur, India	M.Sc.	November 1992	Chemistry
Pt Ravishankar Shukla University, Raipur, India	Ph.D.	August 1999	Analytical Chemistry
Pt Ravishankar Shukla University, Raipur, India	CSIR Research Associate	1999-2000	Atmospheric Chemistry
National ChiaoTung Univeristy, Hsinchu, Taiwan	NSC Postdoc	2000-2001	Aerosol Physics, Sampling instrumentation
Industrial Technology Research Institute (DI), Hsinchu, Taiwan	Researcher	2001-2003	Emission Control Technology, Stack Emission Measurements
Hokkaido University, Sapporo, Japan	JSPS fellow	2003-2005	Aerosol Micro-Physical and Molecular Chemical, Isotope Characterization
Hokkaido University, Sapporo, Japan	University Postdoc	2005-2009	Aerosol Micro-Physical and Molecular Chemical, Isotope Characterization

Personal Statement

Dr. Shankar G. Aggarwal did his Ph.D. in Analytical Chemistry with Prof. K.S. Patel from Pt. Ravishankar Shukla University, Raipur (CG), India in 1999. After his Ph.D. award, he worked with Prof. C. J. Tsai at National Chiao Tung University, Taiwan and at Industrial Technology Research Institute (ITRI), one of the Designated Institutes of Taiwan for several years on gas and aerosol related researches. In 2003, he has been involved in development of an emission control technology for Taiwan Semiconductor Manufacturing Company (TSMC), which is a leading chip making company in the world. Currently this technology has been using by several units of TSMC. Thereafter he received JSPS fellowship and worked at Hokkaido University, Japan with Prof. K. Kawamura on aerosol chemistry/geo-chemistry and its microphysical properties before he joined CSIR-National Physical Laboratory (NPL), New Delhi, India in April 2009. At CSIR-NPL, he is working as Principal Scientist, and his current research focus is ‘‘metrology for national ambient air quality standards (NAAQS)’’ in which he involves in preparation of preparation of gas standards and $PM_{2.5}$ sampler and its calibration work, performance evaluation of air monitoring instruments, sensors, etc. Also, they have designed and developed an aerosol wind tunnel facility at CSIR-NPL for cutoff size calibration of aerosol samplers, first in India. So far, 4 students have been awarded Ph.D. degree under his supervision. At present 6 students are registered with him for Ph.D. degree. So far he has published more

than 80 research papers in high impact factor journals and awarded with 5 patents (https://www.researchgate.net/profile/Shankar_Aggarwal). Apart from this, he has been published more than 150 articles including as book chapters, conference proceedings, reports, institutional journals and magazines. He has been given more than 150 talks in national and international platforms (including talks in >20 different countries). He has been organized several conferences and also in the part of scientific program committees of >50 national and international conferences. He is the PI of several national and international scientific projects. He is the course coordinator of Ph.D. credit course "Air Quality Measurement Science and Technology" for AcSIR. He also serves his duties as assessor (ISO 17034: 2016 and ISO/IEC 17025:2017) for National Accreditation Board for Testing and Calibration Laboratories (NABL). He is also the member of gas and air pollution related committees of Bureau of Indian Standards (BIS). He is the Associate Editor of 2 international journals. He is a life member of several scientific societies including: MSI, IASTA, ISAS, IAAPC, etc.

A. Positions and Honors

- **Employment**

Research Associate at SOS in Chemistry, Pt. Ravishankar Shukla University, Raipur from April, 2000 (1.5 years), "Heavy metal pollution in central India".

Postdoctoral fellow at Institute of Environmental Engineering, National ChaoTung University, Taiwan from October, 2001 (1 year), "Physical characterization of particles, air monitoring techniques".

Research Associate, SOS in Chemistry, Pt. Ravishankar Shukla University, Raipur from October, 2002 (2 months), "Heavy metal pollution in central India".

Researcher, Industrial Technology Research Institute, Hsinchu, Taiwan from December, 2002 (2.5 years), "Emission control technology for semiconductor industries, Air quality study of a high-tech park".

Post doctoral Research Scientist (included 2 years JSPS fellow), Hokkaido University, Sapporo, Japan from April 2005 (4 years), "Chemical characterization of atmospheric aerosols, Microphysical characterization of atmospheric aerosols".

Principal Scientist, National Physical Laboratory, New Delhi from April 2009, "Research work related to aerosol atmospheric chemistry and physics, gas and particulate metrology, air quality metrology and instrumentation".

- **Offices, Honors, and Professional Development**

S. No.	Name of the award/recognition	Year	Awarding Org./ Inst. CSIR, India	Brief citation of the award work/remarks
1	PDF award	2001	NSC, Taiwan	Studied thermophoretic deposition technique for particle deposition from industrial waste gas
2	Best research team member award, ITRI, Taiwan	2004	ITRI, Taiwan	Developed waste gas treatment technology for TSMC, Taiwan
3	JSPS award	2005	JSPS, Japan	Studied/development of HTDMA for hygroscopicity measurement of aerosol particles, studied CCN activity of particles
4	Best paper award in AAC2011, Xi'an, China	2011	Asian Aerosol Research Assembly	Isotopic changes in aged atmospheric aerosols as indicator for their photochemical aging
5	Associate Editor of MAPAN	2014	Publisher: Springer	Journal theme is "Metrology"

6	CITAC best paper award -2013, France	2015	Cooperation on International Traceability in Analytical Chemistry	Traceability Issue in PM2.5 and PM10 Measurements
7	Technology Licensed Award	2017	CSIR-National Physical Laboratory	High-Volume PM2.5 Impactor Sampler
8	Associate Editor of Asian Journal of Atmospheric Environment	2018	Publisher: Asian Association for Atmospheric Environment	

S. No.	Professional development/Place of Training	Duration	Year	Brief description
1	Lucknow	11-15 January	2010	Metrology in Chemistry (MiC) organized by Indo-German technical cooperation in the field of Metrology in Chemistry
2	New Delhi	01-04 February	2011	CRM Production & Certification Workshop organized by Indo-German technical cooperation in the field of Metrology in Chemistry
3	PTB, Berlin, Germany	09-13 May	2011	Training on Isotope Dilution Mass Spectrometry technique
4	Imperial College, London, UK	16-20 May	2011	Training on Inductive Coupled Plasma-Mass Spectrometry technique
5	Nu Instruments Ltd., UK	23-27 May	2011	Hands on training on Nu Instruments ATTOM ICP-HRMS
6	CSIR-NPL, New Delhi	22-24 August	2012	Quality System – Laboratory Management, Need for Calibration/Accreditation as per IS/ISO/IEC – 17025:2005
7	Mumbai	6-10 July	2015	Reference Material Producer Assessor Course As per ISO Guide 34:2009
8	New Delhi	24-28 August	2015	Laboratory Assessor Course as per ISO/IEC 17025:2005
9	New Delhi	23-26 October	2018	General Requirements for Proficiency Testing as per ISO/IEC 17043:2010

B. Contributions to Science

- **Emission monitoring and control technology**

Chuen-Jinn Tsai, Shankar G. Aggarwal, Chung-Tso Chang, I-Fu Hung, Concentration Profiles of Acidic and Basic Air Pollutants Around an Industrial Park of Taiwan, Water, Air, & Soil Pollution, 151, 287-304, 2004.

HungMin Chein, Tzu Ming Chen, Shankar G. Aggarwal, Chuen-Jinn Tsai, Chun-Chao Huang, Inorganic Acids Emission Factors of Semiconductor Manufacturing Processes, Journal of Air & Waste Management Association, 54, 218-228, 2004.

Hungmin Chein, Shankar G. Aggarwal, Hsin-Hsien Wu, Efficient Control System for Low-Concentration Inorgani**c** Gases from Process Vent Stream: Application of Surfactants in Spray and Packed Column, Environmental Science & Technology, 38, 5766-5772, 2004.

Hung Min Chein, Shankar Gopala Aggarwal, Hsin Hsien Wu, Tzu Ming Chen, Chun-Chao Huang, Field Enhancements of Packed Bed Performance for Low-Concentration Acidic and Basic Waste-Gases from Semiconductor Manufacturing Process, Journal of Air & Waste Management Association, 55, 647-657, 2005.

HungMin Chein, Yu-Du Hsu, Shankar G. Aggarwal, Tzu-Ming Chen, Chun-Chao Huang, Evaluation of arsenical emission from semiconductor and opto-electronics facilities in Hsinchu, Taiwan, Atmospheric Environment, 40(10), 1901-1907, 2006.

- **Scientific interpretation based on aerosol physical/optical characterization**

Chuen-Jinn Tsai, Jyh-Shyan Lin, Shankar G. Aggarwal, Da-Ren Chen, Thermophoretic Deposition of Particles in Laminar and Turbulent Tube Flows, Aerosol Science and Technology, 38, 131-139, 2004.

Shankar Gopala Aggarwal, Michihiro Mochida, Yasuyuki Kitamori, Kimitaka Kawamura, Chemical Closure Study on Hygroscopic Properties of Urban Aerosol Particles in Sapporo, Japan, Environmental Science & Technology, 41, 6920-6925, 2007.

Mochida, M., C. Nishita-Hara, Y. Kitamori, S. G. Aggarwal, K. Kawamura, K. Miura, A. Takami, Size-segregated measurements of cloud condensation nucleus activity and hygroscopic growth for aerosols at Cape Hedo, Japan in spring 2008, Journal of Geophysical Research, 115, D21207, 2010.

Jinsang Jung, Young J. Kim, Shankar Gopala Aggarwal, Kimitaka Kawamura, Hygroscopic property of water-soluble organic-enriched aerosols in Ulaanbaatar, Mongolia during the cold winter of 2007, Atmospheric Environment, 45, 2722 – 2729, 2011.

Comparison of Experimental and Modeled Absorption Enhancement by Black Carbon (BC) Cored Polydisperse Aerosols under Hygroscopic Conditions, Environ. Sci. Technol., 46 (15), 8082–8089, 2012.

Bighnaraj Sarangi, Shankar G. Aggarwal, Deepak Sinha, and Prabhat K. Gupta, Aerosol effective density measurement using scanning mobility particle sizer and quartz crystal microbalance with the estimation of involved uncertainty, Atmos. Measurement Techniques, 9, 859–875, 2016.

B. Sarangi, S.G. Aggarwal, B. Kunwar, S. Kumar, R. Kaur, D. Sinha, S. Tiwari, K. Kawamura, Nighttime particle growth observed during spring in New Delhi: Evidences for the aqueous phase oxidation of SO2, Atmos. Environ., 188, 82–96, 2018.

- **Scientific implementation based on aerosol chemical and isotope analysis**

Shankar G. Aggarwal, Kimitaka Kawamura, Molecular distributions and stable carbon isotopic compositions of dicarboxylic acids and related compounds in aerosols from Sapporo, Japan: Implications for photochemical aging during long-range atmospheric transport, Journal of Geophysical Research, 113, D14301, 2008.

Shankar G. Aggarwal, Kimitaka Kawamura, Carbonaceous and inorganic composition in long-range transported aerosols over northern Japan: Implication for aging of water-soluble organic fraction, Atmospheric Environment, 43, 2532-2540, 2009.

Yuzo Miyazaki, Shankar G. Aggarwal, Khem Singh, Prabhat K. Gupta, Kimitaka Kawamura, Dicarboxylic acids and water-soluble organic carbon in aerosols in New Delhi, India in winter: Characteristics and formation processes, Journal of Geophysical Research, 114 (D19). 1984–2012, 2009.

S. Agarwal, S. G. Aggarwal, K. Okuzawa, K. Kawamura, Size distributions of dicarboxylic acids, ketoacids, a-dicarbonyls, sugars, WSOC, OC, EC and inorganic ions in atmospheric particles over Northern Japan: Implication for long-range transport of Siberian biomass burning and Asian polluted aerosols, Atmospheric Chemistry and Physics, 10, 5839-5858, 2010.

Sudhanshu Kumar, Shankar G. Aggarwal, Prabhat K. Gupta, Kimitaka Kawamura, Investigation of the tracers for plastic-enriched waste burning aerosols, Atmospheric Environment 108,49-58, 2015.

S. Kumar, S.G. Aggarwal, J. Malherbe, J.P.G. Barre, S. Berail, P.K. Gupta, O.F.X. Donard, Tracing dust transport from Middle-East over Delhi in March 2012 using metal and lead isotope composition, Atmospheric Environment 132, 179-187, 2016.

Pingqing Fu, Shankar G. Aggarwal, Jing Chen, Jie Li, Yele Sun, Zifa Wang, Huansheng Chen, Hong Liao, Aijun Ding, G. S. Umarji, R. S. Patil, Qi Chen, and Kimitaka Kawamura, Molecular Markers of Secondary Organic Aerosol in Mumbai, India, Environmental Science and Technology, 50, 9, 4659–4667, 2016.

- **Studies on bioaerosol and related compounds**

Agarwal S., Mandal P., Majumdar D., Aggarwal S.G., Srivastava A., Characterization of Bioaerosols and their Relation with OC, EC and Carbonyl VOCs at a Busy Roadside Restaurants-Cluster in New Delhi, Aerosol and Air Quality Research, 16, 3198–3211, 2016.

Kumar S., Aggarwal S.G., Fu P.Q. Kang M., Sarangi B., Sinha D., Kotnala R.K. Size-segregated sugar composition of transported dust aerosols from Middle-East over Delhi during March 2012, Atmos. Research, 189, 24–32, 2017.

- **Air monitoring technology development**

Chuen-Jinn Tsai, Kai-Chung Cheng, Shankar G. Aggarwal, Tung-Sheng Shih, I.-Fu Hung, Simultaneous Sampling of Gaseous- and Aerosol-Phase TDI with a Triple Filter System, Journal of Air & Waste Management Association, 53, 1265-1272, 2003.

Prashant Patel, Shankar G. Aggarwal, Chuen-Jinn Tsai, Tomoaki Okuda, Theoretical and field evaluation of a PM2.5 high-volume impactor inlet design, Atmospheric Environment 244, 117811, 2021.

Prashant Patel, Shankar G. Aggarwal, Theoretical and Experimental Evaluation of a Compact Aerosol Wind Tunnel and its Application for Performance Investigation of Particulate Matter Instruments, Aerosol and Air Quality Research, 21(7), 1-20, 2021.

- **Air quality metrology (standards and calibration)**

Shankar G. Aggarwal, Recent Developments in Aerosol Measurement Techniques and the Metrological Issues, MAPAN Journal of Metrology Society of India, 25 (3), 165-189, 2010.

Shankar G. Aggarwal, Sudhanshu Kumar, Papiya Mandal, Bighnaraj Sarangi, et al., Traceability issue in PM2.5 and PM10 measurements, MAPAN- Journal of Metrology Society of India, 28(3), 153-166, 2013.

Bighnaraj Sarangi, Shankar G. Aggarwal, Prabhat K. Gupta, Performance Check of Particle Size Standards within and after Shelf-life using Differential Mobility Analyzer, Journal of Aerosol Science, 103, 24–37, 2017.

Rishu Agarwal, Shankar G. Aggarwal, Absorption Efficiency Assessment and Uncertainty Measurement of the Sodium Arsenite Method for Ambient NO2 Determination, Aerosol and Air Quality Research, 21(3), 1–12, 2020.

Gung-Hwa Hong, Thi-Cuc Le, -- , Shankar G. Aggarwal, Chuen-Jinn Tsai, Long-term evaluation and calibration of three types of low-cost PM2.5 sensors at different air quality monitoring stations, Journal of Aerosol Science, 157, 2021, 105829

Kritika Shukla, Shankar G. Aggarwal, Performance check of beta gauge method under high PM2.5 mass loading and varying meteorological conditions in an urban atmosphere, Atmospheric Pollution Research, 12, 2021, 101215.

C. Ph.D. Supervised and Awarded to Students: 04

- "Physico-Chemical Characterization of Urban Aerosols", Bighnaraj Sarangi, Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, 2016

- "Understanding Aerosol Sources and Chemistry Using Selctive Markers and Stable Isotopes Analyses", Sudhanshu Kumar, Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, 2016

- "A Study on Online and Offline Measurements of PM_{10} and $PM_{2.5}$ in an Urban City, Raipur", Jaya Dammani, Pt. Ravishankar Shukla University, Raipur, 2019

- **"**Uncertainty Calculation in Aerosol Measurements**",** Jyoti Pokhariyal, Delhi Technological University, Delhi, 2020