

EDUCATION

- National University of Singapore (NUS), Singapore** Sep 2007 – Jun 2012
Doctor of Philosophy, Civil & Environmental Engineering
- Indian Institute of Technology Delhi (IIT Delhi), India** Aug 2003 – Jun 2007
Bachelor of Technology, Civil Engineering

EXPERIENCE

- Instructor** – Civil, Environmental, and Construction Engineering, Jan 2018 - Present
Texas Tech University, Lubbock Texas
- Postdoctoral Fellow** - Climate, Atmospheric Science and Physical Oceanography Feb 2015 – Nov 2017
University of California San Diego, CA
- Research Fellow** - Singapore-MIT Alliance for Research and Technology (SMART) Apr 2013 – Jan 2015
NUS, Singapore
- Research Fellow** - Minerals Metals & Materials Technology Centre, Singapore Sep 2011 – Apr 2013
- Consultant** - VICOM Ltd, Singapore Oct 2009 – Jan 2013

TEACHING EXPERIENCE

- Teaching Assistant:** Civil & Environmental Engineering, NUS, 2009 -2011
1. Air Quality Management, ESE 3201, 1 semester, 60 undergraduate students
 2. Global Environmental Issues, GEK 1522, 1522T, 3 semesters, 70 – 150 students

Research Mentor: Mentored 17 undergraduate students on their final year thesis (Project duration: 1 year) and 4 exchange students in their summer research projects (Project duration: 3 months)

RESEARCH SKILLS

Technical

- High Resolution – Time of Flight -Aerosol Mass Spectrometer (**HR-ToF-AMS**)
- Single Particle Soot Photometer (**SP2**)
- Gas Chromatography-Mass Spectrometry/Flame Ionization/Electron Capture Detector (**GC-MS/FID/ECD**)
- Ion Chromatography (**IC**)
- Inductively Coupled Plasma-Mass Spectrometry
- (**ICP-MS**)
- UV-Visible Spectrometry
- CHN Elemental Analysis
- Fast Mobility Particle Size (**FMPS**)
- In-vitro Toxicity Experiments
 - Cell culturing and handling
 - Cytotoxicity
 - DNA damage

Programming

Igor, MATLAB, Python, R, JAVA, C++, C, FORTRAN 77, 90,

HONORS AND AWARDS

1. NUS Research Scholarship, 2007 – 2011
2. Best Paper Presentation: Chembiotech International Conference, March 2010
3. Merit Scholarship: IIT Delhi, 2005 – 2007

FUNDED RESEARCH

Scripps Institution of Oceanography

1. ***North Atlantic Aerosol and Marine Ecosystems Study (NAAMES) (Funded by NASA)***
NAAMES is an interdisciplinary investigation funded by NASA's Earth Venture Suborbital Program to resolve key processes that control marine ecosystems and aerosols. It is the first EV-S mission focused on studying the coupling of the ocean ecosystem and the atmosphere. NAAMES consists of 4-combined ship and aircraft field campaigns, each aligned to a specific event in the annual plankton lifecycle. I led a team of researchers from Scripps Institution of Oceanography on 2 month-long data collection cruises in the North Atlantic, between November 2015 and June 2016, to study marine aerosols.
2. ***Brown Carbon Study (Funded by California Air Resources Board)***
This study broadly aims to characterize and assess net contribution of Brown Carbon (BrC) to climate forcing in California. Data was collected in 2 extensive month-long field campaigns - Fresno (December 2014) and Fontana (July 2015). A manuscript was published from this work in Journal of Geophysical Research Atmospheres. Three other manuscripts are submitted as a coauthor from this work.
3. ***Gas and Particle Emissions From R/V Robert Gordon Sproul (Funded by Department of Transportation)*** – The effect of Hydrogenation Derived Renewable Diesel (HDRD) on in-use marine diesel engine emissions was investigated in this study. Two 5-day sampling cruises were conducted in 2014 and 2015 in Pacific Ocean. In addition, yearlong stack gas concentrations were measured on several voyages to estimate gas and particle emission factors for HDRD. Three manuscripts were published in Aerosol Science and Technology²¹⁻²³

National University of Singapore

1. ***Trans-boundary smoke haze aerosols in South East Asia (SEA) (Funded by SMART, National Research Foundation in Singapore)*** – Indonesian peat and agricultural land fires in June 2013 enveloped the SEA air basin with smoke clouds leading to severe hazy conditions in the region. This haze episode ranked amongst the worst recorded air pollution in the region and drew widespread international attention. I led an extensive field campaign to collect particulate pollution samples, conducted laboratory investigation and modeling to understand the transport, and the related environmental and public health impacts of smoke haze aerosols^{1,3-5,8,16}.
2. ***Source apportionment of airborne particles in Singapore (Funded by SMART, National Research Foundation in Singapore)*** – In this research project, I investigated the contribution of different emission sources to fine and ultrafine particles in Singapore. A novel method was developed using radiocarbon (C¹⁴) and stable carbon (C¹³) isotopes to determine the contribution of various emission sources. In addition molecular markers specific to peat fires were identified. (Manuscript is currently under preparation)

3. ***Emissions from handheld Sparklers*** – In this study, the physic-chemical properties of emissions from different types of handheld sparklers were measured through controlled chamber experiments. Further the health risk due to the acute exposure of the emissions from handheld sparklers was estimated^{7, 12}.
4. ***Development of New Hydrothermal Technology for Producing Bio-char for Direct Co-combustion with Coal*** – Economical production of biomass derived fuel for use in existing power plant was developed. The production of bio-char is optimized and the product is evaluated for its environmental benefits⁹.
5. ***A Comprehensive Study on Vehicular Emissions and Fuel Efficiency (Funded by Land Transport Authority and National Environmental Agency of Singapore)*** – A 4-phase study was conducted to determine contributions of vehicular traffic to total CO₂ and particulate matter (PM) in Singapore, and to establish appropriate vehicular emission standards using both smoke opacity and PM emission tests for on-road vehicles. The relationship between fuel efficiency and fuel emissions was also studied. The Land Transport Authority and National Environmental Agency, Singapore funded this project.
6. ***Seven South East Asian Studies (7-SEAS)*** – This study involves measurement of light scattering, absorption efficiency, chemical properties ambient PM during Southeast Asia Haze^{2,6,14-15}. The prime objective of this collaborative study was to develop surface level aerosol database in Southeast Asia. The project was completed in collaboration with the Goddard Space Flight Center, NASA and the U.S. Naval Research Laboratory.
7. ***Impact of laser printer emissions in office environments*** – Investigated the contribution of laser printer emissions to indoor air pollution²⁰. Nearly 97% of PM emissions from laser printers are in the nano-size range, which made them easily penetrable into human tissue and harmful to personnel's health.
8. ***Observation of new particle formation in tropical climate of Southeast*** – Ambient air in tropical atmosphere of Singapore was monitored in different seasons. Particle characterization and formation in the atmosphere due to gas-particle conversion were studied in this project. The dependence of the phase transformation of atmospheric gases on weather conditions was explored¹⁰.
9. ***Chemical speciation and health risk assessment of particulate emissions from Indonesian peat fires*** – In this project particulate matter collected from Indonesian peat fires was chemically characterized for different fractions of trace metals. In addition, potential health risk associated with such emissions was estimated¹³.
10. ***A Comparative Study of Diesel and Biodiesel Emissions from Internal Combustion Engines (PhD Thesis)*** –Physical and chemical properties of particulate emissions from a diesel engine fuelled with ULSD and Biodiesel blends were extensively characterized to assess their environmental impact^{11,18-19}. In addition, the health risk associated with inhalation of PM was estimated, and their cytotoxic as well as genotoxic properties were investigated¹⁷.

11. **Estimation of Overall Pollution potential of municipal landfills** – Developed a mathematical tool to estimate the pollution potential of municipal landfills. Two municipal landfills in Delhi are compared using this tool as a case study.
12. **Emissions of heavy-duty vehicles on road and their impacts** – Characterization of gaseous and particulate emissions from heavy duty trucks under real road conditions. Assessing the exposure concentrations of people living near major roadways

PUBLICATIONS

Peer-Reviewed Journal Articles

1. **Betha, R.**, Russell, L.M., Chen, C-L., Liu, J., Price, D.J., Sanchez, K.J., Chen S., Lee, A.K.Y., Collier, S.C., Zhang, Q., Zhang, X., Cappa, C.D., 2018. Larger submicron particles for emissions with residential burning in wintertime San Joaquin Valley (Fresno) than for vehicle combustion in summertime South Coast Air Basin (Fontana). *Journal of Geophysical Research-Atmospheres*. DOI:10/1029/2017JD026730.
2. Chen C.L., Chen S., Russell, L.M., Liu, J., Price, D.J., **Betha R.** et al. 2018. Organic aerosol particle chemical properties associated with residential burning and fog in wintertime San Joaquin Valley (Fresno) and with vehicle and firework emissions in summertime South Coast Air Basin (Fontana). *Journal of Geophysical Research-Atmospheres*. DOI:10/1029/2018JD028374
3. Sanchez, K., Chen C.L., Russell, L.M., **Betha R.**, et al. 2018. Substantial Seasonal Contribution of Observed Biogenic Sulfate Particles to Cloud Condensation Nuclei. *Scientific Reports* 8(1) 3235.
4. Lee, A. K. Y., Chen, C. L., Liu, J., Price, D.J., **Betha, R.**, Russell, L.M., Zhang, X., and Cappa, C.D., 2017. Formation of secondary organic aerosol coating on black carbon particles near vehicular emissions, *Atmos. Chem. Phys. Discuss.*, 1-20, doi:10.5194/acp-2017-665, 2017.
5. **Betha, R.**, Russell, L.M., Sanchez, K.J., Liu, J., Price, D.J., Lamjiri, M.A., Chen, C-L., Kuang, X.M., da Rocha, G.O., Paulson, S.E., Miller, J.W., Cocker, D.R., 2017. Lower NO_x but Higher Particle and Black Carbon Emissions from Renewable Diesel compared to Ultra Low Sulfur Diesel in At-Sea Operations of a Research Vessel. *Aerosol Science and Technology*. 51, 123-134.
6. Price, D.J., Russell, L.M., Chen, C-L., Lamjiri, M.A., **Betha, R.**, Sanchez, K.J., Liu, J., Lee, A. K. Y., Miller, J.W., Cocker, D.R., 2017. Unsaturated Hydrocarbon fraction Increases with Aging for both Renewable and Ultra Low-Sulfur Diesel in at-sea Operations for a Research Vessel. *Aerosol Science and Technology*. 51, 135-146.
7. Kuang, X.M., da Rocha, G.O., Scott, A., Paulson, S.E., **Betha, R.**, Price, D.J., Russell, L.M., Miller, J. W., Cocker, D.R., 2017. Reactive Oxygen Species formation by diesel and biodiesel PM emissions from a marine vessel and their relationship to BC and heavy metal content. *Aerosol Science and Technology*. 51, 147-158.
8. Xian, H., **Betha, R.**, Tan L, Y., Balasubramanian, R., 2016. Risk assessment of bio accessible trace elements in smoke haze aerosols versus urban aerosols using simulated lung fluids. *Atmospheric Environment*, 125, 505-511.
9. Xu, J., Tai, X., **Betha, R.**, He, J., Balasubramanian, R., 2015. Comparison of physical and chemical properties of ambient aerosols during the 2009 haze and non-haze periods in Southeast Asia.

- Environmental geochemistry and health, 37, 835-841.
10. Behera, S.N., **Betha, R.**, Huang, X., Balasubramanian, R., 2015. Characterization and Estimation of Human Airway Deposition of Size-resolved Particulate-bound Trace Elements during a Recent Haze Episode in Southeast Asia. *Environmental Science Pollution Research*, 22, 4265-80.
 11. Aouizerats, B., Van der Werf, G.R., Balasubramanian, R., **Betha, R.**, 2015. Importance of transboundary transport of biomass burning emissions to regional air quality in Southeast Asia during a high fire event *Atmospheric Chemistry and Physics*, 15, 363-373.
 12. **Betha, R.**, Behera, S.N., Balasubramanian, R., 2014. 2013 Southeast Asian Smoke Haze: Fractionation of particulate-bound elements and associated health risk. *Environmental Science & Technology*, 48, 4327–4335.
 13. **Betha, R.**, Zhe, Z., Balasubramanian, R., 2014. Influence of trans-boundary biomass burning impacted air masses on submicron particle number concentrations and size distributions. *Atmospheric Environment*, 92, 9 – 18.
 14. **Betha, R.**, Balasubramanian, R., 2014 PM_{2.5} emissions from hand-held sparklers: Chemical characterization and health risk assessment. *Aerosol and Air Quality Research*, 14, 1477-1486
 15. Engling, G., He, J., **Betha, R.**, Balasubramanian, R., 2014. Assessing the regional impact of Indonesian biomass burning emissions based on organic molecular tracers and chemical mass balance modeling. *Atmospheric Chemistry and Physics* 14, 8043 – 8054.
 16. Parishetti, G.K., Quek, T.Y.A., **Betha, R.**, Balasubramanian, R., 2014. TGA-FTIR investigation of co-combustion characteristics of blends of hydrothermally carbonized oil palm biomass (EFB) and coal. *Fuel Processing Technology*. 118, 228 – 234.
 17. **Betha, R.**, Spracklen, D., Balasubramanian, R., 2013. Observations of New Particle Formation in the Urban Tropical Atmosphere of Singapore. *Atmospheric Environment*, 71: 340 – 351.
 18. **Betha, R.**, Balasubramanian, R., 2013. Emissions of particulate-bound elements from biodiesel and ultra-low sulfur diesel: Size distribution and risk assessment. *Chemosphere*, 90: 1005 – 1015.
 19. **Betha, R.**, Balasubramanian, R., 2013. Particulate Emissions from Commercial Handheld Sparklers: Evaluation of Physical Characteristics and Emission Rates. *Aerosol and Air Quality Research*, 13: 301 – 307.
 20. **Betha R.**, Pradani, M., Lestari, P., Joshi, U.M., Reid, J.S., Balasubramanian, R., 2013. Chemical speciation of trace metals emitted from Indonesian peat fires for health risk assessment. *Atmospheric Research*, 122: 571 – 578.
 21. Behera, S.N., **Betha, R.**, Liu, P., Balasubramanian, R., 2013. A study of Diurnal Variations of PM_{2.5} Acidity and Related Chemical Species Using a New Thermodynamic Equilibrium Model. *Science of Total Environment*, 452: 286 – 295.
 22. Behera, S.N., **Betha, R.**, Balasubramanian, R., 2013. Insights into Chemical Coupling among Acidic Gases, Ammonia and Secondary Inorganic Aerosols. *Aerosol and Air Quality Research*, 13: 1282 – 1296.
 23. Pavagadhi, S., **Betha, R.**, Venkatesan, S., Balasubramanian, R., Hande, M.P., 2013. Physicochemical and toxicological characteristics of urban aerosols during a recent Indonesian biomass burning episode. *Environmental Science and Pollution Research*, 20: 2569 – 2578.
 24. **Betha, R.**, Pavagadhi, S., Sethu, S., Hande, M.P., Balasubramanian, R., 2012. Comparative in vitro cytotoxicity assessment of airborne particulate matter emitted from stationary engine fuelled with diesel and waste cooking oil-derived biodiesel. *Atmospheric Environment*, 61: 23 – 29.
 25. **Betha R.**, Balasubramanian R., 2011. Particulate emissions from stationary engine: Characterization

and risk assessment. *Atmospheric Environment*. 45, 5273 – 5281.

26. **Betha R.**, Balasubramanian R. 2011. A study of particulate emissions from a stationary engine fuelled with ultra-low sulfur diesel blended with waste cooking oil-derived biodiesel. *Journal of Air and Waste management association*, 61, 1063 – 1069.
27. **Betha R.**, Selvam, V., Donald R. Blake., Balasubramanian R. 2011. Emission Characteristics of Ultra Fine Particles and Volatile Organic Compounds in a printing Centre. *Journal of Air and Waste management association*, 61, 1093 – 1101.

Conference Proceeding Publications

1. **Betha, R.**, Sanchez, K.J., Liu, J., Lamjiri, M.A. Chen, C.L., Russell, L.M., Price, D., Cocker, D.R., Miller, W.J., 2016. Gas and Particle Emissions from a Marine Vessel Powered by Ultra Low Sulfur Diesel and Hydrotreated Vegetable Oil. 33rd Informal Symposium on Kinetics and Photochemical Processes in the Atmosphere 2016, Irvine, March 24, 2016.
2. **Betha R.**, Sanchez, K.J., Liu, J., Russell, L.M., Price, D., Cocker, D.R., Miller, W.J., 2015. A Comparative Study of Gaseous and Particulate Emissions From a Marine Vessel Fueled with Diesel and Biodiesel. 32nd Informal Symposium on Kinetics and Photochemical Processes in the Atmosphere 2015, Northridge, April 3, 2015.
3. Karthikeyan, O.P., **Betha, R.**, Rajasekar, A., Manivannan, S., and Balasubramanian, R., 2012. Microwave-Assisted Pre-Treatment of Black Shale for Removal of Carbonaceous Matter. International Conference on Environmental Science and Technology 2012 (ICEST, 2012), Houston, USA, June 25-29, 2012.
4. **Betha R.**, Dongying Ye, Balasubramanian R., 2009. A Study of Particulate Emissions From Stationary Engines Operating on Ultra Low Sulfur Diesel Blended With Biodiesel. 28th Annual conference of American Association of Aerosol Research (AAAR), Minneapolis, USA, Oct 26- 30, 2009.
5. Balasubramanian R., **Betha R.**, Ning Du., Observations of New Particle Formation in the Tropical Atmosphere of South-East Asia. 28th Annual conference of American Association of Aerosol Research (AAAR). Minneapolis, USA, Oct 26- 30, 2009.
6. **Betha R.**, Balasubramanian R., Effects of Diesel/Biodiesel Blends on Particulate Emission From Stationary Combustion Engines. Chembiotech, Singapore, Jan 28th – 29th, 2010.
(Note: This paper was adjudged to be best paper presented in the environmental category)
7. Balasubramanian R., **Betha R.**, and Selvam, V., Characteristics of Ultra-fine Particles Released from Laser Printers. A&WMA International Specialty Conference: Leapfrogging opportunities for Air Quality Improvement. May 10-14, 2010.
8. Pant, S., Sharma, A., Meesa, S., Kumar, D., **Betha, R.**, Alappat, B.J., 2007. Selection of the appropriate aggregation function for calculating air pollution index”, 22nd International conference on SOLID WASTE MANAGEMENT-2007, Philadelphia, USA.

Book Chapters

1. **Betha, R.**, Balasubramanian, R., Engling, G., 2012. Physico-chemical characteristics of particulate emissions from diesel engines fuelled with waste cooking oil derived biodiesel and ultra low sulphur diesel. In Biodiesel – Feedstocks, Production and Applications, Ed. Zhen Fang, 461 – 487. Salvka Krautzeka: Intech, 2012.

Technical Reports

1. **Betha R.,** Balasubramanian, R. Correlation study between smoke opacity and PM emissions. 2010. VICOM, Project Reference PL137
2. **Betha R.,** Balasubramanian.R. Correlation between portable PM meter and laboratory based PM measurement for diesel vehicles. 2011 VICOM, Project Reference PL137.
3. **Betha R.,** Balasubramanian, R. Fuel efficiency and emission from different fuel-mix vehicles. 2011. VICOM, Project Reference PL137.
4. **Betha R.,** Balasubramanian, R. Contribution pattern of PM emitted from overall vehicle population in Singapore. 2012. VICOM, Project Reference PL 137