Arun Duggal Centre for Clean Air (CERCA)
Indian Institute of Technology Delhi
Q2 Report 2021, (April-June)

Important Notification

We are pleased to announce that IIT Delhi has renamed Centre of Excellence for Research on Clean Air (CERCA) as Arun Duggal Centre for Clean Air in recognition of the personal commitment and contribution of Sh Arun Duggal, a former alum of IIT Delhi, towards scientific research on clean air issues and clean air technology development, at IIT Delhi.

CERCA Research Projects Updates

Project: Monitoring Air Pollution impacting Delhi NCR using a Hybrid Approach (**PI:** Prof. Sagnik Dey, CAS IITD)

Objectives: 1. Estimation of contribution of various neighboring states and trans-boundary transport to Delhi air pollution 2. Identifying the changes in open burning patterns, pollutions at large point sources (e.g., TPPs)/source clusters (e.g., brick kilns) 3. Feedback for policymakers to judge the effectiveness of the mitigation measures implemented to curb pollution due to these three major sources.

Update: In this project, the first and second objectives has been completed, i.e., Identifying the changes in open burning patterns, pollution at large point sources (Thermal Power plants (TPPs), and Brick Kilns). In this quarter, the team has examined Hyperlocal PM2.5 concentration in Delhi, a machine-learning-based model (Random Forest) was used to predict PM2.5 at a very high resolution (100-m) over Delhi for the period 2002-2019. For this, the predictor variables considered are aerosol optical depth, meteorological variables (temperature, RH, wind, planetary boundary layer height, rainfall), population density, vegetation cover, road network, etc. The model was trained by data from the Central Pollution Control Board network (70% data was used for training). At 24-hr time scale, the predicted PM2.5 shows a 10-fold cross-validation $R2 = 0.9$ and RMSE = 19.7 μg/m3 with

measurements from reference-grade monitors (remaining 30% data was used for validation). The predicted data was used to map PM2.5 level at the level of municipal ward. The most polluted wards (local hotspots) are identified and the trends in the annual PM2.5 was examined in view of the changing patterns of emission patterns locally and regionally.
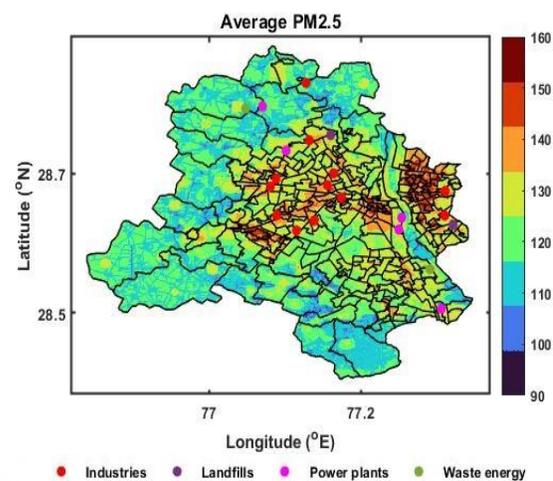
Project: Assessment and prediction of the air-quality using dynamically downscaled high-resolution data from numerical models (**PI:** Prof. Vimlesh Pant, CAS IITD)

Objectives: 1. Air-quality maps at a spatial resolution of about 1 km using numerical models and observational data. 2. Prediction of air-quality a week in advance over a desired state or region, e.g., Delhi-NCR using machine learning.

Update: The project has been completed and a detailed study report is available at the following link:

https://cerca.iitd.ac.in/uploads/Reports/1625909929FinalReport_CERCA_project_VimleshPant_Final.pdf

Project: Study to assess the compliance of the power plants in India to new SO2 emission norms and layout a phased plan for FGD implementation across the country (**PI:** Prof. Sagnik Dey and Prof. Dilip Ganguly, CAS, IITD)

Objectives: 1. Climatology and trends in atmospheric SO2 burden and emissions across India estimated using Satellite (AURA (OMI), TROPOMI) data, emission inventories (Eclipse, CMIP6 and SMOG) and reanalysis data (MERRA-2). 2. Dispersion maps of pollutants (SO2) emitted by the top 20 largest coal-based TPPs across the country generated using AERMOD simulations driven by WRF- simulated meteorological data. 3. Assessment of contribution of coal based TPPs towards the SO2 and sulphate aerosols concentrations across India by switching off emissions from various TPPs using WRF-Chem modelling framework.

Update: In this project, preliminary analysis using the OMI (Ozone Monitoring Instrument) showed some conclusive evidence that the region with the greatest number of thermal power plants with relatively higher capacity of power generation has a significant level of SO_2 concentration. SO_2 positive trend has been observed over the power plants located in Chhattisgarh and Madhya Pradesh during 2005 to 2019. Collation of ambient air concentration data and 'stack emission data' of all running thermal power plants across India from January 2000 to December 2020 to study the trends in SO_2 emissions has been undertaken. In addition, locating the nearest air quality monitoring station to study the impact of thermal power plants SO_2 emissions in its surroundings by analyzing ground level measurements is in the process.

Project: Measurement of Carbon Footprint of IIT Delhi and AIIMS (**PI:** Prof. Sagnik Dey, CAS IITD)

Objectives: This study aims to assess the carbon footprint generated by various emission sources and suggest suitable methods for reducing it. Greenhouse gas emissions for an entity in terms of tons of equivalent CO_2 generated per year is reported using three basic steps including accounting the data, calculation and estimation of CO_2 emitted. The results obtained from study will inform the highest source of CO_2 emission in the entity. Best practices for immediate and long-term reduction of present carbon footprint value can be suggested. The results obtained can be compared with the other results available in the literature.

Update: In this project, literature has been studied to understand the need, utility and methodology for greenhouse gas emission estimation, Identification of different scopes of greenhouse gas emissions and modelling them according to the requirement of the study. Formulation of form for survey for individuals and a Greenhouse Gas (GHG) calculator has been developed. The project would be done in 02 phases. In the first phase, data collection has started for AIIMS. Data collection in IIT Delhi would be started in the second phase

Project: Modelling of Reverse logistics network for consumed EVBs (**PI:** Prof. Nomesh Bolia, Dept. of Mechanical Engg. IITD)

Objective: To make a reverse supply chain model for used Electric Vehicle Batteries to help the electric vehicle industry to set firm foot in India. In the second part of this project, an attempt would be made to design and launch a mobile application that would aid the consumer and the company to undertake the exchange.

Update: The projects team is working on forecasting of used batteries returns from electric vehicles, predict the life of an electric vehicle battery in India, Geospatial mapping of expected "used battery" generation in Delhi, application development.

Project: Study of E-rickshaw Operations & Development of Charging and Parking Infrastructure for E-rickshaws (**PI:** Prof Nezamuddin, Dept. of Civil Engg. IITD)

Objective: i) Analysing the supply characteristics of the e-rickshaw network, ii) Analysing the operational characteristics of e-rickshaw service, and iii) Identifying the optimal locations for setting up physical infrastructure for e-rickshaws and designing the optimal capacity of the charging stations.

Update: The project team has developed the queueing-based facility location model to find out optimal locations for setting up e-rickshaw charging stations. They have applied the developed model on a network of e-rickshaw operational routes in Vishwavidyalaya region in Delhi using data collected from pilot study and literature. They have also designed the survey for e-rickshaw data collection and completed the e-rickshaw data collection survey in Uttam Nagar region and processed the data collected to analyze the operational characteristics of e-rickshaws. They have analyzed the supply and operational characteristics of e-rickshaw service in Uttam Nagar region. Currently, data collection in Karol Bagh area is in progress.

Project: NASA Citizen Science Project Phase II (**PI:** Dr Prakash Doraiswamy (RTI) and Dr Pawan Gupta, NASA; India Partners: Prof Sagnik Dey, CAS IITD and Dr Kartik Ganesan from CEEW)

Objective: This project aims to explore the use of low-cost sensors to measure air pollution through citizens engagement. Adequate ground-based measurements of air quality do not exist in most of the country. Satellite data are used to fill this gap, but satellites cannot provide data at night-time. To provide the required temporal coverage at a minimum cost, low-cost sensors became very popular in the last few years. However, their durability and accuracy remain a question till date. In the first phase, the purple air sensors are tested in California and North Carolina, USA. In the second phase, the sensors are being deployed in India. The broad objectives of the project are:

1. To test the Purple Air sensors in the Indian condition

2. To explore the feasibility of these sensors in expanding the ground-based measurements

3. To engage citizens in hosting these sensors and enhance awareness

4. To evaluate satellite-based PM2.5 estimates in data-scarce regions (e.g. small cities, rural areas, background area)

Before deployment, the sensors are calibrated against the CERCA BAM once in the winter season and once in summer season before deployment. The sensors are being deployed in several clusters covering urban-rural transect in the Indo-Gangetic Basin. Altogether, six clusters, one each in Punjab-Haryana, Delhi NCR, central UP, eastern UP, Bihar-Jharkhand and West Bengal, are chosen. All data will be made available to the general public through the purple air website from the day of deployment.

Update: : Sensor Deployment work is in progress and air quality data of installed sites is available at the following link: https://www.purpleair.com/map?opt=1/mAQI/a10/cC0&select=48929#10.08/28.4779/77.2103/14.2

Project: Developing Air Quality Management model for the Indo Gangetic Plains co-sponsored by World Bank (**PI:** Prof. Sagnik Dey, CAS IITD, World Bank, IIASA)

Objective: To establish an Air Quality Management modelling network among states of Indo Gangetic Plain to support cost-effective AQM in the overall IGP region. The main elements of AQM modelling for the IGP would include methods and

protocols monitoring, AQ monitoring, Emission inventory, Source apportionment, Health impacts, cost-effectiveness and AQM planning. AQMod to be hosted at CERCA IIT Delhi and would be responsible for coordinating the AQMod between the states/UT through a license agreement. A strategic Advisory Board with members from MOEFFCC, CPCB, NKN Coordinator, NITI Aayog, other ministries, experts, etc. would oversee the operations of the Modelling network. It is proposed to establish the AQMod in mid/late 2020 and in 2021, run a first annual model to provide inputs to state AQM plans and regional IGP AQM plans

Update: The team has set up the GAINS model, tuned it for running for the Indo-Gangetic Plain states (Punjab, Haryana, Delhi, UP, Bihar, Jharkhand and West Bengal). Core team is working in close collaboration with the state pollution boards and knowledge network partners. In December, a virtual meeting was held with state partners (IGP region State Pollution Control Board and NCAP Knowledge Network (NKN) partner). The objective was to discuss the strategy for data collection and updating the GAINS-IGP model. After this introduction meeting, an online 2-days training for the IGP Region State Pollution Control Boards and NCAP Knowledge Network (NKN) partners was organised. The objective of this workshop was two-fold, 1) Apprise and take feedback of State Partners on available & identified data sources for various sectors. 2) Highlight the data gaps as per model requirement and seek advice on filling these data gaps. For data storage and efficient working of Model, team set an IGP-GAINS central server at IIT Delhi.

Project: Delhi City Science and Technology Cluster (Theme: Air Pollution)
PI: Theme Lead, Prof. Sagnik Dey, and other 11 institutions
Objective: The broad objective of the project is to tackle air pollution problem in Delhi by providing technical and academic support to the pollution control boards for efficient implementation of the clean air action plan. Specific objectives are management of the pollution hotspots and exposure reduction, identification of the roadblocks in implementation of clean air action plan, identification of sustainable solutions to crop burning problem, conducting feasibility studies for interventions, health benefit study from the interventions, focused awareness programs to enhance public engagement at various levels, development of an open platform for real time air quality management decisions
Update: The project team has been working specifically on hotspot management. Air pollution information has been extracted at municipal ward level to enable implementation of local mitigation measures. A sensitization exercise was carried out for the municipal staffs to make them aware of air pollution and how their day-to-day activities can reduce emissions. Team is also planning another workshop on 'Effective Education' theme to engage teachers from colleges/universities in air pollution dialogue. CAPHER network has been launched through collaboration of AIIMS-IITD (funded by the HEI, Boston, USA) with an objective of capacity building in air pollution epidemiology. An independent tops-down approach was tested to estimate NO_2 emissions from the thermal power plants using satellite data. This would complement the traditional bottoms-up emission estimates that are not periodically updated and can be used to track compliance. The same method can be applied to large industries and brick kilns. A framework is being evolved to identify indicators so that the air quality status of the country can be evaluated in view of the various mitigation measures and government policies.

New Research Projects undertaken by CERCA

(A) DEVELOPMENT OF LOW-COST CLEAN AIR TECHNOLOGY

1. Developing low cost Indoor and Outdoor Air quality monitoring device

CERCA has undertaken a project on developing low cost indoor and outdoor air quality monitoring device. This device will be able to measure both indoor and outdoor air quality simultaneously along with other parameters such as TVOCs, CO_2, Humidity, temperature etc. This low-cost device will be able to generate a lot of awareness about indoor environment and the need for developing indoor air quality standards. The device could be extensively deployed in schools/colleges/restaurants/theatres/ residential complexes/homes/offices and hospitals. The prototype would be ready by the end of July'2021.

2. Development of a low-cost Portable Air Sampler for detection of COVID-19.

Another project undertaken by CERCA in low-cost clean air technology area is development of a Portable Air Sampler for detection of COVID-19. This project will be conducted in two phases. In the first phase, ability to collect air sample at speed desired by the user will be built. In the second phase of the project, the sampler will be fused with viral or bacterial load collector. The individual testing will constantly monitor the quality of air in workplaces, classrooms, meeting halls or any other public place. The device will collect the sample after passing air through a sample for 30 mins and after that RT-PCR will be performed for the presence of virus.

3. Measurement of CO_2 level as a proxy for pathogens in indoor microenvironment and adjusting fresh air intake depending on air quality in indoor spaces.

Growing evidence suggests that Covid-19 infection is airborne and spreads more easily in indoor spaces. Therefore, a greater attention needs to be paid to indoor air quality (IAQ). In most heating, ventilation, and air conditioning (HVAC) systems, carbon dioxide (CO_2) levels are used to control ventilation rates via demand-controlled ventilation (DCV). The primary objective of this project will be to demonstrate a functioning system for automatically controlling the ventilation rate of the HVAC system based on the measured CO_2 level in an air handling unit (AHU) of a building.

4. Testing and determining the efficacy of the Composite Air Purification system (CAPS) in multiple user scenarios and configurations"

CERCA, in collaboration with M/s Honeywell testing solutions lab Bangalore has undertaken a research project on ". The Research project envisages studying the removal efficiency of pathogens suspended in an indoor air environment using a couple of instruments supplied by M/s Honeywell. One of the instruments uses electrostatic precipitation to remove particulate matter from the air, and the other uses UV radiations to remove pathogens and sterilize the air. Controlled experiments would be carried out in an indoor environment such as an office or meeting room of volume about 250-500 ft2 containing suspended pathogens using the instruments supplied by Honeywell. Pathogen dispersal would be carried out in the room using an aerosol generator. The project would use only harmless pathogens for this study, which do not infect humans or animals and are a good proxy for Covid-19.

(B) DEVELOPMENT OF CARBON CAPTURE TECHNOLOGY

Carbon dioxide capture and utilization in metal recovery

CERCA has undertaken a project in the very important area of climate change and reduction in GHG/CO2 emissions. In this work, we propose to capture carbon dioxide using aqueous ammonia and utilize the captured carbon dioxide to extract metal from waste material. In the past, mineralization (CaCO3, MgCO3) has been proposed for the use of captured carbon dioxide. However, substantial costs ($ 8/ton) are involved with the process of mineralization using CO2. To the best of our knowledge integrated system of utilization of captured carbon dioxide for the recovery of heavy metal have not been proposed in the past. We propose to work towards identifying optimum process conditions for running an integrated CO2 capture and metal extraction process including the concentration of aqueous ammonia, carbon dioxide saturation in the ammonia solution, metal concentration in the waste metal, solution volume for per unit mass extraction of the metal. We strongly believe that a seed grant from CERCA at this stage would help us in carrying out preliminary experiments, adequate to get patents for the work and develop a strong base for seeking further grants from other organizations.

Recent Activities and Events

CERCA Monthly Expert Talk series

CERCA has started a Monthly Expert talk series for 2021-2022. From air pollution to climate change, CERCA virtual expert lecture series spotlights a range of contemporary issues while providing a platform for renowned speakers from around the world to share knowledge.

During the Quarter, CERCA hosted Prof Alan Hedge, a Certified Professional Ergonomist, and a Chartered Ergonomist (C. ErgHF) and a professor for over 40 years at Cornell University, Syracuse university and Aston University, UK. He has published 4 books, 40 book chapters, and over 250 articles. He was a founding member of the International Association of Indoor Air Quality and Health and an Honorary Research Fellow of CERCA. He discussed about the airborne transmission of particulate and biological contaminants, and especially the airborne transmission of COVID-19. He described the research basis for social distancing recommendations and ways of protecting yourself against pathogenic particle exposure.

Video Link: https://www.youtube.com/watch?v=L-nn5Ak64a8

The second speaker hosted by CERCA during the quarter was Ms Karin Shepardson, Lead Environmental Specialist from The World Bank's Environment, Natural Resources and Blue Economy Global Practice, South Asia Region, with over 30 years of experience on issues related to environmental science and development policy. Karin currently leads the World Bank's India Air Quality Management team and manages several World Bank investment projects in South Asia on solid waste management and plastics waste reduction. She delivered a talk on "Airshed Management: Converging Science and Policy at the Impact Scale".

She presented an overview of the World Bank's global work on air quality management & discussed why the World Bank places such a strong emphasis on the need for airshed management. Karin shared some of the recent findings from the World Bank South Asia Regional Air Quality Management flagship study and a 2030 vision recently discussed with SARC country Ministries of Finance during the 2021 World Bank spring meetings.

Video Link: https://www.youtube.com/watch?v=TYVE2S__AJE

CERCA celebrates World Environment Day

In collaboration with the Department of Law, Maharaja Agrasen Institute of Management Studies, and ICMRNIIRNCD, Jodhpur, CERCA jointly organized a Panel discussion, on 5th June titled "Delhi's Air Quality Control- A QUEST FOR VIABLE SOLUTIONS!". Eminent speakers from the National Green Tribunal (NGT), namely Justice Swatantra Kumar, former Chairman NGT, Justice S K Singh, MoEF&CC, CERCA IITD, ICMR-NIIRNCD, and the World Bank Group participated. The panel discussion aimed to breed analytical thoughts and knowledge on the issue of air pollution amongst the citizens and young minds of Delhi/NCR by churning practical and viable solutions to this crisis.

Video Link: https://www.youtube.com/watch?v=J4-5I8UjGRk

CERCA Monthly Newsletter

To increase public outreach, we have been reaching out to a wide section of our society through a weekly newsletter since 2018. The newsletter provides latest information on research related to health effects of air pollution, actionable information on air quality data to the Government, Industry and to the Citizens at large for appropriate policy formulation, emerging clean air technologies including new measures/innovative initiatives from across the world to combat air pollution including thought leadership. We endeavour to involve more and more people across our communities in this significant initiative, thereby enhancing public understanding and participation in promoting Clean Air initiatives at the grass-root level. CERCA is also planning to design a separate newsletter for school students.
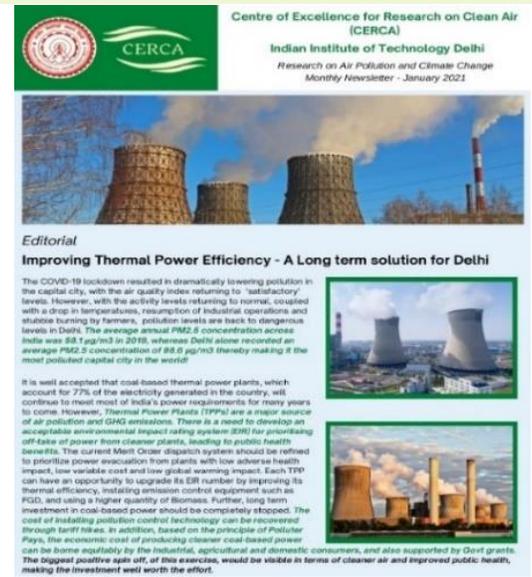
You can access newsletters on our website: https://cerca.iitd.ac.in/

CERCA opinion paper series

CERCA also brings out an Opinion paper series as part of CERCA monthly newsletter which includes expert opinion/discussion papers relevant to clean air and climate change research from faculties/research scholars. The opinions

can be on local, regional and national level air quality analysis and findings, national and international research on emerging clean air technologies and issues impacting policy discussion and formulation.

Read Here: https://cerca.iitd.ac.in/category/past

Beta Attenuation Monitoring (BAM) at IIT Delhi

An air quality measuring equipment for continuous monitoring of ambient air quality has been installed at IIT Campus. The Beta Attenuation Monitoring equipment is an essential reference grade monitor and is currently being used for calibration and co-location of various low-cost sensors prior to their deployment. World Calibration Centre for Aerosol Physics and IIT Delhi have collaborated for studying the precision of Aethalometer and a PM2.5 sensor using a UAV device in Indian condition. The test routine was one of first of its kind for measuring the concentration of black carbon and $PM_{2.5}$ in aerial mode at different heights. BAM is being used for calibration of these instruments before testing. In this quarter, the calibration of low-cost sensors (Purple Air Sensor) continued before their deployment to different states. Currently, a new project titled - Sensor-based Air Measurement Observatory for South Asia (SAMOSA), a collaborative project between various universities and NGOs along with IIT-Delhi, is working towards the development of comprehensive, real-time, and publicly accessible data of $PM_{2.5}$ in the IGP region. These sensors are being collocated against the BAM for accurate calibration. The low-cost sensors will be responsible for filling the gap in the $PM_{2.5}$ data in the rural areas and help to get a better understanding about the various sources in those regions. The data will be crucial for studying the impact of urban and rural air on each other. For this, the first set of 15 sensors have been co located with BAM as a pilot study. Another 150 sensors will be co located with the BAM by the end of this month before their deployment to various clusters in the Indo-Gangetic Plains.

CERCA is constantly collecting data from BAM, and it is also displaying Live $PM_{2.5}$ data on IIT Delhi Digital Notice Board and on the website. For live data, visit: https://home.iitd.ac.in/ or https://cerca.iitd.ac.in/

Research Publications

1.Pallavi Joshi, Santu Ghosh, Sagnik Dey, Kuldeep Dixit, Rohit Kumar Choudhary, Harshal Ramesh Salve, Kalpana Balakrishnan, Impact of acute exposure to ambient PM2.5 on non-trauma all-cause mortality in the megacity Delhi, Atmospheric Environment, 259, 118548, 2021

Link: https://www.sciencedirect.com/science/article/abs/pii/S1352231021003708

2. Prachi Singh, Sagnik Dey, Crop burning and forest fires: Long-term effect on adolescent height in India, Resource and Energy Economics , 65, 101244, 2021

Link: https://www.sciencedirect.com/science/article/abs/pii/S0928765521000294

3. Gautam Shaw, Sagnik Dey, Hemant Kaushal and Kanaiya Lal, Tracking NO2 emission from thermal power plants in North India using TROPIMI data, Atmospheric Environment, 259, 118514, 2021

Link: https://www.sciencedirect.com/science/article/abs/pii/S1352231021003356?via%3Dihub

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