



Arun Duggal Centre of Excellence for Research in Climate Change and Air Pollution

(Academic Think Tank and Research Centre at IIT Delhi)

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MESSAGE FROM OUR FOUNDER

Happy New Year 2023!

We are extremely happy to share with you our Annual Report for Calendar year 2022



First the good news: Air Quality levels in Delhi NCR are improving and Stubble burning in Punjab and Haryana is declining. However, much more needs to be done. Air pollution is a national health emergency, but it is also closely linked to our existential challenge of climate change. Almost all major sources of air pollution such as emissions from thermal power plants, petrol, and diesel in automobiles, industries such as chemicals, steel, and cement, agricultural waste burning, etc, also result in GHG emissions. Thus, our efforts to reduce air pollution will also have the cobenefit of reduction of GHG emissions and climate change. I am a Banker at heart and always think about how these great ideas can be financed. In the recent McKinsey report, it is estimated that to reach our Net Zero goal by 2070, \$ 7.2 Trillion in investments will be needed. In addition to funding by Central and State governments, a significant portion of these investments must come from the corporate sector, financial Institutions, and Capital Markets. In my view, air pollution and climate change are a result of major market failure - i.e., not factoring in an Externality i.e., the societal cost of emissions. Therefore, the solution also lies in harnessing market forces to direct capital to various projects to meet our net Zero goal. To raise a part of the investment requirements, I recommend the creation of a “Clean Investment Program” for corporates and financial institutions, and Capital Markets. Under this program, clean investments will be made in solar energy, hydrogen and electrolytes, coal gasification, batteries, EVs, transportation, emission reduction in Steel, cement, and other Industrial sectors, and in carbon capture including afforestation. How will the “Clean Investment Program” be funded? I propose this be funded by the corporate sector based on three criteria: First - size, in terms of net profits of the corporation on the principle of “Corporate obligation to sustainability”; Second, on the basis of the emission quantum and carbon footprint of the company i.e., scope 1 & 2 GHG emissions and third on the principle of “Polluter Pays”. Therefore, companies like TCS on the basis of their profits, and Tata Steel based on their carbon footprint should be obligated to make these investments. Companies can make these investments directly as projects, such as Solar electricity or Hydrogen production within the company, or through one or more specialized “Venture Capital Clean Investment Funds” which will evaluate each technology from financial viability and emission reduction potential. I expect that in the coming years, this Clean Investment Program will result in new ventures and industries which will have great job creation and economic growth potential. In addition, all banks should be mandated to have at least 10% of their loan portfolio in Clean Investment projects as a priority sector. The program will require Government support in terms of design, Tax Breaks similar to R&D investments, and priority sector lending for Banks. I do believe that by the creation of the “Clean Investment Program”, we will kill three birds with one stone: Improve Air Quality, Reduce GHG emissions and achieve higher economic growth.

CERCA has made remarkable progress over the past four years since its formation in 2018 to evolve as one of the country's important think tanks in the area of air pollution and climate change. To build on this foundation and take it to a new level, CERCA has taken important steps over the years aimed at raising the visibility of its research work and activities. One of the key initiatives of CERCA, the Monthly Expert Talk Series, by eminent speakers from national and international levels is helping to disseminate information on air pollution and climate change to citizens which is indeed a great step in this direction. Additionally, CERCA Monthly Newsletter is also playing a pivotal role in the enhancement of public awareness on air pollution and climate change issues to a wider audience.

CERCA has been making consistent efforts in bringing the academia and industry together to promote high-quality scientific research. CERCA's collaboration with the World Bank, UNEP, and PSA office including MoUs with various State PCBs are indeed serving as a powerful new driver for promoting more scientific research and analysis in these areas. Success requires that we consistently work to achieve our goals in such a way that it has a direct positive impact on the lives of people. I am sure that CERCA will continue to combine the best practices from the entire eco-system by acting as action centre working for clean air and climate change in Delhi, India and beyond.

I wish CERCA the very best in its future endeavors!



Arun Duggal

Founder

Arun Duggal Centre of Excellence for Research in Climate change and Air Pollution

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 Research in Climate Change and Air Pollution in recognition of the personal commitment and contribution of Shri Arun Duggal, a former alum of IIT Delhi, towards scientific research on clean air issues and clean air technology development, at IIT Delhi.

CLIMATE CHANGE AND ACTION

We are glad to announce that CERCA has expanded its scope of activities to undertake research projects on Climate change and more specifically:

- To undertake research projects on impacts of climate change including identification of mitigation options that reduce the risk of longer-term climate change including promotion of international research and collaboration.
- Build capacity for climate assessment through training, education, and workforce development.

Our broad objective is to promote scientific research for developing strategies to understand root causes and implications of anthropogenic climate change and to build resilience to severe climate change impacts on the society through appropriate policy changes.

1. ONGOING RESEARCH PROJECTS

1.1 Monitoring Air Pollution impacting Delhi NCR using a Hybrid Approach

(Investigator – Prof. Sagnik Dey, Centre for Atmospheric Science, Coordinator, CERCA, IITD)

Project Summary:

Three largest continuous sources of air pollution in Delhi NCR are coal-fed thermal power plants (TPPs), brick kilns, and vehicles. In addition, open biomass burning during Oct-Nov (stubble burning) and waste burning throughout the year also contribute to the air pollution in Delhi NCR. In this project, a framework will be developed to understand the trends in air pollution (fine particulate, PM_{2.5} and gaseous precursors) and its linkage to three major sources – TPP, brick kiln, and open biomass burning using a hybrid approach (integrating in-situ, satellite, and chemical transport model (CTM) data) to examine whether the policies to curb emission from these sources are effectively implemented or not.

Deliverables:

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

1.2 Testing and determining the efficacy of the Composite Air Purification System (CAPS) in multiple user scenarios and configurations

(Investigator – Prof. Vikram Singh, Dept. of Chemical Engg. IITD)

Project Summary:

CERCA, in collaboration with M/s Honeywell testing solutions lab Bangalore has undertaken a research project to test and determine the efficacy of a Composite Air Purification System (CAPS) in multiple user scenarios and configurations. 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 radiation 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. Freely suspended pathogens in the air are of sizes in the range of a few nanometers to a few microns. Natural removal of particulate matter of this size takes place by adsorption or deposition on surfaces. A forced way of removing the particulate matter or clean air is to use a HEPA filter or electrostatic precipitation-based instruments. In addition to the conventional instruments used to remove particulate matter, air-containing pathogens can also be sterilized using UV radiation. In this work, we are studying the removal efficiency of pathogens suspended in an indoor air environment using a couple of instruments supplied by Honeywell. One of the instruments uses electrostatic precipitation (F57A) to

remove particulate matter from the air, and the other uses UV radiations (U-Prism) to remove pathogens and sterilize the air.

Deliverables:

- The PM2.5 removal efficiency of the indoor air cleaning instrument.
- The relative pathogen removal efficiency of the F57A and U-Prism instruments.
- The absolute pathogen removal efficiency of U-Prism instrument in the absence of F57A.

1.3 Development of Carbon Capture Technology using CO₂ capture and utilization in metal recovery

(Investigator – Prof. Vikram Singh, Dept. of Chemical Engg. IITD)

Project Summary:

This project aims to develop a disruptive technology to recycle heavy metals from waste using carbon dioxide captured from flue gas. There are many chemical-based technologies available for the recycling of waste metals that are hazardous to the environment. This work proposes a technology that uses captured carbon dioxide from the flue gas mixture to leach the metals out of the waste. Using the solvent extraction process, the leached metal is further purified. The proposed work has the following objectives:

- Capture carbon dioxide from a mixture of nitrogen and carbon dioxide (~15%, representative of flue gas) using an aqueous ammonia solution (15-20%). A packed bed scrubber (or a helical coil) will be used for capturing the carbon dioxide.
- Utilizing the captured carbon dioxide solution of ammonia-ammonium carbonate to leach metal like Nickel, Cobalt, Copper, and Zinc out of metal waste like e-waste, industrial waste, mine waste, etc. Optimum process parameters involving aqueous media concentration, temperature, and the efficiency of metal recovery will be identified for the proposed task.
- Transfer the approach of the above-developed technology to recycle the cathode material of lithium-ion batteries containing metals like Ni, Co, and Cu, keeping the aqueous media still an ammonium-ammonium carbonate solution.

Deliverables:

- The technology proposed here if successful and deployed would aim to utilize an O (1) million tons of carbon dioxide per year, possibly in an environmental manner without any explicit policy to reduce greenhouse gas emissions.

1.4 Measurement of CO₂ level as a proxy to viral load in indoor environments

(Investigator – Prof. Seshan Srirangarajan, Department of Electrical Engineering, Jay Dhariwal, Department of Design, IITD)

Project Summary:

With people spending a large part of their lives in indoor spaces, whether it is in offices, classrooms, or homes, there is an urgent need to improve air quality in indoor environments. This issue has attracted a lot of attention in the last decade or so, and now with growing evidence that Covid-19 infection is airborne and spreads more easily in indoor spaces, greater attention needs to be paid to indoor air quality (IAQ). In most heating, ventilation, and air conditioning (HVAC) systems, carbon dioxide

(CO₂) levels are used to control ventilation rates via demand-controlled ventilation (DCV). This is traditionally for addressing issues related to odor and occupant-generated bio effluents, and providing acceptable indoor air quality for most occupants. The CO₂ level could act as a good proxy for the airborne transmission risk of Covid-19 in indoor spaces. The viral load measurement would further aid in understanding the airborne transmission pathway.

Deliverables:

- To understand how the Covid-19 infection spreads in indoor space by analyzing the workflow of how an air sampler collects air from a space having infected individuals to RT-PCR testing for finding the viral load.
- To understand the effect of ventilation (CO₂ level), air temperature, humidity, masks, and space type on the spread of Covid-19.

1.5 Project on Indoor air pollution survey in different indoor spaces at IIT Delhi

(Investigator – Prof. Sagnik Dey, Centre for Atmospheric Science, Coordinator, CERCA, IITD)

Project Summary:

Air pollution is responsible for many health problems in urban areas. The air pollution status in Delhi has undergone many changes in terms of the levels of pollutants and the control measures taken to reduce them; IIT-D is situated at the heart of National Capital Territory (NCT), and keeping in mind about the Particulate Matter (PM) values in this region; it is necessary to get the detailed PM values and diurnal pattern of PM₁₀ and PM_{2.5} in different microenvironments of IIT-D. The objective of this work is to measure the Ambient Air Quality (AQI) using low-cost sensors in the different microenvironment of IIT-D. Small set of measurements in this project provides an evidence-based insight into the status of air pollution inside IIT-D. In this research we are using the low-cost indoor and outdoor units from an Indian based startup AirVeda.

We have planned to deploy the indoor units at 8 different locations inside IIT-D and the outdoor unit at one fixed location which is close to reference grade monitoring instrument.

Deliverables:

- Study the impact of indoor air quality on human health.
- Study the difference in indoor air quality with respect to outdoor air.

1.6 Study on the contribution of DG (Diesel Generators) set emissions to ambient PM_{2.5} and associated Health Burden in India and develop policy advice to GoI for creating a national policy to reduce DG emissions

(Investigator – Prof. Sagnik Dey, Centre for Atmospheric Science, IITD & Chakr Innovations)

Project Summary:

Diesel generators are one of the most used power backup systems and contribute increasingly to pollution levels. As per a report of the National clean air programme, DG Sets, overall, contribute to 7-18% to the ambient air pollution in non-attainment cities in India. Non-attainment cities are polluted cities which have violated the National Ambient Air Quality Standards. There are 102 such non-attainment cities in India. Studies also show that as DG Sets starts ageing, they might emit 11 times the standards set for the manufacturers. While the automobile sector in India is gradually transitioning towards electric vehicles, the heavy-duty commercial vehicle segment continues to be largely dominated

by diesel vehicles. The PM_{2.5} contribution from vehicle exhaust to ambient air is estimated to be around ~17% and freight movement via heavy duty and light duty trucks are the largest contributors to it. However, it is noteworthy to mention that the emission inventory i.e., accounting of the amount of pollutants like carbon dioxide (CO₂), carbon monoxide (CO), nitrogen oxides (NO_x) or particulate matter (PM) etc. used to calculate the contribution of Diesel engines towards air pollution does not account for market development in the last decade. Hence, there is a need for an impact study to highlight the actual contribution of diesel emissions to the problem of air pollution and help policy makers in deciding right emission reduction options.

The objectives of the project will comprise of the following:

- Mapping the population of diesel engines (diesel generators and heavy commercial vehicles) and estimated addition over the coming years to quantify their contribution to ambient particulate pollution across various geographies.
- Analysis of health and economic burden of air pollution caused by diesel engines to inform policy makers of the financial gains associated with the requisite regulatory framework.
- Analysing the success and status quo of already notified emission control policies by State Pollution Control Boards and various other governing bodies/committees in India. This will help in identifying any technical/ financing/ policy gaps and catalyse the formulation of effective national level policy framework.
- Measuring the potential of climate change mitigation and adaptation by quantifying the impact of reduction in soot emissions from diesel engines due to adoption of emission control retrofit technologies.
- Analysing the impact on ambient air quality of regions where the diesel generator (DG set) retrofit policy has been implemented. This will highlight the absolute impact of a retrofit technology towards climate change mitigation and adaptation.

Deliverables:

- Policy recommendations to the Government of India on DG set emissions and their associated health burden

2. IRD STUDENT START-UP PROJECTS

2.1 Study of E-rickshaw Operations & Development of Charging and Parking Infrastructure for E-rickshaws

(Faculty supervisor - Prof. Nezamuddin, Dept. of Civil Engg. IITD)

Project Summary:

The main idea is to develop a network of charging and parking infrastructure for e-rickshaws so that they can continue with their trips without being stopped by the drained battery issues. E-rickshaw drivers face a problem as they charge their vehicles at home or from shops by paying high tariffs. Due to such hindrances, they are forced to make much fewer trips as taking the vehicle back home for charging is not always feasible in terms of distance and time spent in charging. Due to the unavailability of parking spaces, e-rickshaws pick up passengers from locations that are not suitable. This causes uncontrolled congestion and a lack of passenger safety, so designing an optimal parking location infrastructure will people board and deboard vehicles at some designated places leading to increased safety and decreased congestion on roads. The study will also incorporate owner profile analysis. There have been many studies focusing on the socio-demographic profile of e-rickshaw drivers but there is practically no charging infrastructural requirement and e-rickshaw owner profile-related studies till now. Another important focus of the service will be on developing an algorithm to determine optimally located charging stations and parking stations and to minimize the queue of the e-rickshaws waiting to get charged. So, the scope of this study will cover the areas of supporting infrastructure and owner profiles of e-rickshaws, and the main objectives are i) Analysing e-rickshaw owner profiles ii) Understanding and analysing e-rickshaw operations in Delhi iii) Developing the map of routes for e-rickshaws iv) Identifying and analyzing charging infrastructural requirements for e-rickshaws.

Deliverables:

- To develop a network of charging and parking infrastructure for e-rickshaws,
- To determine optimally located charging stations and parking stations and to minimize the queue of the e-rickshaws.

3. POLICY-DRIVEN RESEARCH PROJECTS

3.1 NASA Citizen Science Project Phase II

(Collaborators: Dr. Prakash Doraiswamy (RTI), Dr. Pawan Gupta (NASA), Prof Sagnik Dey (IITD), and Dr. Kartik Ganesan (CEEW))

Project Summary:

This project aims to explore the use of low-cost sensors to measure air pollution through citizen engagement. Adequate ground-based measurements of air quality do not exist in most of the country. In the first phase, the purple air sensors are tested in California and North Carolina, USA. In the second phase, the sensors are 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 PM_{2.5} estimates in data-scarce regions (e.g. small cities, rural areas, background areas)

Before deployment, the sensors are calibrated against the CERCA BAM once in the winter season. Another round of calibration will be carried out in the summer season before deployment. The sensors will be deployed in several clusters covering the 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. In the first phase, the sensors will be deployed in Delhi NCR. All data will be made available to the public through the purple air website from the day of deployment.

Deliverables:

- Display of sensor air quality data of installed sites at:
<https://www.purpleair.com/map?opt=1/mAQI/a10/cC0&select=48929#10.08/28.4779/77.2103/14.2>

3.2 Developing Air Quality Management model for the Indo-Gangetic Plains

(Co-sponsored by World Bank, Collaborators: Prof. Sagnik Dey, Centre for Atmospheric Sciences, CERCA IITD, World Bank, IIASA)

Project Summary:

High particulate matter (PM_{2.5}) concentration over the Indo-Gangetic Plain (IGP), making it the worst air pollution-affected region in India, and perhaps in the world. The annual PM_{2.5} level over this region is above 80 µg m⁻³, which is twice the Indian national ambient air quality standard (NAAQs) of 40 µg m⁻³. The primary objective of the project is to initiate an AQMmod network for the IGP region in India and advice on cost-effective AQM planning in India. The model will be customized for the local conditions in the IGP which will help the State government of the IGP region and the Government of India (GoI) to reach the air pollution level target set under the National Clean Air Program (NCAP) that is to mitigate air pollution using a systematic approach with a target of reducing PM_{2.5} level by 30% in 2024 compared to the level in 2017.

Deliverables:

- Ensuring that all needed local data are provided and that India-specific source characterization by sectors is developed and applied to enable the set-up of an “IGP edition” of the GAINS expert model for AQM planning. The objective is also to ensure that India masters the GAINS

administration tool which will enable India to sustain the AQM model capacity over the next 10 years or more.

- Providing capacity building and technical knowledge to particularly the state PCBs and NCAP Knowledge Network (NKN) partners and relevant partners at the federal level (e.g., part of the SAB) to ensure good application of the IGP AQM model and gradually a national AQM model.

3.3 Delhi Research implementation and innovation (DRIIV) project funded by PSA Government of India

(Theme- Air Pollution, Coordinator - Sagnik Dey, CERCA coordinator, IITD along with other 11 institutions)

Project Summary:

This project is conceptualized with multi-institutional expertise to identify the technological, economic, societal, and legal hurdles in implementing a clean air action plan in Delhi, conducting feasibility studies for sustainable and effective interventions, and developing an integrated and open data analytical tool to aid policymakers (relevant Ministry and the pollution control boards) in informed decision making. This project is expected to help Delhi attain first the National Clean Air Program target of 20-30% reduction in PM levels in the next few years and lay the foundation for bigger and more aggressive interventions in the next phase that would eventually take Delhi closer to the NAAQS by 2030. The broad objective of the project is to tackle the 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 as follows.

- a. Management of the pollution hotspots and exposure reduction
- b. Identification of the roadblocks in the implementation of the clean air action plan
- c. Identification of sustainable solutions to crop burning problem
- d. Conducting feasibility studies for interventions
- e. Health benefit study from the interventions
- f. Focused awareness programs to enhance public engagement at various levels
- g. Development of an open platform for real-time air quality management decisions

Deliverables:

This project is aimed at helping CPCB and DPCC in implementing the clean air action plan and more particularly preparing them in dealing with the peak pollution period in Delhi during the winter by identifying the major technical and legal hurdles, enhancing public engagement through more focused awareness campaigns and behavioral interventions, assessing techno-economic feasibilities of various interventions targeting at key pollution sources, managing the local pollution hotspots, and developing a model to demonstrate health benefits from these interventions to foster public support to the implementation plan of the Government. The project expects to accelerate actions that will help improve the air quality in Delhi. Also, this initial work will lay down the framework for bigger and more aggressive interventions so that Delhi eventually meets the national ambient air quality standard in near future.

3.4 Sensor-based Air Measurement Observatory for South Asia (SAMOSA)

(Investigator – Prof. Sagnik Dey, Centre for Atmospheric Science, Coordinator, CERCA, IITD)

Project Summary:

This is 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 PM2.5 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 PM2.5 data in rural areas and help to get a better understanding of 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 has 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.

Deliverables:

- To characterize rural vs. urban air pollution gradients.
- Observations in rural settings and smaller cities and towns will provide valuable new information about the sources, dynamics, and consequences of PM2.5 across this region.

3.5 Project on Crop residue management in Kapurthala in Punjab along with ITC

(Collaborators: CERCA & ITC Limited,)

Project Summary:

Punjab, Haryana, Uttarakhand, and Western Uttar Pradesh constitute the majority of India's rice-wheat cropping system which is spread over an area of 10 million hectares yielding ~50 million tons of paddy residue, with Punjab alone accounting for 20 million tons of stubble burning across the region. Paddy stubble burning is used as a quick and labor-saving field preparation measure for sowing wheat in the Rabi season. Stubble burning releases smoke and fine particulates into the environment, thereby, adversely impacting regional air quality. The Central and State government in their efforts to discourage farmers from stubble burning have been implementing several measures such as incentivizing farmers to adopt burning alternatives, including in & ex-situ stubble applications, encouraging the use of appropriate harvesting and sowing machinery and imposition of fines and bans. However, these measures have not been fully effective in yielding the desired results due to the apprehension of the farmers on the economics and practicability of these measures, vis-à-vis the obvious convenience and much lower cost of burning crop residue. CERCA is helping ITC Ltd to develop a GIS mapping tool for accurate digital tracking of stubble management practices. The objective is to develop a GIS tool that is a geography-neutral option to track and monitor stubble burning for the benefit of the larger society. The proposed area of collaboration would be in ITC-supported project villages in Kapurthala.

Deliverables:

- Based on GPS tracking data, create composite signatures for both burning and non-burning areas.
- Based on extrapolation of the signatures, mapping of the entirely burnt and unburnt area including Ground truthing of total data
- Based on ground truthing, decide on the veracity of the map and plan accordingly
- Documentation of the impact of practices in the field and correlation through mapping
- Share the results with States and Central Government

3.6 Air Quality Progress Report for India

(Collaborators: UNEP, CERCA & TERI)

Project Summary:

CERCA has partnered with United Nations Environment Program (UNEP) and The Energy and Resources Institute (TERI) to develop Air Quality Progress Report for India on an annual basis. The report would provide an overview and analysis of the status and trends of air pollutant emissions and air quality concentrations in India by producing a comprehensive presentation of the status of air quality in India and its impacts as well as the control actions/strategies implemented for air pollution reduction. The Assessment will serve as a platform for analyzing and synthesizing the most up- to-date and policy-relevant information for decision-making concerning improving air quality, and energizing existing efforts, and building upon established governmental processes including Central Pollution Control Board (CPCB) activities. Based on the assessment and interpretation of the indicators, suggestions and recommendations would be given for short-term, mid-term and long-term that can be undertaken in each of the following areas to improve the overall AQM work across the country.

Deliverables:

- A Comprehensive Report on Air Quality Progress for India will be launched this year by UNEP

3.7 Air Quality Action Forum (AQAF)

(An Initiative of the United Nations Environment Programme, funded by Paytm Foundation with CERCA as the Implementing Partner)

Project Summary:

The Air Quality Action Forum (AQAF) is founded on bringing all relevant stakeholders, i.e., national, and international philanthropic organizations, international development agencies, expert institutions, the corporate sector, and the UN system of organizations on a common platform to support the Government of India in creating actionable work in synergy to improve air quality. UNEP would like to work collaboratively with the Ministry of Environment, Forest, and Climate Change (MoEF&CC) and/or the Central Pollution Control Board (CPCB) in leading the activities of the Forum. This is highly relevant to the fulfillment of the objectives of the Forum and would give legitimacy to the Forum. Furthermore, besides being aligned with the vision of the MoEF&CC, the Forum will also help the Government have a more holistic overview of various projects and programmes being undertaken by various stakeholders at the national and sub-national level. Additionally, this Forum will also foster the alignment of work that's being undertaken by different line ministries and government institutions under the National Clean Air Programme (NCAP), in a way that would enhance inter-governmental effort and coordination.

AQAF is a unique initiative since it is going to be a national-level forum that brings in various stakeholders working in the sphere of air quality management, on one single platform. As part of the forum different stakeholders under six pillars of the corporate sector, expert institutions (including NGOs, CSOs, and Academia), international development agencies, international philanthropic organizations, national philanthropic organizations, and the UN system of organizations— are to be

brought together on a common platform to support efforts of the Government of India (GoI) in improving air quality and its management. Additionally, as part of AQAF, wider stakeholder engagement will be facilitated by UNEP to undertake better coordination with the MoEFCC in achieving the broader national goals set forth under NCAP.

The objectives of the AQAF are the following:

- Achieve full coordination of national and international support in support of air pollution mitigation efforts in India, especially to NCAP
- Catalyze support of NCAP by bringing national/ international knowledge and experience in direct support of NCAP through the establishment of the forum and leveraging the expertise of forum members
- Maintain a comprehensive and accessible database of existing and planned international air quality programs and projects in India with details on their objectives, timelines, and budgets.
- Establish an air pollution ‘Solutions Centre’ to provide direct support to Indian policy and decision-makers through an “Assistance Service” that is demand-driven, addressing ad-hoc requests from the Government for immediate support.
- Monitor support in a structured and regular manner
- Aligning the AQAF with the annual Air Quality Progress Report (AQPR)¹ to strengthen the assessment & improve the report’s outreach.

Deliverables:

Solutions Centre as part of the AQAF: Establishment and operationalization of a Solutions Centre will be done through a Forum Convention. The Solutions Centre has been conceptualized to provide demand-driven expert assistance and direct support to the Indian policy and decision-makers in the government on specific air quality issues through an “Assistance Service” that is addressing ad-hoc requests from the Government for immediate support.

4. EVENTS

4.1 First Stakeholder Consultations under Air Quality Action Forum

As part of the first phase of AQAF, we have organized consultations with the stakeholders for all six pillars of AQAF. Separate meetings were held in hybrid mode with Indian Expert Institutions (non-Government), Indian Expert Institutions (Government), International Philanthropic Organizations and NGOs, Corporate and National Philanthropic Organizations, UN Agencies and development partners, and International Development Agencies and Embassies on the 7th, 9th, 13th, 15th, 16th, and 17th June 2022, respectively. These consultations were organized to conduct a need assessment which included aspects related to the work that each participating organization is undertaking, the challenges that they are facing, other issues that are of priority to them, and what can be the possible areas/ approaches to moving ahead with the air quality management (AQM) work. Some broader aspects like implementation challenges, capacity gaps of the stakeholders at various levels, interdepartmental and inter-organizational collaborations, wider knowledge and awareness generation, funding constraints, and limited in-roads with the local government departments and agencies emerged as some of the larger issues across most consultations.



Besides the core consultations under the 6 pillars of the AQAF, a separate consultation was also organized for all the pollution control boards (PCBs) on June 24th, 2022, through hybrid mode. This consultation aimed to better understand the viewpoint on various air pollution-related issues, ongoing activities, and initiatives, and the challenges encountered by the PCBs. It was evident that because of

differential resources, manpower, and infrastructure across all PCBs, there is marked variation in the output of each of the PCBs. Most importantly, however, the representatives from each PCB did request



UNEP for support in capacity building of its regulatory and other support staff working on the air pollution. All the feedback and suggestions from these important stakeholder meetings are being compiled into a detailed and comprehensive need assessment report for understanding the challenges, gaps, needs, and synergistic solutions to further the work of AQM under the AQAF. This report will be brought out at the Forum Convention, which is tentatively scheduled to take place in the first quarter of this year.

4.2 Air Quality Action Forum's First Quarterly Meeting

On July 18th, 2022, we have organized the very first AQAF Quarterly Meeting to discuss the action-oriented solutions for addressing the gaps in air quality management within four core domains of science, policy, technology, and capacity building and co-creation of a repository of solutions and prioritization criteria to create an actionable work plan for AQAF to improve air quality in India. Four parallel sessions were held, with each having participants who discussed action-oriented solutions for addressing the gaps in air quality management under each of the four domains. Some other relevant topics that were discussed during the 4/7 Quarter Meeting were the co-creation of a repository of solutions, criteria to create an actionable work plan for the coming months of AQAF, and discussions on the framework of the Solutions Centre which is to be established under the AQAF to



provide focused, time-bound and actionable solutions for supporting the government. The First Quarterly Meeting also saw overwhelming participation from over 80+ organizations that came together to make



this event a documentable success. All the valuable suggestions & inputs gathered from all four groups have been recorded in detail and are being synthesized in the form of a comprehensive report.

4.3 India-Sweden workshop on Addressing Air Quality Challenges in Delhi National Capital

Territory

We hosted a joint Air Quality workshop on 22nd September 2022 along with Team Sweden (Embassy of Sweden and the Swedish Trade and Invest Council - Business Sweden), Swedish agencies & solution providers to discuss the current air quality situation in the NCT and identify possible areas of joint intervention. The main objective of this workshop was to discuss various aspects of poor air quality in the NCT, showcase Swedish best practices in air quality management, discuss possible technology



interventions (monitor, protect, and prevent air pollution), and identify possible areas of collaboration. The roundtable discussion was followed by knowledge exchange, joint studies, awareness campaigns, setting up of pilot/commercial projects, and identification of best practices to mitigate issues related to air quality in the NCT. Under the Sustainability Showroom in India, Team Sweden has established a Clean Air by Sweden (CAIR) Ecosystem and signed an MoU with IIT Delhi to promote collaborations between both countries.



4.3 Sustainable Air Quality Workshop on "Towards Enhancing Understanding of the Educators on Air Pollution and Mitigation Measures"



being conducted by DEEP-C (Delhi Effective Education Pedagogy Cluster), the Effective Education vertical of DRIIV. "Sustainable Air Quality" Workshop is the second workshop in this series for teachers of 7-12 grade students to gain a better understanding of air quality and related issues. Educators teaching grades 7-12 were invited to participate in the workshop, to have hands-on activities to provide insight into air quality and group discussions on air pollution's health effects. Also, interactive sessions were conducted to build lesson plans to contribute to and enhance educators' classroom preparation. It was planned to include

As a part of project SAMEER (Solutions for Air-pollution Mitigation through Engagement, Engineering, and Research), an initiative led by DRIIV, Delhi Research Implementation, and Innovation (an initiative of the Principal Scientific Adviser to the Government of India), we have organized a two days' workshop on 7th & 8th November 2022 at IITD. The workshop is



gamification and other innovative pedagogical tools for the effective integration of sustainability education into the mainstream curriculum. A key motivation for this initiative is to connect educators



with air quality experts, technology partners, regulators, and scientists. Consequently, they will benefit by establishing a network of their own for information and awareness about air quality to build inclusive resources accessible to all developing creative lesson plans for the curriculum mapped to topics to meet teaching requirements Gaining skills in gamification and carbon footprint calculators to cater to different learning styles and learning needs Learning about sustainable solutions to control air pollution & assessing the implementation strategies towards reduction in air pollution.



4.4 Industry Roundtable on Environmental Challenges and Technology Adoption

We conducted the Industry Roundtable on Environmental Challenges and Technology Adoption under the project SAMEER along with DRIIV on 22nd November 2022. At the outset, Prof. Sagnik Dey presented his views on air quality components and source apportionment (PM_{2.5}, PM₁₀). Participating Indian startups (Airveda, Airth, Swachh.io, Cleanos LLC, Umeandus Technologies, OmniIon) presented their technologies for better air quality management. A panel discussion on Air Pollution Mitigation Initiatives & Technology Adoption: an industrial perspective was moderated by Mr. Vijay Rai, Chairman of CII, India. The event saw participation from different industry partners that came together to make this event a documentable success.



4.5 Industry Day 2022

CERCA participated in the IIT Delhi's flagship industry-academia partnership event, Industry Day 2022 was held on December 10, 2022. The fourth edition of the daylong event allowed the industry to witness how IIT Delhi is working to develop technologies that will benefit both the industry and society. Top leadership from over 15 large corporate and business houses was present at the event.

Mr. K. Ananth Krishnan, Executive Vice-President & Chief Technology Officer, Tata Consultancy Services, who is also an IIT Delhi alum, was the chief guest on the occasion. Industry Day 2022 was centered on four themes that are woven into India's commitment to achieving its Sustainable



Development Goals. The thematic sessions on Healthcare, Electric Vehicles, Communication Technologies, and Clean Energy & Environment were attended by industry leaders, scientists, IIT Delhi faculty, research scholars, and students who deliberated on fundamental concepts and new perspectives that will have an impact on civil society as a whole.

The annual event displayed the best of IIT Delhi's collaborative and interdisciplinary sharing through the breadth of the research presented. Over 70 cutting-edge technologies developed by IIT Delhi researchers were showcased as product demonstrations at Industry Day. The event also had over 150 industry-relevant concept posters created by the students of IIT Delhi.

We participated in the IITD Industry Day as a **platinum partner** and showcased air purification technologies developed by our supported startups (Swachh io and Airth) which received an overwhelming response from the dignitaries and visitors. Also, our founder Mr. Arun Duggal presented his views as a panellist in the session on Sustainable Energy, Environment & Climate Changes.



Details of Startups:

Swachh io: This start-up has been founded by Karan Rao, an electrical and computer Engineering graduate from Carnegie Mellon and specializes in several air pollution-related products. They have developed Indoor Filters, Outdoor Smog capture and Recycle Tech

Airth: This start-up's mission is to deliver the cleanest and healthiest air to homes, businesses, frontline warriors and protect them from the dangers of unseen viruses. Their Anti-Microbial Air Purification Technologies deactivate the viruses in real time and tackle the deteriorating air quality with the first-of-its-kind technology developed at IIT Bombay IIT Kanpur and the Indian Institute of Science.

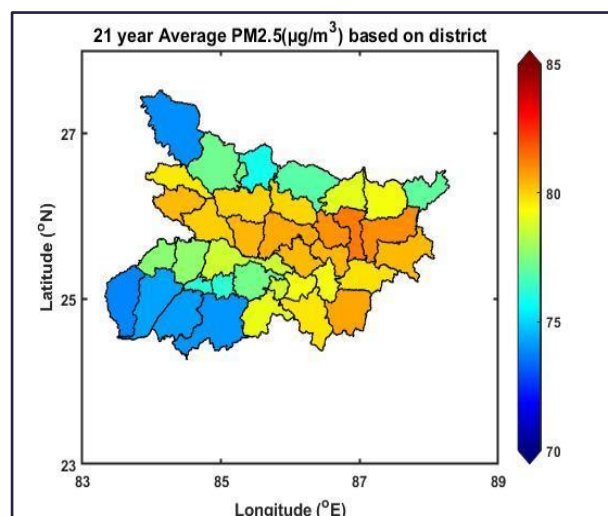


5. RESEARCH ACTIVITIES (Government-Academia-Industry Partnership)

5.1 Collaboration with State Pollution Control Boards

CERCA has collaborated with West Bengal, Madhya Pradesh, Punjab, and Bihar to assist in Capacity building/Training on AQ management, Hotspot analysis, air quality forecasting, Developing guidelines for strengthening air quality monitoring network through a hybrid approach of optimum blending of manual, continuous, sensor & satellite-based monitoring, Periodic source apportionment studies, emission inventory and carrying capacity developing traffic and transport management plan, road carrying capacity studies, E-mobility and net zero emission transport sector plans for states. We will also develop plans for reducing emissions from DG sets, construction dust, road dust, industrial pollution; Biomass, and garbage burning; Evolving SOPs for disposal of collected dust from mechanical sweeping, construction & demolition, Health and Economic impact studies on sets of the population from different pollution sources. A separate emergency action plan for each non-attainment city in line with GRAP for Delhi for addressing the severe and emergency AQIs will be framed.

The Team has completed the study taken in collaboration with Bihar State Pollution Board. They have examined the spatial pattern and trends in columnar aerosol optical depth (AOD), PM_{2.5} and open biomass burning patterns for the period 2001-2019 over the eastern state of Bihar and its 38 administrative districts and discussed the implications for air quality affected by transboundary transport and local emissions. Annual PM_{2.5} exceeds the national ambient air quality standard over the entire state,



suggesting the regional nature of the pollution. PM_{2.5} was found to increase steadily from 2000 till 2016, before stabilizing and then decreasing after 2018 at a regional scale. Open biomass burning was also found to decrease in recent years, suggesting the positive impacts of various interventions undertaken by the Government of Bihar (GoB). The overall study augments policymakers with decision-making support to instigate air quality measures at the state epicenters. The study also recommends the expansion of ground-based measurements and periodic updates of emission fluxes to better understand the observed patterns. We also recommend inter-state coordination to develop an integrated airshed management approach for holistic improvement in state air quality.

5.2 Beta Attenuation Monitoring (BAM) at IIT Delhi

Beta Attenuation Monitoring equipment is installed at IIT Campus for continuous monitoring of ambient air quality. This instrument is an essential reference grade monitor and is currently being used for calibration and co-location of various low-cost sensors before their deployment as a part of the NASA Citizen Science Project and SAMOSA project. Additionally, the World Calibration Centre for Aerosol Physics and IIT Delhi also have collaborated for studying the precision of an Aethalometer and a PM_{2.5} sensor using a UAV device in Indian conditions. The test routine was one of the 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 the calibration of these



instruments before testing. The calibration of low-cost sensors (Purple Air Sensor) continued before their deployment to different states and a regular status has also been sent to the ministry on the monthly basis. CERCA is constantly collecting data from BAM, and it is also displaying Live PM_{2.5} data on IIT Delhi Digital Notice Board and the website. For live data, visit: <https://home.iitd.ac.in/> or <https://cerca.iitd.ac.in/>

5.4 Industry Collaboration

CERCA is working with Honeywell, Sharp, CAMFIL, Swachh.io & Chakr Innovations as part of industry collaboration for undertaking joint projects on developing and testing clean air technologies such as UV, Filtration, and electrostatic precipitator technologies. CERCA is also helping technology start-ups like UMEANDUS Technologies to develop new clean air technologies and scale up these technologies for a wider social impact. CERCA has helped Tadpole projects build one of the first retrofitted vintage electric car in India (a VW Beetle 1948 model) and facilitated the incubation of the start-up at IIT Delhi for scaling up the technology. The start-up is successfully retrofitting several other cars.

5.5 Research Publications

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- P. Singh, "Inter-versus intra-city variations in the performance and calibration of low-cost PM2.5 sensors: A multicity assessment in India", *ACS Earth and Space Chemistry*, 6(12), 3007-3016, 2022 (Impact Factor = 3.556)
2. LBD Household air pollution collaborators, "Mapping development and health effects of cooking with solid fuels in low-income and middle-income countries, 2000-18: a geospatial modelling study", *Lancet Global Health*, 10, e1395-1411, 2022. (Impact Factor = 38.927)
 3. Hang, Y., X. Meng, T. Li, T. Wang, J. Cao, Q. Fu, S. Li, S. Dey, K. Huang, F. Liang, H. Kan, X. Shi, and Y. Liu, "Assessment of long-term particulate nitrate air pollution and its health risk in China", *iScience*, 25(9), 104899, 2022. (Impact Factor = 6.107)
 4. Bhattacharya, A., C. Venkataraman, T. Sarkar, A. Sharma, A. Sharma, S. Anand, D. Ganguly, R. Bhawar, S. Dey, and S. Ghosh, "An analysis of the aerosol lifecycle over India: COALESCE intercomparison of three general circulation models (GCMs)", *Journal of Geophysical Research: Atmosphere*, 127(14), 2022. (Impact Factor = 5.22)
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 6. Sarkar, T., S. Dey, D. Ganguly, L. Di Girolamo and Y. Hong, "A near-global view of individual cloud type distributions from spaceborne active and passive sensors and ground-based observations", *International Journal of Climatology*, 42(15), 8073-8088, 2022. (Impact Factor = 3.651)
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 9. Sharma, A. K., R. Kumar, N. K. Saini, C. Ghosh, S. Dey, P. Balyan, "Spatial epidemiology of COPD in Delhi, India", *Annals of National Academy of Medical Science India*, 58, 100-105, 2022.
 10. Ghosh, S., S. Dey, D. Ganguly, S. BaidyaRoy, and K. Bali, "Cleaner air would enhance India's solar energy production by 6-28 TWh", *Environmental Research Letters*, 17, 054007, 2022. (Impact Factor = 6.947)
 11. Banerjee, A., S. Dutta and S. Dey "Contrasting impacts of net cloud radiative forcing on surface temperature trends in India", *Environmental Research Communications*, 4, 041005, 2022. (Impact Factor = 3.237)
 12. Gani, S., P. Pant, S. Sarkar, N. Sharma, S. Dey, S. Guttikunda, K. AchutaRao, J. Nygard and A. Sagar, "Systematizing the approach to air quality measurement and analysis in low- and middle-income countries", *Environmental Research Letters*, 17, 021004, 2022. (Impact Factor = 6.947)
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- A retrospective cohort study", *Environmental Health Perspectives*, 130(1), 2022. (Impact Factor = 11.035)
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6. OUTREACH ACTIVITIES

6.1 CERCA Monthly Expert Talk Series

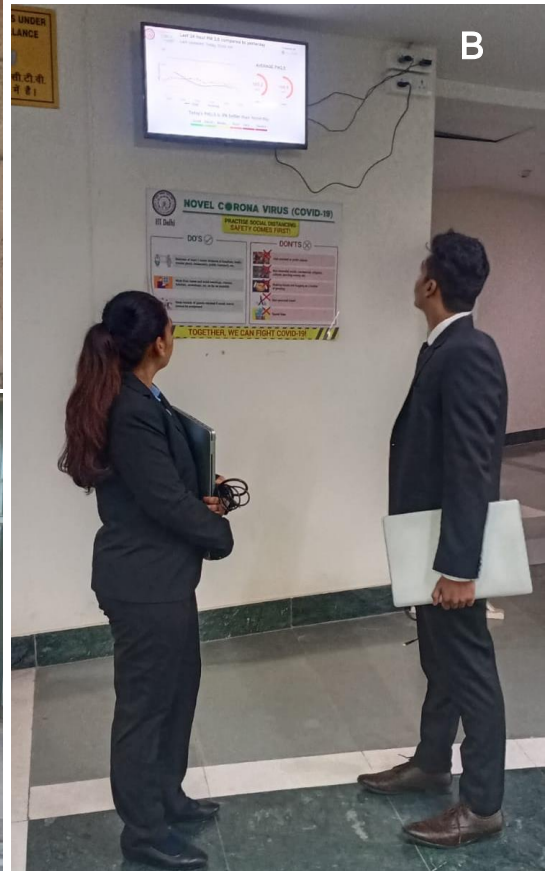
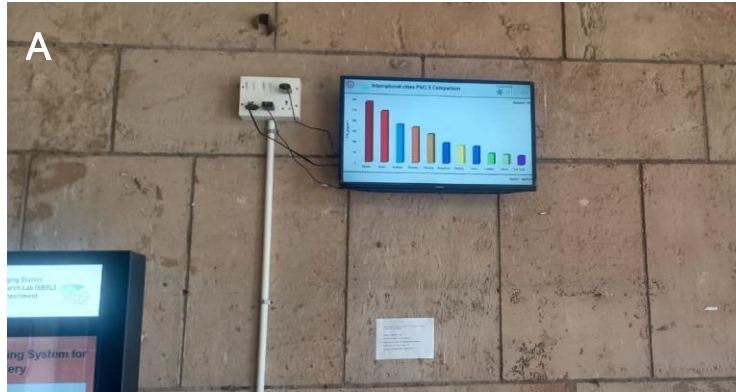
Since March 2021, we are organizing a virtual monthly expert talk series where we spotlight a range of contemporary issues from air pollution to climate change. In the year 2022, we have invited renowned speakers from academia and research institutions around the world to share their experiences and knowledge with our audience. We have covered a wide range of topics such as Air pollution early warning systems, Mitigation techniques for air pollution, designing of clean air policies, Air Quality Management in indoors, Citizen science, international experiences of combating air pollution, management of Agro Waste, Stubble burning and Climate Crisis etc.

You can access the talk recordings at: <https://cerca.iitd.ac.in/category/past>



6.2 Air Quality Data Dashboards

CERCA has developed data dashboards for displaying air quality information daily for the IITD community at different locations within the campus. Additionally, these dashboards also show air quality comparisons between different timelines and locations worldwide.



Data Dashboards Installations

A – Wind T

B – Lecture Hall Complex

C – Wind T

D – Outside Director Office

E – Outside CERCA Office

F – IITD Hospital (to be commissioned)



6.3 CERCA Monthly Newsletter

To get public outreach, we have been reaching out to a wide section of our society through a weekly newsletter since 2018 providing the latest inputs on research on the 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 endeavor 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. Also, we are planning to bring out a separate newsletter for school children. This would not only allow us to include more impactful and qualitative information on issues affecting our climate and air but also involve a very important section of our community in our effort to increase awareness on clean air and climate change issues at the grassroots level.

You can access newsletters on our website: <https://cerca.iitd.ac.in/>

6.2 Media Coverage and Social Media Presence

You can follow us for the latest updates on air quality news highlights, and centre's activities on our website (<https://cerca.iitd.ac.in/>) and social media handles. We welcome your feedback and suggestions.



Armed with science & tech solutions, govt & IIT-Delhi come together to fight air pollution

Office of Principal Scientific Advisor and IIT are working with tech & industry partners to monitor the city's AQI. Their pilot project will run till NCR from Nov '22 to Feb '23.

MOHAN BASU 3 NOV

How 'airshed management' could tackle India's air pollution crisis
The Indian government is moving to a new transboundary way of dealing with air pollution that recognises the problem does not respect political borders

Punjab Announces Staggered Schedule for Paddy Transplantation; Delhi May Witness Better Air Quality This Winter
By IANS - 14 June 2022 - TWC India

Explained: What Does An Air Quality Index Of 450 Mean?
The AQI captures attention only after it crosses 300, but is this just a winter problem in India?
By Nishalika Joshi | 10 MAY 2022

Centre Says Air Pollution an Urban Phenomenon, Experts Say Factually Incorrect
"If the government doesn't monitor air pollution in rural areas, it doesn't mean it doesn't exist," say experts.
THE QUINT
Published: 05 Aug 2022, 6:12 PM IST

Study links air pollution to anaemia in women
Findings suggest if India is able to meet clean air targets, anaemia prevalence among women in the reproductive age would fall from 39 per cent to about 39 per cent

Solar energy output of India reduced significantly by air pollution
15 Mar 2022 Hemish Johnston

Inhaling particulate matter is increasing the prevalence of anaemia among women of reproductive age
by Sahana Ghosh on 3 October 2022

How can India reduce anaemia among women? By cleaning up the air, says a study
Anaemia prevalence among women of reproductive age will fall from 53% to 39.5% if the country is able to meet its clean air targets.

Sahana Ghosh
Oct 08, 2022 - 09:30 pm

IIT Delhi and Koo collaborate to enhance awareness of air pollution

TNN | Posted on Saturday, August 6, 2022 12:17

This joint collaboration will commence as a pilot study for six months, and will help to identify specific sources of pollution

Health as the focus of air pollution policy
Health must be turned into a feature and eventually a function of air pollution policy
November 16, 2022 12:05 am | Updated 11:50 am IST
SANGHVI KRISHNA, SANGHVI DEVI
COMMENTS SHARE

Air Pollution Cut India's Solar Energy Output By 29%, Study Says
14/08/2022



by vehicular traffic and haze in the sky, Bhubaneswar, January 16, 2022. *panji/Unplash*

A team at IIT Delhi has reported that India lost 29% of its utilisable horizontal irradiance potential due to air pollution between 2001 and

