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BUILDING HEALTHY CITIES

Addressing Air Pollution Using Low-Cost Sensor Data and Community Empowerment

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26 August 2022

Air Sensors International Conference, Bengaluru, India

THRIVE NETWORKS

International Organization for Migration (IOM)
The UN Migration Agency

URBAN INSTITUTE

Building Healthy Cities Project (2017-2022)

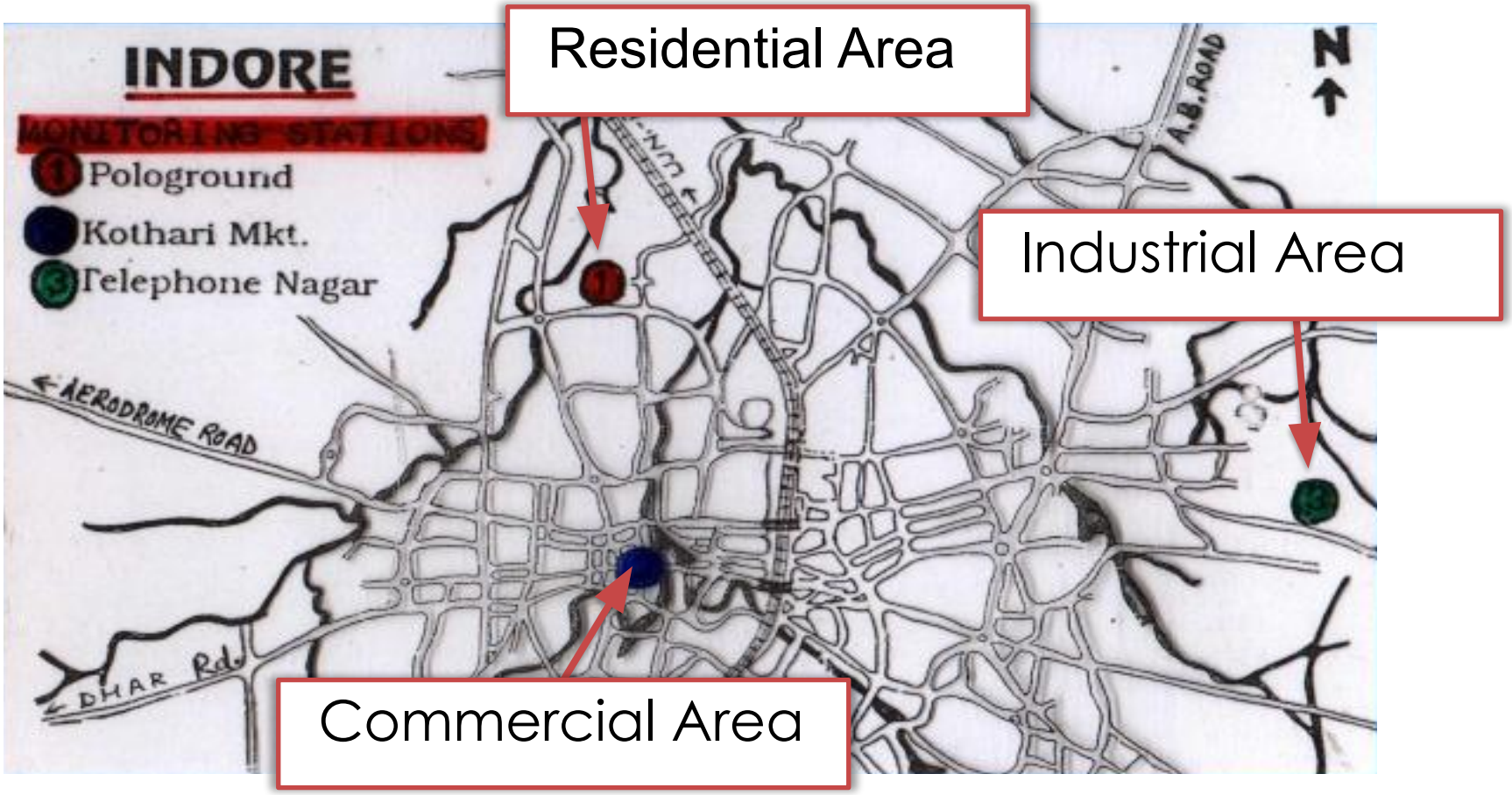
BHC's Approach & Core Values

- Used **systems thinking** to define what must be done to address urban health outcomes
- Created **multi-level, multi-sectoral** platforms
- Used **participatory systems mapping** to document and monitor
- Continual **synthesis** of research & pilot results
- Created **buy-in** for the final coherent action plan

Indore Context

- Indore is a fast-growing commercial capital in the state of Madhya Pradesh, India.
- 2017 population was ~2.5 million, ~3% yearly growth rate.
- Slum dwellers make up 30% of city population.
- Cleanest city in India for 5 consecutive years 2017-2021
- BHC was implemented through an MoU with Indore Smart City Development Limited
- Multisectoral Smart Health Working group constituted to oversee project implementation
- Indore Interactive Infographic

Ambient Air Quality Monitoring Sites at Indore City



Increasing Community Participation in Air Pollution Mitigation Study

Research Questions for Study

Usability	Effectiveness (In behavior change and in source identification)	Acceptance

Research Design

- Mixed method participatory study
- Population covered by CAGs: 326,372
- Surveyed 1,450 households, interviewed community members in two rounds
- Collected and analyzed data from low cost sensors & Clean Air Guides from 19 sites for one year

AQ Study Schedule

PERIOD 1: Study Preparation

- Validate LCS
- Train CAGs
- Pre-test
- Finalize survey tools

Jul 2020: Release of RFP for Low Cost Sensors (LCS)

Dec 2020: LCS installed

Nov 2020: ISSW selected as implementing partner

Jan 2021: CAGs hired and training knowledge tests completed

March- June 2021: Round 1 of community survey

August 2021: CAG-led Community Awareness Meetings begin

June 2021: COVID Lockdown in Indore

Jan 2022: Post-Training Knowledge Tests completed

Jan- March 2022: Round 1 of community survey

Aug 2022: Final Results

PERIOD 2: Official Study

- Hourly PM 2.5 Measurement
- Monthly CAG Meeting
- Quarterly Journey Mapping
- Ad hoc observational & qualitative data collected by CAGs

PERIOD 3: Data Analysis and Final Reporting

Low-Cost Sensors

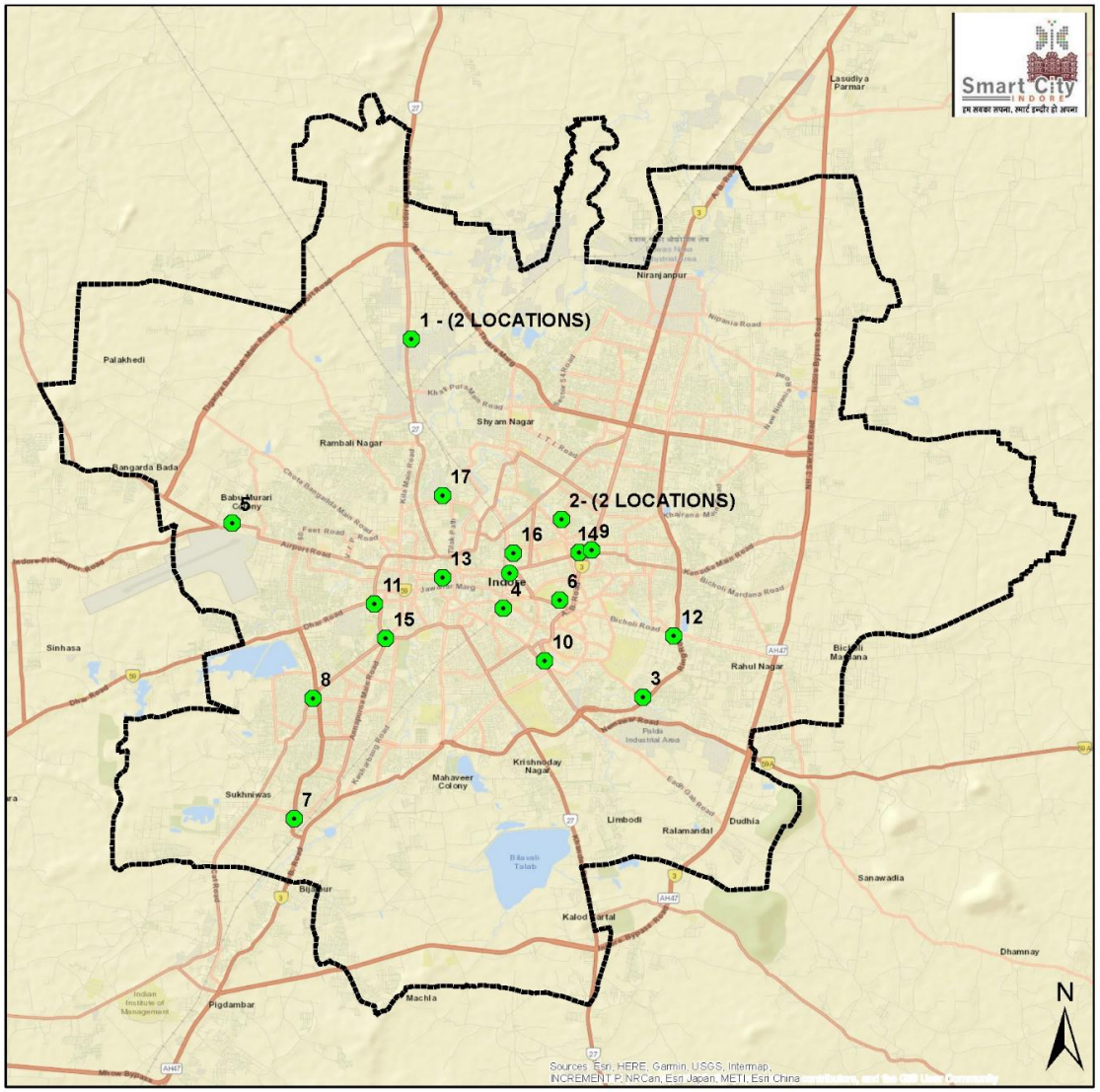
- 20 LCS were procured and tested against the official Indore monitoring stations
- After testing, 19 installed at strategic points including residential, commercial, industrial, and traffic congestion points.
- Data from **LCS were used in concert with "Clean Air Guides"** to suggest actions to reduce emissions and exposure
- IMC deployed real-time display boards at a strategic location for public awareness

Collocation for Data Validation

- Air sensors meet U.S. EPA Performance Targets.
- Collocation results at the PCB site (Chhoti Gwaltoli) show that the PM2.5 air sensors meet the U.S. EPA's Performance Metrics and Target Values for PM2.5 Air Sensors*

EPA Metric	EPA Target Value	Value from collocation PCB site (Chhoti Gwaltoli)	Result
Bias - slope	1.0 ± 0.35	0.85	✓ Meets target
Bias - intercept (b)	$-5 \leq b \leq 5$ µg/m^3	+4.55 ug/m^3	✓ Meets target
Linearity coefficient of determination (R^2)	> 0.70	0.85	✓ Meets target
Normalized root mean square error (NRMSE)	<30%	27%	✓ Meets target
Data completeness	>75%	93%	✓ Meets target

* https://cfpub.epa.gov/si/si_public_record_Report.cfm?dirEntryId=350785&Lab=CEMM



Site
Slum 1 Narwal Slum (2 locations)
Slum 2 Amar Tekri (2 locations)
Slum 3 Indira Ekta Nagar
Luniyapura Slum Sarwate bus stand
In front of airport
Mother and child health facility (Anganwadi center)
Reti Mandi Square
Footi Kothi Square
Palasia Square
Navlakha Square
Gangwal bus stand
Pipliyahana Square
Near Rajwada
56 Dukaan food street shops
Mhow Naka Square (moved to Regional Park
Chhoti Gwaltoli Station
IPCA industrial area

Clean Air Guides (CAG)

- 20 community-based graduate volunteers selected
- Each CAG allotted one LCS location and adjacent neighborhood
- CAGs were trained and supervised by ISSW faculty & BHC team

Main Functions:

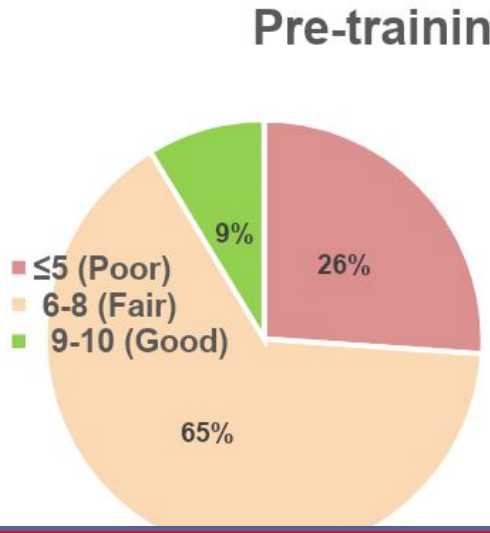
- **Maintain and read low-cost sensors:** Collation and interpretation of data, observing variations over time
- **Educate the community:** Air Pollution levels. Sources, effect on health, actions needed to reduce emissions and exposure to local pollutants.
- **Advocacy efforts:** Identify issues and suggest measures required at the community and/or Government level

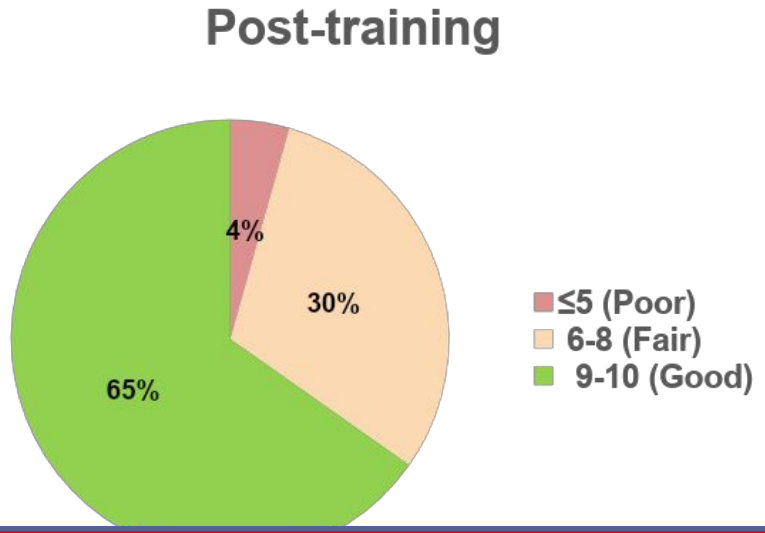
Study Results

Highlights from this One Year Study

Were CAGs Able to Understand and Use the LCS Data?

Yes; CAGs improved their understanding of air quality concepts and sensor data through training, practice, and interaction with city officials.





Color-coded Charts Prepared by Clean Air Guides to Share Air Quality with Citizens

CAG Outreach: Educate Communities on Air Quality Using Local LCS Data

What Did Citizens Think of Air Pollution?

Site	Observed Primary Sources
ISCDL Office Campus	Waste Burning
Choti Gwal Tali DIG Office*	Waste Burning (old tyres)
Luniya Pura	Crematorium, Vehicles, Waste Burning
Amar Tekri, Anganwadi Center	Use of repellant coils
Palasia Square	Biofuels, Waste Burning
Pipliyahana Square	Dust from construction sites, Vehicles
Indira Ekta Nagar	Factories processing pulses, Waste Burning
Narwal, Sanwer Road, Primary School	Industry, Vehicles
Narwal, Sanwer Road, Anganwadi Center	Industry, Waste Burning
M.Y. Teaching Hospital Campus	Vehicles, debris from demolition sites
56 Dukaan Food Street	Use of biofuels
In-front of airport (Panchsheel Nagar)	Vehicles
Navlakha Square	Vehicles
Gangwal Bus Stand	Vehicles
Reti Mandi square	Trucks ferrying sand, Waste Burning
IPCA, Industrial Area	Waste Burning, Use of large generators
Near Rajwada	Vehicles, Road Construction
Footi Kothi Square	Vehicles
Amar Tekri, Primary School	Vehicles

Sources of Air Pollution in Indore identified by CAGs & Community

Dust from construction sites

Use of biofuels for cooking

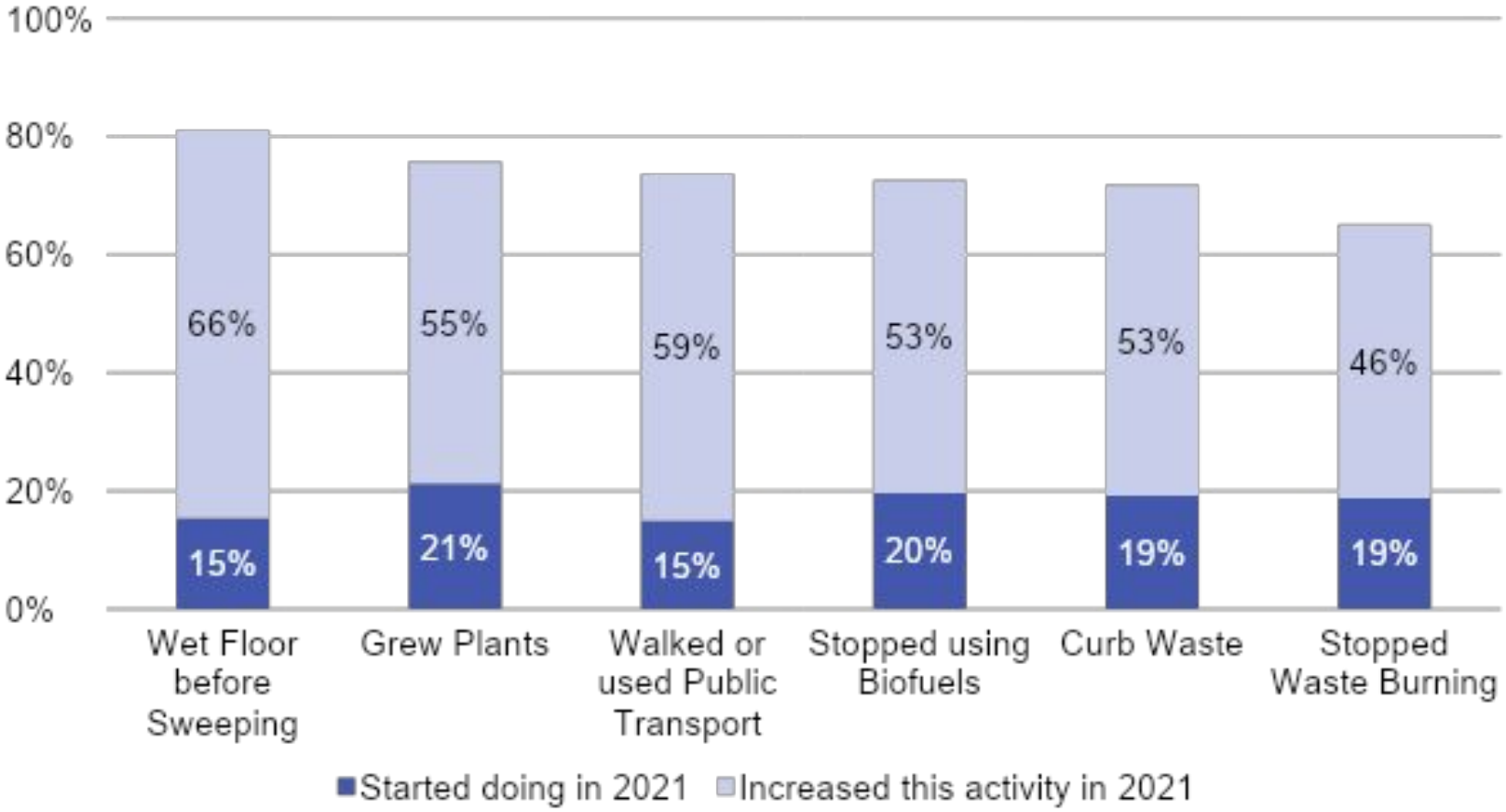
Burning of waste

Burning wood at crematorium grounds

Emissions from vehicles

Food street vendor

Has this Changed Behaviors in Citizens?

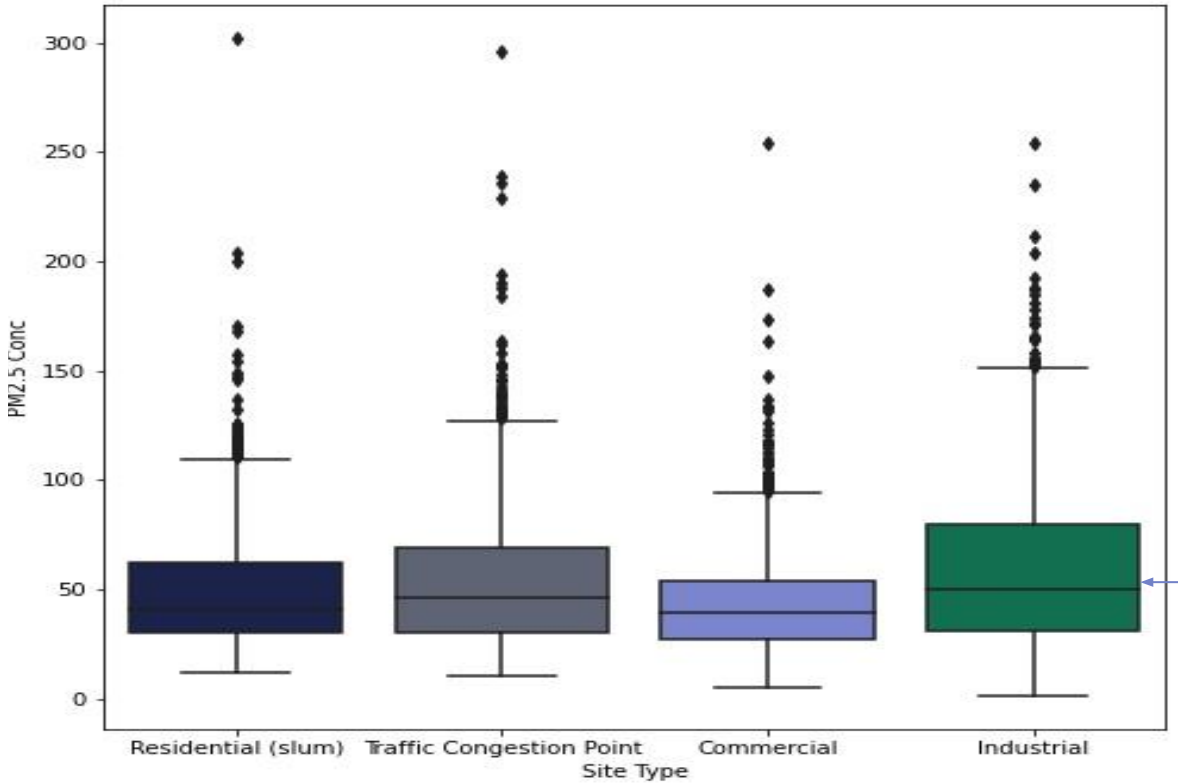


Have the LCS Been Effective at Measuring Air Quality?

Site Type	Commercial				Traffic						Slum						Residential	Industrial		Commercial
AQI Category	Choti Gwaltoli	Indore Smart City Office	M.Y. Teaching Hospital	Near Rajwada	Reti Mandi	Congested Food street	Palasiya Square	Navlakha Square	Phooti Kothi Square	Gangwal Bus Stand	Amar Tekri Primary School	Amar Tekri Anganwadi Center	Luniya Pura	Indira Ekta Nagar	In Front Of Airport	Narwal Sanwer Road Anganwadi Center	Pipliyahana Square	Narwal Sanwer Road Primary School	IPCA Industrial Area	Choti Gwaltoli MPPCB
Good	109	204	67	88	95	84	102	5	81	79	117	79	56	125	104	40	32	49	70	137
Satisfactory	156	132	76	144	162	117	140	63	158	152	135	164	168	161	145	65	166	118	84	124
Moderate	58	14	34	57	59	53	57	68	69	66	21	77	76	49	74	61	26	91	52	65
Poor	17	0	27	11	25	14	29	32	22	37	5	25	29	10	21	20	4	62	36	33
Very Poor	3	1	14	4	3	0	17	12	5	14	0	5	8	3	6	27	1	31	9	6
Severe	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	1	0	0

- Gray bars indicate sites with less than 75% data completeness.
- Industrial and traffic sites generally have more days with Moderate-Very Poor AQI.
- BHC developed a short video summary explaining the data

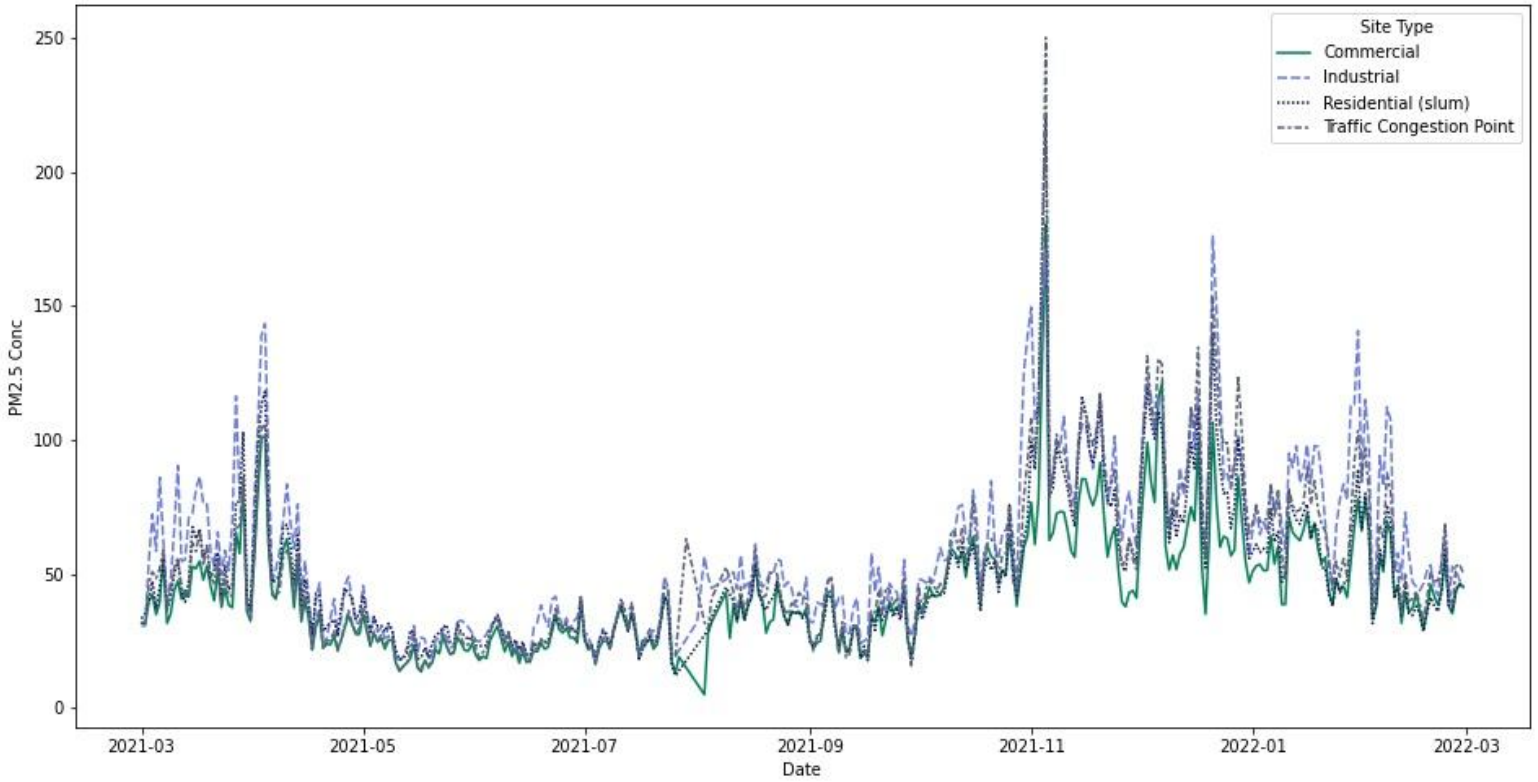
PM2.5 Median & Concentration Ranges by Site Type



Median

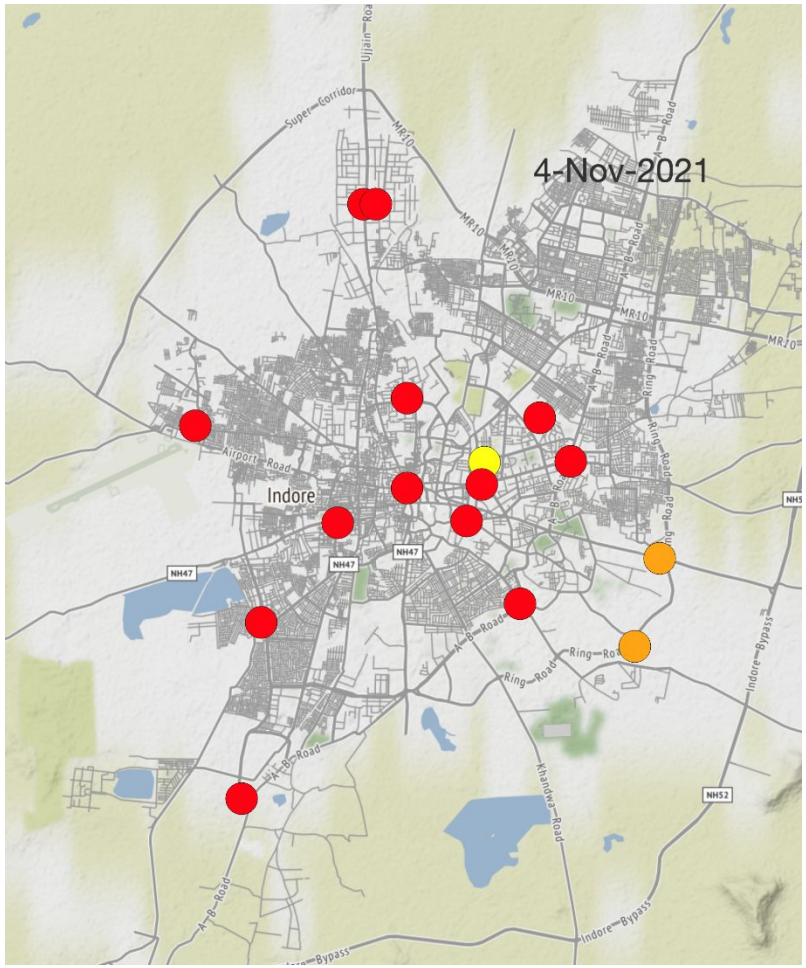
- Industrial sites generally have higher concentrations
- More outliers (high values) in the slums
- Slightly lower concentrations in commercial areas

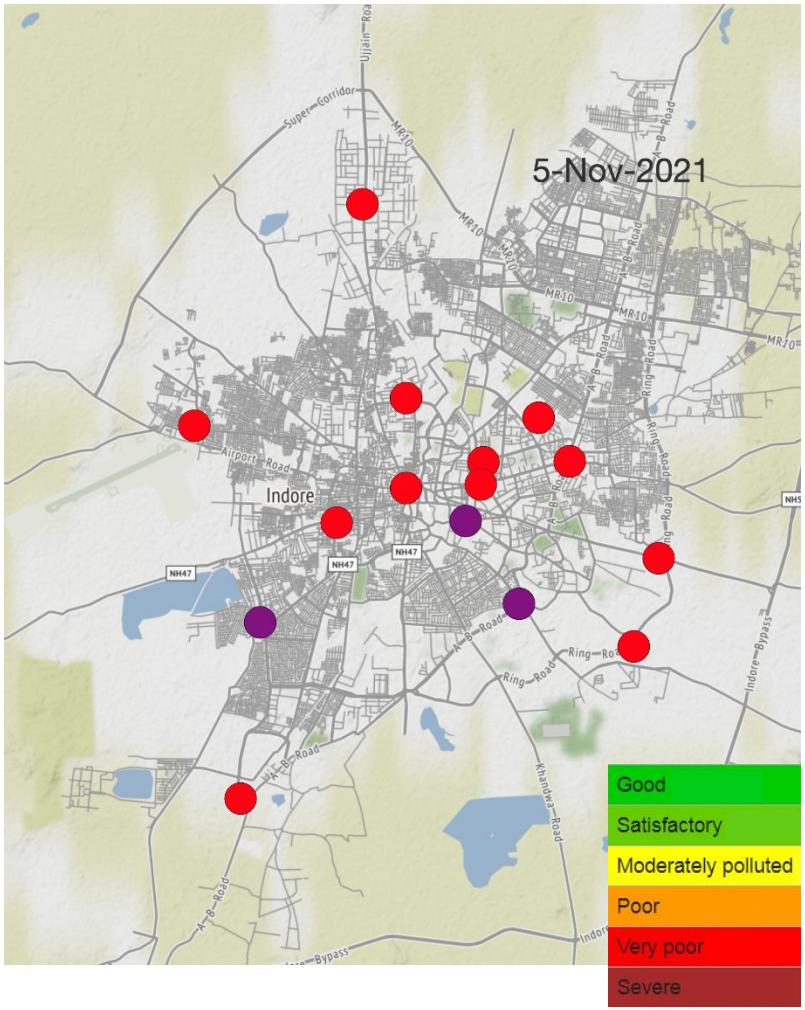
Daily Average PM2.5 by Site Type

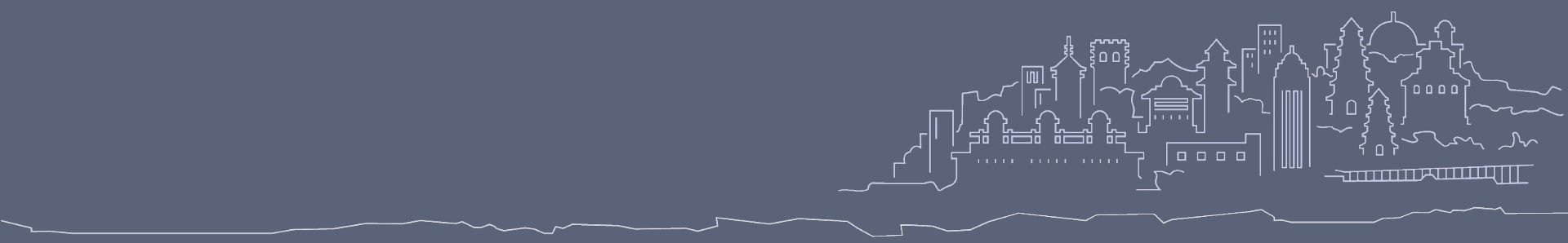


- PM2.5 levels higher in winters (November-March) as compared to summer (May-June) and rainy season (July-September).
- Even in the winter months, residential sites showed lower PM2.5 compared to industrial areas and traffic congestion points.

Air Quality During Diwali Festival 2021



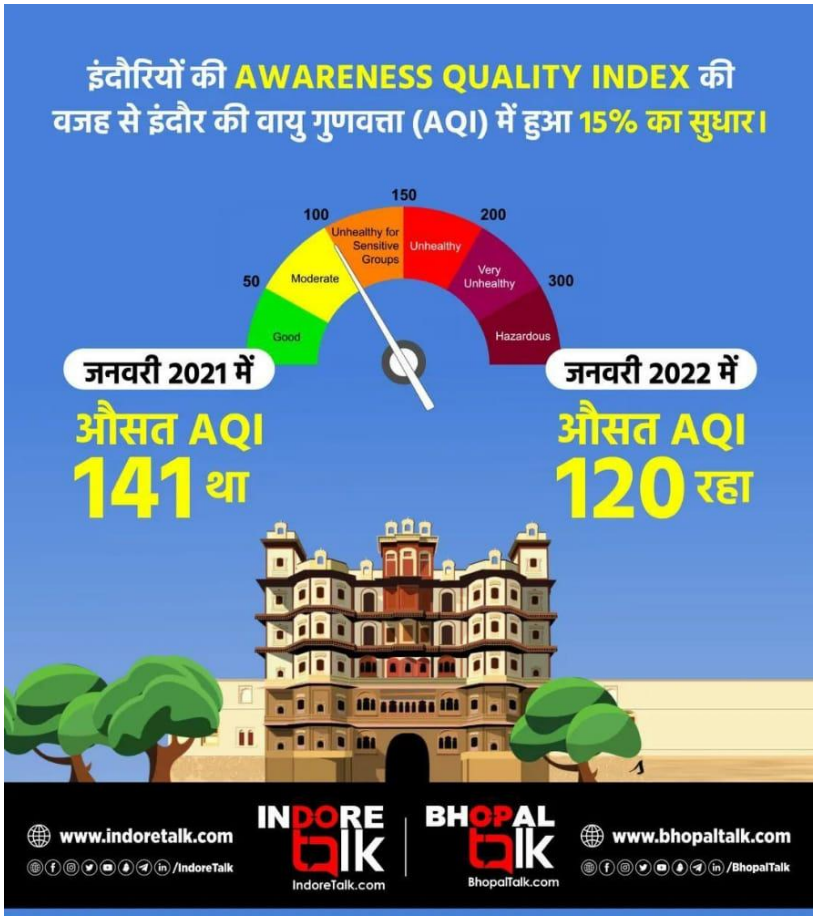




Study Outcomes

Intervention at the Government Level:

Campaign to reduce vehicular pollution in January 2022: Red Light On- Engine Off



Making Industrial Workers Aware about Exposure to Air Pollutants and Protective Measures

Health Promotion: Using Bicycles at least once a week

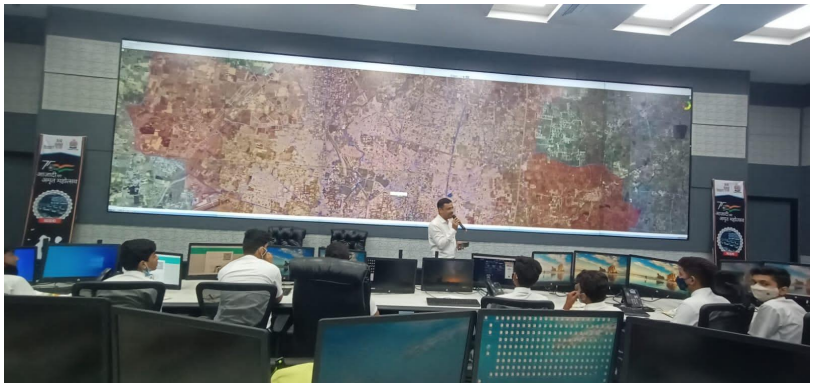
Increasing Tree Plantation for a Green Indore

Reducing Market Congestion

Reducing Dust at Construction Sites

Getting New Air Quality Data in Front of the Public and Decision-makers

- Data from each site were shared with the community by CAGs for awareness, and to identify and address local sources of pollution.
- Multisectoral Working Group directed BHC to make air quality data available to the public through websites.
- It was also agreed to link air quality data from sensors into the Integrated Command & Control Centre (ICCC)
- Confederation of Indian Industry (CII) & USAID funded Clean Air Catalyst Project continuing efforts to improve AQ.
- IMC has given high priority to AQ towards making it the Cleanest City of India



Recommendations

1. Use of LCS for source identification in peri-urban and rural areas also needs to be studied as sources of pollution could be outside city limits (e.g., brick kilns, agro-waste burning, use of biofuels in rural areas)
2. Integration of data from Government pollution measurement stations and LCSs would be more useful for interventions, informed policies development, and resource mobilization
3. Air quality indicators should be included in the definition of Clean Cities
4. The model of Clean Air Guides as advocates for air quality needs to be tried out in other settings following which a sustainable cadre could be decided upon and their cadre recognized and duly compensated.

Thank You