Trial of Ambient Air Purification System (APS) in a Market Place in Delhi NCR

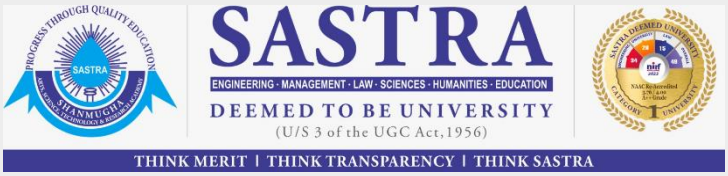
Project Completion Report Submitted to CAQM

Abstract

Project Completion Report of the trial of Ambient Air Purification System (APS) at ISBT Anand Vihar Platform #1

SASTRA Deemed University & Umeandus Technologies India Private Limited

Dr K.S Rajan – Principal Investigator SASTRA Deemed University, Thanjavur and
Rajeev Chanan – Co-Investigator, Umeandus Technologies India Private Limited, Gurgaon



Annexure – I

File No. & Date of Sanction: F. No. R-19011/01/2022-MERD-642 dated November 24, 2022

1. Title of the Project:

Trial of Ambient Air Purification System (APS) in a Market Place in Delhi NCR

2. Principal Investigators (Name & Address):

(i) Dr. K.S. Rajan

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3. Co-Investigators (Name & Address):

(i) Mr. Rajeev Chanan

Umeandus™ Technologies India Private Limited, Gurgaon (Haryana)

4. Date of commencement of programme:

January 19, 2023

5. Duration of the project:

Initial Proposal and approval were for Six months, Extension was requested up to 18th Jan 2024 as per letter dated 11th July 2023. Further extension was granted up to 31 March, 2024 vide letter F. No. R-19011/01/22-MERD (Sastra)/6272 dated March 15, 2024.

6. Amount sanctioned by CAQM:

Sanction (including GST @ 18%): Rs 60,21,540 (Rupees Sixty-One Lakh Twenty-One Thousand Five Hundred and Forty-One)

7.Amount released by CAQM till date:

Rs 48,88,674 (Rupees Forty-Eight Lakh Eighty-Eight Thousand Six Hundred and Twenty-Four).

- **Balance Amount Due is Rs 11,32,866/- (Rs Eleven Lakhs Thirty-Two Thousand Eight Hundred and Sixty-Six Only)**

8. Details of expenditure

A. Non-Recurring

S. No	List of approved equipment	List of procured equipment	Major specifications of equipment procured	Number of units	Date of purchase order	Expenditure, (Rs)
1	Air Purification System	Supplied and Installed at Site		10	March 22, 2023	47,20,000
2	PM Monitoring Sensors	Sensors supplied and installed at site		6		2,39,540
3	Pumps	Supplied and Installed at Site		10		4,72,000
Total (Rs)		54,31,540 (Rupees Fifty-Four Lakh Thirty-One Thousand Five Hundred and Forty including GST)				

B. Recurring

S. No	Item	Budget (Rs)	Expenditure (as on date)
1	Salary (Project Management charges)	3,54,000	3,54,000
2	Contingencies, travel & Overhead	2,36,000	2,36,000
Total (Rs): 5,90,000			5,90,000

Total Expenditure as on date, including commitments for which Tax invoice has been received (A+B): Rs 60,21,540 (Rupees Sixty Lakh Twenty-One Thousand Five Hundred and Forty)

9. Whether there is any deviation from the purpose for which grant was released. If so detail of amount to be given.

There is no deviation from the purpose for which grant was released. The project period was extended till March 31, 2024.

10. Give details of the activities carried out during the project period:

Site survey:

Initial site proposed and survey proposal submitted to CAQM was for market place at Chandni Chowk. This was changed to Anand Vihar in consultation with CAQM.

Revised Site Proposal

Anand Vihar was chosen as the place of trial after discussions with the Commission for Air Quality Management. Three potential locations were considered:

(i) Near the DPCC monitoring station;
(ii) Pacific Mall and
(iii) The Inter State Bus Terminus (ISBT).

Due to various reasons including space, security, and availability of electricity infrastructure site at ISBT was preferred. The other two sites were not found to be feasible.

The platform #A at The Inter State Bus Terminus (ISBT) was found to be a suitable location for conducting the trial. Electricity connection can be made available at required pillars and hence the location is feasible for installation of sensors and Air Purification System (APS). The location is marked in red in the Figure shown below.

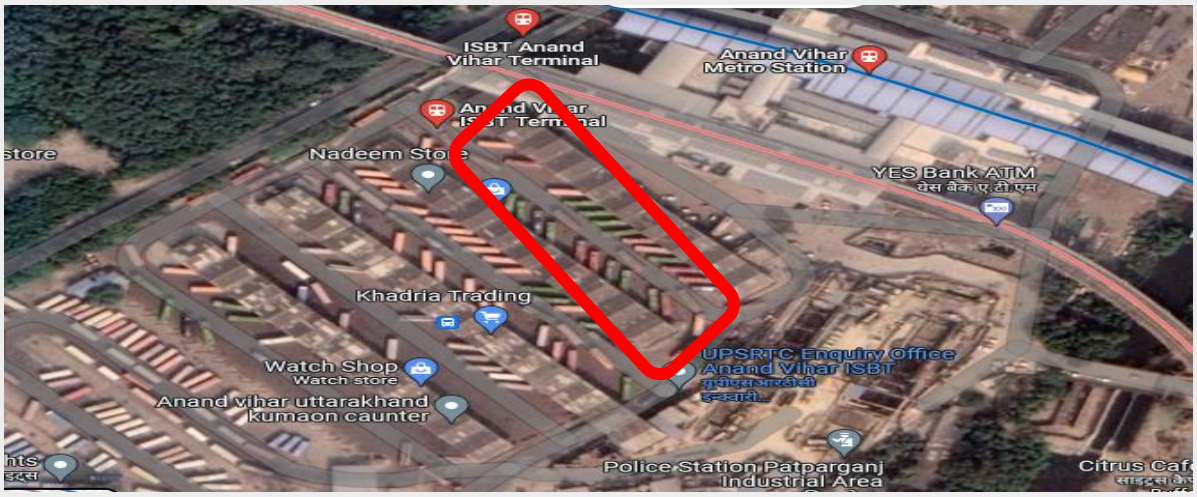


Figure 1. View of the site for trial of APS

Design of Air Purification System (APS):

Based on the site analysis, APS was designed for its suitability for the location and to achieve the targeted outcome. Sufficient care has been taken during the design to minimize the inconvenience, if any to the public. The nature of power supply available at the site was also considered.

Preparation of the site

The Delhi Transport Infrastructure Development Corporation Ltd. (DTIDC) was approached seeking permission for the utilization of space available in the platform #A of ISBT for the installation of APS, sensors. Subsequent to the receipt of permission from DTIDC, permission for electricity connection @ Rs 16.30/unit was accorded in the second week of April 2023.

Installation of sensors & APS

The total length of Platform #A is 126 m. Laboratory tests carried out by SASTRA Deemed University and Umeandus™ Technologies India Private Limited (UTIPL), independently have shown that the coverage of each APS is about 20 m based on ambient air conditions, site condition, obstructions etc. Considering the target area to be the Platform #A, the APS consisting of 10 units was designed to be placed in a staggered manner (marked as A1, A2, A10 and shown in Figure 2).

Design and placement of sensors and APS was to measure performance from different perspective. One sensor (S1) was deployed in the vicinity of bus bay 36 to measure ambient air quality. Sensors S2 and S3 were installed to measure the performance of APS A2 and A6. The sensor S4 placed near bus bay 16 will also report ambient data. The two sensors S5 & S6 were deployed in the adjoining Platforms #B and #C are for comparison.

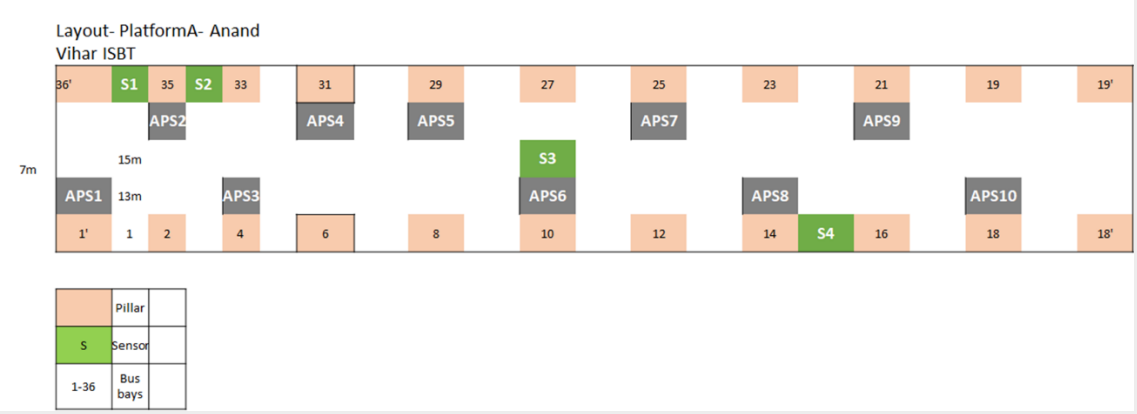


Figure 2. Schematic layout of Platform #A. S1-S4 indicate the locations of sensors. A1-A10 indicate the locations of Air Purification System (APS)

Sensor – Selection, Procurement & Installation

M/s Airveda supplies Air Quality Monitors (sensors) that are manufactured in India. These monitors use high quality-laser based sensor and are calibrated against a standard beta attenuation monitor with a correlation coefficient >0.9. These monitors provide real-time data on particulate matter levels ($PM_{2.5}$ and PM_{10}), temperature and humidity. The dashboard can be accessed through a mobile App or PC with the use of data connectivity. The reports can be generated at the desired time interval. These monitors (sensors) are portable and can be deployed easily.

The sensors S1 to S6 have been installed after completing the necessary electrical work and data connectivity. The sensor S3 was installed in the middle of the platform A, which represents the target area. The sensors S1 and S2 are at the interface between the target area and the reference area (outside the target area). The sensor S4 is at the interface between the target area and the reference area on the other side of the platform. The sensors S5 and S6 are placed in the platform's 'B' and 'C' respectively, which are away from the target area (platform 'A'). While the sensor S3 is meant to indicate Air quality in the target area, the sensors S1, S2 and S4 serve to provide information on air quality at the interface between the target and reference areas. The sensors S5 and S6 indicate air quality in the regions not expected to be greatly influenced by the APS. The wiring layout is shown in Figure 3. The actual photographs of the installed sensors S1 to S4 is shown in Figure 4. All the necessary electrical and mechanical work required to prepare the site for installation of sensors and APS have been completed (Figure 5).

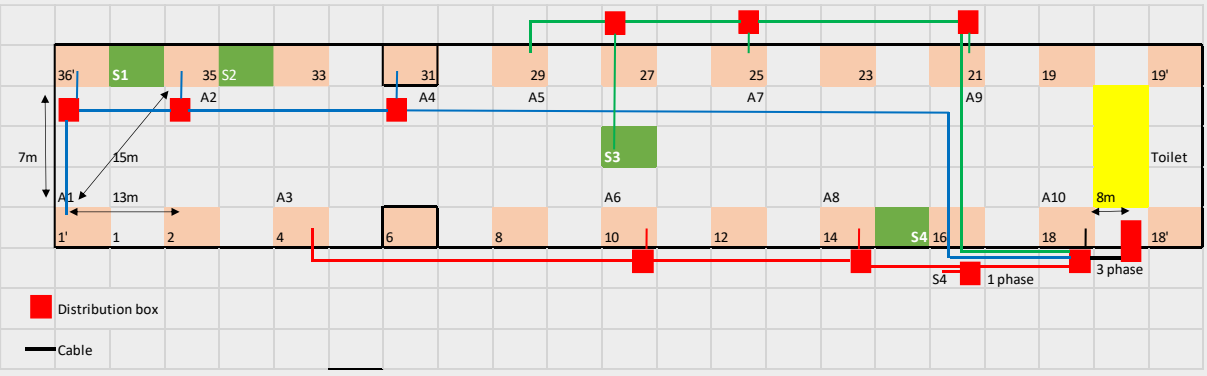


Figure 3. Wiring layout to provide power supply for APS and sensors

Figure 4. Picture of sensors (S1-S4) installed at the site

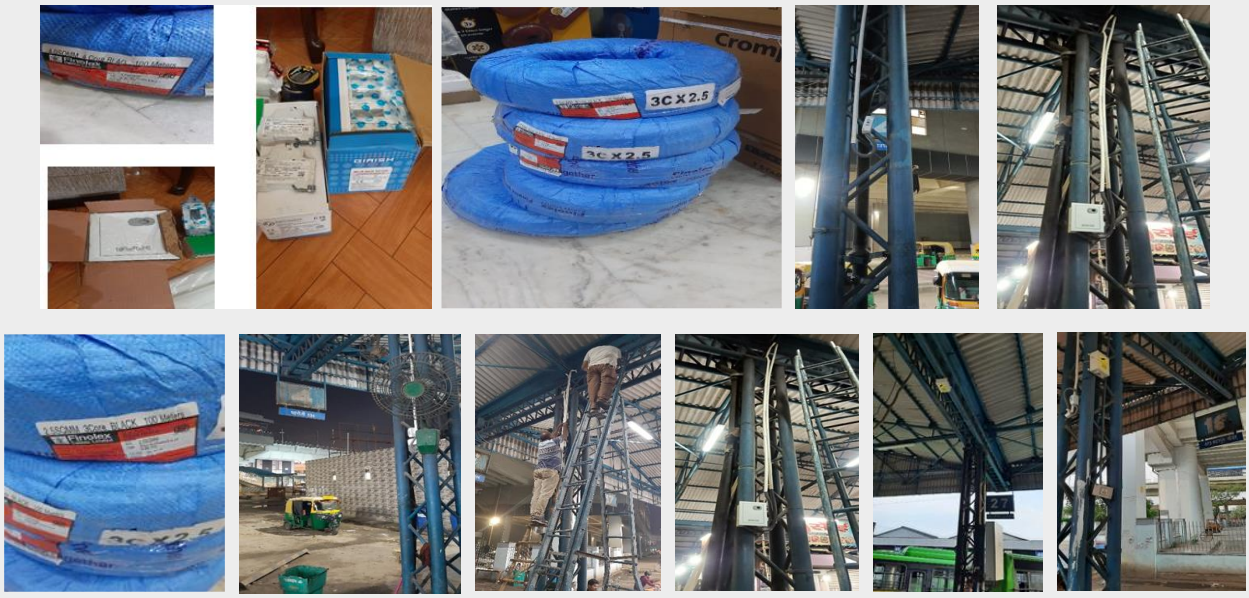


Figure 5. Picture of electrical connections at Anand Vihar ISBT

Sensor – Data collection and Calibration

The data collection from the sensors was started on a real time basis starting 17th May 2023. The data was analysed and calibrated to the DPCC sensor installed at Anand Vihar on 8th June 2023. The sensors were positioned at appropriate locations and readings were recorded on real-time basis. The data reported here are 24-hour averaged readings for PM2.5 and PM10. The sensor data for the two-month period between July 8, 2023 and September 10, 2023 is shown in Figure 6.

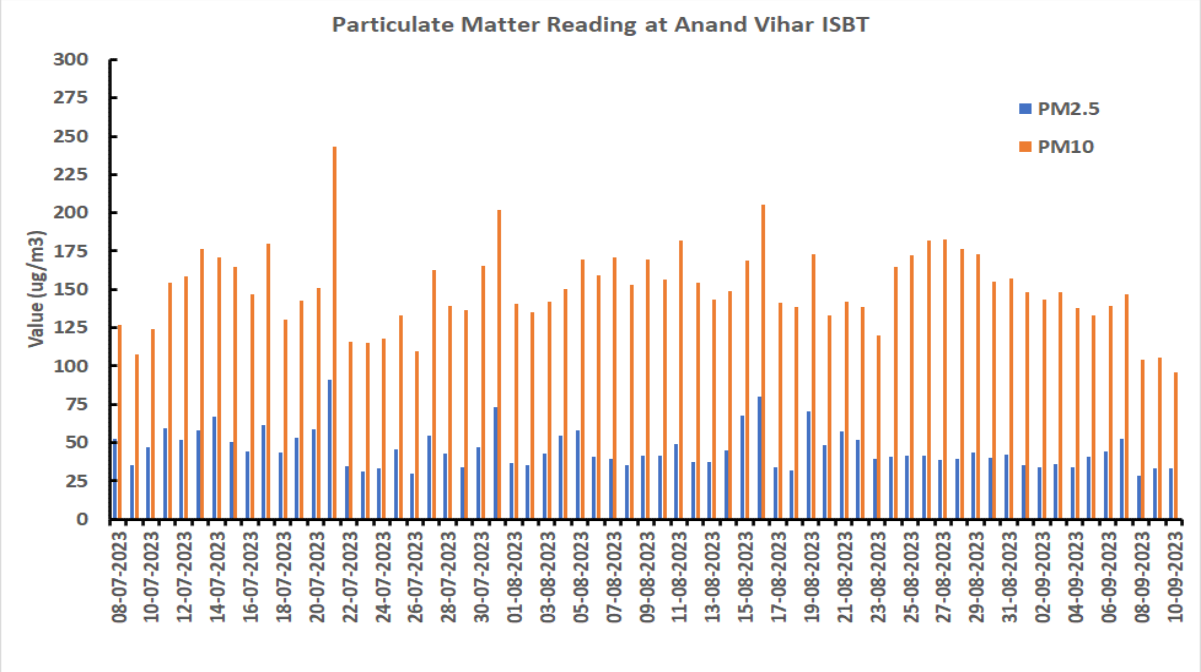


Figure 6. $PM_{2.5}$ and PM_{10} levels at Anand Vihar ISBT from July 8, 2023 till September 10, 2023

<u>Design, Fabrication and Installation of APS</u>

The specially designed APS was fabricated off-site, as shown in Figure 7.

Figure 7: APS being manufactured at factory

All components of the APS system were transported to the site and have been installed. The APS were fastened to the poles to secure and prevent it from tilting or getting shifted. Care was taken to ensure that the APS was placed with proper levelling and stability. The APS has been installed at the site and commissioned (Figure 8).

Figure 8. Picture of APS installed at the Anand Vihar ISBT

Understanding PM2.5, PM10 and AQI Patterns in ISBT

The data obtained from sensors installed at Anand Vihar ISBT Platform #A have been analysed to identify patterns of the concentrations of $PM_{2.5}$ and PM_{10} and AQI. During the review meeting held on October 17, 2023, it was suggested not to have DPCC sensor data for assessment of impact of APS units. Even though DPCC has a monitoring station 200m away from the study area (Figure 9), the DPCC data was not used as a reference due to differences in the surrounding environment between the two locations. Therefore, one of the six sensors installed at the trial site had to be used as control or reference for assessment of the impact of APS units. This requires understanding the spatial variation of PM2.5 and PM10 concentrations in the trial site. Therefore, PM2.5 and PM10 measurements were made at different locations in the trial site using the portable sensors having same calibration standard as that of the sensors mounted. To enable the study of spatial variation of PM2.5 and PM10 concentrations, APS units were switched off during the day of measurement. The locations of PM2.5 and PM10 measurements in platform 'A' are marked X1 to X5; those in platform 'B' marked Y1-Y2 and Z4-Z5; those in other platforms marked Z6-Z9. Z1 and Z2 are between the trial site and entry to metro station. The infographic containing the data is shown in Figure 10.

The average of PM2.5 concentration recorded at various locations in platform – A (test area) on this day was found to be 313 $\mu g/m^3$. Similarly, the average PM10 concentration was found to be 516 $\mu g/m^3$. Within the platform – A, the spatial variation in PM2.5 and PM10 concentrations is less than 6%. Hence any location in platform – A can be considered to be representative of the platform – A, which is the test area.

In other areas of ISBT, the average PM2.5 and PM10 concentrations were 251 $\mu g/m^3$ and 474 $\mu g/m^3$ respectively. The concentration of PM10 in areas outside platform – A (denoted as locations Z4-Z9 and Y1-Y2) vary within 7% of the average concentration recorded in the area. Hence any

location in platform – B or platform – C can be considered to be representative of the reference area (uncontrolled area). Such measurements were made on two or three other days and the inferences are grossly similar, as shown in Figures 11.

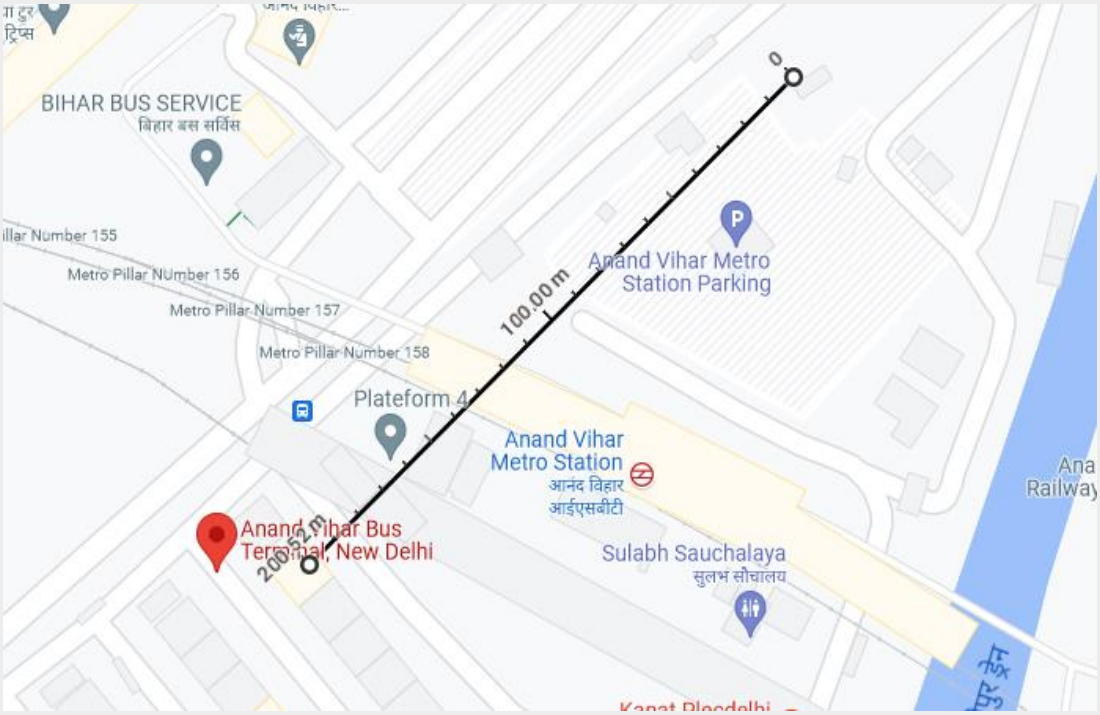


Figure 9. Pictorial representation showing the distance between the trial site and DPCC air quality monitoring station

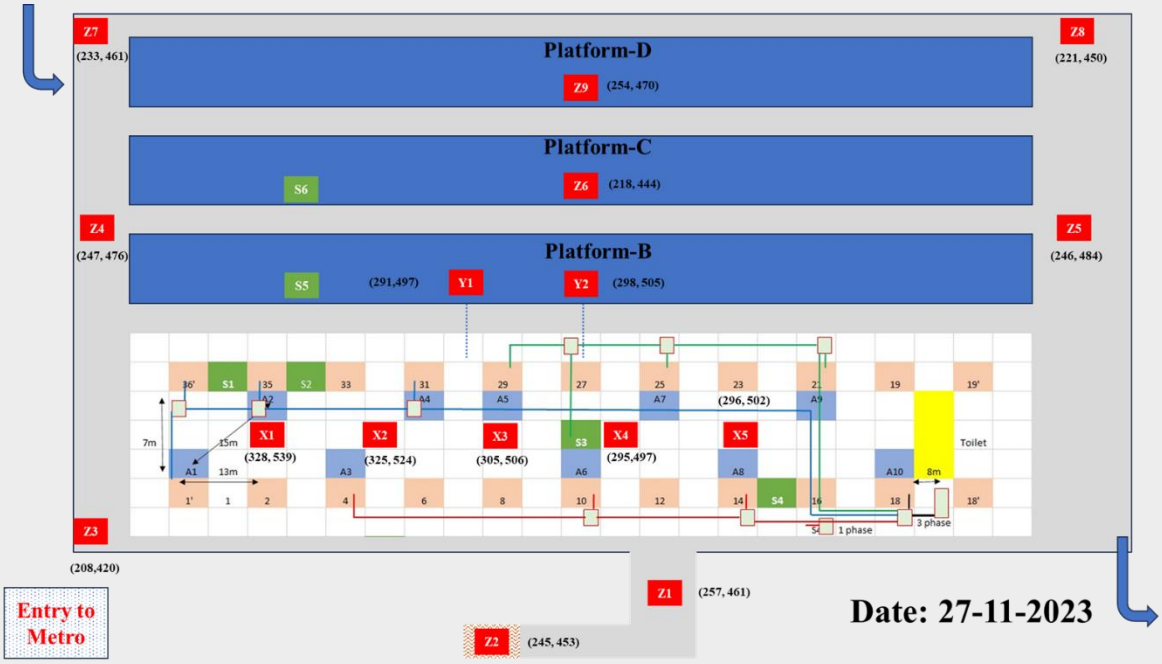


Figure 10. Spatial mapping of PM2.5 and PM10 concentrations at various locations in ISBT, Anand Vihar, when APS was switched off.

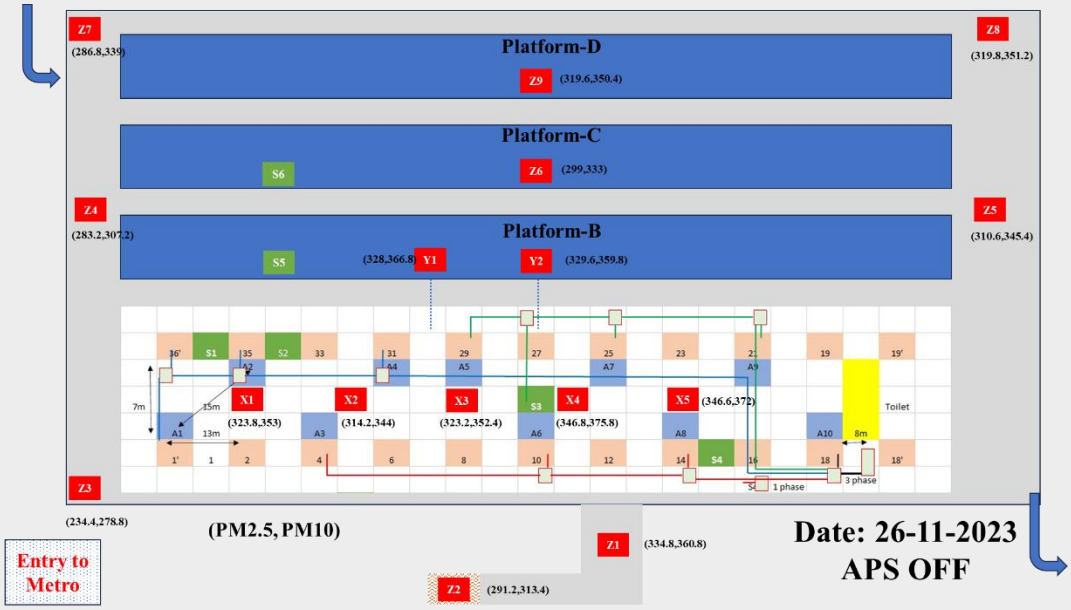


Figure 11. Spatial mapping of PM2.5 and PM10 concentrations at various locations in ISBT, Anand Vihar, when APS were switched off.

Therefore, the data from the sensor 'S3' (mounted at the site with round-the-clock data acquisition) was taken for air quality characterization in Platform – A (test area) and the data from the sensor 'S5' (also mounted at the site with round-the-clock data acquisition) was considered for air quality characterization in the reference (outside the test area) region.

<u>Particulate Matter Concentration Since the Start of APS</u>

The APS was switched on the target area (Platform A) on September 23rd, 2023. It was operated continuously on a 24-hour basis till March 27, 2024. Initially six APS were switched on, and on October 13, 2023, all ten APS became operational. The sensors recorded data during the whole time, except for days when the sensors were removed from the locations for maintenance purposes. Figures 12- 14 show the particulate matter concentration and AQI at the target area (Platform A) and the reference area (Platform B) over a six-month period from the start of the trial. The raw data is tabulated in Annexure 1.

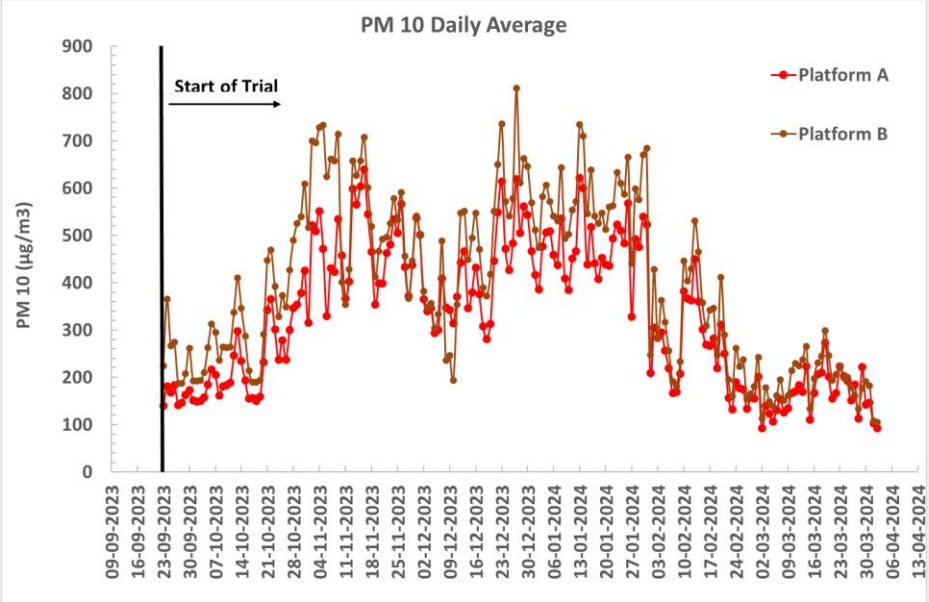


Figure 12. PM10 concentration at Platform A and Platform B from September 23, 2023 till April 2, 2024.

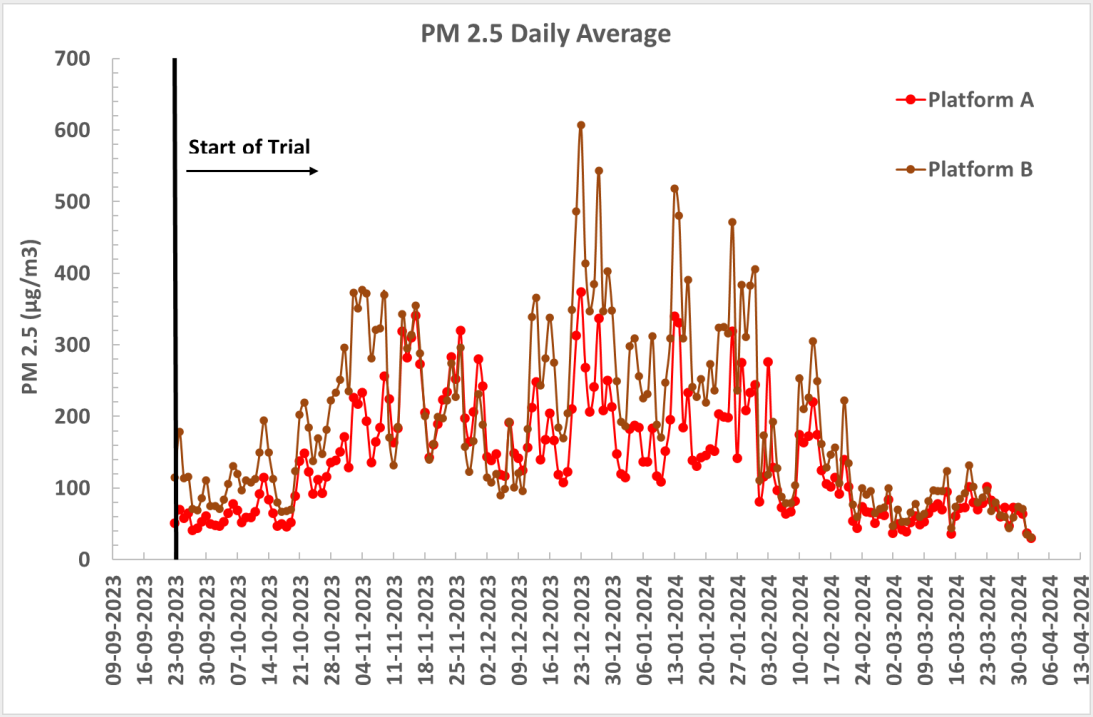


Figure 13. PM2.5 concentration at Platform A and Platform B from September 23, 2023 till April 2, 2024.

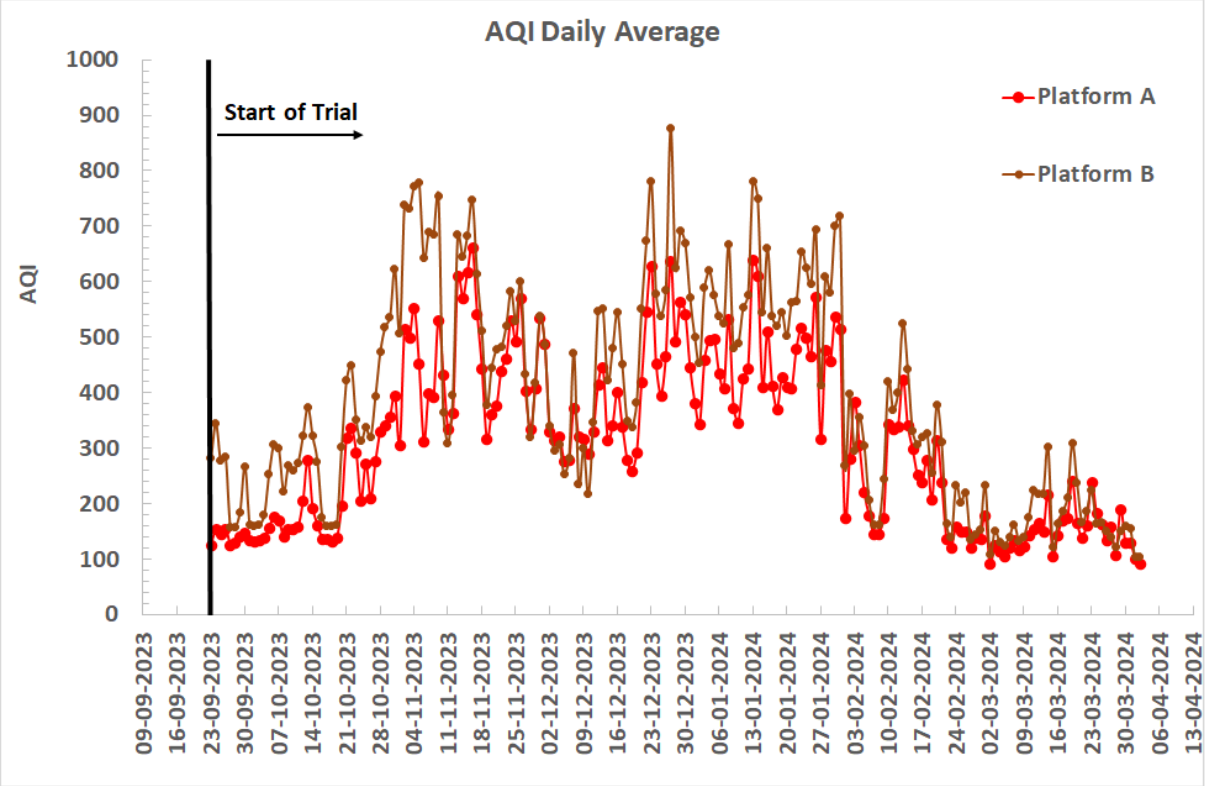


Figure 14. AQI at Platform A and Platform B from September 23, 2023 till April 2, 2024.

Evaluation of APS Performance

The impact of APS on the air quality was quantified as the reduction in PM10 concentration in platform – A (as measured using sensor S3), in relation with PM10 concentration measured in platform – B (measured using sensor S5). In order to understand the efficiency of the APS, the PM10 and PM2.5 concentrations in the target area (Platform A) and reference area (Platform B) was compared, when the APS was switched off. Figures 15 and 16 show the comparison in PM concentrations. As can be seen, when the APS were switched off, the PM concentrations in the platforms were either similar, or Platform A had higher concentrations compared to Platform B. Hence any difference in the measured PM concentration between Platforms A and B is reflective of APS performance.

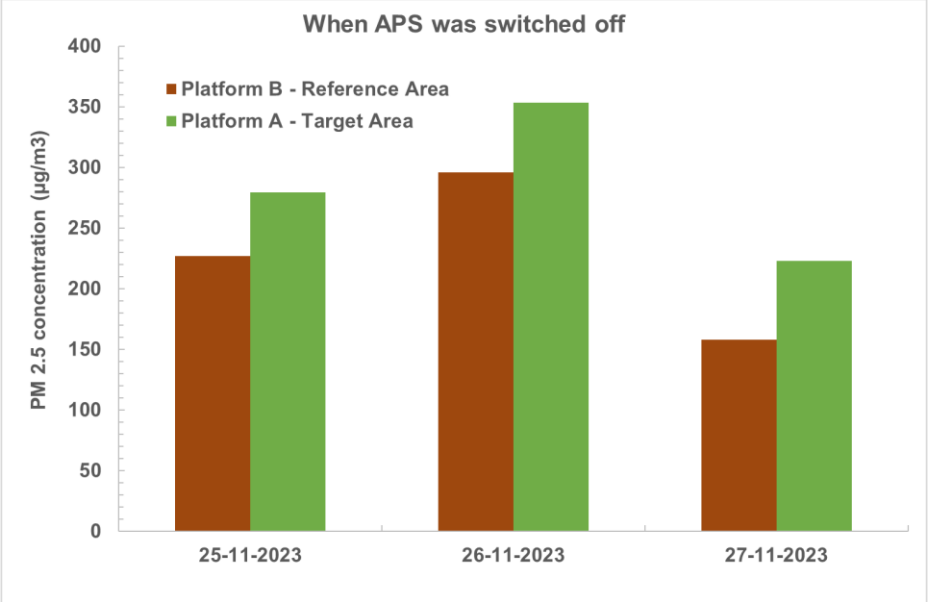


Figure 15. PM2.5 concentration at Platform A and Platform B when APS was switched off.

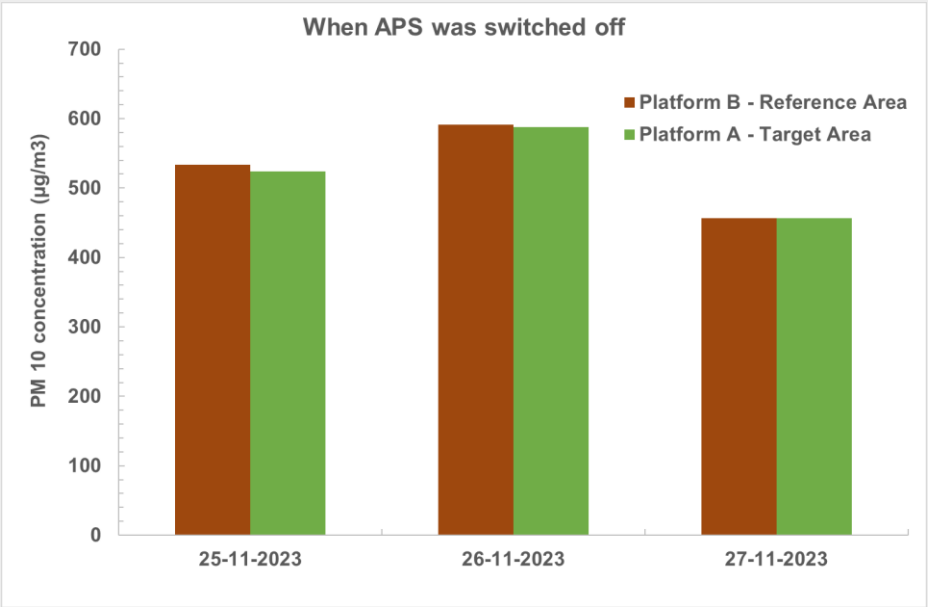


Figure 16. PM10 concentration at Platform A and Platform B when APS was switched off.

During a period of 10-15 days between November 21 and December 7, 2023 maintenance activity was performed on the feed pipe to the sensors. Data acquisition continued from December 8, 2023. As per the recommendations of CAQM, the performance analysis of the APS units was observed for three periods as follows:

- Pre-winter from Start of Trial till November 10, 2023
- Winter from December 7, 2023 till January 31, 2024
- Post – winter from February 1, 2024 till March 31, 2024

The performance of the APS units is shown in Figures 17 to 19.

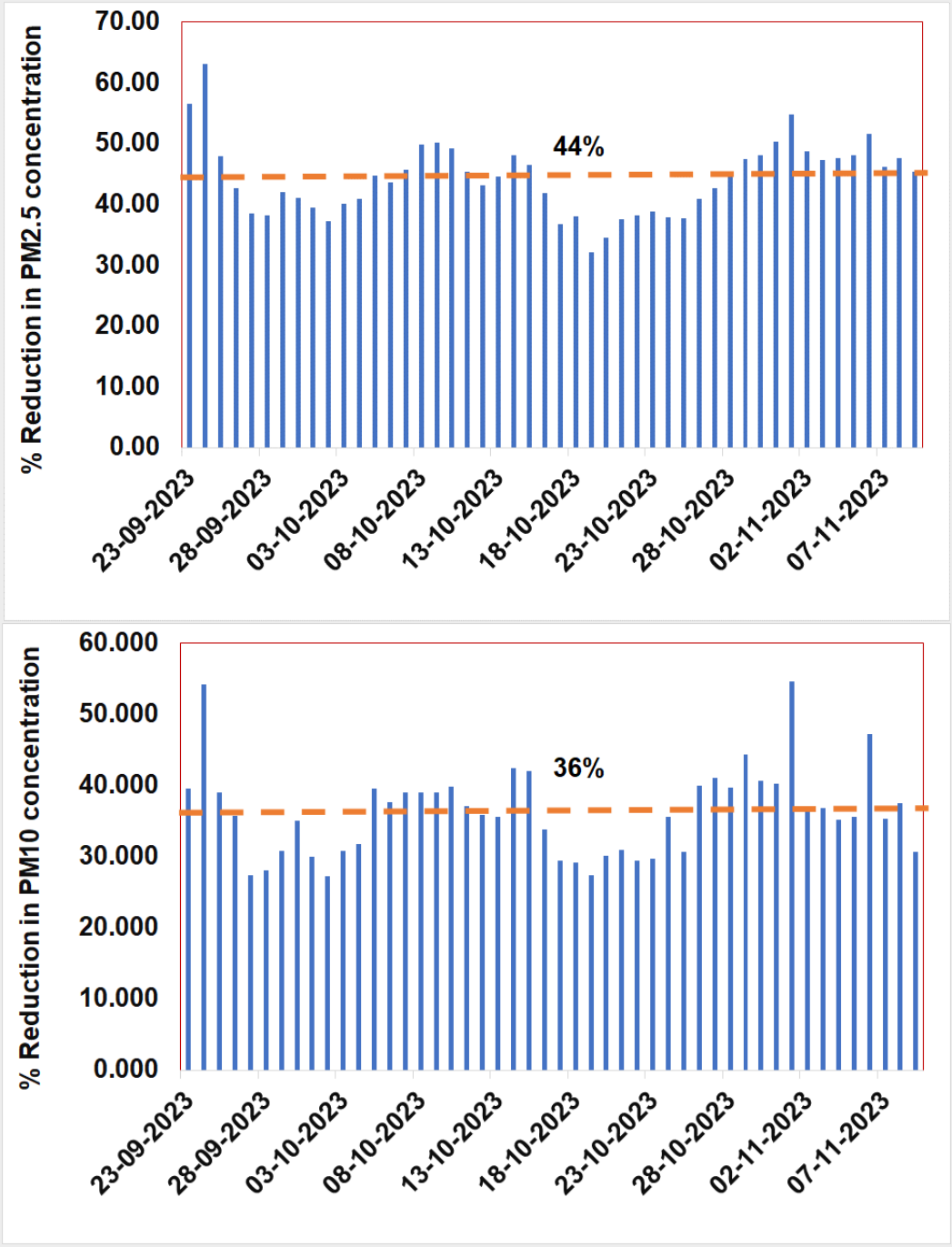


Figure 17. Impact of APS on the percentage reduction in concentration of PM2.5 and PM10 during the pre-winter period.

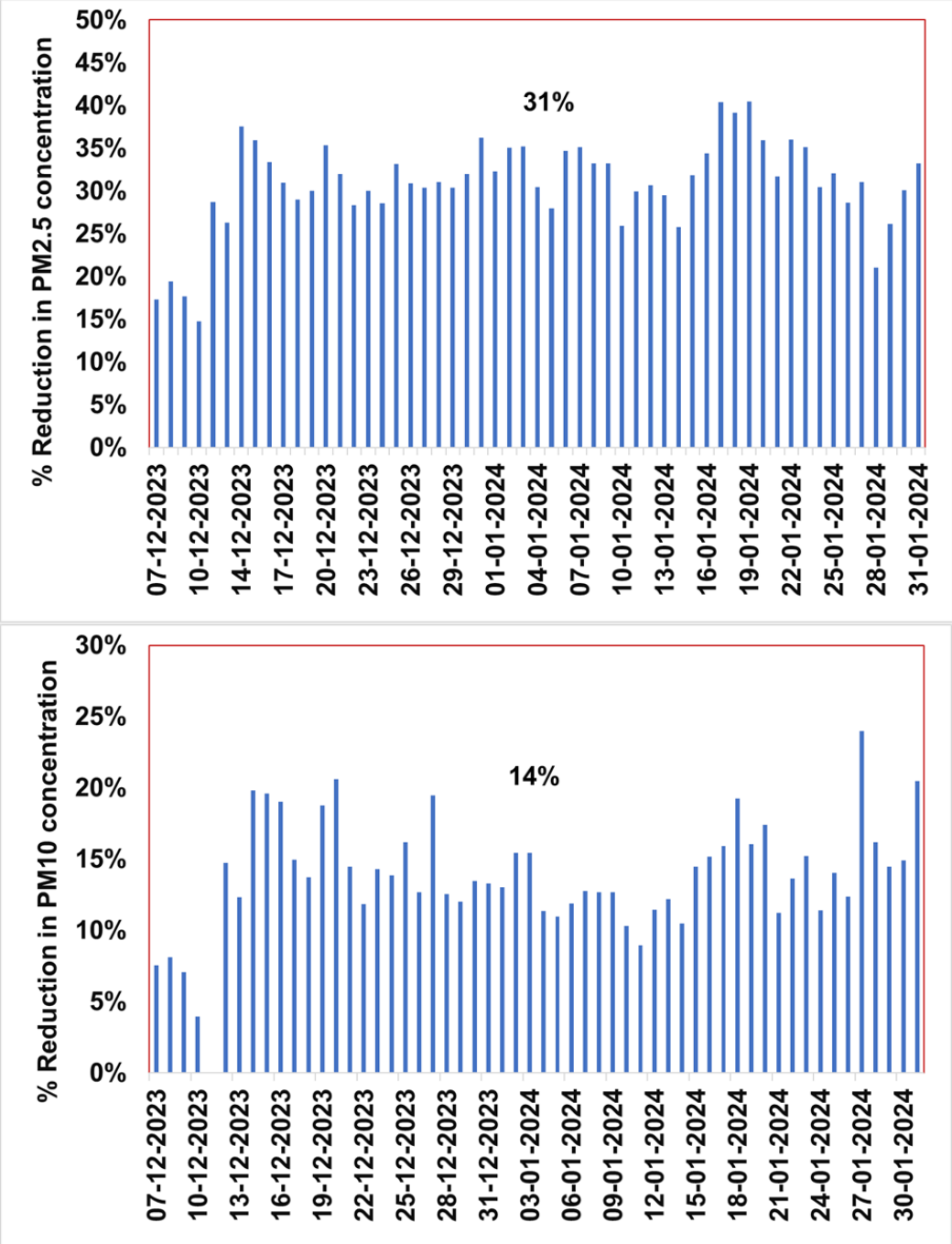


Figure 18. Impact of APS on the percentage reduction in concentration of PM10 and PM2.5 during the winter period.

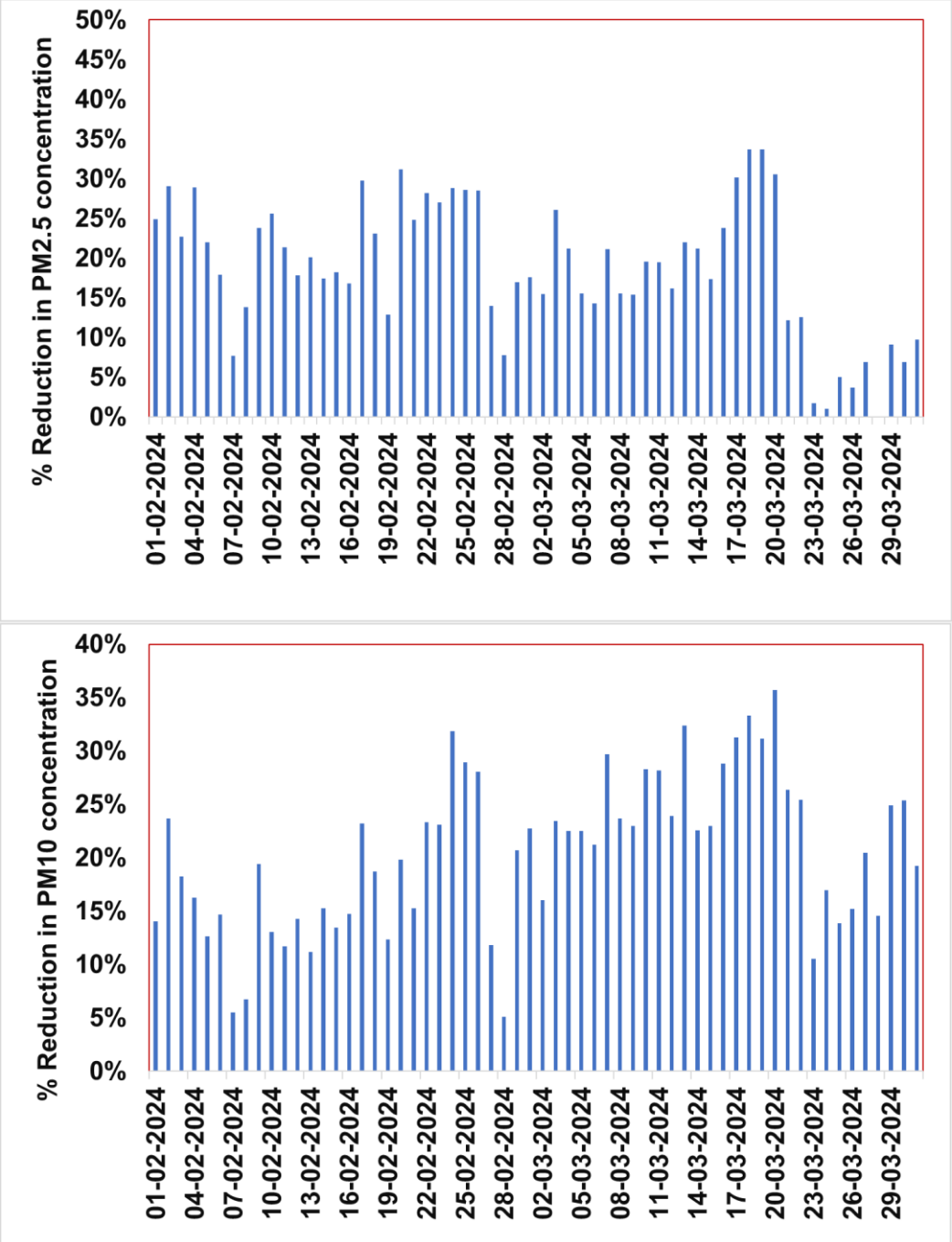


Figure 19. Impact of APS on the percentage reduction in concentration of PM10 and PM2.5 during the post-winter period.

The observations on APS performance are as follows:

- Overall percent reduction in PM10 and PM2.5 was >30%
- Percent reduction was observed to be higher in the pre-winter season when compared to the winter season

Characterization of the PM collected

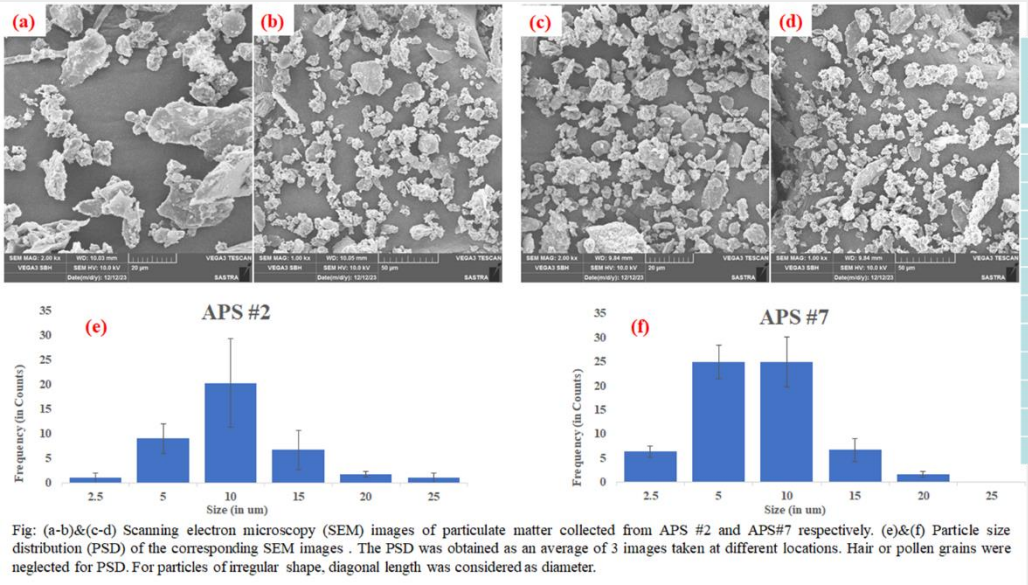
The APS were opened during the week of November 21 – 25, 2023 and the particles collected in the APS were recovered. The mass of particles collected by each APS during the trial period is shown in the table below.

S. No	APS Unit	Date of switching on	Date of particles collection	Mass of particles collected (g) from the day of switching the APS on
1	APS#2	23-09-2023	24-11-2023	370
2	APS#3	23-09-2023	22-11-2023	300
3	APS#4	23-09-2023	24-11-2023	350
4	APS#5	23-09-2023	24-11-2023	340
5	APS#6	13-10-2023	21-11-2023	230
6	APS#7	13-10-2023	25-11-2023	230
7	APS#8	13-10-2023	25-11-2023	200
8	APS#9	13-10-2023	25-11-2023	210

There was some particle loss while removing the same from the collectors, transferring them to plastic containers and weighing. The total mass of particles collected from 8 units during the 2-month window / 40 days window of operation was 2.23 kg. The average particle collection per unit per day is about 5.7 g. Each APS processes 11,500 m^3 of air per day. The mass of PM10 in the total volume of air processed every day was calculated as the product of average PM10 concentration (g/m^3) in platform – A as read by the sensors installed, volume of air processed by each unit (m^3/unit) and the number of APS in operation on that day. The total mass of PM10 in the total volume of air processed from the day of switching the APS on, till the day of particle retrieval, was calculated as the sum of daily particle mass load, to be 2.61 kg. This calculation shows that the individual APS was >85% efficient in particles collection, even after the particulate matter loss due to transfer is neglected. The mass of particles collected from the APS#1 was 620 g for the three months of operation between September 23, 2023 and January 3, 2024 (excluding days on which APS was shut off).

The collected particles were analysed to ascertain the particle size distribution and the elemental composition (elements that are present at >0.05 wt. %). The scanning electron micrographs (Figure 20) revealed that the particles collected were of different sizes and shapes, with particle size ranging between 2 and 30 μm. For particles of irregular shape, the diagonal length was taken as the particle size.

The elemental analysis of the samples, as determined using X-ray fluorescence spectroscopy, revealed the major non-carbon elements to be silicon, calcium, aluminium, potassium, magnesium, sodium and sulphur (all greater than 1 wt.%). Iron and phosphorus were present in the range of 0.3 – 0.5 wt.%, while traces of molybdenum were also detected.



Element	Relative Concentration (%)
O	44.99
Si	24.36
Ca	10.13
Al	8.11
K	2.79
Cl	2.74
Mg	2.39
Na	1.77
S	1.57
Ti	0.45
Fe	0.37
P	0.31

Fig: (a-b)&(c-d) Scanning electron microscopy (SEM) images of particulate matter collected from APS #2 and APS#7 respectively. (e)&(f) Particle size distribution (PSD) of the corresponding SEM images . The PSD was obtained as an average of 3 images taken at different locations. Hair or pollen grains were neglected for PSD. For particles of irregular shape, diagonal length was considered as diameter.

Figure 20. Scanning electron micrographs of particles collected and the particle size distribution. For the analysis, samples from APS#2 and APS#7 have been taken.

The collected PM samples were then subjected to acid digestion (similar to ASTM Method ASTM E2941-21 and similar US EPA methods) and analysed using ICP-MS at **Indian Institute of Technology, Delhi**. The table below shows the key metals detected of interest.

Table 1. Elemental Analysis using ICP-MS

Heavy Metal	Measured Concentration (mg/kg)	International Soil Standard* (mg/kg)
Arsenic	7.68	20
Cadmium	9.39	0.9-3
Chromium	75.57	150
Lead	130.80	30-50
Mercury	101.94	0.03-2
Molybdenum	3.95	NA
Selenium	4.28	NA

**World Health Organization (WHO) (1996) Permissible Limits of Heavy Metals in Soil and Plants*

Based on the observed values, we strongly feel that cadmium, lead and mercury concentrations in the collected suspended PM were significantly high when compared to soil samples, and may be a cause of concern from a human-health perspective. A second set of PM collected was also sent to IIT Delhi for heavy metal determination. The data was almost similar, substantiating the fact the values reported above was not an anomaly.

Further calculations shown below indicate the concentration of the important elements in ambient air. Each unit collected approximately 5.7 g on a 24-hour basis, while operating at 200-285 CFM (339 - 483 m^3/hr). Based on the collected amount and the volume sampled, the particulate bound concentration of the heavy metals is as follows:

Table 2. Concentration of Heavy metals in suspended particulate matter

Heavy Metal	Measured Concentration	CPCB Air quality Standards*	International Standards**
Arsenic (ng/m³)	4-5	6	6
Cadmium (µg/m³)	0.005-0.007	NA	0.0002
Chromium (µg/m³)	0.037-0.053	NA	0.012
Lead (µg/m³)	0.064-0.092	0.5	0.5
Mercury (ng/m³)	50-71	NA	NA
Molybdenum (µg/m³)	0.002-0.003	NA	NA
Selenium (µg/m³)	0.002-0.003	NA	NA

**National Ambient Air Quality Standards (NAAQS), CPCB, 2009 - No.B-29016/20/90/PCI-L*
***Morakinyo, Oyewale & Mukhola, Murembiwa & Mokgobu, Ingrid. (2021). Health Risk Analysis of Elemental Components of an Industrially Emitted Respirable Particulate Matter in an Urban Area. International Journal of Environmental Research and Public Health. 18. 3653. 10.3390/ijerph18073653.*

The presence of arsenic in concentration close to ambient air quality standards, and the presence of mercury at **concentrations 25 times higher** than globally averaged concentration of 1.5-1.7 ng/m³ is a cause of concern. Furthermore, the presence of cadmium and chromium at concentrations higher than international standards set by USEPA is also a significant cause of concern.

There are two samples tested to double check the findings related to heavy metals.

In a separate analysis with **UV-Visible spectroscopy**, there are evidence of presence of **Hexavalent Chromium** in the particulate matter collected.

These findings necessitate that we should continue to remove the suspended PM from the air.

Conclusions

- With the deployment of APS Units, an average of 30 % reduction in PM2.5 and 25% reduction in PM10 was achieved during the 6-month period. On an average, 25% reduction in AQI was accomplished.
- The APS was running 24x7 and did not require any attention or maintenance.
- The average particle collection from the 10 APS systems is 57 g/day during winter. The efficiency of APS in collecting the particulate matter is estimated to be >85% without any maintenance or replacement.
- The particulate matter removed from air contained more than acceptable concentrations of heavy metals such as mercury and hence the APS units provided partial relief to public through collection of particulate matter in air.
- The functioning of APS units did not cause any inconvenience to the users or the shop keepers. The shopkeepers articulated and recorded their testimonials of the improved ambient conditions due to APS serve as testimony to the trial's success.

Recommendations

Based on the experiences gained, data collected and analysed during the trial, the following recommendations are made:

1. The trial in Platform – A has demonstrated the ability of APS to remove particulate matter from air from an important location such as ISBT Anand Vihar. It is recommended that APS may be deployed in other platforms, in addition to the existing 10 APS, so as to realize its impact on the reduction of exposure to PM2.5 and PM10.
2. The trial can be carried out at other 12 hotspots in Delhi-NCR and other industrial areas, industries, busy road junctions, construction sites, dump yards etc. to ascertain the potential benefits in the perspective of air quality.
3. It is recommended that a detailed study on the heavy metals concentration in air be carried out pan Delhi-NCR and potential sources to establish source – hot spot air quality correlation, in the context of the concentration of the heavy metals.

ANNEXURE 1

Measurement Date	APS Operational Status	Platform A			Platform B			Remarks
		PM2.5	PM10	AQI	PM2.5	PM10	AQI	
		µg/m³	µg/m³		µg/m³	µg/m³		
23-09-2023	APS On	50	136	124	115	225	282	Start of Trial (6 Unit)
24-09-2023	APS On	66	168	145	178	366	345	
25-09-2023	APS On	59	163	142	113	266	278	
26-09-2023	APS On	66	176	151	116	274	285	
27-09-2023	APS On	43	136	124	71	187	158	
28-09-2023	APS On	43	135	123	69	187	158	
29-09-2023	APS On	50	144	129	86	208	186	
30-09-2023	APS On	65	170	147	111	262	268	
01-10-2023	APS On	45	135	123	75	193	162	
02-10-2023	APS On	47	140	127	75	192	161	
03-10-2023	APS On	43	134	123	71	194	163	
04-10-2023	APS On	50	144	129	84	210	180	
05-10-2023	APS On	59	158	139	106	262	254	
06-10-2023	APS On	74	195	164	131	313	308	
07-10-2023	APS On	65	180	153	120	295	300	
08-10-2023	APS On	49	144	129	97	236	223	
09-10-2023	APS On	55	161	141	111	264	270	
10-10-2023	APS On	55	158	139	108	263	261	
11-10-2023	APS On	62	166	144	112	264	275	
12-10-2023	APS On	85	216	183	149	337	322	
13-10-2023	APS On	108	264	260	195	410	375	All 10 units operational
14-10-2023	APS On	78	199	166	150	346	323	
15-10-2023	APS On	60	166	144	113	287	276	
16-10-2023	APS On	46	142	128	80	214	176	
17-10-2023	APS On	42	133	122	67	189	160	
18-10-2023	APS On	42	134	123	68	190	160	
19-10-2023	APS On	48	141	127	70	194	163	
20-10-2023	APS On	81	204	170	124	291	303	
21-10-2023	APS On	127	309	305	203	448	422	
22-10-2023	APS On	136	331	312	219	469	449	
23-10-2023	APS On	113	275	277	185	392	352	
24-10-2023	APS On	85	211	184	137	328	313	
25-10-2023	APS On	105	258	252	169	372	338	
26-10-2023	APS On	87	209	191	148	349	321	
27-10-2023	APS On	104	251	248	182	426	395	
28-10-2023	APS On	122	295	302	222	490	475	
29-10-2023	APS On	123	292	302	233	525	519	
30-10-2023	APS On	130	320	308	251	540	537	

31-10-2023	APS On	147	364	321	296	609	624	
01-11-2023	APS On	107	234	255	235	517	508	
02-11-2023	APS On	191	441	414	373	700	738	
03-11-2023	APS On	185	439	412	351	696	732	
04-11-2023	APS On	197	472	453	377	728	773	
05-11-2023	APS On	193	472	452	372	733	779	
06-11-2023	APS On	136	330	312	281	624	643	
07-11-2023	APS On	173	428	397	321	661	689	
08-11-2023	APS On	169	411	376	323	658	685	
09-11-2023	APS On	202	495	481	370	714	755	
21-11-2023	APS On	186	366	350	200	493	478	
22-11-2023	APS On	257	490	474	197	496	483	
23-11-2023	APS On	260	499	486	222	526	520	
24-11-2023	APS On	315	556	557	275	578	584	
25-11-2023	APS Off	279	524	518	227	533	529	
26-11-2023	APS Off	353	587	597	296	591	602	
27-11-2023	APS Off	223	456	433	158	456	433	
28-11-2023	APS On	184	391	351	123	367	321	
29-11-2023	APS On	236	461	439	166	445	419	
30-11-2023	APS On	311	561	564	231	541	539	
01-12-2023	APS On	277	532	527	188	500	487	
02-12-2023	APS On	162	395	356	114	382	340	
03-12-2023	APS On	153	356	326	108	347	297	
04-12-2023	APS On	170	371	338	120	356	308	
05-12-2023	APS On	133	317	310	90	304	254	
06-12-2023	APS On	127	319	305	99	333	283	
07-12-2023	APS On	223	440	413	193	488	472	
08-12-2023	APS On	165	366	335	101	236	236	
09-12-2023	APS On	158	364	329	120	246	300	
10-12-2023	APS On	141	338	316	96	193	218	
11-12-2023	APS On	175	387	347	182	353	348	
12-12-2023	APS On	241	467	446	339	548	547	
13-12-2023	APS On	270	483	466	366	551	551	
14-12-2023	APS On	152	360	324	243	448	423	
15-12-2023	APS On	180	398	359	281	494	480	
16-12-2023	APS On	225	443	416	338	547	546	
17-12-2023	APS On	190	400	363	275	471	451	
18-12-2023	APS On	131	336	308	184	390	350	
19-12-2023	APS On	119	302	296	170	371	338	
20-12-2023	APS On	132	331	309	204	417	384	
21-12-2023	APS On	237	471	452	349	551	551	
22-12-2023	APS On	349	573	578	487	650	674	
23-12-2023	APS On	422	654	680	607	735	781	
24-12-2023	APS On	296	492	478	414	572	578	
25-12-2023	APS On	232	453	428	347	540	538	

26-12-2023	APS On	266	505	493	384	578	585	
27-12-2023	APS On	378	653	679	543	811	876	
28-12-2023	APS On	239	534	530	347	611	626	
29-12-2023	APS On	281	583	591	403	663	691	
30-12-2023	APS On	237	559	561	348	646	670	
31-12-2023	APS On	159	493	479	250	569	573	
01-01-2024	APS On	130	445	418	192	511	501	
02-01-2024	APS On	121	401	364	186	474	455	
03-01-2024	APS On	193	492	477	298	582	589	
04-01-2024	APS On	215	537	534	309	606	620	
05-01-2024	APS On	185	509	498	256	571	576	
06-01-2024	APS On	147	476	458	225	540	538	
07-01-2024	APS On	150	462	440	231	530	525	
08-01-2024	APS On	208	562	566	312	644	667	
09-01-2024	APS On	126	431	401	188	494	480	
10-01-2024	APS On	127	450	426	171	502	490	
11-01-2024	APS On	173	504	492	248	553.29	554	
12-01-2024	APS On	214	506	495	309	572	577	
13-01-2024	APS On	365	644	668	518	734	780	
14-01-2024	APS On	357	635	656	481	709	749	
15-01-2024	APS On	211	467	446	309	546	545	
16-01-2024	APS On	257	541	539	391	638	660	
17-01-2024	APS On	144	455	431	242	541	539	
18-01-2024	APS On	138	425	393	227	526	520	
19-01-2024	APS On	150	459	436	252	547	546	
20-01-2024	APS On	140	424	392	219	513	504	
21-01-2024	APS On	187	497	484	274	560	563	
22-01-2024	APS On	151	486	470	236	563	566	
23-01-2024	APS On	210	537	534	324	633	654	
24-01-2024	APS On	226	541	539	325	611	626	
25-01-2024	APS On	215	504	493	316	587	596	
26-01-2024	APS On	337	583	591	472	666	694	
27-01-2024	APS On	163	335	333	236	441	414	
28-01-2024	APS On	303	501	489	383	598	610	
29-01-2024	APS On	229	492	477	311	575	582	
30-01-2024	APS On	268	571	576	383	671	701	
31-01-2024	APS On	271	544	542	406	684	718	
01-02-2024	APS On	83	212	178	111	247	270	
02-02-2024	APS On	123	327	302	173	428	398	
03-02-2024	APS On	92	232	206	119	283	296	
04-02-2024	APS On	137	303	313	193	362	356	
05-02-2024	APS On	100	276	233	128	316	306	
06-02-2024	APS On	72	219	179	88	257	207	
07-02-2024	APS On	73	180	154	79	191	163	
08-02-2024	APS On	68	169	146	79	181	163	

09-02-2024	APS On	79	188	163	104	233	246	
10-02-2024	APS On	189	388	353	254	446	420	
11-02-2024	APS On	166	357	335	211	404	370	
12-02-2024	APS On	186	369	351	227	430	400	
13-02-2024	APS On	244	471	451	305	530	525	
14-02-2024	APS On	206	394	366	250	465	444	
15-02-2024	APS On	132	309	309	162	357	332	
16-02-2024	APS On	107	263	256	128	309	307	
17-02-2024	APS On	103	263	244	147	342	321	
18-02-2024	APS On	121	281	300	157	346	328	
19-02-2024	APS On	93	217	210	107	248	256	
20-02-2024	APS On	153	330	325	222	412	379	
21-02-2024	APS On	101	245	237	134	290	311	
22-02-2024	APS On	55	150	133	76	196	164	
23-02-2024	APS On	44	123	116	60	160	140	
24-02-2024	APS On	71	178	152	100	261	234	
25-02-2024	APS On	65	159	139	91	223	202	
26-02-2024	APS On	69	171	147	96	237	221	
27-02-2024	APS On	56	136	124	65	154	136	
28-02-2024	APS On	65	158	138	71	166	144	
29-02-2024	APS On	60	143	129	73	180	154	
01-03-2024	APS On	83	187	175	100	242	234	
02-03-2024	APS On	40	95	95	47	113	109	
03-03-2024	APS On	51	136	124	70	178	152	
04-03-2024	APS On	42	115	110	53	149	132	
05-03-2024	APS On	45	108	105	53	139	126	
06-03-2024	APS On	57	127	118	66	161	141	
07-03-2024	APS On	61	137	125	78	195	163	
08-03-2024	APS On	51	115	110	60	151	134	
09-03-2024	APS On	54	124	116	64	161	141	
10-03-2024	APS On	66	153	135	81	214	176	
11-03-2024	APS On	78	165	161	97	229	224	
12-03-2024	APS On	80	170	168	96	224	219	
13-03-2024	APS On	75	161	148	96	238	219	
14-03-2024	APS On	98	205	225	124	265	303	
15-03-2024	APS On	37	102	102	44	133	122	
16-03-2024	APS On	56	140	127	74	197	165	
17-03-2024	APS On	59	159	139	85	231	187	
18-03-2024	APS On	62	163	142	93	245	211	
19-03-2024	APS On	87	206	191	132	299	309	
20-03-2024	APS On	71	159	139	101	246	238	
21-03-2024	APS On	70	142	135	80	194	168	
22-03-2024	APS On	76	154	152	86	207	188	
23-03-2024	APS On	96	199	219	97	223	224	
24-03-2024	APS On	67	165	143	68	199	166	

25-03-2024	APS On	76	172	154	80	200	168	
26-03-2024	APS On	59	151	134	62	179	152	
27-03-2024	APS Off	56	129	119	60	162	141	
28-03-2024	APS Off	47	113	109	44	133	122	
29-03-2024	APS Off	54	133	122	59	177	151	
30-03-2024	APS Off	69	143	130	74	191	161	
31-03-2024	APS Off	64	147	131	71	182	155	End of Project Duration

a. Outputs of significance

(i) Details of patents/copyrights

Umeandus Technologies India Private Limited & SASTRA had jointly filed a patent for an Air Purification System, before the submission of the project proposal. The system has been finetuned for use in ISBT Anand Vihar.

(ii) Details of publications, etc.

Since the objective of the project is to conduct trial of Ambient Air Purification System (APS), the outcomes have been document in the form of a detailed report containing raw data, data analysis & interpretation, instead of journal publication(s). The completion report contains raw data and its analysis.

b. Details of training imparted

This is not within the scope of the project

Date: April 25, 2024

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25/4/2024

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