

1 **Air pollution walk as an impact education tool for air quality sensitization**  
2 **in the global south****Air pollution walk as an impact education tool for air**  
3 **quality sensitization: A pilot from an Indian megacity**

4  
5 **Debabrata Bej<sup>1</sup>, Sandip Sankar Ghosh<sup>2</sup>, Srijan Haldar<sup>3</sup> and Arindam**  
6 **Roy<sup>\*2</sup>**

7 <sup>1</sup>Department of Electronics and Communication Engineering, National Institute of  
8 Technology (NIT) Durgapur, Durgapur, West Bengal, India

9 <sup>2</sup>The Climate Thinker, Kolkata, West Bengal, India

10 <sup>3</sup>Swami Vivekananda University, Barrackpur, West Bengal, India

11  
12 **Abstract**

13 Air pollution has become a serious matter of concern in the global south and a significant  
14 amount of funding has been used to create awareness of air pollution. The conventional method  
15 of sensitization relies on workshops where slide-based presentations, images, plots and graphs  
16 are shown to the participants. However, sensitization about air quality using such an audio-  
17 visual format might not be sufficient to create adequate impact. Here in this study, we propose  
18 a new sensitization technique, the pollution walk, where participants and a subject matter expert  
19 will walk through different urban micro-environments with live air quality monitor. A pilot  
20 involving three such pollution walks with 24 participants were conducted in a south Asian  
21 megacity and pre and post-walk~~ante~~ survey were conducted. The results indicate a greater sense  
22 of understanding among the participants and multidisciplinary nature of the air pollution  
23 problem has been well communicated. To understand the long-term impact, a survey after one  
24 year has been done which clearly indicates high levels of awareness and behavioural changes  
25 among the participants.

26  
27 **Keywords**

28 Air quality; Sensitization; Outdoor education; Risk communication

29  
30  
31  
32  
33  
34  
35  
36 **\*Corresponding author**

37 **arindam.roy@epfl.ch**

38 **1.0 Introduction**

39

40 World Air Quality Report (2020) has listed 37 of 40 most polluted cities in the globe are from  
41 South Asia and the national ranking shows India (Rank 5) is leading in terms of poor air quality.  
42 33% of the global death due to air pollution occurs in South Asian countries and air pollution  
43 contributes to approximately 11 percent of all deaths (Bart and Mattos, 2018). The global  
44 burden of disease study shows that 1.24 million death in India was attributed to air pollution in  
45 2017 and both indoor (0.48 million death) and outdoor (0.68 million death) sources contributed  
46 significantly (Balakrishnan et al., 2019). Overall, the air quality over Indian cities ~~have~~has  
47 significant health impact on the citizens (Guttikunda & Goel 2013; Gargava & Rajagopalan,  
48 2015). Among the air pollutants, PM2.5, or Particulate Matter with less than 2.5µm diameter  
49 is considered as the dominating air pollutants due to its immense health impact (Balakrishnan  
50 et al., 2019). Generated via combustion process, these tiny particles can enter into human lungs  
51 and increase the risk of lung cancer, chronic obstructive pulmonary disease and asthma (Apte  
52 et al., 2018; Bu et al., 2021). PM2.5 exposure is decreasing global life expectancy by 1 year  
53 and for polluted regions over Asia, it can decrease life expectancy up to 1.9 years (Apte et al.,  
54 2018).

55

56 Awareness of air pollution could play a vital role in reducing air pollution (Selden and Song;  
57 1994; Liao et al., 2015; Veloz et al., 2020). Lack of awareness among the air pollution  
58 vulnerable groups was reported in previous studies conducted in the global south (Guttikunda  
59 et al., 2014; Mor et al., 2022). The scope of air pollution through the educational curriculum is  
60 limited and confined to the indoor syllabus-oriented modules, whereas there are scopes to  
61 improve awareness beyond the syllabus-oriented approach (Huo et al., 2020). Community-  
62 based outdoor education approaches have been proven to improve the understanding of the  
63 participants irrespective of the age groups (Commodore et al., 2017; Szczytko et al., 2020;  
64 Garip et al., 2021). Fieldwork, community learning and outdoor engagement could help in  
65 developing better environmental literacy and inspire people to shift towards more sustainable  
66 consumption and environmental-friendly practice (Christie and Waller; 2019; Persson et al.,  
67 2022). Previous studies have shown that citizen participation program or “Citizen Science”  
68 driven air quality monitoring has been able to create active engagement and results in achieving  
69 larger social objectives in cities over global north (Nali & Lorenzini, 2007; Gabrys et al.,  
70 2016; Commodore et al., 2017; Varaden et al., 2018). However, such studies in the polluted  
71 global south are not available where impact sensitization has been created through a citizen  
72 science program in air quality measurement.

73

74 Kolkata is one of the megacities in the eastern part of India with 14.1 million people (Census  
75 data, taken from <https://bengallocal.in/districts/kolkata/>). Previous studies have reported poor  
76 air quality and ~~associated~~adjacent respiratory illness in the city (Ghose et al., 2005; Haque and  
77 Singh, 2017; Dutta and Pal, 2023). Industry, transport and biomass burning are known to be  
78 one of major sources of air pollution in Kolkata and an approximately 10,200 people die  
79 because of air pollution per year (Lelieveld et al., 2015; Gurjar et al., 2016). The deterioration  
80 of air quality is coupled with a lack of air quality information, public display and awareness

81 among the citizens. The present study intends to introduce a new awareness-building tool for  
82 improving the understanding of air pollution among the citizens. A walk across different parts  
83 of the city with air quality monitors and live data display (in brief, “**p**ollution **w**alk”) has  
84 been conducted with diverse groups of citizens and several complex air quality-related topics  
85 have been introduced. To the best of our knowledge, such innovative tools have not been  
86 introduced in India before and globally, only we have found a single approach in London  
87 (Gabrys, 2017). In the global north megacities, where air pollution has become a primary  
88 reason for premature mortality, no such innovative sensitization techniques have been used to  
89 the best of our knowledge.

90  
91

## 92 **2.0 Methodology**

93

94 The air pollution walk began with a short pre-walk discussion and then participants were asked  
95 to follow a specific path comprising of roads, food stalls, traffic intersections etc. with a  
96 handheld PM2.5 monitor (Fig S1). The PM2.5 monitoring procedure has been discussed in  
97 detailed at Section 2.3. A short training was given to all participants regarding operation  
98 process of PM2.5 monitor and data collection procedure. During the path, the participants were  
99 sensitized about the relevant sources by showing them the live PM2.5 data and detailed  
100 explanations were provided. Post-walk, a focus group discussion was organized with the  
101 participants from the walk to discuss the results. Three such air pollution walks have been  
102 organized during the month of July 2022 with 24 participants together. Pre and post-walk  
103 survey ~~were~~ done with the participants. A follow-up open-ended survey was done after one  
104 year (July 2023) with the participants. The walk works as a citizen science program where  
105 scientists designed the program and walk with participants who act as a contributor to the  
106 project (Wildschut, 2017).

107

### 108 **2.1 Route for demonstration**

109

110 Several aspects need to be taken care of before finalizing a route for demonstrating air quality.  
111 The route that has been selected for the study was comprised of indoor housing, followed by a  
112 kitchen, minor roads with residential houses and commercial outlets, a major road, a busy  
113 traffic intersection, roadside food stalls, and an industrial unit. Each of the micro-environments  
114 has different sources of air pollutants. The major roads have a stretch of 400 meters and it  
115 includes a busy cross-section with one minute of signal time. On average, approximately  
116 10,000 cars pass during office hours on the major road. The minor roads (~600m long) have  
117 one-tenth of the traffic as compared to the major road. Multiple roadside restaurants using  
118 biomass as cooking fuel were observed during the trial. The industrial unit uses smelters and is  
119 located on the main road. The entire trail map is represented in Fig 1. The walk took place  
120 during busy hours while most of the city people are returning home from office (6:00pm) and  
121 took nearly two hours to finish.

122

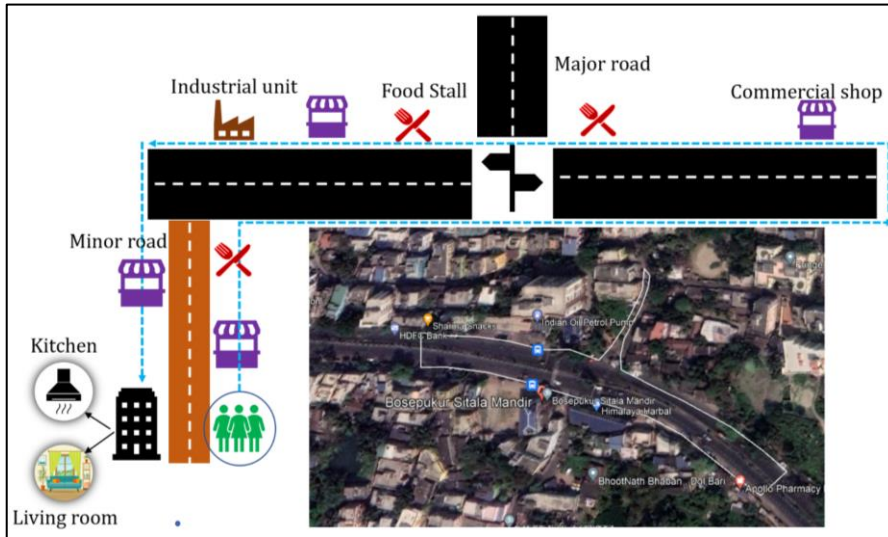


Fig 1: Schematic and satellite image of the pollution walk path for the study. The blue dash line indicates walking trail (© Google Earth).

## 2.2 Targeted air pollutant characteristic

Traditionally air quality has been measured using a fixed monitoring station installed in traffic sites or background sites to understand the compliance and trend of air quality (Varaden et al., 2021). Such stations are limited in terms of data availability and accessibility to the citizens and also do not represent individual pollutant exposure (Snyder et al., 2013; Steinle et al., 2013). The recent advancement of low-cost mobile air quality sensors provides a unique opportunity to improve spatial monitoring extents as well as the perception of air quality among the citizens (Nieuwenhuijsen et al., 2015). Live data also provide an interesting scope to explain several air quality-related topics which generally remain unturned during a conventional workshop. Here, the participants were able to visualize a) how ventilation improves indoor air quality; b) differential emission from different sources; c) improvement of air quality away from the sources; d) impact of meteorology on air quality; e) spatial distribution of air pollutants. The pre-walk briefing was conducted in a room where the entire procedure was described to the participants and we also measured the ambient PM<sub>2.5</sub> concentration in the room. Then the participants were asked to visit the adjacent kitchen to monitor the indoor pollution contribution by cooking. Then the participants moved outside and it was explained how ventilation helps to dilute air pollutants. Further, the participants walked through major and minor roads and measure air pollutants in different settings. The participants walked through the same route to the room and a semi-structured interview was taken.

## 2.3 Measurement of air pollutant

150 PM2.5 has been considered this study's target pollutant since it is indisputably the most  
 151 harmful air pollutant in India (Balakrishnan et al., 2019). A high-precision digital particulate  
 152 matter 2.5 (PM2.5) concentration sensor, Plantower PMS5003, has been used to measure the  
 153 mass and amount of suspended particulate matter (PM2.5) in the air. This PMS5003 sensor has  
 154 been integrated with an Arduino Mega 2560 micro-controller. A temperature and relative  
 155 humidity sensor, DHT22, has also been attached to the micro-controller. DS3231 real-time  
 156 clock (RTC) module has been integrated with the system to provide precise time and date to  
 157 the PM2.5 data. The NEO-6M GPS Module has been connected to the system to receive  
 158 georeferenced PM2.5 pollution data at any location. An LCD has been interfaced with the  
 159 system to display the PM2.5 data. For real-time data capture, a micro SD card has been  
 160 connected to the system using a micro SD card module. A 18650 Lithium Battery Shield has  
 161 been used to supply the required power to operate this system. The code has been written and  
 162 uploaded to the Arduino Mega 2560 microcontroller board using the Arduino IDE 1.8.19  
 163 software. The PM2.5 monitor has been calibrated against a reference monitor, and relative  
 164 humidity corrections have been made following previous literature (Badura et al., 2018;  
 165 Feenstra et al., 2019; Jha et al., 2021)

#### 166 2.4 Participants and interviews

167  
 168  
 169 Three air pollution walks were conducted thrice with a total of 24 participants altogether. The  
 170 participants come from different socio-economical and educational background which has been  
 171 summarized in Table 1. The age range of the participants falls from 18 to 68 (All participants  
 172 are adult, minors are tagged along with some of the parents). Among the participants, there are  
 173 students, government and private employees, housewives, and retired professionals. Pre and  
 174 post-walk survey were conducted among the participants. The immediate post-walk interview  
 175 was done to understand if this improves their understanding of air pollution and if they prefer  
 176 this format (pollution walk) over audio-visual presentation-based sensitization. A follow-up  
 177 interviews were done a year after the walk, after one years of the walk to understand how the  
 178 learning impacted their understanding of air pollution and if the takeaway messages are  
 179 integrated into their lifestyle of not.

180 All the questionnaire from the interviews is represented in Fig 3.

181

182 Table 1: Description about the backgrounds of the participants

183

Variables	Category	Percentage (n = 24)
Gender	Male	46% (n = 11)
	Female	54% (n = 13)
	Unknown	0% (n = 0)
Age	<25	25% (n = 6)

Formatted Table

	25-60	54% (n = 13)
	>60	21% (n = 5)
Education	Undergraduate	29% (n = 7)
	Postgraduate	71% (n = 17)
Occupation	Student	25% (n = 6)
	Employed	38% (n = 9)
	Unemployed	17% (n = 4)
	Retired	20% (n = 5)

Formatted Table

184

### 185 3. Results

186

#### 187 3.1 Distribution of PM<sub>2.5</sub>

188

189 ~~The~~ participants measured PM<sub>2.5</sub> concentration in different microenvironments during the  
 190 pollution walk (Fig 2). The average PM<sub>2.5</sub> concentration was found to be 85±66 micrograms  
 191 per cubic meter which is approximately 17 times higher as compared to the WHO standards  
 192 (<https://www.who.int/tools/airquality-standards>). Higher PM<sub>2.5</sub> concentrations were  
 193 observed in the kitchen (70±19 µg/m<sup>3</sup>) as compared to the room (34±5 µg/m<sup>3</sup>). Pollution level  
 194 drops after the participants began the outdoor walk due to the increased ventilation. As the  
 195 participants started walking toward the main road, gradual increases in pollutant concentration  
 196 were observed. The highest outdoor concentration was observed while ~~walking~~  
 197 ~~at~~ ~~the~~ ~~stalls~~ ~~participants~~ ~~stop~~ at a busy traffic intersection. As the signal turned green, vehicles  
 198 started their engines and participants measured PM<sub>2.5</sub> concentration of 186 µg/m<sup>3</sup> concentration  
 199 of PM<sub>2.5</sub>. The average concentration of PM<sub>2.5</sub> on the main road was found to be 98±31 µg/m<sup>3</sup>.  
 200 An exponential fall in PM<sub>2.5</sub> concentration was observed while the participants entered the  
 201 minor roads with lesser traffic density. Participants also measure pollutant concentration near  
 202 roadside food stalls where biomass has been used as a fuel source. The smoke from the food  
 203 stall was clearly visible and the participant measured 214±51 micrograms per cubic meter at  
 204 meter from the oven. Concentrations near a small workshop near the streets that uses smelter  
 205 were found to be 121±53 µg/m<sup>3</sup>. While coming back, the participants ~~also~~ ~~measure~~ ~~at~~  
 206 to recheck the concentration and it was found to be comparable. During the walk, pollutants  
 207 were monitored during windy periods where substantial reductions in concentration were  
 208 observed.

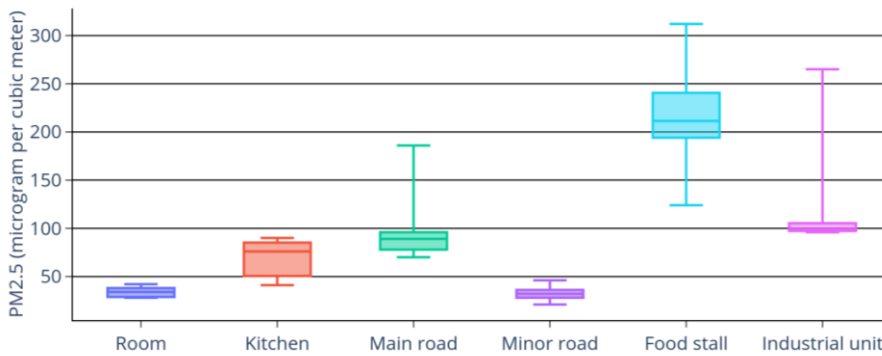


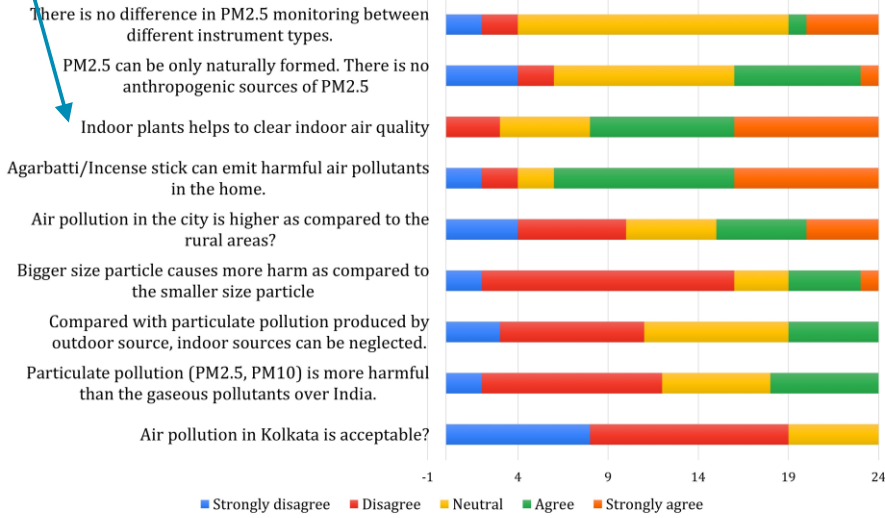
Fig 2: Box plot depicting the PM2.5 concentration profile in different micro-environments during the pollution walk

### 3.2 Participant perception of air quality from pre-walk and post-walk

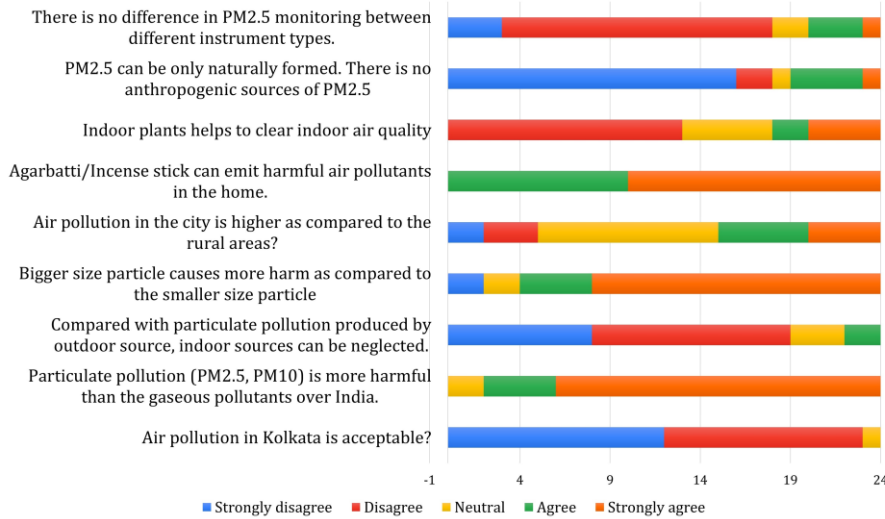
The pre-walk and post-walk survey ~~were~~ was conducted to understand ~~the precipitation of the participants about improvement of participant's knowledge on~~ air pollution, sources and impact (Fig 3). Some questions are very basic and should be answerable by the people who regularly read news reports on air pollution. Other questions are more advanced and require more in-depth understanding to answer. Not all of the participants know about the deteriorating air quality over Kolkata or ~~that~~ smaller size particles are more harmful as compared to the bigger size particles. ~~Half most~~ half of the participants still considered gaseous pollutants as the major air pollutants in the atmosphere. It was also found that the participants have basic knowledge of indoor pollution as well as a significant proportion identified incense stick as harmful air pollutant sources and also support the statement that indoor pollution is a significant source of particulate ~~matter~~ pollution. It was evident that most of the participants did not have specific idea regarding air pollution source or monitoring overall.

The post-walk survey was conducted just after the walk and before the discussion. Significant improvement in air quality knowledge can be observed (Fig 3). Specially, answer to the how smaller size particulate matter has impact on health and source specific questions, has been improved. ~~The~~ participants knowledge on indoor air pollution has been also marginally increased. Overall knowledge on air pollution has been improved and the answer of the questions during post-walk has shifted more towards the extreme (strongly agree and strongly disagree) which indicates that the participants are now confident regarding their understanding on air pollution as well. We have raised the question during post-walk meeting about their preference regarding the mode of the learning exercise. Participants clearly mentioned that the pollution walk is definitely better as compared to conventional PowerPoint presentations.

**(a) Pre-walk**



**(b) Post-walk**



239  
240 Fig 3: Interview questions and answers during pre-walk and post-walk time

241  
242 **3.3 Long-term participant sensitization and behavioural change**

243  
244 At each point of the walk, participants measured particulate matter 2.5 (PM2.5) concentration  
245 and after that, they were briefed about the possible reason behind such observation. Native  
246 language Bengali was used as communication medium. The observation, related concept  
247 introduction and adaptation procedures are summarized in Table 2.



248

249 The walk began in a room where participants measured concentration in the living room and  
250 in the kitchen. The higher concentration in the kitchen was explained by the emission of air  
251 pollutants during the different cooking processes like frying and toasting. The impact of  
252 ventilation was also showed through measurement of PM2.5 while opening and closing of  
253 window. It was surprising for the participants as even after using clean cooking (LPG),  
254 the concentration of PM2.5 was found to be twice as high compared to the room. Here we  
255 elaborate on the emission of PM2.5 in the different cooking processes (Chafe et al., 2014;  
256 Shupler et al., 2018) and participants were advised to use induction cook top or LPG if possible,  
257 install a kitchen chimney, keep the doors and window of kitchen remain open during the  
258 cooking procedure.

259

260 During our interview of the participant after one year, it was observed that 88% of participants  
261 able to remember to keep the doors and window remain open condition at kitchen during the  
262 cooking. 17% of the participants have shifted their cooking process to electrical. Moreover, 4%  
263 of them even installed a kitchen chimney. This change in behaviour indicates these  
264 participants are aware about the harmful effects of indoor air pollution due to cooking through  
265 the previous event and tried to modify their lifestyle accordingly. During the discussion, the  
266 participants has mentioned that they were intrigued by the fact that ventilation can reduce the  
267 pollution in the room, and they have remembered this during cooking process. They have also  
268 mentioned passing the information to several near and dear ones and asked them to do the  
269 same.

270 The participants move out of the building and found the concentration of PM2.5 goes down  
271 significantly. Here, the participants explained how ventilation improves air quality (Becker et  
272 al.; 2007; Vassella et al.; 2021). We have introduced the concept of the boundary layer at this  
273 point to the participants. The accumulation of pollutants inside a room with a certain height,  
274 and on the outside the concentration are low due to the greater mixing plane. Why had  
275 summer O R Z ' he pollutants and the role of the atmospheric boundary layer were explained  
276 to the participants. This example was quickly grasped by participants and they instantly  
277 relate this to high pollutant concentration and haze during winter.

278

279 The participants further went to measure the concentration on the minor and the major roads.  
280 The concentration difference between the two road types was explained by the number of  
281 vehicles counts and types of vehicles. The vehicles fleet on major roads comprises cars, bikes,  
282 autos and buses whereas only motorbikes and very few cars were observed on minor roads.  
283 Exponential decay in pollutant concentration was observed when participants were away from  
284 the main road. This helps participants to understand the impact of PM2.5 in the houses located  
285 on the main street. The participants were sensitized about the extent of pedestrian exposure on  
286 the main road. The participants were also advised to keep this thing in mind while getting a  
287 new home. In addition, participants were advised to use masks while traveling in high  
288 vehicles such as autos due to the proximity of the tailpipe to other vehicles.

289

290 Participants were introduced to the concept of biomass burning and its role in pollutants  
291 accumulation while measuring air quality near the food stalls (et al.; 2018; Xu et al.; 2020).

292 A very high concentration was observed as the smoke was coming from the cooking and  
 293 burning of wood fuel. Here, we briefly introduced participants to stubble burning and its role  
 294 in the formation of haze in rural parts of India. Concepts related to industrial emission have  
 295 been introduced near the smelter. Participants were also sensitized to the inequity of air  
 296 pollution exposure during the measurement near the smelter and the food stall. How poor  
 297 people are more vulnerable to air pollution has been introduced. During the walk, windy  
 298 periods coincided with decreasing PM2.5 concentration. Here the role of wind and overall  
 299 ventilation in the reduction of PM2.5 concentration has been again clarified to the participants.  
 300 The role of low wind speed during wintertime and how air pollutant accumulated during the  
 301 Diwali festival has been explained to the participants. Adaptation statements include how to  
 302 improve cross-circulation and ventilation at home. After the walk, the participants were taken  
 303 to the starting point where a focus group discussion was conducted to evaluate their  
 304 perceptions.

305

306 Table 2: Different concept introduction about air pollution during the pollution walk

Phenomenon	Observation	Concept introduction	Adaptation statement
Higher pollution emits during cooking	Elevated concentration in the Kitchen as compared to the living room	Indoor sources and accumulation of air pollutants	Ventilation during cooking is necessary
Ventilation improves air quality	Moving from inside to outside decreases PM2.5 concentration	Boundary layer, temporal variation of PM2.5	Winter time is more dangerous compared to summer
Vehicles as a source of PM2.5	Concentration difference of PM2.5 in major and minor roads	PM2.5 source and pedestrian exposure	Behavioural change helps to avoid major sources
Traffic junction as pollution hotspots	High PM2.5 in the traffic junction as compared to other parts	Spatial variation of PM2.5 concentration	Pedestrian exposure can be very high in traffic junctions
Biomass burning as PM2.5 source	High PM2.5 in road side food stall with coal fuel	Biomass burning, stubble burning, exposure inequity	Cooking using clean fuel or use well ventilated kitchen area
PM2.5 and meteorology	Decreasing PM2.5 during windy period	Fireworks episode and PM2.5	Dispersion of PM2.5 is important
Industry as PM2.5 source	Increasing PM2.5 near the smelter	Industrial emission, control	People living near industry are vulnerable
PM near source is the highest	PM concentration near tailpipe of vehicle is very high	Daily exposure and health burden	Sitting at low height vehicle can exposed to extra PM2.5

307

308  
309 During the one year after pollution walk discussion, participants have reported about taking  
310 extra precaution during travel in auto or two-wheeler. 33% of the participant has reported  
311 shifting their walk time from winter morning. 21% of participants has mentioned that they have  
312 changed their habit of lighting candlestick inside closed room. All participants have mentioned  
313 that they have discussed air pollution issues in last one year with multiple people and keep  
314 a track of the air quality regularly through apps.

#### 315 316 4.0 Discussion and implication

317  
318 Different approaches were taken to improve sensitization on air pollution. In this study, we  
319 took a very different approach where a walk has been organized with a group of citizens with  
320 live air quality monitors and they were explained several complex concepts about air quality.  
321 The live data helps participants to grasp complex problems easily. A participant quoted during  
322 the postwalk group discussion:

323 I did not understand the complex nature of air pollution and its control strategy before the  
324 walk. Also, the walk shows me how different people are exposed to the air pollution level  
325 differently.

326 The perception of the participants after the pollution walk changes from ~~arsimplified~~

327 VROXWLRQ RI <sup>3</sup>SODQWLQJ WGHYHCEHICURFVKH ~~DDONHURK+G ~~DDON~~ 7DEOH~~

328 The participants raise questions about inequities in pollution exposure as the economically  
329 deprived communities unable to use clean cooking fuel are exposed to massive air pollutants.

330 <sup>3</sup>7KRVEZKR Afford LPG or air purifiers, how they will survive this massive air

331 SROOXWLRQ DVN RQH SDUWLFLS ~~Economic Status and Air Quality~~ QWLDO LPSDFW RI VRFLR

332 exposure was identified by the participants, and this can be considered as one of the major

333 impacts of the pollution walk. Here participants can visualize the enormous pollutants inhaled

334 by the outdoor workers, food vendors or factory workers who are compelled to work under

335 such high air pollution levels. This changes their perception and ~~turned~~ into more

336 analytical which helps them understand the complex nature of the problem. They clearly

337 identified the changes in their opinion as they spoke during the walk interview where they

338 PHQWLRQH <sup>3</sup>FRPPXQLWLYLQDQWRYFB <sup>3</sup>GDW <sup>3</sup>VRFLDO DFWLYLW\ DV VROXW

339 statements (Table 3).

340  
341 100% of the participants voted the pollution walk as a better way of understanding air pollution  
342 as compared to an audiovisual presentation. We ask the participants to rate how the walk with  
343 the sensor helps with their overall understanding of air pollution levels. 96% of the participants  
344 replied that the process is highly innovative and helps them to understand the complex nature  
345 of the air pollution problem much better way. Impact sensitization has always been an open  
346 problem in the field of environment and sustainability (Okaka, 2010; Syaharuddin et al., 2020).  
347 The pollution walk could be a better alternative compared to organizing a seminar or a  
348 workshop on educating citizens about air quality. Our one year after pollution walk survey  
349 among participants clearly indicates that the pollution walk is associated with long  
350 learning and behavioural changes among participants. It would take a lot lesser time, a lot fewer  
351 logistics and engage citizens in a much better way. The pollution walk is an ideal teaching

352 method for small groups (8-10 participants) of individuals with diverse backgrounds. As the  
 353 air quality has been turning ~~worse~~ into an air apocalypse, such a technique could be proven very  
 354 useful and robust in the resource-limited ~~g~~Global ~~s~~South.

355

356 Table 3: Quotation from the interview of the participants

Quote ID	Topic	Quotes
PW1_4	About the workshop	I wish more of the people joined. I want to attend more such workshops. I prefer the “NO POWERPOINT” approach.
PW2_5		I knew about the fact that PM2.5 comes out from cooking but did not have the idea of this amount. The walk and associate discussion help a lot.
PW3_1		I am a retired government employee and have been to such workshops hundreds of times. However, the walking and visualizing data was an eye-opener.
PW2_2	Air pollution source	We prefer living on the main road due to logistical facilities, but even 50 meters away from the main road could really reduce the health impact.
PW3_2		I thought stopping stubble burning as one step solution for combatting air pollution in Delhi. I did not know, that the issue is so complex and interlinked with socio-economy.
PW1_8		Living in a very clean residential area for whole days, but 15 minutes in traffic signal could put all harmful pollutants in our body.
PW2_7	Inequity	Why does the food seller or the person working in the workshop are inhaling high PM2.5 all the time? What would be the solution for them?
PW3_5		My mom cooks for us every <del>and</del> she is risking her life due to bad air quality during cooking
PW3_4		Those who can't afford LPG gas for cooking, or those who work outdoor or the traffic policies who are exposed to pollutants every day-- what about them? How we will help them?
PW1_2	Solution statements	The problem related to air pollution has multiple layers and does not have any easy or over-simplified solution.
PW1_7		From public transport to controlling industries, we have to go a long path to fight air pollution. We need to go for data-driven advocacy.

day

PW2_6		The combination of an expert who is doing research work on air pollution and initiative of the community, especially social activities can promote a pro-air environment, and fix and resolve the issues related to air pollution
PW1_1		We must start to create groups of volunteers in our areas. We need to identify the hotspots and vulnerable communities first.

357

358 **Author's contribution**

359

360 D.B. was solely to design and calibrate the low-cost sensors used in the pollution walk. S.G.  
361 helps in implementing the walking program and provides all the logistical support. All four  
362 authors help in analyzing the data. A.R conceive the idea and design the implementation plans,  
363 conducted the interviews and wrote the first draft of the manuscript. D.B and S.H. helps in  
364 manuscript writing, corrections and editing.

365

366 **Acknowledgement**

367 The authors would like to acknowledge Warrior Moms, a group of mothers fighting against air  
368 pollution for their help and collaboration. AR would like to thank the Laboratory of  
369 atmospheric processes and their impacts (LAPI), EPFL (Athanasios Nenes and Satoshi  
370 Takahama) for hosting him and the Swiss Agency for Development and Cooperation (SDC-  
371 Clean Air Project in India) for his fellowship.

372

373 **Funding Information**

374 The present work did not receive any funding.

375

376 **Ethical statement**

377 For pollution walk event we have collected signed consent documents from each participant  
378 regarding their willingly participation. The survey and group discussion were done following  
379 the ethical guidelines of the associated non-profit organization (The Climate Thinker).

380

381 **Data availability statement**

382 Data generated during the study is represented in the paper, for raw data is available on request  
383 to the corresponding author.

384

385 **Conflicting interest statement**

386 The authors have no conflicts of interest to declare.

387

388 **References**

389

- 390 [1. Apte, J. S., Brauer, M., Cohen, A. J., Ezzati, M., & Pope III, C. A. \(2018\). Ambient](#)  
391 [PM2.5 reduces global and regional life expectancy. \*Environmental Science &\*](#)  
392 [Technology Letters, 5\(9\), 546-551.](#)
- 393 [4-2. Badura, M., Batog, P., Drzeniecka-Osiadacz, A., & Modzel, P. \(2018\). Evaluation of](#)  
394 [low-cost sensors for ambient PM2.5 monitoring. \*Journal of Sensors\*, 2018.](#)
- 395 [2-3. Balakrishnan, K., Dey, S., Gupta, T., Dhaliwal, R. S., Brauer, M., Cohen, A. J., ... &](#)  
396 [Dandona, L. \(2019\). The impact of air pollution on deaths, disease burden, and life](#)  
397 [expectancy across the states of India: the Global Burden of Disease Study 2017. \*The\*](#)  
398 [Lancet Planetary Health, 3\(1\), e26-e39.](#)
- 399 [4. Becker, R., Goldberger, I., & Paciuk, M. \(2007\). Improving energy performance of](#)  
400 [school buildings while ensuring indoor air quality ventilation. \*Building and\*](#)  
401 [Environment, 42\(9\), 3261-3276.](#)
- 402 [3-5. Bu, X., Xie, Z., Liu, J., Wei, L., Wang, X., Chen, M., & Ren, H. \(2021\). Global PM2.](#)  
403 [5-attributable health burden from 1990 to 2017: Estimates from the Global Burden of](#)  
404 [disease study 2017. \*Environmental Research\*, 197, 111123.](#)
- 405 [4-6. Chafe, Z. A., Brauer, M., Klimont, Z., Van Dingenen, R., Mehta, S., Rao, S., ... &](#)  
406 [Smith, K. R. \(2014\). Household cooking with solid fuels contributes to ambient PM2.](#)  
407 [5 air pollution and the burden of disease. \*Environmental health perspectives\*, 122\(12\),](#)  
408 [1314-1320.](#)
- 409 [5-7. Christie, B., & Waller, V. \(2019\). Community learnings through residential composting](#)  
410 [in apartment buildings. \*The Journal of Environmental Education\*, 50\(2\), 97-112.](#)
- 411 [6-8. Commodore, A., Wilson, S., Muhammad, O., Svendsen, E., & Pearce, J. \(2017\).](#)  
412 [Community-based participatory research for the study of air pollution: a review of](#)  
413 [motivations, approaches, and outcomes. \*Environmental monitoring and assessment\*,](#)  
414 [189, 1-30.](#)
- 415 [7-9. Dutta, D., & Pal, S. K. \(2023\). Prediction and assessment of the impact of COVID-19](#)  
416 [lockdown on air quality over Kolkata: a deep transfer learning approach. \*Environmental\*](#)  
417 [Monitoring and Assessment, 195\(1\), 223.](#)
- 418 [8-10. Feenstra, B., Papapostolou, V., Hasheminassab, S., Zhang, H., Der Boghossian,](#)  
419 [B., Cocker, D., & Polidori, A. \(2019\). Performance evaluation of twelve low-cost PM2.](#)  
420 [5 sensors at an ambient air monitoring site. \*Atmospheric Environment\*, 216, 116946.](#)
- 421 [9-11. Gabrys, J. \(2017\). Air walk: Monitoring pollution and experimenting with](#)  
422 [speculative forms of participation. In \*Walking through social research\* \(pp. 145-161\).](#)  
423 [Routledge.](#)
- 424 [10-12. Gabrys, J., Pritchard, H., & Barratt, B. \(2016\). Just good enough data: Figuring](#)  
425 [data citizenships through air pollution sensing and data stories. \*Big Data & Society\*,](#)  
426 [3\(2\), 2053951716679677.](#)
- 427 [11-13. Gargava, P., & Rajagopalan, V. \(2015\). Source prioritization for urban](#)  
428 [particulate emission control in India based on an inventory of PM10 and its](#)  
429 [carbonaceous fraction in six cities. \*Environmental development\*, 16, 44-53.](#)
- 430 [12-14. Garip, G., Richardson, M., Tinkler, A., Glover, S., & Rees, A. \(2021\).](#)  
431 [Development and implementation of evaluation resources for a green outdoor](#)  
432 [educational program. \*The Journal of Environmental Education\*, 52\(1\), 25-39.](#)

433 ~~13~~.15. Ghose, M. K., Paul, R., & Banerjee, R. K. (2005). Assessment of the status of  
434 urban air pollution and its impact on human health in the city of Kolkata. *Environmental*  
435 *Monitoring and Assessment*, 108(1), 151-167.

436 ~~14~~.16. Gurjar, B. R., Ravindra, K., & Nagpure, A. S. (2016). Air pollution trends over  
437 Indian megacities and their local-to-global implications. *Atmospheric Environment*,  
438 142, 475-495.

439 ~~15~~.17. Guttikunda, S. K., & Goel, R. (2013). Health impacts of particulate pollution in  
440 a megacity—Delhi, India. *Environmental Development*, 6, 8-20.

441 ~~16~~.18. Guttikunda, S. K., Goel, R., & Pant, P. (2014). Nature of air pollution, emission  
442 sources, and management in the Indian cities. *Atmospheric environment*, 95, 501-510.

443 ~~17~~.19. Haque, M. S., & Singh, R. B. (2017). Air pollution and human health in Kolkata,  
444 India: A case study. *Climate*, 5(4), 77.

445 ~~18~~.20. Huo, Y. J., Shih, K. T., & Lin, C. J. (2020, November). The study on Integrating  
446 Air Pollution Environmental Education into the Teaching Personal and Social  
447 Responsibility Model in Physical Education. In *IOP Conference Series: Earth and*  
448 *Environmental Science* (Vol. 576, No. 1, p. 012006). IOP Publishing.

449 ~~19~~.21. IQAIR Report. World Air Quality Report, 2020. [https://www.iqair.com/world-](https://www.iqair.com/world-air-quality-report)  
450 [air-quality-report](https://www.iqair.com/world-air-quality-report)

451 ~~20~~.22. Jha, S. K., Kumar, M., Arora, V., Tripathi, S. N., Motghare, V. M., Shingare,  
452 A. A., ... & Kamble, S. (2021). Domain Adaptation-Based Deep Calibration of Low-  
453 Cost PM<sub>2.5</sub> Sensors. *IEEE Sensors Journal*, 21(22), 25941-25949.

454 ~~21~~.23. Lelieveld, J., Evans, J. S., Fnais, M., Giannadaki, D., & Pozzer, A. (2015). The  
455 contribution of outdoor air pollution sources to premature mortality on a global scale.  
456 *Nature*, 525(7569), 367-371.

457 ~~22~~.24. Liao, X., Tu, H., Maddock, J. E., Fan, S., Lan, G., Wu, Y., ... & Lu, Y. (2015).  
458 Residents' perception of air quality, pollution sources, and air pollution control in  
459 Nanchang, China. *Atmospheric pollution research*, 6(5), 835-841.

460 ~~23~~.25. Milà, C., Salmon, M., Sanchez, M., Ambros, A., Bhogadi, S., Sreekanth, V., ...  
461 & Tonne, C. (2018). When, where, and what? Characterizing personal PM<sub>2.5</sub> exposure  
462 in periurban India by integrating GPS, wearable camera, and ambient and personal  
463 monitoring data. *Environmental science & technology*, 52(22), 13481-13490.

464 ~~24~~.26. Mor, S., Parihar, P., & Ravindra, K. (2022). Community perception about air  
465 pollution, willingness to pay and awareness about health risks in Chandigarh, India.  
466 *Environmental Challenges*, 9, 100656.

467 ~~25~~.27. Nali, C., & Lorenzini, G. (2007). Air quality survey carried out by  
468 schoolchildren: an innovative tool for urban planning. *Environmental monitoring and*  
469 *assessment*, 131, 201-210.

470 ~~26~~.28. Nieuwenhuijsen, M. J., Donaire-Gonzalez, D., Rivas, I., de Castro, M., Cirach,  
471 M., Hoek, G., ... & Sunyer, J. (2015). Variability in and agreement between modeled  
472 and personal continuously measured black carbon levels using novel smartphone and  
473 sensor technologies. *Environmental science & technology*, 49(5), 2977-2982.

474 ~~27~~.29. Okaka, W. (2010). Developing regional communications campaigns strategy  
475 for environment and natural resources management policy awareness for the East

476 African community. *Research journal of environmental and earth sciences*, 2(2), 106-  
477 111.

478 ~~28-30.~~ Omanga, E., Ulmer, L., Berhane, Z., & Gatari, M. (2014). Industrial air  
479 pollution in rural Kenya: community awareness, risk perception and associations  
480 between risk variables. *BMC public health*, 14(1), 1-14.

481 ~~29-31.~~ Persson, K., Andrée, M., & Caiman, C. (2022). Down-to-earth ecological  
482 literacy through human and nonhuman encounters in fieldwork. *The Journal of*  
483 *Environmental Education*, 1-18.

484 ~~30-32.~~ Selden, T. M., & Song, D. (1994). Environmental quality and development: is  
485 there a Kuznets curve for air pollution emissions?. *Journal of Environmental*  
486 *Economics and management*, 27(2), 147-162.

487 ~~31-33.~~ Sharma, H. K., Dandotiya, B., & Jadon, N. (2017). Exposure of Air pollution  
488 and its health effects in traffic police persons of Gwalior City, India. *Environmental*  
489 *Claims Journal*, 29(4), 305-315.

490 ~~32-34.~~ Shupler, M., Godwin, W., Frostad, J., Gustafson, P., Arku, R. E., & Brauer, M.  
491 (2018). Global estimation of exposure to fine particulate matter (PM<sub>2.5</sub>) from  
492 household air pollution. *Environment international*, 120, 354-363.

493 ~~33-35.~~ Snyder, E. G., Watkins, T. H., Solomon, P. A., Thoma, E. D., Williams, R. W.,  
494 Hagler, G. S., ... & Preuss, P. W. (2013). The changing paradigm of air pollution  
495 monitoring. *Environmental science & technology*, 47(20), 11369-11377.

496 ~~34-36.~~ Steinle, S., Reis, S., & Sabel, C. E. (2013). Quantifying human exposure to air  
497 pollution—Moving from static monitoring to spatio-temporally resolved personal  
498 exposure assessment. *Science of the Total Environment*, 443, 184-193.

499 ~~35-37.~~ Syaharuddin, S., Hidayanti, H., & Mutiani, M. (2020). The Role of Waste Banks  
500 to Improve Community Environment Awareness. *The Innovation of Social Studies*  
501 *Journal*, 1(2), 129-138.

502 ~~36-38.~~ Szczytko, R., Stevenson, K. T., Peterson, M. N., & Bondell, H. (2020). How  
503 combinations of recreational activities predict connection to nature among youth. *The*  
504 *Journal of Environmental Education*, 51(6), 462-476.

505 ~~37-39.~~ Ullstein, Bart, and Helen de Mattos. "Air Pollution in Asia and the Pacific:  
506 Science-based Solutions-Summary." (2018).

507 ~~38-40.~~ Varaden, D., Leidland, E., Lim, S., & Barratt, B. (2021). "I am an air quality  
508 scientist"—Using citizen science to characterise school children's exposure to air  
509 pollution. *Environmental Research*, 201, 111536.

510 ~~39-41.~~ Varaden, D., McKeivitt, C., & Barratt, B. (2018). Making the invisible visible:  
511 Engaging school children in monitoring air pollution in London. *Research for All*.

512 ~~40-42.~~ Vassella, C. C., Koch, J., Henzi, A., Jordan, A., Waeber, R., Iannaccone, R., &  
513 Charrière, R. (2021). From spontaneous to strategic natural window ventilation:  
514 Improving indoor air quality in Swiss schools. *International Journal of Hygiene and*  
515 *Environmental Health*, 234, 113746.

516 ~~41-43.~~ Veloz, D., Gonzalez, M., Brown, P., Gharibi, H., & Cisneros, R. (2020).  
517 Perceptions about air quality of individuals who work outdoors in the San Joaquin  
518 Valley, California. *Atmospheric Pollution Research*, 11(4), 825-830.



519 [42-44.](#) Wildschut, D. (2017). The need for citizen science in the transition to a  
520 sustainable peer-to-peer-society. *Futures*, 91, 46-52.  
521 [43-45.](#) Xu, H., Ta, W., Yang, L., Feng, R., He, K., Shen, Z., ... & Cao, J. (2020).  
522 Characterizations of PM2.5-bound organic compounds and associated potential cancer  
523 risks on cooking emissions from dominated types of commercial restaurants in  
524 northwestern China. *Chemosphere*, 261, 127758.  
525  
526  
527