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Health Impacts of Particulate Matter Pollution Due to Demolition of High-Rise Buildings, Maradu- Kochi

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ABSTRACT

The public perception on the effects of building destruction was done after Maradu building demolition in Kochi during 11th and 12th of January 2020 to study the influence of short term abnormal deterioration of air quality on human health. During demolition, the concentrations of PM_{10}, $PM_{2.5}$, and SPM increased above the allowed limit, which then decreased but remained above the ambient level observed during the pre-demolition phase. The questionnaire was prepared in consultation with senior pulmonologist, based on resident's health and their general awareness of air pollution. A total of 529 people were surveyed for the study, which was carried out from January to February 2020. There were apprx.59% females and 41% males in the sample population. The 46-60 age group had the highest percentage of participation (31%), followed by the 60 and above group (21%).The effect of particulate matter on different health issues were analysed. It was observed that, allergy sneezing (30.14%) and cough (25.96%) were the most common symptoms right after demolition followed by chest congestion (13.04%) and cold (12.3%). The association between SPM and PM_{10} on allergy sneezing was highly correlated.

Key words: Air Quality, Air pollution, Demolition, Human health, Particulate Matter, Public perception

INTRODUCTION

Air is a critical component of the Earth's ecosystem, and even minor changes in its composition can have a wide range of consequences on the growth and development of life on this planet. Air pollutants have a wide range of negative consequences on numerous platforms. The scientific information regarding air pollution's health effects is compelling.

There was demolition of four apartments in Kochi in January 2020, since it was found that there is violation in the Coastal Zone Regulation rules. The biggest concern with the demolition of the structure was the creation of a big dust cloud that could engulf the nearby residential area, buildings, roadways etc. At the most basic level, the dust generated is particulate matter: both small (PM_{10} and $PM_{2.5}$) and large (SPM). The potential for particles to cause health problems is directly proportional to their size. Particulate matter pollution poses significant risks to patients with pre-existing lung or heart illness, the elderly, and children. SPM is thought to be responsible for about 3% of cardiac fatalities and 5% of lung cancer deaths over the world (WHO 2013). Fine $PM_{2.5}$ particles can enter deeper into the lungs more quickly than coarse mode PM_{10} particles, increasing the risk of respiratory and pulmonary illnesses (Harrison and Yin 2000, Wang et al. 2002). Particulate-related mortality has been extensively demonstrated in numerous studies conducted throughout the world. Children and the elderly are the most vulnerable to chronic obstructive pulmonary disease and asthma, but people of all ages are impacted.

The use of explosive demolition has been connected to a local increase in particulate matter (Dorevitch et al. 2006). The collapse of a 22-story residential structure in Baltimore, MD produced short-term particulate matter (PM) concentrations 1000 times higher than pre-implosion levels, and the

collapse of a hospital in Calgary, Alberta, Canada, produced extremely high peak concentrations that violated the Canadian standard for total suspended particulates (TSPs) (Beck et al. 2003, Stefani et al. 2005). Azarmi and Kumar (2016) measured that the average exposure dose rose by up to 57 times during a building demolition by measuring PM_{10}, $PM_{2.5}$, and PM_1 concentrations. Daily maximum exceedances of PM_{10} had doubled in a period when demolition of a building had been carried out near a monitoring station in Cardiff, UK (Deacon et al. 1997). Another study compared the emissions of PM_{10} before and after the implosion of concrete grain silos on the eastern coast of Aquaba and discovered that the particulate matter concentration significantly increased after the implosion, with a maximum value of 259-587 g/m^3, exceeding the pre-implosion levels by 26 times (Abu-Allaban et al. 2020). Despite the fact that no measurements of the cloud created by the World Trade Center (WTC) collapse were taken, studies conducted after the September 11, 2001 disaster provide some insight into WTC workers' upper airway irritation, including wheezing, coughing, nose and throat irritation, and bronchial hyper-responsiveness (Lijoy et al. 2002).

In addition to the short-term exposure associated with airborne particulate matter during the implosion, $PM_{2.5}$ that disperses throughout the community and is then available to be re-suspended and breathed or ingested via hand-to-mouth contact has the potential for longer-term exposure (Beck et al. 2003). Higher $PM_{2.5}$ concentrations in the atmosphere may occur from the demolition of public housing projects, posing a risk to residents' respiratory health. Because $PM_{2.5}$ causes asthma, respiratory inflammation, compromises lung function, and even promotes cancer, its impact on the human respiratory system should not be overlooked (Nemery et al. 2001).

Because the demolition of Maradu is a first-of-its-kind operation in the country, it is vital to investigate the consequences. There are only a few studies that look at the impact of demolition on human health. To gain a general understanding of the health consequences of air pollution caused by building demolition, a comprehensive study was conducted, which included particulate pollution concentration estimation and a comprehensive questionnaire survey.

STUDY AREA

Kochi is the industrial and coastal capital of Kerala State, which is located in the southwest of India between 9° 56' and 10°10' N, and 76°10' and 76° 25' E. It covers an area of 94.88 km^2 and is polluted by heavy traffic, industrial outflows, solid waste and inevitable municipal wastes etc. The study area is in Kochi's Maradu Municipality is roughly 7 km from the city centre.

The Municipality's geographical features reveal that it is bordered by water bodies and has ecologically sensitive areas (Table 1). The Municipality is bordered on the west by the Lakshadweep sea, the Vembanad backwater, and interconnected canals (Fig.1). The tidal inlet of Kochi maintains a constant link to the sea.

Table 1 Coastal regulation zone (CRZ) details of Maradu Municipality

High Tide Line (HTL) (km)	Mangroves (CRZ IA) (km^2)	Inter Tidal Zone (CRZ IB) (km^2)	Mangrove bufferzone (CRZ I) (km^2)	CRZ II (km^2)
76.78	0.41	0.40	1.07	1.72

The study was carried out at the four demolition sites in Maradu, Kochi. There were four waterfront colossuses housing nearly 350 flats. All the four buildings are within a radius of 2 Km (Fig.2). There were more than 1000 buildings in one km^2 with a population density of aprx.3600 individuals. The apartments are located along North-South orientation. The Golden Kayaoram (site 1) is located on the northern most branch of Champakara canal is the smallest and oldest among the demolished buildings with a height of 55-meter and 17-stories. The Jain Coral Cave (site 4) is on its southern branch of Champakara canal is the largest among the demolished flats a 55-meter high waterfront complex, having 17-storied building with 128 apartments. Compared to the location of other buildings, Holyfaith H_2O (site 2) a 19-storey apartment housing 90 flats was situated in Kundannoor, Wilmington island road, Kochi, and Alfa Serene A&B (site 3) the twin towers that are situated in Thattekad road, Nettoor, Maradu, Kochi also a waterfront Alfa Serene complex houses 73 flats in its 17-storey and 12-storey

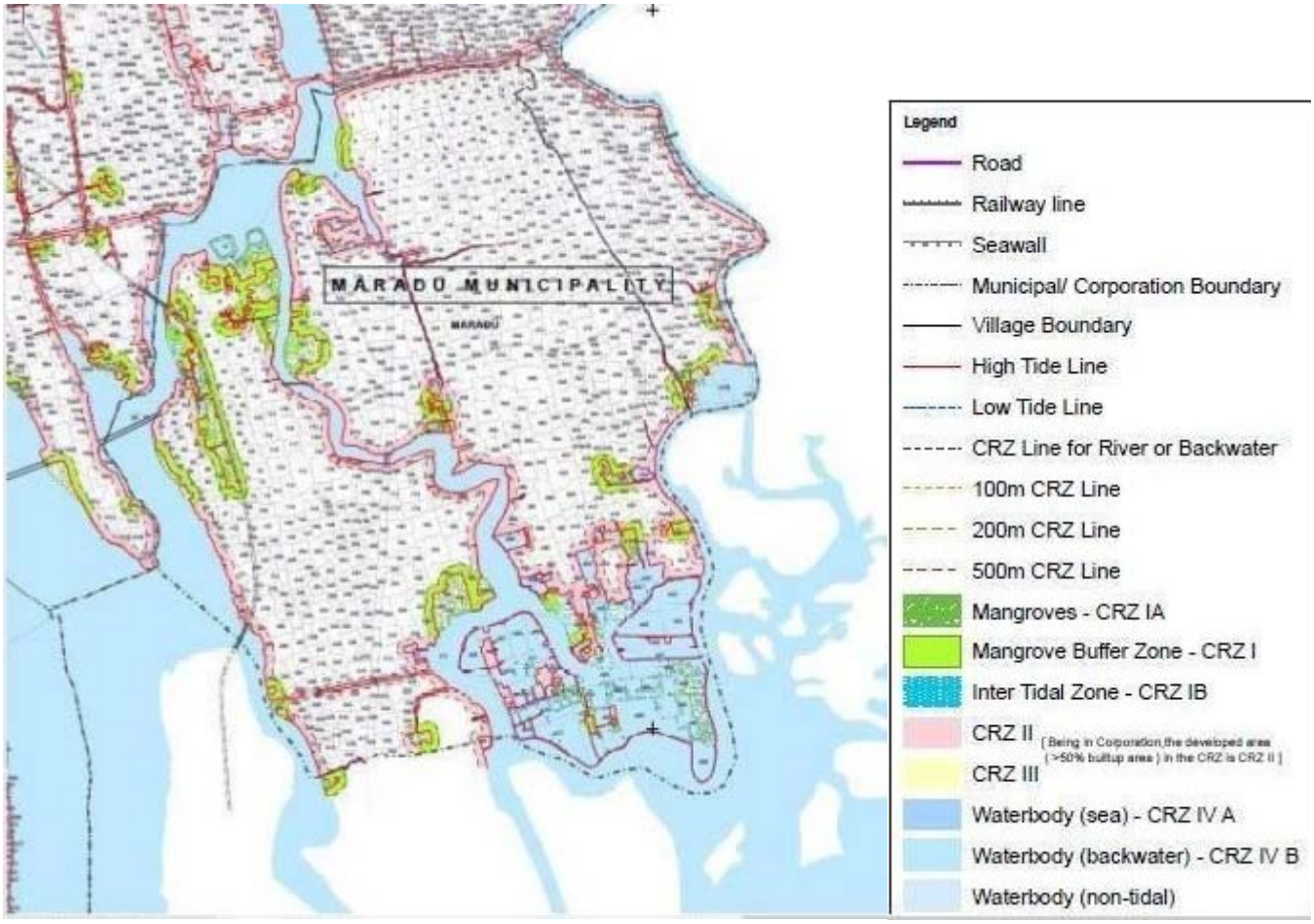

Figure 1. Map of Maradu Municipality (Source: Coastal Zone Management Plan of Maradu Municipality, Ernakulam District, Kerala, prepared by National Centre for Earth Science Studies, Thiruvananthapuram)

Figure 2. Map showing demolished apartments and buffer zones

towers, are located close to each other on the eastern and western banks of the Nettoor stream.

METHODOLOGY

The particulate matter concentration was monitored for a period of 3 months with the help of Kerala State Pollution Control Board (KSPCB), who guarantee accurate data for the study. An extensive questionnaire survey of nearby residents within 200-meter buffer zone of each demolition site was carried out to gather the information about health impacts after the demolition and opinions and attitudes about air pollution issues caused by demolition.

The results of the particulate matter concentration monitoring show that the demolition region has substantial short-term abnormally high particulate matter pollution both during and after demolition (Bindu et al. 2021).

Public perception survey

Study design and data collection

The survey period was 21st January 2020 to 18th March 2020. Survey was conducted within 200m buffer zone of each of the demolished buildings. The questions are originally made in English and distributed to each residents of age above 16, residing in the 200m premises. The questionnaire was prepared by expert team comprising air pollution expert, meteorologist and a senior pulmonologist. It comprised of a series of questions to elucidate the individual impacts of particulate matter pollution on health. The health history of each respondent before the demolition was also enquired.

Structure of questionnaire

The air quality and health information questionnaire was created as a tool for gathering and documenting data as well as determining public opinion on demolition and its health consequences. There were 18 questions, as well as clear instructions, alternative answers, and spaces for specific free replies. The questionnaire was created using current knowledge of the cause-and-effect link between air pollution and its effects on human health. It is divided into three sections: i) personal information about the participants, and how long they have lived there, excluding their names and addresses, such as age, gender, occupation, resident/migrant status, annual income, educational qualifications; ii) Participants' basic understandings of air pollution and its impact on health in general; iii) Participant's health status prior to and after demolition. It took about 10-15 minutes only to answer the questions on the questionnaire. The questionnaire development was verified by a pulmonologist throughout the procedure.

A total of 215 residences and one apartment complex were identified for the survey, and thus 529 individual responses were collected (Table 2). Respiratory problems such as coughing, sneezing, skin disorders, eye difficulties etc. were assessed before and after the demolition activities.

Table 2. Details of the number of respondents and houses covered in each site.

Site number	Number of houses	Number of respondents
Site 1	32 houses	94
Site 2	36 houses	130
Site 3	130 houses	238
Site 4	17 houses + 1 flat	67

RESULT AND DISCUSSION

When compared to pre-demolition pollution levels, there has been an alarmingly significant increase in particulate pollution concentration levels immediately after demolition. During the post-demolition period also, pollutant levels exceeded the permissible limit (Bindu et al. 2021). During the demolition in the case of site 1, SPM levels rose up to a concentration of 3004 gm/m^3. During demolition, PM_{10} and $PM_{2.5}$ levels were also found to be beyond permitted limits. Most of the sites reported high concentration of particulate matter during and after demolition. In general, more sites reported increased $PM_{2.5}$ concentrations exceeding permissible limits. Despite the fact that the abnormal pollution concentration after demolition dropped significantly after three months, the ambient level of pollutants was found higher than pre demolition concentration. $PM_{2.5}$ concentrations are extremely high as compared to ambient levels, which is of particular concern because it causes most serious health consequences.

Table 3. Air quality in different demolition sites (average of 3 monitoring locations)

	During demolition			After demolition		
	SPM µg/m³	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	SPM µg/m³	PM_{10} µg/m³	$PM_{2.5}$ µg/m³
Site 1	1112	187	98	95.6	59.66	96.6
Site 2	127	45	43	94.5	58.5	87
Site 3	118.75	73.8	112	118.75	73.8	112
Site 4	200	93	157	156.75	76.25	62.28

Ambient SPM, PM_{10} and $PM_{2.5}$ concentrations post demolition period are shown in Table 3. All the four sites experienced much higher concentration of pollutants than the pre demolition concentration. Both SPM and PM_{10} are below permissible limit at all the monitoring sites while $PM_{2.5}$ concentration exceeds the CPCB (Central Pollution Control Board) limit in all sites.

Socio-demographic details of sample population

A total of 529 people were interviewed at the four demolition sites: 94 at site 1, 130 at site 2, 238 at site 3, and 94 at site 4. The population density around site 3 is high, whereas it is low in site 4. The age group ranged from ≥16 to ≥60 and the majority in the 46-60 age group (30.81%), followed by the 60 and above group (20.98%). 18.9% of the population was between the ages of 21 and 30. There were 314 females (59.36%) and 215 males (40.64 %) in the sample population. 82.61% of these residents have lived over 10 years in that area.

Perception on air quality and health effects

Among the respondents, 49% were of the view that the pollution had an impact on their prevailing health

Table 4. People's perception on the effect of air pollution on health. B1-Golden Kayaloram, B2-Holyfaith H_2O, B3-Alfaserene twin tower, B4-Jain Coral cave

	No effect				A small effect				A moderate effect			
	B1	B2	B3	B4	B1	B2	B3	B4	B1	B2	B3	B4
Asthma	3.19	7.69	3.78	4.48	2.13	14.62	6.3	11.94	37.23	44.62	37.31	16.42
Bronchitis	4.26	9.23	4.2	5.97	7.45	19.23	6.72	10.45	20.21	51.54	32.84	28.36
Cardiovascular diseases	5.32	11.54	8.82	7.46	6.38	20	5.46	8.96	23.4	40.77	22.39	16.42
Other lung/ chest problems	3.19	6.92	3.78	4.48	6.38	20.77	9.66	11.94	26.6	40.77	37.31	29.85
Cancer	2.13	8.46	9.24	2.99	8.51	16.15	5.04	11.94	23.4	53.85	41.79	23.88
Allergies	2.13	4.62	2.52	2.99	4.26	21.54	6.3	7.46	18.09	42.31	38.81	25.37
Skin problems	1.06	5.38	2.94	1.49	5.32	26.92	7.14	7.46	20.21	49.23	43.28	28.36

Table 5: People's perception on the effect of air pollution on health. B1-Golden Kayaloram, B2-Holyfaith H_2O, B3-Alfaserene twin tower, B4-Jain Coral cave

	A quite big effect				A very big effect				Don't know			
	B1	B2	B3	B4	B1	B2	B3	B4	B1	B2	B3	B4
Asthma	22.34	34.62	15.13	31.34	26.6	52.31	8.4	28.36	8.51	29.23	37.31	7.46
Bronchitis	29.79	43.08	8.4	26.87	22.34	34.62	12.61	16.42	15.96	25.38	47.76	11.94
Cardiovascular diseases	24.47	46.15	9.24	19.4	19.15	36.92	8.82	17.91	21.28	27.69	56.72	29.85
Other lung/ chest problems	28.72	43.08	11.76	26.87	21.28	43.85	10.5	16.42	13.83	27.69	29.85	10.45
Cancer	25.53	45.38	9.66	22.39	29.79	22.31	6.72	19.4	21.28	36.92	43.28	19.4
Allergies	32.98	49.23	14.71	32.84	39.36	33.08	16.39	28.36	2.13	28.46	13.43	2.99
Skin problems	37.23	36.92	14.71	29.85	32.98	45.38	14.29	29.85	3.19	19.23	11.94	2.99

condition and majority of people were aware about the fact that the air quality is very much important for their health and sustenance. The perceptions of individuals at the demolition site on the effects of air pollution on various ailments are shown in Tables 4 and 5. According to 34% of respondents, air pollution has a moderate impact on asthma, while 26% say it has a significant one. The impact of air pollution on illnesses including bronchitis, cardiovascular diseases, other lungs/chest disorders, cancer, allergies, and so on was also investigated. 48% of people think air pollution has quite big effect on allergies, skin problems (30%), cardiovascular (26%) and bronchitis (27%). They also think that air pollution has a considerable effect on cancer (36%). Asthma, lung/chest disorders, and skin problems received the most attention.

Health problems experienced due to air pollution before and after demolition

Epidemiological research suggests that short-term PM exposure increases the risk of cardiovascular morbidity in older persons. Because of the higher frequency of pre-existing cardiovascular and respiratory disorders, which may also confer sensitivity to PM, older individuals represent a potentially vulnerable demographic when compared to children or younger adults (Sacks et al. 2010). Several studies found an increase in cardiovascular disease hospital admissions among older persons when exposed to particulate matter (Pope et al. 2008, Host et al. 2007, Larrieu et al. 2007).

Individuals, particularly elderly who were prone to dust-related ailments, were evacuated prior to the destruction. The responders' health status before to the demolition was inquired about. 26.09% of those interviewed reported a health concern prior to the demolition. Some of them were observed to have had long-term cardiovascular/respiratory disorders such as allergy sneezing, chest congestion, asthma, cold and fever making them more vulnerable to pollution-related diseases. Individuals aged 60 and older make up 45.96% of these vulnerable population. Several people who had been diagnosed with respiratory problems or allergies had their symptoms intensified as a result of the heavy dust. Figure 3 depicts the health concerns that already existed made worse by the building collapse. Allergy

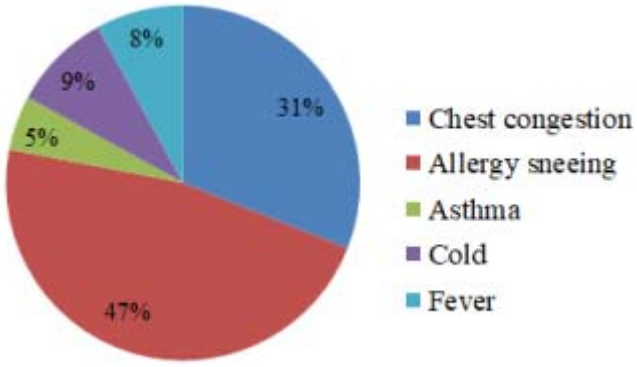

Figure 3. Health problem that made worse by demolition

sneezing (47%) and chest constrictions (31%) are the most common health concerns worsened by demolition.

It has already established in many studies that the short-term exposure has been shown to aggravate pre-existing respiratory diseases such as asthma, chronic obstructive pulmonary disease, chronic respiratory phlegm, cough, wheezing difficulty, breathing problems, and pre-existing cardiovascular illness. As a result, hospitalization and trips to the emergency room are on the rise (Gupta 2008, Patankar and Trivedi 2011, Maji et al. 2015, 2018, Rahul and Aparajitha 2019). A total of 64.46% people experienced different symptoms immediately after demolition. Figure 4 shows that allergy sneezing (30.14%) and cough (25.96%) were the most common symptoms immediately following demolition. Some people complained of chest congestion (13.04%) and cold (12.3%).

From the Figure 5, it is clear that Site 1 (34.81 %) had the most allergy sneezing, which could be linked to excessive SPM pollution due to the explosion of clay brick during the implosion, followed by site.4 (34.23 %) which has the second position in case of

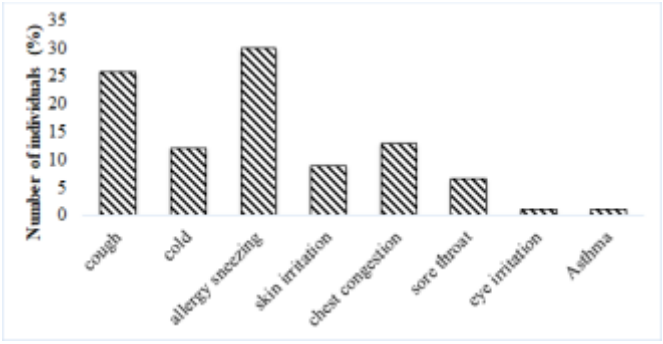

Figure.4 Symptoms immediately after demolition

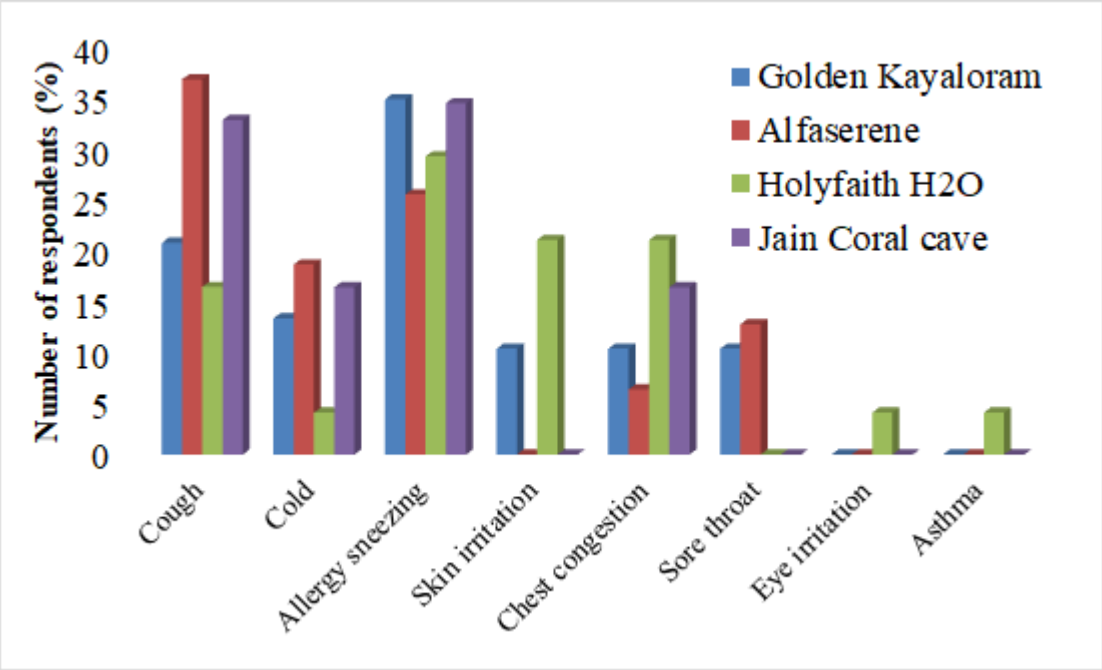

Figure 5. Location wise comparison of health symptoms

pollution concentration during demolition (Table 3) and in the case of cough, site 3 was most affected followed by site 4. Site 3 was the most densely populated of all the sites. Site 2 exhibited all of the symptoms except sore throat. Particulate matter concentrations were highest during demolition in Site 1, particularly SPM and PM_{10}, and second highest in site 4. The particulate matter concentration in site 1 decreased during the post-demolition phase, owing to the downwind advantage. In the post-demolition phase, site 4 had the maximum pollution concentration, followed by site 3. The occurrence of health complaints is also related to the distribution of pollution over each location.

We used Pearson Chi square statistics with SPSS for windows version 20.0 to see if there was an association between perceptions of health consequences and age, gender, educational level, and disease history. Figures 6, 7 and 8 show the linear association between particulate matter concentration and several health symptoms. It is called heat map of Pearson correlation matrix. Negative and positive correlation is represented by blue and red respectively and zero correlation is shown by white. Exposure to higher levels of SPM and the occurrence of cough (R=0.9086) and allergy sneezing (R=0.9491) are statistically correlated, as shown in Figure 6. There's also association between PM_{10} and the common cold (R=0.9353) and allergy sneezing (R=0.925) (Fig.7). Even if the $PM_{2.5}$ concentration exceeds the CPCB (Central Pollution Control Board) recommendation, we cannot statistically verify a correlation between $PM_{2.5}$ and health concerns (Fig.8). It is possible that the lack of a correlation between $PM_{2.5}$ and sickness symptoms is due to the fact that $PM_{2.5}$'s effects can take a long time to appear. The bivariate connection between these variables was assessed using the Chi-square test. All statistical tests were two-tailed, and statistical significance was defined as alpha=0.05 or less. Except for the previous disease condition ($\chi^2 = 7.45$, $P = 0.05$), none of the other variables are statistically significant at alpha 0.05. As shown in Table 6, there is a clear connection between the occurrence of, cold (R=0.8114), skin

Table 6. Categorization of values of coefficient of correlation (R) between air pollution and illness

Degree of association (R)	Diseases associated with SPM	Diseases associated with PM_{10}	Diseases Associated with $PM_{2.5}$
Excellent (R > 0.9)	Allergy Sneezing Cough	Allergy Sneezing, Cold	-
Very Good (0.8≤R≤0.9)	Cold	Cough	-
Good (0.7≤R<0.8)	Skin irritation, Chest Congestion	-	-
Fair (R< 0.7)	-	-	-

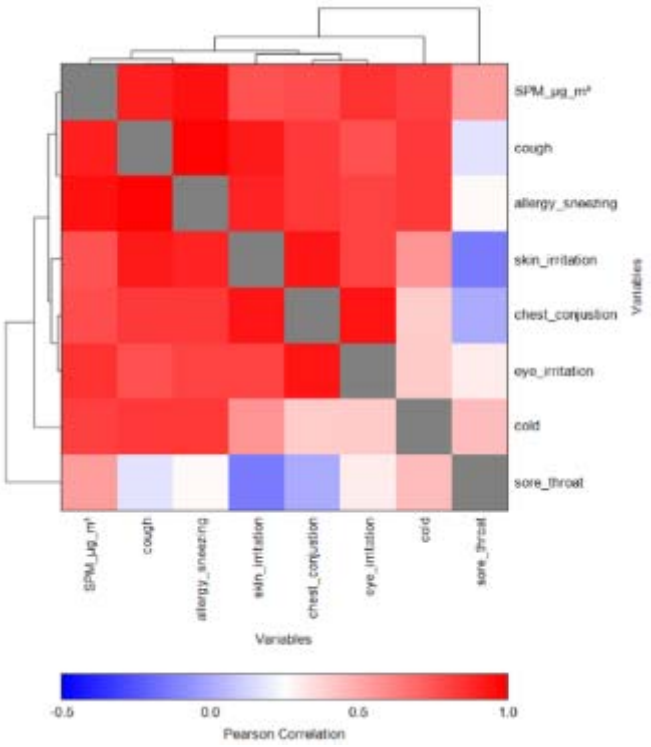

Figure 6. Heat plot of SPM and disease symptoms

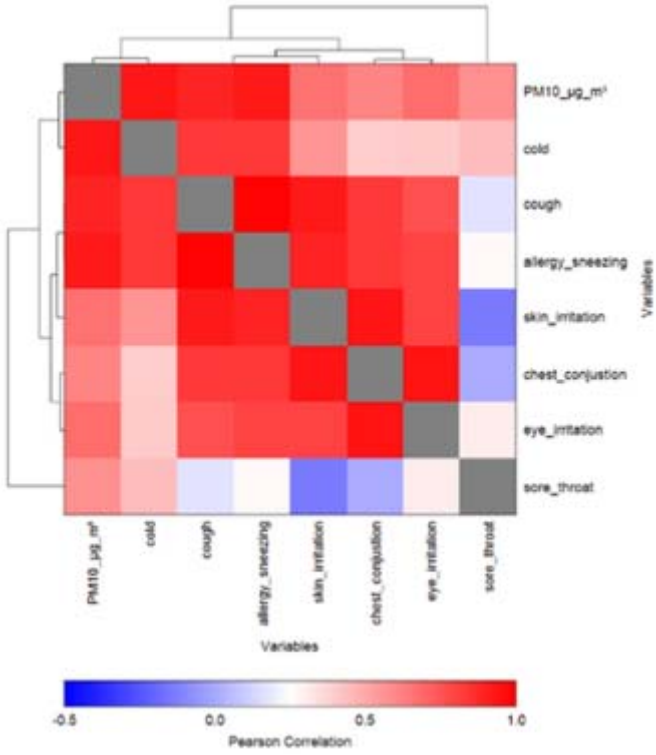

Figure 7. Heat plot of PM_{10} and disease symptoms

irritation (R=0.7555) and chest congestion (R=0.7768) with increase in SPM concentration. Association between cough and PM_{10} (R=0.8928) are also observed.

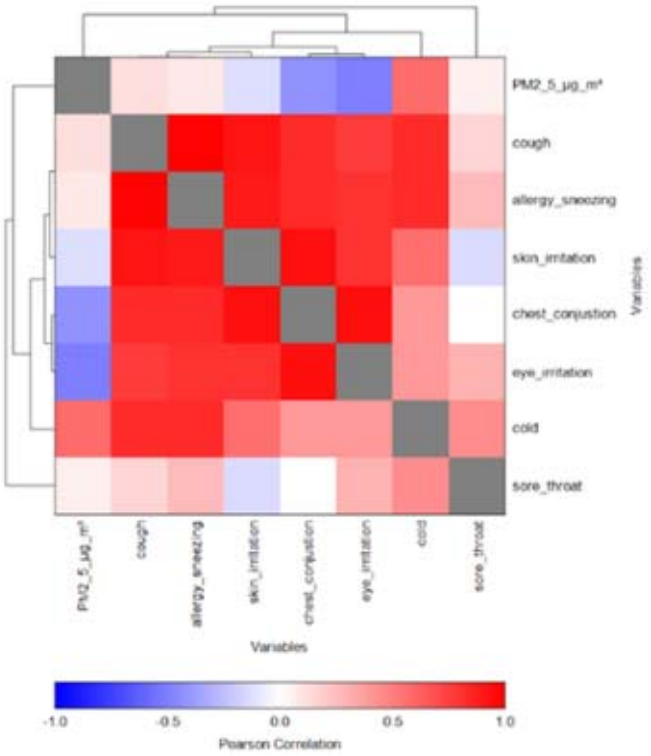

Figure 8. Heat plot of $PM_{2.5}$ and disease symptoms

Children exposed to comparable levels of PM may be more sensitive than adults due to higher time spent outside, activity levels, and minute volume per unit body weight, all of which can result in an increased PM dose per lung surface area and adverse effects on developing lungs. Recent epidemiological studies looked into the relationship between PM and respiratory effects in children. Short-term PM exposure of all size fractions appears to induce more respiratory symptoms (e.g., wheeze, cough, and respiratory hospital admissions) in children (<18 years) than in adults (Host et al. 2007). Despite the fact that the perception data was obtained from respondents over the age of 16, many of them complained about worsened allergy symptoms such as cough, sneeze, running nose, and asthma attacks in children of different ages in the study area.

General awareness of people in the area on air quality issues

The literacy rate in the area was high, and a large percentage of the population has an above average level of education (43.86% have a bachelor's degree or more), which contributes to the high quality of their responses. The perceptions of the respondents on various aspects of air pollution, as well as their

understanding of the quality of air in the locations and solutions to address pollution-related concerns, were investigated. The majority of respondents believe that air pollution is the most prevalent hazard over the four demolition sites. In comparison to last year, the air quality situation in the area has deteriorated.

About 49% of respondents believe that air pollution has a negative impact on health and the environment, which has an impact on quality of life. The majority of people (63%) believe that traffic and construction activities are the primary sources of air pollution in the area. According to them, industrial emissions and waste burning are also major contributors to rising pollution concentrations in the atmosphere. 61% of the population lacks sufficient access to air quality data, while the rest rely on newspapers, television, and the internet for information. Only 10% of people are aware of the Central Pollution Control Board website. However, many of them have noticed the air quality parameters displayed on display boards.

According to the question about personal actions to address the air quality issue, the participants' best choices for fixing the issue are better waste management practises and planting more trees. Taking public transportation, they believe, may help to minimize air quality problems. Some people were willing to contribute funds to projects that will help improve environmental degradation.

CONCLUSIONS

Demolition of high-rise building was first of a kind event in Kochi, so that the environmental risk of the implosion was a primary concern. The evaluation of air quality parameter indicates the short-term deterioration of air quality over the area, mainly due to particulate matter pollution. The scientific literature already establishes the link between SPM and human health problems. Analysis of the questionnaire survey on the effects of particulate matter pollution on health found that all the sites have been seriously affected by the implosion. The major short term health impacts include occurrence of allergy sneezing, cough, cold, chest congestion and aggravation of previous diseases in elderly and children. The perception survey helped to assess the general people's understanding on air quality and health impacts and also the intensity of building demolition experienced by the highly dense population inside a city.

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