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The Impact of a Building Implosion on Ambient Air Quality: A Case Study in an Urban Coastal City

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ABSTRACT

This study was carried out to assess the impact of implosion of four multi-storied apartments in an urban coastal city, Kochi, India on the ambient air quality. Air quality monitoring was conducted pre and post demolition stages indicated that there was short-term air quality deterioration surrounding the demolition sites. The increase of SPM, PM_{10} and $PM_{2.5}$ was above the permissible limits during demolition which reduced afterwards, but was above the ambient level monitored in the pre demolition stage. In the case of SPM the concentration increased to 3004μgm/m³ during implosion in one of the sites, Golden Kayaloram. This site showed PM_{10} and $PM_{2.5}$ also to be above permissible limits during implosion. This is followed by the monitoring sites of Jain Coral Cove, which also showed higher concentration levels above permissible limit during demolition. Other apartments, Alfa Serene and Holyfaith share the same monitoring sites and exceeds permissible limit for SPM and $PM_{2.5}$ during demolition. In general more sites reported concentration above permissible limits for $PM_{2.5}$. The average air quality after three months of implosion shows that, the pollutant concentration was much higher than the pre-demolition level. These results clearly show that building implosion is having severe impact on local air quality.

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Introduction

The Supreme Court of India had on May 8, 2019, ordered the demolition of the four apartment complexes that were built by violating the Coastal Regulation Zone (CRZ) norms, at Maradu municipality in Kochi, Kerala. The flats were built along the coastal region that falls under the CRZ-III category with strict curbs on construction activities [1]. In such areas, constructions are not allowed within 200 metres from the coastline . Four water-front luxury apartments on the Shore of Vembanad Lake in Maradu Municipality, near Kochi, India were demolished during the second week of January 2020. The Maradu demolition is a first of a kind event in India. The buildings under demolition are 50-65 m high and since no such tall, strong buildings has been demolished in the country, this was considered as an experiment [2]. Demolition by implosion has been associated with local increase in particulate matter [3]. The demolition of a 22-story residential structure in Baltimore, MD, by implosion resulted in short-term concentrations of particulate matter (PM) that were 1000 times higher than pre-implosion levels and implosion of a hospital in Calgary, Alberta, Canada, produced very high peak concentrations that violates the Canadian standard for total suspended particulates (TSPs) [4,5]. Azarmi and Kumar assessed the PM10, PM2.5 and PM1 concentration from a building demolition and found that average exposure dose increased up to 57 times during the demolition activities and they observed that the concentration of particulate matter showed decreasing pattern with distance [6]. Daily maximum exceedances of PM10 had doubled in a period when demolition of a building had been carried out near a monitoring station in Cardiff, UK [7]. Even though no measurements of air borne concentrations of the cloud created by the World Trade Centre (WTC) collapse were done, studies following the catastrophic WTC collapse on September 11, 2001 provide some insight on the upper air way irritation of WTC workers including wheezing, coughing, nose and throat irritation and bronchial hyper-responsiveness [8].

The dust plume resulting from an implosion will be immediate, intense, and short-lived. Demolition by implosion is conducted by using nitroglycerine-based dynamite to strategically destroy load-bearing structures, allowing the building to collapse onto itself. Depending on the timing and location, the potential for human exposure to air contaminants from urban building implosions is great because of the combination of high population density, the enormous particulate matter (PM) emission rate and the resulting high $PM_{2.5}$ (particles less than 2.5 micrometers in diameter) concentrations in the atmosphere. Due to the recognised fact that atmospheric PM poses a threat to human health (for example increased mortality amongst the general population as an effect of exposure to PM, the contribution to the PM concentration during and after demolition episodes are a concern [9-12]. $PM_{2.5}$ can penetrate deeply into the lung, irritate and corrode the alveolar wall, and consequently impair lung function [13]. The "Harvard six Cities Study", published in 1996, revealed that $PM_{2.5}$ was one of the causative factors of human non-accidental death and the

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study shows that $PM_{2.5}$ was positively related to daily morality of humans, particularly the elderly people [14]. $PM_{2.5}$ causes asthma, respiratory inflammation, jeopardizes lung functions and even promotes cancers, its impact on human respiratory system should not be dismissed [15]. In addition to the short-term exposure associated with the airborne PM at the time of the implosion, there is the potential for longer-term exposure to $PM_{2.5}$ that disperse across the community and then is available to be re-suspended and inhaled or ingested after hand-to-mouth contact [4]. Demolishing public housing structures could result in higher atmospheric concentrations of $PM_{2.5}$ which may adversely affect the respiratory health of residents of the area.

There is a strong public health rationale for investigating urban $PM_{2.5}$ exposure associated with building implosions. First, such exposures have not been previously reported in the area. Second, urban communities are already at risk for air pollution-related morbidity, including asthma. Lastly, there is strong and growing evidence of $PM_{2.5}$'s adverse respiratory effects. It has also been shown that individuals who are elderly or having cardiovascular disease are at increased risk when $PM_{2.5}$ levels are elevated. The health threat from this implosion was further worsened because of its close proximity to a multi-speciality hospital, placing susceptible individuals (e.g., immune-compromised, cardiopulmonary disease etc.) at increased risk.

This study is designed in such a way that monitoring is done with the association of authorities of Kerala State Pollution Control Board (KSPCB) which promise authentic data for the study. Analysis of ambient air pollution data in terms of concentration of particulate emission before the implosion, on the day of implosion and post implosion phases were done. Buffer zones around the four sites of demolition were selected as 100m and 200m away from the sites.

Study Area

The study involved the implosion of four multi-storied luxury apartments in Maradu, Kochi. Jain Coral Cove (site 1), which is the biggest (24892.3 sq.m area) of the demolished structures is located along the backwaters at Nettoor. Holy faith H_2O (Site 2) is located along the Kundannoor back waters near Kundannoor-Thevara flyover with 19 floors in 18370.49 sq.m in area. Alfa Serene (Site 3) is a high-rise residential complex with twin towers on the shores of the backwaters at Kundannoor. Golden Kayaloram (Site 4) was the smallest (6032.60 sq.m area) and oldest among the demolished building with a height of 50-meter. Golden Kayaloram was a 17-storey (G+16) apartment complex. Fig.1 shows the implosion sites, surrounding residential areas as well as the monitoring locations used to assess the air quality data.

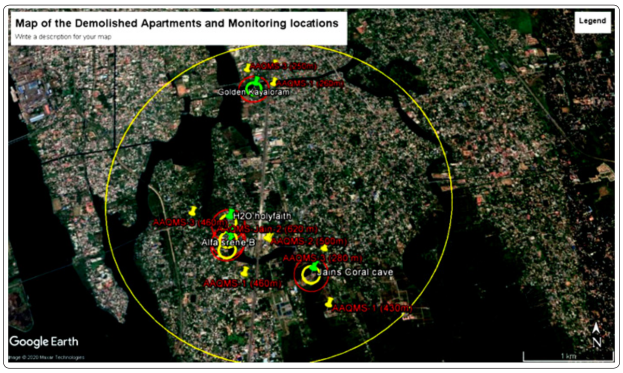

Figure 1: Map showing Demolished Apartments and air quality monitoring locations during pre demolition and on date of demolition.

All the four buildings are within a radius of 2km in Maradu Municipality, Kochi, Kerala (Figure1). The area has high population density with more than 3600 people and more than 1000 buildings in one sq. km. The apartments are located along North-South orientation. The apartment Golden Kayaloram is located on the northern most branch of Champakara canal, while the Jain Coral is on its southern branch. Compared to the location of other flats, Holy Faith and Alfa Serene are located close to each other on the eastern and western banks of the Nettoor stream. Site specific and structural details of demolished apartments are given in table.1.

Site	Jain Coral Cove	Alfa Serene	Holy faith H_2O	Golden Kayaloram
Location	9° 55'49.90' N 76° 19'24.95"E	9°55'59.87" N 76°18'51.95"E	9°56'11.18"N 76°18'51.32"E	9°57'13.71"N 76°18'59.08"E
Demolition date	12-01-2020	11-01-2020	11-01-2020	12-01-2020
Building Size	G+17 story	G+16 story	G+19 story	G+16 Story
Area	24892.3 sq.m	12149.29 sq.m	18370.49 sq.m	6032.60 sq.m
Construction Material	Cement brick and steel	Cement brick and steel	Cement brick and steel	Clay brick and steel
Demolition technique	Controlled implosion	Controlled implosion	Controlled implosion	Controlled implosion
Distance and position of Sampler from demolition site	S1-430m,SE S2-620m,NE S3-280m,N	S1-460m, SE S2-500m,E S3-550m,NW	S1-460m,SE S2-500m,E S3-550m,NW	S1-260m, NW S2-380m,N S3-250m,NE
Wind Direction	SW	SW	SW	NE

Materials and Method

In this study, ambient air quality parameters such as PM, PM_{10} and $PM_{2.5}$ were monitored in three stages: pre-demolition, on demolition date and post-demolition. ie; debris removal stage. Respirable Dust Samplers (model: Envirotech APM 460) and $PM_{2.5}$ Sampler (Model: Envirotech APM 550 MMFC) were installed for the purpose.

Respirable Dust Samplers is equipped with a cyclone unit in it.The high efficiency cyclone unit retain particulate matters >10 micron in size and allow particulates <10 micron particles to reach the filter paper. It is one of the most commonly used devices for ambient air quality surveys. The Sampler was placed approximately 1-3 m above the ground surface. After 8 hrs the filter paper collecting particulate matter was then weighed for PM10. Similarly the dust collector cup containing dust>10 micron was carefully removed and obtaind the final weight for SPM.

The APM 550 system is a manual method for sampling fine particles (PM2.5 fraction) and is based on impactor designs standardized by USEPA for ambient air quality monitoring. Ambient air enters the APM 550 system through an omni-directional inlet designed to provide a clean aerodynamic cut -point for particles greater than 10 microns. Particles in the air stream finer than 10 microns proceed to a second impactor that has an aerodynamic cut point at 2.5 microns. The air sample and fine particulates exiting from the PM2.5 impactor are passed through a 47mm diameter Teflon filter membrane that retains the fine Particulate matter. The sampling rate of the system is held constant at $1m^3/hr$ by a suitable critical orifice. After 8 hrs the filter paper was removed and weighed to get PM2.5.

Figure 2: Respirable Dust Samplers (Envirotech APM 460) and PM2.5 Sampler (Envirotech APM 550 MMFC)

Sampling was done from 10th and 11th January 2020 for the pre demolition data and 11th and 12th January for on demolition data. Distance and position of sampler are given in table.1. Sampling was also done from 2st January to 18th March 2020 for collecting the data during debris removal stage. The prevailing wind direction were observed using wind vane during the sampling period. Calculations involved are given below:

1. Calculation of Air Volume Sampled (m^3)

V= [(Q1+Q2)*T]/2

Where,

Q1= Initial air flow rate, m3/min, Q2=Final air flow rate.m3/min

T= sampling time in minute

2. Calculation of SPM and PM_{10}

= [Wf - Wi] *10^6

Vm^3

Wf= Final weight of filter paper/dust collector cup,g,

Wi= Initial weight of paper/dust collector cup,g

V= Air volume sampled, m^3, 10^6 = Conversion g to µg

3. Calculation of $PM_{2.5}$

= (Wf- Wi)mg * 10^3 µg

V (m^3)

Where, Wf= final weight of filter paper

Wi= Initial weight of filter paper

V= total volume of air sampled

Results and Discussion

Since this is for the first time in India, little is known about the impact of demolition on air quality. At the four high-rise apartments of Maraud municipality, Kochi, particulate matter with an aerodynamic diameter <2.5µm, <10µm and >10µm were measured during three stages of demolition: pre-demolition, on demolition date and after demolition (debris removal period). Substantial increase were observed during demolition for SPM, PM10 and PM2.5. Each demolition site has three monitoring locations for measuring pollutant concentrations on pre-demolition date and on the date of demolition, because the concentration varies with sampling distance, wind direction and building material. After demolition, during the debris removal also pollutant concentration was measured for 8 hrs within the 100 m radius of the demolition site daily from 21st January to 18th March 2020 during which the clearing process was being done. The location details of sampler location during post demolition are given in fig.3. At Holy faith H_2O and Alfa Serene twin towers demolished sites the wind direction monitored was SW while for Golden Kayaloram it was NE. The prevailing wind direction in Jain's coral Cove site was SW. The sampling locations were placed in downwind direction except for Alfa Serene and Holy faith H_2O due to technical difficulties.The particulate matter concentrations from the different monitoring locations of four demolition sites collected during the study are discussed below.

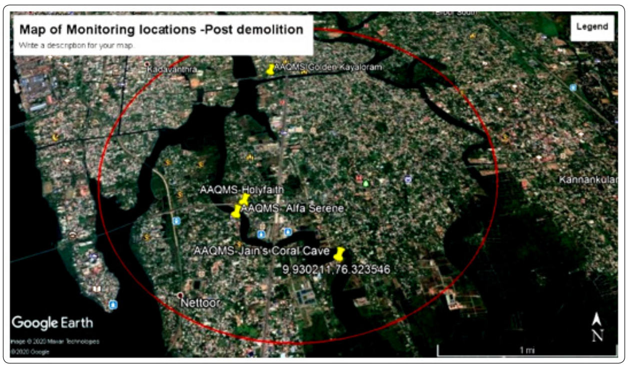

Figure 3: Location details of Dust sampler during debris removal stage.

Ambient particulate matter concentration before Demolition

The pre and on demolition concentrations of particulate matter are summarized in table.2 and presented graphically in figure 4, 5 and 6.The air pollution concentration at the apartments Alfa Serene twin flats and Holyfaith H_2O, which are located close to each other, were monitored the day before the demolition. It was found to be within limits with concentration of SPM, PM_{10} and PM2.5, 21µgm³, 15µg/m³, 15µg/m³ respectively. The apartment Jain's Coral Coveshowed the concentration 17µg/m³, 12µg/m³ and 29µg/m³ for SPM, PM10 and PM2.5 respectively. At Golden Kayaloram, it was found to be 12 µg/m³, 15µg/m³ and 22µg/m³ respectively. All the values are given in table.2. Comparing all the sites, Alfa Serene and Holy Faith show comparatively higher values for SPM, and PM_{10}. Jain's Coral Cove shows higher values for $PM_{2.5}$. These values are much lower than the permissible limits by Central Pollution Control Board (CPCB) for residential area category ie: SPM (200µg/m³) PM_{10} (100µg/m³) and $PM_{2.5}$ (60 µg/m³).

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Table 2: Air quality monitoring data summary

Station	AAQMS	Distance (m)	SPM µg/m³		PM10 µg/m³		PM2.5 µg/m³	
			Pre-demolition	On demolition date	Pre-demolition	On demolition date	Pre-demolition	On demolition date
Alfa Serene & Holy faith H_2O	1	460	17	41	14	20	9	79
	2	500	33	75	20	35	27	35
	3	550	32	266	11	81	10	17
	Mean		**27.33**	**127.33**	**15**	**45.33**	**15.33**	**43.67**
Golden Kayaloram	1	260	17	3004	5	477	9	79
	2	380	11	153	6	50	8	48
	3	250	9	179	1	35	50	169
	Mean		**12.33**	**1112**	**4**	**187.33**	**22.33**	**98.67**
Jain Coral cove	1	430	14	180	12	143	36	265
	2	620	24	218	15	59	31	154
	3	280	14	203	11	78	22	52
	Mean		**17.33**	**200.33**	**12.67**	**93.33**	**29.67**	**157**

Concentration of Particulate Matter on demolition day

Table.2. shows the Ambient SPM, PM_{10} and $PM_{2.5}$ concentrations during demolition. The concentrations were very high at all the four demolition sites. In the case of SPM the concentration increased to 3004µgm/m³ in of the site in Golden Kayaloram. This site showed PM_{10} and $PM_{2.5}$ to be above permissible limit during demolition. This is followed by the monitoring sites of Jain Coral Cove, which also showed higher concentration levels above permissible limit during demolition. Alfa Serene and Holy faith share the same monitoring sites and exceeds permissible limit for SPM and $PM_{2.5}$ during demolition. In general more sites reported concentration above permissible limits for $PM_{2.5}$. SPM and PM_{10} concentration was very high at Golden Kayaloram (figure 4 & figure 6) while Jain Coral Cove shows the highest $PM_{2.5}$ Concentration (figure 5) on the demolition day. The highest concentration of SPM and PM_{10} in Golden Kayaloram attributed mainly by the downwind location of sampler and distance to the demolition sites. All the four sites experienced much higher concentration of pollutants than the ambient concentration.

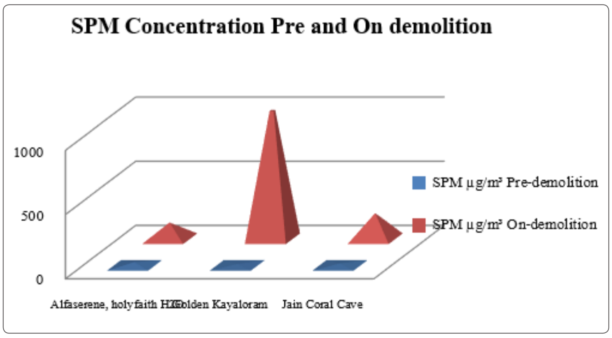

Figure 4: SPM concentration during pre and on the demolition day

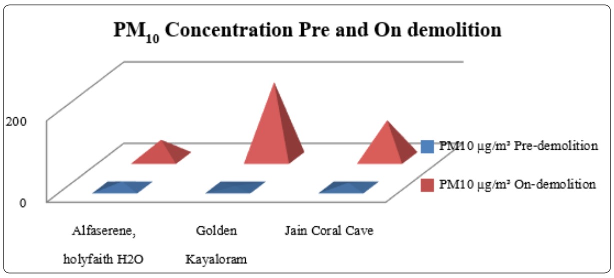

Figure 5: PM10 Concentration during pre and on demolition day

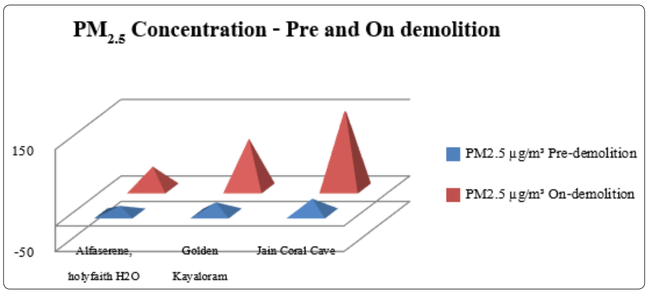

Figure 6: $PM_{2.5}$ concentration during pre and on-demolition day

Figure 7: Map showing Alfa Serene and Holyfaith H_2O and nearby monitoring locations

Figure 7. Shows that Alfa Serene and Holyfaith H_2O are two nearby apartments and both shared common monitoring locations for particulate sampling. The prevailing wind direction was observed to be towards west in general and monitoring locations were placed in the downwind as well as upwind directions. The monitoring location 1 was 460 m away and placed South East of demolition site shows the values SPM-41µg/m³, PM_{10}-20 µg/m3, $PM_{2.5}$-79 µg/m³ . The second location was in east direction (500m away) and the concentration was 75µg/m³, 35µg/m³, 15µg/m³ for SPM, PM_{10} and $PM_{2.5}$ respectively. The monitoring location 3 was placed NW to the site and it was 550m away. SPM concentration was found to be 266µg/m³, which is above permissible limit and PM_{10} and $PM_{2.5}$ values were 81µg/m³, 17µg/m³ respectively (Table 2). The monitoring location placed in the downwind direction to the site was third monitoring location and it shows higher SPM and PM_{10} values compared to other locations, even though the

distance was more than others. $PM_{2.5}$ was highest for location 1 which is in the upwind direction, but closer location.

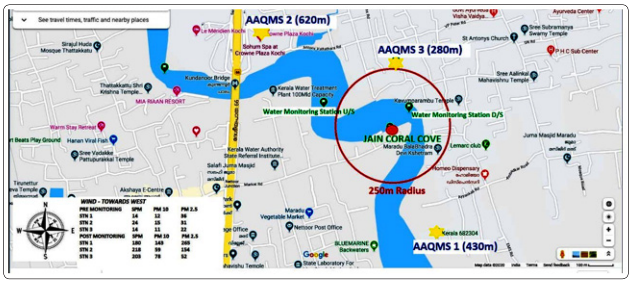

Figure 8: Map showing Jains Coral Coveand nearby monitoring locations

The 17-storey Jain Coral Covewith 128 apartments was the largest apartment building. Fig 8 shows the locations of monitoring sites and wind direction. The prevailing wind direction was towards west. The monitoring location1 was placed 430 m away and in the South-East side of the demolition site (Figure 7). It shows comparatively high values for SPM, PM_{10} and $PM_{2.5}$ (180µg/m³, 143µg/m³, 265µg/m³ respectively) (Table 2). The PM_{10} is 1.43 times and $PM_{2.5}$ is 4.4 times higher the CPCB limit. SPM found to be 11.5 times higher the ambient level. The monitoring location 2 was placed along NW and 620 m away from the site and in the prevailing wind direction. The SPM and $PM_{2.5}$ exceeds the permissible limit and PM_{10} is 2-3 times higher the ambient value. The values are 218µg/m3, 59µg/m³, and 154µg/m³ for SPM, PM_{10} and $PM_{2.5}$ respectively(Table.2). The third monitoring location was 280m away and placed north to the site shows the values 203µg/m³, 78µg/m³, 52µg/m³ for SPM, PM_{10} and $PM_{2.5}$ respectively. Here also SPM concentration exceeds the CPCB limit. The SPM values show highest concentration for monitoring location 2 which is in the downwind direction. But PM_{10} and $PM_{2.5}$ values are highest for location 1 which is in the upwind direction away from the location.

Figure 9: Map showing Golden Kayaloram and monitoring locations

Golden Kayaloram was the smallest among the four luxury apartments of Maradu demolition. The apartment is demolished on 12th Jan 2020 afternoon and the prevailing wind direction was westerly. Figure 9 clearly depicts the distance of monitoring location from demolition site and wind direction in Golden Kayaloram. The monitoring station 1 of Golden Kayaloram was located 260m away from the demolition site and in the East to demolition site and that was in the down wind direction. A dramatic increase in particulate matter concentration was observed in this monitoring location; SPM- 3004 µg/m³, PM_{10}- 477 µg/m³ and $PM_{2.5}$ - 79 µg/m³ (table.2). All these values exceed the Central Pollution Control Board CPCB) limits. Here the highest concentration was observed and it was found SPM was 92 times (15 fold permissible limit), PM_{10} 12 times (4.7 fold the permissible limit) and $PM_{2.5}$ 4 times (1.3 fold permissible limit) higher the ambient level. This may be due to monitoring location being placed downwind from the demolition site and its proximity to demolition site. The other two monitoring locations are 380m and 250 m away and located along N and NW direction of the demolition site which is not in the prevailing wind direction. The pollutant concentrations are 153µg/m³ (SPM), 50µg/m³ (PM_{10}) and 48 µg/m³ ($PM_{2.5}$) for location 2 and 179µg/m³ (SPM), 35µg/m³ (PM_{10}) and 169 µg/m³ ($PM_{2.5}$) for location 3. SPM and PM_{10} concentrations were observed to be highest in downwind direction with $PM_{2.5}$ highest in upwind direction with shorter distance.

On the demolition day the highest concentration of 3004µgm/m³ of SPM and 477µgm/m³ of PM_{10} was observed in Golden Kalayoram site 1 in downwind direction, closer to the location. Highest $PM_{2.5}$ observed was 265µgm/m³ near Jain coral Cove site 1 in upwind direction.

Taking the average of three sites, SPM concentration exceeds the permissible limit in two sites; Jains Coral Coveand Golden Kayaloram, whereas in Holy faith H_2O and in Alfasrene, SPM value increased approximately 4.6 times higher than the ambient concentration. Average PM_{10} concentrations exceed the permissible limit in Golden Kayaloram and showed 46.8 fold increase than the ambient concentration. Compared to pre-demolition concentration, there found about 7.4 times higher concentration of PM_{10} in Jain Coral Coveand 3 times in Alfa Serene and Holyfaith H_2O. $PM_{2.5}$ concentration crossed the CPCB limit in two sites namely Jains Coral Coveand Golden Kayaloram. There found to be 3 times increase than the local level in $PM_{2.5}$ concentration in Alfa Serene and Holy faith H_2O (table2).

Concentration of PM on Post-Demolition Phase

The monitoring was continued after the demolition which was followed by debris removal during the period 21.01.2020 to 18.03.2020. The data shows the concentration values to be much above the ambient level before demolition, throughout the period of debris removal, even though within permissible limit. The wind direction were also monitored at the sites. It was found that the concentration of particulate matter is decreasing for all sites in course of time. It is seen that the decrease is more evident in the case of $PM_{2.5}$ for the site Alfa Serene and SPM and PM_{10} for the site Golden Kayaloram. The decreasing trend is more evident in Golden Kayaloram.

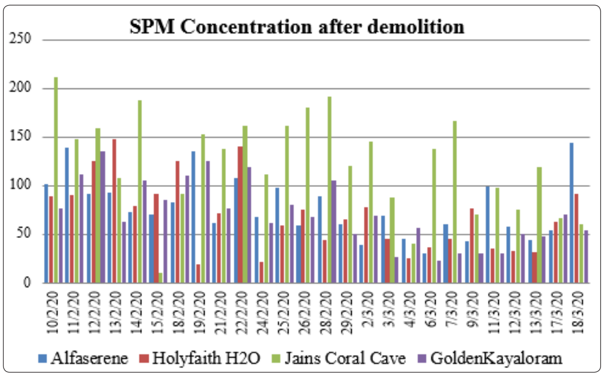

Figure 10: SPM Concentration during Post demolition phase

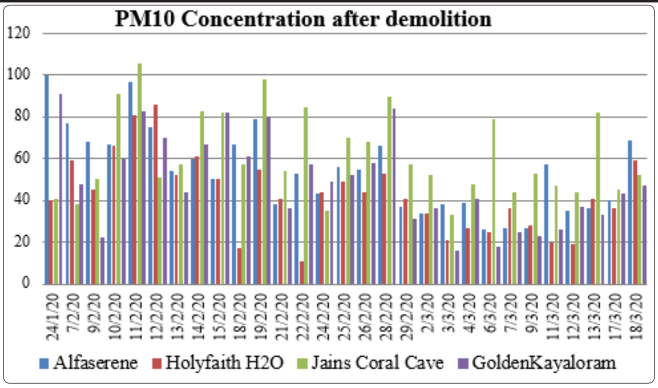

Figure 11: PM10 Concentration during post-demolition phase

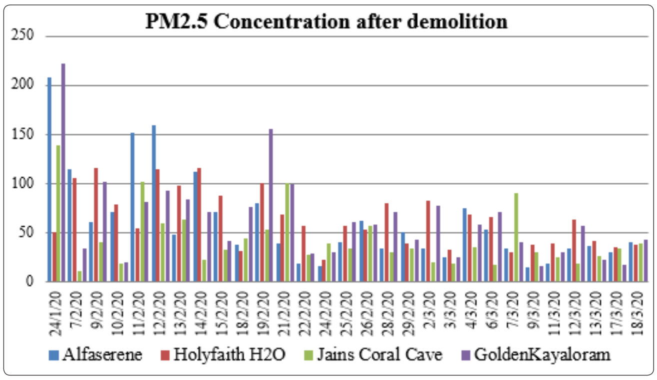

Figure 12: PM2.5 concentration after demolition

For the site Alfa Serene the prevailing wind direction was found to be South-West (Figure.13) and measurements were done in the west direction. The highest concentration of 208 µgm/m^3 for PM $_{2.5}$ was observed on 24/01/20 which reduced to 41 µgm/m3 on 18/03/20. The SPM concentration level of 127 µg/m^3 during demolition was reduced to the range 54µg/m3 on the last day which was also 2 times above the ambient value. The concentration was always higher than ambient value at all the sites, without exceeding the limit (Figures 10, 11&12). The monitoring equipment was placed 70m away from demolition site in the down wind direction. And dust produced due to the continuous working of separating the steel and iron rods and concrete debris using JCBs makes the pollutants concentration high above the ambient level.

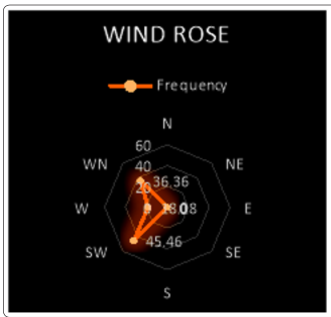

Figure 13: Wind direction – Alfa serene

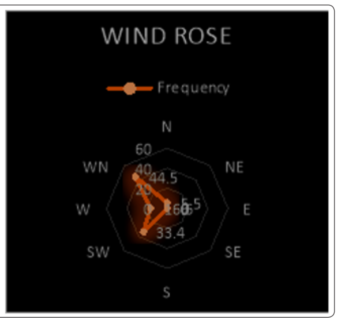

Figure 14: Wind direction – Holyfaith H_2O

In the case of Holyfaith H_2O, the monitoring locations are placed 200m away and along SW direction. The prevailing downwind direction was found to be North-West (Figure 14). Here also the concentration of SPM, PM_{10} and $PM_{2.5}$ are below the permissible limit but much above the ambient level. The average concentration was 3, 3, and 2 times the ambient concentration of SPM, PM_{10} and $PM_{2.5}$ (21µg/m^3, 15µg/m^3, 15µg/m^3 respectively). SPM and PM_{10} is below the permissible limit throughout the debris removal period. $PM_{2.5}$ exceed the permissible limit during first few days and then came under permissible limit but always showed higher than the ambient value. The highest concentration of $PM_{2.5}$ (112 µgm/m^3) was observed on 07/02/2020.

The monitoring values of Jain's coral Covealso are decreasing from initial days to final day but always higher than ambient concentration. The monitoring location is placed South-West of demolition site and it was 65m away and in downwind direction. The average concentration of SPM, PM_{10} and $PM_{2.5}$ (123.9 µgm/m^3 ,69.7 µgm/m^3 and 41.6 µgm/m^3) were 3, 1.75 and 2 times above ambient level. The highest concentration of SPM was 212µgm/m^3 was observed on 10/02/20.

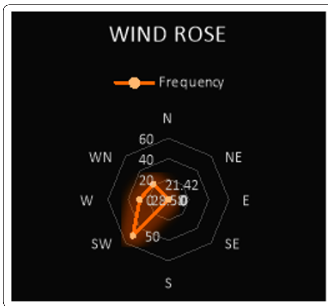

Figure 15: Wind direction – Jains Coral Cove

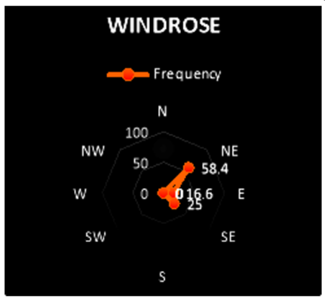

Figure 16: Wind direction – Golden Kayaloram

The prevailing wind direction near Golden Kayaloram is North-East (Figure16). But the monitoring location could be placed along NW direction to the site and it was 90m away. SPM and $PM_{2.5}$ in Golden Kayaloram is observed to be respectively 203µgm/m3 and 222 µgm/m^3, higher than the permissible limit on initial day of debris removal and PM10 was 91µg/m^3. The average concentration of SPM, PM_{10} and $PM_{2.5}$ (76.9 µgm/m^3 , 50 µgm/m^3, 61 µgm/m^3 respectively) were 6,12.5 and 2.8 times above ambient level. The highest concentration of SPM and $PM_{2.5}$ (203µgm/m^3 and 222 µ gm/m^3) was observed on 24/01/20.

Conclusion

During demolition, SPM concentration increased to 3004µgm/ m^3 in Golden Kayaloram site. This site showed PM_{10} and $PM_{2.5}$ also above permissible limit during demolition. This is followed by the monitoring sites of Jain Coral Cove, which also showed higher concentration levels above permissible limit during demolition. Alfa Serene and Holy faith share the same monitoring sites and exceeds permissible limit for SPM and $PM_{2.5}$ during demolition. In general more sites reported concentration above permissible limits for $PM_{2.5}$. The concentration of SPM was observed to be affected by wind direction. It is found to be much higher than permissible limit in the downwind direction for all the sites. PM_{10} also shows the same pattern. $PM_{2.5}$ is found to be above permissible limit for most of the monitoring sites without being much affected by wind direction. Another factor affecting the concentration is distance of monitoring locations. Some of the observations seem to be highest in the nearby monitoring location even though it is in the upwind direction. Jain coral Cove shows slight difference in the pattern for some observations of PM_{10} and $PM_{2.5}$, which may be because of the location with the surrounding back waters. During debris removal phase also the concentration was observed to be much above the ambient level before demolition at all sites. In certain instances it crossed the permissible for SPM and $PM_{2.5}$. Even though precautions like water sprinkling by means of jets and other means was done, It is found to be effective to a certain extend only for SPM and PM_{10}. But $PM_{2.5}$ concentration, which is causing more serious health effects, is not very much decreased by these measures. This shows that the measures are not enough to bring back the air pollutant concentration to ambient level before demolition and serious health effects can be expected [16].

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Conflict of interest
None

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