Environmental retrieval during COVID-19 lockdown in the megacity Karachi, Pakistan

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Abstract. The global devastating effect of COVID-19 has also wrapped up the mega city of Pakistan-Karachi. The study was conducted to reveal the effects of limited anthropogenic activities, in terms of national lockdown, on the environmental pollution in Karachi. No study has been conducted to monitor the effect of the COVID-19 lockdown on levels of PM2.5 and noise in Karachi so far. The levels of PM2.5 and noise were monitored before and during the imposition of the COVID-19 lockdown with the help of a particulate monitor and environmental meter, respectively. The monitoring was conducted for 12 hours at 25 locations. The spatial distribution of mean PM2.5 and noise levels were represented by thematic maps. Statistical evaluation revealed a significant decrease in PM2.5 and noise pollution by 53.55% and 24.98%, respectively. The percentage of locations where the mean PM2.5 level was surpassing the Sindh environmental quality standards before the lockdown had dropped from 56% to 8% during the lockdown. Similarly, the percentage of locations where the mean value of noise exceeded the standard values before lockdown had descended from 96% to 24 % for residential areas; 72% to 12% for commercial areas; and 44% to 0% for industrial areas, during lockdown.

Keywords: COVID-19, Karachi, Lockdown, Noise, PM2.5.

1. Introduction

The newly transpired coronavirus disease has accounted for immense global health challenges and produced unforeseeable economic loss. Wuhan-China is the 1st place on Earth where it was recorded foremost in December 2019, therefore this new syndrome was defined as COVID-19 (“Corona Virus Disease 2019”) by the WHO (“World Health Organization”) (WHO, 2020). The virus causing the disease is named SARS-Cov-2 because of its similarity with a previously

occurred “severe acute respiratory syndrome” (SARS)- a global epidemic in Years 2002-2003 (Fattorini & Regoli, 2020). The complications caused by SARS-Cov-2 infection in patients include pulmonary oedema, organ failure, severe pneumonia, septic shock, and acute respiratory stress syndrome that could be fatal in many cases (Chen et al., 2020).

The most devastating effect of this virus is its easy transmissibility from human to human which caused the rapid spread of this epidemic across countries (Li et al., 2020; Khan et al., 2023). In Pakistan, the first case of COVID-19 was confirmed in Karachi on 26th February 2020 by the Ministry of Health, Government of Pakistan. On the same day, another case was also reported in Islamabad by the Pakistan Federal Ministry of Health. Within 15 days, this number has increased dramatically; all COVID-19-positive cases had recent travel history from London, Iran, and Syria. The continuous increase in COVID-19 cases was occurring due to Pakistan’s geographical location, therefore the Government of Pakistan had started acting according to the “National Action Plan for Preparedness & Response to Corona Virus Disease (COVID-19) Pakistan” (Waris et al., 2020). On 11th March, the COVID-19 outbreak was labeled as a global pandemic by WHO, and countries around the globe had taken strict measures to control the spread of the virus and preserve the health of their citizens (Yao et al., 2020). Like other countries, Pakistani cities were also locked down and most of the commercial and industrial activities were forced to stop until further notice. Transportation and traveling were shut down, educational institutes, mosques, and restaurants were closed and mass gatherings were banned. On the other hand, citizens were advised to stay at home except for the need for essential supplies or in case of a medical emergency. The Government has continued these sanitary measures in terms of complete lockdown, partial lockdown, and smart lockdown in different situations to ensure efficient and timely response against the spread of the COVID-19 pandemic (https://www.sindh.gov.pk/).

Studies have suggested a positive association between particulate matter (PM) pollution and infection caused by SARS-Cov-2 (Comunian et al., 2020; Mehmood et al., 2020; Zoran et al., 2020;). According to other studies, particulate matter could carry viruses and thus can act as a carrier for long-distance transmission of viruses (Alonso et al., 2015; Yang et al., 2011). Along with it, particulate matter especially PM2.5 (PM of diameter less than 2.5 micrometers) also impairs respiratory cilia which are the first line of defense of the respiratory system, and could also cause respiratory inflammation due to which the patient becomes more vulnerable to SARS-Cov-2 infection (Yongjian et al., 2020). The present study monitored the levels of PM2.5 before and

during the lockdown period due to COVID-19 in Karachi city of Pakistan, which is the largest industrial and commercial hub of Pakistan. PM2.5 is generally known as Air Quality Index is high generally all over the metropolitan (Kausar et. al., 2023a, Kausar et. al., 2023b).

The increasing interest in environmental effects on the health of individuals usually neglects the effect of the acoustic environment. “The city of light Karachi”; experiences excessive environmental noise (or community noise) pollution due to high industrial, commercial, and recreational activities (Mehdi et al., 2011). This causes psychosocial as well as physiological effects on the exposed population. The major psychological response to environmental noise is annoyance which can result in depression, anger, anxiety and disappointment (King & Davis, 2003; Kou et al., 2020; Daiber et al., 2019). Whereas, physiological risk factors that can result from environmental noise include myocardial infarction and hypertension (Mannucci & Ancona, 2021). Therefore, levels of noise were also monitored before and during the lockdown period due to COVID-19 in Karachi, to assess the impact of decreased anthropogenic activities on environmental noise pollution.

This study aimed to convey the urge of the environment about reducing the anthropogenic effects, to be retrieved.

2. Materials and Methods

Pakistan’s largest city-Karachi, which is located in the province of Sindh, has a strong industrial sector. Due to rapid industrialization and urbanization in Karachi, boundaries between industrial, commercial, and residential zones have nearly diminished therefore locations cannot be demarcated distinctly as industrial, commercial, and residential areas (Ali et al., 2020). For this study, 25 locations were selected for measuring the levels of PM2.5 and noise in Karachi (Table 1), to get representative data of the city.

Table 1. Selected locations with GPS coordinates for the measurement of PM2.5 and noise levels in Karachi

S. No.	Location	GPS Coordinates	S. No.	Location	GPS Coordinates
1.	Ayesha Manzil	24°55'32.59"N 67° 3'42.83"E	14.	Manzil Pump	24°51'17.13"N 67°13'44.89"E
2.	Gulberg Chowrangi	24°56'13.33"N 67° 4'33.80"E	15.	Vita Chowrangi	24°50'28.34"N 67° 8'1.52"E
3.	Nursery Flyover	24°51'34.89"N 67° 3'32.60"E	16.	Shan Chowrangi	24°50'19.44"N 67° 7'15.23"E

4.	City School	24°51'42.37"N 67° 5'16.28"E	17.	National Refinery Limited	24°50'46.63"N 67° 7'30.64"E
5.	Chakiwara	24°52'13.69"N 66°59'54.20"E	18.	Qayyumabad	24°49'44.42"N 67° 5'1.30"E
6.	Shahrah-e-Firdousi	24°48'48.16"N 67° 1'36.25"E	19.	EBM Road	24°50'3.46"N 67° 6'8.30"E
7.	Cantt. Station Road	24°50'32.92"N 67° 2'15.76"E	20.	Korangi Creek	24°48'7.92"N 67° 7'27.00"E
8.	Khayaban-e-Ittehad	24°47'26.38"N 67° 3'56.64"E	21.	Dawood Chowrangi	24°51'1.36"N 67°12'26.07"E
9.	Shahbaz Commercial	24°48'29.40"N 67° 3'42.88"E	22.	Murtaza Chowrangi	24°51'3.08"N 67°10'52.79"E
10.	Empress Market	24°51'45.82"N 67° 1'40.76"E	23.	Landhi No. 2	24°50'32.04"N 67°11'43.90"E
11.	Amaan Steel	24°57'14.06"N 67° 1'37.79"E	24.	Rayta Plot No. 2	24°52'55.44"N 67° 9'59.20"E
12.	Manghopir	24°58'47.66"N 67° 2'7.97"E	25.	Shah Faisal No. 4	24°52'34.51"N 67° 9'34.62"E
13.	Port Qasim Chowrangi	24°50'1.75"N 67°17'53.57"E			

The monitoring of PM2.5 and noise was conducted with the help of a particulate monitor and environmental meter, respectively. At every location, equipment was deployed for 12 hours (06:00 h to 18:00 h). Global Positioning System (GPS) readings along with photographs were also taken to identify the locations (Fig. 1).

Figure 1. Some photographs were taken during field measurement of PM2.5 and noise levels

Monitoring was avoided during any abnormal activity noted like construction work near the location or unusual weather conditions etc. The monitoring conducted in February and March 2020 was considered as “before lockdown” and that conducted in April and May 2020 was considered as “during lockdown” in the present study. The data were presented in the form of Geographic Information System (GIS) thematic maps and graphs by using ArcMap 9.8 and MS Excel software, respectively.

3. Results and Discussion

3.1 Monitoring of particulate matter (PM2.5)

A paired t-test was performed to determine if the lockdown due to COVID-19 was effective in terms of PM2.5 pollution reduction (Table 2a, b). The mean PM2.5 level decrease (M=47.89, SD=27.24, N=25) was significantly greater than zero, t(24)=8.79, two-tail p=5.72x10-9; this provided evidence that the lockdown was effective in reducing PM2.5 levels in Karachi. According to 95% confidence interval (C.I.) about mean PM2.5 levels reduction, the mean difference could be as low as 36.65 µg/m^3 and as high as 59.14 µg/m^3.

Table 2. Results of paired t-test (a) and descriptive statistics (b) of mean $PM_{2.5}$ levels before and during lockdown in Karachi

(a)	**t-test: Paired Two Sample for Means**	
	$PM_{2.5}$ levels before lockdown	**$PM_{2.5}$ levels during lockdown**
Mean	89.432	41.5388
Variance	1029.385592	391.985936
Observations	25	25
Pearson Correlation	0.534710997	
Hypothesized Mean Difference	0	
df	24	
t Stat	8.790758893	
P(T<=t) one-tail	2.85984E-09	
t Critical one-tail	1.71088208	
P(T<=t) two-tail	5.71968E-09	
t Critical two-tail	2.063898562	

(b) Difference between $PM_{2.5}$ levels before and during lockdown	
Mean (M)	47.8932
Standard Error	5.448130313
Median	39.9
Mode	#N/A
Standard Deviation (SD)	27.24065156
Sample Variance	742.0530977
Kurtosis	-0.112250399
Skewness	0.904120903
Range	96.5
Minimum	1.9
Maximum	98.4
Sum	1197.33
Count (N)	25

Confidence Level (95.0%)	11.24438832

Figure 2(a) represents a GIS thematic map of mean PM2.5 levels in Karachi before the lockdown. The highest mean value was observed at Manghopir (153.5 µg/m^3), whereas the second highest mean PM2.5 levels were found near Amaan Steel (150.1 µg/m^3) and National Refinery Limited (149.1 µg/m^3); all of them were almost doubled than the Sindh Environmental Quality Standards (SEQs) i.e., 75 µg/m^3 (SGG, 2016). A previous study conducted by the authors found four times higher Pb concentration in PM2.5 samples collected from Manghopir than WHO standard (0.5 µg/m^3), on characterization (Ali et al., 2020). The Manghopir road contains almost 380 marble processing factories, workshops and showrooms along the road while around 190 are found in the residential areas and their surroundings. Marble dust in the form of fine powder can be attributed for the highest PM2.5 concentration at Manghopir. Marble processing at this site not only contaminates the outdoor and indoor air but also causes hearing loss and hearing disturbances due to noise pollution in the exposed population (Kaleem, 2018). Studies have suggested that particulate matter and noise emitted from marble factories are accountable for various health effects in workers and exposed population (Madhoun et al., 2013; Iqbal et al., 2022).

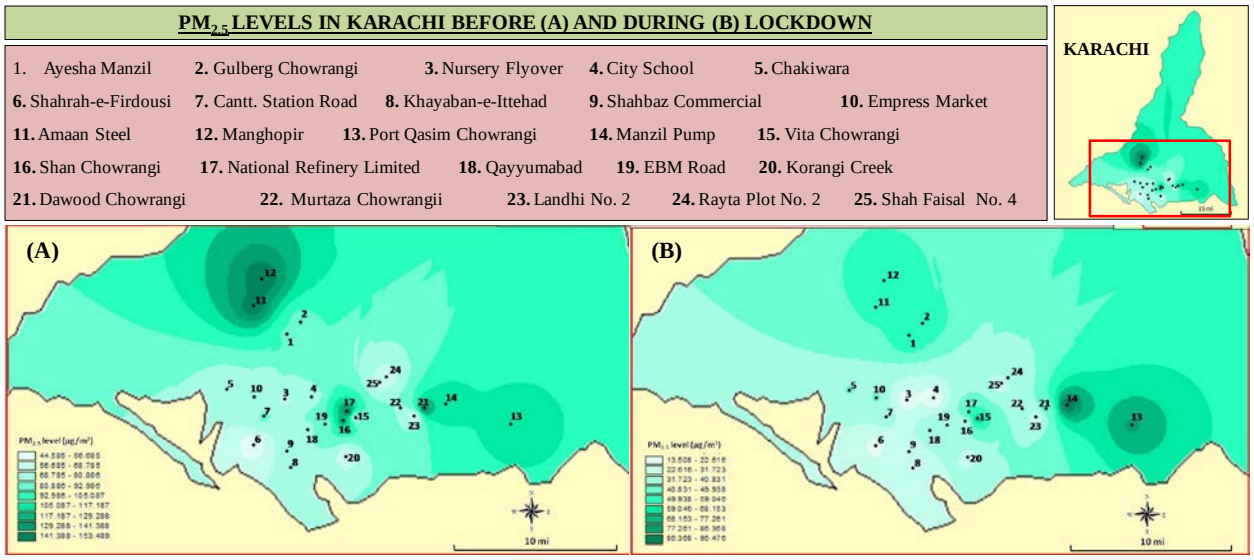


Figure 2. Spatial distribution of mean $PM_{2.5}$ concentrations before (a) and during (b) lockdown in Karachi

Figure 2(b) represents a GIS thematic map of mean PM2.5 levels in Karachi during lockdown. A sharp decrease in mean PM2.5 concentration at each location can be observed by comparing Figures 2 a and b. The mean PM2.5 concentrations recorded during lockdown at Manghopir,

Amaan Steel and National Refinery Limited were 57.7 µg/m^3, 51.7 µg/m3, and 52.3 µg/m^3, respectively; none of which were exceeding the SEQs. The ban on industrial, commercial, social, and transportation activities has not only lowered the threat of coronavirus exposure but also reduced the risk of health damage due to PM exposure.

Overall, a 53.55 % decrease in mean PM2.5 level was noted during lockdown; which revealed that lockdown had significantly helped the environment to retrieve itself. A comparison of mean PM2.5 concentrations before and during lockdown with an individual percent decrease in PM2.5 level at each location is presented in Figure 3. The air around the "City school" showed the highest decline in mean PM2.5 concentration i.e., 81.68 %, this is because of the closure of the school during lockdown. The educational institutes are the indirect source of air and noise pollution because they attract traffic and become the cause of vehicular emissions and noise pollution. Before lockdown, 56 % locations had surpassed the SEQs for mean PM2.5 level i.e., 75 µg/m^3 (SGG, 2016), whereas during lockdown this percentage had significantly dropped to only 8 %.

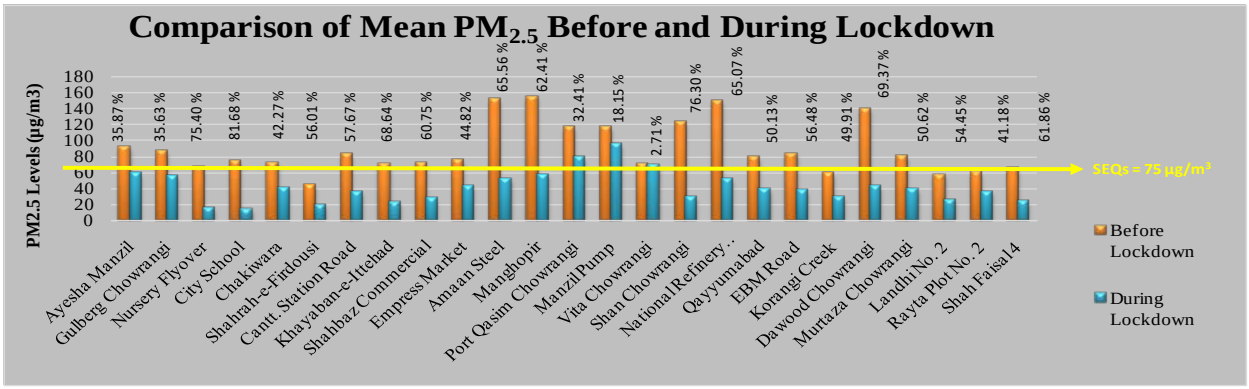


Figure 3. Comparison of mean $PM_{2.5}$ concentrations before and during lockdown in Karachi

Figure 4 (a, b) showed the lowest and highest PM2.5 concentration values at each location before and during lockdown with a time of the day. Most of the locations experienced the highest PM2.5 level in the afternoon than in the morning.

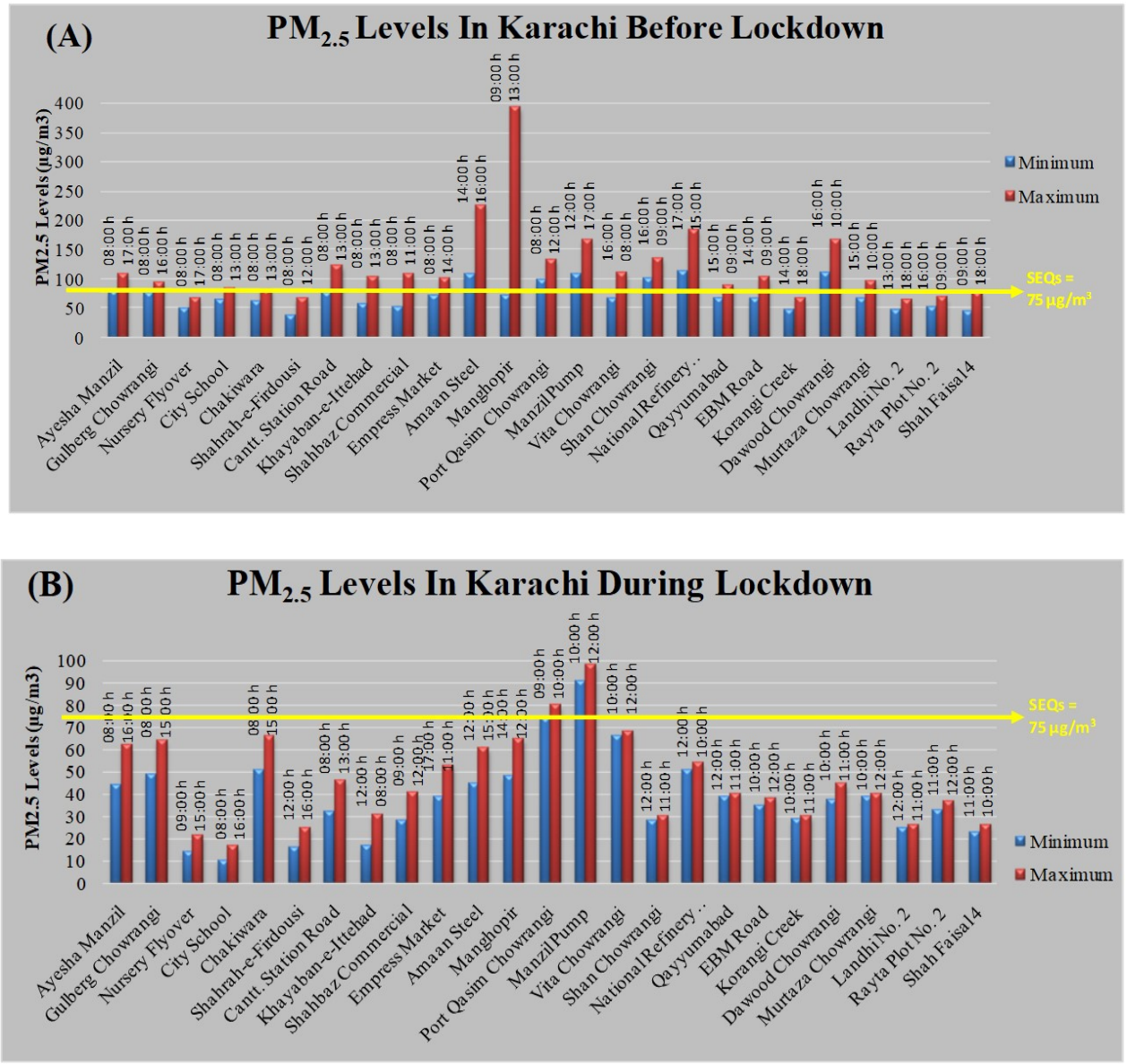


Figure 4. Minimum and maximum $PM_{2.5}$ concentration values at each location before (a) and during (b) lockdown in Karachi

The maximum concentration had reached approximately 400 µg/m^3 before lockdown whereas that had decreased to below 100 µg/m^3 during lockdown. 36 % of locations had minimum PM2.5 concentration exceeding the SEQs while in 84 % of locations, maximum PM2.5 concentration had

crossed the SEQs, before lockdown. Whereas during lockdown, only 8 % of locations had surpassed SEQs for both minimum and maximum values of PM2.5.

3.2 Monitoring of noise

A paired t-test was performed to determine if the lockdown due to COVID-19 is also effective in reducing environmental noise pollution (Table 3a, b). The mean decrease in noise levels (M=19.27, SD=8.81, N=25) was significantly greater than zero, t(24)=10.94, two-tail p=8.22x10-11; providing evidence that the lockdown was effective in decreasing noise levels in Karachi. According to 95 % confidence interval (C.I.) about mean noise level reduction, the mean difference could be as low as 15.64 dB(A) and as high as 22.91 dB(A).

Table 3. Results of paired t-test (a) and descriptive statistics (b) of mean noise levels before and during lockdown in Karachi

(a)	**t-test: Paired Two Sample for Means**	
	Noise levels before lockdown	**Noise levels during lockdown**
Mean	77.18	57.9092
Variance	90.97166667	73.764616
Observations	25	25
Pearson Correlation	0.53230413	
Hypothesized Mean Difference	0	
df	24	
t Stat	10.94323289	
P(T<=t) one-tail	4.10903E-11	
t Critical one-tail	1.71088208	
P(T<=t) two-tail	8.21806E-11	
t Critical two-tail	2.063898562	

(b) Difference between noise levels before and during lockdown	
Mean (M)	19.2708
Standard Error	1.760978698
Median	16.9
Mode	14.4
Standard Deviation (SD)	8.804893488
Sample Variance	77.52614933
Kurtosis	-0.808236414
Skewness	0.402660106
Range	31.6
Minimum	5

Maximum	36.6
Sum	481.77
Count (N)	25
Confidence Level (95.0%)	3.634481401

Figure 5 (a, b) represented GIS thematic maps of mean noise levels in Karachi before and during lockdown. The highest mean value of noise was observed at Qayyumabad i.e., 102 dB(A), which is one of the highly populated areas of Karachi with more than 70,000 population at an area of 109 acres (Zaman & Ali, 2016). It serves as an intermediary zone that connects the South end of Karachi to the East and North ends of Karachi; this could be attributed to the highest value of noise at this location.

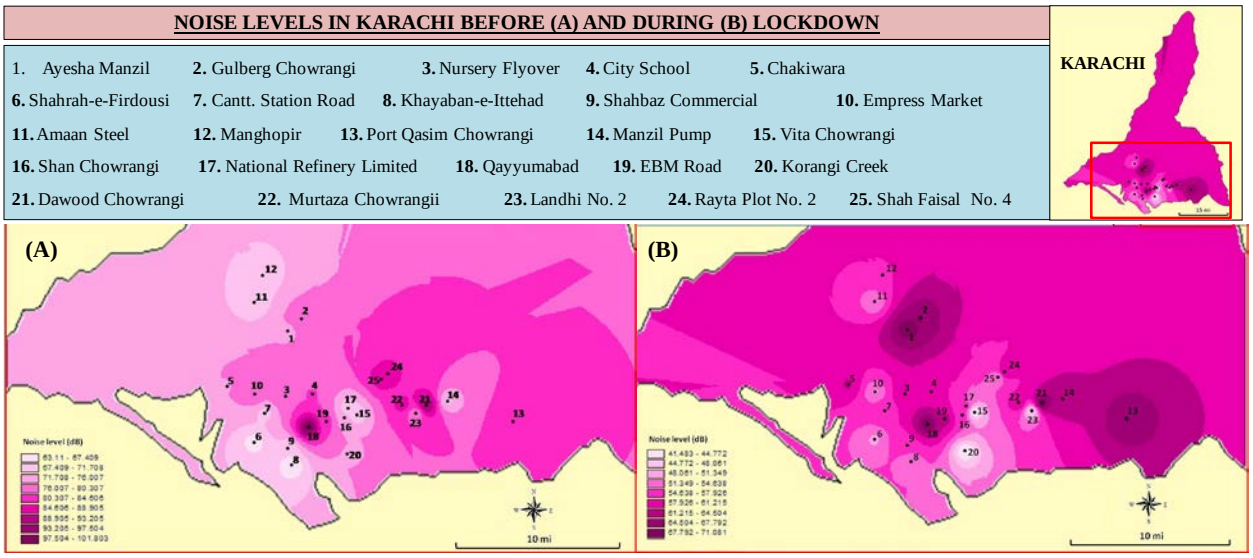


Figure 5. Spatial distribution of mean noise levels before (a) and during (b) lockdown in Karachi

In comparing Figure 5(a, b), the mean value of noise at each location can be observed to be drastically lowered during lockdown than before the lockdown period. Traffic is the major source of noise pollution in Karachi, which emerges from autorickshaws, buses, trucks, motor cycles, pickups, water tankers, cars and wagons etc. (Munir et al., 2021). The ban on public transport and ride-hailing services by the Government in lockdown had become one the most significant reasons of noise level reduction in Karachi.

Overall, a 24.98 % decrease in mean noise level was recorded during lockdown, which is worthy for the population in terms of environmental noise-related health problems. Figure 6 shows the comparative graphs of mean noise levels before and during lockdown with an individual

percent decrease in noise level at each location. As mentioned before, the locations cannot be recognized specifically as industrial, commercial, and residential areas, therefore the noise value at each location was compared with all the SEQs for residential, commercial and industrial areas. The mean value of noise before lockdown had surpassed the SEQs for residential area (i.e., 65 dB(A)) at 96 % locations; for the commercial area (i.e., 70 dB(A)) at 72% locations and for industrial areas (i.e., 80 dB(A)) at 44 % locations (SGG, 2016). Whereas, these percentages had lowered to 24%, 12%, and 0% locations for residential, commercial, and industrial areas respectively, during lockdown.

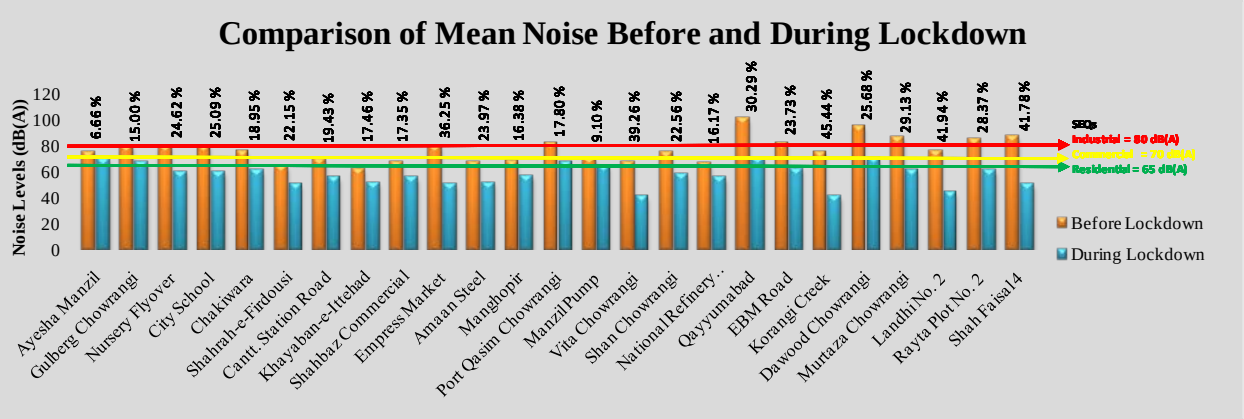
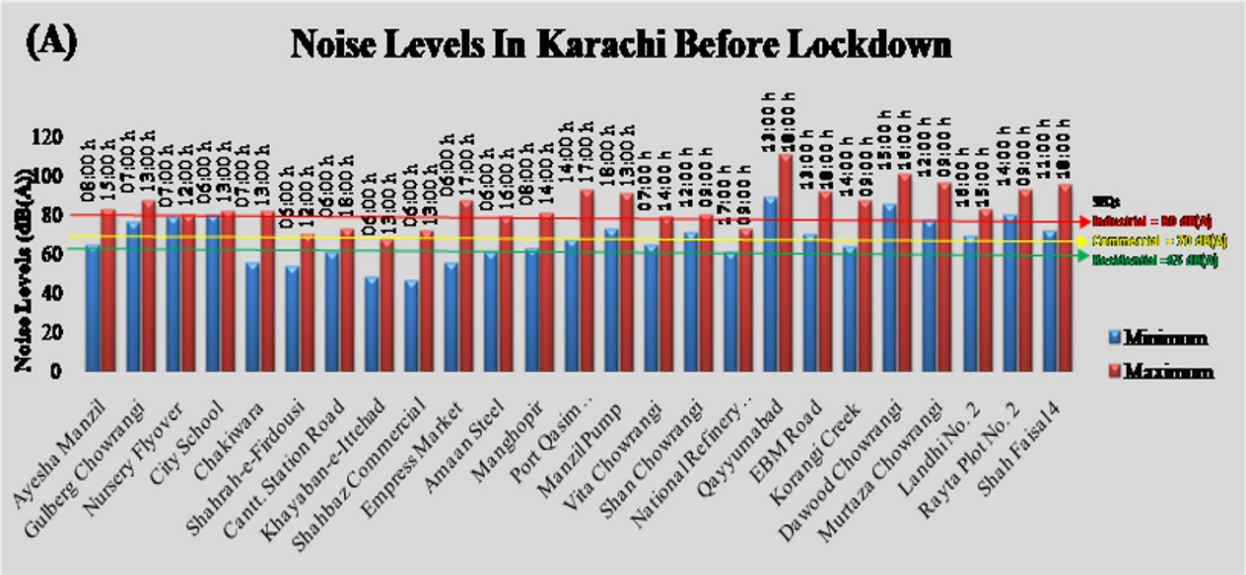


Figure 6. Comparison of mean noise levels before and during lockdown in Karachi

Among individual locations, Korangi Creek had shown the highest percent decrease (45.44 %) in mean noise level during lockdown (Fig. 6). Korangi creek extends up to 27 km length, 1.5 km width and 12 m depth with 38 species of fishes found in it. This creek is a source of income for approximately 100,000 people associated either directly or indirectly with fisheries (Alamgir et al., 2018). The imposition of a ban on all fishing-related activities during lockdown could be attributed for the highest percent decrease in noise level at this location. Although the ceasing of fishing activities made the fishermen suffer financially but the aquatic environment may have gotten benefit from it. Study suggested that coral reef get negatively affected by the boat noise in terms of decrease recruitment of coral larvae and reef fish. Since healthy coral reef has an acoustic

ecosystem, therefore boat noise possibly produces difficulty for coral larvae and reef fish in listening and detecting a reef to reside in (Arora et al., 2020).



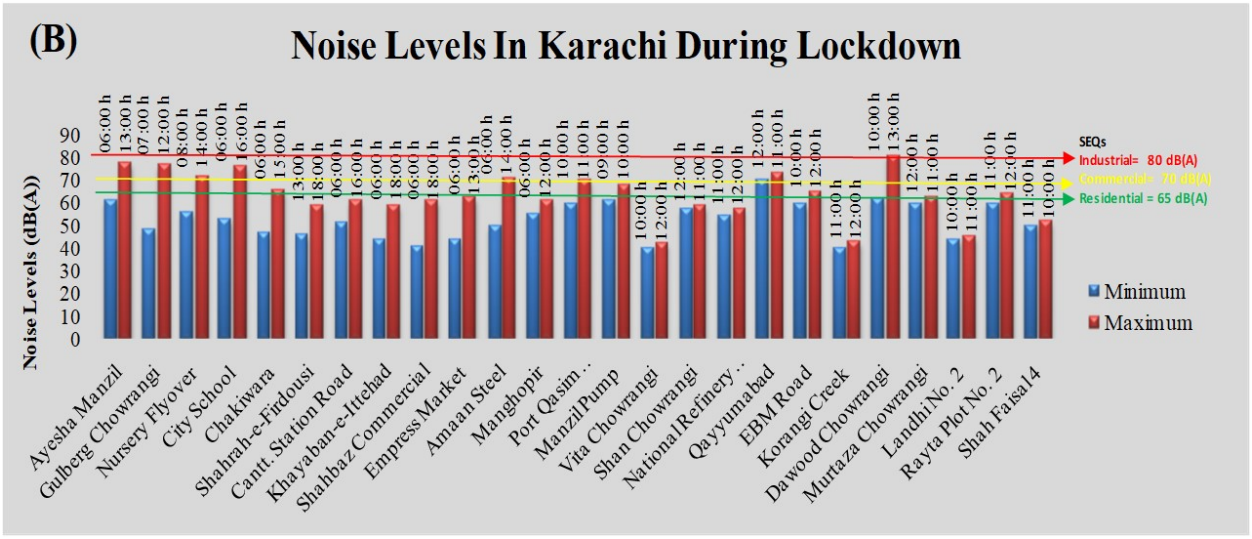


Figure 7. Minimum and maximum noise values at each location before (a) and during (b) lockdown in Karachi

Figure 7(a, b) showed the lowest and highest noise values at each location before and during lockdown with a time of the day. The highest noise values were recorded mostly in the afternoon than in the morning, both before and during lockdown. The maximum noise level had exceeded even the highest SEQs (i.e., 80 dB(A) for industrial area) at 80 % of locations before lockdown; whereas the maximum noise values during lockdown had exceeded the same at only 4 % of locations.

4. Conclusions

This study revealed that the lockdown in Karachi due to COVID-19 was found significantly effective in terms of air and noise pollution reduction. The limitation on industrial, commercial, social, and transportation activities in lockdown had not only lowered the threat of coronavirus exposure but also reduced the risk of health damage due to PM2.5 exposure and noise pollution by 53.55 % and 24.98 %, respectively.

A remarkable decrease in the percentage of locations was observed during the lockdown, where the mean PM2.5 and noise levels surpassed the SEQs before the lockdown. Significant reductions in PM2.5 and noise levels were detected in every kind of environment i.e., industrial (e.g., Manghopir, Amaan Steel and National Refinery Limited), commercial (e.g., City school), residential (e.g., Qayyumabad) and coastal (e.g., Korangi creek) areas. Most of the locations experienced the highest PM2.5 and noise levels in the afternoon than in the morning. In this regard, it was necessary to reduce the intensity of patient visits to medical institutions without losing the quality of medical care. A similar problem has arisen in many countries around the world and research has begun in the field of creating digital clinics (Kryvenko et al., 2022). At the same time, clinics need competent specialists, especially in emergency medical care (Hrynzovskyi et al., 2019) and auditing the quality of services (Dovhan et al., 2023).

4.1. Suggestions and Recommendations

Though this pandemic has posed a substantial effect on human society including economic structure, health care, and social relationships, the measures taken to control the pandemic have created an environment-friendly impact. The environment is self-healing in terms of pollution reduction, especially by decrease in air and noise pollution. Due to the risk of this kind of viral agent emerging periodically, this study suggests that the air quality of cities like Karachi should be monitored as part of the approach toward epidemic spread prevention, protection of human health, and sustainable development. Because the particulate matter may act as a carrier of viruses as well as their exposure can make the respiratory system more vulnerable to viral infection.

Declarations of interest

None

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