

Pilot Study of Air Quality during Pre and Post COVID-19 Lockdown: An Inadvertent Assistance to the Environment

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The main object of this study was to examine the levels of air quality in Karachi, Pakistan, before and during the 1st, 2nd and 3rd wave of lockdown period levied to control the spread of a novel coronavirus (COVID-19) in the environment of Karachi city. Momentous improvement in the air quality has been found during the 'Lockdown' being implemented due to the Corona Virus Disease (COVID -19) pandemic in Karachi city. Concentrations of trace gases and particulate matter were used to calculate the results according to the criteria of USEPA. We have analyzed data from fourteen different locations along the busy roads in commercial, residential and industrial areas of Karachi during the period of lockdown. Data were compared to the before lockdown (BL) and during the complete lockdown (CL 1st wave), smart lockdown (SL 2nd wave) and again complete lockdown (CL-2 3rd wave) of COVID pandemic. The results show drastic reductions in criteria pollutants (PM₁₀, CO, SO₂ and NO_x) concentrations in all the selected area during lockdown period. This study explained the level of air quality and its relation to prepare alternative plans to mitigate the air pollutants and to improve the environment of urban areas.

Keywords: *Corona virus; air pollution; trace gases; particulate matter; transportation; demographics; social activity levels and public health responses.*

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1. INTRODUCTION

COVID-19 is an enormously contagious disease, at first identified in December 2019 [1], now it has been completed its birthday in December 2020, with first and second waves. To date, the whole world has experienced 3rd waves of the coronavirus disease (COVID-19) pandemic. WHO (World Health Organization) had already been declared this COVID-19 outbreak as Sixth Public Health of Emergency Services (SPHEC) [2]. This coronavirus was entered in Pakistan in the month of February and March during the year, 2020 (First Wave). It is an extremely contagious and transmittable virus that transferred through the respiratory functions, such as sneezing, coughing and respiratory droplets from infected peoples [3]. The common symptoms of COVID-19 include fever, body ache, loss of smell and taste, chills, breathlessness. Due to increased cases of COVID infection the situation had becomes worst, and on 1st April 2020, partial lockdown was ordered by the Government of Pakistan, closing transportation, shopping malls, restaurants, fitness center, elementary, middle and high schools, and universities, groceries shops, meat seller and medical stores were working with restrictions concerning face mask, gloves, with social distancing in reduced hours. The country had been put under a nationwide lockdown until 9th May 2020 and later extended twice that was 1st wave of COVID. We are currently suffering the effects of the first wave, where deaths and health issues are directly linked to COVID-19. The first wave claimed 6795 lives, infected 332,186, left behind 632 on ventilators [4].

On 7th August, 2020, a meeting of the National Command and Operation Centre (NCOC) was held and publicized that COVID-19 pandemic had been controlled due to effective strategy of Government and health care workers, and the country was declared open for routine [5]. The registered cases in September, 2020 were recorded up to 295, 236 mark and a new version of the smart lockdown, the 'mini smart lockdown', was introduced in some parts of the country [6]. The government of Pakistan announced 2nd wave of Covid-19 on October 28, 2020, due to daily increase in active cases reached up to 750, and sudden increase of hospital admissions from 6,000 to 11,000, whereas critical cases of 93 on ventilators were recorded across the country [7]. Researchers were informed that the second wave of the virus

change the way of infection / symptoms, many gastrointestinal complaints coming in. New study declares that pink eyes, diarrhoea, vomiting, abdominal cramps, nausea, and hearing impairment are signs of COVID-19 infection [8]. If you are facing any digestive discomfort, you must get yourself tested. The third waves started from 4 November to present. Analysis showed that the—third wave of the COVID-19 is more deadlier than the 1st and 2nd wave, Due to mass violations of SOPs (Standard Operating Procedures) , such as not wearing face masks and ignoring social distancing, eating out, tour / trips, increasing social activity with poor social distancing, the spread was mitigated successfully by rapid strengthening of social distancing policies during the early stages of the first and second wave but not during the third wave.

Researchers in Pakistan say that the lockdown has an unbelievable impact on Environment [9]. They have observed amazingly improvements in the air quality index of the city linked with social distancing measures, and decreasing use of vehicle transit. NASA (National Aeronautics and Space Administration) and ESA (European Space Agency) also released fresh reports, showing that environmental quality improved due to decrease in vehicular emission. NO₂ is mainly produced by vehicles (fuel combustion), industrial sites, bio-mass burning, lightning and thermal power stations. It is a short-lived pollutant, with a life span of about one day in the atmosphere. As a result, this pollutant is mainly found near the emissions sources and can be used as a proxy for the intensity of activity in different sectors (NASA). A similar decrease also found in CO, CO₂ and Black-carbon concentrations and air quality was improve during the period of lockdown.

The aim of the present study is to provide a bird's eye view of air quality during COVID-19 pandemic lockdown. The objectives of the study are three fold: (1) mapping the air pollution level in Karachi city during lockdown; (2) to analyze the air pollution level before lockdown (BL) and compare with the complete lockdown (CL 1st wave), smart lockdown (SL 2nd wave) and again complete lockdown (CL-2 3rd wave) of COVID pandemic; (3) to evaluate the criteria air pollutant concentrations during the lockdown period. Thus, findings of the present study provide updated information of air quality during the COVID-19 lockdown. Further, this information can be used to prepare alternative plans to

mitigate the air pollutants and to improve the environment of urban areas.

2. MATERIALS AND METHODS

2.1 Study Area

Karachi lies between 24°45'N in longitude and 66°37'E in latitude. It has an area of 3,640 km² and is situated along the coast of Arabian Sea. It is the largest metropolitan city of Pakistan. Karachi has a moderately temperate climate with a generally high relative humidity. In winter, the average temperature of the city is about 21°C while in summer it reaches up to 35°C. Karachi receives about 256 mm of average annual rainfall [10]. Vehicular emission, biomass burning for cooking and industrial emission are the main contributors of atmospheric pollution in Karachi.

2.2 Ambient Air Monitoring

2.2.1 Sampling

Sampling was carried out at fourteen different locations along the busy roads of Karachi used to assess the levels of Carbon monoxide (CO), Nitrogen oxides (NO_x), Sulphur dioxide (SO₂) and particulate matter (PM₁₀) with a diameter of less than 10µm. To investigate the impact of COVID-19 on load of ambient air pollutants in the environment, the whole sampling period was divided into BL(before lockdown), CL(complete lockdown, 1st wave), SL(smart lockdown, 2nd wave) and CL-2 (complete lockdown, 3rd wave). Monitoring of gaseous pollutants was carried out by UV Fluorescent SO₂ Analyzer Model AF22 M, NO-NO_x Analyzer Model AC 32M and Snifit CO Analyzer (Model 50). These analyzers are considered as reliable for monitoring the pollution level.

PM₁₀ samples were carried out by using "Particle Matter Analyzer" Model HT-9600. The analyzer is provided with high measurement precision, stable performance and simple operation and convenient to carry. Eight hour sampling was done in duplicate at each location during the year 2020 and 2021.

The locations were chosen to reflect the influences from residential, commercial, industrial areas regarding the low, moderate and heavy traffic sources. This was done with an intention to get better representation of the city. Eight hour sampling / monitoring was done in duplicate at each location during the year 2020 and 2021.

3. RESULTS AND DISCUSSION

Present study was carried out to estimate the concentrations of ambient air pollution with PM₁₀ size fractions at fourteen different locations in Karachi. The concentrations of four pollutants, namely PM₁₀, CO, SO₂ and NO₂ were measured in micrograms per cubic meter. The concentrations of measured pollutants were also compared with NEQS (National Environmental Quality Standards) and US-EPA (United States Environmental Protection Agency) standards for ambient air pollutants (Table I). Overall, concentrations of most pollutants were found to be within the permissible range of the above-mentioned standards, except for PM₁₀ in some locations.

This study was an attempt to provide a bird's eye view of air quality during COVID-19 pandemic lockdown. Scientist / environmentalist in the world and also in Pakistan say that the lockdown has an incredible impact on Environment. Environmental expert amazingly noticed very good improvements in the air quality index of the city allied with social distancing measures, and decreasing use of transportation means. Likewise different countries such as China estimate 20–30% reduction in PM_{2.5} [11], Spain observed 31% and 51% reduction in PM₁₀ and NO₂ respectively [12] and India was perceived 43% and 31% reduction of particulate matter (PM_{2.5}) and particulate matter (PM₁₀), respectively [13] during lockdown situation.

Concentration of pollutants (SO₂, NO_x, CO and PM₁₀) in the period of BL (before lockdown), CL (Complete lockdown, 1st wave), SL(Smart lockdown, 2nd wave) and CL-2(Complete lockdown, 3rd wave) presented in Fig 1,2,3 and 4 respectively.

Table 1. Limits of air pollutant concentrations according to Pakistan and United States-EPA

Parameter	PAK-EPA (µgm ⁻³)	US-EPA (µgm ⁻³)	Average time (h)
O ₃	130	235	1
CO	5000	10 300	8
SO ₂	120	365	24
NO ₂	80	110	24
PM ₁₀	150	150	24

Particulate matter of 10 microns aerodynamic diameter (PM_{10}) is one of the crucial sources / issue for urban dwellers, not only affect the position of cultural heritages, particularly affecting the pulmonary system, it can penetrate deep into the lungs and cause respiratory disorder and increased incidence of bronchitis, chronic cough and conjunctivitis [14]. In addition, with the combination of COVID-19 coronavirus, the pollutant became adverse for human life in metropolitan cities. As Karachi is one of the leading industrial city of Pakistan which experiences the worst air pollution level due to congested traffic and industrial activities clogged in COVID pandemic. Results of the study show that, before lockdown the average concentrations of dust particles in terms of PM_{10} were higher in commercial, industrial and traffic congested areas with heavy traffic and commercial activities, than the residential areas. Results also presented that in most of the areas PM_{10} concentrations exceeded the specified permissible limits by US-EPA [15]. (Fig. 1). Similar results of PM_{10} decline are also reported in the study conducted in Delhi, India during the period of lockdown [16]. Similarly, another study of Otmani et al. (2020) [17] also reported the same results in the period of lockdown. However, the basic reasons of lowering the PM_{10} levels are closure of industrial and social activities during the COVID pandemic. The implemented control measures of COVID-19 have improved the level of air quality in Karachi city within a short period, remarkable reduction was recorded in PM_{10} during 1st wave lockdown period (Figure-1). With the unavailability of a specific antiviral or a vaccine, non-pharmaceutical interventions are the obvious cause of a 2nd second wave of

Covid-19 in Pakistan [18]. Not following the standard operating procedures (SOPs) like, not wearing face masks, social distancing, political, religious and regular business activities, eating out, transport and tourism led to the second wave of Covid-19. Results of the study during the second wave of COVID 19 show same situation as before lockdown or before COVID situation. Due to mass violations of SOPs, third wave started from 4th November becomes sevir. Analysis showed that the third wave of the COVID-19 is more deadlier than the 1st and 2nd wave. The Government forcefully imposed partial lockdown from March 2021 to May, 2021 and tried to implement by armed forces. The result during 3rd wave is different and in between the 1st and 2nd wave presented in Fig. 1.

Based upon the results of NO_2 level during the year 2020-2021 (Fig. 2) it was revealed that before lockdown period highest trends of air pollutant in terms of NO_2 were found in commercial and traffic congested areas. The main sources of NO_2 pollutant into the atmospheric air are various natural and anthropogenic sources. The most important and major anthropogenic source is the combustion of fossil fuel in motor vehicle engines. It creates several toxicological problems. Common adverse health complications of nitrogen oxides are bronchitis, coughing and wheezing whereas ENT irritation, chest pain, headache, dyspnea, diaphoresis, bronchospasm and pulmonary edema may also occur. According to Fig. 2, the air pollutant level have shown sudden drop of pollution level, NO level during 1st wave March 2020 when the lockdown came into effect.

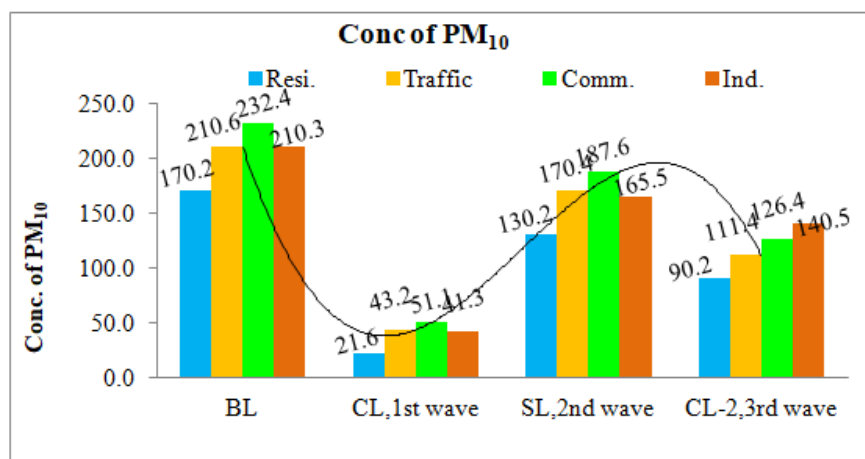


Fig. 1. Period of assessment

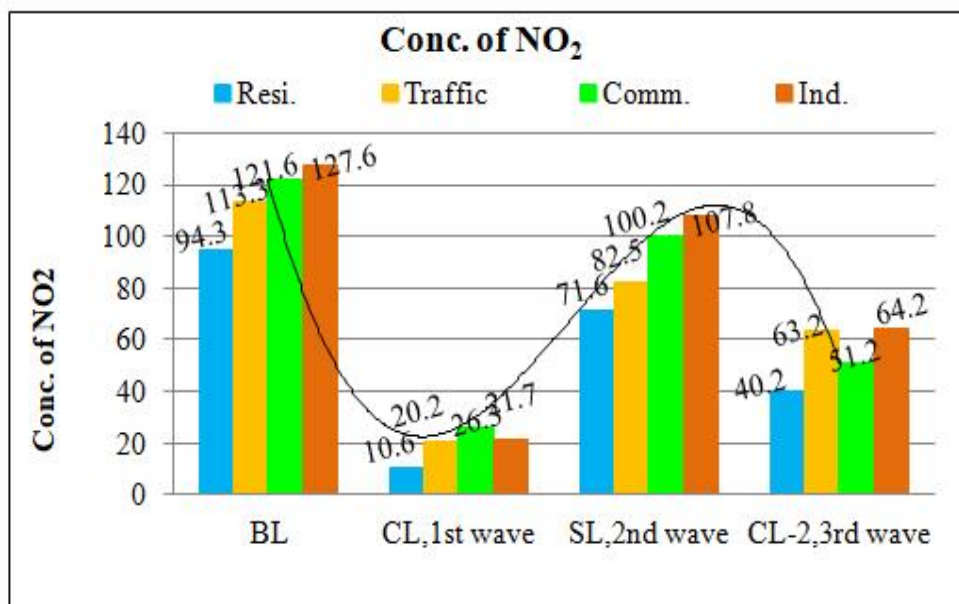


Fig. 2. Period of assessment

SO₂ is one of the principal criteria pollutants that are notorious for smog and the presence of this pollutant in the air is highly toxic for the respiratory system of human being. Karachi is experiencing its worst episode due to high emission from vehicular and industrial emission. During the pandemic of COVID 19 in the year of 2020 (Fig. 3), the AQI (Air Quality Index) array of SO₂ is upgraded, allied with the suspension of industrial activities [17] and credited with the heavy rainfall in Karachi city which cleaned the atmospheric air during coronavirus lockdown [19].

Carbon monoxide is one of the major air pollutants in metropolitan cities. In the congested part of cities like Karachi, where traffic jams usually occurs, this pollutant show high concentration and producing serious problems on human health. CO is a poisonous gas and its symptoms may include headache, tiredness, dizziness, nausea, vomiting and drowsiness and in very acute situation consciousness and death will follow [20]. The affinity of CO to hemoglobin (as an oxygen carrier in the body) is about 250 times greater than that of oxygen. The effect of CO on human being depend on the concentration, exposure time, health status of the people, their age and daily activities [21].

However, the overall results indicate that air quality index has improved in 1st wave of COVID

-19 due to the closure of anthropogenic activities. The adopted contingency measures to overcome pandemic has altered the concentration level of air pollutants and resulted in a significant reduction of NO_x (Fig-2), SO₂ (Fig-3) and CO (Fig-4) at all the selected locations in Karachi city. Similarly the maximum average concentration of NO_x, SO₂ and CO were observed in industrial and commercial traffic congested areas having industrial clusters on both sides of the way, also having high traffic density due to heavy duty diesel vehicles like, tractors, trucks, trailers, vans, buses and minibuses. Likewise in these areas the roads are also poorly maintained, unpaved and dusty with limited vegetation along the sides. The industrial processes especially combustion of boilers fueled by heavy duty diesel and heavy electric generators also fueled by diesel are the main source of CO, SO₂, NO_x and PM₁₀ pollution. Whereas, traffic congested areas surrounded by various commercial activities like food street, push carters and self-made rickshaw stand and parking of lot of scotars/ bikes of seller and purchaser. These traffic areas having narrow road with heavy traffic density and surrounded by high rise buildings for commercial activities on both side of the road producing tunnel effect where the pollutants are suspended for long spell and it is associated with impending health effects for the resident chiefly for infant and old age group/ sensitive residents.

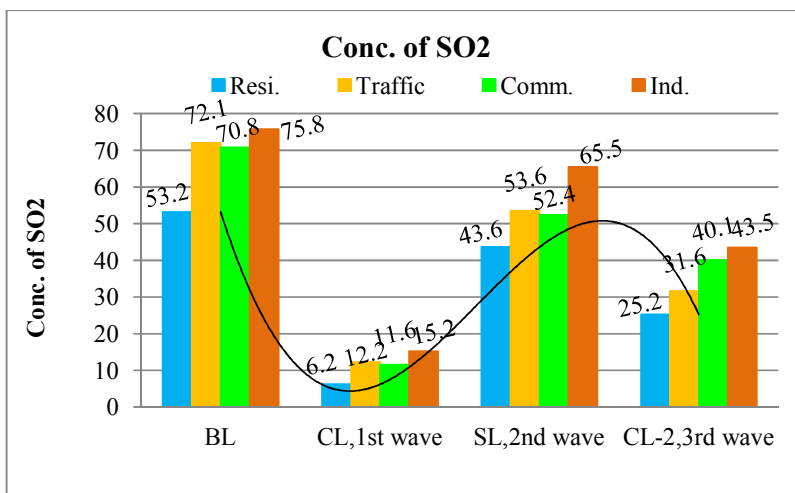


Fig. 3. Period of assessment

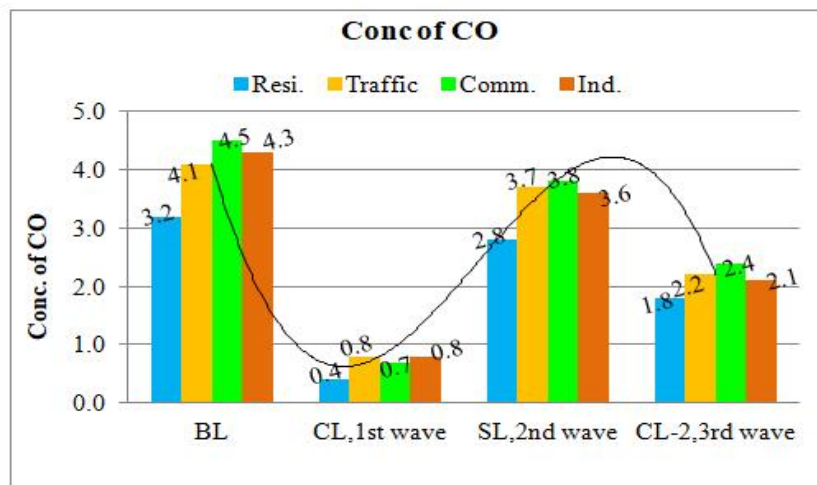


Fig. 4. Period of assessment

Due to the infected virus of COVID-19, a nationwide lockdown was necessary to imposed. By this nationwide lockdown almost all industrial activities and mass transportation had been banned. As a result, the pollution level in all the cities across the country dramatically reduced down. In the traffic, commercial and industrial areas results of the study shows significant air quality improvements considering decreases in air pollutants concentrations monitored in the selected areas highly influenced by vehicular traffic density.

Drastic reductions on PM₁₀, CO, SO₂ and NO_x concentrations were observed in all the selected area during lockdown period (Fig. 1-4). One recent research has demonstrated that traffic

emissions from heavy-duty diesel trucks are major sources of NO [22], as during the partial lockdown vehicle traffic considerably decreased in all analyzed areas, positively affecting the air quality. Therefore lockdown presumes to be the effective alternative measure to be implemented for controlling air pollution and the present work intended to explore the degree of air quality change during lockdown at spatial scale in the megacity Karachi.

4. CONCLUSION

As the COVID infection spreading continuously, this study is an effort to provide aspirated guidance for scientist regarding the atmospheric pollution in Karachi City. This study was

characterized in terms of trace gases and PM. Researchers in Pakistan say that the lockdown has an unbelievable impact on Environment. They have observed amazingly improvements in the air quality index of the city linked with social distancing measures, and decreasing use of vehicle transit. Scientist / environmentalist in the world and also in Pakistan say that the lockdown has an incredible impact on Environment.

Results of the study show that, before lockdown the average concentrations of dust particles in terms of PM₁₀ and trace gases were higher in commercial, industrial and traffic congested areas with heavy traffic and commercial activities, than the residential areas.

Remarkable reduction was recorded in PM₁₀ and trace gases during 1st wave lockdown period. Similarly, due to unavailability of a specific antiviral or a vaccine, non-pharmaceutical interventions are the obvious cause of a 2nd second wave of Covid-19 in Pakistan. Results of the study during the second wave of COVID 19 show almost same situation as before lockdown or before COVID situation. Due to mass violations of SOPs, third wave of the COVID-19 again started which is more deadlier than the 1st and 2nd wave. The result during 3rd wave is different and in between the 1st and 2nd wave. From the studies it is evident that development and planning of the transport system and social awareness can play a major role in improving the quality of air in the city. However, the overall results indicate that air quality index has improved in 1st wave of COVID -19 due to the closure of anthropogenic activities. The adopted contingency measures to overcome pandemic has altered the concentration level of air pollutants and resulted in a significant reduction of trace gases (NO_x, SO₂ and CO) at all the selected locations in Karachi city. Government and local bodies should take immediate measures, planning and social awareness to reduce the pollution load and improving the status of air quality in the city. The study is also a thought to be a useful complement to the regulatory authorities that may lead to re-thinking of the existing regulatory plans and may provide pledge towards implementing strict alternative measures like short term (2 to 4 day) lockdown in purpose to control air quality.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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