AIR QUALITY MONITORING OF PARTICULATE MATTER ($PM_{2.5}$ & PM_{10}) AT NIAZI AND DAEWOO BUS STATION, LAHORE

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Abstract

In this study, Niazi and Daewoo bus station, Lahore were selected for the measurement of Particulate matter, $PM_{2.5}$ and $PM_{10.}$ The concentration of $PM_{2.5}$ and PM_{10} was measured using an air sampler for one week in each station in May 2016. The measurement results were strongly associated with bus traffic volume, type of transport and fuel. Overall results revealed that the concentration of $PM_{2.5}$ and PM_{10} was higher than the permissible limit given by National environmental quality standard (NEQS). The emissions from buses in Niazi bus platform were higher than Daewoo station. This was because the bus traffic volume was high as compared to Daewoo station and the internal maintenance of buses was also different. It is concluded that vehicles are the major contributor of $PM_{2.5}$ and PM_{10} pollution which have hazardous effects on air quality and the health.

Introduction

Clean air is imperative for human survival and prosperity, but in today's urbanized world, clean air is something that is extremely hard to discover. Cites of today to a great extent rely upon transport framework for their social services, economic survival and environmental services. Land usage, Housing designs, commerce centers and economic centers are all developed by the transport system. In spite of the fact that the transport framework has coordinate effect on all areas of an economy, its ecological, economic and social effects are noteworthy as these are directly related to the quality of life and urban profitability (Ali *et al*., 2012).

According to WHO (2005) people spend 1- 1.5 hours per day in travelling. High exposure to air pollution experienced while travelling in those areas where vehicle density is greater. The level of environmental pollution in the major cities of Pakistan is around three times more prominent than the safety levels suggested by the WHO. A key factor is vehicular emissions which account for approximately 60-70% of the total annual emissions in cities (Javed Masud, 2009).

Particulate matter or PM is a combination of fine solids and liquids that are suspended noticeably all around. Particles are made up of different things. PM can be solids, like dry powder consisting of tiny particles or residues. PM can also be completely liquid aerosols or solids suspended in liquid mixtures. Particulate matter is classified as "coarse" PM (PM10) with a diameter less than 10 μm, "fine" PM (PM2.5) with a diameter less than 2.5 μm, and "ultrafine" PM (PM0.1) with a diameter less than 0.1 μm (Zeger and Dominici, 2002).

Buses being a main mode of urban public transport can assume an imperative part in social and financial advancement of urban areas. However, a key environmental concern about public transport identifies with its commitment to local air contamination. Motor vehicles have been perceived as a prevailing source of ambient particulate matter in urban areas (Abu-Allaban *et al.,* 2007). Bus stations many times present high concentrations of PM released due to incomplete combustion of fuel when buses stand idle for long period of time, decelerate and accelerate (Jayaratne *et al.,* 2009).

Public transportation services are now days situated in enormous commercial buildings and often confined and semi-confined spaces so the air quality inside bus terminal is important health concern for passengers, as travelers spend considerable time for waiting buses. The previous couple of years have seen a noteworthy increment in number of vehicles on roads alongside small scale industries which are contributing significantly to the deterioration of ambient air quality (Mirza, 2013). Ambient air pollution, especially exposure to particulate matter (PM), presents 3.7 million unexpected premature deaths annually, 88% of these deaths occurring in developing countries.

PM is one of the six criterion pollutants and responsible for cardiac and respiratory diseases. The disease burden is large with 16% of deaths due to lung malignancy, more than 20% deaths due to stroke and other heart problems, and 11% of deaths by chronic obstructive pulmonary illness (WHO, 2014). Pollution emission are determined by vehicle engine type and the fuel used. Emission of hydrogen and nitrogen oxide can be reduce by more than 50% and the emission of particulate matter by more than 75% from uncontrolled level by the engine design and the improved fuel injection system. These changes improve fuel economy and reduce pollution level in air (Faiz *et al*., 1996).

The present study has been conducted to assess the concentration of particulate matter (PM2.5 and PM10) at Daewoo Bus station and Niazi Bus station, Lahore and compare with NEQS. Air quality inside the two bus terminals was monitored for one week. PM emitted directly from buses may accumulate within these semi-confined spaces, and cause adverse health effects on both passengers and workers.

Materials and Method

For this study, two bus stations Niazi bus station and Daewoo bus station, Lahore were selected for the assessment of particulate matter ($PM_{2.5}$ and PM_{10}). PM level on the platform of indoor bus stations were strongly associated with bus traffic volume, buses internal maintenance, type of fuel and management of buses platform.

MiniVol SN: 3224 air sampler was used to measure the mass concentration of particulate matter ($PM_{2.5}$ and PM_{10}). The readings were taken at three different times (morning, noon and evening) of a day. The measurements were taken for two weeks from 5 May to 18 May. At each bus station readings were taken for one week. To measure the concentration of $PM_{2.5}$ and PM_{10} gravimetric analysis procedure was used.

Results and Discussion

The first part of study was conducted at Niazi bus station for one week. The measurement was taken at different time on the basis of which concentration differed and the maximum concentration was found mostly in afternoon and evening and minimum concentration was found in morning. The minimum and the maximum average concentration of $PM_{2.5}$ were recorded to be 321±17.2 µg/m^3 and 559.7± 157.6 µg/m^{3}respectively.On the other hand, the average values of PM_{10}(µg/m^3) with NEQS measured during a week at Niazi bus station. The minimum and the maximum average concentration of PM_{10} were recorded to be 407.3±49.7 and 787±230 µg/m^3 (Fig. 1, 2).

Similarly, the second part of study was conducted at Daewoo bus station for one week. The highest concentration was found mostly in morning and evening and lowest concentration was found in noon. The minimum average and the maximum average concentration of $PM_{2.5}$ were recorded to be 307.3±40.5 µg/m^3 and 543±112.6 µg/m^3. On the other hand, the average values of PM_{10} (µg/m^3) with NEQS measured during a week at Daewoo bus station. The minimum average concentration and the maximum average concentration of PM_{10} were recorded to be m^{3}289.4±17.2 µg/m^3 and 672± 203 µg/m^3, respectively (Fig.3, 4). With reference to the comparison of both bus stations highest concentration of particulate matter ($PM_{2.5}$ and PM_{10}) was found at Niazi bus station .The overall average values of $PM_{2.5}$ of Niazi and Daewoo bus station are shown in Fig. 5. The average concentration measured was 448±12µg/m^3. The overall average values of PM_{10} of Niazi and Daewoo bus station are shown in Fig.6. The average concentration measured was 544±58µg/m^3. Road traffic can be marked the most critical source for some pollutants of great concern, such as No_x, benzene and carbon monoxide. Recently, emissions of particulate matter (PM) have attracted the great interest, mainly because of epidemiological findings that suggest that it is a major risk to human health. While waiting at bus stops, transit patrons may be exposed to larger amounts of vehicle-generated pollution, including particulate matter (PM), because of their proximity to the roadway.

The exposure to PM level to the bus users is dependent on some factors and varies from location to location, according to traffic intensity and the bus condition. Personal exposure in transport microenvironments are also affected by another factors other than the transport mode. These factors include personal factors, transport condition, fuel type, ventilation, routes and travel speed (Karanasiou *et al*., 2014).According to a number of studies, traffic related air pollution and short term and long term exposure to particulate matter can cause respiratory diseases and result in cardiovascular mortality and morbidity (Adar *et al*., 2007; Anderson *et al*., 2012).

In the present study, the concentration of particulate matter ($PM_{2.5}$ and PM_{10}) was found to be higher than the permissible limits given by NEQS for $PM_{2.5}$ i-e 35 µg/m^3 and PM_{10} i-e 150µg/m^3. The measurement results were strongly associated with bus traffic volume and exposure levels are influenced by the mode of transport and by the route and type of fuel. In the first part of this study particulate matter ($PM_{2.5}$ and PM_{10}) from the buses exhaust at Niazi bus station were assessed. All the concentrations of ($PM_{2.5}$ and PM_{10}) were very high than the permissible limit of NEQS. The concentrations vary during different times of the day. Sometime the morning concentration were found to be higher than the evening and afternoon, in some days the afternoon concentration were found to be higher than the morning and evening and in some days of monitoring the evening concentration of ($PM_{2.5}$ and PM_{10}) was higher than the morning and afternoon. This was because of bus traffic volume varies, lack of traffic control department and the internal maintenance of buses and most of the buses are diesel fueled. Mostly the new and well maintained buses emit less particulate matter than the poorly maintained buses.

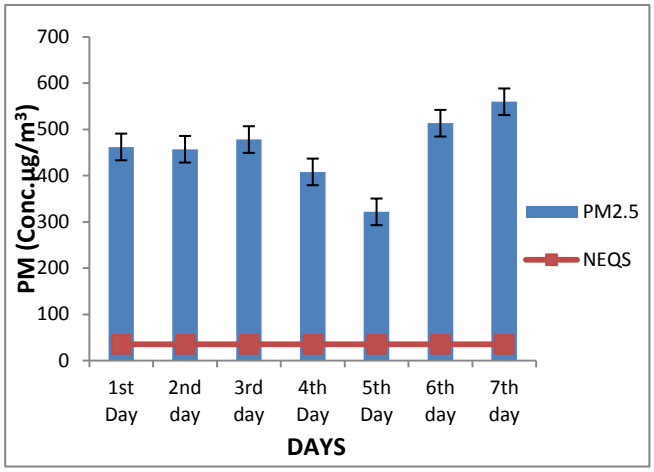

Fig.1: Graph showing the comparison between average values of $PM_{2.5}$ (µg/m^3) with NEQS measured during a week at Niazi bus station

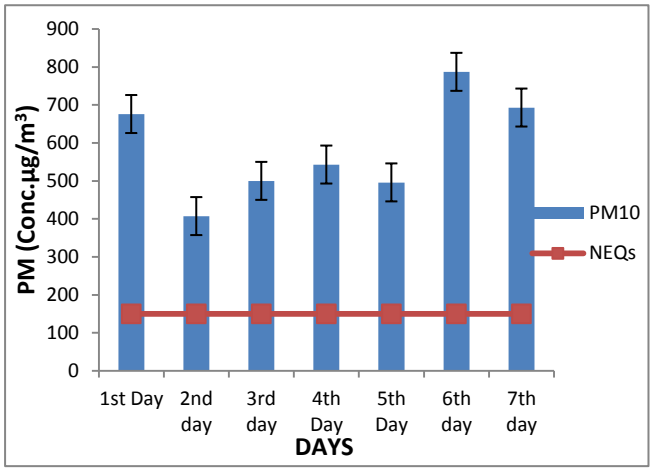

Fig.2: Graph showing the comparison between average values of PM_{10} (µg/m^3) with NEQS measured during a week at Niazi bus station

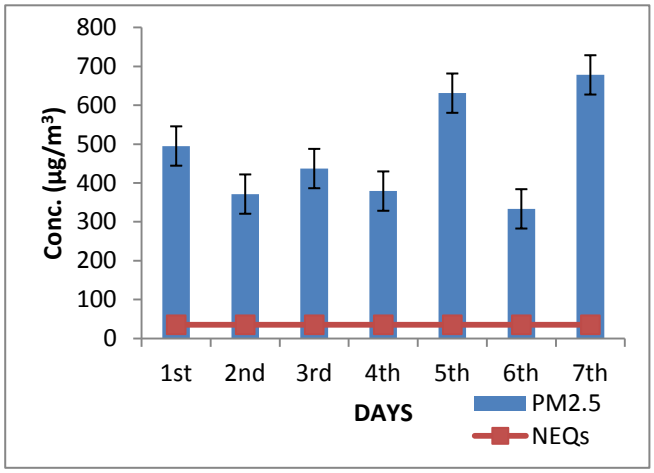

Fig.3: Graph showing the comparison between average values of $PM_{2.5}$ (µg/m^3) with NEQS measured during a week at Daewoo bus station

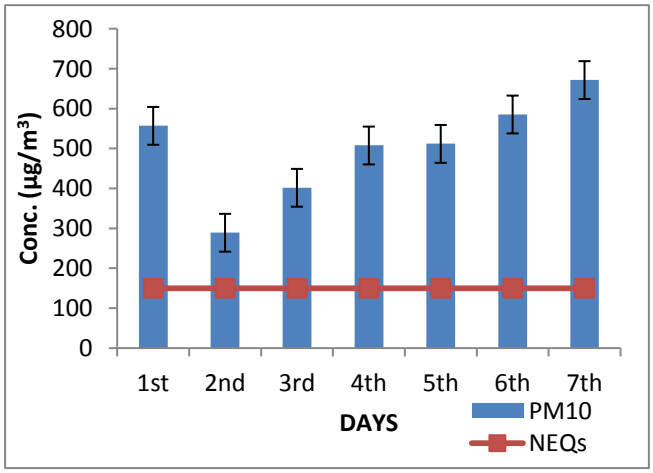

Fig.4: Graph showing the comparison between average values of PM_{10} (µg/m^3) with NEQS measured during a week at Daewoo bus station.

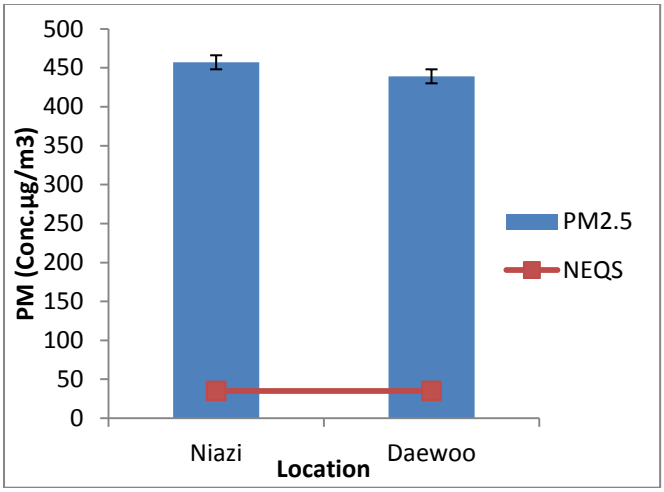

Fig.5: Graph showing the comparison between average values of $PM_{2.5}$ (µg/m^3) with NEQS measured at Niazi and Daewoo bus station

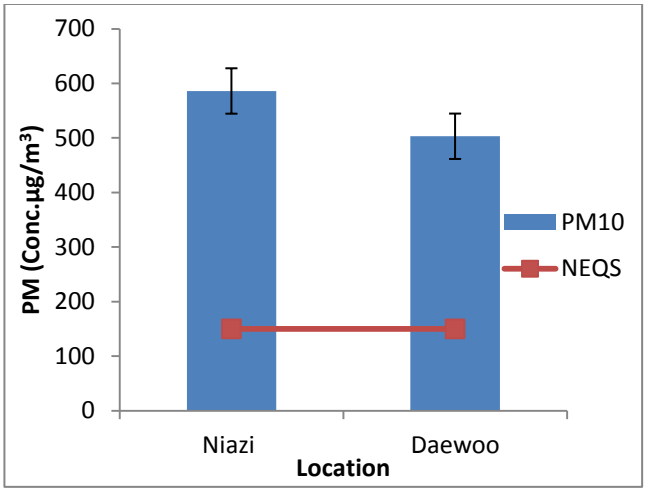

Fig.6: Graph showing the comparison between average values of PM_{10} (µg/m^3) with NEQS measured at Niazi and Daewoo bus station

ANNEXURE-I

Table showing the average values and standard deviation of $PM_{2.5}$ concentration (µg/m^3) found from Niazi bus station

Day/Time	Morning	Noon	Evening	Mean ± SD
1	544	266	478	462 ± 90
2	310	392	770	457 ± 271
3	389	304	742	478 ± 232
4	472	346	408	408 ± 63
5	341	316	308	321.6 ± 17.21
6	520	490	530	513.3 ± 20.8
7	660	378	641	559.7 ± 157.6

ANNEXURE-II

Table showing the average values and standard deviation of PM_{10} concentration (µg/m^3) found from Niazi bus station

Day/Time	Morning	Noon	Evening	Mean ± SD
1	628	869	531	676±174
2	351	656	529	407.3 ± 49.7
3	589	288	624	500 ± 185
4	621	330	678	543 ± 187
5	315	392	701	496 ± 204
6	523	939	899	787 ± 230
7	418	890	832	693 ± 238

ANNEXURE-III

Table showing the average values and standard deviation of $PM_{2.5}$ concentration (µg/m^3) found from Daewoo bus station

Day/Time	Morning	Noon	Evening	Mean ± SD
1	511	296	677	495 ± 191
2	331	390	393	371.3 ± 35
3	474	288	549	437 ± 134.4
4	466	373	298	379 ± 84.2
5	312	380	397	498 ± 257
6	306	341	312	307.3 ± 40.5
7	429	398	642	543 ± 112.6

ANNEXURE-IV

Table showing the average values and standard deviation of PM_{10}concentration (µg/m^3) found from Daewoo bus station

Day/Time	Morning	Noon	Evening	Mean ± SD
1	562	468	642	557.3 ± 87.1
2	290	706	675	289.4 ± 28.9
3	386	265	555	402 ± 145.7
4	473	425	638	508 ± 280
5	307	390	828	512 ± 111.7
6	691	397	669	585.7 ± 163.8
7	732	446	839	672 ± 203

In the second part of this study particulate matter ($PM_{2.5}$ and PM_{10}) from the buses exhaust at Daewoo bus station were assessed. All the concentrations of ($PM_{2.5}$ and PM_{10}) were very high than the permissible limit of NEQS. The concentrations vary during different times of the day. Mostly the morning and evening concentration of ($PM_{2.5}$ and PM_{10}) were found to be higher. This was because of bus traffic volume at that time was high as compared to noon and mostly the buses are diesel fueled.

By comparing the average values of both bus stations it was found that the Niazi bus station generates greater amount of particulate matter because Niazi bus station is one of the largest bus station of Lahore it covers a wide surface area and in the same context bus traffic volume was also high and most of the buses are diesel fueled. It is evident from the previous studies that diesel buses and diesel generators can produce large amount of pollution compare to petrol dependent buses (Abbas *et al*, 2016). One of the main reasons for increase in concentration of $PM_{2.5}$ and PM_{10} at both stations is buses stand sit out of gear for drawn out stretch of time, decelerate, and accelerate.

These results support the previous studies (Aziz and Bajwa, 2004) showed that the areas with intense traffic densities and during the peak traffic hours, the exposure to particle number concentration was found to be higher and various factors such as exhausts from running engines, movement of people on the bus stations and movement of passengers in and out of the bus play a major role in the fluctuating PM levels.

However, it is found that the particulate matter in both bus stations is not in compliance with the NEQS standards. This was because the vehicular pollution in Lahore is increasing day by day due to transport sector. So this cause serious health effects on population. Exposure to PM_{10} and $PM_{2.5}$ is also associated with cardiovascular disease, respiratory disease and mortality. The effect of PM is increasing day by day. Strategies should be adopted to overcome all of these effects.

Conclusion

From the present study it is concluded that vehicles are one of the major source to release particulate pollution into the air and general environment from their internal combustion engine in which incomplete combustion of fuel releases a lot of pollutant including particulate matter in higher amount. The present study was conducted to analyze the extent of $PM_{2.5}$ and PM_{10} concentration emitted from buses at Niazi and Daewoo bus terminal, Lahore by using air sampler. According to our findings it was concluded that means of transportation are releasing high amount of particulate pollution in the air. During the visits it was found that PM emitted directly from buses can gather within this restricted space, and causes an adverse health effects on both passengers and workers. It is suggested that more planned and coherent studies be conducted and monitoring strategies be adopted to reduce further damage on air and human health.

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