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EXPOSURE TO NO_2 IN OCCUPATIONALBUILT ENVIRONMNETS IN URBAN CENTRE IN LAHORE

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ABSTRACT

Increased economic growth, urbanisation and substantial rise in automobile vehicles has contributed towards the elevated levels of air pollution in major cities in Pakistan. Aone week study was conducted by using passive samplers to assess NO_2 concentration in occupational built environments at two most congested and populated sites of Lahore. Both sites were locatedon the busy roads of Lahore. At Site-I the highest concentration was in outdoors followed by corridor and indoor. While at Site II all the sampling location wereindoors and level were comparable to that of outdoor levelsat Site I. The results suggest the likely contribution of ambient sources in exposure to indoor NO_2 in educational and other occupational built environments in urban centres.

Keywords: Lahore, NO_2, passive samplers.

INTRODUCTION

In the developing countries, like Pakistan, industrialization is the key factor for economic growth. Along with industrialization, number of automobiles and population has also increased in these countries in last two decades. These factors havedeteriorated environmental quality, especially, in urban areas. With growing pollution as well as population little attention is paid towards the environmental safety.Environmental policies areinappropriate and pollution control strategies are not yet fully developed. Among range of environmental issues air pollution has emerged as major threat to public health. Different studies have demonstrated adverse effect of air pollution on cardiopulmonary health. Susceptible population (children, elderly, immunocompromised) are at increased risk of adverse health outcome (Chen *et al*., 2015 Kaushik *et al*.,2006). According to the WHO report, air pollution in 2012 caused premature deaths of around 3.7 million people worldwide (WHO, 2014).

Pakistan is the 6th major country with respect to its population, comprising 2.62% of the world's population (World Population Prospects, 2012). Due to increased urbanisation (34% of population live in urban areas), substantial rise in automobile vehicles, industrialization and poor compliance with environmental quality control standards the country is facing severe air pollution (Sanchez-Triana *et al.*, 2014).Available literature on state of air quality in Pakistan clearly shows the gravity of situation and this may have public health implications, particularly, in urban areas. Among different air pollutants NO_2 is of major concern, following particulate matter, in the country (Colbeck et al. 2010a). It is hazardous to human health and also one of the main precursor to form secondary pollutant (ozone, fine particles).According to US EPA short term exposure (30 minutes to 24 hours) to NO_2 is associated with range of respiratory illness - airway inflammation, asthma (USEPA, 2014).

The available literature on NO_2 levels in Pakistan is scattered and is mostly on ambient concentration. The knowledge base on indoor levels of NO_2 is limited (Colbeck *et al*., 2010b). Nonetheless, people both in rural and urban areas may be exposed to excessive levels of NO_2 in different built environments due to specific indoor sources (solid fuel use) or contribution from outdoors combustion sources(especially in urban areas).

There is a need to carry out studies to evaluate NO_2 in different built environments. The present study was carried out to examine the level of NO_2at two different higher education institutes in Lahore in order to demonstrate the level of indoor NO_2 exposure in different occupational settings in urban centres.

MATERIALS AND METHODS

Sampling sites: NO_2 samples were collected from two higher education institutes of Lahore. Lahore is the capital city of the Pakistani province of Punjab, the second largest metropolis in the country with a population of more than 10 million (Demographia, 2015). Available studies on air pollution in Lahore indicate that state of air quality in the city is poor (Jafar and Faridi, 2006; Colbeck *et al.*, 2011; Ashraf *et al.*, 2013; Abrar *et al.,* 2014).Two sites were selected to measure NO_2: Site I -University of the Punjab, New Campus and Site II: Islamia College for Women Cooper road. Both the selected sites were located along heavy traffic roads in populated urban areas.

Site I:Site-I was surrounded from all sides by the roads with continuous flow of heavy traffic. (Figure 1).Three sampling locations in site-I were selected in zoology department and named as outdoor (roof), semi ambient (corridor) and indoor (Wildlife and Ecology laboratory).

There were traffic within the university mainly buses run by university and private student/staff cars, composing and printing shops, cafeterias and laboratories in surroundings of sampling locations.

Figure 1. Location of site-I and site-II in the Lahore (source google maps)

Site II:Site II was located on the road in a populated area with high traffic density and nearby fuel filling stations. A number of different shops and hotels were located in the nearby vicinity that used natural gas and LPG gas as fuel for the purpose of cooking and heating the food (Figure 1). Three sampling locations were selected and named as (A) Zoology laboratory, (B) Physics laboratory and (C) Chemistry laboratory. A few lab activities were performed as students only visited these laboratories twice a week for practical. Most of the time, laboratories were used as class rooms for lectures. Ventilation in all the laboratories was natural and occurred through the windows, doors and ventilators.

Preparation and analysis of Passive samplers: Passive sampler (Plames diffusion tube) comprises of an acrylic tube of 7cm long and 1cm diameter capped at both ends. At one end, two stainless steel grids coated with 50% triethanolamine TEA/acetone solution were placed. These samplers were mounted on the sites approximately 2m above the ground. Three samplers were mounted at each sampling location. After one week, samplers were subjected to spectrophotometric analysis. The NO_2 reacted TEA as nitrite. Mixture of sulphanilamide in orthophosphoric acid and N-1-naphthlethylenediamine dihydrochloride (NEDD) was used as colour reagent. The nitrite diazotised the sulphanilamide and diazonium salt reacted with the NEDD. This formed a purple azo dye and intensity ofwhich was determined at 540 nm. By using standard solutions of nitritespectrophotometer was calibrated to determine the total NO_2collected by sampler as nitrite.Mean, maximum, minimum and standard deviation values were derived.

RESULTS AND DISCUSSION

Site-I: Average NO_2concentration in outdoor environment was observed to be 79µg/m^3 that was greater than the semi-ambient and indoor (Table 1). The key factors elevating the outdoor levels were most probably emissions from vehicular exhaust (in and outside of university).Whereas the levels in corridor (average - 69µg/m^3) were likely to be influencedby activities in adjacent departments labs as well as outdoors.The NO_2level in indoor environment (laboratory) were lowest and ranged from 35 to 50µg/m^3 with an average concentration of 44µg/m^3. The lower concentrations were very likely due the less usage of lab and low ventilation rates.

Table 1: Summary of NO_2(µg/m^3)at Site I.

Location	Ave	Max	Min	SD*
Outdoor (Roof)	79	93	54	21.7
Semi-ambient (Corridor)	69	91	30	34.12
Indoor (Lab)	44	50	35	8.14

Ave. Average, Max. Maximum, Min. Minimum, *SD. Standard deviation

Site-II*:* The weekly average concentration in Zoology, Chemistry and Physics laboratory were 77, 79 and 67µg/m^3 respectively (Table 2). These levels most probably reflect the contribution from both outdoors and indoors activities. The site was surrounded by heavy traffic and contribution from outdoors via ventilation or infiltration is might be the dominant source of indoor $NO_{2.}$

Table 1: Summary of NO_2 at site-II (µg/m^3)

Location	Ave	Max	Min	SD*
(A) Zoology lab	77	84	66	9.64
(B) Chemistry lab	79	82	74	4.16
(C) Physics lab	67	68	66	1.15

Ave. Average, Max. Maximum, Min. Minimum, *SD. Standard deviation

There was less variation in meanlevels at different locations at Site II in comparison to site I. It is of note that all the sampling locations at site II could be classified as indoor and levels in these settings were considerably higher than indoor at Site I. In fact indoor levels at site II were comparable to outdoor levels at Site I. This trend can elucidate the dynamic contribution of various activities/sources to NO_2 levels. The vehicular emission within and nearby locality and road proximity seemed to play a considerable role in enhancement of indoor NO_2 level at site-II as compared to site-I.

Mirza *et al.*, (2013) measured the concentrations of NO_2 using passive samplers biweekly in three phases (pre-monsoon, monsoon and post-monsoon). The mean values were observed to be 74.09, 79.87 and 86.09 µg/m^3, respectively.Despite of difference in total exposure time (two weeks) than present study (one week), the average outdoor value is comparable and in close relation to the values of all the three phases. During winter and summer of 2010, Colbeck and his colleagues measured the NO_2 concentration at different household in Lahore. The mean concentrations during winter sampling campaigns in kitchen, living room and courtyard were 218,136 and 64µg/m^3, respectively whilst in summers the subsequent levels were recorded to be 234, 103 and 138 µg/m^3.These levels are higher than our study and the observed differences could be due the differences in sources specific tobuilt environment types.

Our sampling sites were educational /occupational, had no direct burning of any type of fossil fuel very close to the sampling location, spacious and well ventilated as compared to kitchens and living rooms in households.

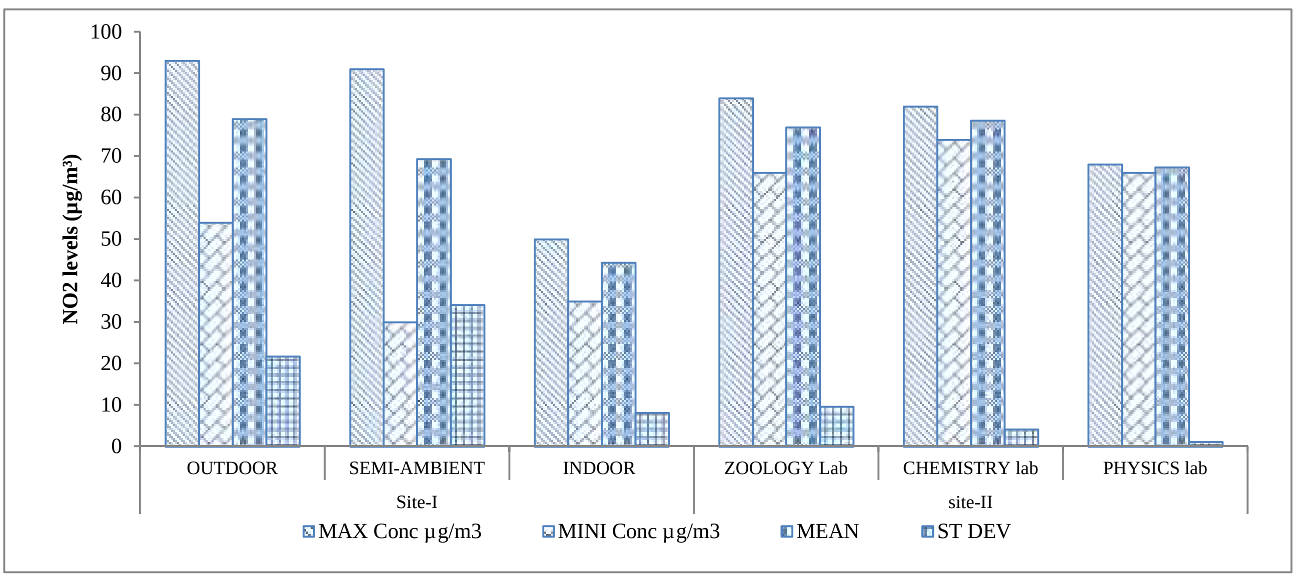

Figure 2 Comparison of mean concentration of NO_2 along with maximum, minimum and standard deviation at two sites.

Conclusion: The present study found high concentration of NO_2atdifferent sampling locations inhigher education institutes located in city centre. Due to limited sampling sites and duration no firm conclusions can be made. However, the results suggest that outdoor sources are a major contributor to indoor exposure to NO_2 in heavy traffic urban areas (Site II) and ventilation and infiltration play a major role in NO_2level in urban built environments. Direct comparison of observed levels of NO_2 cannot be made with WHO guideline or Pakistan National Environmental Quality Standards (NEQS) for ambient air due to differences in the averaging period. However, it is likely that levels of NO_2 probably exceeded WHO guideline value of 200 $\mu g/m^3$ (1 hour mean) and NEQS value of 80 $\mu g/m^3$ (24 hour mean) especially at site II and outdoors and corridor at site I. There is urgent need to put in place stringent emission control strategies to improve air quality in urban areas. Further long term studies are required to assess the actual exposure to air pollutants in different built environments in urban as well as rural areas in the country.

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