

## QUANTIFICATION OF PM<sub>10</sub> CONCENTRATION IN OCCUPATIONAL ENVIRONMENT OF TRAFFIC POLICE PERSONNEL IN POKHARA SUB-METROPOLITAN CITY, NEPAL

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### ABSTRACT

Air pollution, particularly particulate pollution has been emerged as the major air quality issues in urban centers of Nepal including Pokhara. Pokhara is one of the major cities in Nepal located at 28.24 N, 83.99 E, and also one of the most popular tourist destinations. This study has been conducted to assess the traffic police personnel exposure to PM<sub>10</sub> (Particulate Matter of diameter 10 micron or less) in their occupational environment in Pokhara. This type study has been conducted for the first time in Pokhara. The monitoring was carried out for seven days in three shifts (morning: 7:30 am to 11:30 am, afternoon: 11:30 am to 3:30pm and evening shift: 3:30pm to 7:30pm) in three major HDTA's (High Density Traffic Areas) of Pokhara. On an average, the duration of sampling in each day was 8 hours in each of the sites. Subjective exposure to PM<sub>10</sub> was monitored by personal monitoring technique. Personal air sampler (PCXR4) manufactured by M/s SKC, USA was used. Altogether 35 samples were collected and analyzed gravimetrically in the laboratory. The overall mean concentration (averaged for 8 hours) of PM<sub>10</sub> was found to be 1559.107  $\mu\text{g}/\text{m}^3$  in Mahendrapul, 1759.032  $\mu\text{g}/\text{m}^3$  in B.P chowk and 1733.846  $\mu\text{g}/\text{m}^3$  in Prithvi chowk. The overall mean concentration of PM<sub>10</sub> was observed higher in morning shifts (2093.790  $\mu\text{g}/\text{m}^3$ ) than evening (1704.005  $\mu\text{g}/\text{m}^3$ ) and afternoon (1192.670  $\mu\text{g}/\text{m}^3$ ) shifts. PM<sub>10</sub> concentration was observed higher in Weekdays than Weekends. However, no significant difference in overall mean PM<sub>10</sub> concentration was observed in different sampling sites and week days (weekdays and weekends) at 0.05 level significance. Significant difference in PM<sub>10</sub> concentration was observed in different shifts only. It was concluded from the findings of the present study that traffic police personnel are exposed to very high level of PM<sub>10</sub> (almost 10 to 15 folds higher than National Ambient Air Quality Standard for PM<sub>10</sub> for Nepal i.e. 120 $\mu\text{g}/\text{m}^3$ ) in all three HDTA's of Pokhara city.

**Key words:** Nepal, Pokhara, personal air sampler, occupational environment, HDTA's

### INTRODUCTION

Millions of people in urban centers are confronted with environmental and health problems owing to harmful emissions caused mainly by motor vehicles (ADB and ICIMOD, 2006). Worldwide, the World Health Organization (WHO) estimates that as many as 1.4 billion urban residents breathe air with pollutant concentrations exceeding the WHO air guideline values (WRI, 1998). Much of the urban air pollution in Nepal, particularly in Kathmandu Valley, is caused by vehicular emissions. Besides this, narrow and dusty roads, poorly maintained

traffic, fuel adulteration and improper traffic management play a vital role in accelerating air pollution (Joshi 1993). In a normal city center, motor traffic accounts for practically the whole emission of carbon monoxide (CO), 60% of the oxides of nitrogen (NO<sub>x</sub>) and hydro carbons (HC), 10% of the oxides of sulphur (SO<sub>x</sub>), and about one half of the particulate matter. Further, motor vehicles are also responsible for spread of particles through the wear of tires, road surface and brakes, and the circulation of road dust. This emission can be about 10 times greater than that through the exhaust pipe (NSIEM, 1983).

In Nepal, vehicular density is increasing at alarming rate but road expansion is creeping. Till fiscal year 2061/62 B.S., 34,199 vehicles were registered in Transportation Management Office, Gandaki zone. According to Birjung Tax Office, import of trucks and buses has increased by 300 percent, while import of motorbikes increased by 100 percent compared to last two years in Nepal (Clean Energy, 2007). Of the total road length of 2,051 km in 2000 in Nepal, 45% were blacktopped, 30% was graveled, and the remaining 25% was earthen (ADB, 2005). The increase in the number of vehicles has not been matched by expansion and upgrading of road infrastructures, leading to increased traffic congestion in major urban centers of the country further aggravating the problem of air pollution.

### **Objectives**

The main aim of our study is to quantify the PM<sub>10</sub> concentration in the occupational environment of traffic police personnel in the Pokhara sub-metropolitan city of Nepal.

The Specific Objectives of the study are as follows:

- To quantify the concentration of PM<sub>10</sub> in occupational environment in three major HDTA's of Pokhara City (Mahendrapul, Prithvi chowk and B.P chowk).
- To determine the variation of PM<sub>10</sub> concentration at different times of the day (morning, afternoon and evening) and for different days of the week (week days and weekends) in all three HDTA's.

### **Hypothesis**

Following hypotheses were formulated for the present study:

- There is a significant difference in PM<sub>10</sub> concentration among three sites.
- The concentration of PM<sub>10</sub> differs according to the shift (morning, afternoon and evening).
- PM<sub>10</sub> concentration differs during week days and weekends.

## MATERIALS AND METHODS

### Study Area

The study was conducted in three major High Density Traffic Areas (HDTA's) of Pokhara sub- metropolitan city (Mahendrapul, Prithvi chowk and B.P chowk) of Nepal. Pokhara is one of the major cities and also important tourist destinations in the country located at 28.24 N, 83.99 E, 198 km west of Kathmandu. Prior to sampling, District Traffic Office, Kaski, Pokhara was consulted for the identification of HDTA's in the city for the selection of sampling sites. Prithvi chowk lies in the southern part of the city while Mahendrapul and B.P chowk lies in the central part. All three sampling sites are characterized by narrow, rough and dusty roads and high traffic influx. Sampling sites are shown in figure 3.1

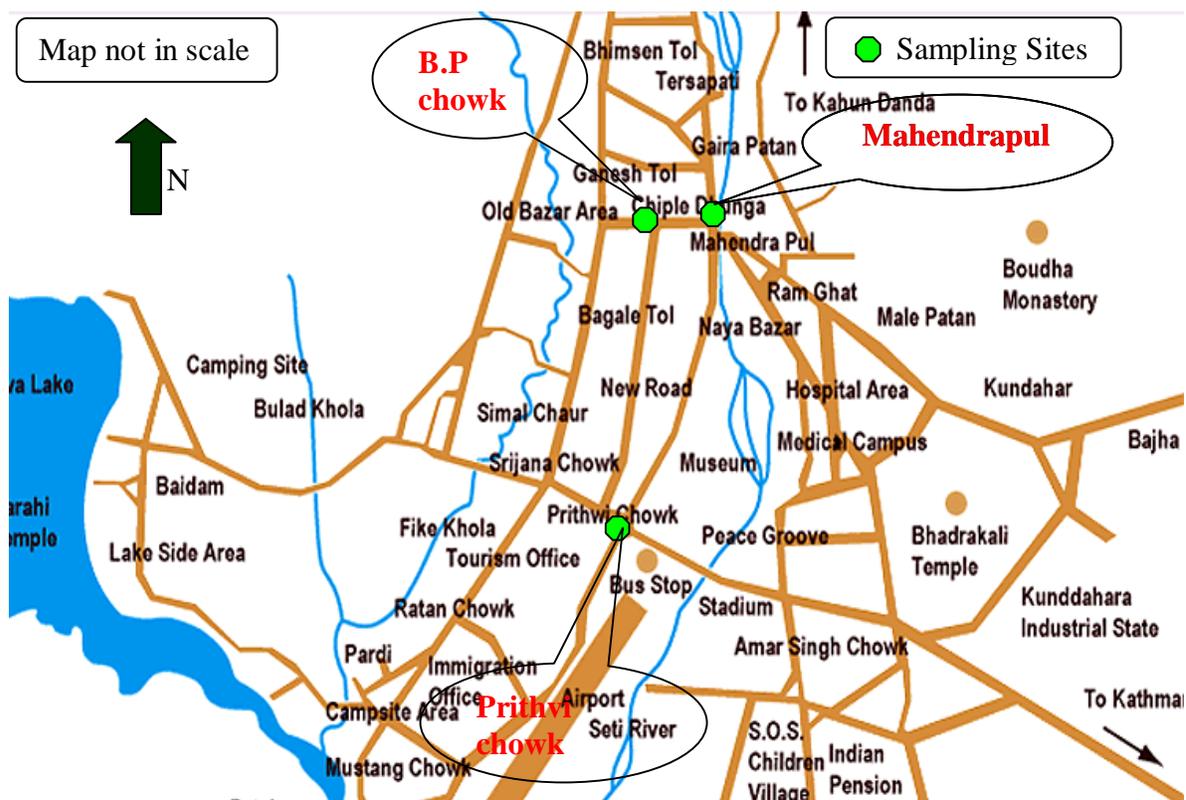


Figure 3.1: Map of Pokhara city which shows sampling sites

### Sampling and Analysis

Air sampling was carried out for seven consecutive days in mid March 2008 in three HDTA's of Pokhara city. The sampling was carried out in three shifts in a day ( sampling shifts and time are shown in table 3.2) in order to have the comparative  $PM_{10}$  concentration to which traffic police personnel are exposed to in rush hour (morning and evening shifts) and off hour(afternoon shift). Subjective exposure to  $PM_{10}$  was monitored by personal monitoring technique. On an average, the duration of sampling in each day was eight hours in each of the sites. Personal air sampler (PCXR4) manufactured by M/s SKC, USA was used. With an operating range of 5 to 5000 ml/min, this battery-operated air sampling pump is ideal for

industrial hygiene studies as well as environmental testing. Air flow was maintained constant 2 liters per minute (simulating almost human respiratory rate) with the help of adjustment knob in the personal air monitoring sampler. The sampler was charged for 10 to 12 hours every night prior to sampling.

Table 3.2 Sampling shifts and Time

Shift	Time
Morning	7:30 am to 11:30 am
Afternoon	11:30 am to 3:30pm
Evening	3:30pm to 7:30pm

In the field, the sample collection media (filter paper) was clipped in the breathing zone of traffic police and then pump was clipped to their belt. Before starting the sampling, batteries were checked and the flow rate was adjusted according to the requirement using the screw. Then the sampler was turned ON. The starting and ending time were noted.

The concentration of  $PM_{10}$  was calculated using Gravimetric Test. Upon the completion of sampling, the filter paper was removed carefully from the filter holder with the help of forceps, and kept in the filter paper storage bag and stored in the desiccators and then weighted. For a given volume of sample collected, the amount of the particulate matter ('W' in  $\mu\text{g}$ ) can be calculated by taking the difference in the weight of the filter paper before and after sampling. The volume of airflow ('V' in  $\text{m}^3$ ) was calculated by multiplying the flow rate of air ('Q' considered 2lit/min in the present study) through the filter medium with the sampling time ('T' in minutes) and by dividing with 1000 (to covert air volume into  $\text{m}^3$ ). The concentration ( $\mu\text{g}/\text{m}^3$ ) of  $PM_{10}$  was calculated by dividing the actual weight of  $PM_{10}$  ('W' in  $\mu\text{g}$ ) by volume of airflow ( $\text{m}^3$ ).

### Laboratory Preparation for the Sampling

The conditioning of filter media was carried out using moisture absorbing chemical, anhydrous calcium chloride in a closed vessel called desiccators in-order to subject filter paper to standard condition of temperature and humidity. The filter paper used was made up of fiber glass with the pore size of 7 micrometer and diameter of 37mm. Before air sampling, the numbered filter papers were kept inside the chamber of desiccators for 24 hours and then taken out for pre weight and then stored in the labeled air tight plastic pouch. After the sampling, the filter media was again kept inside desiccators for 24 hours and then the weight was taken as post weight. The filter paper discs were weighed in an environmentally controlled area. The balance used was capable of weighing a minimum of 0.0001gm.

### RESULTS AND DISCUSSIONS

Table 4.1 represents the mean  $PM_{10}$  concentration at different HDTA's. The average occupational exposure of traffic police personnel to  $PM_{10}$  level was found to be 1559.107  $\mu\text{g}/\text{m}^3$  in Mahendrapul, 1733.846  $\mu\text{g}/\text{m}^3$  in Prithvi chowk and 1759.032  $\mu\text{g}/\text{m}^3$  in B.P chowk. The highest concentration of  $PM_{10}$  was reported in B.P chowk (1759.032  $\mu\text{g}/\text{m}^3$ ) while mean

concentration in Prithvi chowk ( $1733.846 \mu\text{g}/\text{m}^3$ ) was also reported very close to that in B.P chowk. All the three sampled sites had very high concentration of  $\text{PM}_{10}$  which exceeds the National Ambient Air Quality Standard (NAAQS) for  $\text{PM}_{10}$  i.e.  $120 \mu\text{g}/\text{m}^3$  by as much as 12 to 14 folds. From Kruskal-Wallis Test between mean  $\text{PM}_{10}$  concentration in different sites, it was observed that there is no significant difference between the overall mean  $\text{PM}_{10}$  concentration in three different sites. This means that the traffic police personnel are exposed to similar level of  $\text{PM}_{10}$  in all the three sampling sites in Pokhara.

Table 4.1: Descriptive Mean  $\text{PM}_{10}$  level in each Sampling Sites

Sites	N	$\text{PM}_{10}$ concentration ( $\mu\text{g}/\text{m}^3$ )				
		Mean	Std. Deviation	Minimum	Maximum	Range
Mahendrapul	12	1559.107	408.4935	896.9	2222.2	1325.4
Prithvi chowk	13	1733.846	532.5026	1000.0	2753.6	1753.6
B.P chowk	10	1759.032	598.1149	1000.0	2807.0	1807.0

N- number of samples

Similarly, Table 4.2 represents the mean  $\text{PM}_{10}$  concentration in each of the shift in which sampling was conducted. Mean  $\text{PM}_{10}$  concentration was found to be  $2093.790 \mu\text{g}/\text{m}^3$  in morning shift,  $1192.670 \mu\text{g}/\text{m}^3$  in Afternoon shift and  $1704.005 \mu\text{g}/\text{m}^3$  in Evening shift. It was observed that traffic police personnel are exposed to very high level of  $\text{PM}_{10}$  in morning shift as compared to afternoon and evening shift. In afternoon shift the concentration was significantly lower ( $1192.670 \mu\text{g}/\text{m}^3$ ) relative to morning ( $2093.790 \mu\text{g}/\text{m}^3$ ) and evening ( $1704.005 \mu\text{g}/\text{m}^3$ ). From Kruskal-Wallis Test between mean  $\text{PM}_{10}$  concentrations in different shifts, it was observed that there is significant difference between overall  $\text{PM}_{10}$  concentration in different shifts i.e. traffic police are exposed different level of  $\text{PM}_{10}$  concentration in morning, afternoon and evening shifts.

Higher  $\text{PM}_{10}$  concentration in the morning might be due to higher number of traffic in the road as well as “re- emission” through the circulation caused by passing vehicles. The particles start to settle during the night time as the vehicular movement begins to cease and the settled particles are disturbed and re- suspended in the morning as the vehicles begin to move. As re-emission is the important factor governing the spread of particles, it might have substantial impact on higher concentration in the morning. As the day progresses, the vehicle density decreases and this decreases both emission as well re-emission. Therefore  $\text{PM}_{10}$  concentration was observed to be lower in afternoon shift that other two. During few sampling days there was rainfall for short duration in the late afternoon. This might also have pronounced effect on concentration of  $\text{PM}_{10}$  in afternoon and evening shift as rainfall causes the suspended particles to settle down. The analysis of pollution concentration for days “with rain” suggested rainfall has a scavenging effect in the concentration (Sani, 1987).

Shrestha (2007) also observed the higher concentration of mean PM<sub>10</sub> concentration in morning shift than the evening shift in all seven major HDTA's of Kathmandu city. The findings of this present study also suggest the similar trend in mean PM<sub>10</sub> concentration correspondence to shifts.

Table 4.2: Descriptive- mean PM<sub>10</sub> vs. Shift

Shift	N	PM <sub>10</sub> concentration (µg/m <sup>3</sup> )				
		Mean	Std. Deviation	Minimum	Maximum	Range
Morning	15	2093.790	399.8578	1370.9	2807.0	1436.2
Afternoon	13	1192.670	171.1971	896.9	1401.9	505.0
Evening	7	1704.005	283.9014	1067.3	1864.8	797.5

Further, Table 4.3 represents the Mean PM<sub>10</sub> concentration according to week day's category. 7 days in a week have been categorized as weekdays (from Sunday to Friday) and Saturday as weekends as traffic density is significantly reduced in Saturdays relative to other working days. The mean concentration of PM<sub>10</sub> was higher in week days (1755.037 µg/m<sup>3</sup>) than weekends (1323.923 µg/m<sup>3</sup>). It was also observed that traffic density was significantly lower in weekends (127 vehicles averaged for 5 minutes during sampling period) than week days (196 vehicles averaged for 5 minutes) because all the governmental and non- governmental organizations, educational institutions as well as major commercial areas are closed. As transport or mobile sources contribute the majority of pollutants in urban areas, particularly when viewed in terms of human exposure, reduction in vehicle density would significantly contribute to reduction in vehicular emission and hence reduction (NSIEM, 1983). But from Mann-Whitney Test between mean PM<sub>10</sub> concentration in weekdays and weekends it was observed that there is no significant difference between overall PM<sub>10</sub> concentration in weekdays and weekends i.e. traffic police are exposed to same level of PM<sub>10</sub> concentration in weekdays as well weekends.

In study conducted by LEADERS Nepal, (1999) it was observed that weekdays have higher concentration of PM<sub>10</sub> than weekends. Similar result was also obtained by Shrestha (2007).The findings of this study also follows the similar trend.

Table 4.3: Descriptive Mean PM<sub>10</sub> Level vs. Week Days Category

Week days category	N	PM <sub>10</sub> concentration (µg/m <sup>3</sup> )				
		Mean	Std. Deviation	Minimum	Maximum	Range
Weekdays	29	1755.037	495.9362	1000.0	2807.0	1807.0
Weekends	6	1323.923	429.5923	896.9	2034.4	1137.6

## CONCLUSIONS

This study was conducted to quantify PM<sub>10</sub> concentration in occupational environment of traffic police in Pokhara. It was observed that traffic police personnel are exposed to very high level of PM<sub>10</sub> in their occupational environment along the HDTA's of Pokhara sub-metropolitan (almost 10 to 15 folds higher than National Ambient Air Quality Standard for PM<sub>10</sub> for Nepal i.e. 120µg/m<sup>3</sup>). Chronic exposure to this high concentration of PM<sub>10</sub> can have significant impact on the health (especially respiratory complications) of traffic police personnel. It is also concluded that not only traffic police personnel but the general community along the junctions of HDTA's (for instance: vendors, pedestrian etc) might also be vulnerable to exposure to same level of the pollutant.

Based on present study, it is recommended that there should be provision for the regular check up campaign of traffic police personnel especially for respiratory complications. Some other suggestions like wide, black topped and well maintained roads, routinely watering in roads, planting trees on both sides of the road and age limits on public transport vehicles and other commercial vehicles would be effective in reducing present level of particulate pollution in Pokhara.

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