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Mini Review

Assessment of Ambient Particulate Air Pollution and its Attribution to Environmental Burden of Disease in Kathmandu Valley, Nepal: A Review

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Abstract

Ongoing and past monitoring of ambient particulate air pollution assessed by PM10 and PM2.5 levels have shown high pollution concentrations in Kathmandu valley with levels more than five times than the accepted WHO and National Ambient Air Quality guideline values. Studies which associated ambient air quality with different health effects particularly related to respiratory diseases have also demonstrated significant health effect coefficients leading to substantial attributable environmental burden of disease in Kathmandu valley. These findings call for more attention towards reduction of dust particle and emission levels through proper and effective implementation of environmental management strategies and regulations including pragmatic preventive measures and henceforth deal effectively with public health burden concerns of Kathmandu valley inhabitants and achieve the targeted sustainable development goals related to safer environment.

Keywords: Ambient air pollution; Attributable fraction; Attributable burden; Dusty roads; Health effect coefficients; Particulate matter; Public health; Respiratory ailments

Introduction

Amongst many air pollutants, particulate pollution is found to be the most serious polluting air contaminant both in indoor as well as ambient air in Nepal. Indoor air pollution (IAP) generated through biomass fuel burning such as dung, wood and crop residue is found very high in Nepalese rural and poor households and exposed population particularly women and children showed significant prevalence of respiratory problems such as respiratory symptoms (cough, phlegm, wheezing, breathlessness), chronic bronchitis, asthma, chronic obstructive pulmonary disease (COPD), acute respiratory infection (ARI), etc. as shown by studies in Nepal [1-3]. According to National Population and Housing Census 2011 of Nepal, around two-third (64%) of households still use firewood as the cooking fuel in Nepal [4]. Evidently, IAP is particularly a rural problem in Nepal. However, in contrast to IAP, ambient air pollution in Nepal is mainly an urban phenomenon. Urban areas in Nepal and particularly Kathmandu valley is stressed by ambient particulate air pollution. Many studies and ongoing monitoring results have collectively demonstrated this fact which indicates and highlights the possibility of substantial public health burden in Kathmandu valley inhabitants which can be attributed to ambient particulate air pollution.

Reviewing of air pollutant monitoring studies in the valley, for the first time, six fixed monitoring stations were installed within Kathmandu valley at different locations by the Ministry of Population and Environment (MOPE) with the support from Danish International Development Agency (DANIDA) to observe PM10 (particulate matter of aerodynamic size less than 10 micron) continuously round the clock in 2003 which continued till 2005. The locations constituted high traffic zones like Putalisadak and Thamel in Kathmandu, moderate traffic zones and residential areas like Patan (Lalitpur) and Bhaktapur and valley background areas like Kirtipur and Matsyagaon.

The annual averages were 134μg/m^3 in 2003, 129μg/m^3 in 2004 and slightly decreased to 121μg/m^3 in 2005 [5]. On the average, the annual averages were roughly 6-7 times high than the WHO guidelines of 20μg/m^3 which is alarmingly higher. Even though there has been many sporadic, occasional and campaign basis monitoring of particulate air pollutant at different places within the valley there was a long gap of continuous 24-hour non-stop monitoring of particulate air pollution in the ambient air in Kathmandu valley for almost a decade. In 2014, Nepal Health Research Council (NHRC) conducted a study which included monitoring of particulate matter of aerodynamic size less than 2.5 micron (PM2.5) along with carbon monoxide (CO) and Nitrogen dioxide (NO_2) round the clock for one whole year and found that the annual average of PM2.5 was around 49μg/m^3 which is about 5times higher than World Health Organization (WHO) guideline of 10μg/m^3.

Moreover, ambient particulate pollution was found much higher in dry seasons (winter and spring) which is around 70-80μg/m^3 and almost 4times higher compared to rainy season (summer and

autumn, around 23μg/m^3). Fixed stations were installed at three places within the valley located in Kathmandu (Putalisadak, a high traffic zone), Lalitpur (Mahalaxmisthan, a moderate traffic zone) and in Bhaktapur (Jagati, a low traffic zone). Since monitoring results were obtained everyone minute, averages were also obtained for different time periods (of 3-hour interval each) within 24hour of a day in order to examine and assess the differences between the periods.

The time periods segregated for analysis were post-midnight period (Midnight-3AM), early morning period (3AM-6AM), morning period (6AM-9AM), before noon period (9AM-12noon), afternoon period (12noon-3PM), late afternoon period (3PM-6PM), evening period (6PM-9PM), and late-night period (9PM-Midnight). Monitoring results showed interesting result with a sine curve like variation of average PM2.5 level with almost minimum in post-midnight period of 36μg/m^3 and increased marginally in early morning period registering around 41μg/m^3 then increased sharply to 74μg/m^3 during morning time which is also the peak average in a whole day.

The pollution average then started to decrease gradually to around 66μg/m^3 in late morning period and further dipped down sharply to attain the lowest average of around 35μg/m^3 during afternoon period and remain roughly the same (around 36μg/m^3) for another three-hour interval during late afternoon period. The average level then increased rapidly and attained an average of around 56μg/m^3 in late evening period then again dipped down to 49μg/m^3. The results demonstrated that PM2.5 pollution in ambient air is highest during morning time from 6AM to 9AM which suggests that it is relatively unsafe for morning walkers during 6-8AM compared to early morning period before 6AM and evening time period. This was quite a revelation of the monitoring study by NHRC in 2014. In the study, CO and N_{02} levels were also continuously monitored for the whole period in the ambient air of Kathmandu valley. Their results showed much safer levels of CO of around 440μg/m^3 which is well below the National Ambient Air Quality Standard (NAAQS) of 1000μg/m^3 for 8-hour average. However, average N_{02} level showed more than 4times higher annual average of around 176μg/m^3 compared to the NAAQS guideline of 40μg/m^3 [6].

Due to increasing need and demand of continuous monitoring of particulate air pollutant concentration in the ambient air in Kathmandu valley, MOPE again started the process of round the clock monitoring in 2016 through installation of two roadside fixed stations within the valley which monitored total suspended particles (TSP), PM10, PM2.5 and PM1. In addition, some civil society organizations also monitored PM2.5 in the ambient air. The results of the monitoring at different places again showed very high particulate ambient air pollution in the valley. For instance, the annual average of PM10 and PM2.5 from MOPE station at a roadside place (Ratnapark) were 180μg/m^3 and 38μg/m^3, respectively. The figures are 9times and 3.8 times higher than the respective WHO guidelines. Environment Sector Programme Support (ESPS)/MOPE has also done 6 hourly monitoring of PM10 and PM2.5 (Midnight-6AM, night; 6AM-12 noon, morning; noon-6PM, afternoon; 6PM-midnight, evening). At nighttime and afternoon, the concentrations were lowest and highest during morning time and moderately high during evening time which is consistent with the results obtained from the monitoring study by NHRC in 2014 [7].

The burden of disease which can be attributed to environmental risk factor like ambient air pollution is a critical issue concerning public health concerns of Nepalese population. In Nepal, studies have been conducted in this area even though few in number. In this context, NHRC conducted a study entitled 'Development of procedures and assessment of Environmental Burden of Disease (EBD) of local levels due to major environmental risk factors' concerning the issue of computing health effect coefficients related to exposure to particulate ambient air pollution and water pollution in which several health effects including all-cause mortality, respiratory hospital admissions like chronic obstructive pulmonary disease (COPD), chronic bronchitis, etc. were addressed and showed that increase in 10μg/m^3 PM10 is associated with around 0.7% increase in all-cause mortality, 1.9% respiratory admission including COPD, asthma, bronchitis and acute respiratory infection (ARI) and 3.2% COPD admission without accounting distributed lag effects.

The corresponding attributable factors (AFs) were 0.08, 0.21, and 0.32, respectively which means that out of the total specific disease burdens 8%, 21% and 32% of all-cause mortality, respiratory morbidity and COPD morbidity can be attributed to ambient particulate air pollution in Kathmandu valley [8].

These estimates were the pioneering work done related to health effects attributable to ambient air pollution in Nepal based upon local daily time series data since all the other studies conducted before the NHRC study were based upon extrapolated health effect coefficients derived from studies conducted in other parts of the world [9]. Later on, estimates were reanalyzed and refined to obtain distributed lag effects of ambient particulate air pollution since health effects on a particular day can be due to several days or weeks of exposure prior to the onset of effects. Accounting of distributed lag effects showed that increase in 10μg/m^3 PM10 is associated with around 2.6% increase in all-cause mortality, 3.5% increase in respiratory morbidity and 4.9% increase in COPD admission and the corresponding attributable factors (AFs) increased substantially compared to the AFs obtained without accounting distributed lag effects.

These findings demonstrated that short term health effects which accounted only few days of exposure underestimate health effect coefficients and therefore distributed lag effects needs to be accounted for such types of estimations [10,11]. Again in 2015, the NHRC study calculated and assessed the environmental burden of diseases which showed 1-2%, 2-3%, and 3-5% increase in COPD, ARI and pneumonia hospitalizations, respectively per 10μg/m^3 increase in PM2.5 in the ambient air of Kathmandu valley. The

corresponding figures of AFs were 0.06, 0.10 and 0.16 which suggests that out of the total specific disease burdens 6%, 10% and 16% of COPD, ARI and pneumonia morbidities, respectively can be attributed to ambient particulate air pollution (PM2.5) in Kathmandu valley [6].

Discussion

The urban high population density areas and traffic areas within the Kathmandu valley are characterized by high ambient particulate air pollution which undoubtedly pose serious public health concerns to the exposed population particularly related to respiratory ailments. The major sources of pollution are identified as vehicular emission, brick kilns, urbanization, dusty roads of the valley, etc. Government of Nepal has time and again imposed regulations that prohibit old vehicles that are more than 20 years old and operate under public transportation. However, implementation side of such regulations have not been as effective as should be and streets are full of such vehicles and more so vehicles that emit visibly black smoke still run in substantial quantity and their emission checking strategies are still weak in Nepal. Adding to the problem and making scenario even worse is the ongoing process of street widening in widespread manner due to which outdoor air is very dusty particularly in main street locations and people are compelled to breathe in such unhealthy air environment. The management and timely completion part of such development works are below par and needs to be improved urgently.

Conclusion

Particulate ambient air pollution is very high in Kathmandu valley with levels many folds higher (more than 5times) than the acceptable guidelines with substantial respiratory ailments related health burdens in Kathmandu valley residents. High population density residing inside the valley with more than 3 million inhabitants and their exposure to such high ambient air pollution is indeed a serious concern regarding their health safety and warrants policy and decision makers for effective plans and policies including decentralization policies under the new constitution and federal states transformation scenario in Nepal which needs to be implemented effectively by government and achieve sustainable development goals (SDGs) in years to come.

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