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Urban air pollution & its assessment in Lucknow City — The second largest city of North India

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HIGHLIGHTS

- Indoor air quality is an issue of major concern in developing countries like India.
- The study deals with urban pollution monitoring.
- The work was done in Lucknow City, 3rd most polluted city of India according to WHO.
- By calculating indoor/outdoor ratio we found which one of both is dominant.
- I/O correlation was established and the effects of IAQ on human health were studied.

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ABSTRACT

Investigations were carried out during the summer season (March–June 2012) to observe the quality of indoor air by monitoring the levels of some selected air pollutants at 15 different houses covering the urban areas of Lucknow City. Concentrations of CO_2, CO, PM_{10}, $PM_{2.5}$, SO_2 and NO_2 were monitored indoors and outdoors simultaneously and I/O ratios were calculated. Regression analysis for I/O relationship was performed to assess the contribution of outdoor sources to indoor air quality. Air Quality Index (AQI) for indoor air was also calculated to have an idea about the quality of indoor air and their health effects. In collaboration with the medical college doctors of the city, we surveyed 197 persons to find out different diseases/symptoms being faced due to indoor air pollution. Results of the study revealed that the average levels of PM_{10} and $PM_{2.5}$ were above the permissible limits laid by WHO at densely populated and roadside sites with 189 μg/m^3 ($PM_{2.5}$ 76 μg/m^3) and 226 μg/m^3 ($PM_{2.5}$ 91 μg/m^3) respectively. Correlation analysis showed positive results. At sites like Alambagh and Chowk, the indoor AQI range was alarming with the values of 302 and 209. Survey results also showed that 46% of urban people suffered from acute respiratory infections like bronchial asthma, headache, depression and dizziness and these people were mostly from Roadside colonies.

1. Introduction

In India, over the past two decades there has been a rapid increase in urbanization and industrialization in many cities. The urbanization process has both positive and negative effects on indoor air quality in many cities of the world (Kim, 1992). Hence there is an urgent need to know indoor air quality issues, to share the latest information, to make people aware of the risks of indoor air pollution and to let them know how to avoid it. Various regulations and guidelines have been imposed by local governments attempting to limit human exposure to potentially harmful particulate materials in environment (WHO-http://www.epa.gov/air/criteria.html and NAAQS-http://www.who.int/mediacentre/factsheets/fs313/en/index.html). But these standards are based upon exposure to pollutants measured outdoors. The problem is that in urban environments, people spend most of their time indoors- at home or at work (US-EPA, 1995). Outdoor pollutant concentrations may not be reliable indicators of indoor and personal pollutant sources (Wallace et al., 1997). Thus, for many people, the risk to health may be high due to exposure to air pollution indoors than outdoors (Misra et al., 2012). In addition, people who may be exposed to indoor air pollutants for the longer periods of the time are more susceptible to the effects of indoor air pollution like acute lower respiratory infections (Ramesh Bhat et al., 2012). Such groups include the young, the elderly and physically ill, especially those suffering from respiratory or cardiovascular diseases.

Current and previous research indicates that more than 900 contaminants are present in indoor environment (David, 1992). Burning of fuel in any form largely releases various kinds of unburned or waste product in the environments as particulate matter (Khan et al., 2010). Some sources of indoor air pollution in homes are solvents used in cleaning, building materials, paint, radon, allergens, cooking, smoking, plastics, carpets,

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Fig. 1. Detailed location of the sites selected for sampling.

and biomass burning for fuel or cooking (Ballester et al., 2009; Brown et al., 2010; Kaplan, 2000; Roberts and Dickey, 1995; Zhang and Smith, 2003). Indoor air pollutant levels are affected by trends in building design and construction practices, such as reduced ventilation rates, more tightly sealed buildings, and synthetic building materials and furnishings. Solvents involved in renovations and painting in homes have been associated with increased risk of general respiratory symptoms for children under 5 years (Ballester et al., 2009). Many can be respiratory and sensory irritants, carcinogens, developmental toxins, neurotoxins, hepatotoxins, and immunosuppressants, and may cause symptoms that manifest as sick building syndrome (Prazad et al., 2008).

According to the WHO report, particulate matter (PM) affects more people than any other air pollutant. Even low concentrations of PM have been related to adverse health effects (Agarwal, 2012). Very limited work has been carried out to investigate air pollution from growing urbanization and its effect on human health in Lucknow City. Population and pollution are strongly correlated to each other; if population increases so does the pollution (Barck et al., 2005). Population explosion, industrial growth and increase in vehicles are the main reason for air pollution nowadays (Bell et al., 2006). Lucknow is the capital of the most populated state of Uttar Pradesh, it is the second largest city in northern and central India. It is placed among the fastest growing cities and now it is a metropolitan city in India and is rapidly emerging as a manufacturing, commercial and retailing hub. Lucknow has insufficient transport infrastructure. Due to increasing urban population, use of personalized vehicles, mainly two wheelers and intermediate public transport is growing at a rapid rate. Total vehicle population is more than 13 lacs with a growth of 8.68% during 2011–2012 (IITR Report, 2012). Due to encroachment at the parking spaces and also at street places the traffic flow becomes restricted and results in more emission of pollutants. In most parts of the city, poor quality of road surface and unavailability of traffic rotaries and light signals at the intersections have also increased the emission of pollutants in the environment. The research on air pollution done so far in Lucknow has focused only on ambient air pollution (Sharma et al., 2006; Barman et al., 2008; Shukla et al., 2010; Pandey et al., 2012; Kisku et al., 2012; Pandey et al., 2013). Very limited work has been done related to health effect due to indoor air pollution. Hence there is an urgent need of assessment and research on indoor air quality in urban houses of Lucknow to ameliorate the incoherent risks from these pollutants on health and well-being of the concerned population.

Table 1
The threshold limit of each pollutant (laid by WHO) with its method of measurement adopted by Taneja and Lawrence, 2005.

Pollutants	Concentration in air		Methods of measurement
	Outdoor	Indoor	
Carbon dioxide (CO_2), ppm	5000	1000	Nondispersive infrared (NDIR) spectroscopy
Carbon monoxide (CO), mg/m^3	02	01	Nondispersive infrared (NDIR) spectroscopy
Sulphur dioxide (SO_2), μg/m^3	80	40	Improved West and Gaeke method
Nitrogen dioxide (NO_2), μg/m^3	80	40	Jacob & Hochheiser modified ($NaOH–NaAsO_2$) method
Particulate matter (size less than 2.5 μm) or $PM_{2.5}$, μg/m^3	60	25	Gravimetric method
Particulate matter (size less than 10 μm) or PM_{10}, μg/m^3	100	50	Gravimetric method