

Mini Review

Air pollution and respiratory health

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As per report of WHO [1] (World Health Organization), air pollution (ambient/outdoor and household/indoor air pollution) kills an estimated seven million people worldwide every year largely as a result of increased mortality from stroke, heart disease, chronic obstructive pulmonary disease, lung cancer and acute respiratory infections. Data of WHO shows that 9 out of 10 people breathe air containing high levels of pollutants. World Health Organization is working with countries to monitor air pollution and improve air quality. From smog hanging over cities to smoke inside the home, air pollution poses a major threat to health and climate. More than 80% of people living in urban areas and around 91% of the world's population live in places where air quality levels exceed WHO limits, with low- and middle-income countries suffering from the highest exposures, both indoors and outdoors¹. While outdoor air pollution comes from the motor vehicles, burning of fossil fuels and other industrialization activities, indoor air pollution is the result of tobacco smoke and burning fuel for cooking & heating. Furniture and construction materials also emit such pollutants. Both outdoor and indoor air pollution are harmful to the human health

Outdoor air pollution

Air pollution is a mixture of the hazardous material from both human-made and natural sources. Vehicular emissions, fuel oils and natural gas to heat homes, by-products of manufacturing and power generation units the primary sources of human-made air pollution. Nature releases hazardous substances into the air, such as smoke from wildfires, which are often caused by people; ash and gases from volcanic eruptions; and gases decomposing organic matter in soils. Traffic-Related Air Pollution (TRAP), from motor vehicle emissions, is the most recognizable form of air pollution. It contains: ground-level ozone, various forms of carbon, nitrogen oxides, sulfur oxides, volatile organic compounds, polycyclic aromatic hydrocarbons, and fine particulate matter. Ozone, an atmospheric gas, is often called smog when at ground level. Noxious gases, which include carbon dioxide, carbon monoxide, nitrogen oxides (NO_x), and sulfur oxides (SO_x).

More Information

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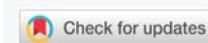
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Outdoor air is often referred to as ambient air. The common sources of outdoor air pollution are emissions caused by combustion processes from motor vehicles, solid fuel burning and industries. Other pollution sources include smoke from bushfires, windblown dust, and biogenic emissions from vegetation (pollen and mould spores). The most common air pollutants of ambient air include: Particulate matter (PM₁₀ and PM_{2.5}), Ozone (O₃), Nitrogen dioxide (NO₂), Carbon monoxide (CO), Sulphur dioxide (SO₂). As per WHO report, 4.2 million Deaths every year as a result of exposure to ambient (outdoor air pollution) and worldwide it contributes to 7.6% of all deaths in 2016. There are vulnerable group of people who are exposed outdoor air pollution are affected more.

A study was carried out in auto rickshaw drivers of Delhi to determine the respiratory morbidity due to air pollution. The auto rickshaw drivers are directly exposed to the air pollutants for hours. It was concluded that auto rickshaw drivers have a high respiratory morbidity due to exposure to pollution. They had significantly more symptoms of cough, phlegm production, breathlessness and nasal symptoms. Their problem increases when they were in more polluted areas. The respiratory morbidity was directly proportional to the duration of their working hours [2]. A study of respiratory symptoms and lung functions of welders was performed at ten different sites in Delhi. This study has documented high presence of symptoms of chronic bronchitis, other work related symptoms and airway obstruction in welders. Longer the duration of exposure more are the chances of developing



chronic bronchitis was observed [3]. The prevalence of asthma and wheeze found among petrol pump workers of Delhi in the study are similar to the prevalence of asthma and wheeze in the general population and prevalence of asthma had highly significant relationship with duration of stay in Delhi [4].

Indoor air pollution

Around 3 billion people cook using polluting open fires or simple stoves fuelled by kerosene, biomass (wood, animal dung and crop waste) and coal. Indoor/Household air pollution is one of the leading causes of disease and premature death in the developing world. Exposure to smoke from cooking fires causes 3.8 million premature deaths each year, mostly in low- and middle-income countries. Close to half of deaths due to pneumonia among children under 5 years of age are caused by particulate matter (soot) inhaled from household air pollution¹. Household air pollution accounts for 7.7% of global⁵ mortality. Nearly all deaths are in low- and middle-income countries where household air pollution is a leading cause of deaths from non-communicable. Common household pollutants are: Burning fuels produces a variety of health-damaging pollutants including particulate matter, methane, CO, PAH and VOCs. Radon, Lead, Asbestos, VOCs and moisture build-up moulds and biological particles i.e. Dust mites, Fungi, mold, airborne bacteria, animal & dander. Particulate matter is a pollutant of special concern. Smaller-diameter particles (PM_{2.5} or smaller) are generally more dangerous. The second-hand tobacco smoke and certain outdoor pollutants are known risk factors for acute respiratory infections, Indoor air pollution from biomass fuel is one of the major contributors to the global burden of disease [5].

Why indoor air pollution is important

There is a popular saying 'Home is where the heart is' [5]. Homes convey images of peace and security, protection and shelter. We spend 80-90% of our lives indoors. According to the *Environmental Protection Agency (EPA)*, the average American spends 93% of their life indoors. 87% of their life is indoors (home, office, schools, college, and all indoor working places), then another 6% of their life in automobiles. That's only 7% of your entire life outdoors. The public is not much aware about indoor air pollution. In one of study it was found that 85% of the people were not aware about the indoor air pollution. It is important that public should be made aware about it.

The person's occupation is important and accordingly occupational related diseases should be treated. According to Kumar, et al. [6] in 1997, occupational asthma is a respiratory disorder characterized by intermittent and reversible obstruction of the airways and caused by inhalation of substances which are manufactured or directly used by workers at the work site. Incidences varies from 5% - 15%. A number of occupational exposures (e.g. nickel, asbestos, chromium, arsenic, etc.) place, individuals or increased risk for lung tumors.

In 2005, Kumar, et al. [7] in his review paper suggested that the main indoor air pollutants which are highly responsible for respiratory morbidity and mortality are: particulate matter, sulphur dioxide, nitrogen dioxide, carbon monoxide, benzene, ammonia, chloroform, formaldehyde, benzopyrene, hydrocarbons, asbestos fibers and bio-pollutants. Sources of these pollutants are: combustion by-products, environmental tobacco smoke, carpets, paints, building construction materials, transportation, incinerators, industrial exhaust and almost every manufacturing process.

These indoor air pollutants can lead to serious public health problems, including asthma, chronic bronchitis, irritation of lungs, pneumonia, decreased resistance to respiratory infection, chronic obstructive pulmonary disease (COPD), chronic cough, phlegm production, allergy, headache, fatigue, lung cancer and premature death [7].

Is outdoor air pollution contributes to indoor air pollution

One of the source of the indoor air pollution is the outdoor pollution, meaning if there is increase in the outdoor air pollution, there is increase in indoor air pollution. Kumar, et al. [8,9] conclude that indoor SPM level and rhinitis and asthma in children were correlated to each other and both were higher in industrial areas. In industrial area the indoor air pollution increases there by outdoor air pollution. Hence industries play a vital role in rhinitis in children and concentration of indoor Suspended particulate matter (SPM) in developing countries like India [8,9]. Kumar suggest that both indoor and outdoor particulate exposure may be important risk factors in the development of respiratory illness in children in which indoor air pollution in industrial areas may be a major risk factor [10]. A study was undertaken in Shahdara and shahzadabagh which are industrial areas of Delhi to determine mineralogical and chemical compositions of indoor suspended particulate matter (SPM) that's correlate with the health of children especially respiratory allergy [Asthma, Rhinitis and upper respiratory tract infection (URTI)] [11].

Urban air pollution is an environmental concern of many cities throughout the world and now recognized as an important health problem, both nationally and worldwide. An appraisal of indoor air quality is the most important aspect in the understanding of the impact of urban air nitrogen dioxide, carbon monoxide, carbon dioxide, ozone, volatile organic compounds are especially pulmonary disease, cough, shortness of breath, wheezing, and lung cancer, skin cancer, irritation of eyes. Particulate matter is associated with more frequent respiratory illness because airborne particulates easily reach the deepest recesses of lungs and damage. Air pollutants in urban areas having several sources such as combustion of fossil fuels, power plants, automobile exhaust, incinerators, industrial processes, and natural sources such as sea spray, volcanic eruption, pollen grains and particles of soil [12,13].

Mineral and chemical composition of Indoor air pollution and respiratory morbidity

In industrial area of Delhi, high concentration level of indoor SPM with presence of trace elements including chromium, cobalt, lead, copper, nickel, and zinc may cause the respiratory diseases including asthma, rhinitis and upper respiratory tract infection in children [14]. Another study in industrial area of Delhi revealed that high concentration level of particulate matter containing quartz, carbonate, mica, and several major and trace elements including Si, Cr, Ni, Pb, Zn and Cu an important factor causing increased asthma among children [15]. Industries play an important role to increase the concentration of indoor suspended particulate matter and occurrence of asthma in children in developing countries [16,17]. The high values for mean level of indoor SPM was associated with environmental factors in industrial areas of Delhi. Quartz mica contents were high in indoor SPM where children having asthma, rhinitis and upper respiratory ailments [18,19].

Use of the Biomass and its use place and time of maximum indoor air pollution

Indoor air pollution from biomass fuel combustion results in an increased level of PM_{2.5} in indoor air, which may be responsible for increased respiratory illness in children [20-22]. The place of the kitchen, ventilation, use of the exhaust is very important factor for indoor air pollution and the respiratory morbidity. In a study it was found [23] indoor air concentrations associated with biomass smoke were four-fold greater in households of closed *verandah* kitchen than *separate kitchen* due to poorly ventilated condition and high exposure to particulates (PM₁, PM_{2.5}, and PM₁₀) and volatile organic compounds. The study demonstrated, significantly high particulate matter (PM_{2.5}), in households not using a separate room for cooking with biomass fuel are the main respiratory disease causing agents in children. It was also observed that PM_{2.5}, PM₁₀ were significantly high (maximum) during 6-8 am and 5-7 pm. This may be during this time the maximum cooking of the food takes place in this area. It was also observed that in spite of having Liquid petroleum gas (LPG) in their houses they prefer to cook the food on the biomass.

Not only biomass fuel, LPG also increase the concentration of indoor air pollutants and may subsequently play a significant role in the development of respiratory allergy [24].

In 2016 [25], concentration of indoor air pollutants (24 hrs. PM_{2.5} and 12-hour concentration of VOC) were found raised in households in low socioeconomic status households as compared to households of middle/high socioeconomic status with PM_{2.5} being statistically significant. This might be due to decreased use of exhaust in kitchen and increased use of kerosene oil. The increased reporting of respiratory symptoms in low socioeconomic group may be attributed to higher levels on indoor air pollutants.

In Some studies Kumar [26-28] suggests that BMF play a major role to occurrence of asthma and COPD in adults (smokers & non-smokers) in the developing countries like India where BMF is main fuel for cooking in rural areas.

Kumar, et al. [29] in 2016 concluded that Airway obstruction in children was occurred where families were using Biomass fuel (BMF) for cooking. So this study suggests that BMF play a significant role to occurrence of airway obstruction in children in the developing countries like India where BMF is main fuel for cooking in rural areas.

Tobacco use and indoor air pollution and respiratory morbidity

Kumar, et al. in 2008 monitored and estimated the level of exposure to indoor SO₂, NO₂, and SPM, as well as demographic information. Indoor SO₂, NO₂, and suspended particulate matter levels were high in houses where there was a family history of tobacco smoking. SO₂ level was high and NO₂ and suspended particulate matter levels were significantly high in houses where children had respiratory problems [30].

Kumar, et al. in 2014 revealed that Environmental Tobacco Smoke (ETS) and biomass cooking fuels increased the concentration of SPM with heavy metals in the indoor environment. The high concentration of indoor SPM and heavy metals may be harmful for human health and may cause different types of diseases in the family members [31]. Kumar, et al. suggests that ETS and BMF play a significant role to occurrence of asthma in children in the developing countries like India where BMF is main fuel for cooking in rural areas [32].

The available evidence of toxicity, indoor concentration and number of people exposed suggest that some indoor air pollutants mainly produced from ETS and biomass fuel may constitute significant public health problems (asthma and rhinitis) [33] and in addition to exposure to passive smoking, the indoor SPM level has significant effect on respiratory symptom of children [13]. Rhinitis was significantly high in smokers compared to smokeless tobacco users. It is further concluded that rhinitis was more common in cigarette smokers compared to bidi smokers [24]. Prevalence of asthma, rhinitis and URTI and mean level of indoor SO₂, NO₂, and SPM were significantly higher in homes with ETS

Kumar suggest that indoor air pollution from passive smoking/or second hand smoking results in increased levels of PM_{2.5} and volatile organic compounds in indoor air, which may be responsible for increased level of respiratory illness in children and adults³⁴. Abnormally high level of breath CO observed in passive smokers exposed to ETS may suggest that these subjects may be prone to develop the tobacco related diseases [35]. Kumar, et al. [36] concluded that Bidi is a more harmful or at least equally harmful as cigarette, this hypothesis is concluded by calculating pack-year for bidi, equating one bidi with one cigarette.



Indoor air pollution and prevalence of asthma, rhinitis and upper respiratory infection

Given below are few studies done in Delhi and nearby area of Delhi which suggest the significance of the indoor air pollution and its correlation with the respiratory morbidity

In a study entitled “Effect of indoor air pollution on respiratory function of children” was done in nine zones of Delhi namely Ashok Vihar (residential area), I.T.O. (residential area), Janakpuri (residential area), Nizamuddin (residential area), Siri Fort (residential area), Shahdara (industrial area), Shahzada Bag (industrial area), Dallupura (Village) and Jagatpur (Village) from March 2004 to July 2008. A total of 3,456 children were examined from there, of which 26.4% children were from lower, 27.5% from middle, and 26.0% from upper socioeconomic classes. Among these children, 59.2% were male and 40.8% were female, 20.1% were from urban villages. Among these, 31.2% of the children’s families were using biomass fuels for cooking and 68.8% were using liquefied petroleum gas. Levels of indoor SO₂, NO₂ and RSPM were measured. Out of 3,456 children, 7.7% Asthma, 26.1% rhinitis and 22.1% upper respiratory tract infection (UTRI) were diagnosed following medical histories and examinations of the children were completed [17]. It was found that in area where the industries were there, there was more indoor air pollution and the prevalence of asthma, Rhinitis was higher. Industrialization also contributes to indoor pollutants and developments/exacerbation of asthma, rhinitis and URTI in children [37].

In another study entitled “Indoor air pollution asthma in children

A population based study” were done at Khanpur Village, Loni, Ghaziabad, Delhi-NCR from March 2011 to Sep. 2015. A total of 1525 individuals were examined (Males- 809; Female-716) from 210 households. The adults participate in our study were 918 in which 470 males and 448 female candidates. In children there were 607 (male-339 & females-268) children were enrolled, of which 46.52% children were from lower, 17.11% from middle, and 36.36% from upper socioeconomic classes. PFT, PEFR, 24 hour monitoring of indoor air pollutants (PM₁₀, PM_{2.5} & PM₁) and VOCs were measured by using spirometer, UCB/Grimm Aerosol spectrometer & dust monitor, and Phocheck Tiger. Among these, 78.6% of the children’s families were using biomass fuels for cooking, 13.9% were using liquefied petroleum gas and 7.5% were using both BMF & LPG. Out of 607 children, 17% Asthma, were diagnosed following medical histories and examinations of the children were completed [23].

In another study entitled “Indoor air pollution asthma in children: A population based study” were done at Dujana Village, Dadri, Greater Noida, Delhi-NCR from Sep. 2015 to May 2018. A total of 5066 individuals were examined

(Males- 2224; female-2842) from 871 households. The adults participate in our study were 2791 in which 996 males and 1795 female candidates. In children there were 2275 (male-1228 & females-1047) children were enrolled, of which 1.9% children were from lower, 97.4% from middle, and 0.7% from upper socioeconomic classes. Among these, 83.5% of the children’s families were using biomass fuels for cooking, and 16.5% were using liquefied petroleum gas. PFT, PEFR, 24 hour monitoring of indoor air pollutants (PM₁₀, PM_{2.5} & PM₁) were measured by using spirometer, Grimm Aerosol spectrometer & dust monitor. Out of 607 children, 13.4% Asthma, 26.1% rhinitis and 22.1% upper respiratory tract infection (UTRI) were diagnosed following medical histories and examinations of the children were completed [39].

Recently Kumar, et al. [38,39] suggest that tobacco smoking, use of kerosene oil for lighting and combustion of solid fuel for cooking results in an increased level of particulate matter and VOCs in indoor air and are the major contributing factors for allergic in the paediatric population.

Dhoop, Incense use and indoor air pollutants

Kumar, et al. [40] suggested that burning of dhoop, incense sticks and mosquito coil in the indoor environment emit quiet higher respirable particulate matters, which may accumulate on prolonged exposure. The households should have better ventilation in order to avoid build of the PM. Thus, residing in such a higher particulate concentration may lead to serious respiratory health concerns.

Pollen and pollution

Pollen also contributes in the atmosphere and causes allergy to the patient. A study on OPD/ED visit patients and pollens count of different types of pollen provides a preliminary data of atmospheric pollen count in North Delhi region that provides information to the allergy practitioners in order to advice avoidance of exposure to allergens⁴¹. In 2018, Kumar, et al. also quantified and identified the pollen grains in the atmosphere of Delhi. In this study, various pollens of different plant species were counted and identified in this short study period. The common pollens found were *Juniper sp.*, *C. sativa*, Poideae grasses (e.g. *Poa sp.*, *Lolium perenne*, *Dactylis glomerata*), *C. dactylon*, *Amaranthus sp.*, *C. album*, *H. autumnale*, *Parthenium*, and *Artemisia sp.* in 2 months. The relationship between pollen number and respiratory allergy episodes is known. The findings of our study have shown the dominance of pollens of various plant species in the environment of Delhi with reference to affect respiratory diseases. This short study may be helpful for the respiratory allergic patients to protect themselves by pollens [42].

Birds feathers and droppings and indoor air pollution

There are many people keep birds at their home. The feathers and the droppings of these birds contributes to indoor air pollution, and exposure to these to the human



being is a health issues. Bird fancier's lung (BFL) is a type of hypersensitivity pneumonitis occurring in response to avian antigens (usually inhaled proteins in bird feathers and droppings). BFL can exhibit a wide range of radiological patterns, and a high index of suspicion must be maintained, with particular attention to detailed exposure history in every case of interstitial lung disease [43].

Biological pollutants

Indoor biological pollutants are also major factors contributing to the indoor air pollution. Kumar studied the indoor biological pollutants (pets and pests), and found that about 40% of asthmatic patients are sensitized to cockroach antigen and 15% to house dust mite. They are also sensitized to different pollens also [44].

Intervention to reduce the indoor air pollution and respiratory morbidity

An intervention/follow-up (3 months, 6 months and 9 months) study [45-48] conducted in which the change in cooking fuel (BMF) to safer fuel (LPG) was found to be one of the factors decreasing indoor pollutants and respiratory symptoms/morbidity among asthmatic children in rural areas. So Kumar suggested that the changes in the cooking fuel is better to decreasing the indoor particulate matters (PM₁₀, PM_{2.5} & PM₁) that's controls asthmatic symptoms and decreased morbidity. To conclude when domestic fuel was replaced with the LPG for cooking in few houses, he found out that exacerbation was significantly reduced, that shows the Government of India initiative (UJJWALA YOJNA) helps in reduction of the diseases morbidity.

Menace of Air Pollution in 21st Century suggested that the pollution is an undesirable change in the physical, chemical or biological characteristic of air, water and soil which may affect life or create potential hazards for any living organism [49]. It is concluded that respiratory allergies (asthma, rhinitis and URTI) in children and adults could be associated with indoor ETS and biomass fuel used for cooking from the different study areas. We should also make aware the public about indoor as well as outdoor air pollution and how to protect/or avoid these for their better respiratory health.

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