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# Indoor Air Pollution and Reactive Nitrogen: A Serious Health Issue

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Recently, it has been realized that increasing air pollution at work places as well as in the ambient air has serious health hazards. Air pollutants such as CO, $SO_2$, NOx, dust, toxic vapours, volatile organics, carbon soot and heavy metals have significant impact on human health. Inhalation and accumulation of toxic substances impact children and women significantly.[1] Indoor air pollution is generated by outdoor sources as well as indoor sources. Indoor sources include fuel burning, carpet, furniture, household products, paints etc. Building materials, furnishings, paints etc. may have low viscosity or high porosity which enables diffusion of the molecules into them. Consequently, species which are volatile in the outdoor atmosphere behave as semi-volatile compounds indoors and their concentrations are higher on the surface because of partitioning to these static surfaces as compared to their gaseous forms, thereby, uniquely changing the indoor chemistry.[2-3] Around 4 million people die prematurely due to household air pollution mainly contributed by polluting cook stoves biomass and kerosene.[4] Indoor air pollution results in non-communicable diseases such as stroke, ischaemic heart disease, lung cancer and chronic obstructive pulmonary disease (COPD) etc.

Biomass burning is a major source of carbonaceous aerosols also. Indoor emissions of black carbon (BC) and organic carbon (OC) impact health of women and children. These emissions of BC and OC can be reduced in the indoor environment by following soft approach such as fuel practice change from solid biomass to liquified petroleum gas (LPG). In fact, soft approaches need change of mindset of people. In such study, mean OC concentrations from dung cake burning were 56% higher by 56.14% and 33.57% as compared to the LPG usage. Similarly, EC concentrations were 34% higher during dung cake burning as compared to LPG usage.[5]

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Indoor air pollution has spatial variations too in different geographical regions due to mixing of outdoor air and indoor living practices. In a study comparing the concentration of fine aerosols in in three cities in India, the highest mean concentration was recorded in the Delhi households (196.5±48µg/$m^3$) followed by Imphal (173.6±46µg/$m^3$) and Trivandrum (69.4±38µg/$m^3$) site.[6] In this study, kitchens had lower fine particle loadings as compared to other parts of houses in each city in India.

Daily exposure to indoor air pollutants may cause respiratory and cardiovascular diseases leading to 'sick building syndrome' and 'building-related illnesses'.[7] $NH_3$ and $NO_2$ are two major reactive nitrogen (Nr) gaseous species for contributing air pollution. HONO is also an important Nr species in the indoor environment and influences indoor pH unlike outdoor.[2,8] $NO_2$ gets dissolved in the available surface water which is an important sink indoors and the reaction releases HONO and $HNO_3$. HONO maintains an active partitioning between the indoor surfaces and gaseous phase whereas $HNO_3$ influences the indoor pH. $NH_3$ and $NO_2$ can aggravate respiratory and heart conditions, and may lead to premature deaths.[9-10] This means that there is a need to carry out comprehensive research on Nr species including in indoor environment. In a study, NH3 contributed about 90% to the total Nr gaseous air pollution in a residential area household. $NH_3$ had the highest concentrations in indoor air during monsoon season due to wash out effect.[3] $NO_2$ concentrations were lower in the same household. $NO_2$ concentrations were recorded highest during winter season due to increased sources. These workers found that gas to particle conversion of $NO_2$ was higher than $NH_3$ indicating more gaseous $NH_3$ in air.

Dung cakes, poor sanitation, solid-waste etc. are major sources of $NH_3$ in the indoor air. In addition, outdoor $NH_3$ sources include vehicular emissions, humans, sever lines, fertilizers etc. which also transport $NH_3$ to indoor households. $NH_3$ above its permissible limit has health hazards and hence needs to be monitored in the indoor air. In a study $NH_3$ concentrations were constantly higher during sampling period in a residential area with a mean value of 102.5 µg/$m^3$, as compared to a household in an industrial area with a mean value of 57.2 µg/$m^3$ in Delhi.[11]

In order to mitigate indoor Nr pollution, indoor plants are very effective options. Accoring to reports, indoor plants are potential option to reduce $NO_2$ levels in households. In a study lily (*Spathiphyllumwallisii*), corn plant (*Dracaena fragrans*) and fern arum (*Zamioculcaszamiifolia*) reduced $NO_2$ levels significantly.[12-13] In this study, each plant was placed in a test chamber having almost same level of $NO_2$ as expected in a roadside office. The researchers noticed that after one hour, around half of the $NO_2$ was reduced by all the plant species in the chamber.

In most of developing nations, traditional cooking practices utilize biomass as an energy source which a significant source of air pollution. There have been significant efforts to replace traditional fuel which has low calorific value with the improved high-density bracket having relatively higher calorific value. This also helps in reducing air pollution. In a study which compared the indoor aerosol chemistry during use of traditional cook stoves (TCS) and improved cook stove (ICS), concentrations of different aerosol components including NO3- formed by the oxidation of NO2 in the household air during the operation of ICS were recorded lower (32%) in comparison to the values recorded during TCS operation.[14]

Therefore, in order to protect human health, there is great need to mitigate indoor air pollution particularly, emissions of $NH_3$ and $NO._2$ In this regard, we need to have properly ventilated houses and workplaces. Use of efficient cookstove needs to be encouraged in rural areas for reduced emissions. Selected indoor plants may be chosen for indoor air pollution mitigation. In addition, efforts should be made by different regulatory bodies to practice soft approaches to reduce emissions of gaseous pollutants.

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