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Environmental Factors affecting Indoor Air quality (Educational institution) in Urban Settings

Tasneem Amina[1*], Venkataraman[2] and Rajesh Kumar T.[3]
[1]HOD Zoology, Al Ameen Arts Science and Commerce College, Bengaluru (Karnataka), India.
[2]HOD and Chairman, Department of Environmental Science, Manasagangothri, Mysore University, Mysore (Karnataka), India.
[3]Professor, Department of Biochemistry, JSS Medical College Mysore (Karnataka), India.

(Corresponding author: Tasneem Amina)*
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ABSTRACT: Educational Institute indoor environment, where students spend a lot of time, is a major problem because of how vulnerable and sensitive they are to exposure to air pollution. The rising prevalence of asthma & respiratory disease among students, who spend a substantial portion of their lives on educational institutes' grounds, has contributed to the growing interest in indoor air quality (IAQ) of educational buildings. Students of the afflicted educational facilities frequently mention a wide variety of vague and frequently subjective health issues. These are frequently ascribed to the poor air quality. However, several instances of indoor air pollution offer a useful perspective on the challenges faced by researchers attempting to demonstrate causality. The designated institutions are located in metropolitan settings. As a result of high occupancy inadequate ventilation, building structure, seasonal variations as well as elevated levels of particulate matter (PM) & total volatile organic compounds (TVOC), educational Institutes in Delhi had generally poor indoor air quality, as measured by air quality measurements. Educational Institutes near urban areas are substantially more affected by the dispersion of pollutants than educational Institutes in rural areas & other adjacent environments. Therefore, management suited to the characteristics of educational Institute buildings is required. In conclusion, the review suggests that qualitative data could supplement the traditionally quantitative field of indoor air quality. It is likely that multidisciplinary research will comprehensively explain environmental health trends noticed in student by quantitative research. This study intends to contribute for the understanding of the role of environmental factors affecting indoor air quality of educational institutes, namely indoor air pollution, on considering a risk group of different ages of students, and for the development of preventive measures, which are considered priority issues by WHO. Provided explanations are essential for managing environmental health of students, seasonal variations, building structures & devising effective strategies for prevention, mitigation, & communication.

Keywords: IAQ, Educational Institutes, Factors, Urban settings, Mitigation.

INTRODUCTION

Student's foremost source of social interaction & the most crucial interior environment for them, after their homes, is educational Institute. Students spend most of their time inside, where air pollution is often greater than outside educational Institutes contribute to their exposure (Branco *et al.*, 2019). Over the last two decades, scientists have become worried about indoor air quality's health impacts (Yang *et al*., 2015). Energy-efficient building design makes modern homes & businesses more hermetic than older ones. Construction technology has enhanced the use of synthetic building materials (Sameh *et al*., 2021; Xie & Suuberg 2022). These advancements have improved the comfort & cost-effectiveness of buildings, but they have also produced indoor circumstances where pollutants are easily generated & may accumulate to much higher levels than outside (Yang *et al*., 2015).

IAQ, is crucial to health and well-being (Bahramian & Yetilmezsoy 2020; Ingrao *et al*., 2021). Scientists & Educational institutions have recently focused on educational institute indoor environments because IAQ is a risk factor for human exposure to environmental pollutants & the average person spends 87% of their time indoors & 56% in vehicles (Rodi *et al.*, 2022; Branco, 2019; Zhu *et al.*, 2021).

Students spend much of their time inside, making them exposed to indoor air contaminants. Ultrafine particles affect most urban students (Zhu *et al.*, 2021). Because students breathe more air per unit of body weight & have growing tissues & organs, therefore more

vulnerable to air contaminants than adults (Bluyssen, 2017; Sadrizadeh *et al.,* 2022). Thus, IAQ in institutions is more important than in other public places.

Industrial sites with high outdoor PM concentrations from considerable vehicle traffic also affect indoor air quality. Due to traffic & industrial emissions, roadside & industrial plant areas had higher PM concentrations than general urban areas (WHO, 2021; Thakkar, 2013; Tran *et al.,* 2020). Young kids having bronchial hyper responsiveness, severe allergy sensitization, or combined were more prevalent in educational Institutes close to heavily trafficked roads (Tran *et al.,* 2020). Consequently, this review of scientific studies provides a comprehensive range of pollutants recognised in indoor environments, highlighting trends and research gaps in IAQ. In addition, the analysis of literature data provided us to evaluate the various IAQs in educational institutions located in various regions, thus reflecting the current scientific comprehension of IAQ on a global scale. Given review's objective is to characterise IAQ levels within urban educational Institutes so as to assess the IAQ of the educational Institutes due to all the unhealthy conditions, seasonal variations & difficulties experienced by the students.

Approach to the problem. Human exposure & health effect studies of the interior environment must include air pollutant factors & their concentrations. The investigation is complicated by pollutant concentrations, interior ventilation & penetration rates, source intensity, human activities, outside weather, & more. Few computer models predict interior air quality & its causes. Since the theoretical link between these techniques (Qualitative & Quantitative approach) & the relevant circumstances have not yet been studied, this is a promising study field. More study is needed to assess how climate change will influence indoor pollution & health.

Indoor air pollution faced by students in educational Institutes. Students & faculty in educational Institutes are more likely to develop long- & quick health problems if indoor air pollution is present. There is a link between air pollution levels in educational Institutes & the development of paediatric health issues (Branco *et al.,* 2019). According to research by Yang *et al*. (2015), air pollution & physical features of educational Institutes, such as moisture & ventilation systems employed, are associated with the frequency of daily illness-related absences.

The quality of indoor air for kids in relation to the settings around urban primary educational Institutes has not yet been the subject of much research. According to a recent review of research, the primary outdoor sources in every setting —urban, rural, industrial— affected the association among indoor & outdoor pollutants quantities at various locations as well as the difference between indoor levels (Oh *et al*., 2014).

Environment Factors affecting indoor air quality in educational institutes in urban settings. Indoor air pollution sources cause damage to health. Due to increased population density, limited outside air supply, & poor design & upkeep, educational Institutes may have worse IAQ than other buildings. Educational Institute facilities suffer from financial shortages (Tran *et al.,* 2020). Educational Institutes are considered environmentally vulnerable. IAQ monitoring data & student health reactions to educational Institute exposure. Environmental & behavioural variables causing educational Institute pollution were examined (Chatzidiakou *et al.,* 2012). Some educational Institutes have deteriorated IAQ that exceeds WHO recommendations, while health effects of educational Institute exposure have been recorded at concentrations below current guidelines. If the inside air is not properly vented, these air pollutants may collect & harm students (WHO, 2021).

VOCs, respirable dust, thermal conditions (air temp & relative humidity), CO_2, smoking, & individual facets have all been associated with sick building syndrome (SBS) effects in primary educational Institutes (WHO, 2021). Indoor levels of CO_2 1000 ppm greater than the outside level were associated with a drop in annual attendance of 0.5-0.9% & an increase in student absenteeism of 10–20% (Tran *et al.,* 2020). Childhood asthma & other respiratory conditions may be exacerbated by PM, CO, CO_2, NO_2, O_3, VOC, formaldehyde & bioaerosol (WHO, 2021).

The impact of several indoor environmental pollutants are discussed VOCs from paints, varnishes, solvents & preservatives may be particularly important. Asbestos exposure & biological materials may also increase the risk of serious health impacts in deteriorating buildings (Manisalidis *et al.,* 2020). Immune, infectious, & direct poisoning cause sickness of some interior pollutants come from outdoor sources.

According to Yang *et al.* (2015), outside sources, & generators in educational Institutes are the primary causes of indoor CO emissions. Nitrous acid (HONO), a powerful oxidant & common pollutant of indoor environments, is produced when NO_2 combines with water (WHO, 2021). Additionally, according to Manisalidis *et al*. (2020), indoor SO_2 is mostly derived from the outside air. It is remarkable that the concentrations of ozone over cities are minimal compared to the greater quantities present in urban areas, & that might prove detrimental to cultures, forests, alongside vegetation due to the fact that they inhibit carbon assimilation (Manisalidis *et al*., 2020).

In a six-classroom study Radon, a radioactive gas inside buildings was conducted in Italy (Fuoco *et al.,* 2015), the levels of indoor particle count during classroom hours were found to be mainly affected by the quantities of outdoor particle number. Lead is aero toxicant as well as causes learning disabilities, memory impairment, hyperactivity, as well as intellectual disabilities (Manisalidis *et al.,* 2020). Young student and new borns are exceptionally susceptible to even the smallest quantities of lead. Manisalidis *et al.* (2020) identified Polycyclic Aromatic Hydrocarbons (PAH) compounds including benzopyrene, acenaphthylene, anthracene, as well as fluoranthene as significant lung cancer risk factors.

IAQ in Seasonal Variations. The assessment of IAQ in designated urban slums in Delhi, India during each of the three seasons (summer, monsoon season & winter) demonstrated tenfold higher concentrations of air pollutants during the winter than the permitted level (WHO, 2021). Student typically experienced heat exhaustion & high humidity & had been subjected to high IAQ levels in nursery & primary educational institutions, more in urban than rural sites, while significantly based on season & student's occupation & behaviours (which vary age groups differ in occupation & activity trends) (Branco *et al.,* 2019).

The utilisation of biomass fuels inside during the winter makes the concentrations of indoor pollutants worse, & cleaning operations are identified as the primary contributors. Because it is not common practise in India to heat schools during the winter, kids have little choice but to keep the windows & doors shut (Kulshreshtha & Khare 2011). Whereas summer concentrations of outdoor area of educational institute are significantly greater than the winter concentrations. Also, the condition is observed to be much more within the institutes in Delhi, India (Singh & Dewan 2022).

PM (PM2.5) and carbon monoxide (CO_2) were the most concerning IAQ factors for student's exposure, with a number of building & classroom characteristics serving as significant predictors of their levels. According to Majd *et al.* (2019) study, fine PM (PM 2.5), NO_2 and CO indoor concentrations were evaluated in 16 urban educational Institutes throughout three varied seasons. So, WHO guidelines over IAQ were exceeded, particularly for the hourly standard NO_2 amounts. There was statistically significant seasonal variation over indoor NO_2 & CO levels, exhibiting greater exposures in the autumn & winter. Per De Gennaro *et al*. (2014), indoor educational Institute environments have been a source of public concern. Per their research, 3- to 14-year-olds spend 90% of their time indoors, regardless of the season.

IAQ at different elevations. Raysoni *et al.* (2016) determined that the Oxygen levels at this urban high-altitude educational Institute are 27% fewer than those at sea level, leading to less effective combustion & higher vehicle emissions. At $p<0.05$, the IAQ found on distinct floors of educational institutions is not substantially different.

Outdoor construction sites affecting indoor air quality around educational institutes. At most of the construction sites are nowadays near educational institutes, where the occupational exposure limits of air pollutants frequently exceed norms. Fine dust particles of cement, sand, silica, & asbestos initially cause mucus hypersecretion & lung irritation & trigger an inflammatory reaction. This can lead to defective oxygen diffusion & impaired lung function, consequently leading to chronic obstructive pulmonary disease (COPD) or acute respiratory distress syndrome (ARDS). It is estimated that 42% of COPD & a gradual loss-of-lung function are attributed to such occupational exposures (Li *et al.,* 2016). Studies in different parts of India too have found poor respiratory health in construction workers as well as the people who get the exposure from this (Purani & Shah 2019).

According to the World Health Organization, nearly one-third of the world disease burden may be attributed to environmental risk factors, with an incidence of lower respiratory infection being the second largest (WHO, 2016). Considering the proportion of construction sites in India, their contribution to this larger disease burden cannot be ignored.

Despite registration under the BOCWA, regulations have been ineffective in protecting the health of students near the construction sector in Delhi. The BOCWA Welfare Boards in coordination with civil society groups & trade unions should conscientize & enforce the employers to assure that the workers are provided with protective equipment & assured of safety measures at the workplace (BOCWA, 2021).

Indoor air quality of educational institutes in Delhi, India. The health & happiness of building occupants are directly related to the quality of their indoor environments. The fast increase in Delhi's population has led to a corresponding rise in the number of squatter settlements, which today make up as much as half of the city's total housing units (Datta *et al.,* 2017; Singh & Dewan 2022). Students & the poor are particularly vulnerable to the public health concerns associated with poor indoor environmental quality, & these diseases have significant social costs (Wu *et al.,* 2015).

When asked directly about the quality of the air inside their homes, residents generally agreed that it was higher than the air outside. However, one resident noted, "sometimes air quality is bad, because of the uncleanliness of the street," indicating a lack of awareness about the potential problems caused by the ambient air quality & the generation of pollutants from cooking & other activities.

The indoor air quality at Delhi's educational institutions is discovered to be subpar, thus more has to be done to ensure the safety & well-being of the city's young people. Modelling work should be done to assess treatments like upgrading roof materials & expanding window areas, which may have a major influence on IEQ (both in terms of real & perceived quality) (Datta *et al.,* 2017; Singh & Dewan 2022). Better intervention selection, taking into account many factors including cost & energy trade-offs, requires further monitoring work to further examine influencing aspects, & the participatory design procedure with residents would assist with that.

Indoor air quality of building settings & structures. Better ventilation, for example, may boost both indoor air quality & occupant satisfaction, thus it makes sense to prioritise its installation when renovating a structure. In order to better understand the relationship between IAQ & building settings, particularly those created for educational institutions, the IAQ sector analysed from a variety of viewpoints.

Researchers have focused on indoor air quality (IAQ) at educational institutions since students are more susceptible to air contaminants than adults & spend a significant amount of time there. Similar concerns have

been raised about IAQ in school buildings because of the significant effect it has on student performance (Tripathi *et al.,* 2022). Indoor air pollution in schools has been linked to a number of factors, including chemical emissions from construction supplies or furnishings & a lack of proper ventilation.

Material selection was pinpointed as one of the main concerns for IAQ in Educational Institute building settings (Sameh *et al.,* 2021). This should consider both the quality & quantity of materials used their environmental impact (Bribian *et al*., 2011; DeWolf, 2014). Prioritizing the use of green-certified materials & discussing market availability raised practitioners' attention (Rodi *et al.,* 2022). Measurements & evaluations are carried out in a variety of ways, all of which adhere to the guidelines set out by the various IAQ standards across the world. Insulation's effect on emission levels, chemical compositions, & how various material combinations might produce varied outcomes was taken into consideration (Shrubsole *et al.,* 2019). The sorption capacities of various indoor materials & their potential effects on students' indoor air quality (IAQ) in a variety of configurations have also been the subject of another research (Sameh *et al.,* 2021; Xie & Suuberg 2022). Wood interior renovation has been suggested as a means of reducing indoor air pollution (Megahed & Ghoneim 2021). This research demonstrated the significance of routine IAQ monitoring for precise evaluation. The Educational Institute also took into consideration the environmental effects of its construction materials & goods by using the Life Cycle Assessment technique (Bahramian & Yetilmezsoy 2020; Ingrao *et al*., 2021).

Few studies have taken into account essential elements such the kind of finish, furniture material, cleaning chemical, or household activities, although they are all relevant to indoor air quality (IAQ). Likewise, the interior materials that have the greatest impact on air pollution have not been the focus of extensive study in studies of commercial building IAQ. Construction and/or materials, surface coatings, & resident activities were shown to be major contributors to the high VOC level in the investigated commercial buildings (Tripathi *et al*., 2022).

Ismail *et al.* (2022) provide the findings of a research done with college students. The results are likely to apply to other Klang Valley (Malaysia, a nation with a tropical climate) educational building designs with a similar high interior air quality, humidity, & temperature pattern, as well as comparable workplaces in any tropical location.

Information on indoor air quality & its effects on students' health in a single school setting are provided in this research. There may be unique difficulties associated with certain sorts of educational institutions, such as unique psychosocial situations, unique outdoor circumstances, unique building designs, ventilation, & distinctive relationships with the environment. In order to maintain or develop an adequate indoor air environment & avoid excessive, indoor symptoms that will impair productivity, facility managers, maintenance personnel, building designers, architects, & interior designers should consider any crucial advice.

Quantitative & Qualitative Research of indoor air quality approach. There is a dearth of quantitative studies pertaining to IAQ. A minority of the studies in the study adopted a mixed-method approach, with the majority of them basing their findings on in-person interviews & focus groups. Both the opinion about getting exposed to air pollution & the impression of the health effects linked to air pollution was interestingly discussed (Noel *et al*., 2021). There is growing evidence that air pollution in enclosed spaces is harmful to people's health. Qualitative studies provide substantial support for the hypothesis that contact with high air pollution levels raises health risk or other negative health outcomes (an increase in ischaemic heart disease, strokes, lower respiratory tract infections, asthma, or chronic obstructive pulmonary disease) & also negatively impacts mental health indicators like stress, depression, & suicidal ideation (WHO, 2021). Furthermore, dementia & decreased cognitive performance seem to be linked to brain damage brought on by air pollution across the lifespan (Chen *et al*., 2017). Additionally, early-life exposure to air pollution may have deleterious impacts on pregnancies & also long-term consequences that influence a person's vulnerability to illness in later life (Saenen *et al.,* 2019).

Mitigation measures to maintain IA Qin Educational Institutes. Ionization air purifiers are used in homes & factories worldwide owing to their low power consumption & noise (Zhu *et al.,* 2021). Beijing primary & intermediate educational institutes are installing ionization air purifiers for indoor intervention. Ionization air purifiers have great air pollution purification efficiency (Yang *et al.,* 2015), however their cardiorespiratory consequences are unclear. Due to enhanced airflow, classrooms with more windows/doors opened had decreased particle mass, potassium, acetone, & sodium ions (Frietus *et al.,* 2011). Chalk & whiteboard pens release different chemicals. Whiteboard pens increased benzene, chlorine (Cl-), phosphate (PO_4), Nitrous acid (NO^{3-}), & fluoride (F-) ions concentrations. Major mitigation measures could be avoiding chalk & whiteboard markers & to provide a safe, pleasant & healthy educational Institute environment depending on the ventilation system (Frietus *et al.,* 2011). Thermal comfort & IAQ are also essential for good educational & health results. We recommend using low volatile organic compound (VOC) paint on newly constructed structures. Planning for a better fresh air intake during construction may help stop CO from seeping into the facilities once they're finished. Indicators for temperature, RH, & air circulation may be derived from this study's model of exposure symptoms (Ismail *et al.,* 2022).

Gap of Knowledge regarding indoor air quality in educational institutes in urban settings. The data requirements & knowledge gaps are gathered for the exposure of students in educational institutions to urban environments & the health effects assessment. A

comprehensive analysis of existing information on indoor air pollutants is required, as is the identification of the most influential factors affecting the environment & their concentration range. This database could be included in an existing source of information that is relevant. The procedure would gather background data on indoor contaminants, including allergens, & make it easier to utilise the data to spot data gaps. This data could inform both a potential routine monitoring programme & future research. Collecting & systematising practical experiences to establish risk assessment approaches based on evidence. Such examples would aid in solving problems of similar nature & reduce occurrences of redundant risk assessment.

FUTURE SCOPE

Peer-reviewed journal analysis throughout this evaluation revealed that while undeveloped nations still lack IAQ-focused research, educational institutes are increasingly interested in researching IAQ in terms of its influence on student health in developed and a few emerging countries. The pattern of indoor air pollutants in educational institutions in developing and underdeveloped nations, as well as the resulting health effects, should be studied further in order to develop more effective IAQ policies in these regions. Therefore, additional research is required for future scope in these regions to ensure healthy and sustainable building environments around the world.

CONCLUSIONS

The susceptibility of student to respiratory disease is due to the factors affecting the educational Institute's air environment. A multidisciplinary study utilising mixed methods can more comprehensively explain health-related environmental trends seen in both quantitative & qualitative studies. While health effects of educational Institute exposure were identified at concentrations below current standards, the study has emphasised the impaired IAQ in particular educational institutions in urban settings which often surpass WHO guidelines.

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