Chelonian Conservation And Biology

Vol. 18 No. 2 (2023) | https://www.acgpublishing.com/ | ISSN - 1071-8443

DOI: doi.org/10.18011/2023.11(2).1155.1173

# A STUDY ON REVIEW OF AIR POLLUTANTS WITH THE IMPACT ON HUMAN HEALTH AND THE CONCEPTUAL DESIGN BASED IMPROVEMENT FOR WELL BEING OF THE SOCIETY

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## ABSTRACT

Studying about the indoor and outdoor air quality status is need of the hour. Air pollutants, such as particulate matter (PM), ozone ($O_3$), nitrogen dioxide ($NO_2$) and sulphur dioxide ($SO_2$) are having the strongest evidence for public health concern. Particulate matter is a major air contaminant in the ambient air and wide information is assessable on its concentrations from various parts of the world. Global Platform on Air Quality and Health has been established to systematically consolidate data on air quality and health by bringing together information on air pollution exposure. Therefore collecting the information and reviews on air pollutants distribution, variation on the season, indoors - out door air pollution analysis with their health impacts and associated studies pave a way to get better acquaintance with air pollution, health and air pollution dilution. In research reviews the existing architecture principles being applied in the developed areas and proposes a solution to the design while keeping in mind that the environment is not harmed.

**Key words:** Indoor and outdoor air quality, Industrial, Residential and sensitive zone buildings, Architectural design solution.

## INTRODUCTION

Clean air is the first prerequisite to continue solid existences of mankind and individuals of the helping biological systems which consequently influence the human wellbeing. Release of numerous gaseous emissions and particulate matter has been on the rise due to extensive industrialized increase anthropogenic emissions of various types are being pumped into the environment and lead to the formation of new pollution due to chemical reactions in the environment. These are building up the concern of ambient air pollution as a distinguished worldwide risk to human health in lots of ways.

Air pollution can happen anywhere in the world. It causes due to the contamination in the atmosphere by changing its physical, chemical and biological changes in the composition of the air which produces an unwanted effects on man and his environment. These substances comprise of gases ($SO_2$, $NO_2$, CO, hydrocarbons), particulate issue (smoke, residue, vapor, and pressurized canned products), radioactive materials and numerous others. The vast majorities of these substances are normally present in the air in low concentration and are ordinarily viewed as harmless (Rao, 1996).

Due to the high usage of fossil fuel and rapid development results huge energy demand and causes climate change implication. The sources of air pollutants includes all point (power plants, oil refineries, industrial facilities, and factories), line (cars, buses, planes, trucks, and trains) and area (agriculture, cities, local construction, smoking, unpaved roads, sweeping, hotels long-range transport).

Air pollution is an important determinant of health. WHO estimates that in 2012 around 1 in 8 deaths were attributed to exposure to air pollution, making it the largest environmental risk factor for ill health. WHO is leading a collaborative effort with other international and national organizations to strengthen the capacity of the health and other sectors to develop, implement and monitor air pollution abatement strategies that protect health with the establishment of a Global Platform on Air Quality and Health.

Hence an attempt has been made to review the relevant literature on scholarly articles, books, dissertations, conference proceedings, websites and other resources to get knowledge about the air pollution studies.

Some of the relevant studies such as air pollutants distribution, variation on the season, indoors - out door air pollution analysis with their health impacts, existing architecture principles being applied in the developed areas and design based improvement for the better environment and associated studies are listed below.

| **Author/ Title** | **Findings** |
|---|---|
| H Ross Anderson, Antonio Ponce de Leon, J Martin Bland, Jonathan S Bower, David P Strachan, 1996 | The results illustrate that Ozone levels (same day) were associated with a significant increase in all cause, cardiovascular, and respiratory mortality; the effects were greater in the warm season (April to September) and were independent of the effects of other pollutants. In the warm season an increase of the eight hour ozone concentration from the 10th to the 90th centile of the seasonal range (7-36 ppb) was associated with an increase of 3-5% (95% confidence interval 1*7 to 5.3), 3*6% (1.04 to 6.1), and 5 4%/ (0.4 to 10.7) in all cause, cardiovascular, and respiratory mortality respectively. They concluded that daily variations in air pollution within the range currently occurring in London may have an adverse effect on daily mortality. |
| Marios P. Tsakas, Apostolos P Siskos and Panayotis Siskos, 2011 | There are many indoor air contaminants, which can be separated based on their effects on human health, the frequency of their appearance, their usual concentration levels, their sources etc namely Radon, Oxides of nitrogen, HONO and $HNO_3$, CO and $SO_2$, Volatile Organic Compounds (VOCs), ozone, Particles and Asbestos and manmade mineral fibres. Te study stated that there are many factors that influence the exposure of indoor air pollution namely site occupancy, building design, occupancy, and operations. They clearly explained about the methods of studying health effects and criteria for the assessment of the impact of IAP on the community. |
| Sangeeta Sharma, Guishan Rai Sethi, Ashish Rohtagi, Anil Chaudhary, Ravi Shankar, Jawahar Singh Bapna, Veena Joshi, and Debarati Ghua Sapir, 1998 | A study was conducted at two urban slums of Delhi, Kusumpur Pahari and Kathputly Colony, in the peak winter season from November 1994 through February 1995. Bronchiolitis was reported in 22.5% of the wood group and 27.1% of the kerosene group in Kathputly Colony versus 13.7% in the wo group and 12,1% in the kerosene group in Kusumpur Colony. In conclusion, a higher incidence ofALRI was reported in kerosene users in Kathputly Colony, a high pollution area; however, the reasons for the differences observd need firther elucidation. |
| Paul H. Fischer, Marten Marra , Caroline B. | They studied the long-term exposure to particulate air pollution has been associated with mortality in urban cohort studies. The aim of the study was to evaluate the associations between long-term exposure to particulate air |

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| Ameling , Guus J.M. Velders , Ronald Hoogerbrugge , Wilco de Vries , Joost Wesseling , Nicole A.H. Janssen , Danny Houthuijs ,2020 | pollution from different source categories and non-accidental mortality in the Netherlands based on existing national databases. They found that statistically significant associations between total and primary particulate matter (PM10 and PM2.5), elemental carbon and mortality. Adjustment for nitrogen dioxide did not change the associations. Secondary inorganic aerosol showed less consistent associations. All primary PM sources were associated with mortality, except agricultural emissions and, depending on the statistical model, industrial PM emissions. They suggested that present policy measures should be focussed on the wider spectrum of air pollution sources instead of on specific sources |
| Jones N.C, C.A Thornton, D Mark and Roy M Harrison,2000 | They studied the indoor/outdoor relationships of particulate matter in domestic homes with roadside, urban and rural locations at UK. They concluded that fine particles of lead and sulphate with indoor sources also penetrate indoor homes; fine organic particles originate due to high temperature during cooking and smoking activity of indoor. |
| Lee S.C. , M. Chang,2000 | Five classrooms in Hong Kong (HK), air-conditioned or ceiling fans ventilated, were chosen for investigation of indoor and outdoor air quality. The study identified that the average respirable particulate matter concentrations were higher than the HK Objective, and the maximum indoor PM10 level exceeded 1000 µg/m3. Indoor CO2 concentrations often exceeded 1000 µl/l in air-conditioning and ceiling fan classrooms, indicating inadequate ventilation. |
| Roosli M, G Theis, N Künzli, J Staehelin, P Mathys, L Oglesby, M Camenzind, Ch Braun-Fahrländer,2001 | Temporal and spatial variation of the chemical composition of $PM_{10}$ at urban and rural sites in the Basel area, Switzerland and found that in rural sites predominant component of PM10 is carbonaceous substances (elemental carbon, organic matter) and inorganic substances of secondary origin such as sulfate, nitrate and ammonium. They also concluded that in carbonaceous compound are higher in particulate matter of urban environment. Fine PM and found Si and S were the most abundant in ambient air where as K and Cl were in abundance with frequent smokers indoor and it was also found that concentration of trace elements were lower in indoor than outdoor. |
| ArindamDatta, R.Suresh, Akansha Gupta, DaminiSingh, Priyanka | Indoor air quality of non-residential urban buildings in Delhi, India has done, the average $CO_2$ concentration in both office buildings (1513 ppm and 1338 ppm) was recorded much higher than the ASHRAE standard. They identified that Ductless air-conditioning system couple with poor air-circulation and active air-filtration could be attributed to significantly higher |

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| Kulshrestha, 2017 | concentration of $PM_{2.5}$ in one of the office buildings (43.8 μg $m^{-3}$). They concluded that the total hazard ratio analysis ranks one of the office buildings as most hazardous to workers health compared to others. |
| David Núñez-Alonso, Luis Vicente Pérez-Arribas, Complutense, Sadia Manzoor, Jorge O Caceres,2019 | Statistical Tools for Air Pollution Assessment: Multivariate and Spatial Analysis Studies in the Madrid Region was done from 22 monitoring stations during 2010 to 2017. The annual average concentrations of nitrogen oxides, ozone, and particulate matter (PM 10 ) possible sources and mechanisms that govern air pollution. In addition, the ordinary kriging technique has been carried out to elaborate contour maps for the different pollutants. Principal component analysis (PCA) and hier- archical cluster analysis (CA) have allowed to establish the correlation between different variables (pollutants) and classify different monitoring stations, based on the significance of each variable, allowing to have a clearer view of the possible sources and mechanisms that govern air pollution. In addition, the ordinary kriging technique has been carried out to elaborate contour maps for the different pollutants. . A mapping of the distribution of these pollutants was done, in order to reveal the relationship between them and also with the demography of the region. Multivariate analysis employing correlation analysis, principal component analysis (PCA), and cluster analysis (CA) resulted in establishing a correlation between different pollutants. Results obtained allowed classification of different monitoring stations on the basis of each of the four pollutants, revealing information about their sources and mechanisms, visualizing their spatial distribution, and monitoring their levels according to the average annual limits established in the legislation. Elaboration of contour maps by the geostatistical method, ordinary kriging, also supported the interpretation derived from the multivariate analysis demonstrating the levels of $NO_2$ exceeding the annual limit in the centre, south, and east of the Madrid provinc. A mapping of the distribution of these pollutants was done, in order to reveal the relationship between them and also with the demography of the region. Multivariate analysis employing correlation analysis, principal component analysis (PCA), and cluster analysis (CA) resulted in establishing a correlation between different pollutants. Results obtained allowed classification of different monitoring stations on the basis of each of the four pollutants, revealing information about their sources and mechanisms, visualizing their spatial distribution, and monitoring their levels according to the average annual limits established in the legislation. Elaboration of contour maps by the geostatistical method, ordinary kriging, also supported the interpretation derived from the multivariate analysis demonstrating the levels of $NO_2$ exceeding the annual limit in the centre, south, and east of the Madrid provinc The multivariate analysis employing |

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| Bujar Bajçinovci, Florina Jerliu,2016 | A study was conducted on challenges of Architectural Design in relation to Environment and Air Pollution. A Case study: Prishtina's first public parking garage. In this paper they argued that the chosen location for public parking garage may not be the most fruitful approach to urban design and prefered urban pattern where parking garages can be certainly located in primary and secondary urban ring. According to the data for air pollution in the actual location, and distance of parking garage to CHCP campus, it is expected that air pollution has to affect more campus and patients of clinics.<br><br>Hence its proven that spatial designing are important in pollution management. |
| Ingrid Juhásová Šenitková,2017 | Environmental quality of indoors is the conceptual system principle of architectural, constructional and environmental design development. Healthy/green/sustainable buildings are determined with mass and environs aspect. The study also highlighted the difference between the sustainable and green building. Green building design revolves around four key issues: • Designing for energy efficiency including the use of renewal energy sources, • Creating a healthy indoor air environment with adequate ventilation, • Making material choices that minimize volatile organic compounds, • Specifying building materials and resources that are sustainable, have low embodied energy, and produce a minimal amount of upstream environmental impact. Sustainability is ultimately a question of mass flows. Thus, the best way to make buildings more sustainable is to reduce mass flows. There are four main strategies for reducing mass flows in buildings: • Re-use existing buildings, • Re-use building materials, • Recycle building materials that cannot be reused, • Accommodate the same function in buildings. |
| Wilson WE, Suh HH. 1997 | The World Health Organization (WHO) reports on six major air pollutants, namely particle pollution, ground-level ozone, carbon monoxide, sulfur oxides, nitrogen oxides, and lead. Air pollution can have a disastrous effect on all components of the environment, including groundwater, soil, and air. Additionally, it poses a serious threat to living organisms. In this vein, our interest is mainly to focus on these pollutants, as they are related to more |

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| | extensive and severe problems in human health and environmental impact. Acid rain, global warming, the greenhouse effect, and climate changes have an important ecological impact on air pollution. |
| Zhang L, Yang Y, Li Y, Qian ZM, Xiao W, Wang X. 2019. | Multiple epidemiological studies have been performed on the health effects of PM. A positive relation was shown between both short-term and long-term exposures of $PM_{2.5}$ and acute nasopharyngitis. In addition, long-term exposure to PM for years was found to be related to cardiovascular diseases and infant mortality. |
| Manderson L. 2019. | People living in poorly constructed buildings in warm-climate countries are at high risk for heat-related health problems as temperatures mount. |
| | |

By reviewing the research papers the major concern about the public health and government policies continuously focusing on outdoor and indoor air pollution with the directive or in directive measures for the protection. Many of the researches supported that design based the existing architecture principles being applied in the developed areas and proposes a solution to the design while keeping in mind that the environment is not harmed.

## INDOOR POLLUTANTS

Indoor pollutants are mainly classified into three categories (physical, chemical and biological) based on the source and nature (Table-1).

**Table-1: Classification of causative agents responsible for Indoor air pollution**

| Type of causative agent | |
|---|---|
| Biological pollutants | Bioaerosols (fungi, molds, bacteria, dander on etc.) |
| Chemical pollutants:<br>a. Gaseous pollutants b.Trace Metal Particulate pollutants | Toxic gaseous pollutants, VOCs, Environmental Tobacco smoke (ETS) Trace metal enrich $PM_{10}$, $PM_{2.5}$, $PM_{100}$ |
| Meteorological factors | Humidity, Wind circulation and Thermal environment |

There is well established link between the health of inhabitant and indoor air pollutants, IAQ define as quality of air within and around the buildings, represented by the concentrations of pollutants and thermal (irrespective to relative humidity and ambient temperature) environment. In urban environment, indoor air quality problems have been fostered due to rampant usage of chemicals by the individual, tighter close building envelopes with less ventilation and other poor facilities (like faulty building design).

## PARTICULATE MATTERS (PM)

Particulate Matters is sum of solid and liquid particles (organic and inorganic in nature) in air which affects more people than any other gaseous pollutants. Majorly PM, includes both organic and inorganic particles, comprises of sulfate, nitrates, sodium chloride, ammonia, mineral dust, black carbon, bioaerosols and water droplets. The particulate matter most dangerous to human being those with a diameter of 10 microns or less, ($\leq PM_{10}$), which can penetrate and lodge themselves deep inside the lungs (Kulshreshtha, and Khare, 2010) or in other parts of the body. Long-lasting exposure to these particles contributes to chances of developing cardiovascul r and respiratory related diseases; additionally it can be responsible for lung canceralso (Nahar et.al.,2016).

## BIOAEROSOL AS A POTENT POLLUTANT

Aerosol particles having biological in origin are termed as 'bioaerosols', which include bacteria, fungi, viruses, pollen and spores as well as their byproducts. The presence of pathogenic bio-aerosols in indoor spaces is often linked with Sick Building Syndrome **(**SBS**)** and Building Related Illness **(**BRI**)** (Yassin, & Almouqatea, 2010)**.** There are number of sources of bioaerosols inside building like building construction materials, furnishing items and; fungal growth within ceiling, in thick wall and also in floor cavities and spores via wall openings and gaps at structural joints (Srikanth et.al., 2008). The common airborne fungi causing respiratory infections and allergic reactions are dominated by genus Penicillium, Acremonium, Aspergillus, Paecilomyces, Mucor and Caldosporium (Kembel et.al., 2012). Bacteria and fungi (Bioaerosol) are abundant in the atmosphere, indoor development can cause many fungal and bacterial diseases such as infections, allergies or toxic reactions (Toivola et.al., 2002) . About 42% of the population in developed world has allergies against biotic and abiotic environmental agents, and three hundred million people globally suffered from 'asthma'. Exposure to biological allergens which ultimately triggers bronchial Asthma (via touching surfaces person-to-person contact or inhalation) is often arbitrated with in ambient enclosed environment (Mentese et.al., 2009). Bioaerosols exposure could be responsible for respiratory infection and other health related problems such as skin infections, hypersensitivity pneumonitis and other harmful reactions (Kembel et.al., 2012). Fungi are ubiquitous in ambient (indoor and outdoor) environments and worldwide nearly one tenth of populations are reported to have fungal allergy (Fung, & Hughson, 2003).

Indoor air quality get worsen due to moisture, dampness and mold problems within buildings and it is also well linked with health effects such as respiratory symptoms and asthma. In modern building, frequently various signs of dampness or moisture based damages are visible (Engvall et.al., 2001) and the occurrence of mold varies between 1.5-20% (Fung, & Hughson, 2003). Although fungal spores are ubiquitous in nature but it grow and develop into visible mold only when suitable moisture and dampness are unrestrained. General practice use for, like application of fungicides or disinfectant products do not solve the problem and may even be an additional burden to indoor chemical exposure. Humidity regulation generally difficult within an existing building, and therefore after the development of damaging mold needs time to dry. In the future, urban communities are normal that the development materials of a building ought to be strong and impervious to microbial development. All type of microbial exposure should be viewed on the basis of the nature of pathogenic microbiome, whether it belongs to a transient or in a steady community. Designing our in built environment in such a way to promote beneficial microbial exposures is not yet feasible. Designing our inbuilt up environment in such the simplest way to push useful microbial exposures isn't however possible because the identification and concentrations of useful microbes still underway, researcher should concentrate on improving ability to foresee how constructing attributes sway building microorganisms and shapes the "human microbiome.

## AIR CONDITIONING SYSTEM

In air-conditioned buildings, indoor air quality is dependent on the effectiveness of cooling and humidifier frameworks since these e- structures give an appropriate domain to the expansion of microbes (Ohnishi, 2002). Dispersion of indoor air pollutants like bioaerosols in environment through the air-conditioning system plays a pivotal role.

**'**Humidifier fever**'** could be a disease with similar symptoms of **'**hypersensitivity pneumonitis**'** associated with bacteria, fungi and end toxins that found among humidifier reservoirs, air conditioners and additionally in aquaria**.** The common associated sickness is characterized by uneasiness, headache, fever, chills and myalgia**.** It unremarkably subsides among twenty four hours while not residual effects**.** Humidifier respiratory organ sickness with cough fever, pain and hurting was delineated as a result of inhaling end toxin present in the humidifier water (Ohnishi, 2002).

## VOLATILE ORGANIC COMPOUNDS (VOCs)

Organic compound defined as chemical compound that contains no less than one carbon and a hydrogen atom in its sub-atomic structure. VOCs are those having initial boiling point less than or equal to 250°C (ranges between 40°C to 250°C) because of that they will readily emit gas vapors into indoor air. However, use of VOCs in construction projects is widespread and materials containing VOCs should exhibit desirable characteristics of good insulation properties, resistance, and ease of installation (Wallace et.al., 1989). Different types of available common VOCs, and their source which are generally found within Indoor environment are represented in Table-2.

The VOCs exposure can result in both intense and chronic health impacts. Asthmatics and different people with earlier respiratory issues might be especially prone to low-portion of VOCs doses (Norback et.al., 1995). The common sources, characteristics of indoor air pollutant and their human health effects (Brooks et.al., 1991) discussed in detail (Table-3).

## INDOOR POLLUTION AND METEOROLOGICAL PARAMETER

Meteorological parameters plays a crucial role in the dispersion of pollutant not only in outdoor environment but also within indoor environment as well. Various indoor pollutants like VOCs, bioaerosols, particulate matter and other gaseous pollutants like carbon monoxide (CO) and carbon dioxide ($CO_2$) react differently within indoor environment. Diverse meteorological parameters as for e.g. temperature, humidity, wind speed and solar radiation affect the pollution level in closed environment. In Indoor environment, it is necessary to regulate moisture, temperature and rate of air circulation speed within recommended limit. Presence of high dampness and dirt can be a reason for molds and other biological contaminants to flourish (Engvall et.al., 2001). If moisture levels are remain normally high within indoor environment it may be lead to the bioaerosols growth and dispersion and if humidity levels remain too low may reason of irritation in eyes, mucous membranes and lead to sinus discomfort. Indoor temperature and pressure differ in comparison to outdoor environment play a major role in pollutant dispersion process (Lu et.al., 2016). Air moves from a region of high pressure to low pressure so regulating building pneumatic force is a vital piece of controlling contamination and which at last upgrade building IAQ (indoor air quality) performance.

**Table-2: Typical volatile organic compounds within indoor environment (Wallace et.al., 1989)**

| Sources | Examples of typical contaminants |
|---|---|
| Building materials | Aliphatic hydrocarbons (n-decane, n-dodecane), aromatic hydrocarbons (toluene, styrene, ethylbenzene), halogenated hydrocarbons (vinyl-chloride), aldehydes (formaldehyde), ketones (acetone, butanone), ethers and esters (urethane, ethylacetate). |
| Paints and associated supplies | halogenated hydrocarbons (methylene chloride, propylene dichloride), alcohols, ketones (methyl ethyl ketone), esters (ethyl acetate) and ethers (methyl ether, ethyle ether, butyl ether) |
| Furnishings and clothing item | Aromatic hydrocarbons (styrene, brominated aromatics), halogenated hydrocarbons (vinyl chloride), aldehydes (formaldehyde) and esters. |
| Adhesives | Aliphatic hydrocarbons (hexane, heptane), aromatic hydrocarbons, halogenated hydrocarbons, alcohols, amines, ketones (acetone, methyl ethyl ketone), esters (vinyl acetate) and ethers. |
| Consumer and commercial products | Aliphatic hydrocarbons (n-decane, branched alkanes), aromatic hydro carbons (toluene, xylenes), halogenated hydrocarbons (methylene chloride), alcohols, ketones (acetone, methyl ethyl ketone), aldehydes (formaldehyde), esters (alkyl ethoxylate), ethers (glycol ethers) and terpenes(limonene, alpha-pinene). |

**Table-3: Indoor air pollutants with their sources and health effects**

| Pollutant | Sources and characteristics | Associated health effects |
|---|---|---|
| Particulate matters | PM10/PM2.5/PM1 Motor vehicles, wood burning stoves and fireplaces. Dust from construction, landfills, agriculture & Industrial site | Irritation of the air-ways, coughing, or difficulty in breathing, decreasing pattern in lung function, chronic bronchitis; asthma, heart or lung disease |
| | Asbestos**:** insulation of heating gadget and mixed with cement, it is used for roofs and water deposits. | Known human carcinogen and synergic effects with tobacco smoking impact increase approximately five fold. |
| Radon | A naturally occurring gas (air, water and soil)produce by geological activities. | Carcinogenic in nature especially to lung cancer. Radon can cause synergistic bad effect on health related issues. |
| Gaseous pollutants | Carbon Dioxide ($CO_2$) produced by cellular metabolism, combustion activities | At higher concentrations increased respiratory rate, tachycardia, convulsions, coma and death. |
| | Carbon monoxide (CO): from incomplete combustion | Binds with hemoglobin, reduce transport of oxygen. Headache, nausea & dizziness |
| | Nitrogen oxides **(**$NO_x$**):** fossil fuel burning, | Irritant, affecting the mucosa of eyes, nose, throat and respiratory tract |
| | Sulfur dioxide **(**$SO_2$**)**, Main source coal & wooden based cooking | Irritates and inflammation in mucosa lining of eyes, nose, throat, lungs. High concentration leads to asthma attacks and worsen cardiac and respiratory systems. |
| | VOCs (daily routine products, building materials, cosmetics and domestic products and fuel burning ) | Irritation in eyes, nose and whole respiratory systems , long and high concentration can damage liver, kidney and CNS. Adverse effects on eyes and also in upper and lower respiratory tract, Carcinogenic in nature |
| | Tobacco smoke **(**TS**):** Complex mixture of more than 4000 identified chemicals, causing toxic or carcinogenic in nature. | Children: acute lower and upper respiratory infections, bronchitis, bronchiolitis and pneumonia, tuberculosis, severe asthma Adults**:** difficulty in breathing, exacerbation of respiratory disease like COPD and cardiovascular disease (heart stroke and Heart attack) |
| Biological Pollutants | Bacteria, molds, dust mites, fungus, products from men and pets, pests (mice, cockroaches, rats). Microbial products (endotoxins, microbial fragments etc. | Allergic reactions (rhinitis conjunctivitis etc.),Asthma, COPD, hypersensitivity pneumonitis, Legionellosis, Sick building syndrome and toxic reactions |

## BUILDING DESIGN

Building design plays a significant role in accumulating indoor pollutant concentration. It has many aspects like ventilation pattern, inner wall composition, direction of house, Kitchen (as a source) position inside house, window and door position, roof height from ground, construction material used in building, paint and coating of wall beside flooring (carpet and non-carpet area) (Liu et.al., 2010) etc. If the building design are faulty then indoor air pollutants start accumulating with in close confined space (Evans and McCoy, 1998). People and their day-to-day activities, building construction materials, different steps of renovations like furnishings, paints, wooden work and closed combustion and other emit pollutants within the indoor air (Cao and Meyers, 2015) whereas ventilation or air exchange capacity of the building is intended to remove emitted pollutants and ultimately reduce their concentrations in occupied spaces. Spatio-temporal pollutant variation which was observed inside and outside of a building possibly affect public health whether breathe in outdoors or indoors environment. The ventilation system can also serve as a way of bringing outdoor contaminants into indoor spaces of building. Physiochemical reactions which happen in indoor environments alter the composition of indoor ambient air it lead to effects indoor ambient air and health of exposed occupants. Generally, the reliance of indoor pollutant concentration on air exchange rate differs among pollutants but it has not been completely characterized till now.

All around, the aim of air exchange in any confined area is to supply fresh air in indoor spaces to the inhabitants and to take out generated heat from the enclosed spaces. A research study had been explained the building structure design features of an indoor environment, which comprises air exchange and design of improvements, can improve the health status of the residents and deliver a improved working atmosphere for the office employees (Colton, 2014). (Engvallet et.al., 2001) had reported strong correlation between ventilation (air exchange/circulation) and the spread (transmission) of contagious diseases such as smallpox, chickenpox, measles, influenza, tuberculosis and Severe Acute Respiratory Syndrome (SARS) within indoor environment (Wong and Huang, 2004) showed in their study most of the residents that practically all inhabitants who utilized air-conditioners systems amid sleeping showed at least one SBS indications even shown more SBS side effects in the wake of utilizing cooling contrasted with utilization of natural ventilation.

Qian et.al., 2009 conducted a study on naturally air exchange in hospital wards of Hong Kong city and reported advantage of natural ventilation for infection control in hospital wards and reported that natural aeration were more effective(high air circulation rates), especially when the windows and the doors were placed in opposite wall in a ward. The high air exchange rate (WHO 2009) provided by natural aeration can decrease cross-infection of airborne diseases, and thus it is suggested for using of practice in appropriate hospital wards for disease control (Chan et.al., 2016) had encouraged to improve building air exchange by using regular opening of windows and also recommended to use an exhaust fan in toilet and bathroom to decrease domestic mold/dampness and also to control air pollution emissions during home renewals.

## VENTILATION RATES WITHIN BUILDING

Emissions of toxicant vary greatly either temporarily or spatially within the buildings. Ventilation (air exchange) can work as a way of introducing these pollutants within enclosed areas. Physiochemical reactions which happen within enclosed environment alter the composition of indoor air and apparently affect both the air quality and become health associated risk for inhabitants.

## SICK BUILDING SYNDROME (SBS)

A complaint in which occupants of building (residential/official) people in a building feeling unwell and facing symptoms of illness for no apparent reasons. The complaints may probably intensify in severity as a proportional of time spent within building or recover over time and even disappear when individuals left the specific building (Guo, 2013). Some specific and non-specific symptoms are listed in Table-4.

**Table-4: List of common observed SBS (sick building syndrome) symptoms**

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| Eye symptoms | Dryness, redness and irritation, Itchiness and watering and pain in the eyes |
| Nausea, dizziness | Sensation of dry mucous membranes and skin |
| Respiratory tract symptoms | Cough, congestion, nosebleeds, dryness and irritation in the nose and throat, irritation of the nasal mucous membranes, pharyngeal symptoms, sinus pain and exacerbation of asthma and High frequency of airway infection and cough |
| Skin symptoms | Erythema (Superficial reddening of the skin) |
| General symptoms | Mental fatigue, Headache, Hoarseness, wheezing, itching and unspecific hypersensitivity |

Establishing sick building syndrome is always a challenging task especially when people's symptoms are relatively mild and possibility of having other causative agents. General sick building syndrome is neither disabling nor dangerous (Rotton and White, 1996), but the cases of sick building syndrome among working class or in residential population does have an economic impact (Hagström et.al., 2000), SBS can negatively affect the work efficiency of people, if someone experience SBS symptoms at home, that illness may also be carry pass on to the place of work, so impacting the effects of SBS on persons efficiency at their workplace too. Since last several decades SBS has been acknowledged as a major concern in the America,, Canada, Australia, Japan and European countries in but subtropical counties like India whose environment generally remain humid and hot throughout the year never addressed this issue although geographical location is more prone towards having SBS illnesses.

In general among all "sick leaves" respiratory illness accounts for a large fraction (Nichol et.al., 1995). Sick leave (data of employee) is outcome that could be used to study the health status within indoor environment. This database has been used very frequently for epidemiological study like indicators for respiratory diseases among agricultural workers, or to identify ergonomic problems (Knave et.al., 1991). (Teculescu et.al., 1998) described that the inhabitants of naturally ventilated building complaint lesser SBS symptoms and took less leave from work compare to the persons who residing in an air-conditioned building a in North- eastern France. However, the study work was undertaken only in two buildings and due to absence of control of air exchange rates and sample size was not large that may have proved the strong relationship between sick leave and particular building.

## HUMAN HEALTH

Various household products generally we use alone or used simultaneously with other cleaning or cosmetics products. Similar observation (Mentese et.al., 2012) had been found that there can be `dependence of an individual on the regularity, extent, types and exposure of product such as cleaning and Cosmetics product, hair-styling products dishwashing detergents, pesticides (Berglund et.al., 1992) and Generally day-today activities can increase exposures to VOCs up to a factor of hundred compared to the exposure during resting time and also far above the observed outdoor concentrations. Consumer products with particular indoor chemical exposures are many which include deodorizers, the dishwasher and laundry detergents, tobacco product, paints and the paint remover (Wallace et.al., 1993).

In addition, consumer product combinations or a mixture of consumer products with outdoor air can also act as irritants in the respiratory tract. Air fresheners and cleaning agents may contain certain chemicals that react to other air contaminants to produce potentially harmful secondary products, such as terpenes that can react with indoor air ozone to produce other secondary pollutants ( Nazaroff and Weschler, 2004).

## CONCLUSION

The residents who expose themselves in unhealthy indoor environment reported more SBS related complaint. This study attempted to advocate the important role of building design and their significant impacts on occupant's health through exploring the negative effects of buildings related illness (BRI). This review critically analyzed that sick buildings are passively affecting resident's health status but actively affecting their work potential. On the other hand, the concept of healthy building has been talked through emphasizing its main encouraging points like maintainable indoor air quality and also identified many parameters which are major contributors for SBS like psychological, biological, physical or chemical. Reviewing recent studies, it has been categorically revealed that design of buildings and its physical characteristics can influence directly appearance of SBS symptoms. The health impact can be carefully minimizes specifically during the operational (construction) phase of building by certain architectural changes (building orientation or using quality building material). Modifications in building design may potentially facilitate air exchange rate throughout the building and will also manage to receive sufficient amount of solar radiations to provide a required amount of illuminance for occupants. Indoor air pollution is a dynamic process with complete varied responses in different climatic zone either in tropical or in temperate climate. To safeguard our community health a national standard or guideline is urgently needed in India.

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