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Convertion of Conventional Buildings into Green Buildings by Indoor Air Quality

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ABSTRACT:

Indoor Air Quality (IAQ) is important to occupant health because it affects the health and comfort. Many health care providers are concerned with the role environmental exposures play in the development of respiratory disease. While most individuals understand that outdoor air quality is important to their health status, many are unaware of the detrimental effects of Indoor Air Pollution (IAP) can potentially have on them. According to the Environmental Protection Act (EPA), indoor levels of pollutants may be up to 100 times higher than outdoor pollutant levels and have been ranked among the top 5 environmental risks to the public. There has been a strong correlation between air quality and health, which is why it is crucial to obtain a complete environmental exposure history from occupants. The present study focuses based on the gap analysis using experimental data with the following parameters of Radon gas, CO, CO_2, VOCs and particulates of PM 2.5 and PM 10. Specifically, address the effects of IAQ has on the respiratory system and other vital organs of the body. These parameters are common agents that may lead to hazardous impacts among individuals whose exposed. It is very imperative to avoid health effects on the occupants by providing proper design of buildings and using appropriate building materials in construction etc., is of major concern to have a look on conventional buildings to green buildings.

Keywords: Conventional building, Green buildings, IAP, IAQ, GPS

1. Introduction

Green buildings may promote energy efficiency and other aspects of sustainability, but not necessarily health & well -being of occupants through better indoor air quality (IAQ) The identification of green practices and green products that can have unintended and unfavorable effects on IAQ[1]. They evaluated elementary schools in the city of Coimbra, Portugal that included questions regarding the demographic, social and behavioral Characteristics of students, as well as pre-eminence of smoking in the family.

The Co_2 concentration was sometimes high as 1942 ppm which causes health risk for child & most prevalent symptoms and respiratory diseases identified in the children were, sneezing wheezing, rhinitis and Asthma. Other Signs and symptoms are poor Concentration and irritation of mucous membrane [2]. Evaluated the indoor air quality and thermal Comfort of the patient room in one of the hospitals in Madurai, Tamil Nadu, India. The poor - meters studied under various rates of ventilations, fresh air supply and load this investigation provides the detailed technical specifications to improve the human and thermal Comfort [3].

Review of Current State of art on indoor air quality monitoring system based on Internet of things (IOT) and wireless sensor (Networks (WSN) in Last 5 years (2014-2019). The main contribution is to synthesize the existing body of knowledge and identity Common threads & gaps that open up new significant and challenging future research directions The result show that 57% of the indoor air quality monitoring systems is based on Arduino, 53% of system use LOT and WSN architectures represents 38% [4]. The idea is to discuss the use of wireless technologies for the development of Cyber-physical Systems for real-time monitoring. The investigation also presents some of new ideas and scopes in the field of IAQ monitoring for researches [5].

In hot and humid climates in industries, indoor humidity levels are usually high & are a matter of concern from thermal comfort and Indoor Air quality perspectives (IAQ). The effect of their supply & flow Analysis has ben done I'm the industrial turbine room at Vikram Cement, Nemuch (M.P). Environmental Conditions, Local thermal boundary Conditions and donate data are Collected from the site [6]. An Extensive literature review and Conducted Comprehensive 1AQ assessments in nine hospitals However, IAQ Analysis was Studied carefully in the development of the recommendations [7]. It describes the system (IAP), a low-cost indoor air quality monitoring wireless sensor network system developed using Arduino xebec modules and micro sensor for storage and of monitoring data on a Five micro-Sensors of environmental Parameter (air temperature, humidity, Carbon monoxide, Carbon dioxide and Luminosity) were used [8].

Presented a Systematic review of the accent state of the art on indoor air quality monitoring systems based on the Internet of Things (IoT). The rout show that 70%, 65% and 27.5% of studies focused on monitoring thermal Comfort parameters, Co_2 and PM Levels respectively. Additionally, there are 37.5% and 35% of systems based on Arduino and Raspberry pi controllers [9]. The National Health and Medical Research Council (NHMIRC) defines indoor air as air within a building occupied for at least one hour by people of varying states of health. Despite this, relatively little research has been done on the quality of air in our homes, universities, recreational buildings, restaurants, public buildings, offices, hospitals, inside cars poor indoor air quality can result in Significant adverse impacts on our health and environment (USEPA, 1993) [10]. An indoor Environment with good IEQ improves the occupant's mood. which affects the Comfort perception of the occupant productivity increases with good health and improves the mood of the worker inside the building, which is well Supported by research [11].

Objective

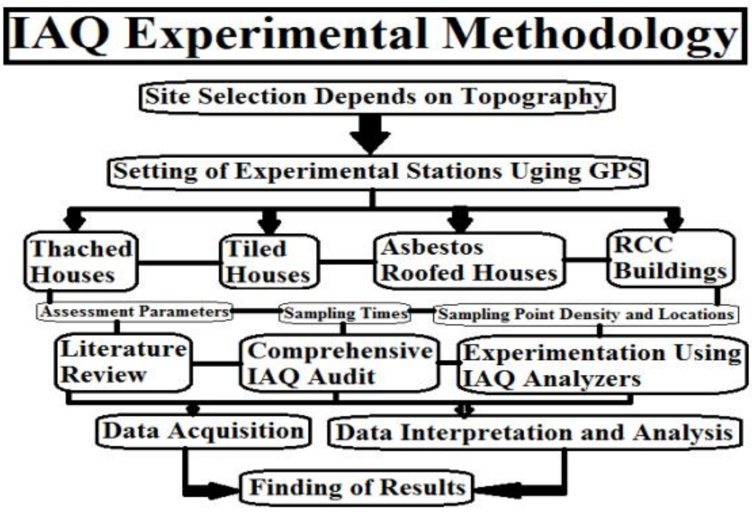
Various air pollutants, such as volatile organic compounds (VOCs), microbes, particles, etc. daily enter to the atmosphere, thus changes to get contamination of indoor air quality is possible. Hence, it is important to estimate the extent to which the indoor air pollution and consumed the same by the residents and the periphery areas have been indispensable. In these areas so many people spend indoor, they are not aware of the air pollution and its effect; moreover, diseases which are purely air borne occur in some parts of the study area.

Due to increasing urbanization, indoor environment is getting over contaminated and more stringent treatments would be required to make clean indoor environment. Therefore, it is required to explore additional sources for fulfilling the requirements of air. Hence, studies of physicochemical characteristics of indoor air to find out whether it is fit for living or some other beneficial uses.

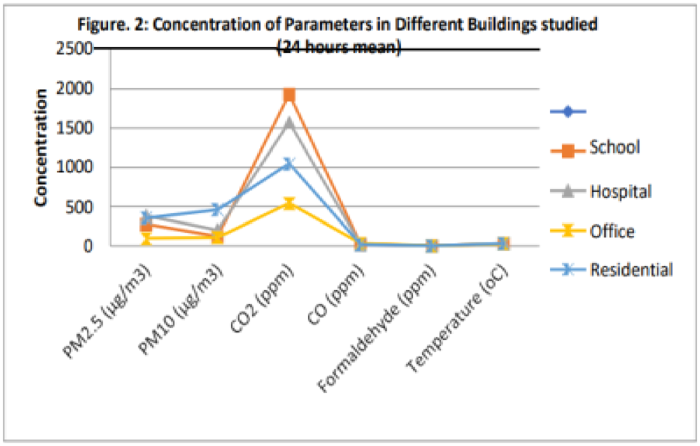
The study was conducted in order to represent local satisfaction of the people and students regarding the quality of indoor air inside the different buildings due to impact of surroundings. On the other hand, this study also might also help in improving the air quality and measuring and enhancing pollutants levels by applying strategies of controlling the source, improving the current ventilation systems and providing air cleaners in future development

In this study, we did an extensive literature review and conducted comprehensive IAQ audits in hospital, offices and school, residential building. After analyzing the IAQ audit results, the serious chemical and microbiological indoor air pollutants as well as their sources, adverse health effects, and exposure limits were identified. After analyzing the IAQ audit results, the serious chemical and Microbiological indoor air pollutants as well as their sources, adverse health effects, and exposure limits were identified. The step-by-step process of indoor air quality monitoring was presented in (Fig. 1).

Fig. 1: Showing Detailed Study Methodology flow Chart



Among all the studied parameters in school, hospital, office and residential buildings the CO2 is recorded at highest concentration irrespective the building. However, formaldehyde is recorded at lowest concentration in all the buildings is shown in Figure: 2.



2. Materials and Methods

Site selection depends on Topography
Physical requirements of the monitoring site for a long period of time.
Topographical and Meteorological factors.
Selection of pollutants based on their measurements criteria
Experimentation using Indoor Air quality Analyzer.

3. Discussions

Schools

The mean age of 1st-grade students was 6.20 ± 0.42 years, and the mean age of 4th-grade students was 9.25 ± 0.48 years. Most (51.63%) of the children were male. There was a relatively uniform distribution of the 493 female children between the two grades studied. A similar trend was observed in male students. The mean concentrations of indoor air quality parameters in the elementary schools in the two sampling periods, i.e., morning at 8:00 AM and evening at 5:00 PM. Mean concentrations of CO and CO2 were significantly higher in the evening than in the morning ($p < 0.001$). There was an increase of 0.28 ppm in the concentration of CO from one sampling period to another. Regarding CO2 levels, there was a reduction of 425.36 ppm in the morning. We found mean CO2 concentrations that were well above the maximum reference value (i.e., 1000 ppm) and therefore posed health risks to the children studying in those schools were represented in Table: 1.

Table.1: Distribution of the concentrations of pollutants in the indoor air of the classroom studied.

Pollutants	Sampling period		mean	Maximum reference value according to WHO
	morning (at 8:00 AM)	evening (at 5:00 PM)		
CO, ppm	24.42 ± 0.53*	26.42 ± 0.53*	25	10.7
CO2 , ppm	1878.16* ± 712.49	1952.80 ± 595.41	1932	1000
PM2.5, mg/m3	0.18 ± 0.04	0.30 ± 0.03	0.274	Not mentioned
PM10, mg/m3	0.12 ± 0.05	0.11 ± 0.03	0.118	0.15
Formaldehyde, ppm	0.01 ± 0.01*	0.02 ± 0.02	0.016	0.08

(Source: Elsevier, Investigation of indoor air quality in primary school classroom, 2015)

The most prevalent symptoms/diseases in the 1st-grade children were as follows: sneezing attacks, in 24%; lack of concentration, in 20%; riles and wheezing, in 17%; cough, in 16%; and allergic rhinitis, in 16%. In the 4th-grade children, the most prevalent symptoms/diseases were as follows: sneezing attacks, in 27%; lack of concentration, in 24%; allergic rhinitis, in 20%; and cough, in 16%. When we compared the children who were in the 1st grade with those who were in the 4th grade in terms of the prevalence of each symptom, we found that riles and wheezing were more common in the 1st-grade children (having been found in 55%), as was cough (in 51%). The remaining symptoms/ diseases were found to be more common in the children who were in the 4th grade. Of all environmental parameters analyzed, CO2 levels showed the worst results, posing serious health risks. In the indoor air of the schools evaluated, mean CO2 concentrations were in general well above the maximum reference value (984 ppm), being sometimes as high as 1,932 ppm. Given that CO2 concentrations in indoor air were found to be much higher in the evening than in the morning, we sought to estimate the risk of symptoms/diseases in the elementary school children. The classrooms were classified as posing health risks or as posing no health risks on the basis of the reference value.

Hospital Buildings

The experiment was carried out in patient room of hospital building in India. Measurement data in variable volume rate the room should be in various climatic environments. The measurable parameters are CO2, CO, PM 2.5, PM10 and Formaldehydes was measured. The stated six parameters are observed in patient room in mentioned standard load conditions. The relative velocity did not deviate from the intended levels. No significant thermal comfort was found in natural ventilation and 200 cfm air flow rate. From our result the maximum and minimum temperature and relative humidity are obtained 32°C, 29.1°C and 55 %, 41%. In the morning and evening time the temperature is nearer to minimum and Relative humidity Maximum. In after noon time period the temperature maximum and Relative humidity minimum. In our result conclude about Human and Thermal comfort is good on morning and evening time period compare to afternoon in natural ventilation condition. In afternoon 11.00am to 3.00 pm there has increasing of temperature and decrease of relative humidity. Between these times is inconvenient to patients is shown in Table: 2.

Table.2: Distribution of the concentrations of pollutants in the indoor air of the Hospital room studied

Pollutants	Sampling period		Mean	Maximum reference value according to WHO
	morning (at 8:00 AM)	evening (at 5:00 PM)		
CO, ppm	20	22	21	10.7
CO2 , ppm	1365	1675	1573	1000
PM2.5, mg/m3	0.398	0.287	0.384	Not mentioned
PM10, mg/m3	0.212	0.184	0.198	0.15
Formaldehyde, ppm	0.261	0.335	0.31	0.08

(Source: Reaserchgate, Indoor air quality investigations in hospital patient room, 2018)

Carbon monoxide is exceeding WHO standard level in indoor environment (0 to 9 ppm). It is 21ppm in morning peak hours between 9.00 am to 11.00 am and the remaining time recorded at 18 ppm. Carbon dioxide is constantly increase in the room and it is minimum at morning 8.30am 974 ppm and maximum at 5 .00 pm 1695 ppm. It can be above the WHO standard indoor value is 1000 ppm. Poor thermal comfort impairs cognitive performance in patients, and more significantly, impacts in difficult to take rest in patient room.

Office Buildings

The WHO notes that complete protection for every individual against all possible adverse health effects of PM is unlikely to be guaranteed by any limit value due to the substantial inter-individual variability in exposure and in the response to a given exposure; therefore, the lowest concentrations possible in the context of local constraints, capabilities and public health priorities should be achieved (WHO, 2005.In this context, the median 5-day PM2.5 concentrations, 92 and 132 µg m−3 for the morning and evening, respectively, were below the 24-h limit but exceeded the annual one. The mean concentrations of PM 2.5 and PM 10, 97 and 107 µg m−3 in morning and evening, respectively, appeared high compared to both AQGs. Mean concentrations of CO and CO2 were significantly higher in the evening than in the morning. There was a increase of 0.24 ppm in the concentration of CO from one sampling period to another. Regarding CO2 levels, there was a reduction of 235.36 ppm in the morning. We found mean CO2 concentrations 543ppm that were well below the maximum reference value (i.e., 1000 ppm) and therefore, there is no posed health risks to workers is presented in Table: 3

Table.3: Distribution of the concentrations of pollutants in the indoor air of the office room studied.

Pollutants	Sampling period		Mean	Maximum reference value according to WHO
	Morning (at 8:00 AM)	evening (at 5:00 PM)		
CO, ppm	27.65	41.55	34.6	10.7
CO2 , ppm	288.64	797.36	543	1000
PM2.5, mg/m3	92	132	0.097	Not mentioned
PM10, mg/m3	0.091	0.123	0.107	0.15
Formaldehyde, ppm	0.023	0.049	0.036	0.08

(Source: Elsevier, assessment of indoor air quality in office building, 2017)

Residential Building

Indoor air samples of CO2, CO, Formaldehyde and PM4 were collected. Air samples were collected at a height of about 1.5 m from the floor and away from the door, thus avoiding disturbances resulting from air currents. Ambient air samples were collected simultaneously at the same height. Indoor air temperature ranged from 17 to 23 °C (average 21 °C), and outdoor temperature ranged from 28-31 °C (average 29.5 °C). The average humidity indoors ranged from 28.4 to 52.8% (average 39.2%) in bedrooms and 32.3–58.7% (average 40.7%) in kitchens, respectively; while in outdoor air humidity ranged from 43.2 to 96.7% (average 70.9%). All the houses had natural ventilation and were insulated. No cigarettes were smoked, and windows were kept closed during the sampling. The average CO2 concentrations in the living rooms ranged from 520 to 780 ppm with an average of 622 ppm. These CO2 levels did not exceed the WHO standard of 1000 ppm. On the other hand, the mean CO2 concentrations in the kitchens ranged from 977 to 1123 ppm with an average of 1050 ppm. The monitored kitchen had higher indoor concentrations of CO2 than the WHO standard. The results show that the elevated CO2 levels observed in these domestic kitchens were related to insufficient ventilation.. Therefore, small size of the kitchens enhanced the influence of the emissions from combustion sources so that higher concentrations of CO2 were found in kitchens than in living rooms. Carbon monoxide is exceeding WHO standard level in indoor environment (0 to 9 ppm). It is 17.6 ppm in morning peak hours in between 9.00 am to 11.00 am and remaining time recorded at 15.2 ppm. Respondents who had the information about the sources and methods to regulate indoor air quality had been asked to mention the common sources of CO, vehicle smoke, cooking inside the living room and utilization of kerosene for cooing were mentioned as sources is shown in Table: 4.

Table.4: Distribution of the concentrations of pollutants in the indoor air of the Residential building studied

Pollutants	Sampling period		Mean	Maximum reference value according to WHO
	morning (at 8:00 AM)	evening (at 5:00 PM)		
CO, ppm	17.6	15.2	16.4	10.7
CO2 , ppm	977	1123	1050	1000
PM2.5, mg/m3	0.223	0.485	0.354	Not mentioned
PM10, mg/m3	0.912	0.536	0.456	0.15
Formaldehyde, ppm	10.5	22.3	16.4	0.08

(Source: Pergamon, indoor air quality at residential homes, 2002)

Comparative Analysis among the Studied Buildings:

The data obtained from a range of sources to analyze the concentration of particulate matter (PM2.5), particulate matter (PM10), carbon dioxide (CO_2), carbon monoxide (CO), formaldehydes buildings have been studied for data collection and analysis for this study (N=4) Among these, the and air temperature from different buildings at different localities, In total, there are 4 types of samples were collected from school buildings, hospital buildings, office buildings and residential buildings as data represented in Table: 5.

Table.5: Comparison of the concentrations of indoor air pollutants in the buildings studied.

Parameters/ Buildings	**Concentration of pollutants in School**	**Concentration of pollutants in Hospital**	**Concentration of pollutants in Office**	**Concentration of pollutants in Residential**	**Mean Value**
$PM_{2.5}$	274 µg/m3	384 µg/m3	97 µg/m3	354 µg/m3	277.25
PM_{10}	118 µg/m3	198 µg/m3	107 µg/m3	456 µg/m3	219.75
CO2	1932ppm	1573ppm	543ppm	1050ppm	1274.5
CO	25ppm	21ppm	34.6ppm	16.4ppm	24.25
Formaldehyde	0.016 pm	0.31ppm	0.036ppm	0.27 ppm	0.158
Indoor air temperature (in degrees)	27.3	29	23.76	28.6	27.175

4. Results

Subsequently the study analysis is compared the results with standard limits provided by WH (World Health Organization) and IGBC (Indian Green Building Council) as data is presented in Table: 6

Table.6: Standard Limits for Pollutants of Indoor Air Quality provided by WHO and IGBC

Pollutnts	**WHO**	**IGBC**			**Effect**
		Concentration reported	**Concentrations of limited or no concern**	**Concentration of concern**	
$PM_{2.5}$	25 µg/m3 (24 h avg.) 10 µg/m3 (Annual avg.)	0.05 – 0.7	<0.1	>0.015	Type: Immediate Causes: Liver, kidney disorders, irritation to the eyes, nose and throat, skin rashes and respiratory problems.
PM_{10}	50 µg/m3 (24 h) 20 µg/m3 (1 year)	0.05 – 0.7	<0.1	>0.015	Type: Immediate Causes: Liver, kidney disorders, irritation to the eyes, nose and throat, skin rashes and respiratory problems.
CO2	100 mg/m3 (15 min) 35 mg/m3 (1 h) 10 mg/m3 (8 h) 7 mg/m3 (24 h)	500 – 5000 ppm	< 1000 ppm	>1000 ppm	Surrogate index of ventilation
CO	86 ppm (15 min avg.) 51 ppm (30 min avg.) 25 ppm (1-h avg.) 8.6 ppm (8-h avg.)	1-1.5	<2	>5	Type: Immediate Causes: headache, shortness of breath, higher conc. May cause sudden deaths. -
Formaldehydes	mg/m3 (30 min) 0.2 mg/m3 (long term)	0.05 – 2	< 0.06	>0.12	Type: Immediate Causes: irritation to the eyes, nose and throat, fatigue, headache, skin allergies, vomiting etc.

5. Conclusions

Following are the conclusions drawn from the present study;
The analysis has been revealed from all parameters studied, carbon dioxide (CO2) is present at highest concentrations in all the buildings. Subsequently respirable suspended particulate matter (RSPM) both PM 2.5 & PM 10 is occupying second place followed by carbon monoxide (CO) and formaldehyde (HCHO) are at third and fourth place respectively. Whereas building wise analysis has been discovered that CO2is present at highest concentration in school building at 27.3 0C temperature, RSPM (both PM 2.5 & PM 10) is present at highest concentration in residential building at 28.6 0C temperature, CO is present at highest concentration in office building at 23.76 0C temperature and formaldehyde is present at highest concentration in hospital building at 29 0C temperature. Because of the importance of indoor air, it is mandatory to assess the indoor air quality in certain period to ensure it not jeopardize human health. The quality control plan should be ready before the measurement and analysis. The quality criteria value helps to classify indoor air quality to different levels, which can be used as reference to make decisions and have the mitigation plan accordingly. There are many sources of indoor air contaminants, but the indoor air quality should be defined with measurable values. Some of the common factors for good indoor air are defined. Their parameters have two classes to identify indoor air quality. Although the reasons of poor indoor air are variable, the indoor air can be significantly improved by reducing the indoor air pollutants.
The present study allowed us to assess the risks to which the population is exposed and provide guidelines for the development of measures to minimize these risks. We hope that our findings will contribute to environmental health planning in different buildings and the improvement of political strategies to promote quality of life. This current study has identified several limitations; however, the main results are significant, and future research on IAQ will promote Enhanced Living Environments and sustainable buildings. This study has identified key elements of indoor quality that significantly affect the health of individuals in different areas of buildings. We have attempted to target areas of significance to health care practitioners as well as educated professionals. During this process, we have emphasized the relationship between indoor air quality and health as it pertains to exposure to the many different agents described in this. There are many different hazardous agents that can 45 potentially affect persons from secondhand smoke and cleaning agents to the family pet, many individuals remain unaware of the potential detrimental effects associated with these exposures. Lung health is important to both young and old alike and so it becomes crucial to target environmental exposures that may increase the risk for health problems, including asthma, allergic reactions, lung cancer, and in a small but significant fraction, accidental death. More research is needed to cope with the growing number of new pollutants and their possible side effects, better define the effects of volatile organic compounds, and the effect of poor indoor air quality on health care cost. Certainly, life-long awareness, elimination of potential indoor environmental hazards, and increased awareness within health care providers and professional are essential to promote longterm health and well-being. Much more work is required to determine the total environmental impacts of the buildings that are built. The work should include detailed evaluation of the pollution emissions, operation and use of buildings, and embodied and life cycle resource consumption. In addition, a management program specially designed for controlling the emission sources, coordinating preventive activities, promoting staff awareness, etc. are essential, in order to provide the patients and hospital staff as well as schools, offices and residential buildings with maximum protection. Of note, direct comparison of indoor air pollutant levels is difficult and not straightforward because evaluations have been conducted over different time periods, using different instruments and sampling techniques, and in different indoor environments. Thus, it is highly recommended that more detailed

scientific studies be conducted by following standardized regulations, which will allow for an inter-comparison of IAQ from studies in the future to close the existing knowledge gaps regarding IAQ.

Compliance with ethical standards

Conflict of interest the authors declared that there is no conflict of interest.

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